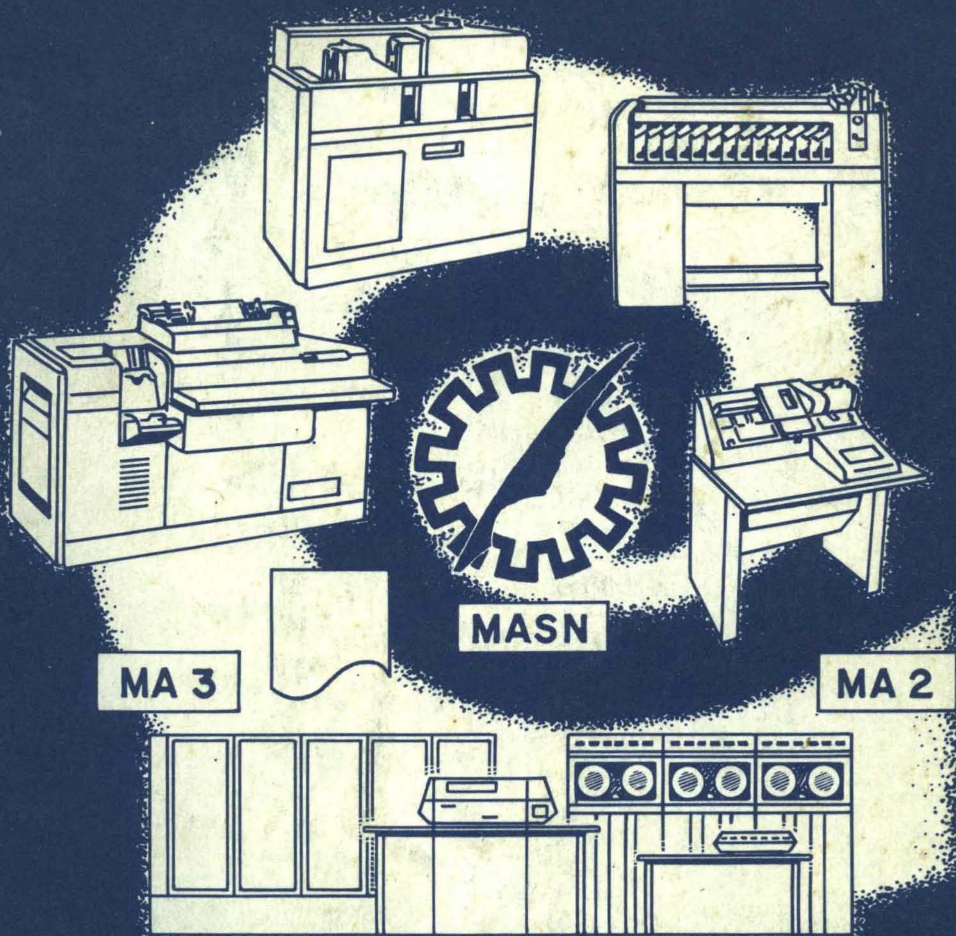

MACHINE ACCOUNTANT 3 & 2

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSE NAVPERS 10264—A

PREFACE

As one of the Navy Training Courses, this book was prepared by the Training Publications Division, Naval Personnel Program Support Activity, Washington, D. C., for the Bureau of Naval Personnel. Technical assistance was provided by the Personnel Accounting Machine Installation, U. S. Atlantic Fleet, Norfolk, Va.; Personnel Accounting Machine Installation, Continental United States, Bainbridge, Md.; Enlisted Personnel Distribution Office, Continental United States, Bainbridge, Md.; Aviation Supply Office, Philadelphia, Pa.; U. S. Naval Examining Center, Great Lakes, Ill.; U. S. Naval Command Systems Support Activity, Washington, D. C.; Manpower Information Division, Bureau of Naval Personnel; and by International Business Machines Corporation, Washington, D. C.

As this book goes to press, the Navy has undergone a major reorganization, in which certain bureaus have been redesignated as Systems Commands.

Check Instructions and Notices for further information concerning this change.

First Edition 1963
Major Revision 1966

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CREDITS

The machines described in this Navy Training Course were manufactured by International Business Machines Corporation; UNIVAC, Division of Sperry Rand Company; Honeywell, Incorporated; and Radio Corporation of America. Preparation of this manual was aided by the cooperation and courtesy of the aforementioned companies and Lincoln Technical Institute, Incorporated. These companies have supplied technical information, machine reference manuals, data processing management manuals, photographs of machines and machine features, and wiring diagrams for use in developing this training course. Permission to use these materials is gratefully adknowledged.

Illustrations not listed below are from Navy sources.

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HONEYWELL	2-29, 2-35, 2-36, 2-41, 2-42
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CHAPTER 1

MACHINE ACCOUNTANTS IN THE NAVY

This training course is designed to help you meet the professional qualifications for advancement to Machine Accountant 3 or Machine Accountant 2. The Machine Accountant qualifications which were used as a guide in the preparation of this training course are those contained in the Manual of Qualification for Advancement in Rating, NavPers 18068 (revision B).

Chapters 2 through 17 of this training course deal with the technical subject matter of the Machine Accountant rating. Chapter 2 introduces all concepts of Automatic Data Processing (ADP), Electric Accounting Machines (EAM)—Electronic Data Processing Machines (EDP), using generalities. Chapter 3 is a detailed introductory chapter on EAM Data Processing, providing the fundamentals of all phases of punched card accounting. Chapters 4 through 10 cover the operation and control panel wiring of specific unit record machines used in punched card accounting. Each of these chapters contains a complete unit of information for the more commonly used machines by type. Chapter 11 presents the concept of EAM processing and data flow, as represented by flow charts. Chapters 12 through 17 contain an introduction to the fundamentals of electronic data processing systems, in which components, functions, languages, procedures, and some Navy systems are discussed.

In general you will find that information on types of unit record machines is presented in the following order: first, the functions of the machines; second, the operating features, including machine controls and switches; third, principles of control panel wiring; and fourth, operating suggestions designed to assist you in obtaining the best results in machine operations.

The remainder of this chapter gives information on the enlisted rating structure, the Machine Accountant 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 Machine Accountant. This chapter includes information on how to make the best use of Navy Training Courses. Therefore, it is strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of this training course.

THE MACHINE ACCOUNTANT RATING

Men of the Machine Accountant rating operate many types of electric and electronic data processing equipment to provide accounting and statistical services for the Navy. They wire control panels for electric accounting machines and write programs for electronic data processing machines. They process incoming information and make routine and special reports as required. They are thoroughly familiar with accepted data processing applications, and in the higher paygrades are thoroughly familiar with accepted electronic data processing applications and management of data processing offices and installations.

Types of PO Ratings

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.

MA—A General Rating

The Machine Accountant 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 a Tabulating Machine Serviceman, who adjusts and repairs electric tabulating equipment, and Electronic Data Processing Systems Operator, who develops programs and operates large-scale electronic data processing machines.

The rating of Machine Accountant as such dates back to the year 1948, when the Navy revised the enlisted rating structure. However, the use of naval personnel to operate electric accounting machines goes back even further, to the early days of World War II. The enormous expansion of the naval forces resulted in a greatly increased workload for clerical personnel. Concerned with this problem, the Chief of Naval Personnel explored possibilities for handling the mountains of paperwork more efficiently. As a result of this exploration BuPers installed and began using punched card data processing equipment, resulting in the establishment of the Specialist IBM rating. This rating remained a specialist rating until 1948, at which time it was re-designated Machine Accountant and incorporated into the Regular Navy rating structure.

MA Assignments

Machine Accountants are assigned to many different activities which perform data processing by electrical or electronic methods. These include ships and shore installations of the Operating Forces, activities of the Shore Establishment, and Bureaus and Offices of the Navy Department. The nature of the Machine Accountant's duties depends on the mission of the activity to which assigned. For example, Machine Accountants assigned to auxiliary ships classified AD, AF, AKS, AR, and AS perform accounting functions relating to stock control, repair work, and shipboard personnel administration. Personnel Accounting Machine Installations (PAMIs) are staffed almost entirely by Machine Accountants. Each PAMI is an integral component of the Naval Manpower Information System, under the direction of the Chief of Naval Personnel. The mission of each PAMI is to collect, process, maintain, and disseminate naval manpower information concerning assigned activities: to provide data processing support to Fleet and Shore Commanders and District Commandants responsible for personnel functions and to furnish processed personnel data as required by the Chief of Naval Personnel.

Machine Accountants assigned to data processing offices in naval hospitals and medical centers perform fiscal and supply operations, prepare clinical studies, prepare civilian time cards and civilian and military payrolls, and produce various reports for the Public Works Department.

Other Machine Accountants may be found in supply centers and depots, naval stations, aviation activities, weapons stations, and other types of activities. Regardless of where they are assigned, all Machine Accountants are controlled and distributed by the Enlisted Personnel Distribution Office, Continental U.S.

Training and Responsibilities

The Machine Accountant rating is open to both male and female personnel. The newly formed Class A School is responsible for formal training of Machine Accountant Personnel. Seamen and personnel of other ratings who are selected for Machine Accountant training are normally assigned to a Class A School, where they are taught the basic fundamentals of the rate. Candidates for the Machine Accountant rating should possess a high degree of clerical aptitude, and be interested in mechanical work.

Data processing installations accomplish their work on an assembly-line basis. They are often 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 cards, and verifies the punched data. Still 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.

The MA as a Leader

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 responsibility 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, and practice the habit of setting a good personal 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 Seamen on up. You exercise leadership in the way you perform your job, whether it be keypunching, sorting, or any other task. The manner in which you follow instructions, the care you exercise when handling cards, 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 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 abilities. Nothing more could be asked of anyone.

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 pointers on how to exercise good leadership that can be easily applied to the Machine Accountant rating. In addition, you will find quotations from Navy Department General Order 21, which all of us should be familiar with.

ADVANCEMENT IN RATING

Some of the rewards of advancement in rating 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 advancing in rating are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By each advancement in rating, you increase your value to the Navy in two ways. First, you become more valuable as a technical 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 in rating? 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 professional training courses.
3. Demonstrate your ability to perform all the PRACTICAL requirements for advancement by completing the Record of Practical Factors, 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 a written examination on (a) military requirements and (b) professional qualifications.

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

Advancement in rating is not automatic. After you have met all the requirements, you are ELIGIBLE for advancement. You will actually be advanced in rating only if you meet

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.	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 (formerly NavPers 760) 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.		Navy-wide examinations required for all PO advancements.				Navy-wide, selection board.	
NAVY TRAINING COURSE (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		
	TARS attached to the air program are advanced to fill vacancies and must be approved by CNARESTRA.							

* All advancements require commanding officer's recommendation.
† 2 years obligated service required.

1.1:1

Figure 1-1.—Active duty advancement requirements.

INACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *	FOR THESE DRILLS PER YEAR	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	48	6 mos.	6 mos.	15 mos.	18 mos.	24 mos.	36 mos.	36 mos.	24 mos.
	24	9 mos.	9 mos.	15 mos.	18 mos.	24 mos.	36 mos.	36 mos.	24 mos.
	NON-DRILLING	12 mos.	24 mos.	24 mos.	36 mos.	48 mos.	48 mos.		
TOTAL TRAINING DUTY IN GRADE †	48	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
	24	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
	NON-DRILLING	None	None	14 days	14 days	28 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 (formerly NavPers 760), must be completed for all advancements.							
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Completion of applicable course or courses must be entered in service record.							
EXAMINATION		Standard exams are used where available, otherwise locally prepared exams are used.						Standard EXAM, Selection Board,	
AUTHORIZATION		District commandant or CNARESTRA					Bureau of Naval Personnel		

* Recommendation by commanding officer required for all advancements.

† Active duty periods may be substituted for training duty.

1.2:1

Figure 1-2.—Inactive duty advancement requirements.

all the requirements (including making a high enough score on the written examination) and if the quotas for your rating permit your advancement.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement in rating? You must study the qualifications for advancement, work on the practical factors, study the required Navy Training Courses, 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, NavPers 760, (3) a NavPers publication called Training Publications for Advancement in Rating, NavPers 10052, and (4) applicable Navy Training Courses. Figure 1-3 illustrates these materials; the following sections describe them and give you some practical suggestions on how to use them in preparing for advancement.

The Quals Manual

The Manual of Qualifications for Advancement in Rating, NavPers 18068B (with changes), gives the minimum requirements for advancement to each rate within each rating. This manual is usually called the "Quals Manual," and the qualifications themselves are often called "quals." The qualifications are of two general types: (1) military requirements, and (2) professional or technical qualifications.

MILITARY REQUIREMENTS 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.

PROFESSIONAL QUALIFICATIONS are technical or professional requirements that are directly related to the work of each rating.

Both the military requirements and the professional qualifications 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.

The written examination you will take for advancement in rating will contain questions relating to the practical factors and the knowledge factors of both the military requirements and the professional qualifications. 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 professional 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, however, 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 in rating, there must be an entry in your service record to show that you have qualified in the practical factors of both the military requirements and the professional qualifications. A special form known as the Record of Practical Factors, NavPers 760, is used to keep a record of your practical factor qualifications. This form is available for each rating. The form lists all practical factors, both military and professional. 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 in Rating, and revised forms of NavPers 760 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also 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.

If you are transferred before you qualify in all practical factors, the NavPers 760 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.

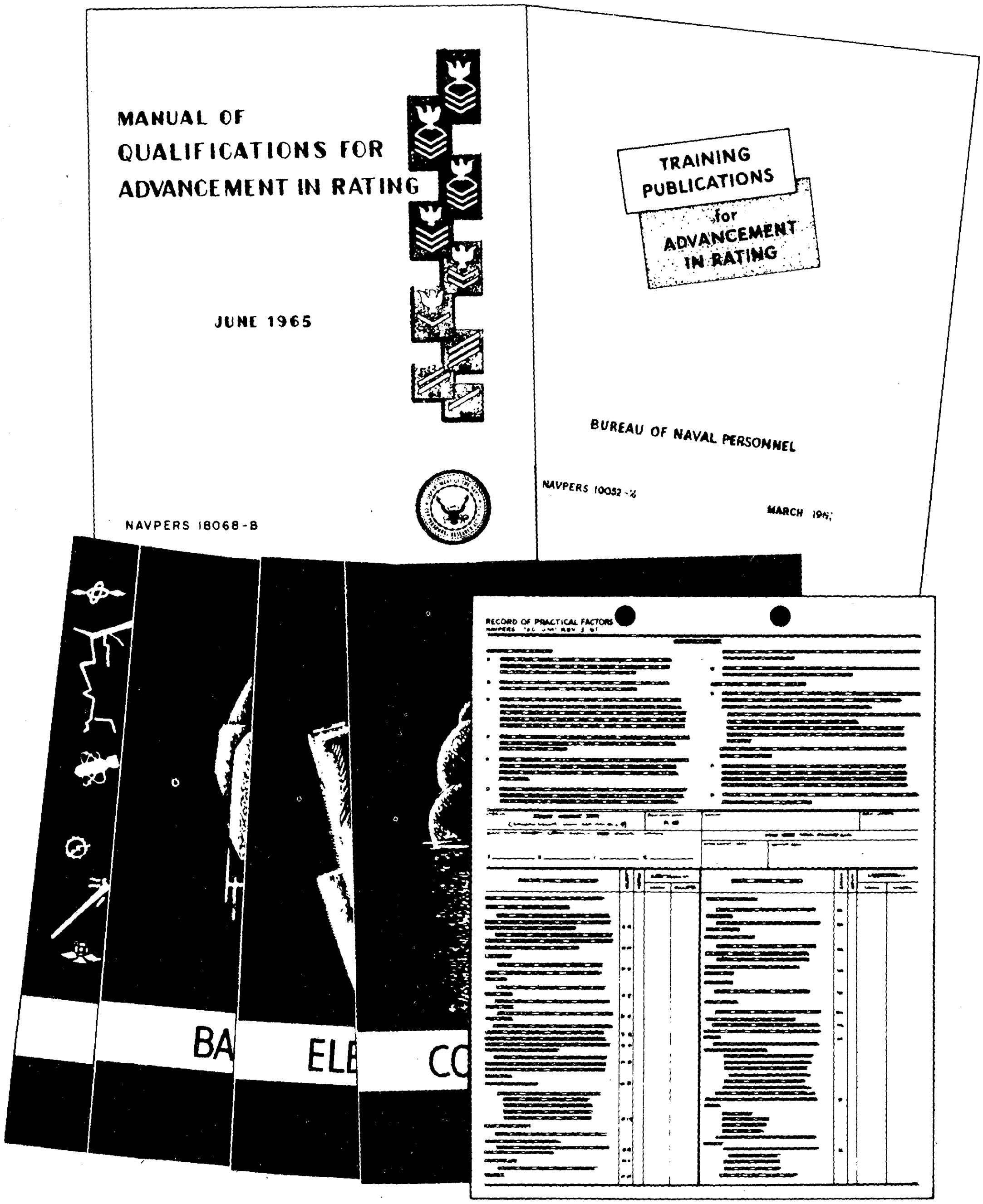


Figure 1-3.—Materials used in preparing for advancement.

NavPers 10052

Training Publications for Advancement in Rating, NavPers 10052 (revised), is a very important publication for anyone preparing for advancement in rating. This bibliography lists required and recommended Navy Training Courses and other reference material to be used by personnel working for advancement in rating. 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 rate level 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 Navy Training Courses are marked with an asterisk (*). Any course 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 in rating. Each mandatory course may be completed by (1) passing the appropriate enlisted correspondence course that is based on the mandatory training course; (2) passing locally prepared tests based on the information given in the training course; 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 requirements for advancement. Personnel of ALL ratings must complete the mandatory military requirements training course for the appropriate rate level before they can be eligible to advance in rating.

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

Navy Training Courses

There are two general types of Navy Training Courses. RATING COURSES (such as this one) are prepared for most enlisted ratings. A rating training course gives information that is directly related to the professional qualifications of ONE rating. SUBJECT MATTER COURSES or BASIC COURSES give information that applies to more than one rating.

Navy Training Courses are revised from time to time to keep them up to date technically. The revision of a Navy Training Course is identified by a letter following the NavPers number. You can tell whether any particular copy of a Navy Training Course 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 lists all current training courses and correspondence courses; you will find this catalog useful in planning your study program.)

Navy Training Courses are designed to help you prepare for advancement in rating. 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 in rating.

1. Study the military requirements and the professional qualifications for your rating before you study the training course, and refer to the quals frequently as you study. Remember, you are studying the training course 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 a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the training course 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 things that interest you.

4. Look at the training course 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 in rating?

5. When you have a general idea of what is in the training course 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 course 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 a 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 course, 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, the chances are that you have not really mastered the information.

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

10. Think of your future as you study Navy Training Courses. You are working for advancement to third class or second class right now, but someday you will be 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. It is recommended that, in order to broaden your knowledge of the particular device or devices you are working with, you obtain and study the appropriate manufacturer's technical manuals. These manuals contain detailed information concerning machine operation, including information on optional and special devices with which machines may be equipped.

Each different type of data processing installation where Machine Accountants are assigned has a different set of operating procedures and guidelines. For example, Personnel Accounting Machine Installations adhere to the Instructions for the Naval Manpower Information System, NavPers 15,642, part II. Data processing in Naval hospitals conforms with instructions contained in the Data Processing Management Handbook, NavMed P-5069. Similarly, data processing at other types of activities is guided and controlled by applicable manuals and instructions. It is important that you obtain and study the appropriate publications pertaining to the type of work your installation performs.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. A selected list of training films that may be useful to you is given in appendix I of this training course. Other films that may be of interest are listed in the United States Navy Film Catalog, NavWeps 10-1-777. This catalog, published in 1966, supersedes three earlier publications: the former catalog with the same title but numbered NP 10000-A; the Supplement, NavWeps 10-1-772; and the Navy Classified Film Catalog, NP 10001-A.

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 official publication or manufacturer's manual.

CHAPTER 2

AUTOMATIC DATA PROCESSING

To know all there is to know about 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. This generalization has also been prompted by the fact that you, as a Machine Accountant, in addition to knowing the functions and capabilities of the equipment within your own installation, should have a working knowledge of equipment used in other naval installations to which you may be assigned.

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

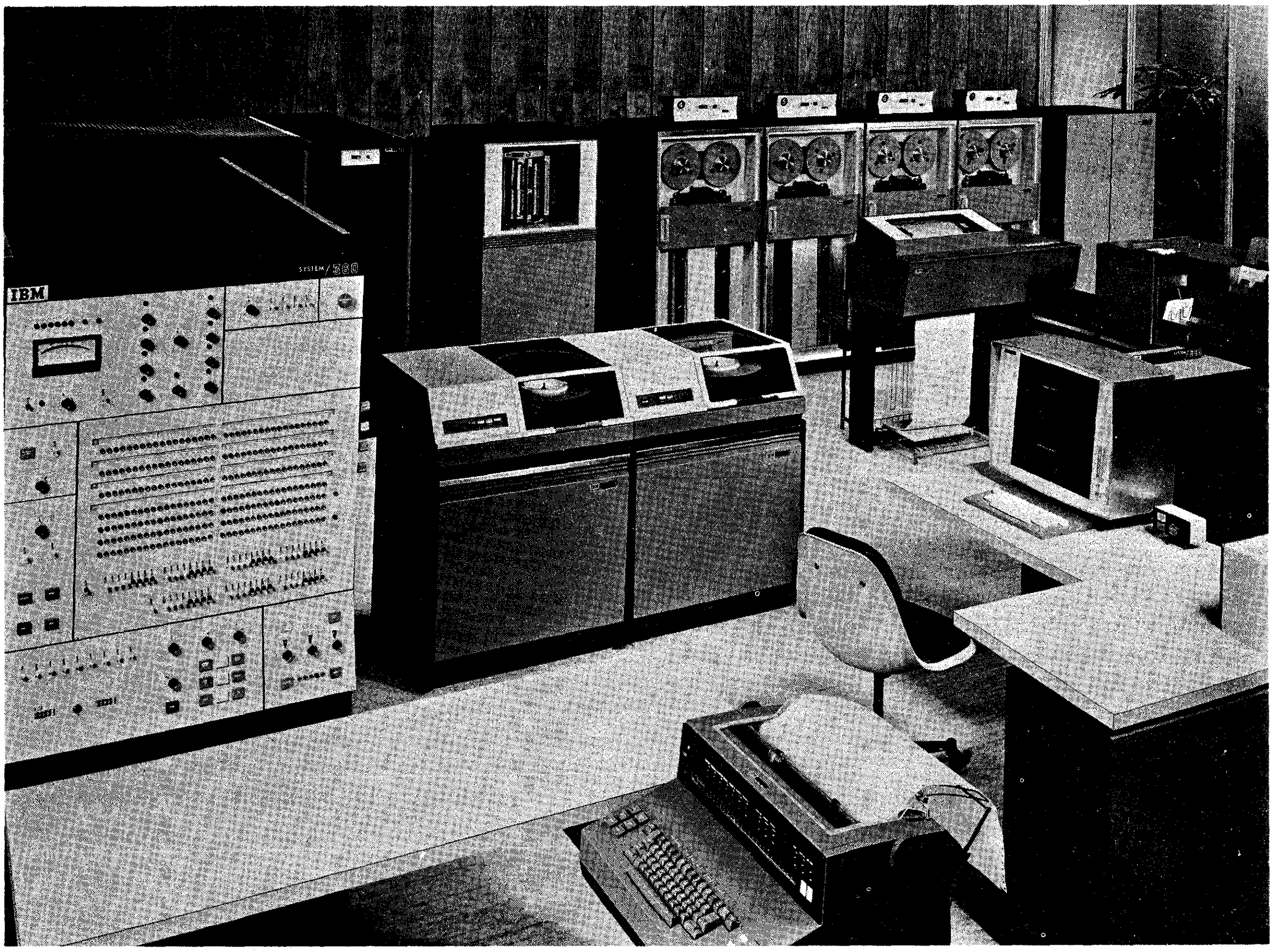
No one can be certain when counting began, for even ancient man used his fingers and toes to indicate numbers. Down through the centuries, as the science of mathematics was developed, symbols and numbers dispensed with the job of counting things over and over each time, one by one. At the same time, 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 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 with mechanized tools.

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," and simplified multiplication. In 1642, Blaise Pascal's "toothed-wheel" adding device, the first calculating machine, had the additional



49.176

Figure 2-1.—Automatic data processing.

ability to subtract. Refinements to this have resulted in the open market stylus calculators of today. Gottfried Wilhelm, Baron von Leibnitz next invented the first mechanical calculator which could accurately 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 keyboard.

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 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

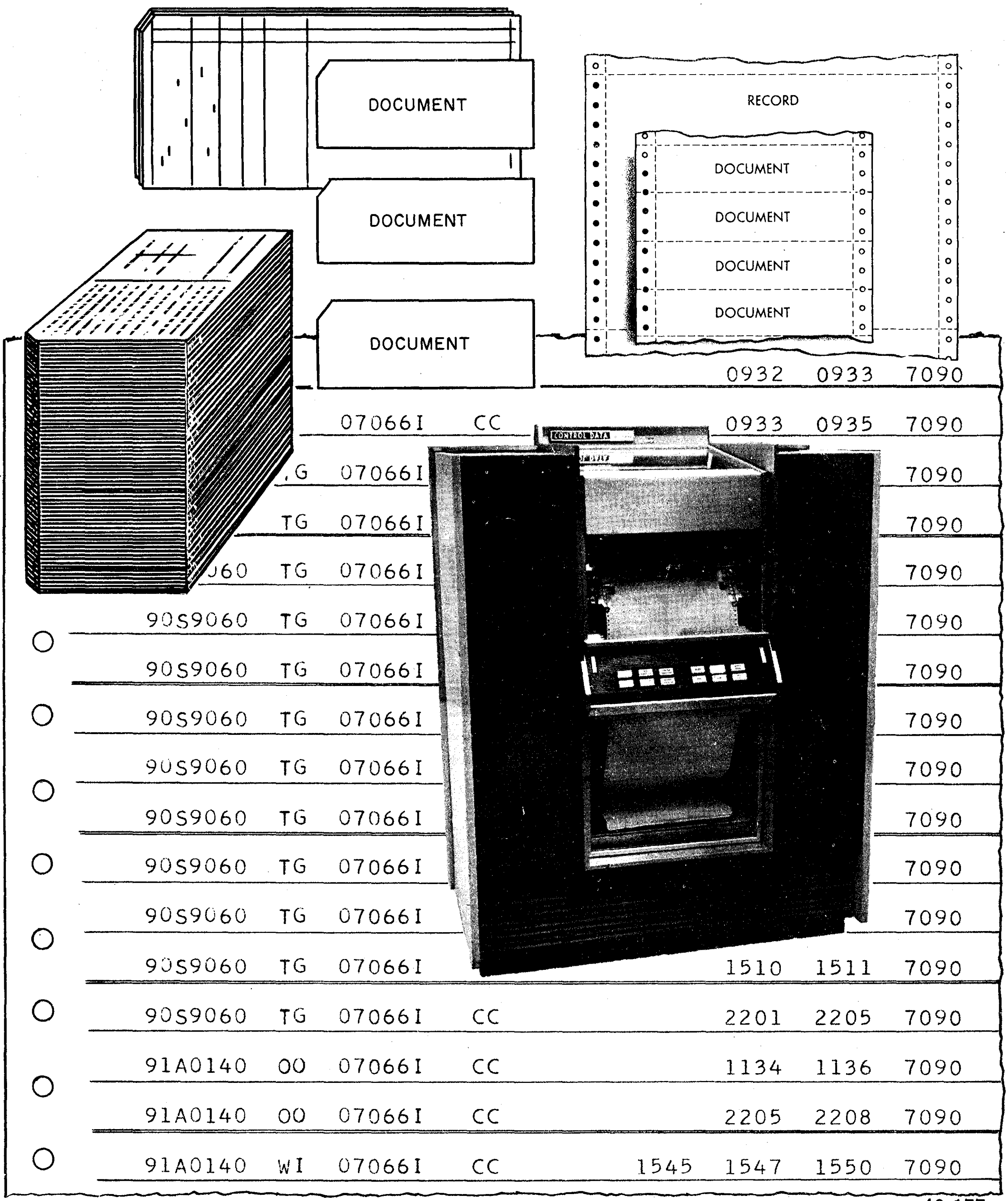


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Figure 2-2.—The end result of data processing.

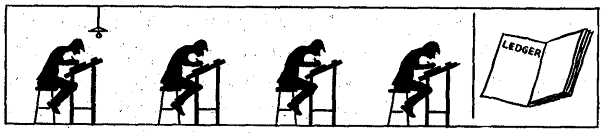

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Figure 2-3.—Pencil and paper accounting.

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Figure 2-4.—Key driven accounting.

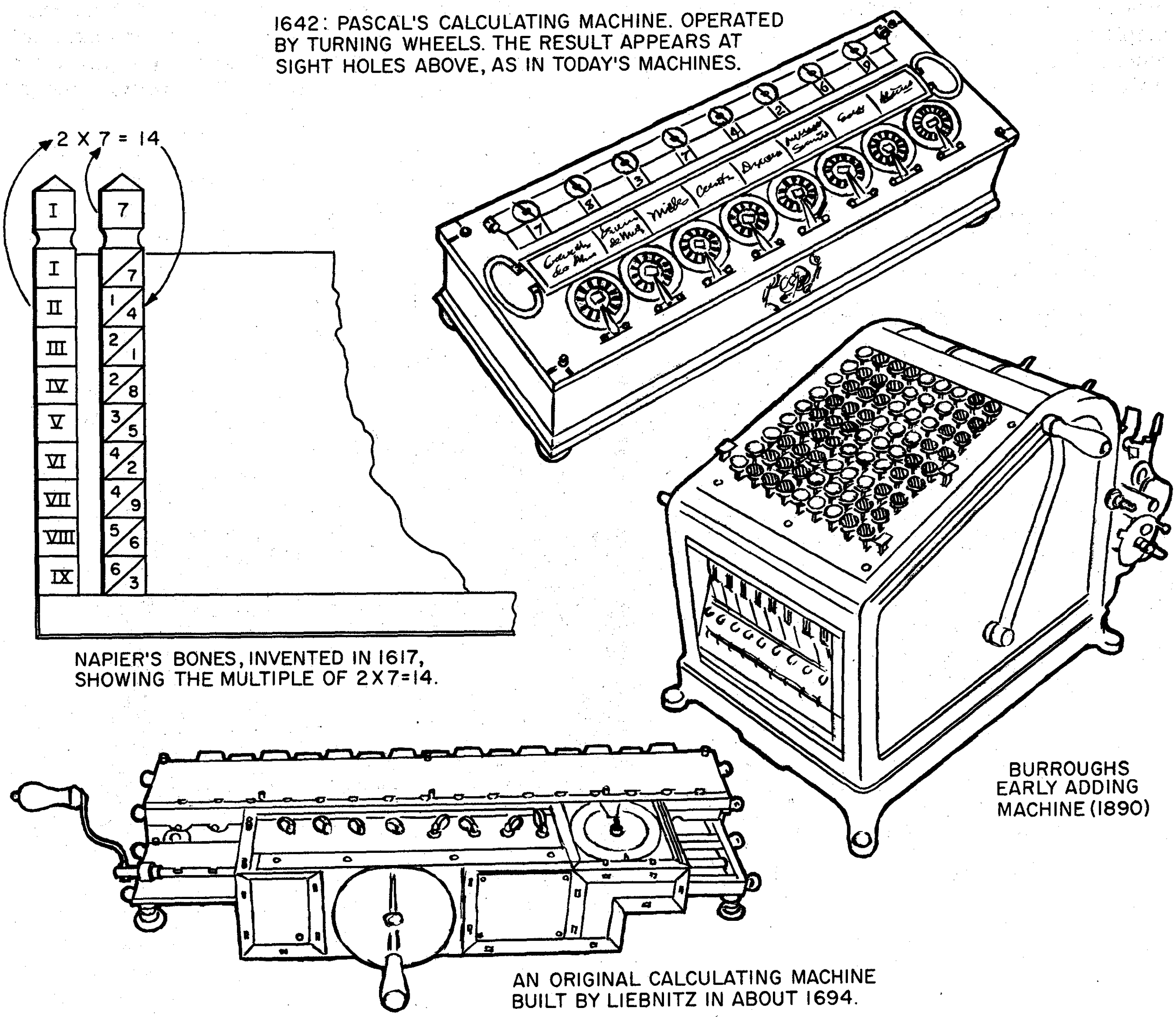

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Figure 2-5.—Advancement of calculating devices.

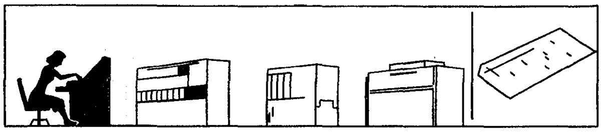

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Figure 2-6.—Punched card accounting.

the theory to a smaller, more convenient card in which information could be punched. 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, 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. Classifying data preparatory to punching, starting and stopping machines, and moving cards from one machine in a system to another is the only required manual control.

Electronic Data Processing

Electronic data processing (EDP) functions through principles of electronics rather than those of a mechanical or electro-mechanical nature. The first attempt to build a computer largely independent of operator action was in

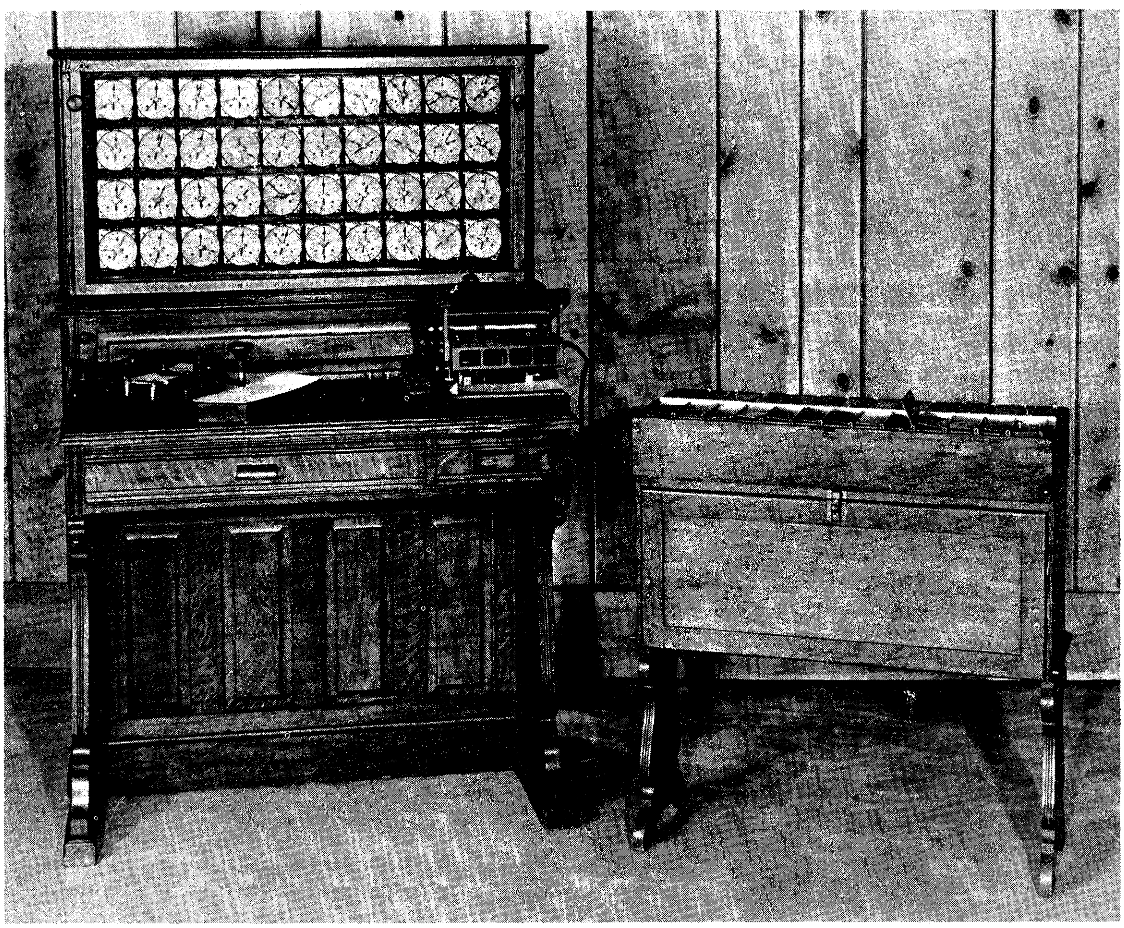

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Figure 2-7.—Hollerith's early model tabulating machine and sorting box.

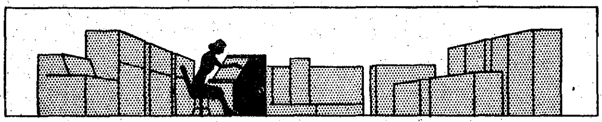

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Figure 2-8.—Electronic data processing.

England in 1830 by Charles Babbage. Though the machine was a practical failure 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) 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

With the expansion of the Navy during World War II, more and more records had to be maintained, and many additional reports had to be prepared. Equipped with a pencil, a typewriter, and an adding machine, clerical personnel maintained inventories, recorded the expenditures of supplies and money, accounted for personnel, and manually prepared many different kinds of reports.

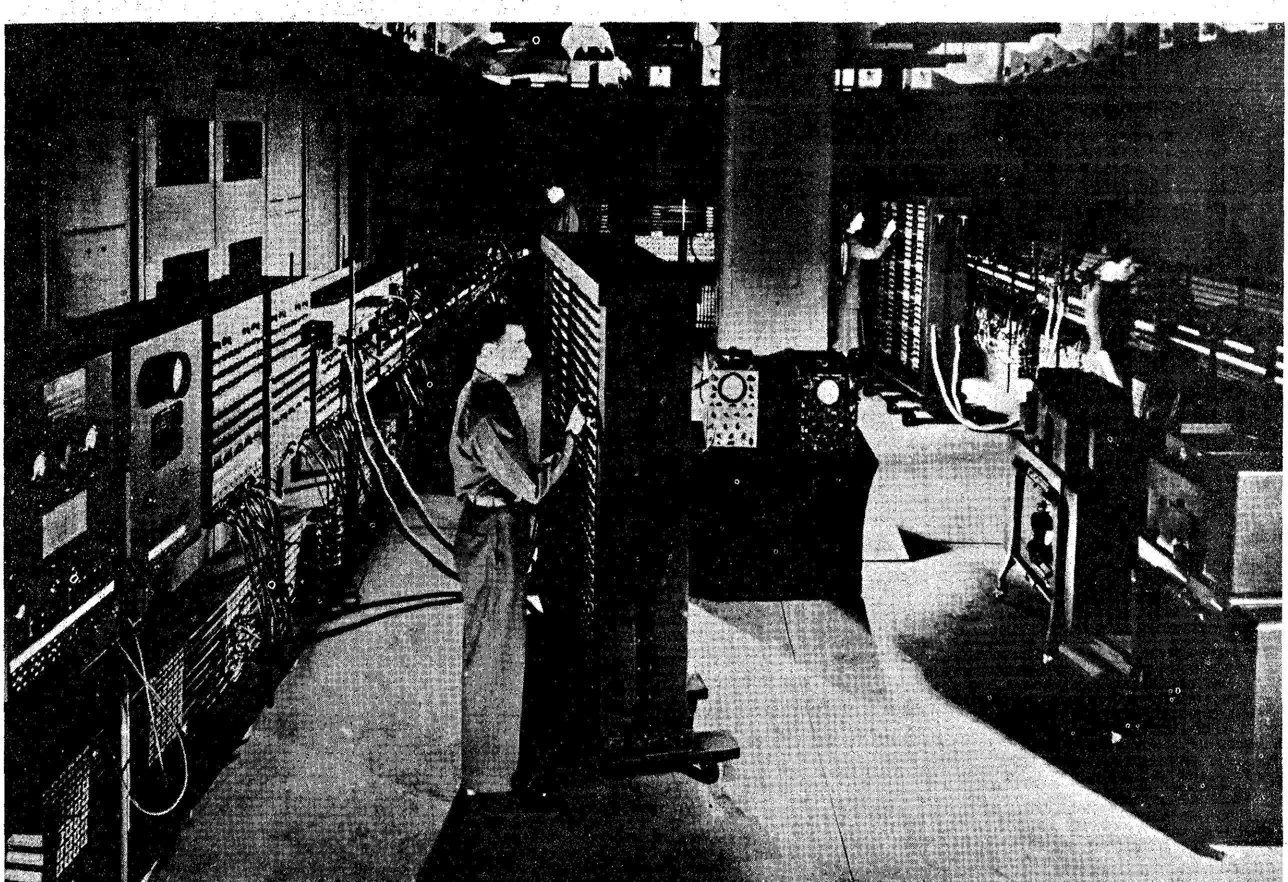

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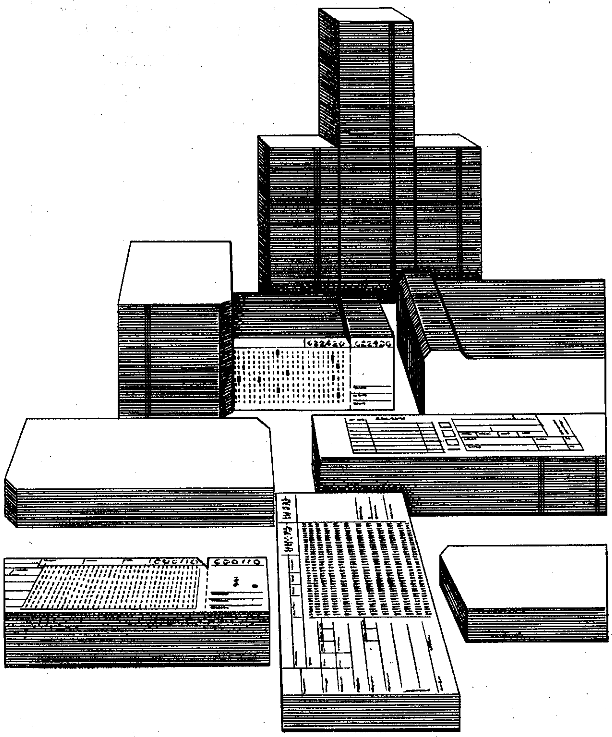
Figure 2-9.—ENIAC, the first all-electronic digital computer.



49.185
Figure 2-10.—Punched card record keeping.

Punched card data processing systems were eventually developed by naval activities to perform many of these functions, for it was found that punched card accounting machines could sort, collate, calculate, tabulate, and print useful information more quickly and accurately than these tasks could be performed by hand.

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 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. (See page 18.)

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 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, or its equivalent, the unit record, is the basic unit of punched card accounting and the basis from which all mechanical data processing applications evolve.

The success of varied formats of punched cards in meeting the requirements of small and large data processing systems has been phenomenal, as evidenced by their ever-increasing importance and widespread use in feeding information into processing systems. Those to be discussed have been modified in many ways to satisfy the needs of diversified processing systems.

The Punched Card.—Cards are of many and varied designs, but the most common is the standard 80-column card into which codes can be punched to indicate numeric digits, alphabetic characters, and special characters. Dependent upon the type of equipment and installation, punches will be in the form of either rectangular or round holes, as evidenced by figures 2-13 and 2-14. Some cards are designed for less than 80 columns of punching while others exceed this capacity. Such is the case with one type of Remington Rand UNIVAC card, shown in figure 2-13, which permits the punching of 90 columns of information. This is due to its horizontal division of two 45 column sections. A recent innovation to the IBM card is its optional round corner which permits easier joggling of cards and their placement in feed hoppers of machines. The round corners also aid in the prevention of cards from becoming dog-eared from constant use. Electrically powered key punch machines

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Figure 2-11.—Accounting turmoil prior to automatic data processing.

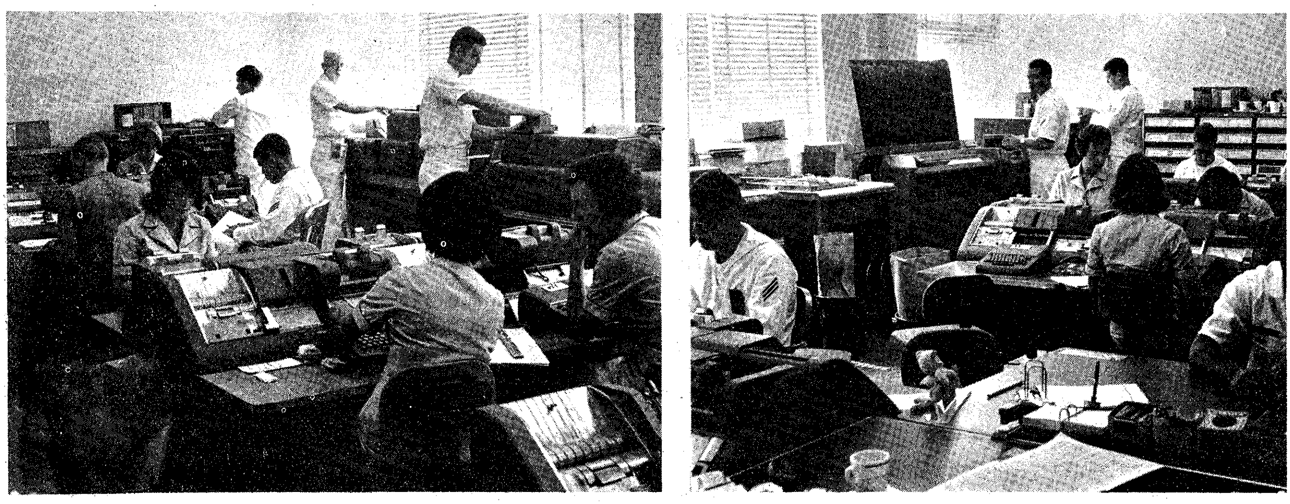

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Figure 2-12.—Machine Accountants in typical punched card data processing installations.

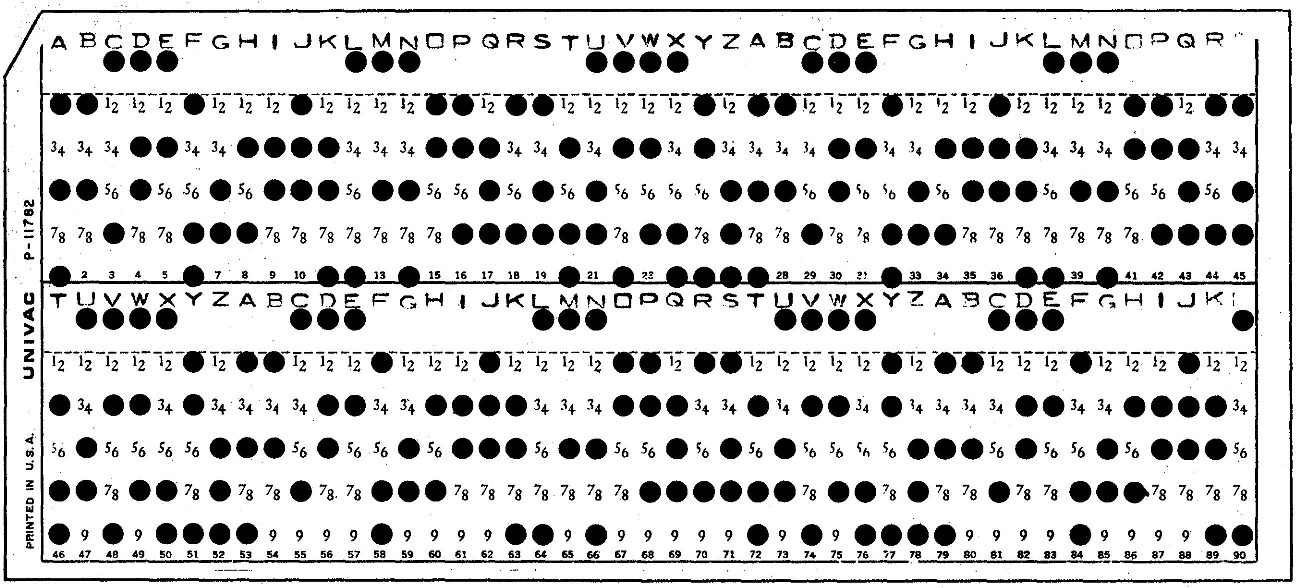

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Figure 2-13.—The Remington Rand UNIVAC punched card.

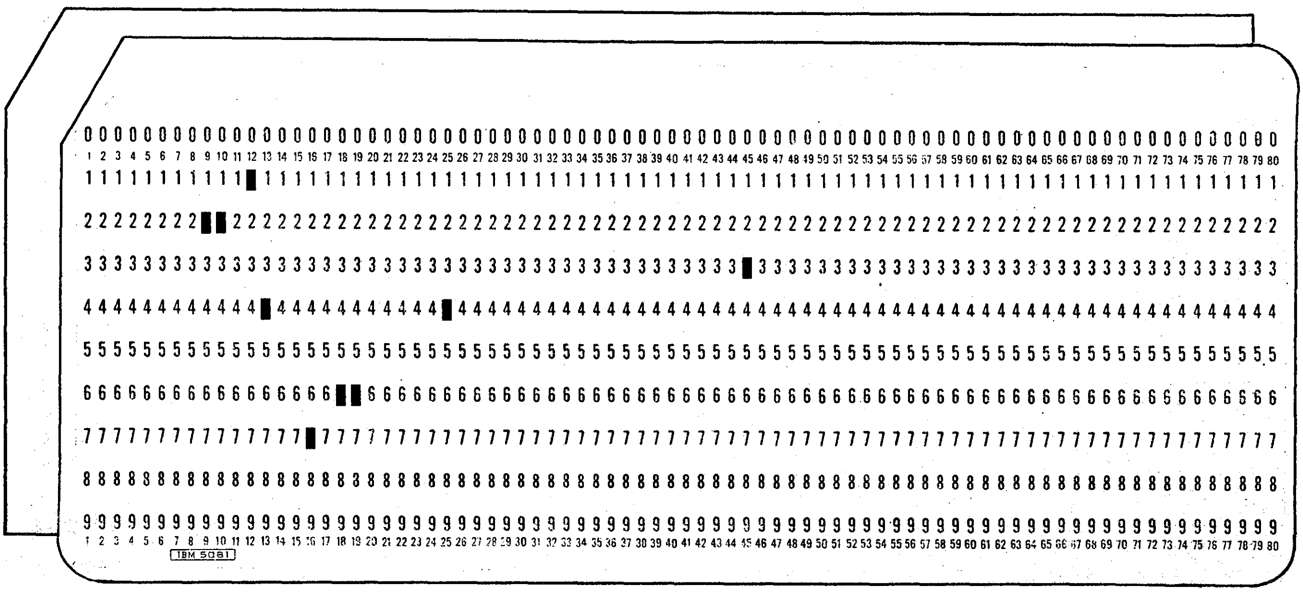

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Figure 2-14.—The International Business Machines (IBM) punched card.

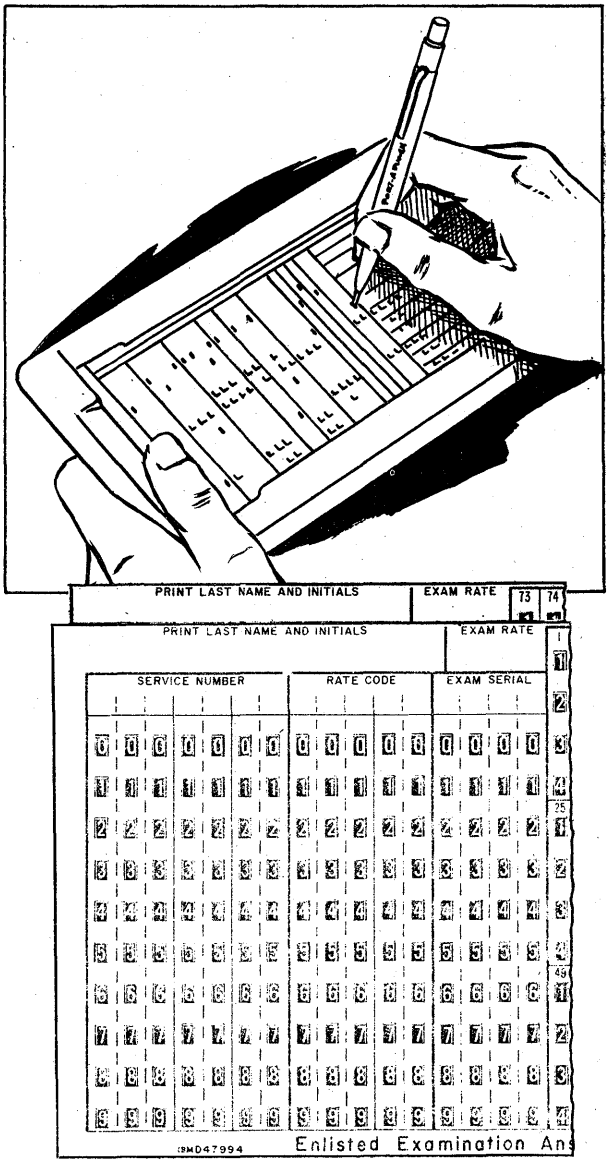

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Figure 2-15.—Creating a punched card with an IBM port-a-punch.

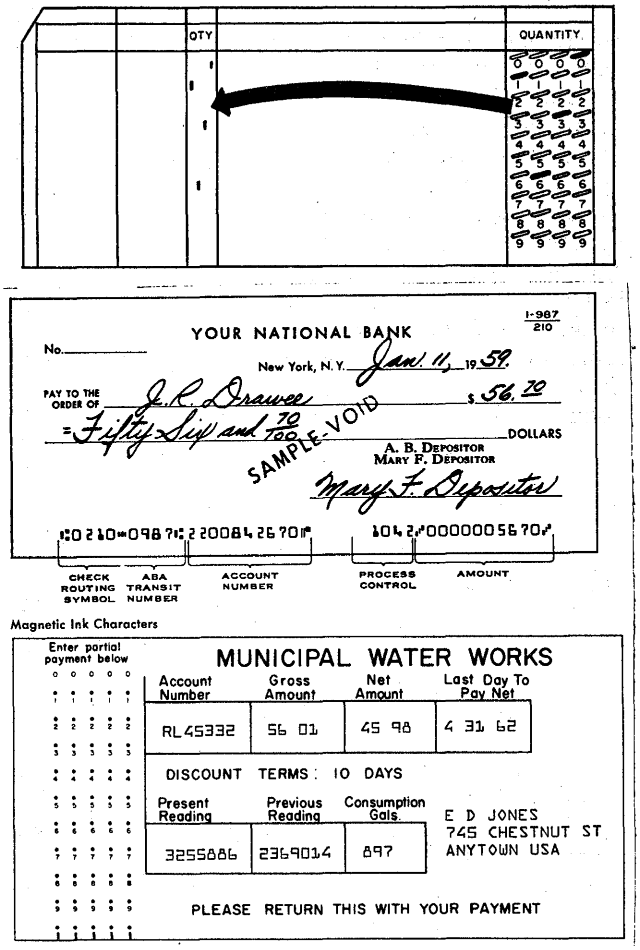

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Figure 2-16.—An IBM mark sense card, magnetic ink and optically character documents.

are normally employed for the initial punching of information into these types of cards.

Port-A-Punch Card.—This is a card punched from a portable device at a place remote from the data processing installation. Examining figure 2-15 closely, you can see the perforated punching positions of the card. With the stylus-like device shown, information may be manually punched into the card. Cards of this type can be extremely useful in taking inventories, and a similar card is used for the Fleetwide examinations.

Mark Sense Card.—Another card upon which data is recorded manually is the mark sense card (fig. 2-16). Marks made on the card must be electrically conductive and therefore necessitate the use of a special lead with a high graphite content. 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.

Optical Scanner Card.—Any type of mark made by ordinary pen or pencil within a designated area of this card can be read by the optical scanner through the principle of reflected light—a powerful light source and lens system capable of distinguishing between black and white patterns. Late model optical character readers have the ability to read uppercase letters, numbers, and certain special characters from printed paper documents and to introduce this data directly into a computer. Consequently, transcribing source data into cards is eliminated, and the time element of entering data into an electronic data processing system is decreased.

Magnetic Ink Character Card.—Characters on this particular card or paper document (for example, a check) are printed as illustrated in figure 2-16 with special magnetic ink readable by both man and machine. Each magnetic ink character is read and examined for acceptable valid character patterns by the Magnetic Ink Character Reader. The optically scanned and magnetic ink cards are more widely used by commercial enterprises than by the Navy.

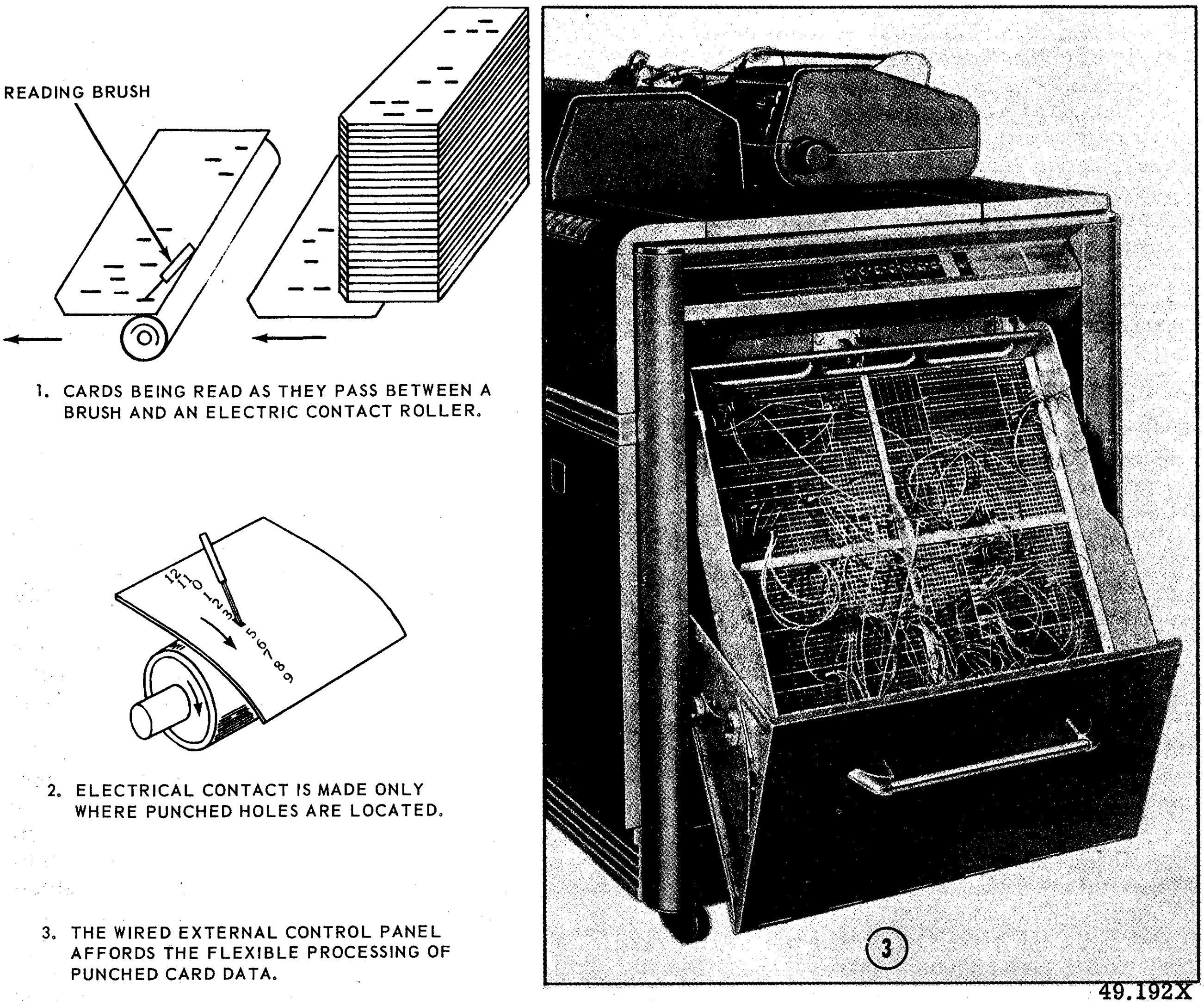

Figure 2-17.—Machine conversion and processing of data.

These two sensing systems are discussed more thoroughly in chapter 13.

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 figure 2-17, page 21.)

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 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.

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.

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 2-18 through 2-26, depicting punched card equipment, illustrate both 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 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.

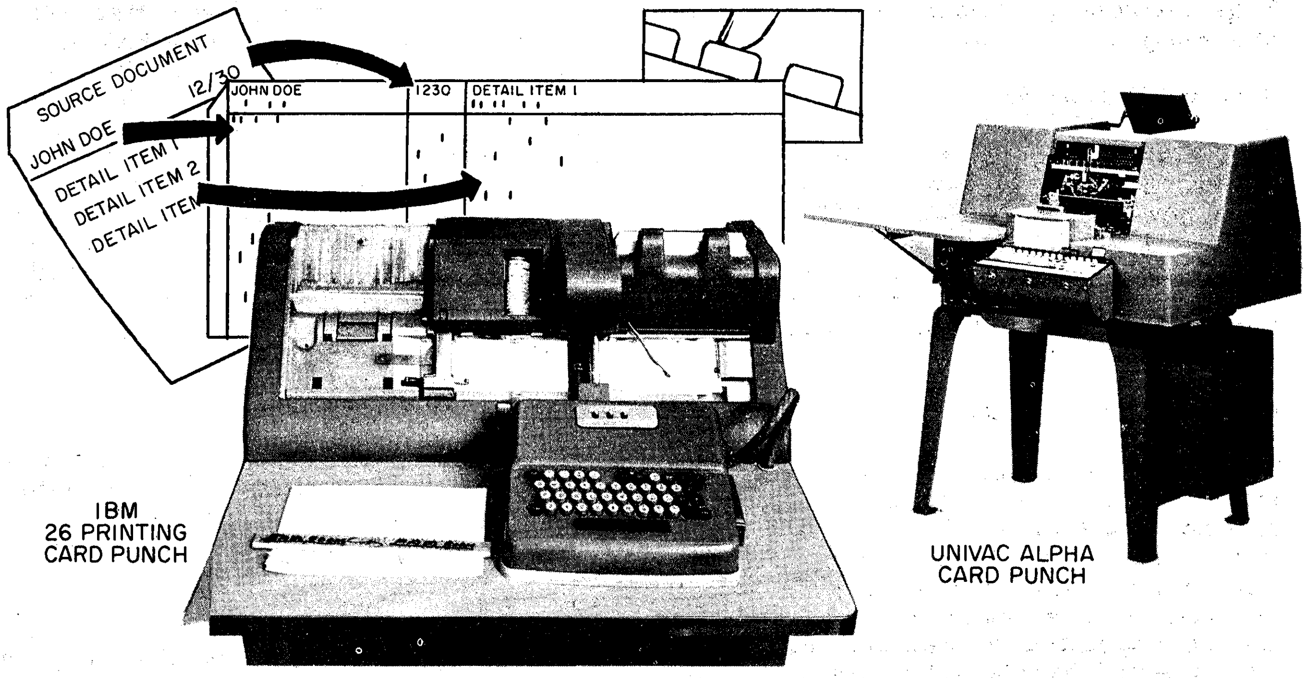

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Figure 2-18.—Converting source data to punched cards.

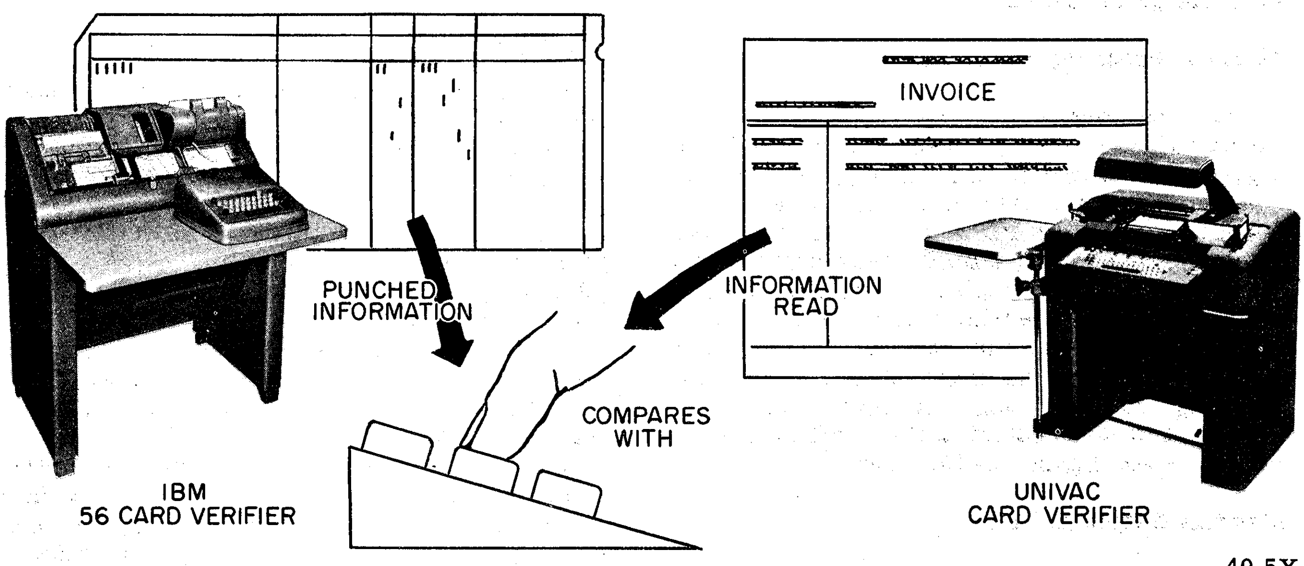

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Figure 2-19.—Checking the accuracy of the original keypunching.

The CARD VERIFIER 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

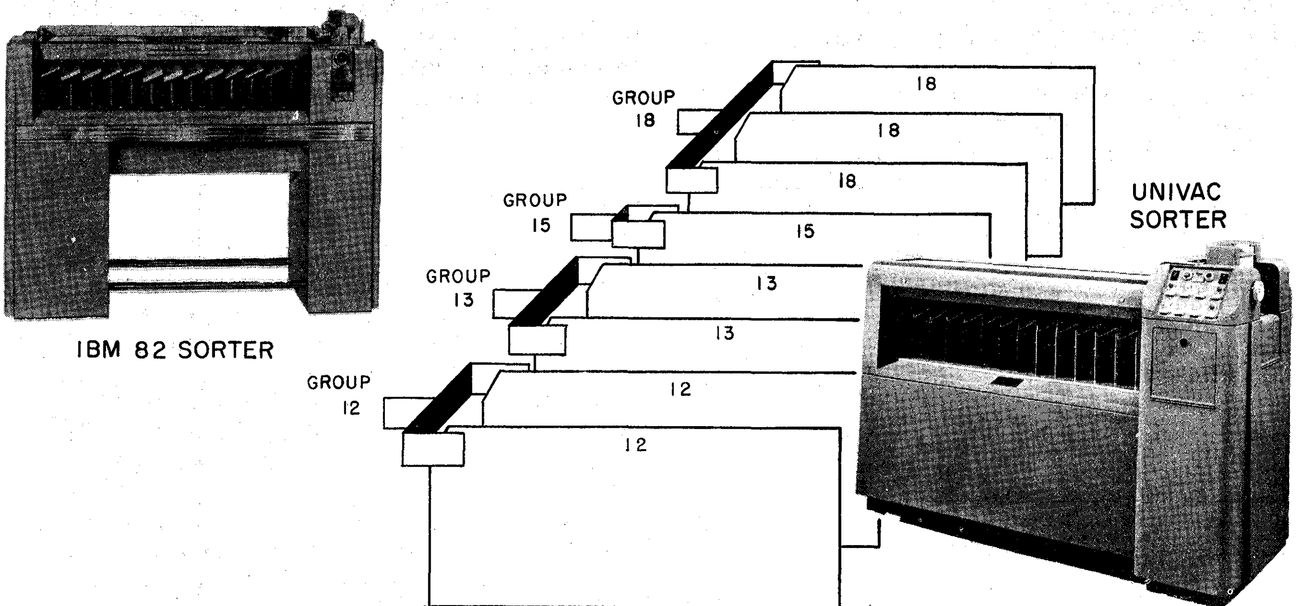

Figure 2-20.—Grouped cards in a definite sequence. 49.9X

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. Although sorting cards to a particular sequence is the major function of a card sorter, certain

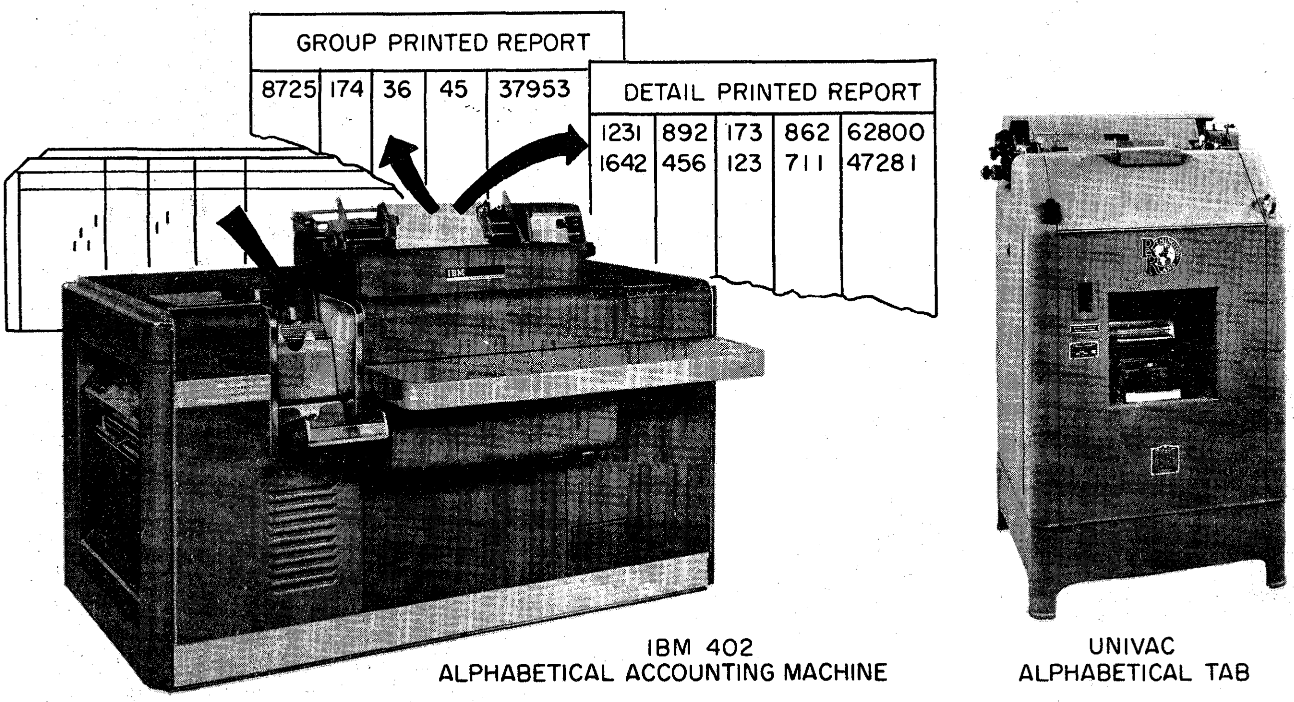

Figure 2-21.—End of the line processing. 49.119X

types of selection of individual cards that require special attention can also be automatically accomplished.

Accounting Machines.—The basic function of the accounting machine 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 of 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.

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 found in any normal installation, 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 translates the punched holes into printed information on the face of the card thereby increasing the use of the card as a documentary 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.

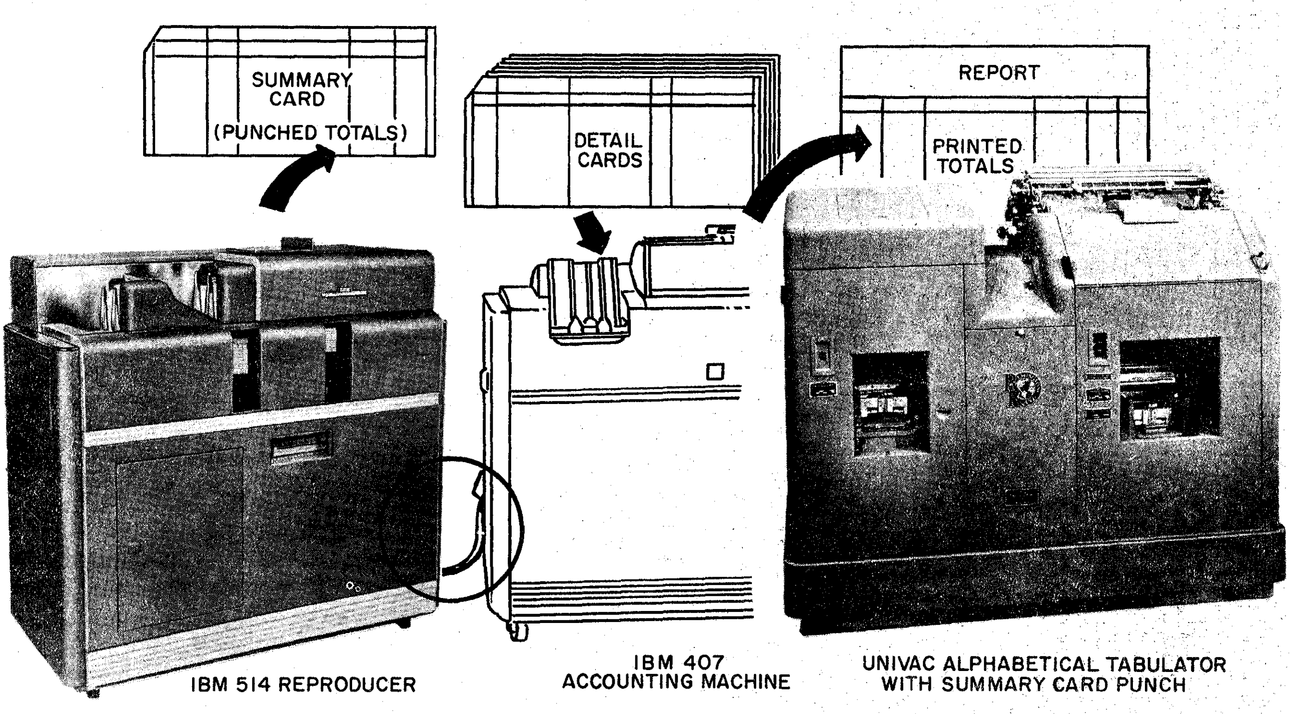

Figure 2-22.—Summary punching grouped information. 49.194X

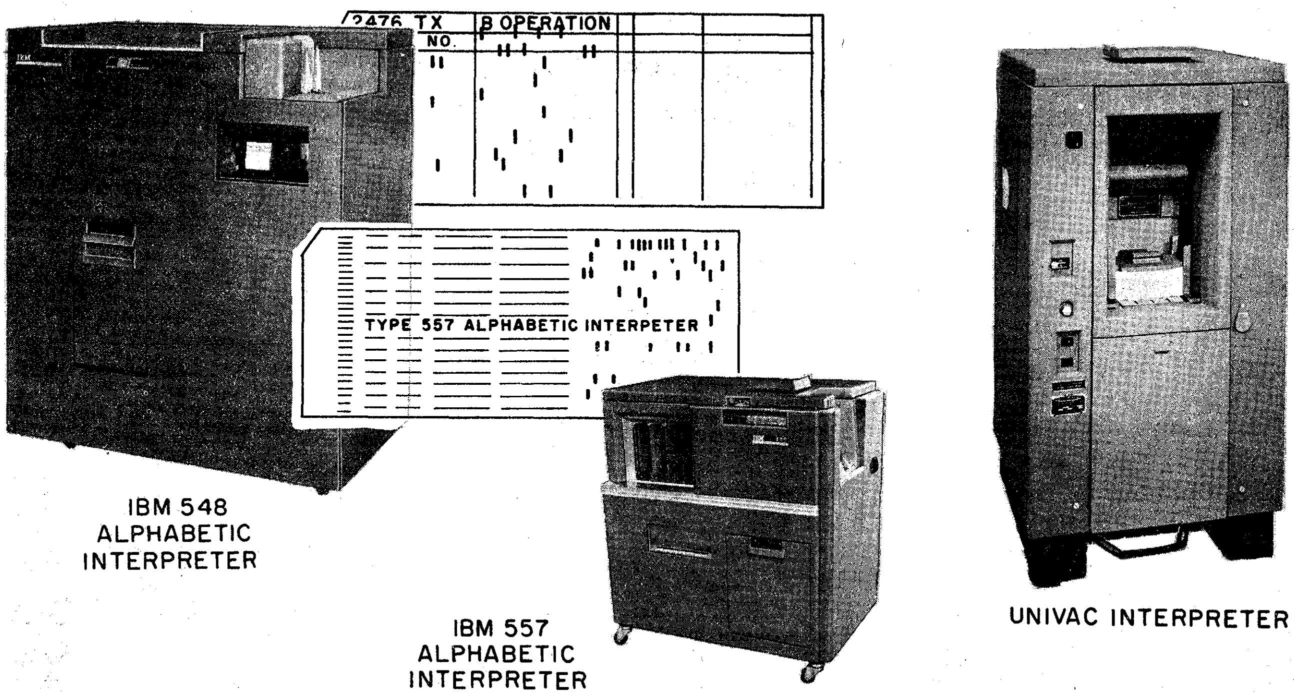

Figure 2-23.—Translating punched holes into printed information. 49.20:.29X

49.195
Figure 2-24.—Referencing interpreted information in a punched card file.

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. 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, the operation 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 was principally 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

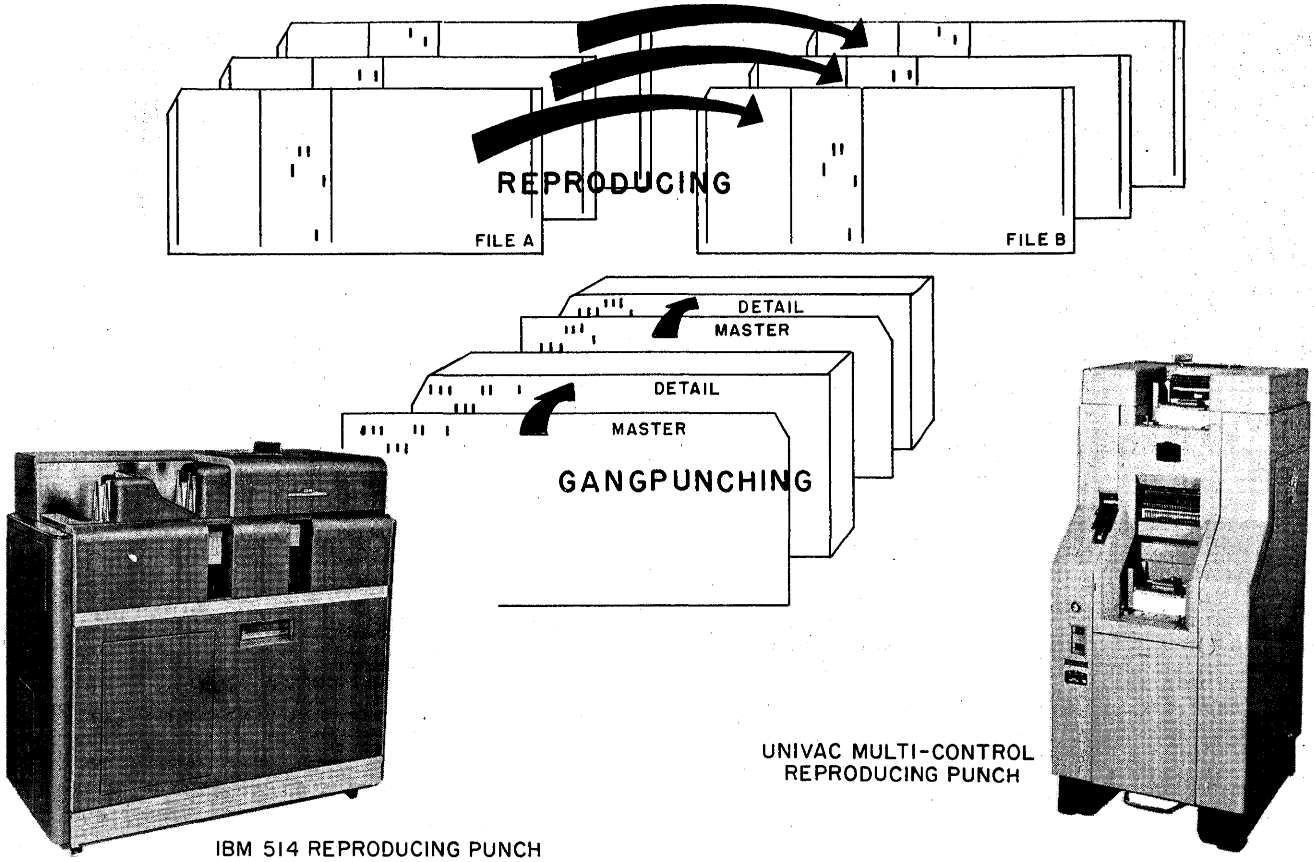

Figure 2-25.—Automatic reproducing and gang punching. 49.35X

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 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 electromechanical 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. 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

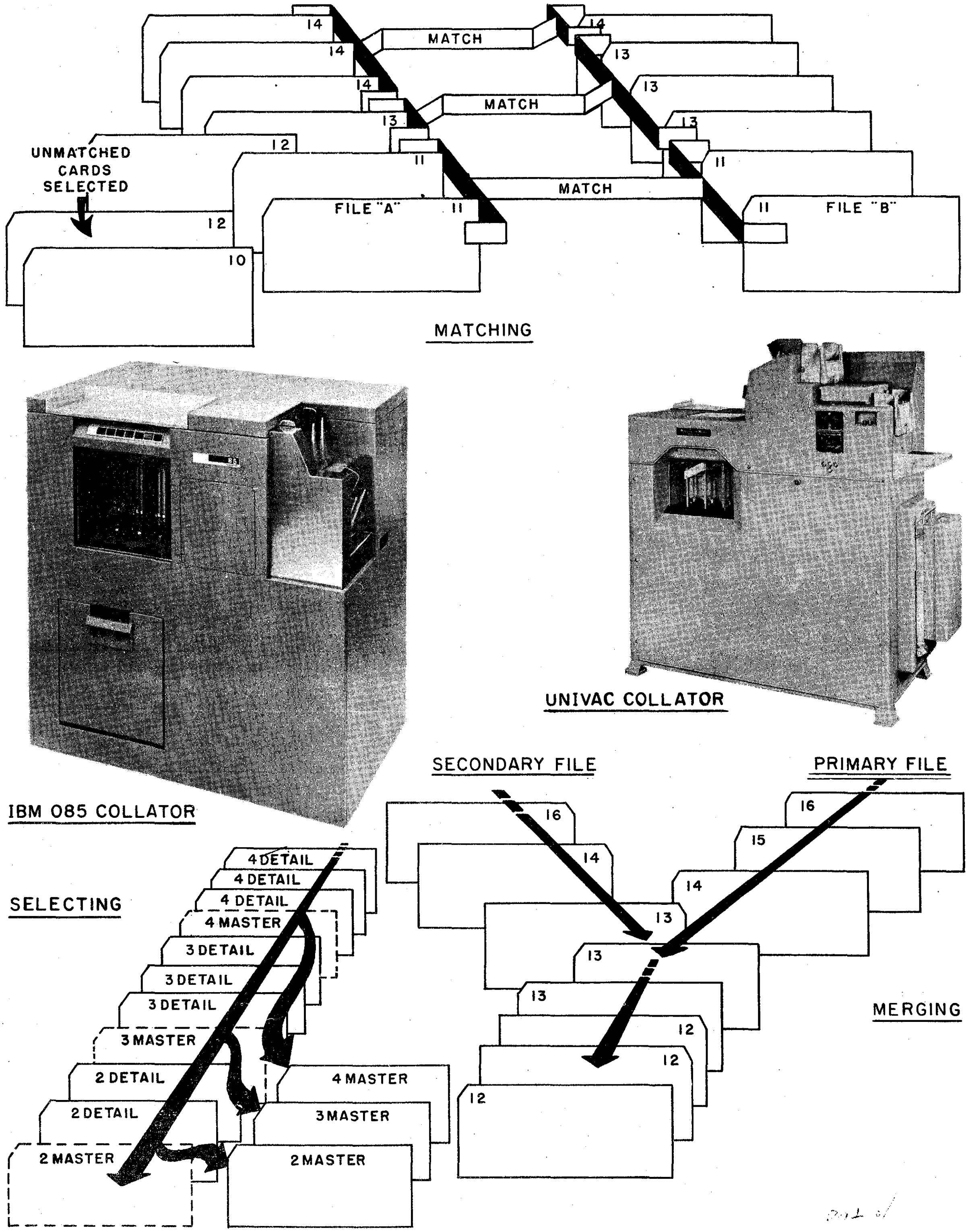

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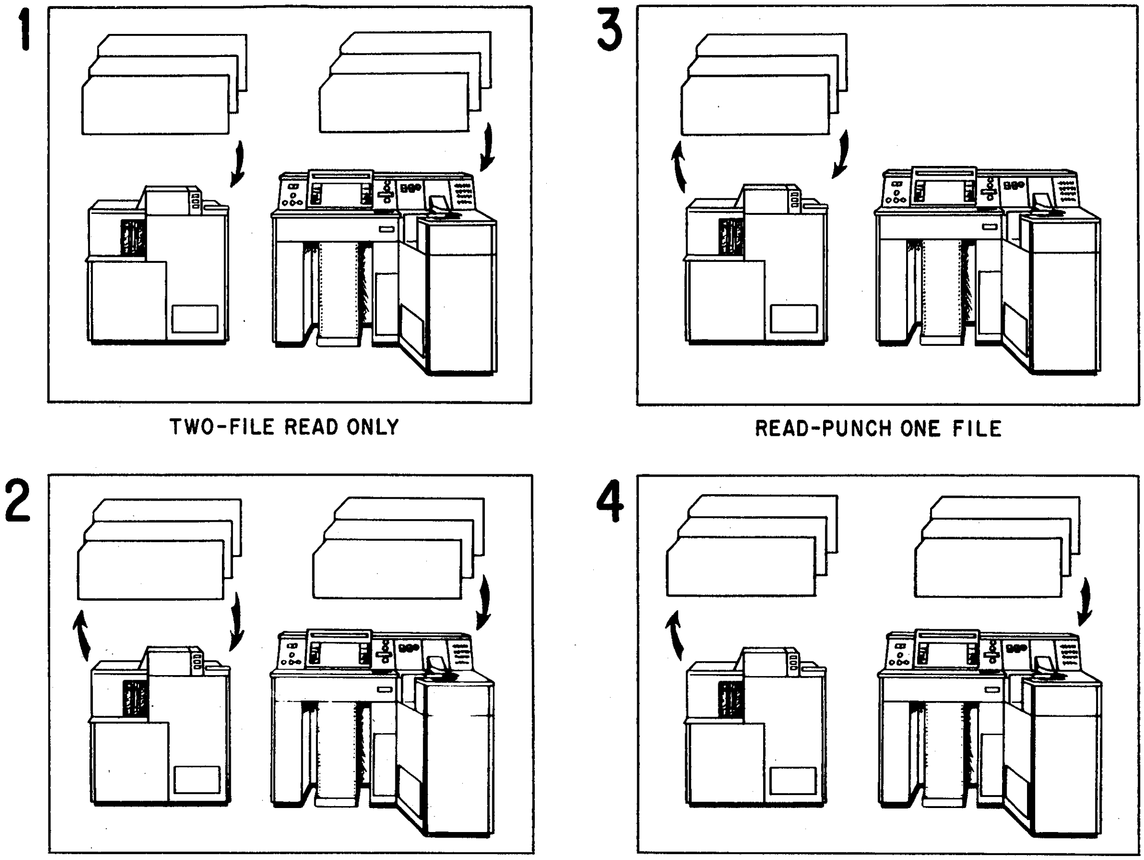
Figure 2-26.—Filing machines that arrange cards for subsequent operations.



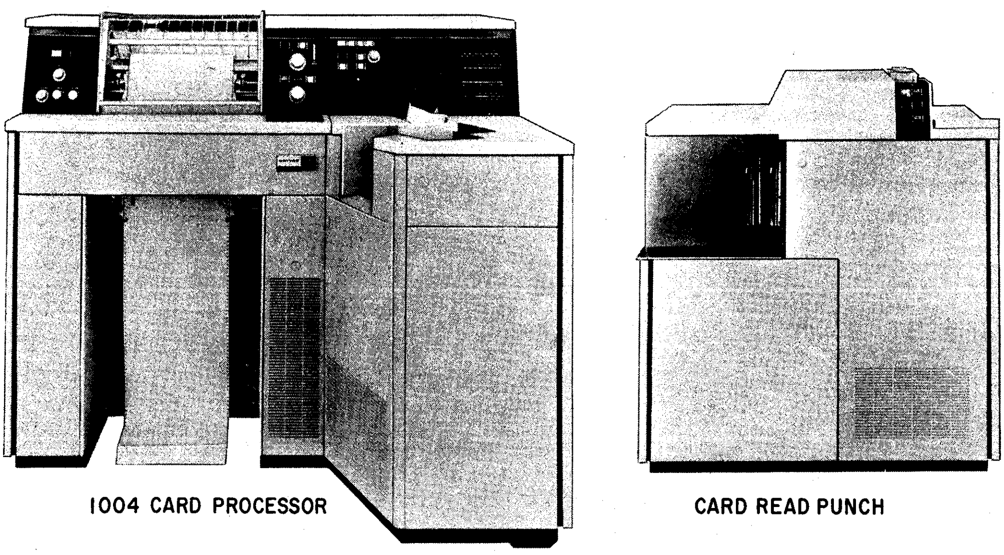
1 TWO-FILE READ ONLY

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.

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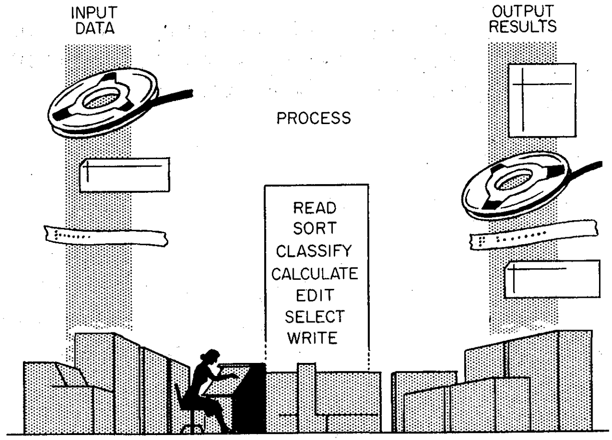
Figure 2-27.—The UNIVAC solid-state electronic 1004 card processor.



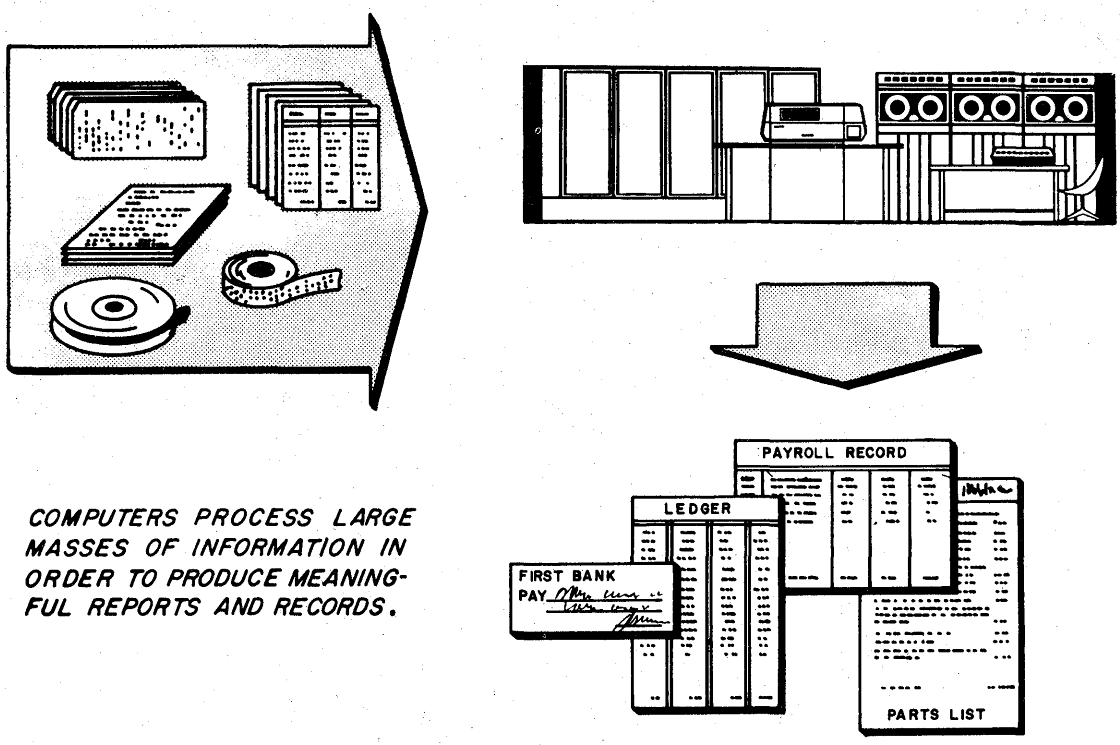
49.197X
Figure 2-28.—Data processing by computer.

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 and magnetic cores. 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.

ELECTRONIC DATA PROCESSING

The trend in recent years has been toward the use of electronic data processing equipment,



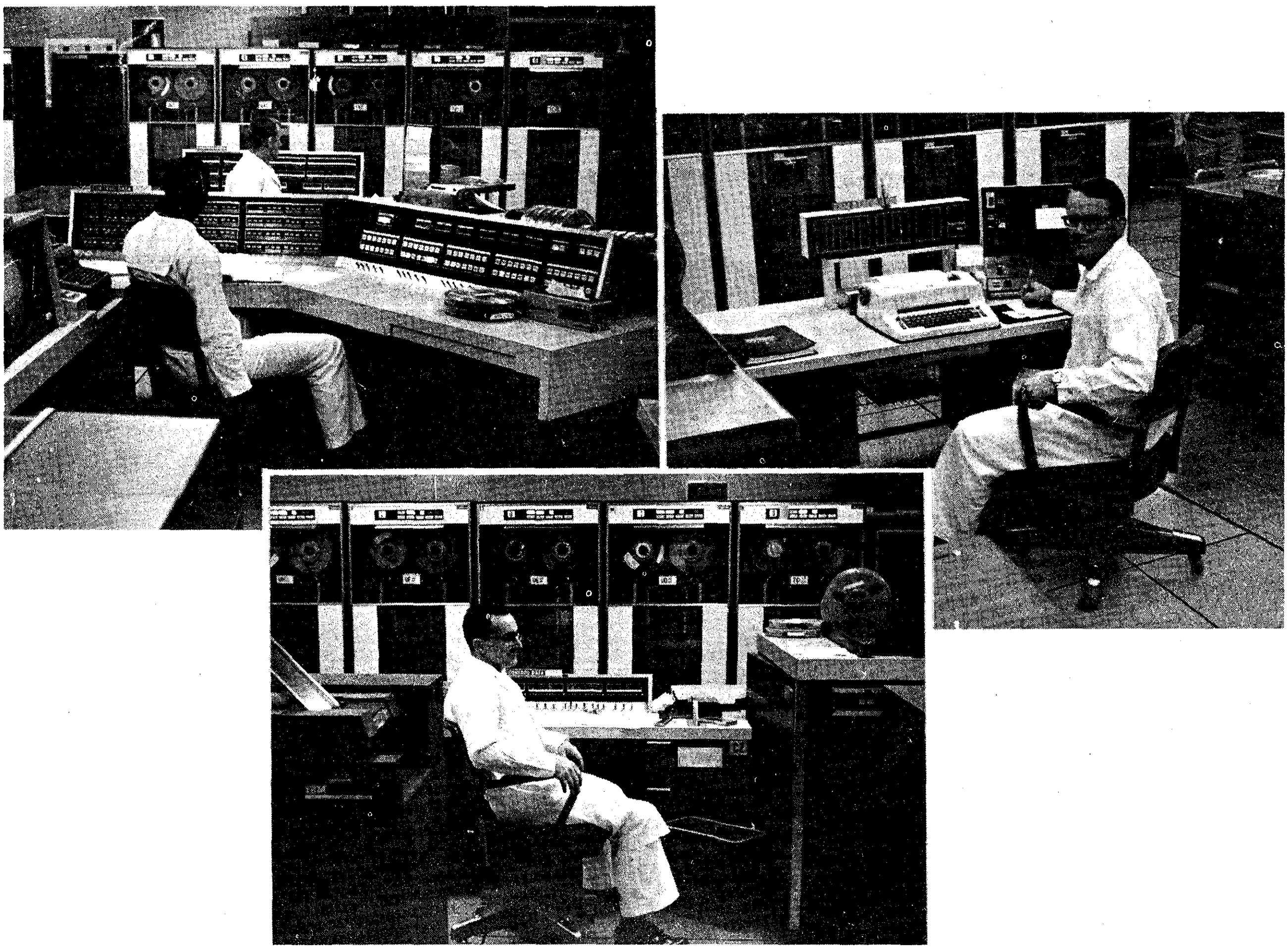
49.198X
Figure 2-29.—Functions of electronic data processing systems.

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.

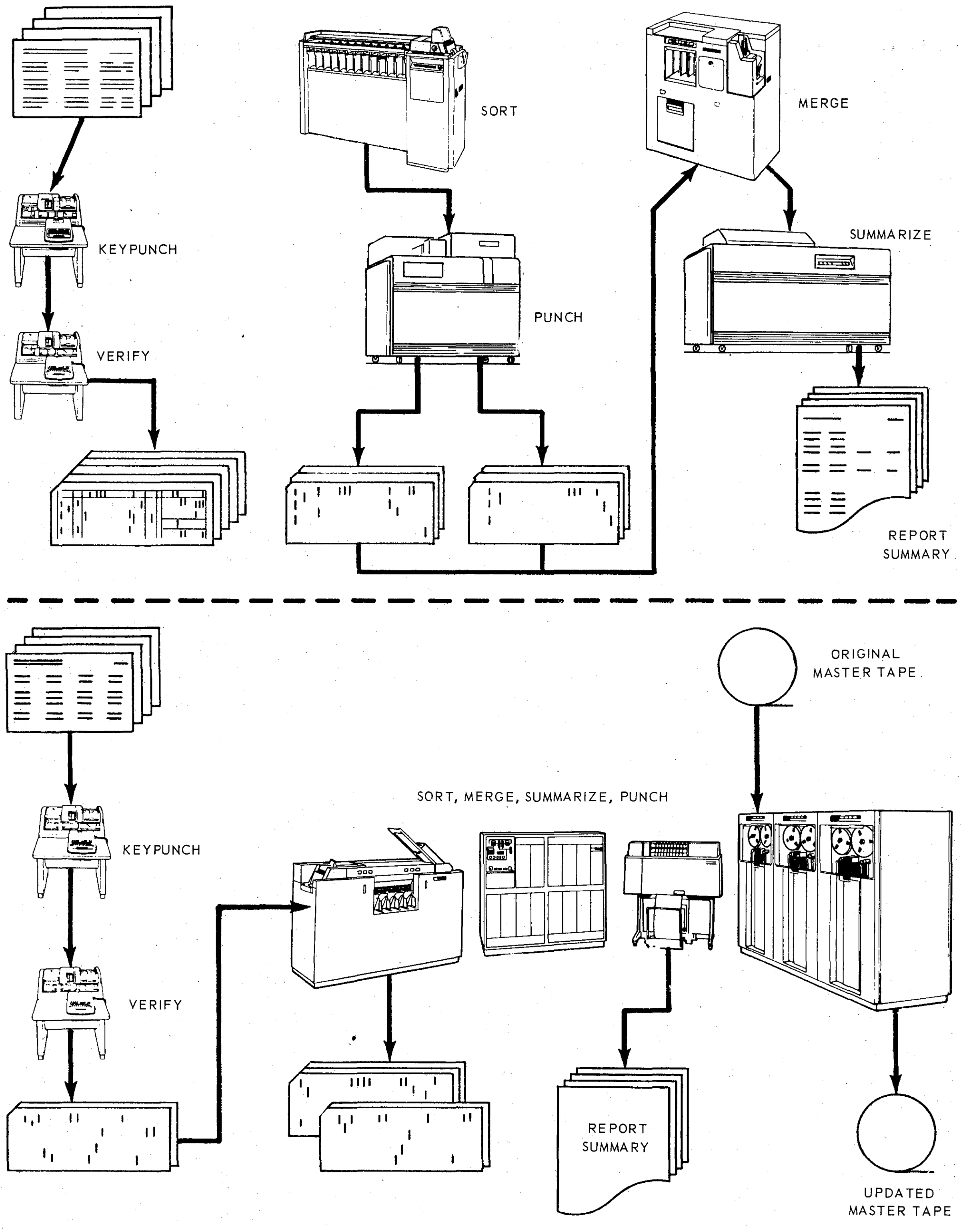
Data Processing by EDP

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 required the physical movement of cards from one machine to



49.199

Figure 2-30.—Machine Accountants in naval electronic data processing installations.



49.200
Figure 2-31.—A simple anology of EAM vs EDP processing applications.

another, the electronic system permits many processing functions to be performed in one operation. (See fig. 2-31). 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, controls 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.

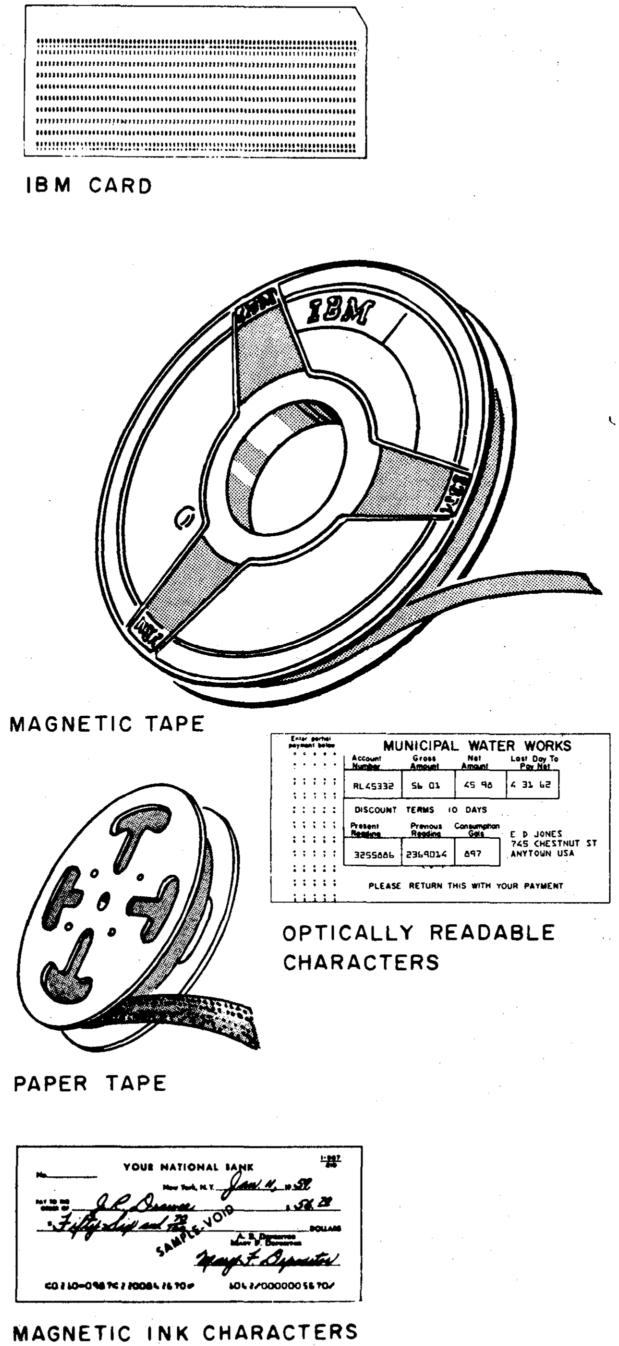


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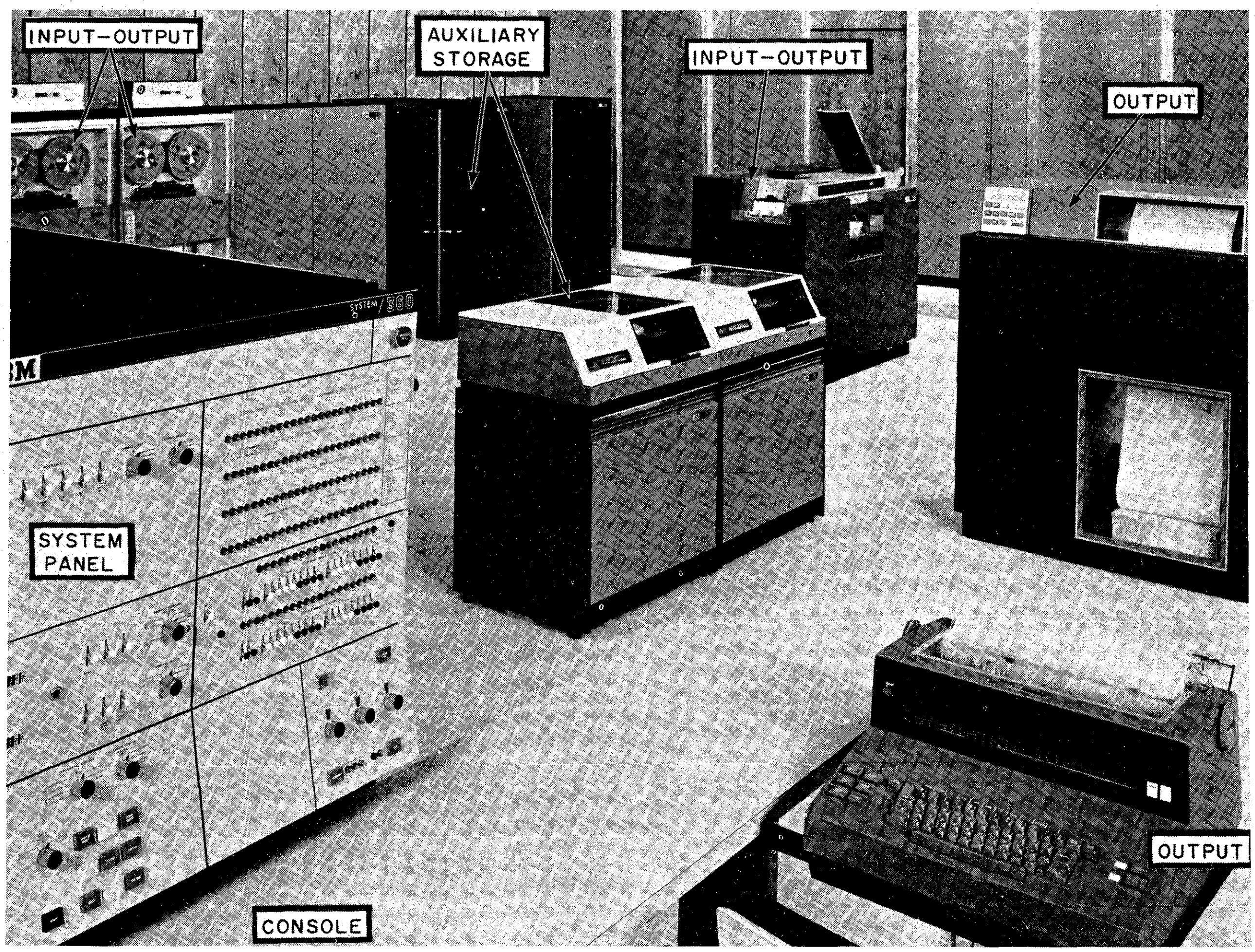
Figure 2-32.—Examples of EDP input media.

The Electronic Brain

The computer has earned for itself the reputation of an electronic brain, but this is a gross misunderstanding 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 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



49.202

Figure 2-33.—IBM system/360 model 40 computer system.

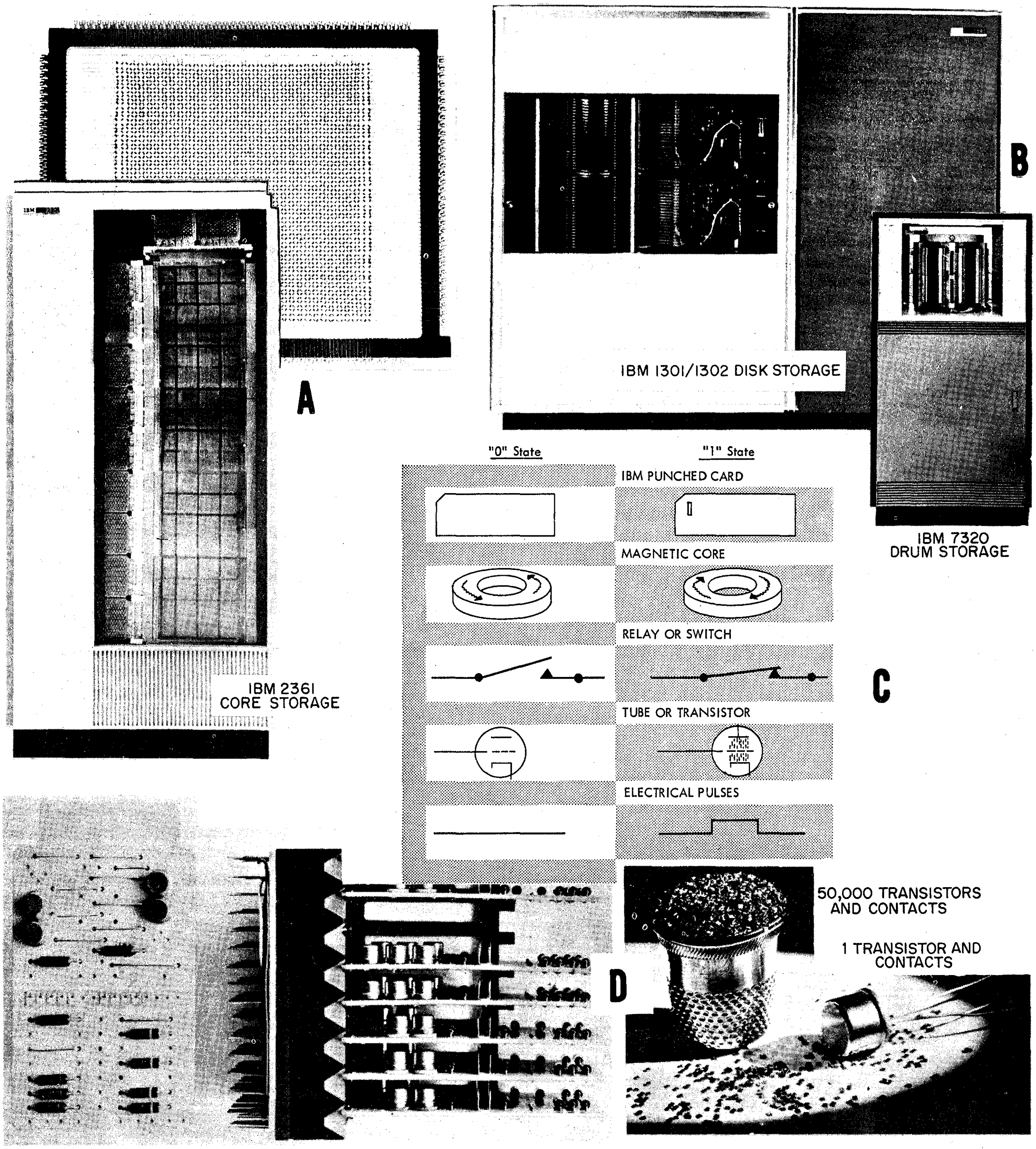
reliability with which it performs the functions of which it is capable, and it is notable among machines for both speed and flexibility.

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, 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



A. MAGNETIC CORE STORAGE
B. ADDITIONAL MAGNETIC STORAGE DEVICES
C. TWO-VALUE OR BINARY SYSTEM
D. SOLID-STATE CIRCUITRY AND TRANSISTORS

49.203X

Figure 2-34.—Some of the essentials in making a computer work.

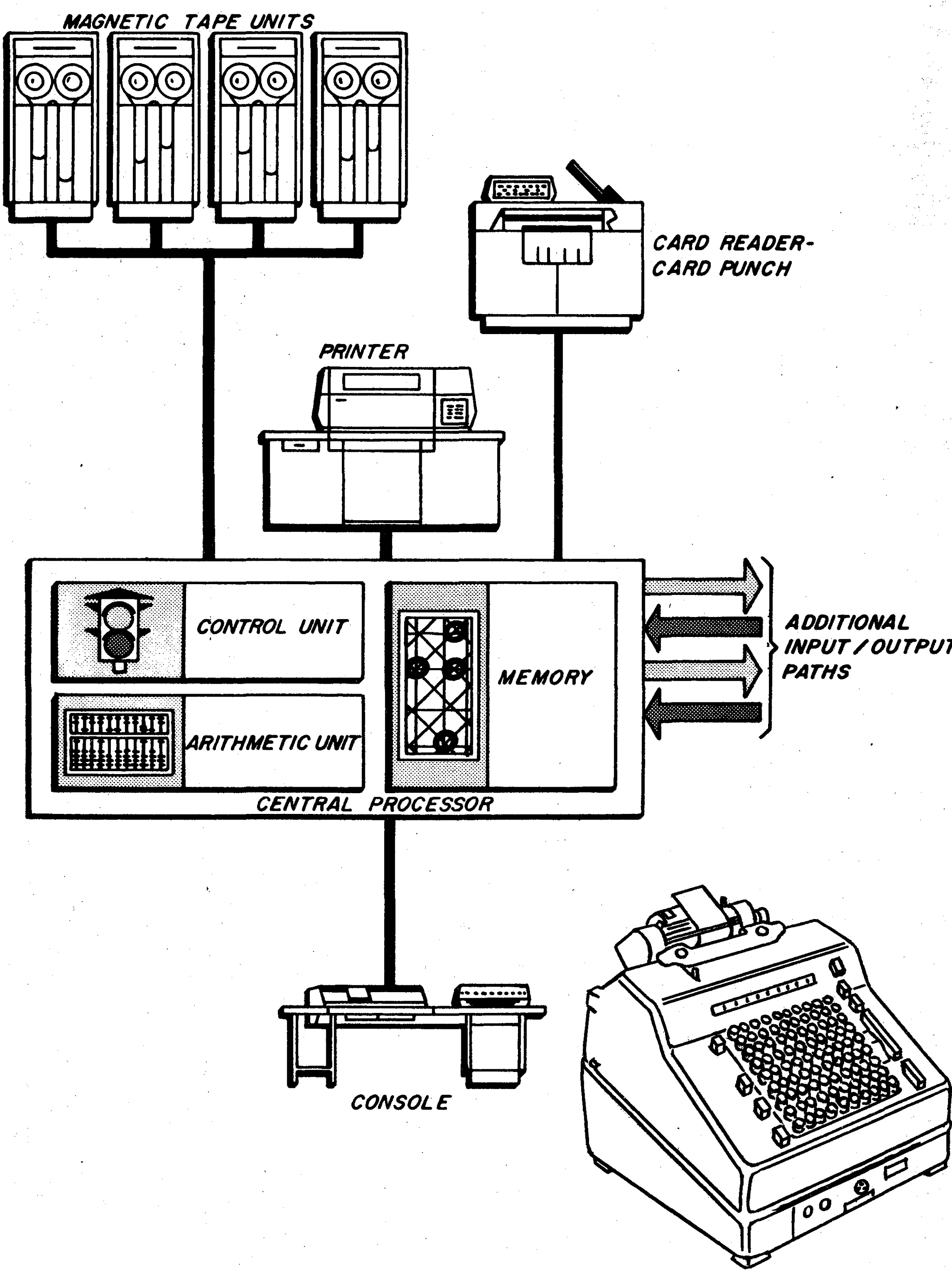


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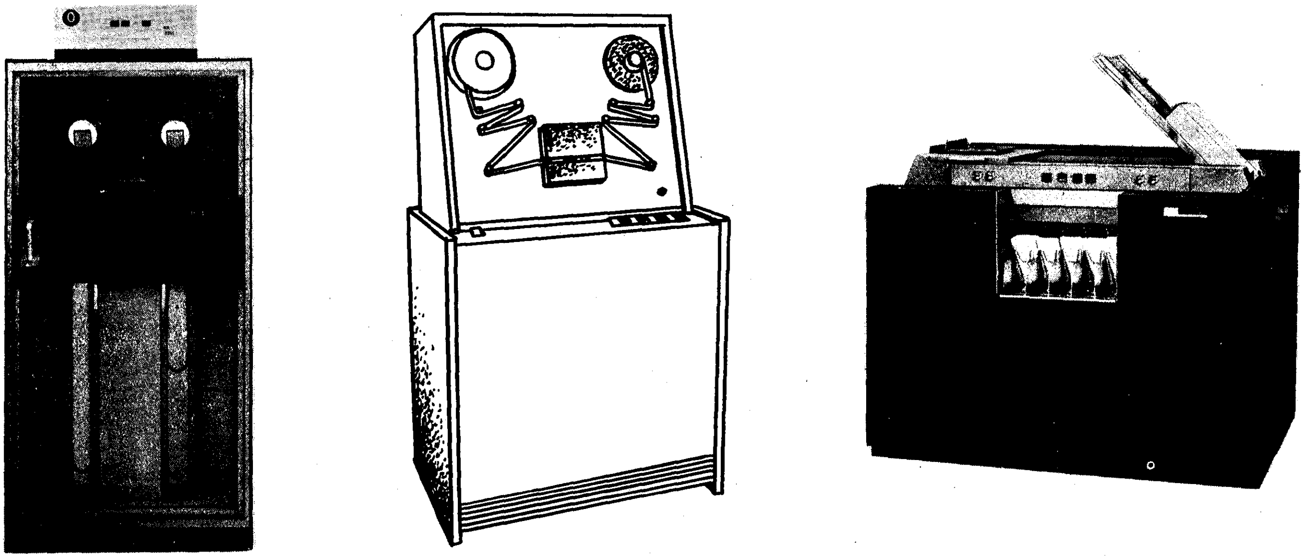
Figure 2-35.—The adding machine and the computer.



IBM 2401 MAGNETIC TAPE UNIT

MODEL 322 RCA PAPER TAPE READER

IBM 1402 HIGH-SPEED CARD READER

Figure 2-36.—EDP input units. 49.205X

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.

How Does It Work?

To answer this question, suppose we compare the simple adding machine to its larger counterpart—the electronic computer.

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. 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 introduced 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 a source medium onto a type of INPUT MEDIUM 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 PROCESSOR is the computing center of the electronic data processing system and is made up of three major units: control, arithmetic, and memory.

The CONTROL UNIT automatically directs the step-by-step operation of the entire system, including the operation of input and output devices as well as the selection, interpretation,

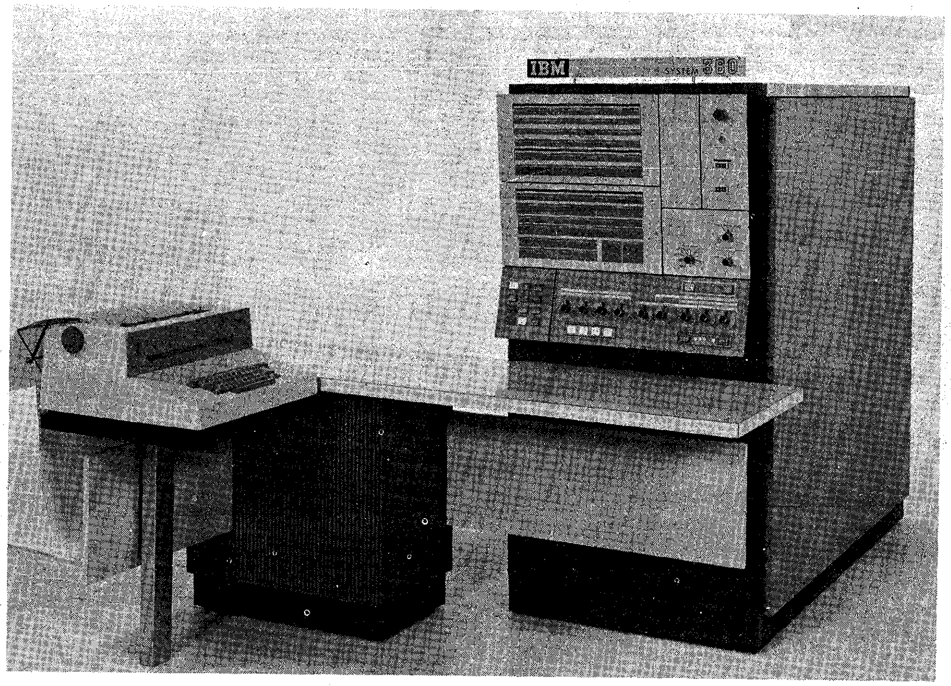


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Figure 2-37.—Central processing unit and console.

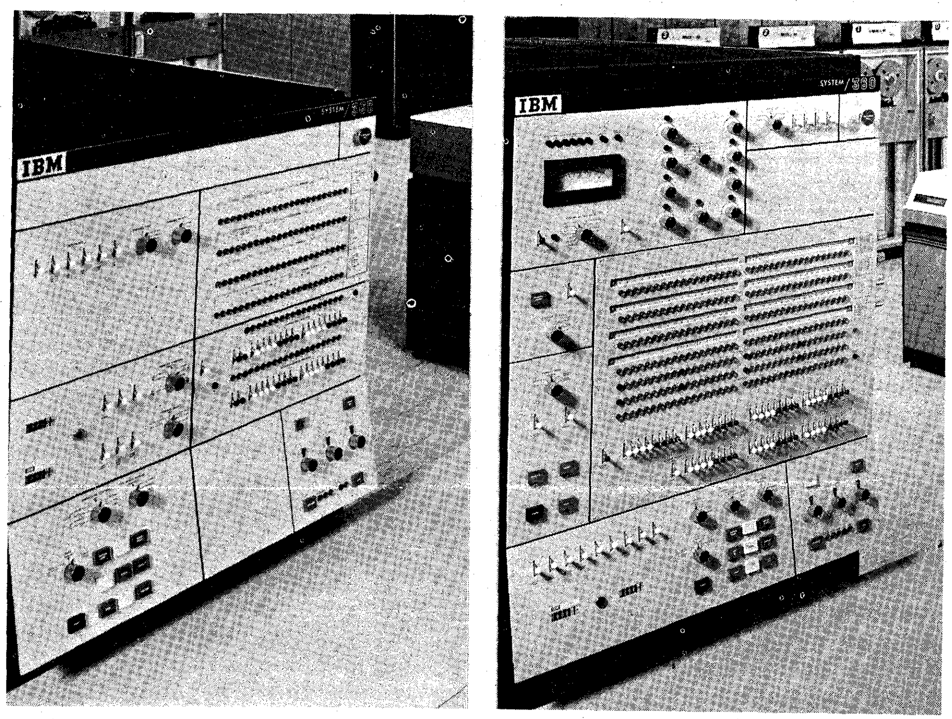

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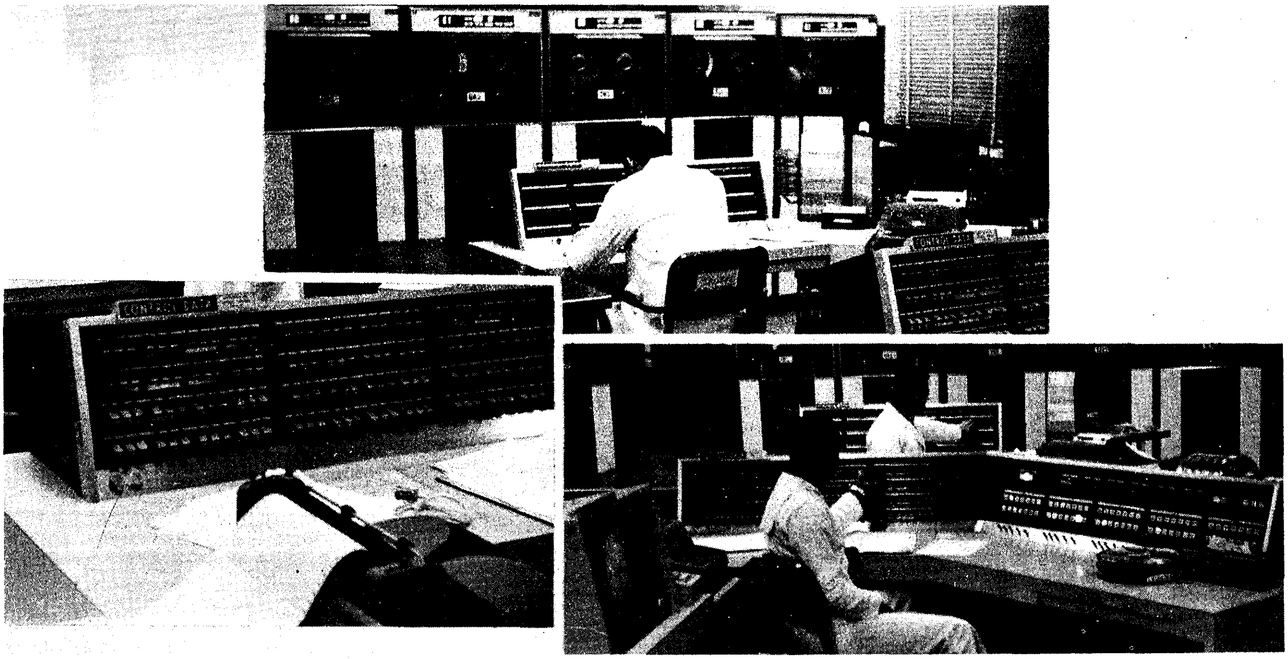
Figure 2-38.—Typical control panels of computer consoles.



49.208X

Figure 2-39.—Monitoring and communicating with the central processor.

and execution of instructions from memory. 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 provides external control over the entire system, for through it, the operator can monitor the central processor and maintain manual control over all operations. Remember, the computer does not rely on the operator to feed it data and initiate its every command; the control panel and electric typewriter (provided by some systems) 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 mechanism, you will find a set of racks used to turn the counting wheels and cause the arithmetic functions to be performed. Likewise, the ARITHMETIC UNIT of the computer performs arithmetic operations of adding, subtracting, 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 programmed instructions for an indefinite period of time.

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, 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

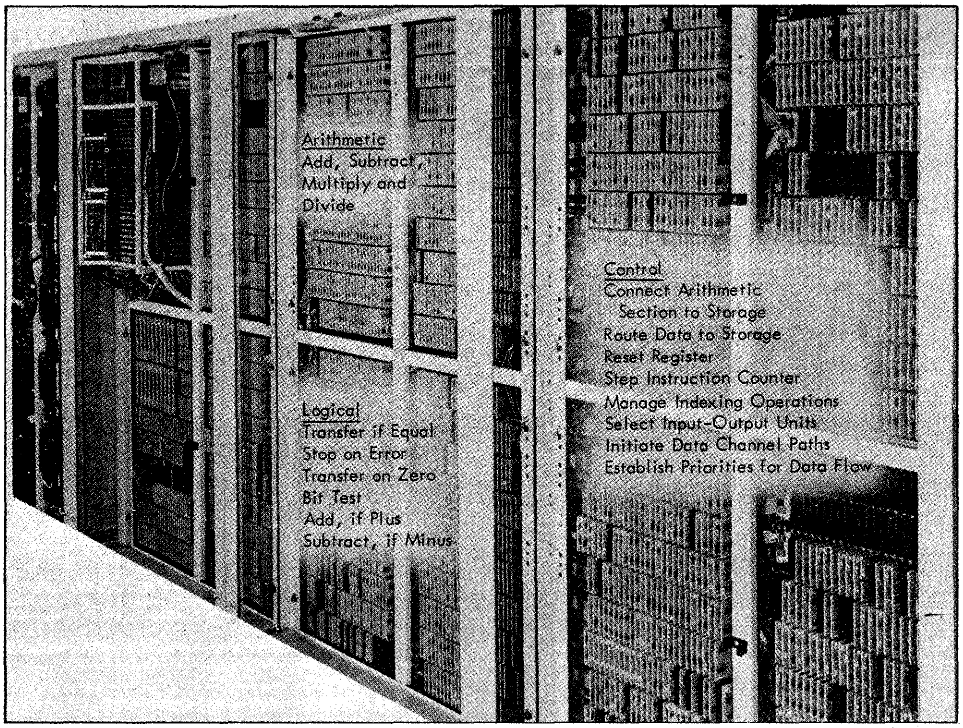


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Figure 2-40.—Control and arithmetic-logical sections.

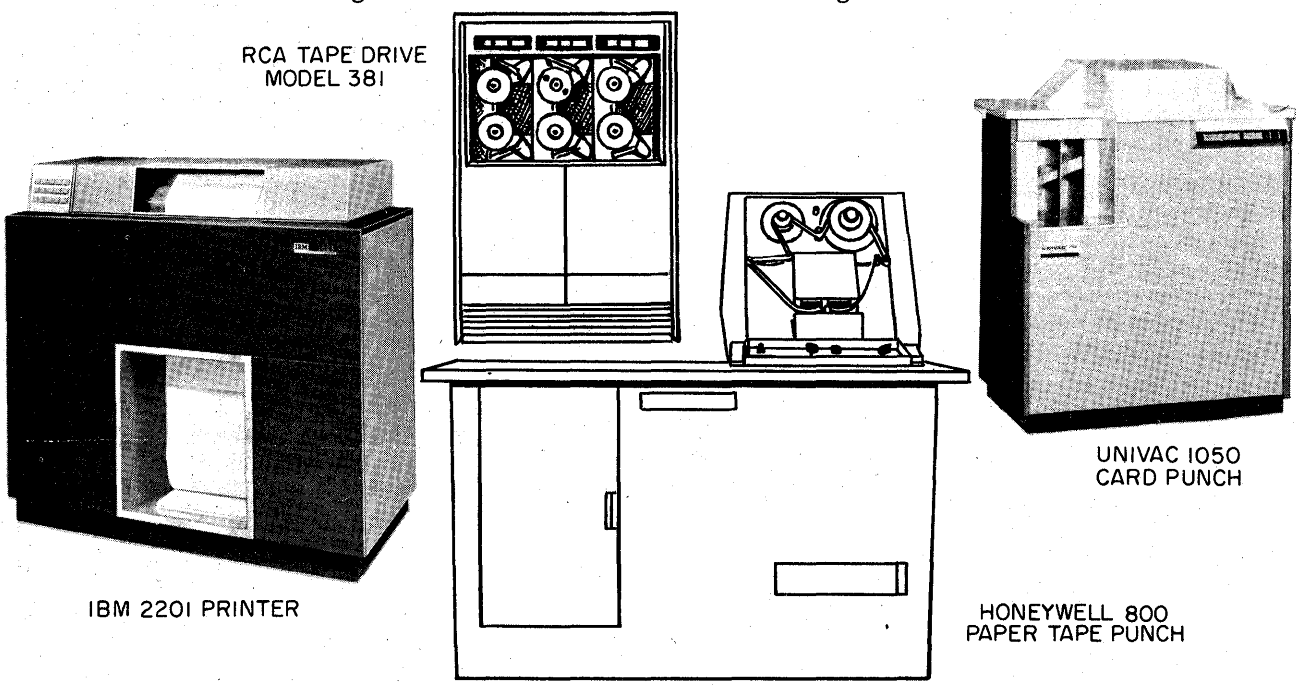

Figure 2-41.—Various EDP output devices.

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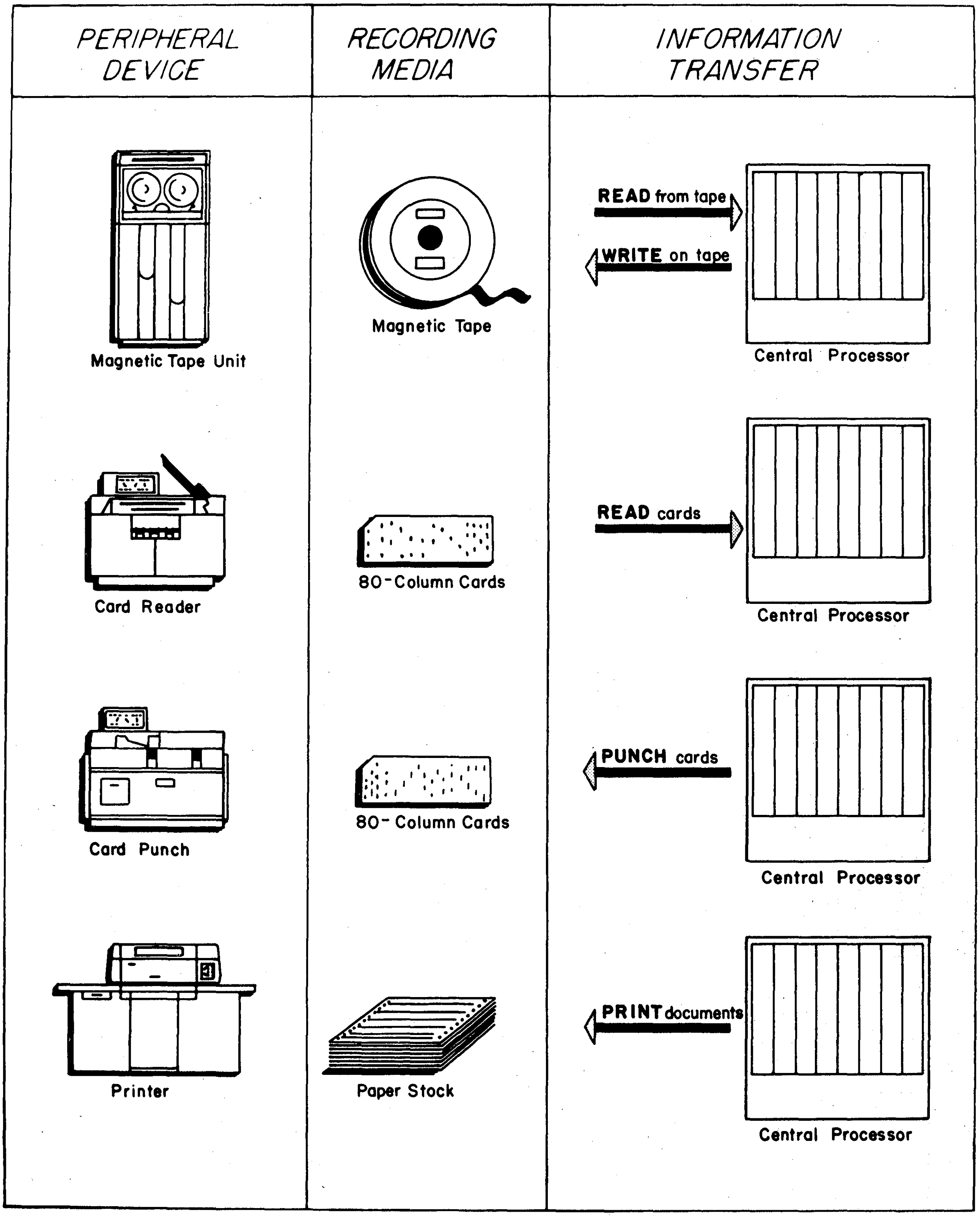


49.211X

Figure 2-42.—On-line peripheral equipment and recording media.

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 with punched cards, or magnetic tape units with magnetic tape. This peripheral equipment can operate ON-LINE, under direct control of the central processor (see fig. 2-42) or OFF-LINE, independently of the central processor. (See fig. 2-43.)

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 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 central processor. For example, a system's output data could be written on magnetic tape and in an off-line operation, converted to some other record form 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 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 page 44.)

Tape Oriented System

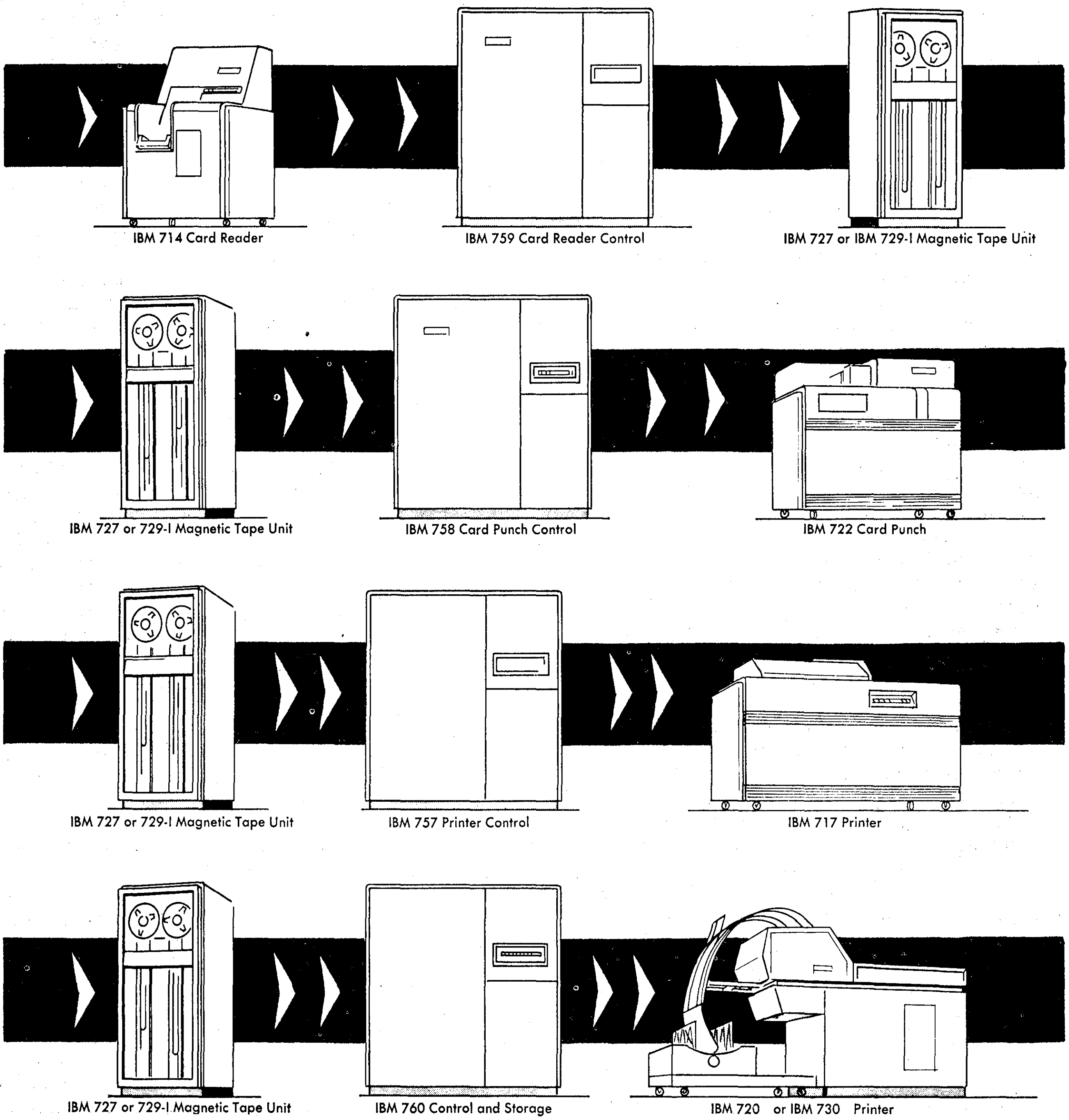
Systems whose source of input data is from almost any medium, but essentially from perforated paper or magnetic tape, are referred to as TAPE SYSTEMS. Because these systems are large and complex, they demand more processing ability, and therefore require faster input media than the much slower punched 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

"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 page 45.)

REAL TIME COMPUTER SYSTEMS can store enormous masses of information and act upon any item within thousandths of a second. Data is received and transmitted between locations at remote points, and priorities are automatically assigned to different operations to ensure that action and response is 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.

The scope of data processing performed by Machine Accountants has greatly expanded and become extremely diversified since the establishment of our rating in 1948. Models and

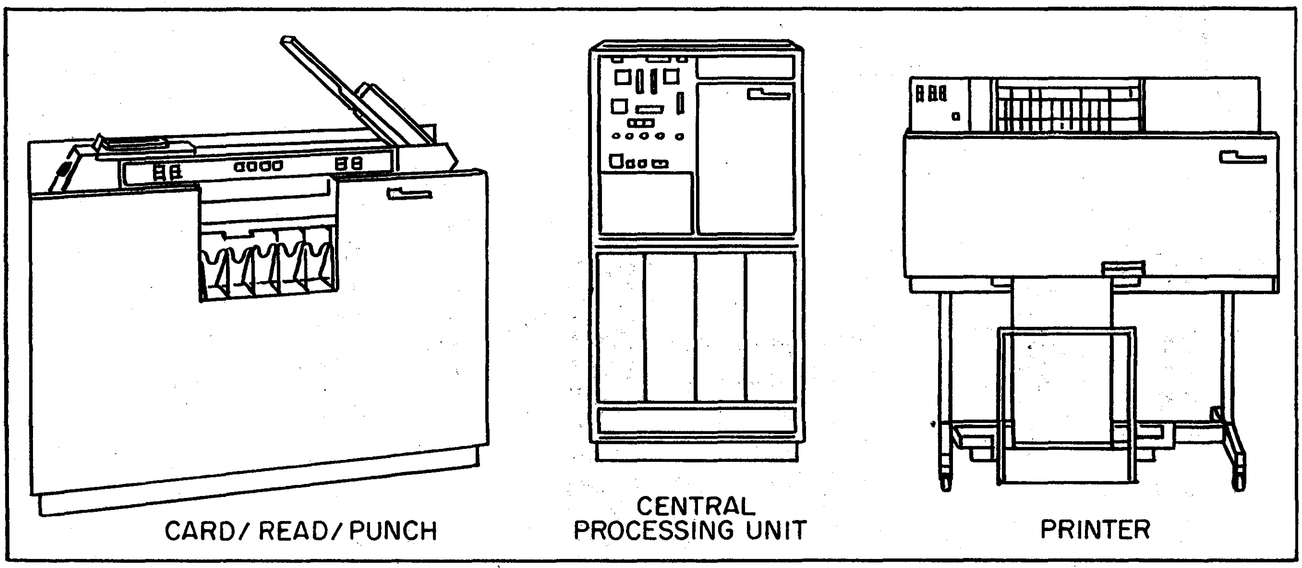


49.212X

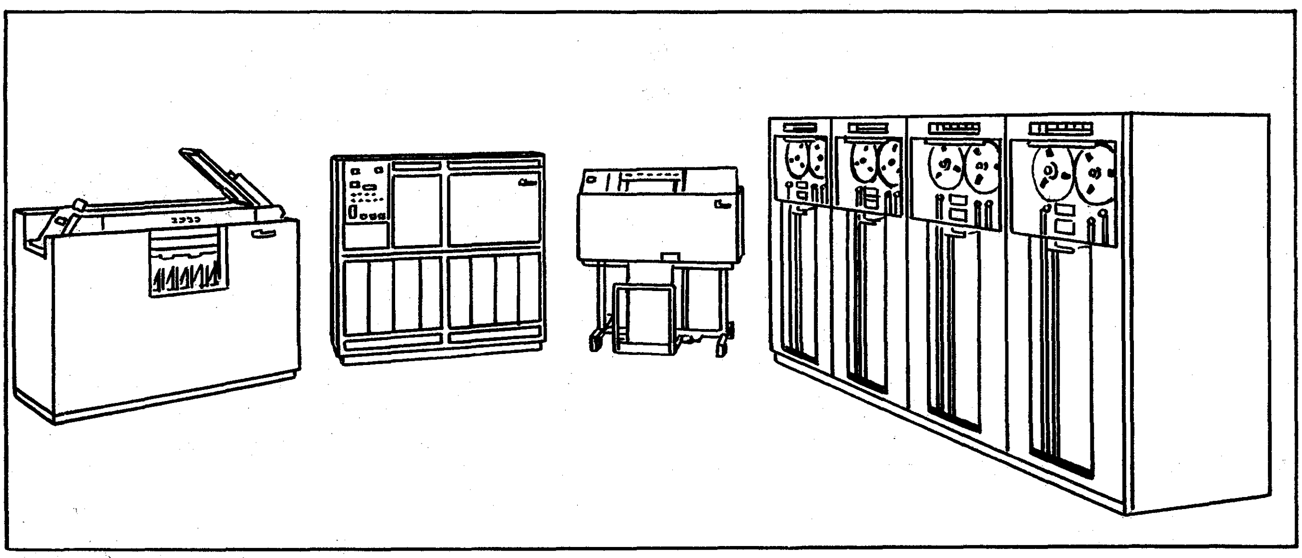
Figure 2-43.—Off-line data conversion operations.

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



ESSENTIAL COMPONENTS OF A CARD ORIENTED SYSTEM.

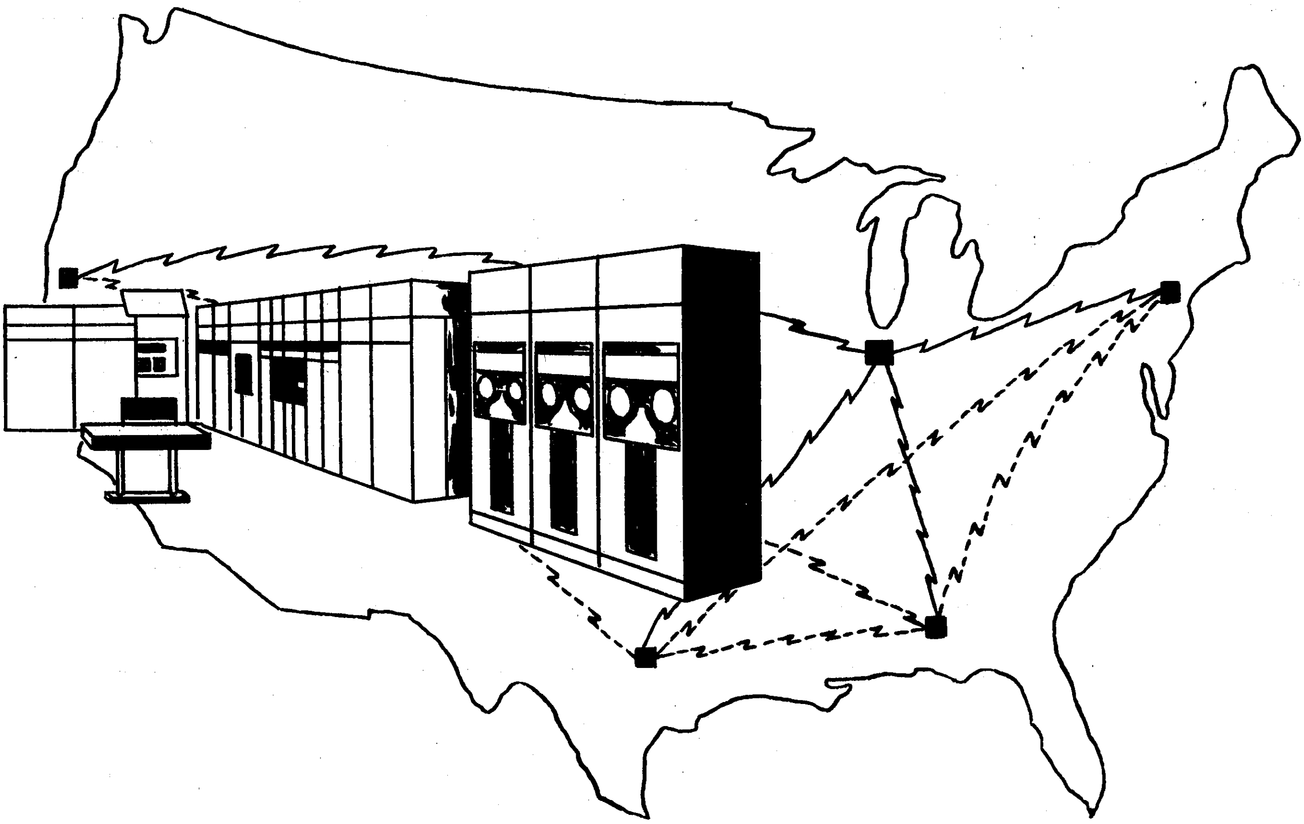


THE SAME COMPONENTS WITH THE ADDITION OF TAPE UNITS, FORMING A TAPE ORIENTED SYSTEM TO INCREASE THE SCOPE, AS WELL AS THE INPUT AND OUTPUT SPEEDS, OF THE SYSTEM. NOTE THE INCREASED SIZE OF THE CENTRAL PROCESSOR.

49.213X

Figure 2-44.—Card and tape oriented systems.

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 tabulating machine unit (TMU), or filling a billet in a stock control system aboard ship. You might find yourself in a shipboard management maintenance program billet operating the UNIVAC 1004 card processor or filling any number of billets within a fleet PAMI, a statistical or guided missile unit, or in a supply, security, communication, or personnel research activity. In any of these



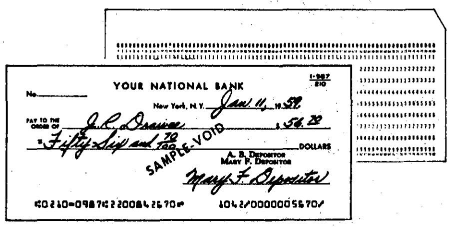
49.214

Figure 2-45.—Remote communication linkage affords real time processing.

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.

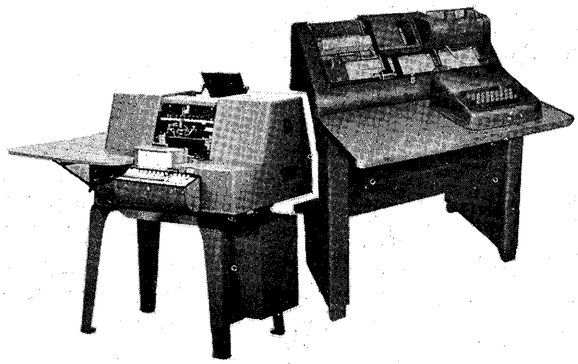
The pictorial summaries which follow this chapter are designed for review, as are the glossaries of terms, following this and all other chapters.

UNIT RECORDS



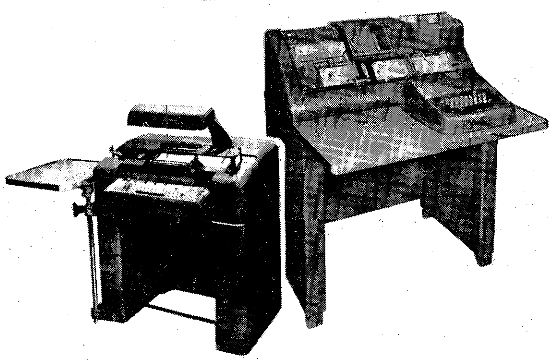
RELATED FACTS TREATED AS A UNIT, RECORDED ON INPUT MEDIA ACCEPTABLE TO A DATA PROCESSING SYSTEM.

CARD PUNCH



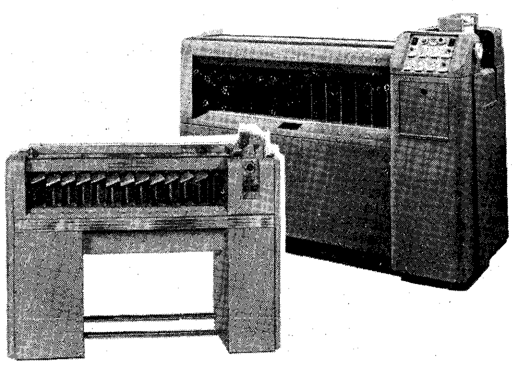
A MACHINE WHICH ALLOWS AN OPERATOR TO PUNCH DATA INTO CARDS FOR CONVEYANCE INTO OTHER MACHINES OR DEVICES. SYNONOMOUS WITH KEYPUNCH.

CARD VERIFIER



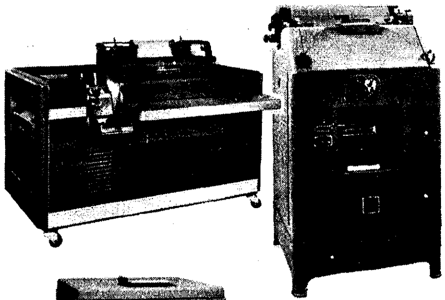
CHECKS ORIGINAL PUNCHING OF DATA IN CARDS FOR TRANSCRIPTION ERRORS.

CARD SORTERS



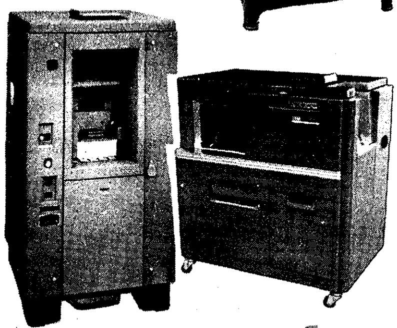
SELECTS OR ARRANGES PUNCHED CARD UNIT RECORDS IN A DESIRED SEQUENCE.

ACCOUNTING MACHINE



PERFORMS END OF THE LINE PROCESSING OF PUNCHED CARDS THROUGH ITS ABILITY TO ADD, SUBTRACT, AND PRINT REPORTS. SYNONYMOUS WITH TAB AND TABULATOR.

INTERPRETER

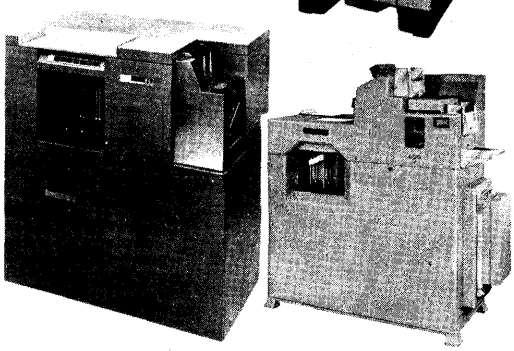


READS, INTERPRETS, AND PRINTS PUNCHED CARD DATA ON THE FACE OF A CARD.

REPRODUCER

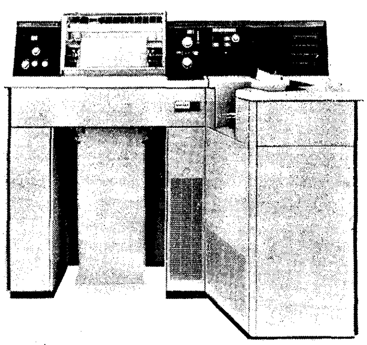
USED PRIMARILY TO CREATE NEW FILES BY REPRODUCING ALL OR PORTIONS OF DATA FROM ONE UNIT RECORD TO ANOTHER, OR ADDING NEW INFORMATION TO EXISTING FILES.

COLLATOR



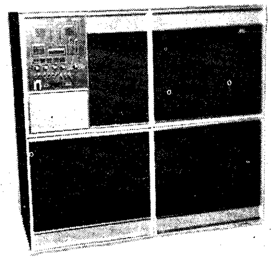
A FILING MACHINE USED TO ARRANGE OR SELECT CARDS FOR SUBSEQUENT OPERATIONS.

1004 CARD PROCESSOR



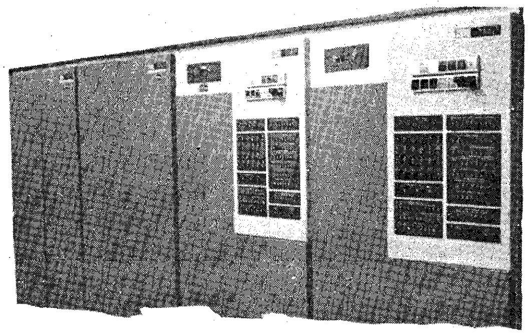
A SOLID-STATE ELECTRONIC PROCESSING MACHINE WITH AN EXTERNAL CONTROL PANEL, INCORPORATING CARD READING, ARITHMETIC PROCESSING, AND PRINTING FUNCTIONS.

CENTRAL PROCESSING UNIT



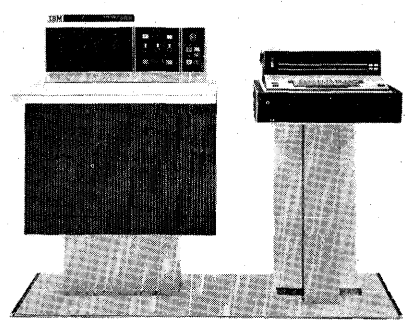
THAT PORTION OF A COMPUTER EXCLUSIVE OF PERIPHERAL EQUIPMENT THAT CONTAINS THE MAIN STORAGE, ARITHMETIC-LOGIC UNITS, AND CONTROL SECTION. SYNONOMOUS WITH CPU.

SYSTEM CONTROL UNITS



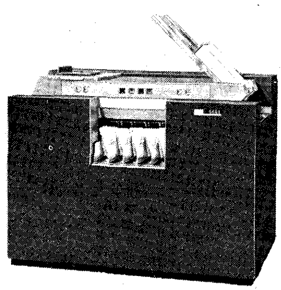
USED PRIMARILY TO CONTROL ALL OPERATIONS INCLUDING INPUT AND OUTPUT FUNCTIONS.

CONSOLE



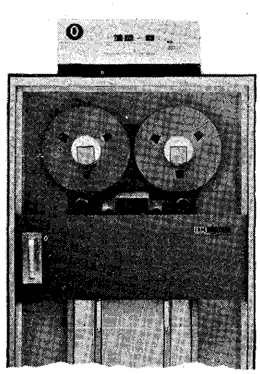
PROVIDES EXTERNAL CONTROL OF A DATA PROCESSING SYSTEM. USED MAINLY TO DETERMINE THE STATUS OF CIRCUITS, COUNTERS, PANEL REGISTERS, AND CONTENTS OF STORAGE.

CARD READ PUNCH



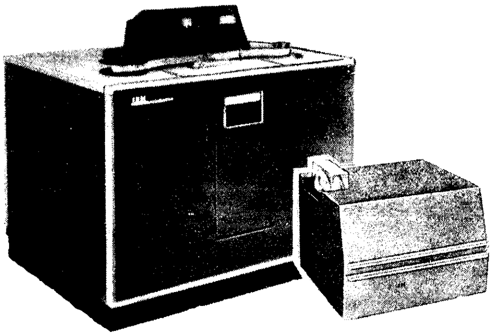
AN INPUT AND OUTPUT DEVICE THAT READS AND CONVERTS PUNCHED CARD DATA FOR TRANSFERENCE INTO STORAGE OR ONTO MAGNETIC TAPE; TRANSFERENCE FROM STORAGE OR MAGNETIC TAPE TO PUNCHED CARDS; CAN BE INDIVIDUAL UNITS.

MAGNETIC TAPE UNIT



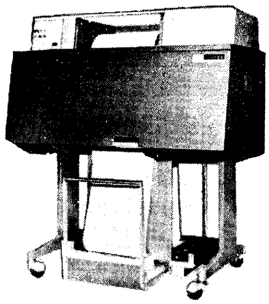
INPUT AND OUTPUT DEVICE CAPABLE OF READING AND WRITING INFORMATION (REPRESENTED BY MAGNETIC SPOTS) ON AND FROM MAGNETIC TAPE.

PAPER TAPE READER AND PUNCH



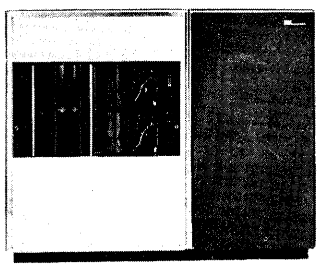
INPUT AND OUTPUT DEVICES WHICH CAN SENSE AND PUNCH THE HOLE PATTERNS OF PAPER TAPE, COULD BE A COMBINED UNIT.

HI-SPEED PRINTER



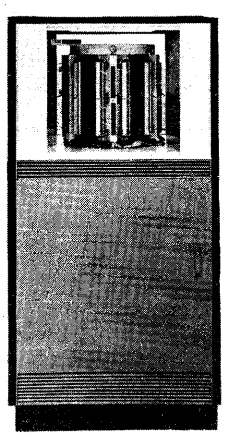
A PRINTER OUTPUT DEVICE WHICH OPERATES AT A SPEED COMPATIBLE WITH THE SPEED OF COMPUTER COMPUTATION AND PROCESSING, ENABLING IT TO OPERATE ON-LINE IF NECESSARY.

DISK STORAGE



A STORAGE DEVICE IN ADDITION TO MAIN STORAGE OF THE CPU WHEREIN DATA IS RECORDED BY MAGNETIC SPOTS ON THE SURFACE OF FLAT CIRCULAR MAGNETIC DISKS.

DRUM STORAGE



A STORAGE DEVICE IN ADDITION TO MAIN STORAGE OF THE CPU WHEREIN DATA IS RECORDED BY MAGNETIC SPOTS ON BANDS OR CHANNELS OF A ROTATING CYLINDER.

ARITHMETIC UNIT—That portion of computer hardware in which arithmetic and logical operations are performed.

AUTOMATIC DATA PROCESSING (ADP)—Data processing performed by a system of electronic devices or electrical machines interconnected and interacting to reduce human assistance or intervention.

AUTOMATION—The theory, art, or technique of processing data automatically.

BINARY MODE—A computer system of data representation; a two value system in which decimal digits are represented by a pattern of ones and zeros.

CARD SYSTEM—A computer system which utilizes only punched cards as its input medium.

CODE—A system of abbreviations used in preparing information for input into a machine; a system of symbols for representing data or instructions in a computer.

COMPUTER—A device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes in a usable form.

CONTROL PANEL—A removable interconnection device employing wires to control operations of a punch card machine; on computers, it is used primarily to control input and output functions.

DATA—Denotes any or all facts; numbers, letters, or symbols that refer to or describe information which can be processed or produced by a machine or computer.

DATA PROCESSING—The preparation of source media which contain data, and the handling of such data according to precise rules of machine or computer procedures for the production of records and reports.

ELECTRIC ACCOUNTING MACHINES (EAM)—Conventional punch card machine (PCM), most of which receive their processing instructions through an externally wired control panel; synonymous with tabulating equipment.

ELECTRONIC DATA PROCESSING (EDP)—Processing performed largely by equipment using electronic circuitry for storing and manipulating data.

ELECTRONIC DATA PROCESSING SYSTEM (EDPS)—An interacting assembly of methods, procedures and electronic equipment that perform a complex series of data processing operations.

HARDWARE—The physical equipment or devices that comprise a computer system, including its peripheral equipment; contrasted with software.

IBM—International Business Machines. An International Business Machines Corporation trademark.

INPUT—Information or data recorded on a proper medium for transference into a machine or storage of a computer for processing; the act of introducing data into a system.

INPUT DEVICE—A device designed to transfer data from its particular recording medium into a computer for processing; e.g., a card reader.

MACHINE LANGUAGE—A representation of machine sensible information common to a related group of data processing machines and devices.

MAIN STORAGE—Usually the internal or fastest storage device of a computer and one from which instructions are executed; synonymous with memory unit.

MICROSECOND—A millionth of a second.

MILLESECOND—A thousandth of a second.

NANOSECOND—A billionth of a second.

OUTPUT—Data that has been processed; the process of transferring data from a machine or storage of a computer.

OUTPUT DEVICE—A device designed to receive processed data from a computer, convert and record it on to its particular recording medium; e.g., card punch.

PERIPHERAL EQUIPMENT—Devices which may or may not be under the control of the central computer; synonymous with hardware and on-line or off-line equipment depending upon computer design and processing needs.

PROGRAM—A plan for the solution of a problem; a complete sequence of machine instructions and routines to be executed by the computer in solving a given problem.

PROGRAMMER—A person who plans and prepares the sequence of events a computer must follow to solvé a problem; e.g., procedures, flow charts, and normally the writing of coded instructions.

RAW DATA—Data which has not been processed; may or may not be in machine-sensible form. (A form readable by a specific machine or device.)

READ—The sensing of information contained in some source; the conversion of punched holes into electrical impulses; to transcribe data from input devices or from one form of storage to another.

REAL TIME—Computer systems designed to keep pace with "live" operations, accept data directly without manual conversion, process these data and establish relationships among data of disparate types. Further, they produce data, on demand or as a result of programmed logic, to men and/or machines in a timely and digestible form.

SOFTWARE—Professionally prepared programs and routines ordinarily supplied by computer manufacturers to simplify programming and computer operations.

SOLID-STATE—Electronic components that convey or control electrons within solid materials; e.g., transistors, magnetic cores.

SOURCE DOCUMENT—The original document on which are recorded details of transactions; documents from which data is extracted.

STORAGE—The computer's filing system that can be internal; that is, a part of the computer itself such as drums, disks, and cores. Or, it can be external such as paper tape, magnetic tape, or punched cards.

TAPE SYSTEM—A computer system whose input medium is usually perforated paper, or magnetic tape.

TRANSISTOR—A tiny electronic device which performs the same function as a tube, but whose current travels through solid materials, hence the term solid-state.

UNIVAC—A name meaning Universal Automatic Computer; a Sperry Rand Corporation trademark.

UPDATE—To process current changes to a master file by adding, deleting, and modifying its information.

VERIFY—To check the accuracy of a transcribing operation; usually applies to transcriptions which can be read mechanically or electrically.

CHAPTER 3

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 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.

THE PUNCHED CARD

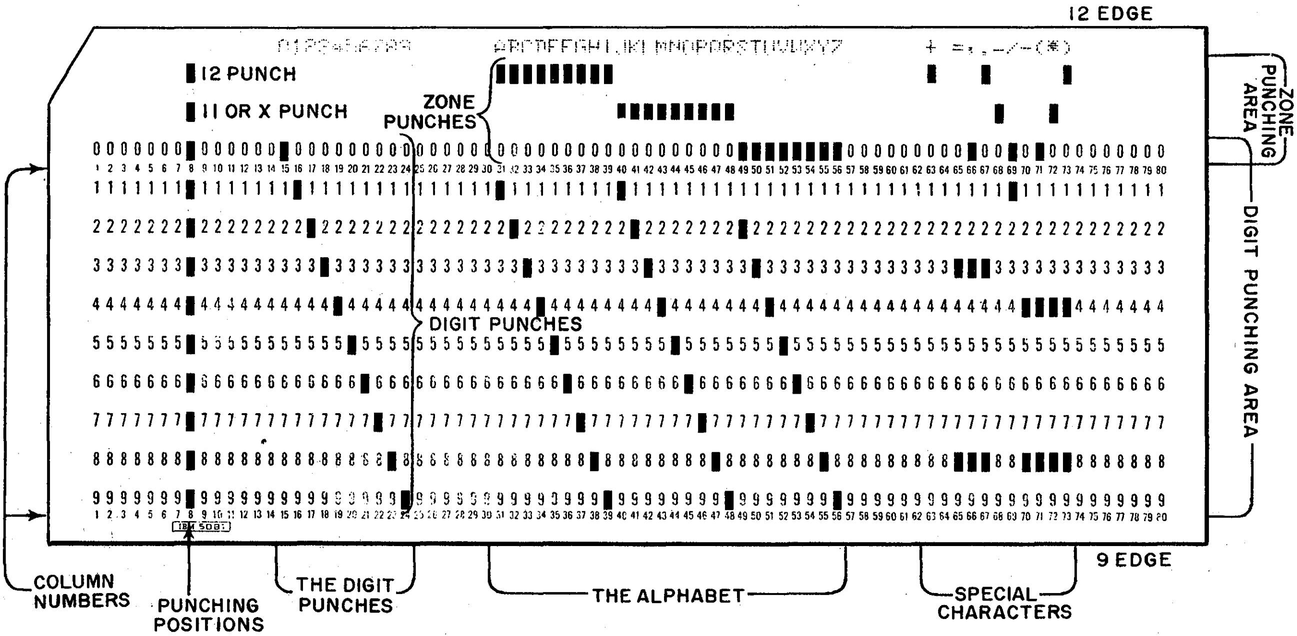
The punched card is one of the most successful media for the exchange of information between machines. To be capable of this, the card stock must be of a controlled quality in order to meet the rigorous requirements for strength and stability. Strict compliance with these specifications by manufacturers ensures the accuracy of results, the proper operation of machines, and the continued use of the punched information.

The standard punched card is 7 3/8 inches in length, 3 1/4 inches in width, and .007 inches thick. Cards 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. 3-1.) The 0 through 9 punching positions correspond to the 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



49.220X

Figure 3-1.—Card punching codes.

by digit), or column by column. Figure 3-2 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. The same figure also shows how cards fed either 12 or 9 edge first, are actually fed on a digit by digit 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.)

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

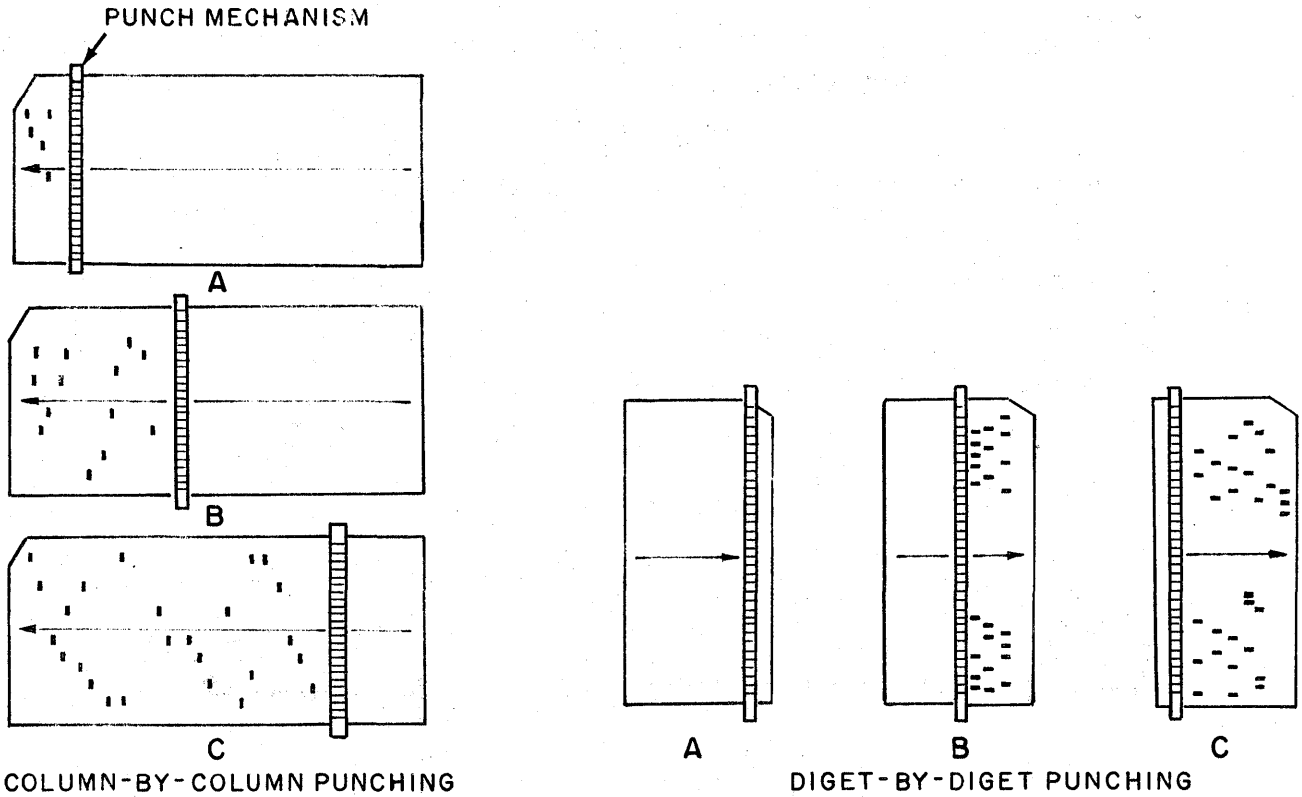


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Figure 3-2.—Punching the card.

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 3-1, 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. The 11 standard special characters are shown in figure 3-1.

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 3-3 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 service number, another for punching rate 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. 3-4.)

Field Positions.—From right to left, the positions in each field are known as the units position, tens position, hundreds position, and

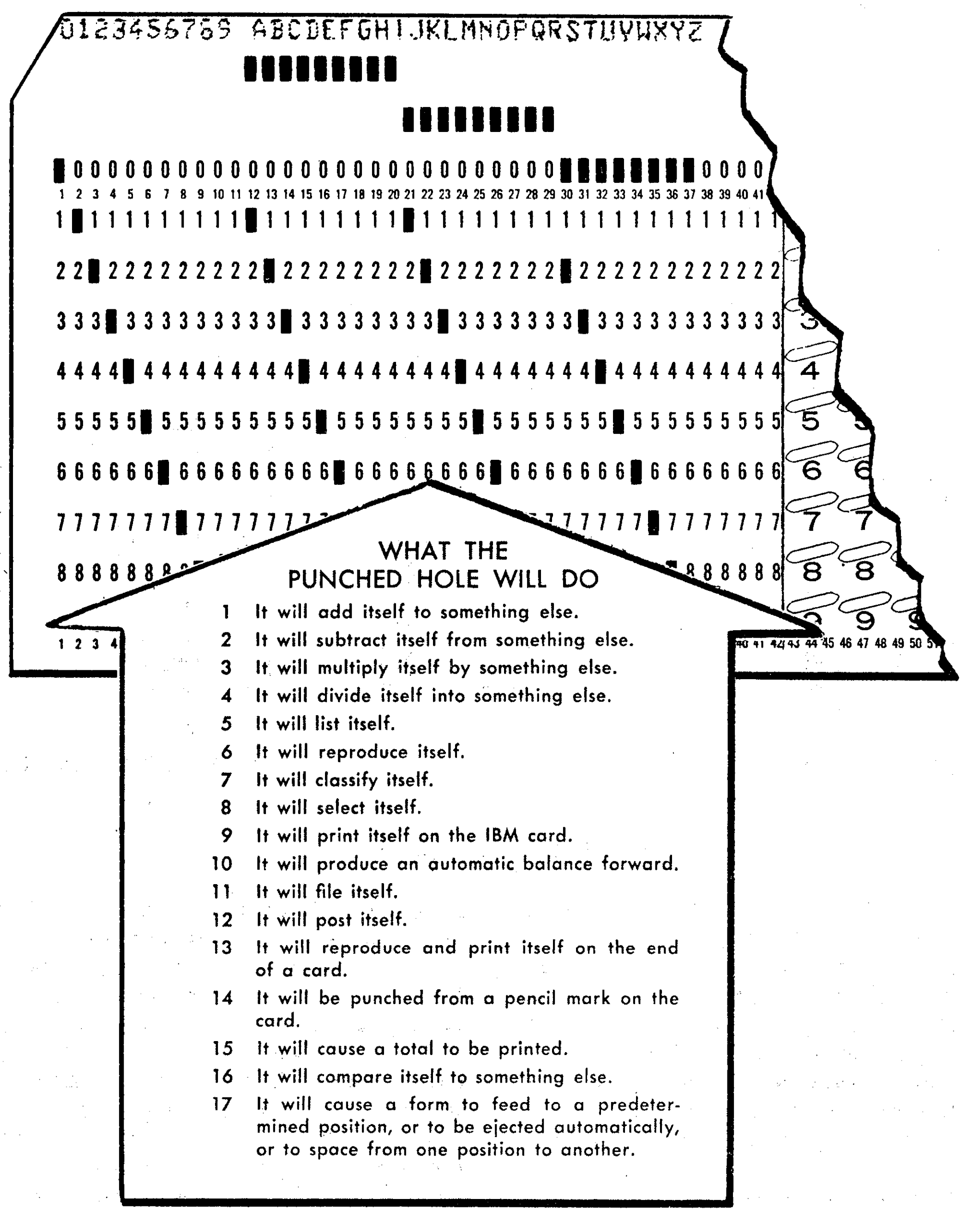

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Figure 3-3.—Capabilities of the punched hole.

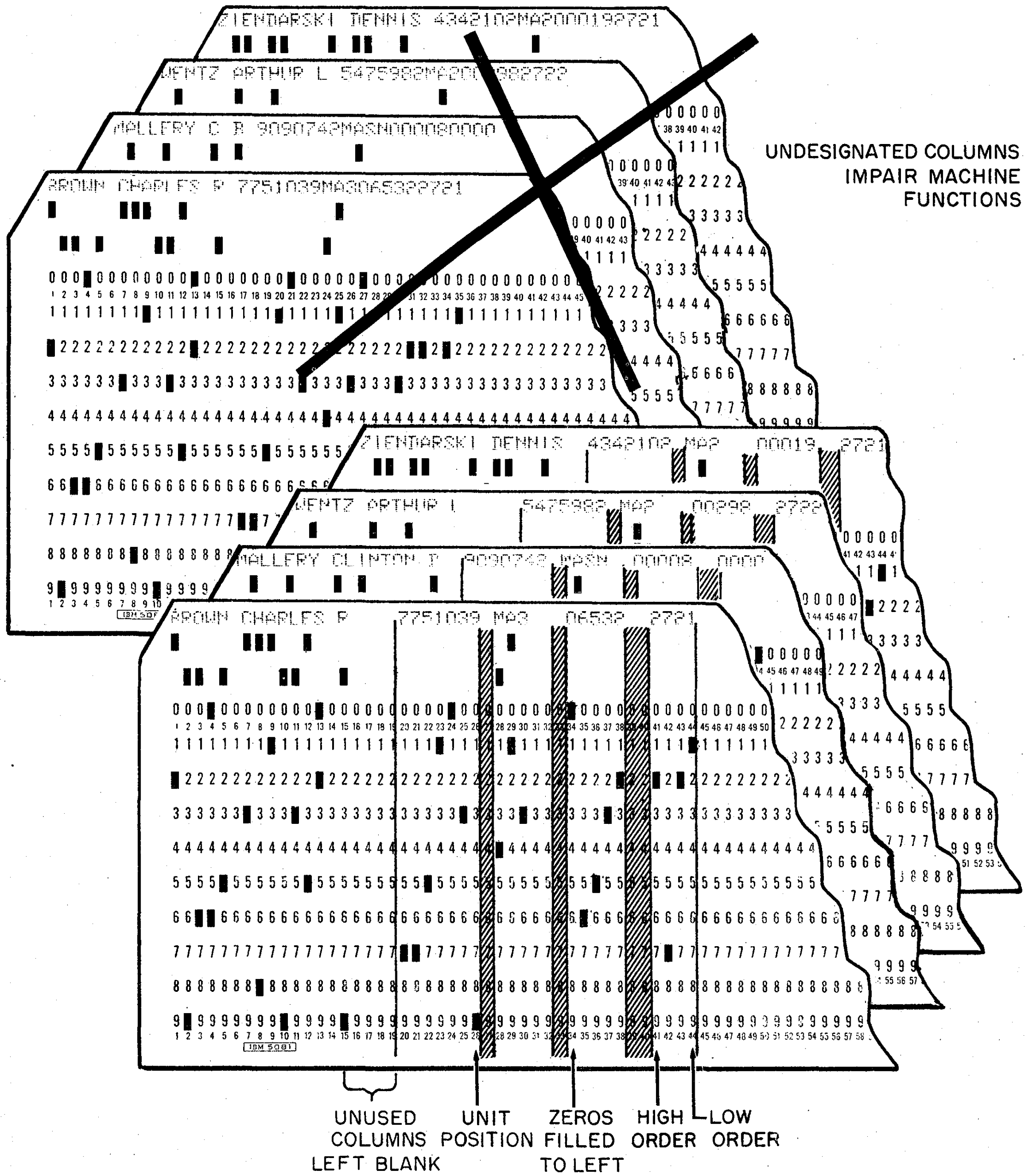
so on. The extreme right position of a field is also called the LOW ORDER position, and the extreme left position is the HIGH ORDER position. When punching numerical fields, the punching is from left to right, with the units position of the number punched in the low order position of the field. If the 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:

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



49.223

Figure 3-4.—Card fields facilitate machine processing.

processing medium, permitting the only automatic means of sorting original documents.

3. MARK-SENSE cards are those punched automatically from graphite markings discussed under examples of unit records in chapter 2.

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, also discussed in the previous chapter.

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 familar with some of the patterns of card design will further your understanding of punched card applications. Figure 3-5 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.

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.

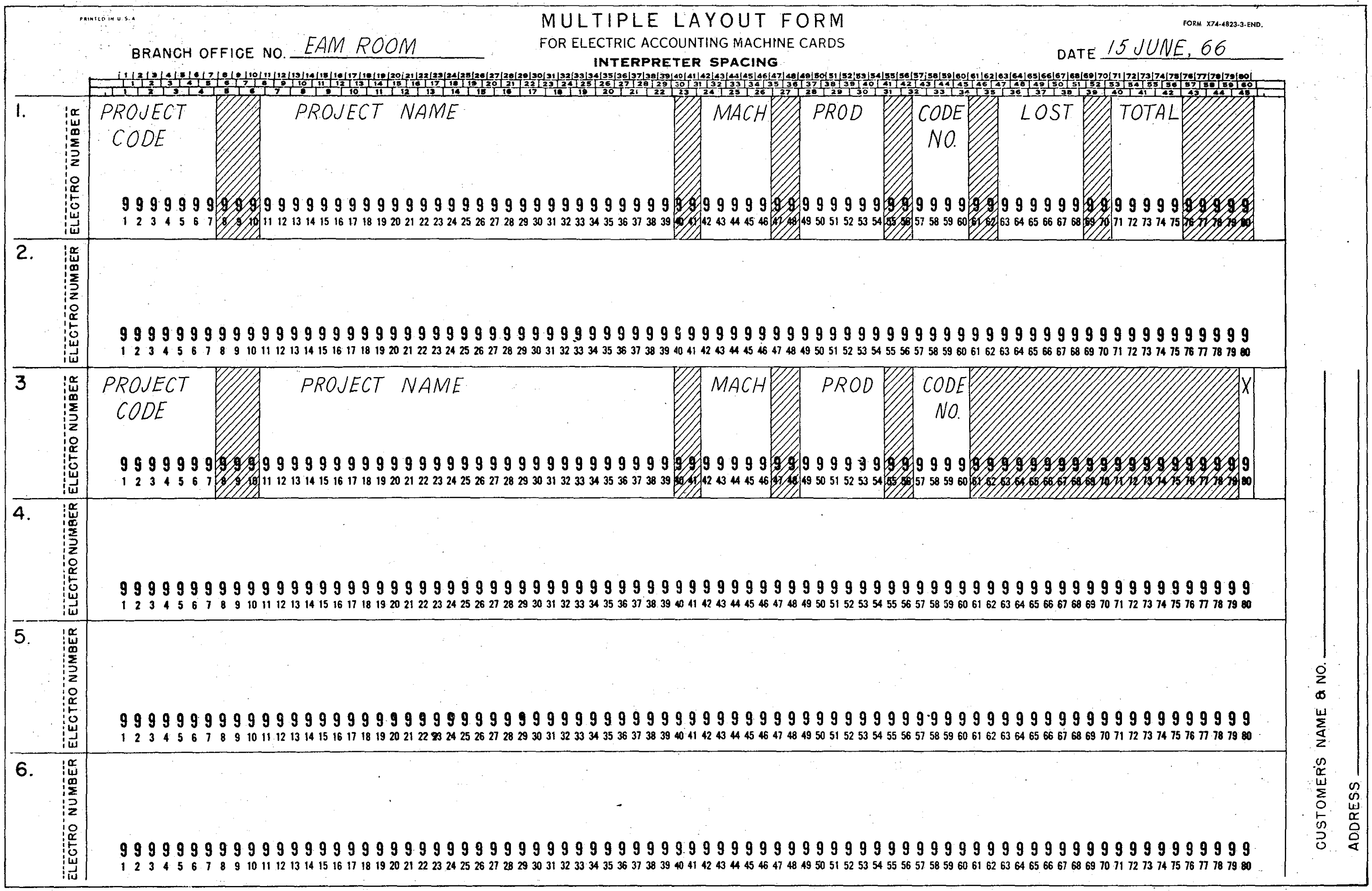


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Figure 3-5.—Multiple card layout form.

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 and at the left end of the card.
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 and illustrated in figure 3-6.

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.

FUNDAMENTALS OF EAM ACCOUNTING

Applying what you have learned about card language and design to actual accounting practices 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.

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 or grouping of transactions.

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

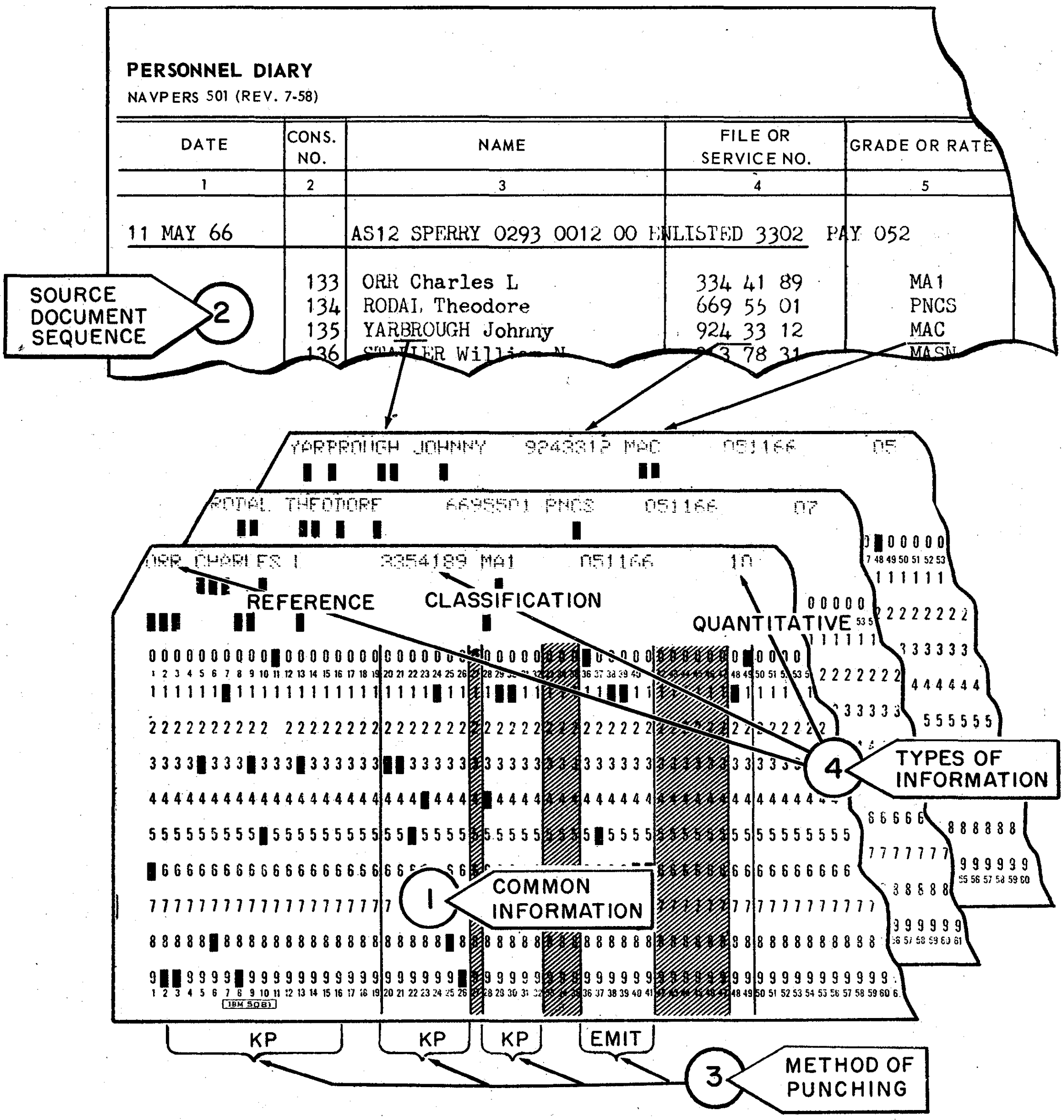

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Figure 3-6.—Card design analogy.

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

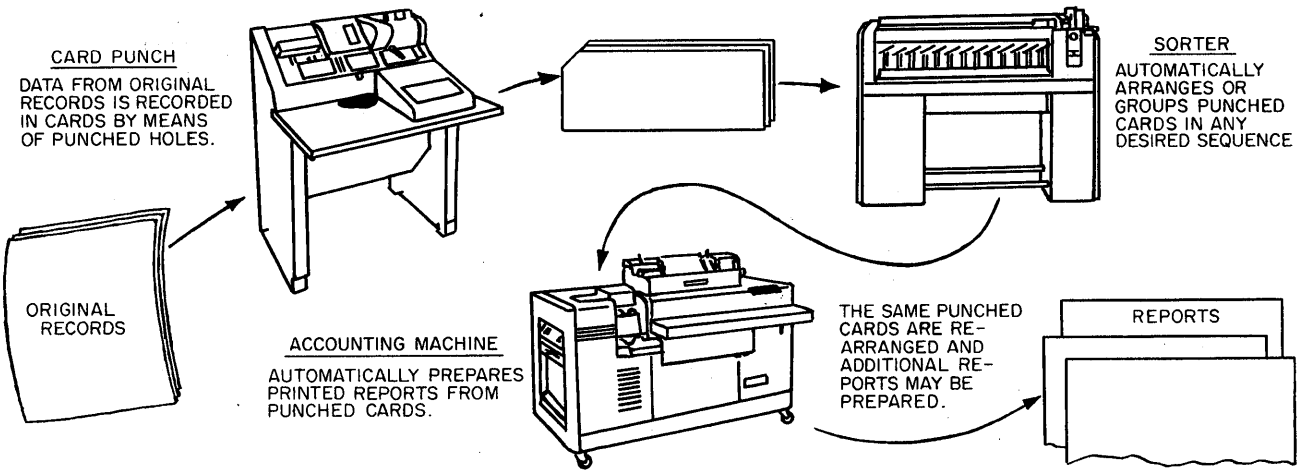

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Figure 3-7.—Principle of punched card accounting.

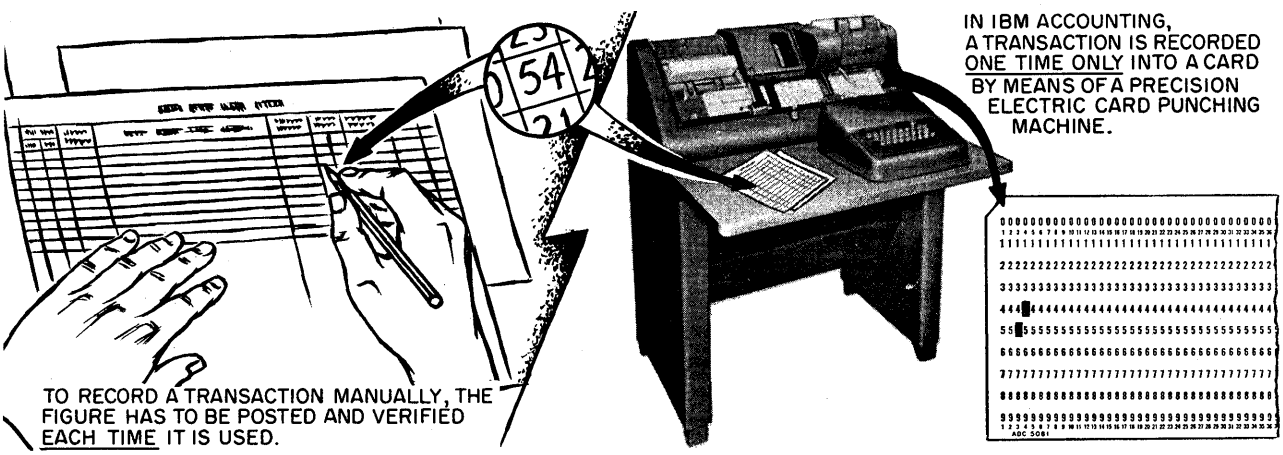

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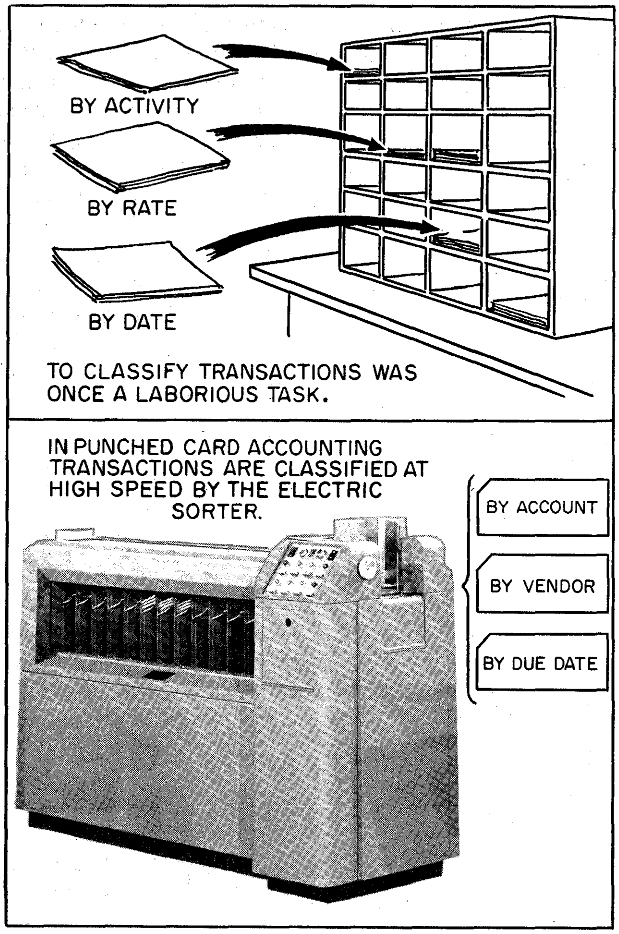
Figure 3-8.—The element of recording.

machine until all necessary totals have been taken. Because machine functions are flexible, many types of accounting and analytical reports can be produced. Figures 3-8 through 3-10 illustrate the above three basic elements of punched card accounting.

Principles of Coding Data-

Quite often, information on a source document is written in a lengthy descriptive form and if punched exactly as it appears, would require several cards per transaction. Coding systems have been devised to condense this information, making better use of the card and speeding machine processing.

One of your first assignments in a data processing installation may be that of coding documents. There are some important points to remember about any coding job. Codes must be properly assigned if they are to serve the purpose for which they are intended. Improper assignment of codes can result in long hours of research to determine the correct codes, or if the bad codes are not detected during screening operations, erroneous data may be placed in files or printed in reports. Do not guess when coding. If you are uncertain about the proper



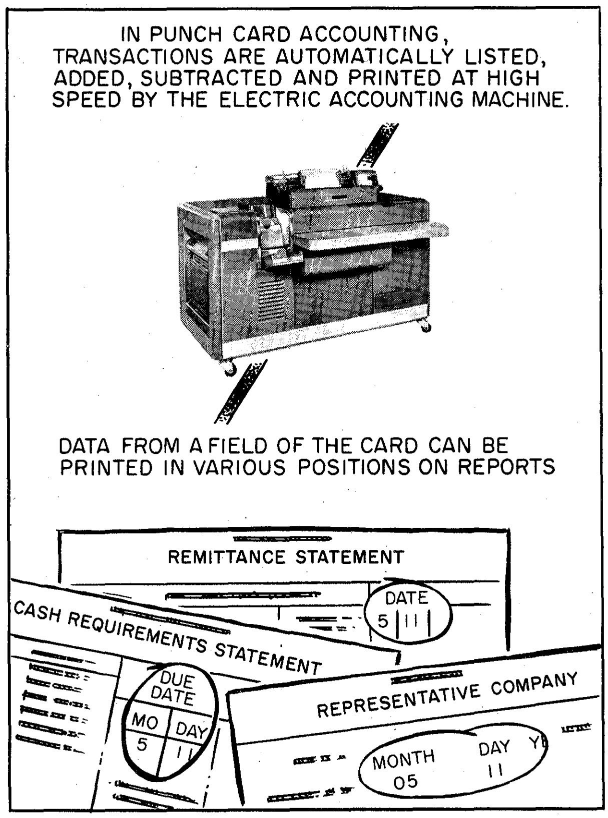
49.227
Figure 3-9.—The element of classifying.

code to use, refer to a coding table, or ask your supervisor. You will probably find yourself referring to a coding table frequently when you first start coding, but as you become more familiar with the codes, reference will seldom be necessary. Watch out for changes to coding tables. Be sure to adopt the new codes as soon as they become effective, and discard the codes they replace. If the data you are coding seem not to be constructed properly, check with your supervisor. Remember, coding is an important job, and any job worth doing is worth doing right.

Types of Codes.—The selection of the type of coding system and the assignment of the codes to data are predicated by the nature of the data to be analyzed and the informational needs of an EAM system. Codes are predominately of a numerical nature. A good example of this type of coding is the personnel diary. If a person were reported on the diary as "received for duty," we could assign a code, such as "200," to represent received for duty and punch this code in the card. If the diary reported a person "released to inactive duty," we could assign and punch a different code. Codes may be alphabetical, such as using the letters "F" and "M" to denote sex (versus punching the words female or male), or they may be alphanumerical, which is a combination of letters and numbers, such as the rate abbreviation of MA1 instead of Machine Accountant First Class.

Construction of Codes.—The ability to present related data in report form depends upon the coding structure used. The simplest is that of assigning numbers in sequence to items on a list or in sequence to data in alphabetical order. (Reports generally reflect the data designation by name, rather than by code, although sometimes both are printed.)

More sophisticated methods of code construction take into consideration the relationship



49.228
Figure 3-10.—The element of summarizing.

of data such as ship, aircraft, and activity classifications, and each segment of the code is descriptive of the item. For example, in supply accounting, the Federal Stock Number of KZ 5340 033 4376 would be deciphered as follows:

KZ - Cognizance symbol. (Inventory control point having control of this item.)
5340 - Group/Class designation.
53 - Commodity classification. (e.g., hand tools.)
40 - Class within a group. (e.g., powered/nonpowered hand tools.)
033 4376 - FIIN. (Federal Item Identification Number.)

Use of Codes.—The assignment of codes to information serves various purposes:

1. They allow data to be presented in its most meaningful and useful form.
2. They afford the easiest and most accurate way of expressing the relationship between items of the same or similar nature.
3. They reduce the amount of card punching by permitting the more efficient use of card columns.
4. They enable data processing machines to arrange, control, and process data faster by acting upon the code, rather than the longer data designation.

Principles of Punched Card Processing

The flow of data in an EAM installation revolves around the performance of certain job steps. Each of these steps usually requires a different type of machine to do the job. The number of steps required depends upon the particular processing application involved.

The major steps in these processing applications are input, process, control, and output. Input consists of all source information necessay for rendering specified final documents. Processing entails the manipulation of source information to provide records from which the final results can be prepared. Control necessitates the use of appropriate procedures and checkpoints to ensure the proper performance of all jobs, and that the results obtained are in accordance with prescribed standards. Output is generally produced after all processing has been completed and is occasionally produced as a byproduct of, or in conjunction with, a function performed during a processing routine.

Input.—One of the most common sources of input in EAM data processing is a source document from which information is punched manually into cards. Other sources of input are cards already on file or from which special reproductions of all or portions of information are made. Byproducts or end results of other processing applications, such as summary cards, frequently are used.

Input preparation embraces all steps which are necessary to prepare source data for the processing phase. These steps could include such functions as logging, coding, auditing, and batching source documents; card punching and card verifying; reproducing and mark sense punching; and screening or editing operations which guarantee the presence and validity of all required items.

It is also essential that appropriate controls and checkpoints be established throughout the input preparation phase to ensure that data entered into the system is up to date, complete, and accurate. Remember, any inaccuracy in the input information—no matter how small—destroys the accuracy of your final results.

RECORD FILES are involved in all EAM data processing operations. A file is a collection of unit records containing information about a group of related accounts. For example, a payroll file contains a record for each employee, showing such items as name, payroll number, pay rate, and other items required in the calculation of taxes, contributions, and net pay. A job order file contains a record for each job order; each record may show job order number and amount of labor, materials, and other costs allocated and expended. Files such as these contain semipermanent information, and generally are called MASTER files.

Another type of file is the TRANSACTION, or DETAIL file. This file consists of records containing information about transactions or changes to accounts in the master files. These transactions must be processed against the master files to keep the master files valid and up to date.

Processing.—File processing normally refers to the addition, alteration, or deletion of records in a master file from information provided by a detail file. The wide range of EAM data processing equipment makes possible a variety of methods and techniques for effecting the actual processing. However, all EAM file processing routines are regarded as being

SEQUENTIAL, because records are maintained in sequential order, starting (usually) with the lowest key or control number and proceeding in sequence to the highest. Therefore, all files involved in a processing routine must be in sequence by the field used to control the search and comparison of records. This is necessary, as any comparison of one record with another by a machine always results in an equal or unequal condition, or a high, equal, or low condition, to which the machine will react and perform accordingly. Thus, if comparison of one file with another is to be completed in one pass of the files through particular machines, both files must be in the same sequence.

It is obvious then, that the entire master file must be read each time transactions are processed against it. This forces the sorting of transactions, or detail files, so that the master file need be read only once. It is also necessary to accumulate transactions into batches of fair size before doing any processing, in order to reduce the number of times that the master file must be read. For this reason, reports are prepared periodically at specified times, such as weekly, monthly, or quarterly.

Control.—In any accounting system, there must be safeguards to ensure the accuracy of the data used in the system. These safeguards are known as CONTROLS. In each phase of a data processing application, there are certain controls which must be established by your supervisor if the finished product is to represent exactly what was intended. Some of these common controls are listed as follows:

1. Controls must be established to ensure that all source documents to be used in an application are actually received and correctly keypunched. If an error is made in keypunching, and that error is not detected, erroneous information may be placed in files, or printed on reports.

2. Certain information in cards must be screened prior to use in order to check the validity of the data. For example, in personnel accounting, cards containing a rate abbreviation must be checked against a master deck of rate cards to make sure that the rate is a valid one.

3. Certain predetermined totals must be maintained to make certain that, after processing has been completed to a file of cards, the file contains all the cards it is supposed to contain, or that totals in the cards balance to what they should be.

4. Reports must be checked to see that they contain the information they are supposed to contain, and that totals appearing in these reports are accurate. They must be checked to ensure that the data are printed in the proper sequence.

5. Each type of accounting procedure has its own particular controls. It is your duty to see that these procedural controls are maintained as you progress from one job step to another, in order to provide for the accuracy and completeness of all jobs for which you are responsible.

Output.—In punched card accounting, output represents the final phase of processing routines essential to each job. Operator procedure manuals (to be discussed in ch. 11) will supply detailed instructions for setting up all machines used in a processing routine, including information on control panels, switches, cards, and so forth. These manuals also contain necessary instructions to ensure that output requirements are met. Included are card descriptions (such as the color, corner cut, and type of card to be used in punched card output) and details of the required format, number of copies, disposition, and so forth, of printed reports or document output.

After the final output product is produced, whether it be a report, document, updated files, or punched cards requiring additional processing or further disposition, you will normally be held accountable for the following end-of-job routine tasks:

1. Reassembly to their proper sequence of card files disturbed during processing routines.

2. Proper marking and stowage of terminated files for easy reference.

3. Thorough checkage of all output, regardless of form, for accuracy and completeness.

4. Delivering of all output to your supervisor, or elsewhere, as specified.

5. Cleanup of all machines used and return of unused materials to their proper receptacles.

Identifying the Card

Visually.—Corner cuts can be used effectively to distinguish card types during clerical operations. Card types may also be visually indentified by their color or the use of a colored stripe. Color should be such that it will not interfere with the utility of the card, especially the reading and writing of data.

Electro/Mechanically.—Machines through which cards are processed are not capable of distinguishing between card types by color or corner cuts. (On some machines, the latter can be done by the installation of special rail brushes.) For this reason, an 11 or 12 punch is often used and commonly referred to as a CONTROL PUNCH. When the 11 punch is used for control, it is generally referred to as a CONTROL X. Control punches are not restricted to these two, however, for though they are the most popular, many machines will accept for purposes of control, impulses created by the reading of any punch, 12 through 9 inclusive.

The ability of machines to perform operations based upon the presence or absence of control punches, in addition to proper control panel wiring and machine setups, is known as SELECTION. Selection enables machines to differentiate between types of cards and card data and also to choose and initiate the proper course of action required to process the card or data. For instance, when accumulating data, a control punch in a specific column of a card could identify it as one having an amount field to be subtracted. Cards without the control punch would be identified as those whose same amount fields were to be added.

It should be noted that X control punches used to govern types of selection are never placed over fields used for automatic control or alphabetic printing.

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.

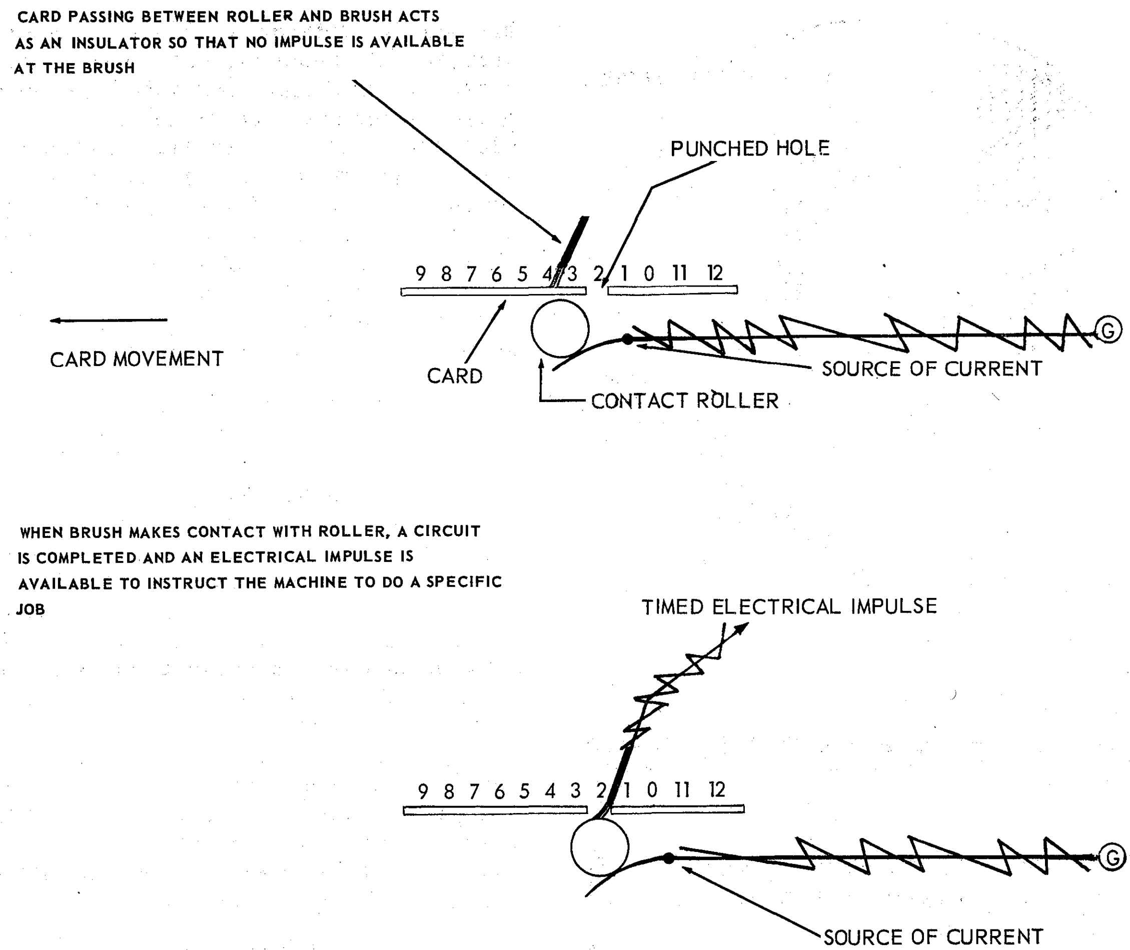
As the card passes through the machine, it passes between an electric contact roller and a reading brush. As long as there is no hole punched in the column the brush is reading, the card acts as an insulator to prevent the brush from making contact with the roller. When a punched hole reaches the brush, contact is made between the roller and the brush through the 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 3-11 illustrates how a brush reads a "2" punched in the card.

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 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 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 passes under the brush to the moment 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 3-11 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



49.2

Figure 3-11.—Brush reading the numeral "2."

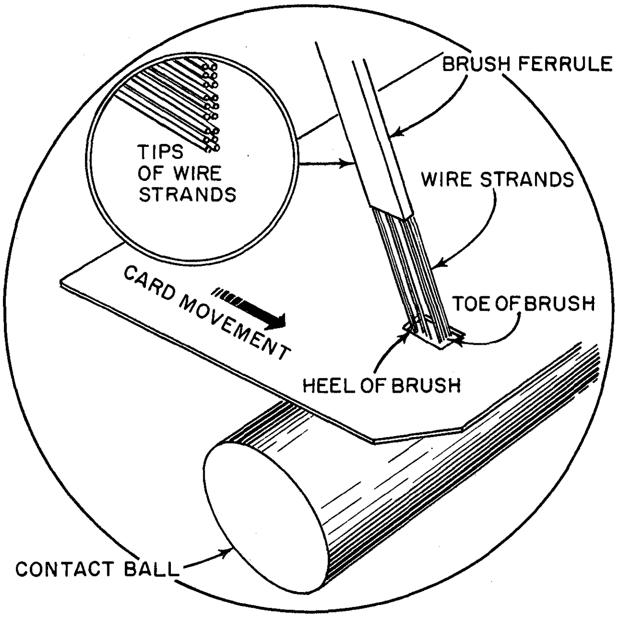
reading brushes, one brush for each column of the card, so that the entire card may be read as it passes through the machine. A single brush and an 80-column brush assembly are illustrated in figure 3-12.

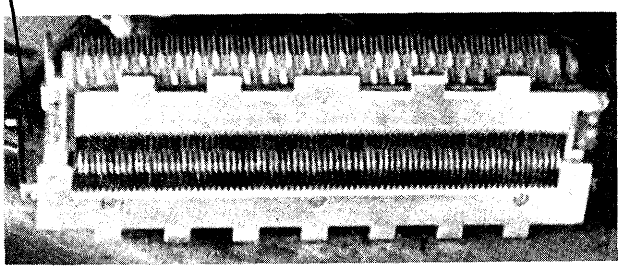
Theory of Timing.—When we speak of impulses being available and machine action occurring at 9 time, 8 time, and so forth, we simply mean that impulses are available and things are happening at those particular times when cards are in position for a 9, 8, and so forth to be read. For example, when a 9 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. 3-13A).

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. 3-13B).

Specific points in a cycle during which time holes are read or punched, or typebars positioned for the printing of specific digits, are





49.229
Figure 3-12.—An 80 column brush assembly (block).

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. 3-13C). 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. 3-13D), 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 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 (figs. 3-14 and 3-15) 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"

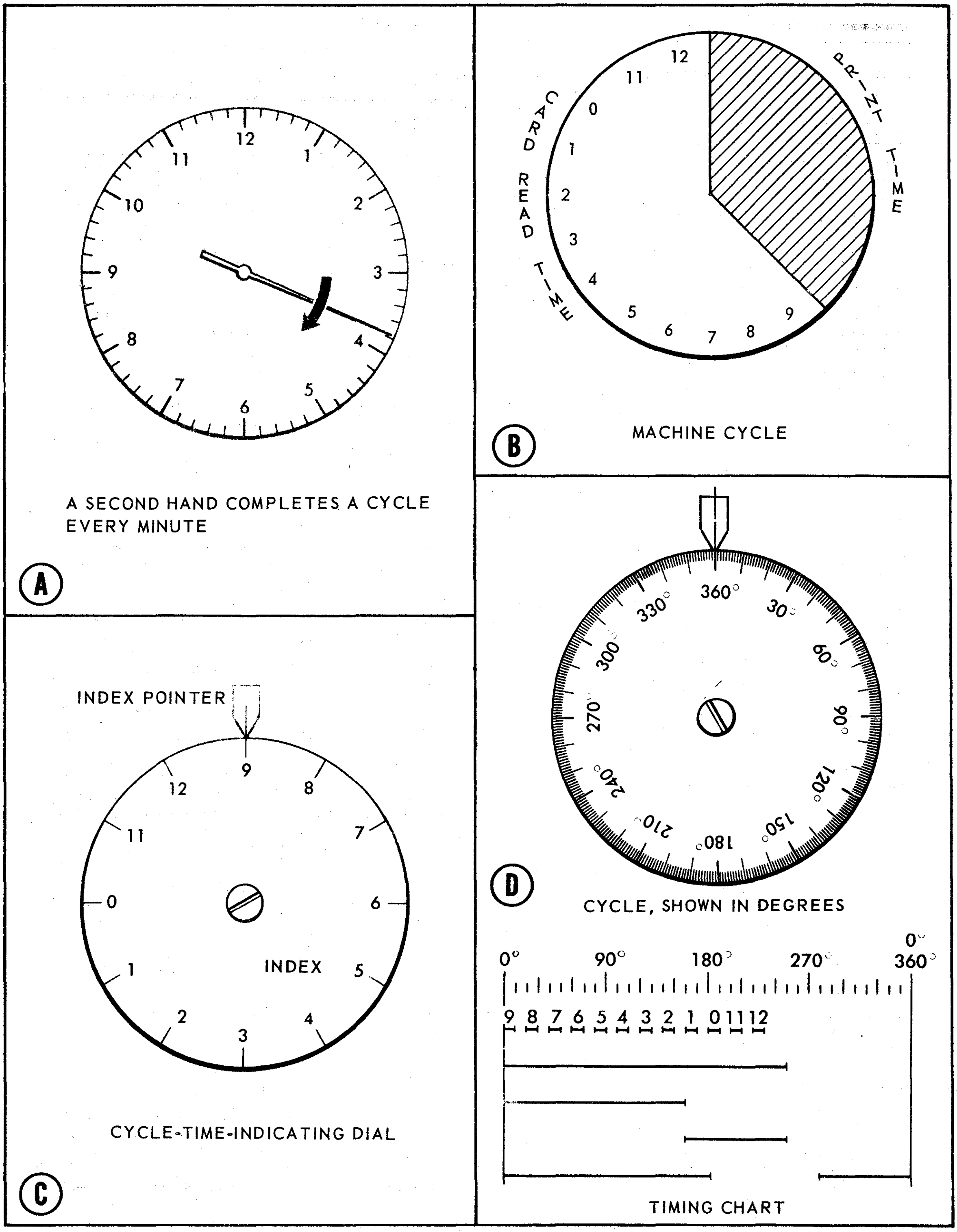
A control panel is a panel or board which, in most cases, can be removed from, or inserted into, the machine when desired. The panel has many small holes, called HUBS, into which you can insert wires with special tips to control the functions of the machine. Each of these hubs has a specific purpose or function. Figure 3-16 illustrates what one type of wired control panel looks like.

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. 3-17A.)



49.230

Figure 3-13.—The concept of cycles.

Normal Exit | Other Exit | Normal Entries | Other Entries

HUBS	LOCATION	TIMING FROM	TIMING TO	NOTES
Asterisk Control (Left)	AH-AK 21-22	192°	192°	1,2
CC Switch (Left)	AG-21-22	227°	240°	2
Column Splits	C-H 21,22			
Interpret 11-12		189°	24°	
0-9		24°	189°	
Proof 11-12		188°	48°	
0-9		48°	188°	
Comparing	A-B 27-31			
ALTN	A-B 31	112°	162°	3
ISUP	A-B 29	207°	232°	4
STOP	A-B 27	112° 207°	169° 232°	
SUP	A-B 28	112° 207°	169° 232°	
UNEQ	A-B 30	144°	169°	
Compare Entry	T 1-20	5°	159°	
Control X Read	C, 1-20	198°	210°	
Digit Selector Pickup	A-B 11-18			5
Interpret Emitter	W-X, 1-22 Y-Z 21-22	5°	169°	6
Interpret Read	D-L 1-20	358°	273°	7
Plug to Print	U 1-20	358°	273°	
Posting	AB-AC 23-35, AE-AF 23-34	96°	248°	
Print Entry 1 and 2	M-S 1-20			8
Print Entry Zero Selector	Y-AA 23-34			9
Print Line	AD 23-35 AG 23-34	96°	248°	
Proof Entry 1 and 2	M-S 23-42	30.5°	181.5°	
Proof Emitter	W-X, 23-44 Y-Z, 43-44			
Proof Reading	D-L 23-42	358°	273°	10
Repeat Print	J-K, 21-22 L-M -21			11
Control X		198°	210°	
Proof X		42.5°	46.5°	
X Switch (upper)		0°	360°	12
Selectors	Y-AD, 1-20			
T(Interpret Read)		29°	187°	
T(Proof Read)		54.5°	187°	
SLP 25	AA-AC 21-22			
DCPL	AC 21-22	96°	248°	
OFLO	AB 21-22	96°	248°	
ON	AA 21-22	0°	360°	
SLP 50	AD-AF 21-22			
LLCTL	AF 21-22	96°	248°	
OFLO	AE 21-22	96°	248°	
ON	AD 21-22	0°	360°	
SLP Selector	AE-AG 35			13
C	AG 35	0°	360°	
25	AF 35	0°	360°	
50	AE 35	0°	360°	
Stacker	A-C 23-26			
Comp	A-C 26	152°	159°	
Ctrl X	A-C 23	198°	210°	
IMM PK	A-C 24	0°	360°	
Int Br	A-C 25	5°	146°	
Suppress Print	N-S 21-22			
Interpret X		5° 17°	12° 24°	
N Switch (Upper)		204°	254°	12,14
Non-Suppress Switch (Left)		204°	254°	2,15
Proof X		42.5°	46.5°	
X Switch (upper)		204°	254°	12,14
X-O Split	A-B, 1-2			
Interpret		24°	187°	
Proof		46.5°	187°	
X-O Split or Control X Selector Pick-up	A-B, 3-10	198° 24°	210° 187°	16
Zero Print Control	AE-AK 1-20			
Upper		358°	273°	17
Lower				18

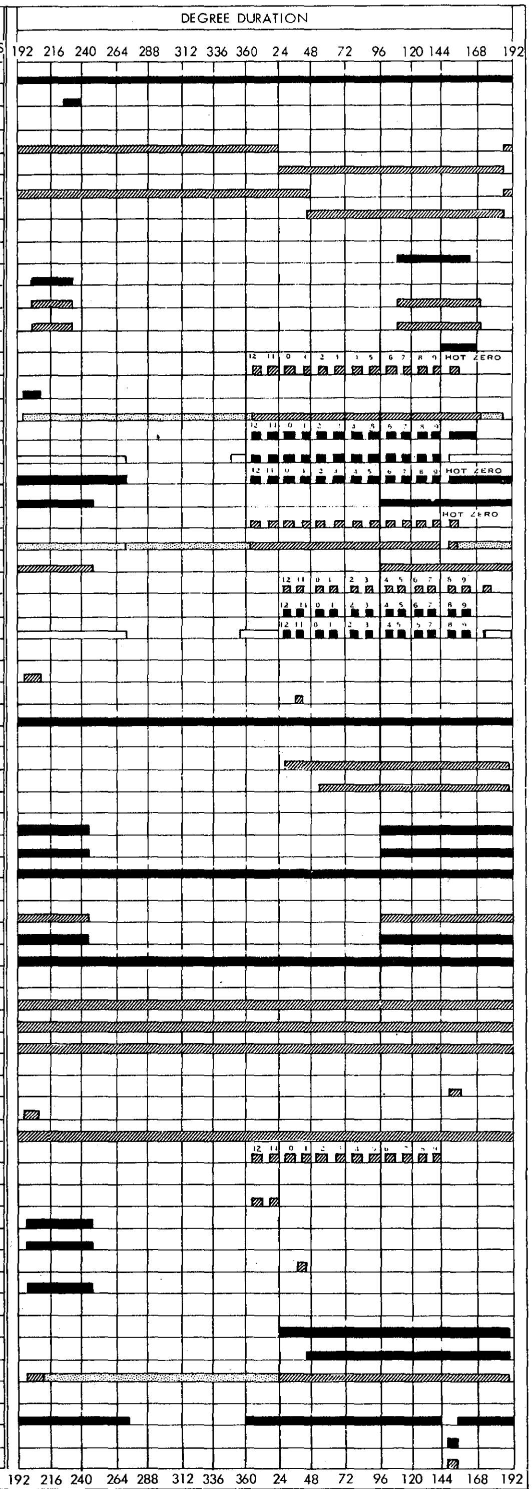


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Figure 3-14.—Timing chart for IBM type 557 interpreter.

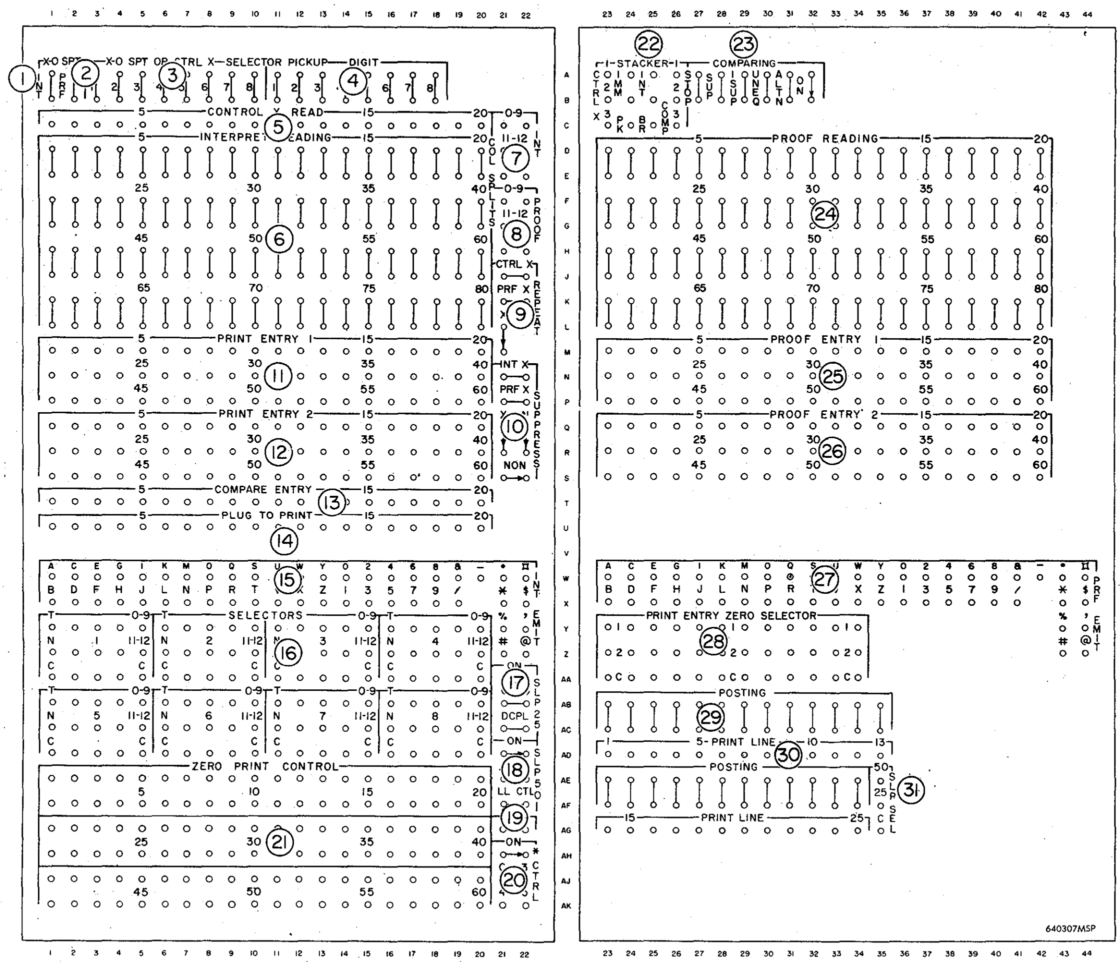

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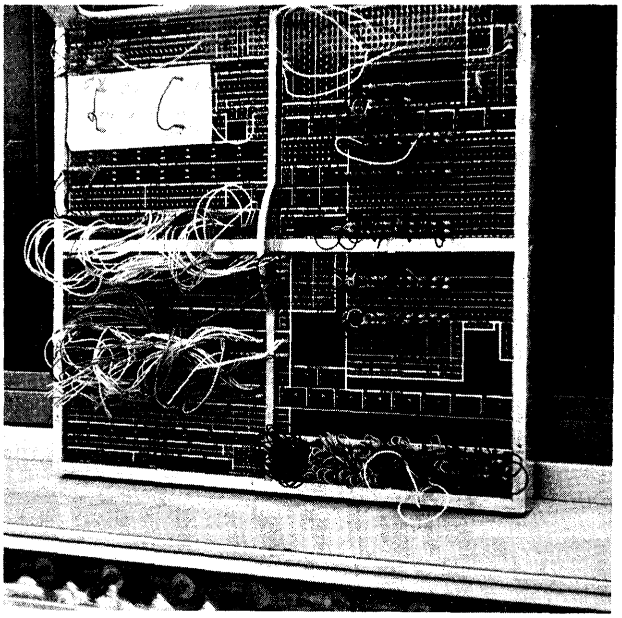
Figure 3-15.—Control panel summary of the IBM type 557 interpreter.

Figure 3-18 shows four concepts regarding electricity that apply to the wiring of all unit record equipment. With these in mind, let us analyze figure 3-19, which illustrates the internal and external wiring of an accounting machine. The control panel indicated in this illustration is the one shown in figure 3-16, and figure 3-17 shows how the hubs pass through the panel. 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. 3-19), 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.



49.232
Figure 3-16.—A wired control panel.

One type of panel has metal jacks that press against the metal prongs in the machine. (See fig. 3-17A.) 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. 3-17B.) 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. 3-20.)

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 connecting block is available from all other terminals in the block. (See fig. 3-20.)

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

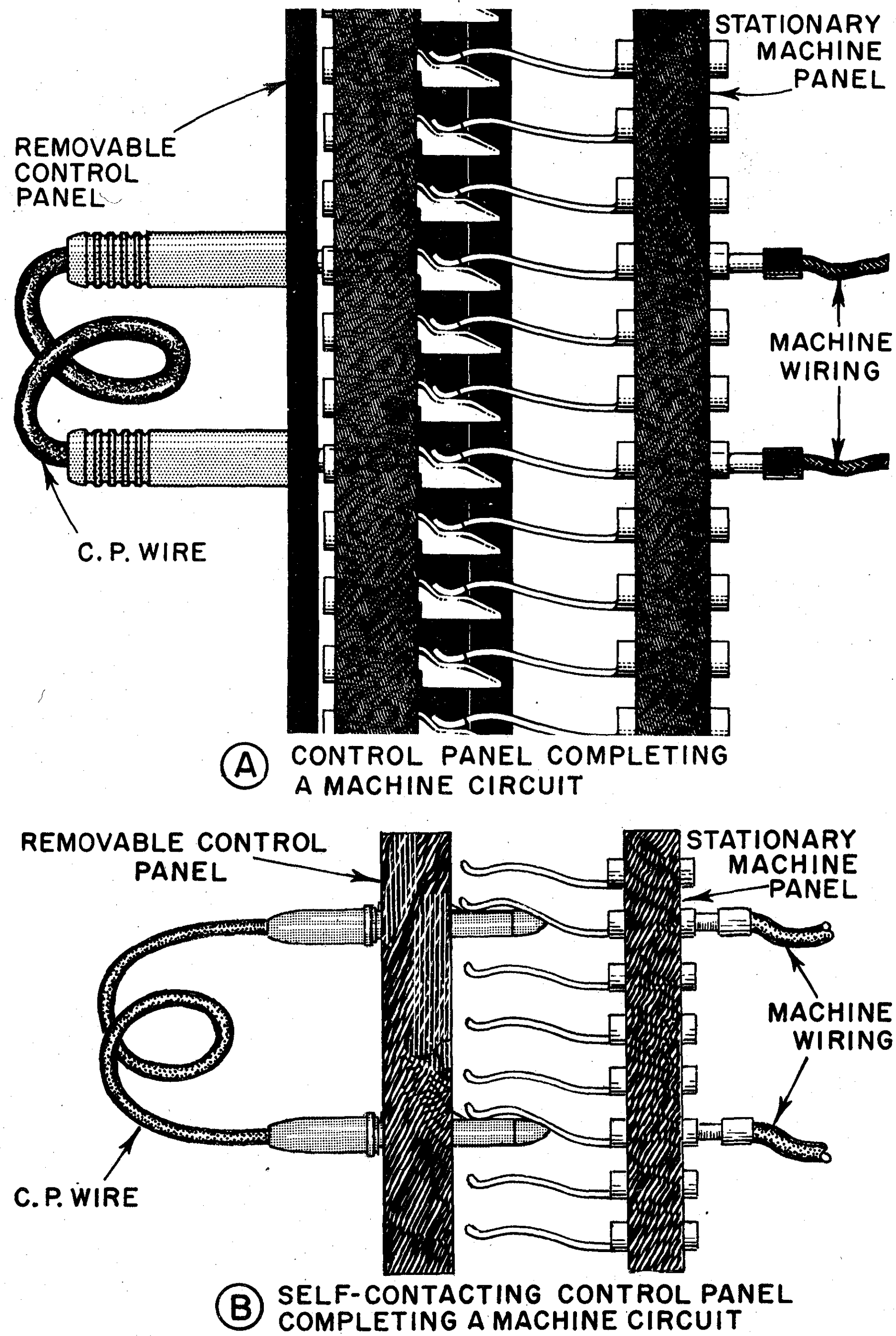


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Figure 3-17.—Circuits completed by external wiring.

used in preference to wires when connecting two adjacent hubs, also illustrated in figure 3-20.

Shaded areas of the unwired accounting machine control panel in figure 3-21 depict other than the standard hubs. You will find illustrations such as this in most manufacturers' reference manuals. Always acquaint yourself with what is standard and what is optional on

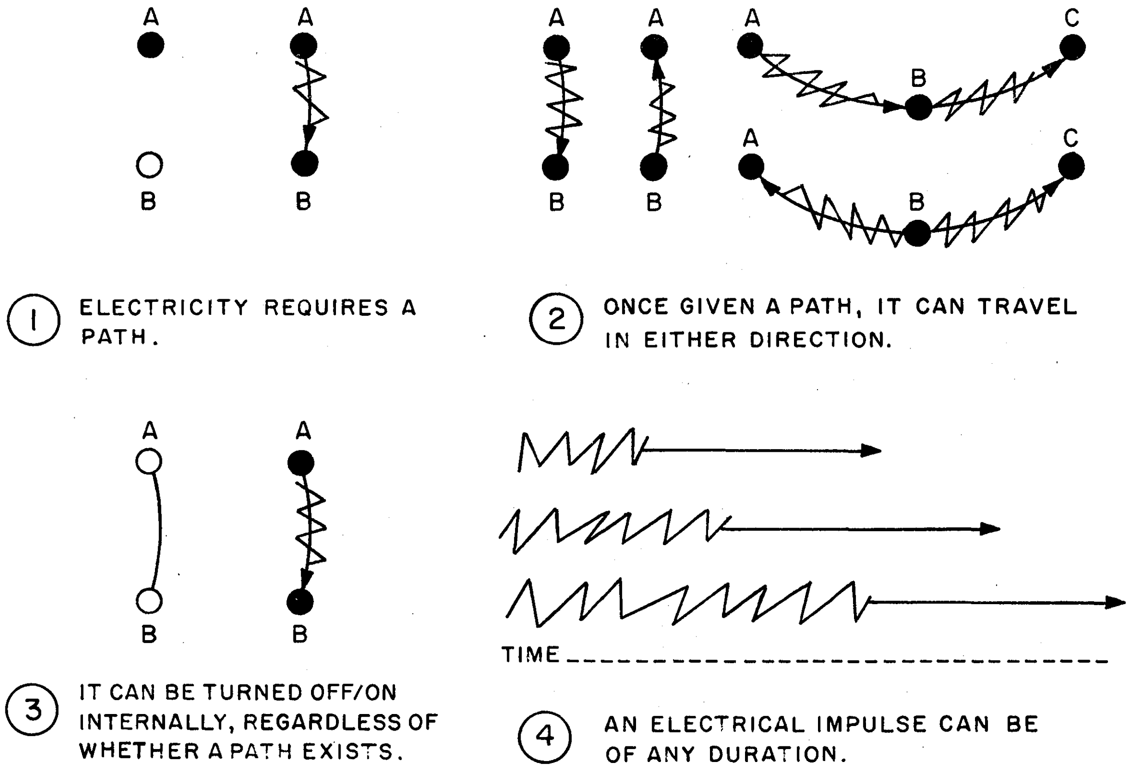

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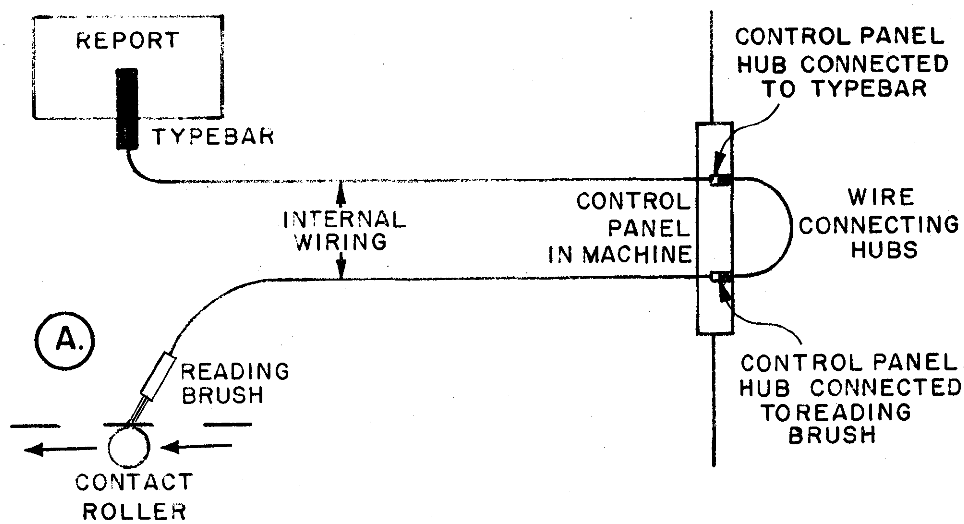
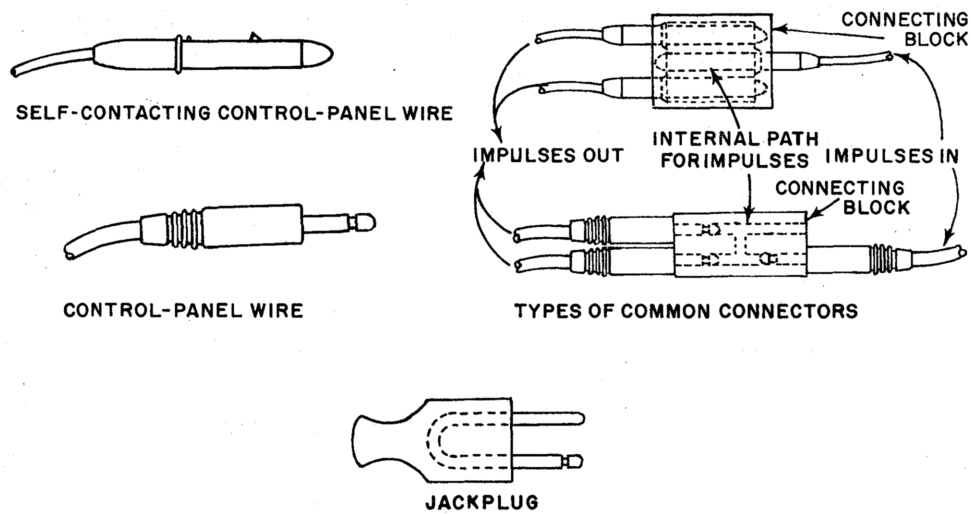
Figure 3-18.—Concepts of electricity.



49.234

Fig. 3-19.—Internal and external wiring to cause printing.



49.235

Figure 3-20.—Control panel wires and wiring aids.

the panels of each machine you are expected to wire. Looking closely at this same figure, you should be able to detect some of the hubs just discussed.

Paper Diagrams (Drawings)

Eventually, you will be required to draw a permanent record of a control panel setup. Paper diagrams (fig. 3-21) of the hub layouts for each machine type control panel are available and used for this purpose. To ease the drawing of a wiring diagram and to provide legibility, certain rules must be followed:

1. Pencil-in and connect the hubs of fields with HORIZONTAL lines.
2. Connect entry and exit fields with ONE line. This one line abbreviation is used for the sake of clarity, even though it may represent many individual wires. (A six position field would require six wires on the actual control panel.)
3. Exit and entry hubs are indicated by an ARROW pointed to the entry hubs.
4. When crossing lines on a diagram, one line is BROKEN to avoid confusion in following the lines of a complicated drawing.
5. Though not shown in figure 3-21, COLORS are often used to indicate different functions.

In the chapters on EAM equipment which utilize control panels, you will see applications of the above rules.

OPERATION OF EAM EQUIPMENT

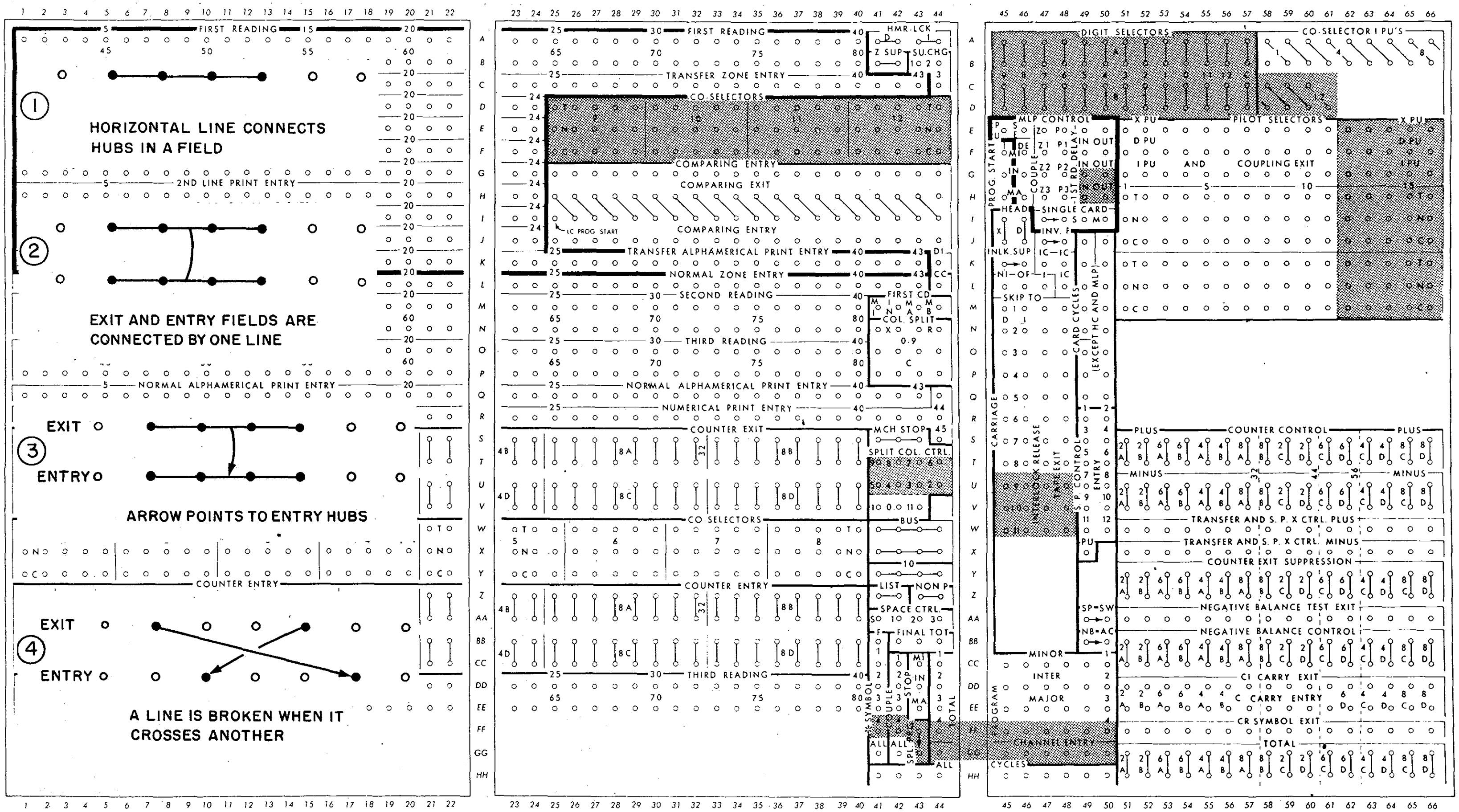
Skill in operating any machine requires practical experience, but experience alone is not enough. A machine operator can become skilled only through a combination of personal instruction, practice, and study of written manuals. The basic operating steps of all machines are very much alike, although the results obtained from each type of machine may vary considerably.

Regardless of the type of machines you operate, or the accounting procedures you follow, there are certain rules you should observe in order to maintain the highest degree of efficiency.

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



49.122

Figure 3-21.—Paper diagramming.

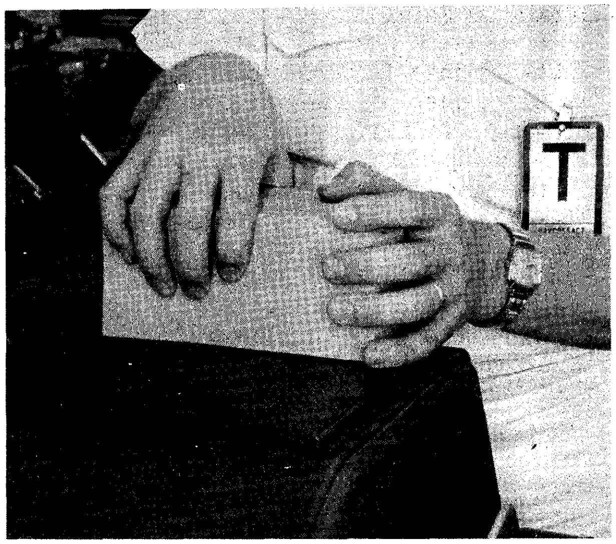
edge of the card that passes under the throat of the machine.

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 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.

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 found later.



49.236
Figure 3-22.—Joggling and aligning cards.

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 the cards.

3. Keep all beverages, such as coffee and soft drinks off the machines. Liquids, if spilled, are detrimental to the proper operation of interior machine parts.

4. Brush feed hoppers daily to remove lint.

5. Do not allow unused wires to hang loose from the control panel, 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 secures 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 when cards are passing through the machine, or 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. Remove all cards from stackers upon completion of an operation.

10. Turn power off and cover machines when no assigned shift is using them.

Rules for Working Spaces

The efficiency of a machine installation is often judged by its appearance. You can help maintain a neat appearance by observing a few simple rules of good housekeeping.

1. Keep cards and paper forms in their proper stowage when not in use.

2. Place discarded paper and cards in receptacles provided for them.

3. Place control panels in their proper racks when not in use.

4. If you have a desk, keep it neat. Do not clutter it up with a lot of unnecessary material.

5. In general, abide by the well known adage, "a place for everything, and everything in its place."

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. Some installations requires that all machine malfunctions be noted on special cards, time sheets, or other forms as provided.

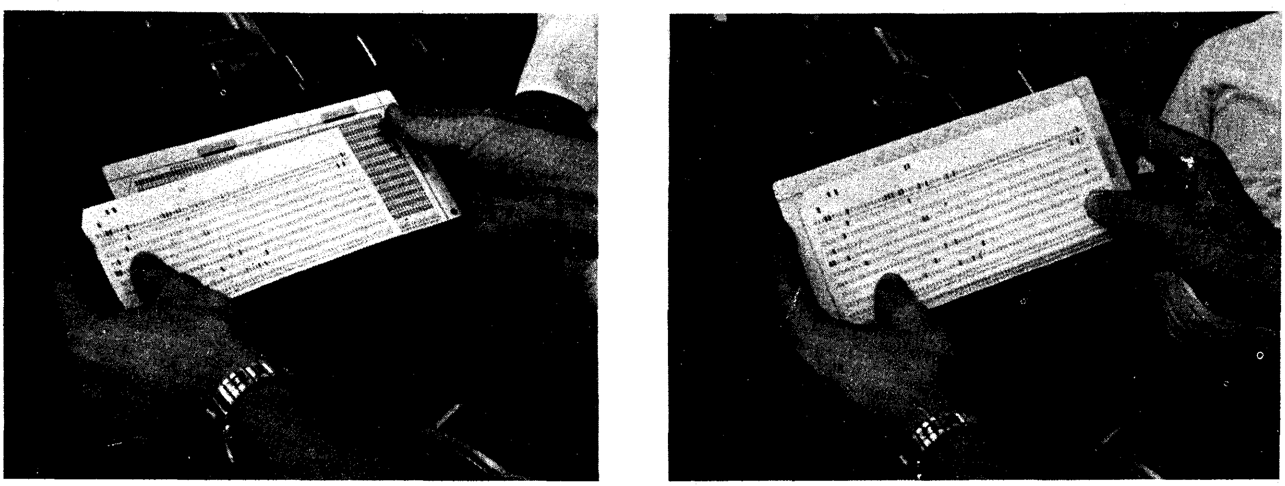
Maintenance of EAM

As a general rule, electric accounting machines are installed on a rental basis and equipment is maintained by customer engineers of the supplying company. (To the extent possible, the responsibility for maintenance of equipment installed aboard ship, lies with qualified Machine Accountants or Data Systems Technicians.) Schedules are established to provide customer engineers with the necessary time for accomplishing routine machine inspections and internal preventive 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 ignorant of machine failures that occur during a processing phase. This ignorance 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.

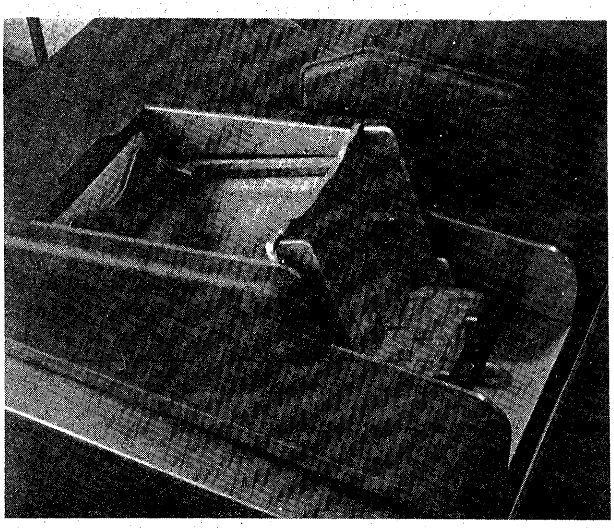
Your compliance with the following rules of machine operating can reduce many of these nonproductive hours:

1. Before operating any punching machine, check its punching registration with a card gage.
2. Make use of test decks that are provided for ensuring that machines are functioning properly to perform specific jobs.
3. Do not feed other than standard cards into the machines (e.g., tab index cards). Keep card weights on cards in feed hoppers of

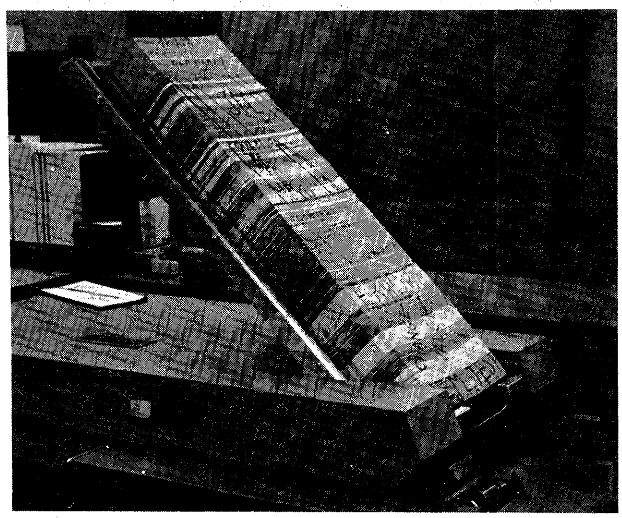


49.237

Figure 3-23.—Checking the punching registration.



49.238X
Figure 3-24.—Feed hopper, stacker and prescribed card weight.



49.239X
Figure 3-25.—Type of file feed not requiring a card weight.

machines at all times while machines are running (except when not required by certain type card feeds); do not use heavier-than-normal card weights or rest your hands on the cards in the hopper.

4. 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 punch die or brush assemblies, exercise special care to prevent damage to them. If damaged, replace only those brushes authorized by your supervisor. Make certain they are properly reseated before resuming the operation.

5. Do not change or switch the overhead rail electrical drop cords between machines unless duly authorized to do so.

ALPHA—A term used to indicate alphabetical characters; synonymous with alphabetic.

ALPHABETIC—Alphabetical characters or codes as differentiated from numerical quantities.

ALPHAMERIC—A contraction of alphanumeric and alphabetic-numeric; characters which may be either letters of the alphabet, numerals, or special characters.

ALPHANUMERIC—A contraction of alphabetic and numeric; synonymous with alphameric.

APPLICATION—A problem to which an EAM or EDP system is applied.

BATCH NUMBER—A number assigned to grouped source documents prior to punching; assures the delivering of punched cards in batches for processing.

BOARD WIRING—Inserting removable wires in an interconnection device to control machine functions; synonymous with control panel wiring and plugboard wiring.

BRUSH—An electrical conductor for reading information from a punched card; normally has a corresponding hub on the control panel.

CARD GAGE—A metal plate, precisely inscribed with all punches of an 80-column card; used to check the accuracy of punching registration; see registration.

CARD JAM—A pile-up of cards in a machine.

CARD WEIGHT—A weight placed on cards in machine hoppers to ensure proper feeding, particularly the last cards.

CHARACTER(S)—One or a set of symbols arranged in ordered groups to express information; e.g., decimal digits, letters A through Z, punctuation symbols.

COMPARE—To check information or data to determine whether it is identical, larger or smaller, or in sequence; examining the representation of data to discover identity or relative magnitude.

CONTROL FIELD—A field(s) of information by which cards are identified and/or controlled; synonymous with key.

CONTROL PANEL WIRING—Synonymous with board wiring and plugboard wiring.

CONTROL PUNCH—A punched hole (usually the 11 or 12 zone punch) for controlling machine operations.

CONTROL TOTAL—A sum formed by adding specific fields within a group of records; has some significance as a number; used for checking machine and data reliability.

CYCLE—A complete series of operations at the end of which the entire series can be repeated; expressed in time, points, type, or degrees.

DECIMAL NUMBER SYSTEM—The common number system using the base ten and having ten symbols, 0 through 9; column unit values from right to left of 1, 10, 100, 1000, etc.

DETAIL FILE—A file of current information generally used to update a master file.

DOWN TIME—The time data processing equipment is not operable due to malfunction; not available for productive work; contrasted with up-time.

DUPLICATE—To automatically copy (punch) repetitive information.

EMIT—To originate digits, letters, and special characters electrically within the machine rather than from the punched card.

FANNING CARDS—The act of 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; used to remove foreign particles and static electricity.

FIELD—One or more fixed columns regularly used to report a standard item of information; a group of related characters treated as a unit of information.

FILE—A collection of records; a set of punched cards arranged or classified in sequence according to a key or control field, for convenient reference and processing.

HIGH ORDER POSITION—The leftmost position of a number, field, or word, contrasted with low order.

HOLLERITH CODE—The configuration punched in vertical columns of cards to represent decimal digits from 0 to 9, letters from A to Z, or special characters.

HOPPER—The receptacle for holding cards to be fed into a machine.

JOGGLE—To align a deck of cards by jostling them against a plane surface

KEY—A group of characters used in the identification or location of an item; synonymous with control field.

LOW ORDER POSITION—The rightmost position of a number, field, or word; contrasted with high order.

MASTER FILE—A file of semipermanent information, which is updated periodically.

NUMERIC—An allowable digit in a machine's number system; the punching of numeric quantities as contrasted with alphabetic codes.

OVER PUNCH—A punch (usually a control punch) over a significant digit in a column.

PLUGBOARD WIRING—Synonymous with board wiring and control panel wiring.

PUNCH—A machine that provides punch card output; a mechanism to punch holes in a card; e.g., punch dies or magnets.

PUNCH STATION—The position in a card feed where punching occurs.

RAIL BRUSH—A specially installed brush capable of reading corner cuts to distinguish cards.

READ STATION—The position in a card feed where reading occurs.

REGISTRATION—The accurate position of punched holes in a card; see card gage.

SELECTION—Removing cards from a file, or processing cards according to predetermined conditions.

SERIAL PROCESSING—A type of processing whereby all records are handled and processed sequentially.

SPECIAL CHARACTER—A character other than one of the digits 0—9 or letters A—Z having definite configurations.

TEST DECK—A set of cards representative of all operations performed in a particular application. Used to test control panel wiring and machine operations.

TIMED IMPULSE—An electrical impulse created by the reading of a punched hole at a precise time, moment, or degree of a cycle.

TYPEBARS—Movable bars containing letters, digits, and special characters for printing.

UNDER PUNCH—The low punch in a card column. (Usually the digit punch under a zone punch.)

UNIT POSITION—The rightmost position of a numeric field; synonymous with low order.

UPTIME—The time during which machines are available for productive work; contrasted with downtime.

X PUNCH—A hole punched in the 11th punching position to control machine operations; see control punch.

ZONE PUNCH—A hole punched in the 12, 11, or 0 row of a card; used in conjunction with a digit under punch to form an alphabetic letter or special character.

CHAPTER 4

CARD PUNCHES, VERIFIER, DATA TRANSCEIVERS

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 an MA 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

Two common card punch machines in use today are the IBM types 24 and 26. These two 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 4-1 pictures the IBM type 26 card punch, with the operating features indicated.

Operations which may be performed on card punch machines include manual punching by depression of the proper keys, duplicating data contained in one 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. 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 10 columns per second.

OPERATING FEATURES

Card Hopper

Cards are placed in the card hopper face forward, with the 9 edge down. A card may be fed from the hopper to the card bed 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 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

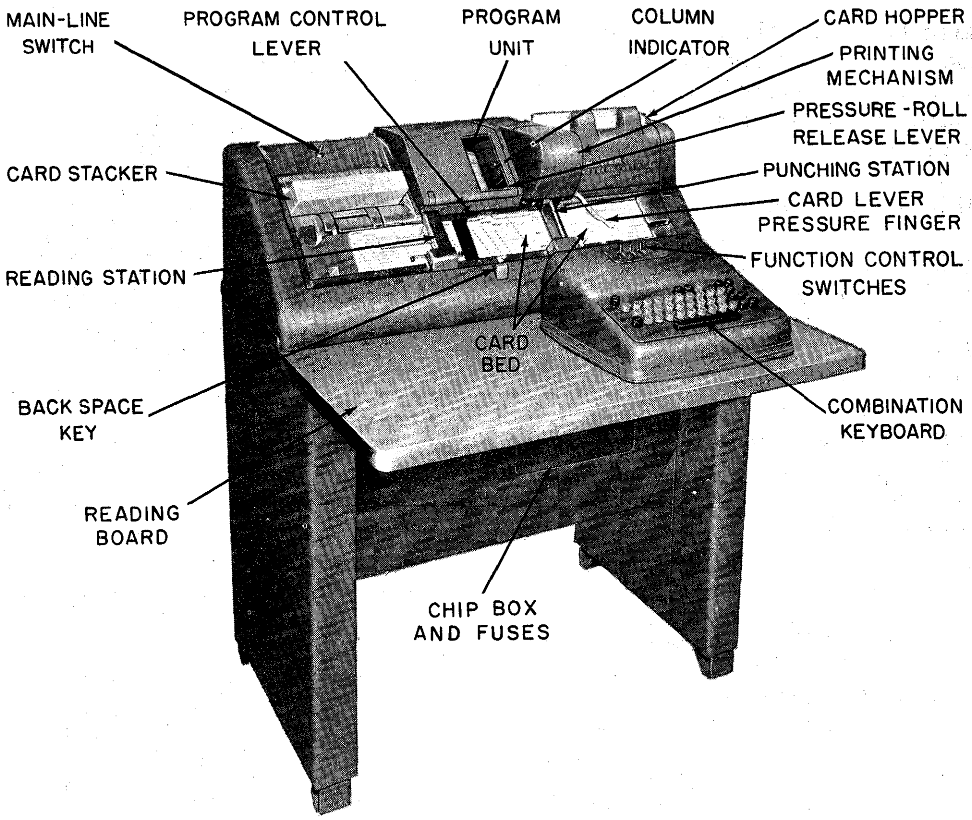


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Figure 4-1.—Type IBM 26 Printing card punch.

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 line 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 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 read or punched at the read and punch stations. You will find this indicator especially useful for locating a specific column when spacing or backspacing. (See fig. 4-5A.)

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.

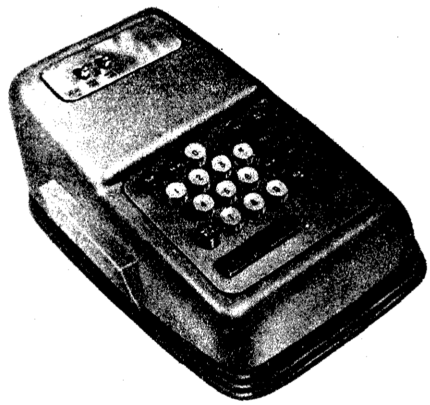
KEYBOARDS

Figure 4-2 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.

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 4-3.

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. 4-4) will punch a 7 in numeric shift or an M when in alphabetic shift. 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 4-4 and



NUMERICAL KEYBOARD

COMBINATION NUMERICAL AND ALPHABETIC KEYBOARD

49.240X

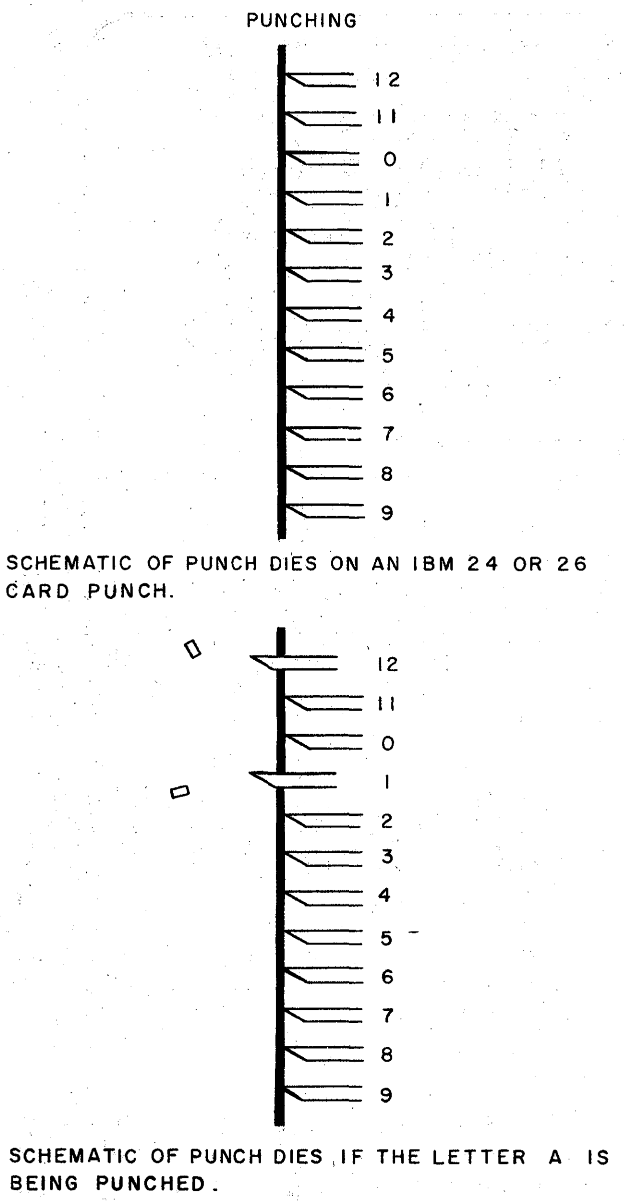
Figure 4-2.—Card punch keyboards

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), 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



49.241
Figure 4-3.—Punching the letter A.

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 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

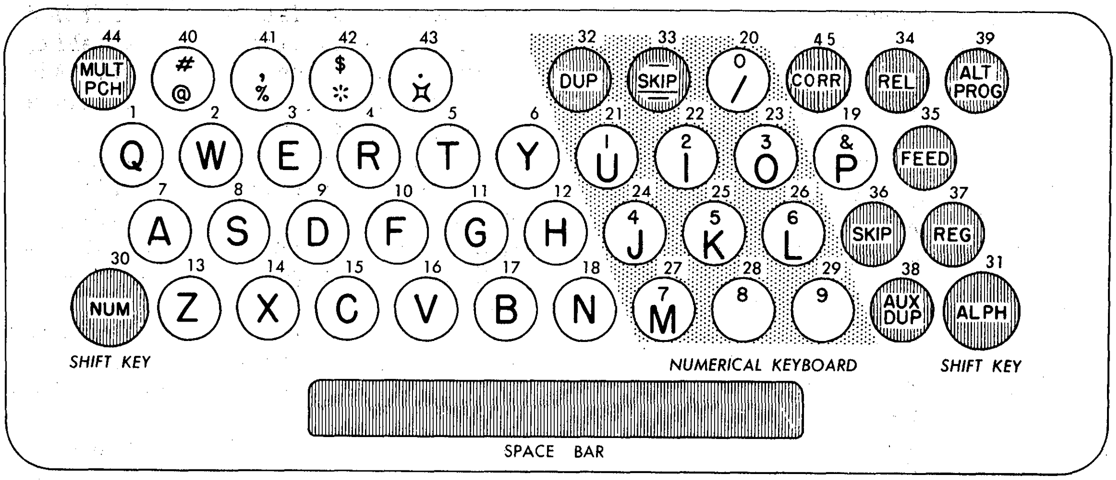


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Figure 4-4.—Combination keyboard chart.

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 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 when 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.

Function Control Switches

By referring to figure 4-2, 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 4-5 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 4-6. 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.

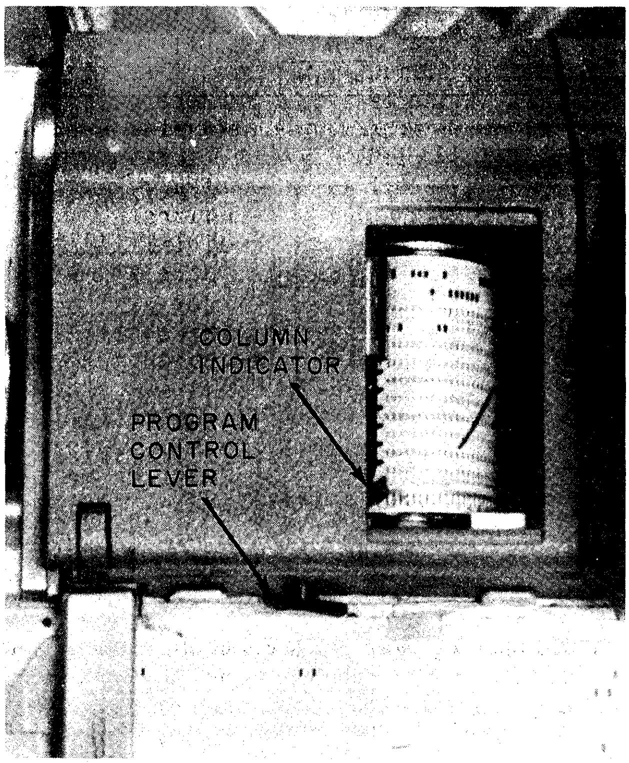
2. (Left Zero Print.) With program control effective, the type 26 card punch will not print zeros to the left of the high order significant digit in a numerical field unless a special code is placed in the program card. In order to print these zeros, a 2 must be punched in each column of the field in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

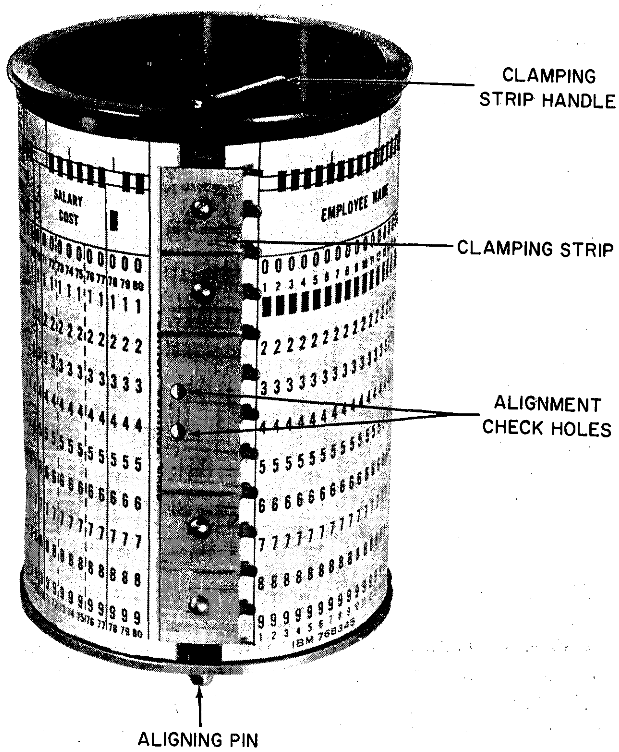
3. (Print Suppression.) When the print switch is ON, printing normally occurs for each column that is punched. Printing can be suppressed by punching a 3 in the program card for each column in which print suppression is desired.

Effects of these last two codes can be seen in figure 4-7. 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,





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

B.—Program card wrapped around a program drum.

Figure 4-5.—Program unit.

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, 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. 4-5B.) 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 counter clockwise 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

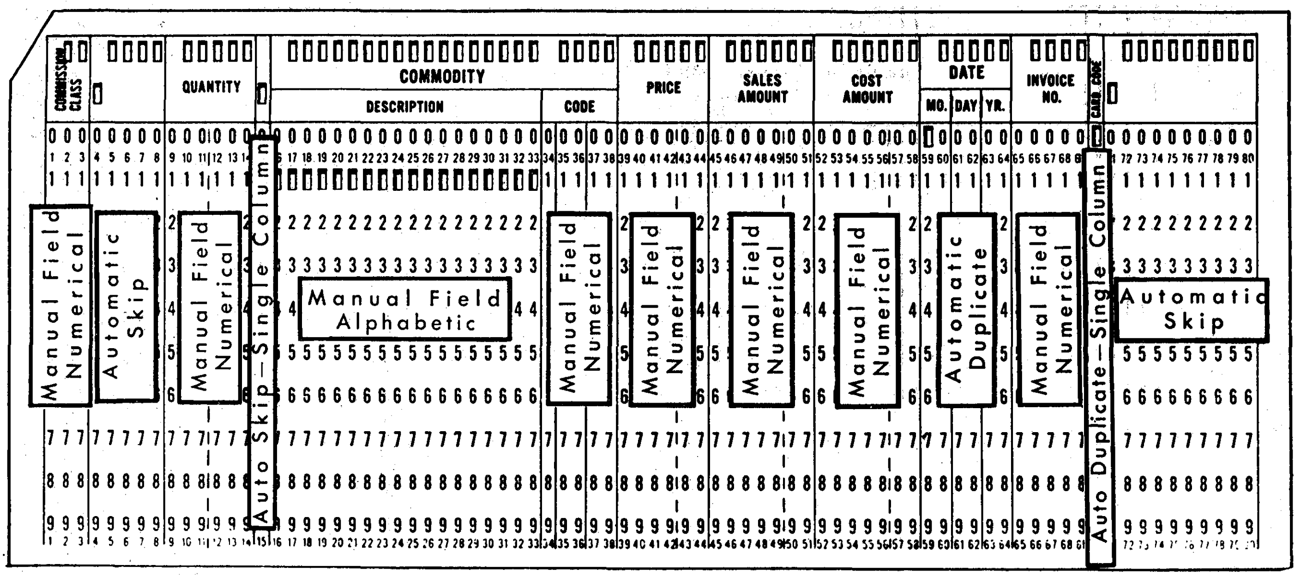

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Figure 4-6.—Program card.

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. 4-5.) 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.

OPERATING PROCEDURES

There is no set procedure that governs all keypunching operations. The procedures to be followed depend upon the requirements of the

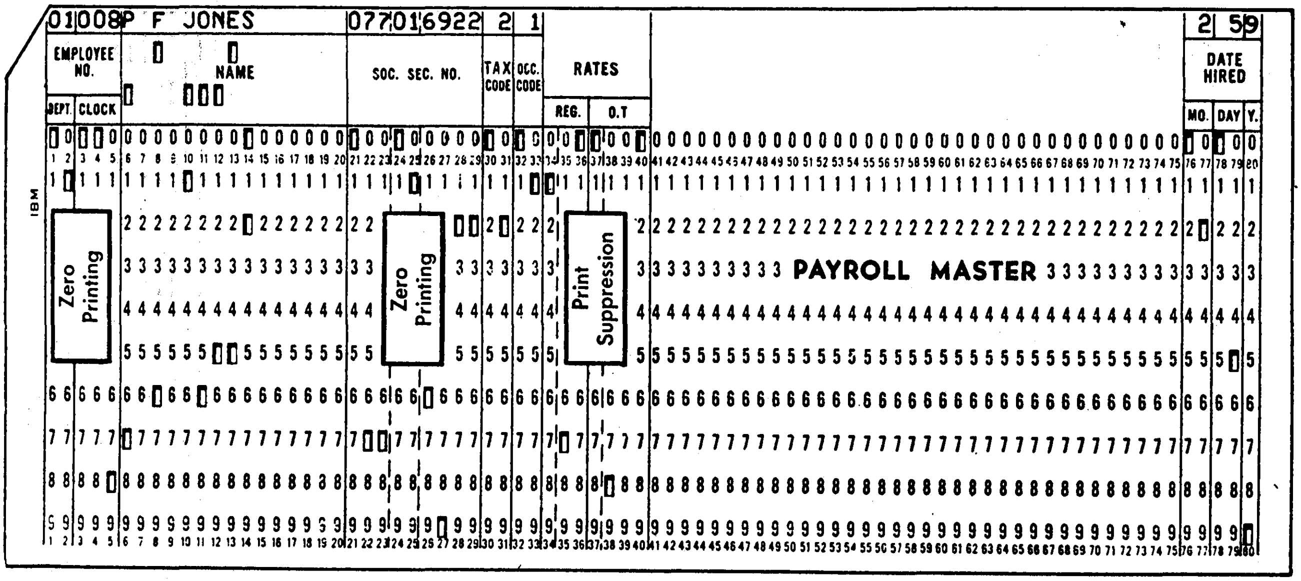

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Figure 4-7.—26 Character printing.

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.

Procedures for performing some of the more common keypunching operations are listed in the following paragraphs.

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 repunching, 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.

Prepunched Master Card Insertion

In operations involving duplication of certain fields from prepunched master cards, it is necessary to insert each master card manually before duplicating the first card of the group. The following steps describe one procedure for inserting master cards.

1. Turn the automatic feed switch OFF before punching is completed for the last card of the preceding group.

2. After the last card is released from the punching station, manually move it to the left until it touches the feed rolls at the reading station. While still maintaining a slight pressure on the card against the feed rolls, depress the release key to move the card past the reading station.

3. Place the master card in the card bed between the punching and reading stations, aligning it so that the left edge is just between the feed rolls, but not in registered position.

4. Depress the feed key to register the master card and the detail card which is waiting at the right of the card bed, and to feed a new card from the hopper. Turn the automatic feed switch ON. Normal punching of the first card of the new group can then proceed, with automatic feeding of the following detail cards.

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 and punching ease.

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

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

Starting a Punching Operation

When the main line switch is turned on, the release key should be depressed, but not held, in order to determine when punching may be started. After a short warm-up period, a release cycle occurs, indicating the machine is ready for operation. If the automatic feed switch is OFF, the feed key should be depressed twice to register the first card at the punching station. If the automatic feed switch is ON, the feed key need be depressed only once.

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 a 26 card punch 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 (refer to fig. 3-23 of the previous chapter) 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 by depressing the release key.

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 backspace 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.

CARD VERIFIER

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.

OPERATING FEATURES

The type IBM 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 4-8 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. 4-9.) 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

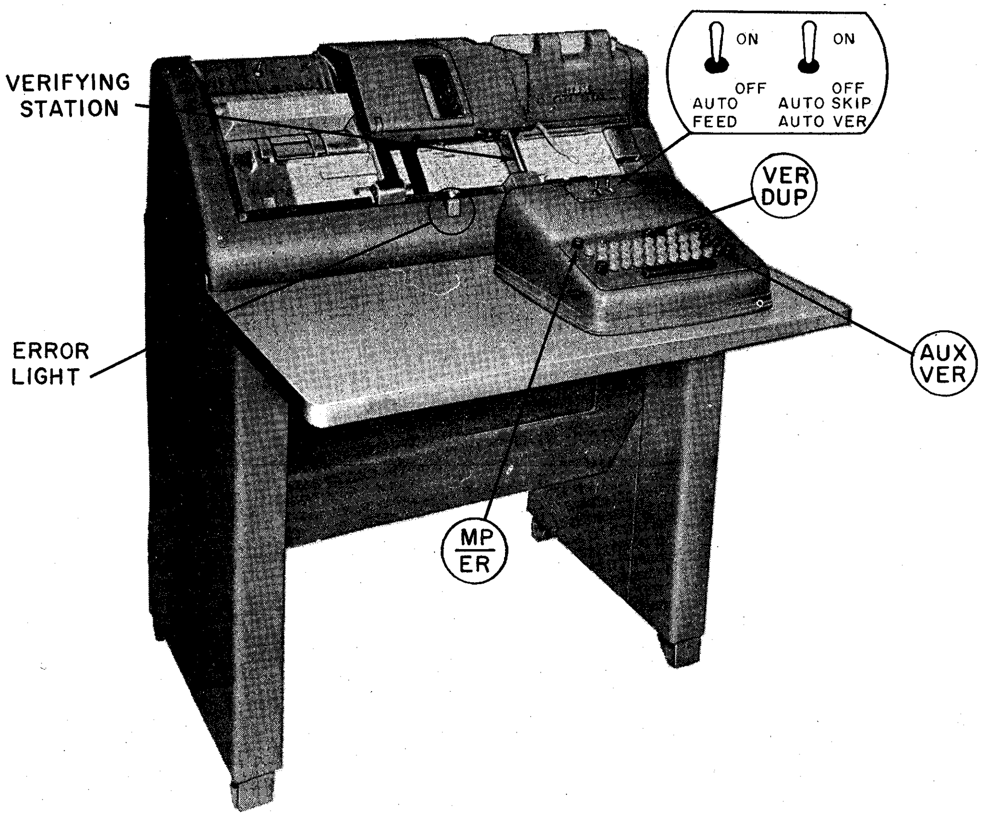
The card verifier is equipped with an error light in place of a backspace key. When an error is detected, the light goes on, and the keyboard becomes locked. The procedure to be followed in such a situation is described under Operating Procedures.

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 4-4 and 4-8 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



49.5X

Figure 4-8.—Differences of the verifier.

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 4-8, you will notice that the automatic skip and verify switch replaces the automatic skip and duplicate switch of the card punch.

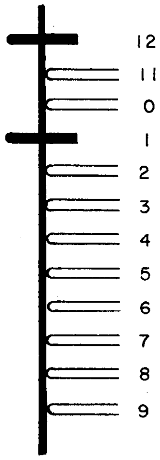
The AUTOMATIC FEED SWITCH performs the same functions as the card punch except feeding is suppressed when an error card moves from the verifying station. This allows the error card to stop between the verifying station and the reading station so that the correct information can be written on the card.

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.

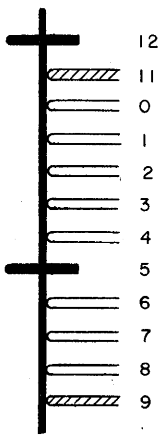
OPERATING PROCEDURES

The operating principle is the same as for the type 24 card punch, with the exception of the error routine. Errors may be committed 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.

VERIFYING



SCHEMATIC OF SENSE PINS IN AN IBM 56 VERIFIER CHECKING 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.

49.245X

Figure 4-9.—Sensing pins of the verifier.

1. Depress the error release 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 verification can be continued. If it registers incorrect, the error light remains on and the keyboard becomes locked again.
3. Depress the error release key again.
4. Make a third attempt to verify the column. At this time the light goes off and verification can be continued in the next column 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 depressed 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. 4-10A.)

OPERATING SUGGESTIONS

The procedures to be followed for setting up a verifying operation are the same as for keypunching. Therefore some of the suggestions 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 below.

Multiple Punch Verification

Two or more digits can be verified in the same column by holding down the multiple punch key while the digit keys are depressed one at a time. All punches in a column must be verified unless the machine is equipped with a special 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 opposite the 1 row (fig. 4-10B), separating the incorrect cards (those not having the OK notch) for repunching is simplified. An upper right corner cut card should not be used for a program card as it may interfere with the check notching.

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

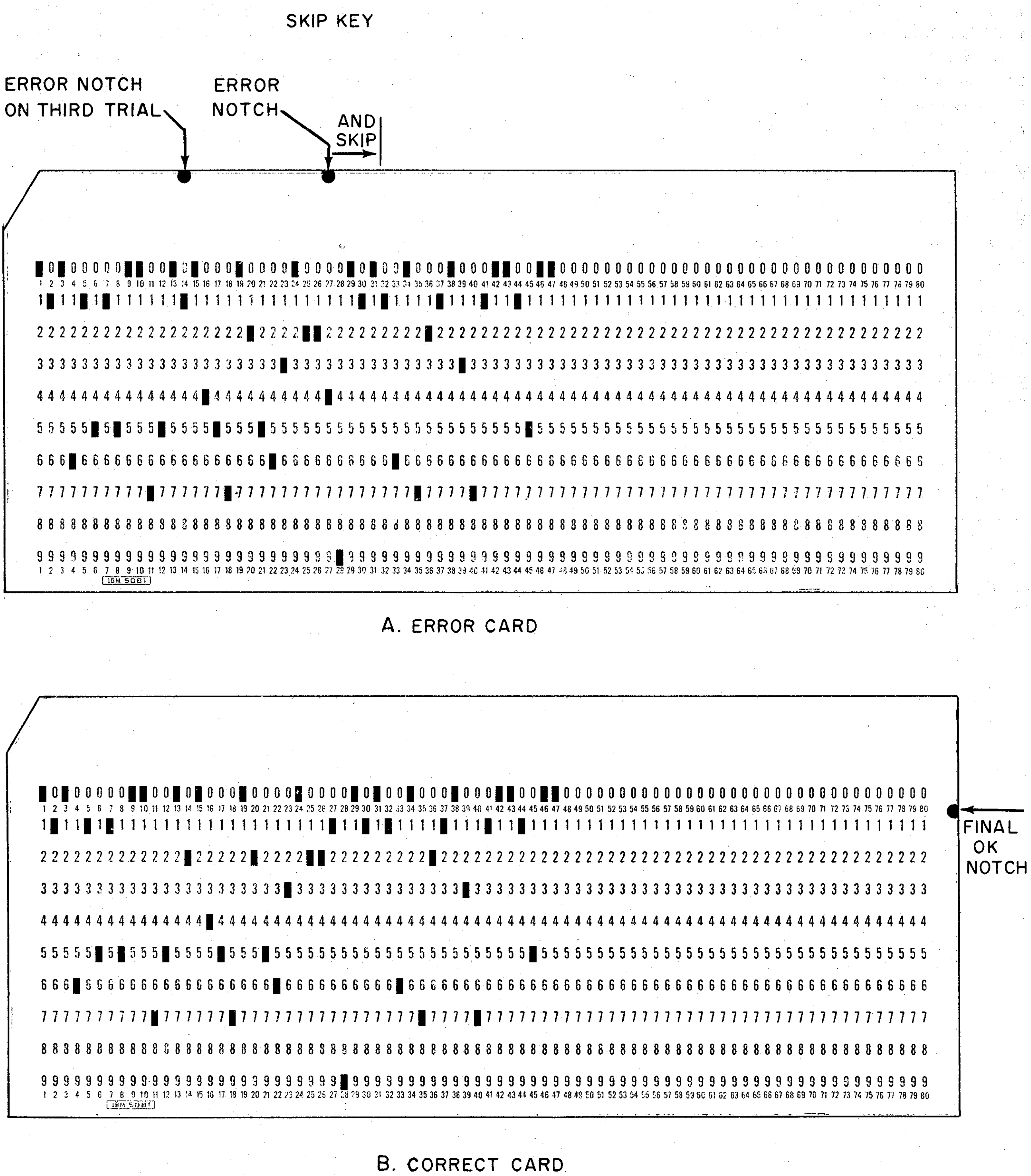


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Figure 4-10.—Verification notches.

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 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 key.

DATA TRANSCEIVERS

Data transceivers may be employed in any situation which calls for rapid transmission of punched card data between activities physically removed from each other. This data may be transmitted either by telephone or telegraph lines. As a Machine Accountant you may be assigned to duty in an installation which has data transceivers, such as a Personnel Accounting Machine Installation, designed to send punched card data over telephone lines to other locations containing data transceivers, 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 transceiver is designed to send as well as receive, only one machine is required at each station to provide data exchange in both directions.

PRINCIPLES OF OPERATION

The IBM 66 data transceiver (illustrated in fig. 4-11) 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

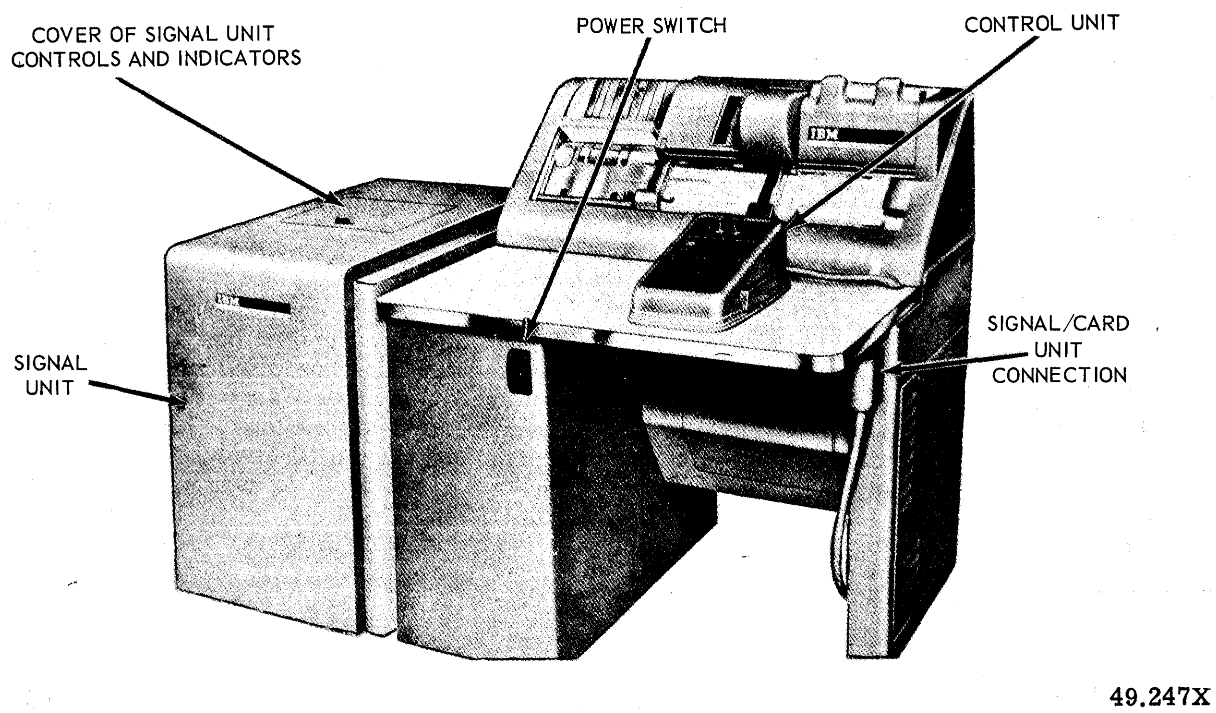

Figure 4-11.—IBM 66 Data transceiver and signal unit.

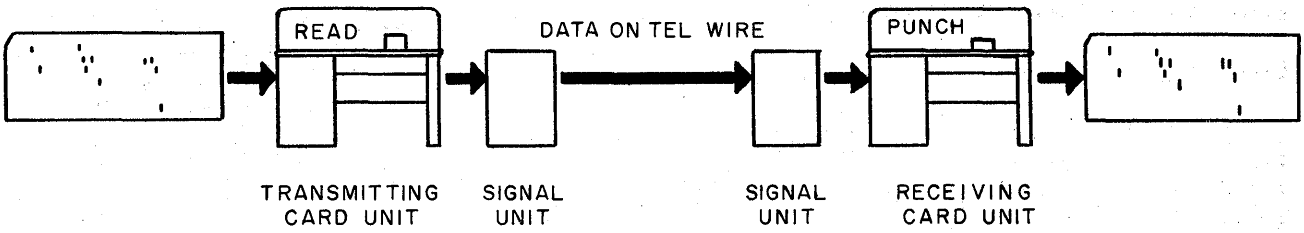

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Figure 4-12.—Flow of information.

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 fig. 4-12).

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 band pass, with center frequencies of 800, 1300, 1800, and 2300 cycles per second (cps).

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	Channel Number 4-Wire
1	800 cps	21	41
2	1300 cps	22	42
3	1800 cps	23	43
4	2300 cps	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 4-13, 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.

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.

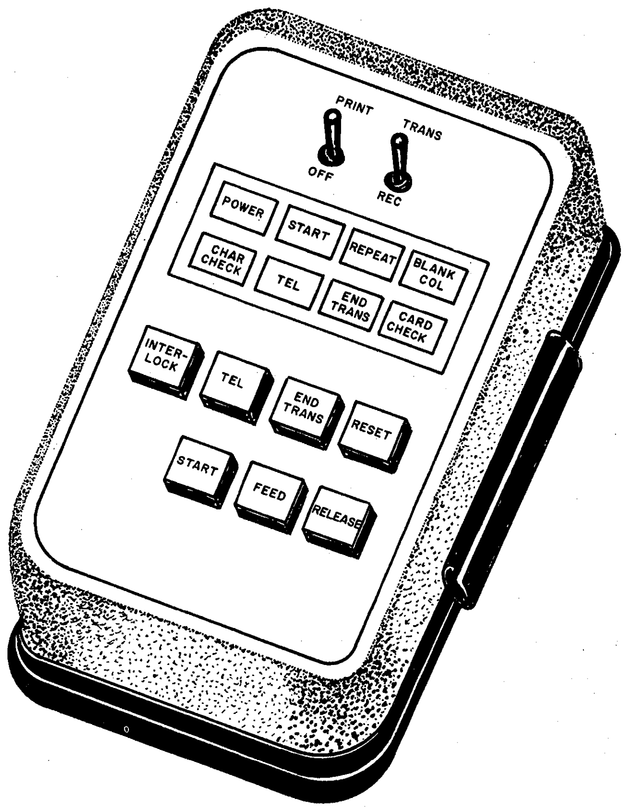

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Figure 4-13.—Transceiver control unit.

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.

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 pre-registration 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 pre-registration 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 depressed. This light is a signal that communication 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-transmission 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 indicates 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 controlled 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 required for each transmission. One card is used with the transmitter, and the other with the receiver. The control punching required in the program cards depends on the functions to be controlled, 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
5	End of Card	End of Card with X Punch

Code	Transmitting	Receiving
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 except the high order position. These 12 punches serve to continue to the end of the field any transmission, 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 suppressed.

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 signalled.

8. (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.

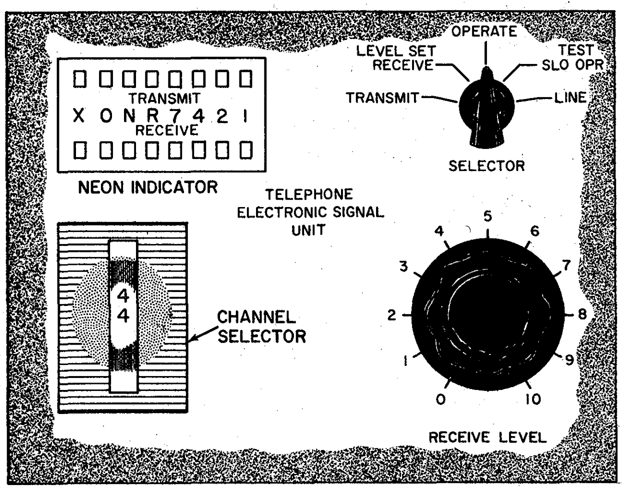
8. (Delayed Start.) If skipping or duplicating is to be performed at the receiver before transmission can start, the receiver end-of-card signal must be delayed until the card to be punched is in position to receive the punching. An 8 punch causes the signal to be sent at the column in which it appears 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 4-14, which has a scale from 0 through 10. The following procedure should be followed to set the receiver levels:

1. Set the receive level knob on both machines to zero.
2. Move the SELECTOR switch, shown in figure 4-14, to RECEIVE on one machine and to TRANSMIT on the other. The transmit neon indicators O, 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.



49.8
Figure 4-14.—Telephone signal unit controls.

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 machines.
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.

ALTERNATE PROGRAM—A special feature designed to handle two types of cards in one punching operation; specific codes identify the alternate mode.

AUTOMATIC OPERATION—An action performed or executed independently of manual operations; normally dependent upon certain conditions.

CARD PUNCHING—The basic method for converting source data into punched cards; reading a source document and depressing keys to convert information into punched holes; see keypunching.

CABLE—A group of wires bound together and used to connect machine units; hence the term, "cable connected."

CARD BED—A flat plate over which cards travel from hopper to stacker.

CARD LEVER/PRESSURE FINGER—A lever for electrically detecting the presence of a card along the card path or bed.

CHIP BOX—A container that holds the punched-out chips from the punches.

COLUMN 81—The remaining portion of a card to the right of column 80; not used for normal card punching.

COMBINATION KEYS—Can be depressed in either alphabetic or numeric shift; keys 19-29; numbers, special characters, and alphabetic letters.

FUNCTION CONTROL SWITCHES—"ON" and "OFF" toggle switches which control automatic functions; see toggle switch.

FUNCTIONAL KEYS—Can be depressed to control machine functions in conjunction with, or independently of, the program unit.

INTERLOCK—A means of preventing machine operation until required mechanical or electrical conditions are met; see keyboard locking.

KEY VERIFYING—Manually operating a keyboard device (verifier) to ascertain the conformity of punched information with the source information; contrasted with visual or automatic verification through machine circuitry and panel wiring.

KEYBOARD LOCKING—An interlocking of a keyboard because of improper operation or keying.

INDICATORS—Devices which register conditions; operations may be varied according to the position of an indicator.

KEYPUNCHING—Manually operating a keyboard device that punches holes in cards representing definite configurations of letters, digits, and special characters; contrasted with automatic punching through machine circuitry and panel wiring.

LEFT ZERO PRINT—Printing zeros in a numeric field to the left of a high order significant digit.

MULTIPLE PUNCH—More than one digit per column; normally representative of specific letters or special characters.

OFF-PUNCHED—Punching not properly positioned in a card.

OPERATION—A specific action of a machine or device performed automatically when so instructed.

PROGRAM CARD—One punched with specific coding and placed around a program drum to control automatic operations; basic part of the program unit.

PROGRAM CODES—Specific codes punched in a card to control machine functions automatically.

PROGRAM CONTROL—A method capable of automatically directing, holding, and making changes in the operation of a device; normally based on a prescribed sequence of events.

PROGRAM CONTROL LEVER—Controls operation of the program unit; places program control in either "on" or "off" status; a component of the program unit.

PROGRAM DRUM—The revolving cylinder on which a program card is mounted; a component of the program unit.

PROGRAM UNIT—Comprises four main components: program card, program drum, sensing device, and program control lever; functions to allow certain repetitive operations automatically.

PUNCHING KEYS—Can be depressed only when in alphabetic shift; keys 1-18; letter keys.

READING BOARD—The space provided for source documents from which cards are punched.

SENSING DEVICE—A mechanism which rides along on the program card from column to column to detect holes; a component of the program unit.

SKIPPING—Advancing past columns not to be punched; performed automatically under program control or through key depression.

SPECIAL CHARACTER KEYS—Can be depressed in either alphabetic or numeric shift; keys 40-43; punch special character configurations only.

STAR WHEELS—Rotating contact wheels that read the program card; the sensing device of the program unit.

STATION—Any position along a card feed, path, or bed, where a card is processed; see verifying station.

TOGGLE SWITCH—A manually operated electric switch that may be placed in an "on" or "off" position and remaining in that position until changed; contrasted with an electronically operated circuit switch.

TRANSCEIVER—A machine which automatically converts and transmits punched card data (normally between remote locations) in the form of coded electrical impulses over telephone or telegraph lines, and receives and reconverts such impulses into punched cards.

TRANSCEIVER CONTROL UNIT—Cable connected to a card unit; contains switches, keys, and signaling lights essential to the operation of the transceiver.

TRANSCEIVER SIGNAL UNIT—Cable connected to a card unit; contains electronic circuits for transmitting and receiving coded impulses over telegraph or telephone wires.

VERIFICATION NOTCH—A crescent shape cut in the edge of a card; its position signifies erroneous or correct columnar punching.

VERIFYING STATION—The first of two stations in the card bed of the verifier; employs the use of sensing pins to verify the accuracy of the initial punching.

CHAPTER 5

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.

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

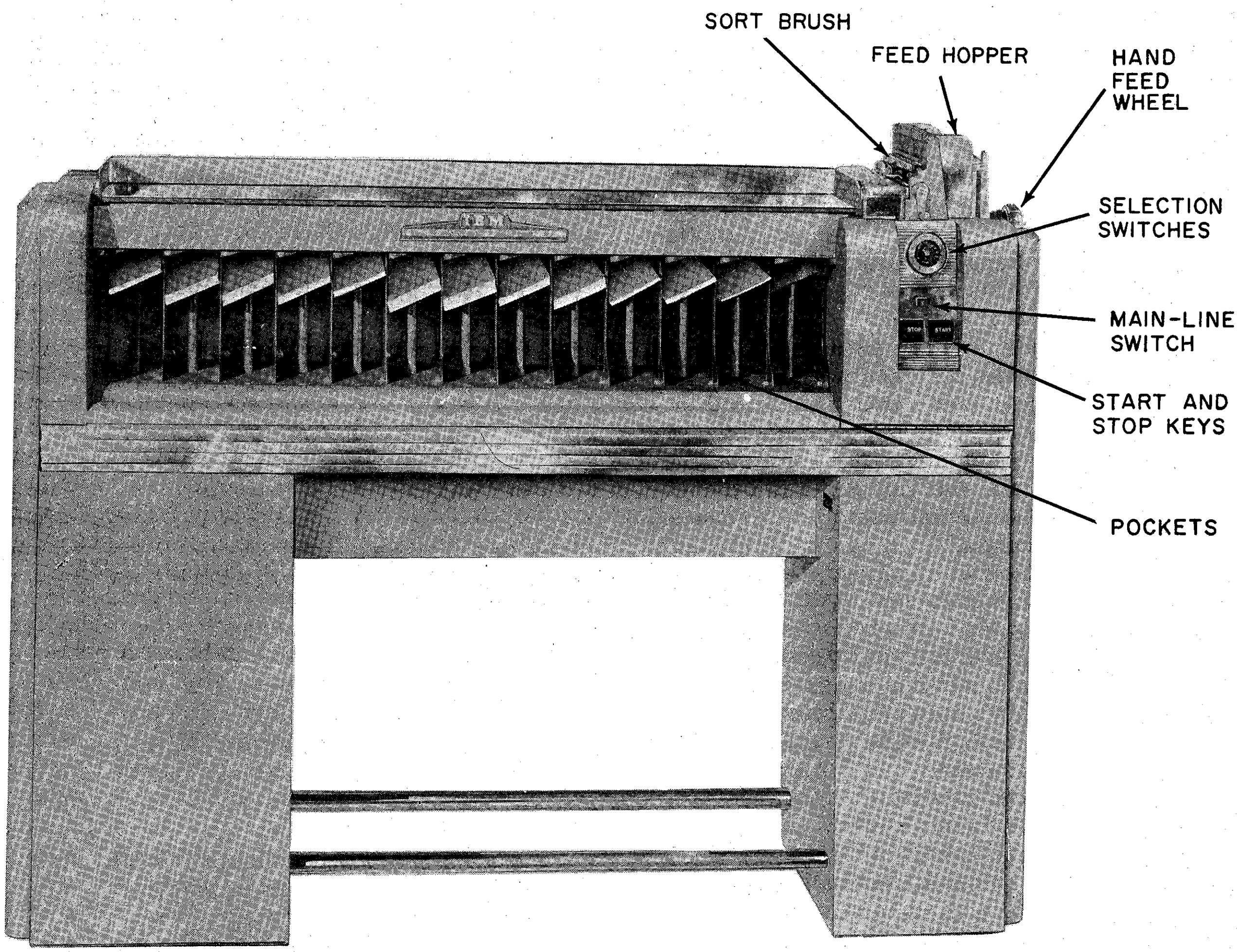
CARD SORTER, TYPE 82

The IBM type 82 card sorter, as illustrated in figure 5-1, 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.

OPERATING FEATURES

Machine Controls

The lower part of figure 5-2 illustrated 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



49.9X

Figure 5-1.—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

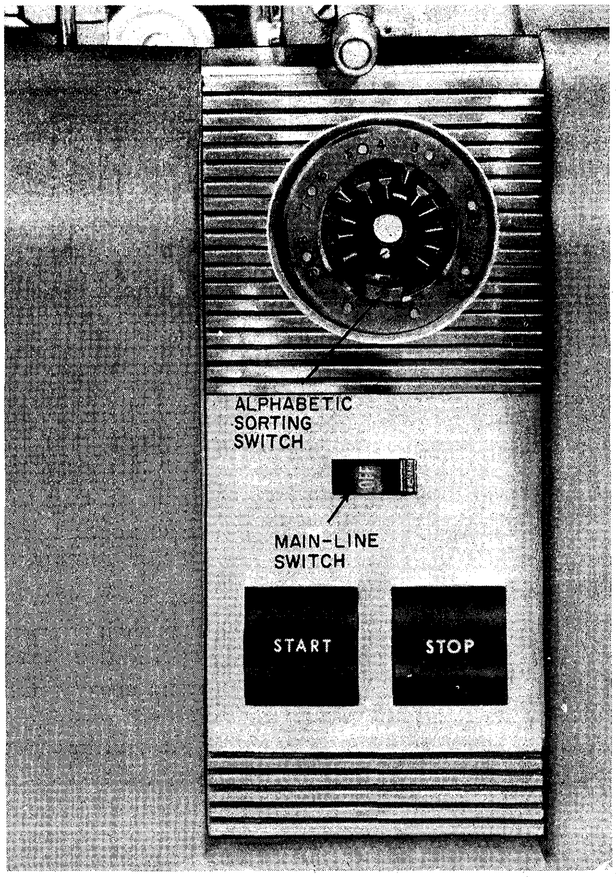
In normal sorting operations, all cards are directed to a specific pocket, corresponding to the particular digit punched in the card. In certain sorting applications you may wish to sort out only those cards containing certain digits and leave the remaining cards in their original sequence. Selection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

The selection switches are visible in the upper part of figure 5-2. 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 either 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 Indication

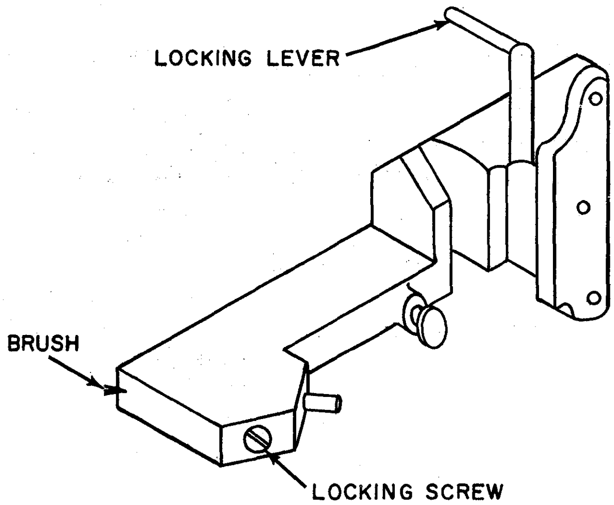
The actual sorting of cards is controlled by a sort brush, as illustrated in figure 5-3. The brush is mounted in a holder immediately to the left of the card feed hopper. Cards feed under the brush, and over an electrical contact roller. When the brush makes contact with the roller through a punched 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.



49.10X
Figure 5-2.—Machine controls and selection switches.

Pockets and Pocket Stops

The 13 receiving pockets, as shown in figure 5-1, 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.



49.11X
Figure 5-3.—Sort brush assembly.

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, the 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 card from making contact with the roller. The card then passes under all chute blades and falls into the reject pocket.

In figure 5-4, 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 through 12—not held up to 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

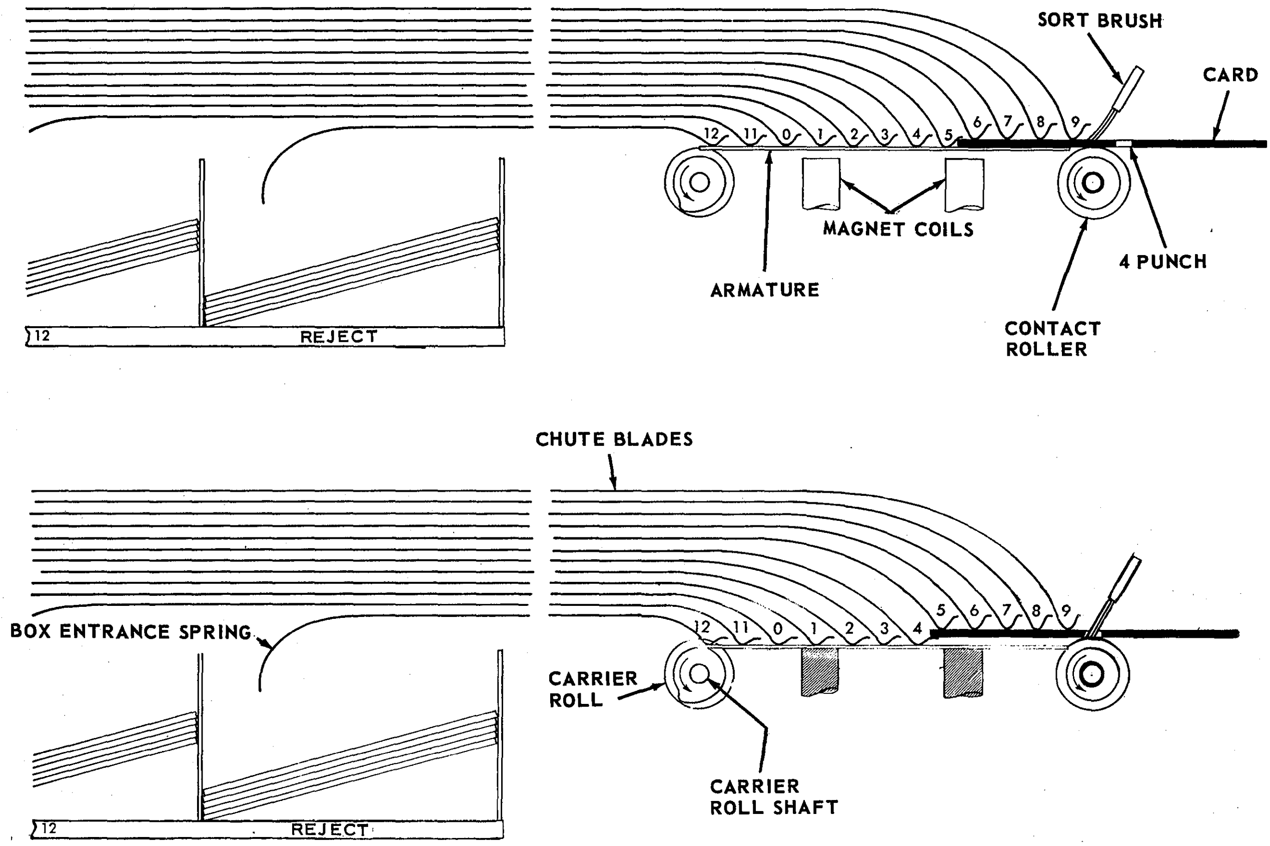
In order to arrange cards in numerical sequence, each column in the control field requires one sort. Sorting begins with the units or low order position and progresses from right to left through the high order position. The sort brush is set to read the first column to be sorted.

In figure 5-5, 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.



49.12X

Figure 5-4.—Sorter operating principle.

"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 5-5, 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 ASCENDING 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

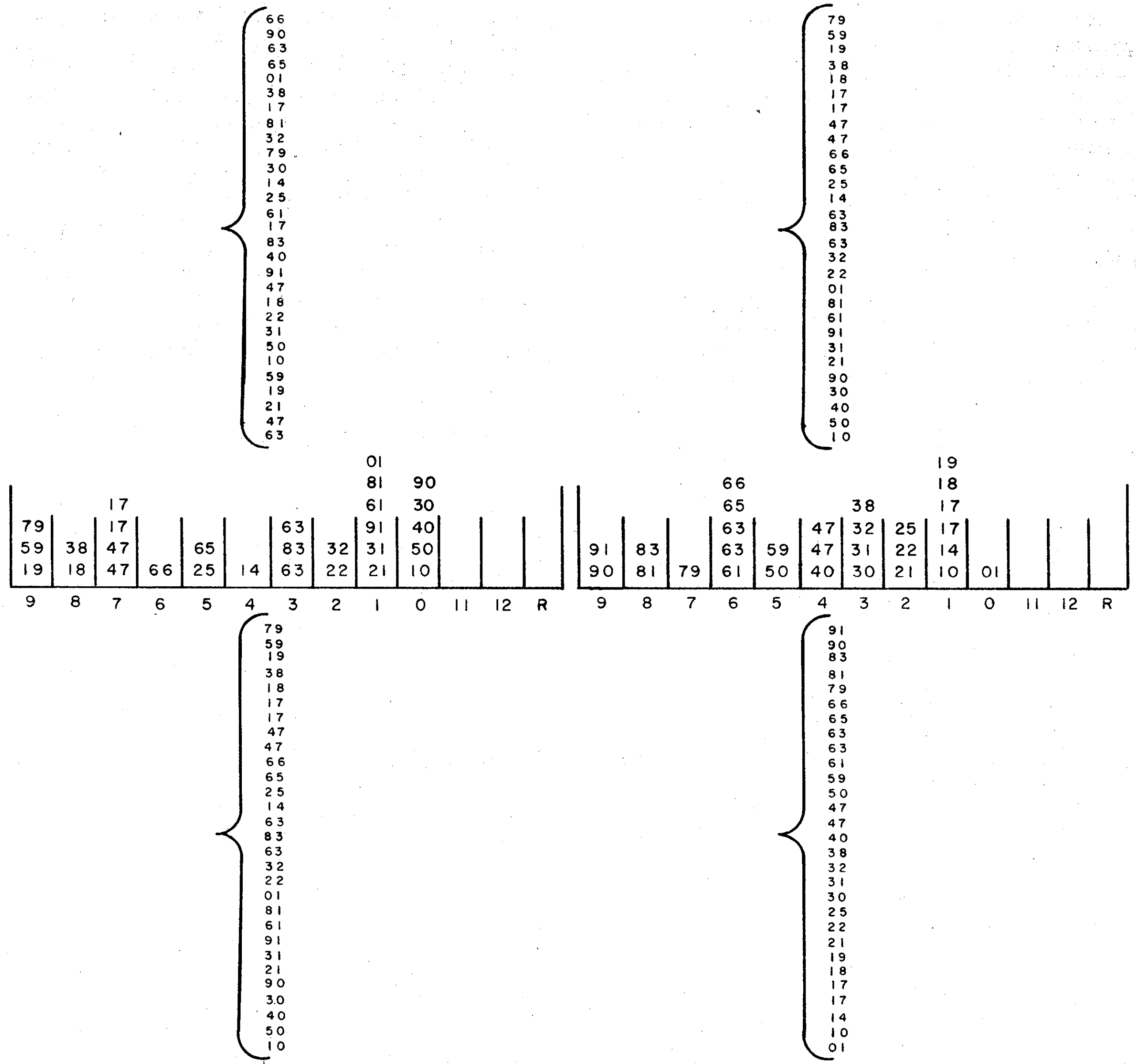


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Figure 5-5.—Numerical sorting.

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. 5-6.) 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. 5-7.) 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.

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 smaller 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 (Fig. 5-8). Each block can then be sorted individually in the usual manner.

Block sorting reduces the overall time required to prepare a report (Fig. 5-9) 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.

1

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

2

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

3

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

49.250

Figure 5-6.—Reports sequence before analyzing.

1

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

2

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

49.251

Figure 5-7.—Reports sequence after analyzing.

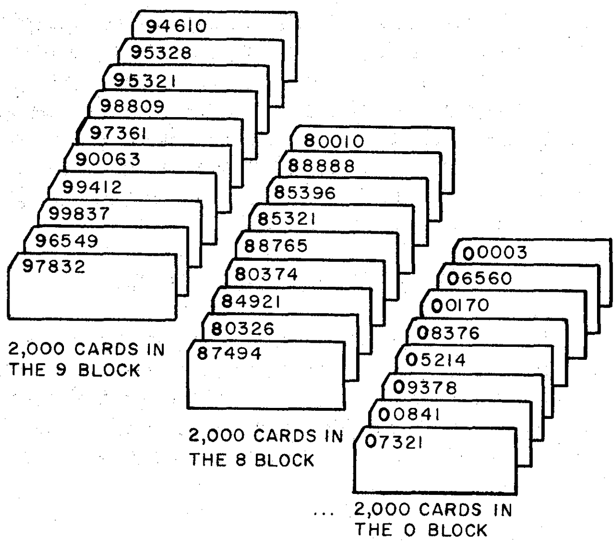

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Figure 5-8.—Block sorting.

In operations involving more than one field, block sorting is accomplished by first sorting the high order position of the major field. 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.

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 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

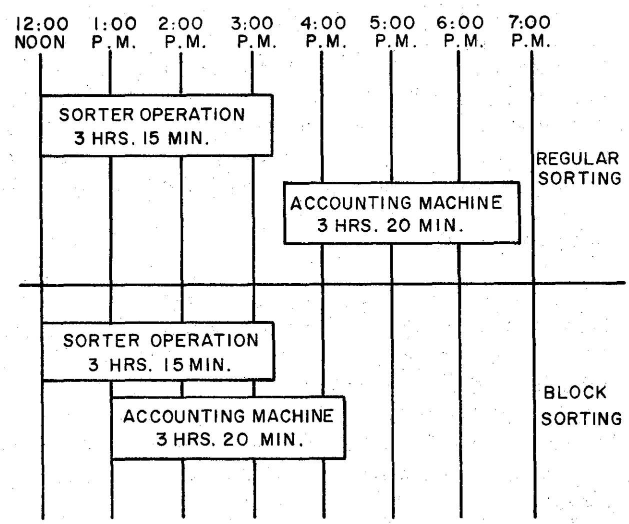

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Figure 5-9.—Reducing the overall elapsed time through the earlier use of other equipment.

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 As 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 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 missort 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 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.

Card 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, place a card in the machine with an 8 punched in any column. Set the column indicator so that the brush reads that 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 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. Simply place the needle in the hole you are checking and push it gently through the cards. The needle will 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.

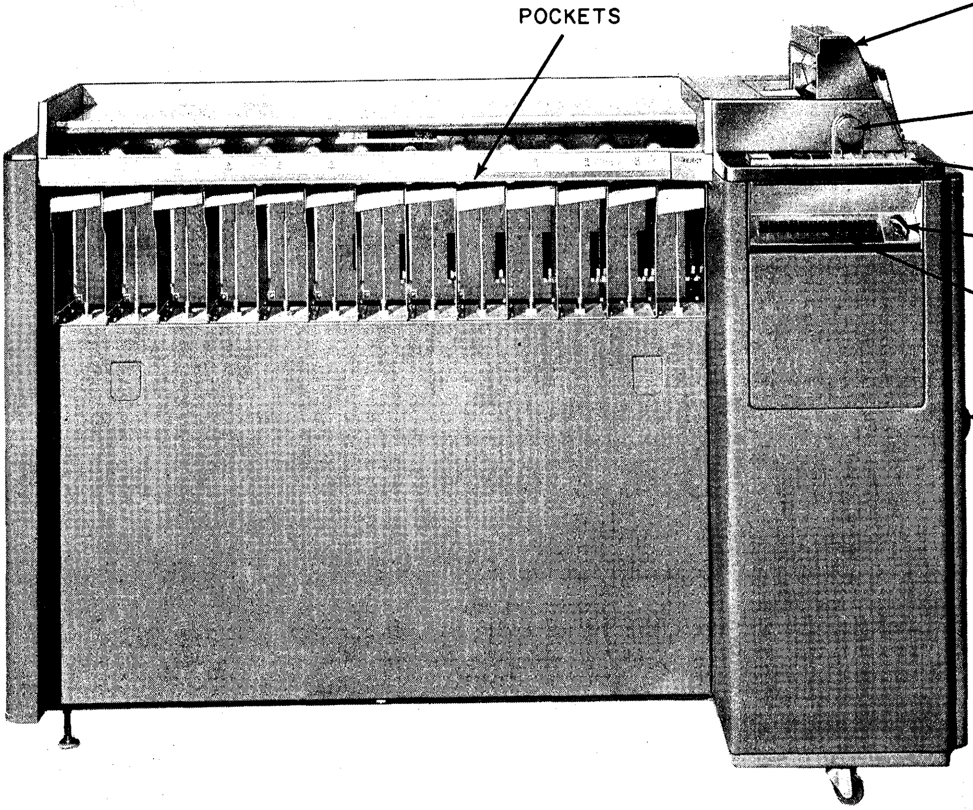
CARD SORTER, TYPE 83

The IBM type 83 card sorter, illustrated in figure 5-10, 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.

OPERATING FEATURES

Digit Suppression Keys

Figure 5-11 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. All other cards sort into their respective pockets.



49.14X

Figure 5-10.—IBM type 83 sorter.

These keys may be released by running your fingertip along the bottom edge of the keys.

Sort Selection Switch

By referring to figure 5-11, 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, cards with digits only, and cards with letters A through I are rejected. Multiple digit or some 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

49.15X

Figure 5-11.—Machine controls.

the 12 pocket. Multiple digit or zone punches are rejected as errors if the edit or edit stop switch is ON.

Figures 5-12 summarizes the sorting pattern established by each setting of the sort selection switch.

Editing

The editing device 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 ERROR 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 error 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 5-13, operates the same as for the type 82, but with

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

49.16X

Figure 5-12.—Sorting pattern for standard 83 sorter.

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 figure 5-13, 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 approximately 400, 565, 735, or 800 cards per pocket before the pocket stop lever causes card feeding 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 5-14.

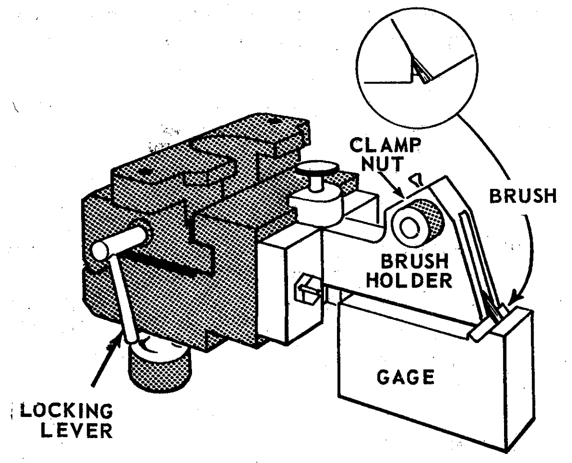
The chute blades are controlled by 12 selector pins, with each pin centered above the exposed portion of its corresponding chute blade tab. When a punched hole is sensed, a magnet armature is attracted, which in turn pushes down the appropriate selector pin and separates the chute blades. The card is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

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



49.17X
Figure 5-13.—Sort brush holder and gage.

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. Rejects 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.

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.

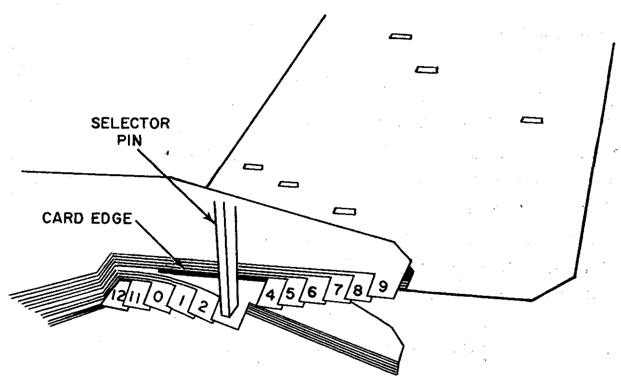
CARD SORTER, TYPE 84

The IBM type 84 sorter 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.

OPERATING FEATURES

Full Pocket Light

The full pocket light signals that a stacker is approaching its maximum holding capacity



49.18X
Figure 5-14.—Chute blades, type 83.

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 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 hoper, 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, which may be rotated to read any column desired. The light shines from beneath the card, through a hole in the card, and onto a light-sensitive diode. The card is then directed to the appropriate stacker by a chute blade. The light source should be cleaned daily with a dust cloth. Any adjustments to the sensing mechanism should be made by a customer engineer. If a card 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, 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. Cards may be easily removed from the stackers without stopping the machine.

OPERATING SUGGESTIONS

If you must correct cards by placing patches over the punches, be sure the patches are opaque. The photoelectric sensing mechanism will read through a translucent patch.

Oil spots on cards should be avoided, since they make the card translucent and cause the machine to read the spots.

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 bursh or sensing mechanism. The sorting speed and method of operation are not affected when the 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 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 5-15. 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 thrugh 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

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

49.19X

Figure 5-15.—Sorting pattern for alphabetic sorting device.

11, 12, and the reject pocket as shown in figure 5-11. 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.

ALPHA-NUMERICAL SORTING—Sorting of a field with intermixed alphabetic and numeric punching.

ALPHABETIC BLOCK SORTING—Reducing large volumes of cards to workable size groups by letters of the alphabetic, etc.

ALPHABETIC FIELD—One or more fixed columns regularly used to report a standard item of alphabetic information.

ALPHABETIC SORTING—Same as sorting; but deals only with the letters of the alphabet.

ALPHABETIC SORTING FEATURE—A device that can be installed on the 83 and 84 sorter, is used to speed the operation of alphabetic sorting.

ALPHABETIC SORTING SWITCH—Conditions the 82 sorter to read zone punches only.

BLOCK SORTING—Reducing large volumes of cards to workable size groups.

CHUTE BLADE—A metal blade that directs cards to their appropriate pockets; activated by the reading of the card.

CONTROL SORTING—Same as sorting, but refers to sorting of fields for control, as opposed to numbers or letters.

DIGIT SUPPRESSION KEYS—Designed to control selective sorting on the 83 sorter.

EDITING—When referred to the 83 sorter, the editing device detects punches that do not conform to a particular sort pattern.

HAND FEED WHEEL—Used to advance cards in the machine while timing a sort brush; may be used to assist in removing card jams.

INTERMEDIATE CONTROL FIELD—An intermediate subdivision of the major; of less importance or priority of the major but greater than the minor.

MAJOR CONTROL FIELD—The highest division of multiple control fields; the field of greatest importance or priority; contrasted with minor.

MINOR CONTROL FIELD—The lowest subdivision of the major; of the least importance or priority; contrasted with major.

MISSORTING—Cards sorting into the wrong pockets, due to damaged cards or improper timing of the sort brush.

NUMERICAL SORTING—Same as sorting; but deals only with numbers.

PHOTOELECTRIC SENSING—Reading of punches by a light-sensitive diode as opposed to a reading brush.

POCKET STOP LEVERS—A device that stops the machine when any one of the stackers becomes full.

SELECTION SWITCHES—Switches designed to control selective sorting on the 82 sorter.

SELECTIVE SORTING—A method of selecting from a file of cards only the cards required in a particular sorting operation.

SORT BRUSH—A single reading brush on the 82 and 83 sorter that can be manually set on any one of 80 columns; for reading only one column at a time.

SORT PATTERN—A sort pattern is determined by the setting of the sort selection switch, which in turn conditions the machine to follow a predetermined sequence of events.

SORT SELECTION SWITCH—Controls the 5 sorting patterns of the 83 and 84 sorter.

SORT SUPPRESSION—A device used on sorters to select particular cards from a deck due to particular punches without disturbing the sequence of either group.

SORTING—Arranging cards into a predetermined sequence.

SORTING NEEDLE—A instrument used to check the accuracy of the sorter for any given sorting operation.

SPECIAL FEATURES—Devices that can be installed on the sorters to extend the application possibilities.

TEST-SORT SWITCH—When the switch is in the test mode, it is used for timing of the sorter; it is used only for sorting when it is in the sort mode.

VACUUM LIGHT—Indicates that the vacuum level for the vacuum-assist feed has fallen below the required level for proper card feeding.

CHAPTER 6

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 6-1 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 the rate of 60 cards per minute.

OPERATING FEATURES

Machine Controls

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.

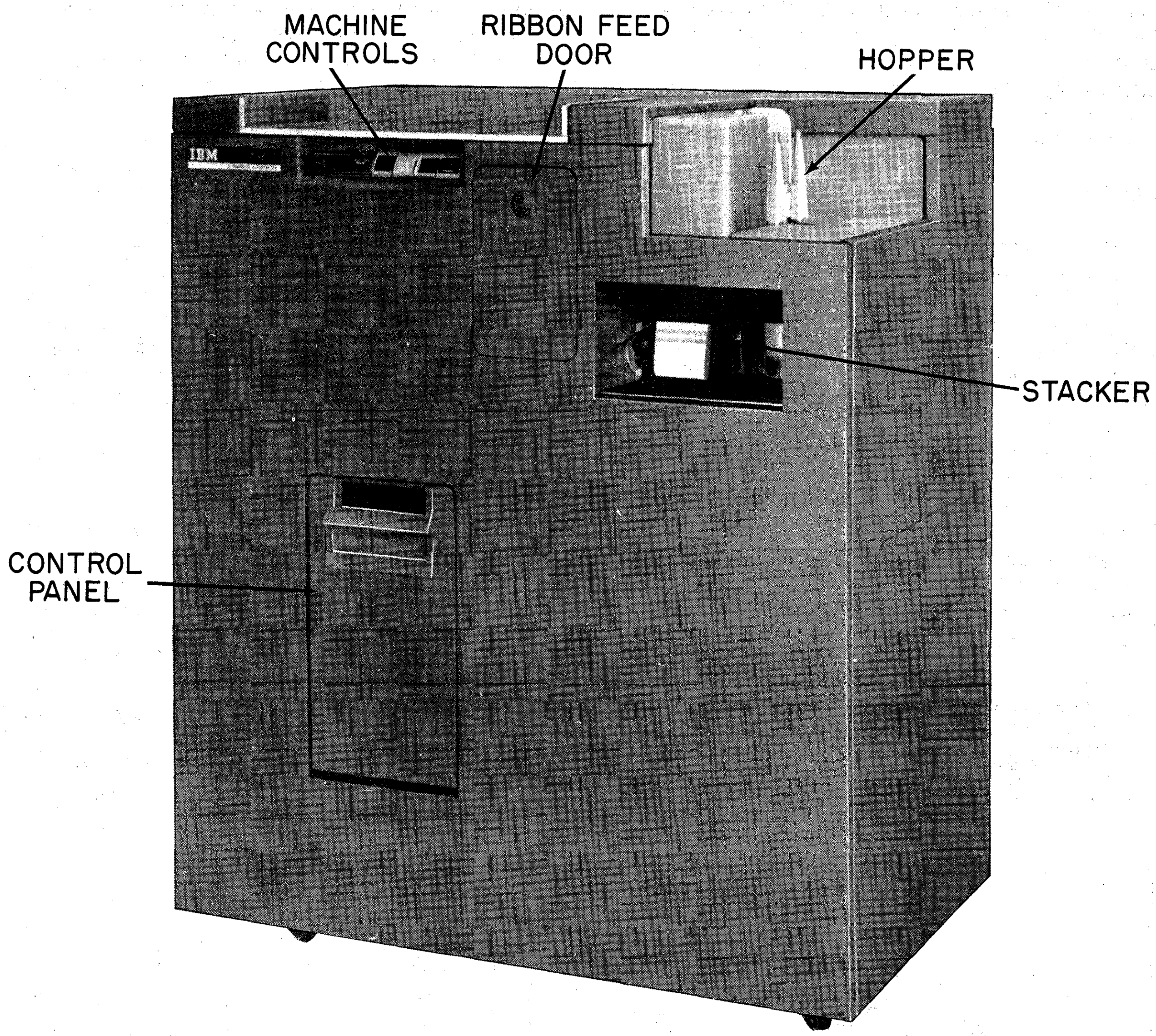


Figure 6-1.—Type 548 interpreter.

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 stacker 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. 6-2). 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 special characters. These special characters are actuated by an 11, 12, or combination 0-1 punch, as seen in figure 6-3.

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 over column 4, typebar 30 would print over column 40, typebar 45 would print over column 60, and so on. Figure 6-4 outlines each printing position in relation to the card columns.

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. If you believe your interpreter needs a new ribbon, notify your supervisor. Do not attempt to change the ribbon yourself. This is a job for your customer engineer or supervisor, and only in rare circumstances should anyone else attempt the change. The exception is a Machine Accountant who is qualified as a repairman and has the proper tools.

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 6-5 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

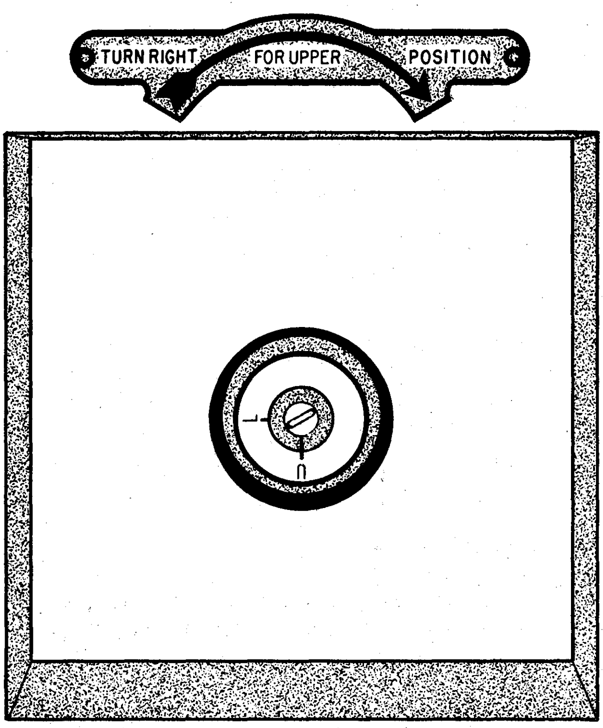


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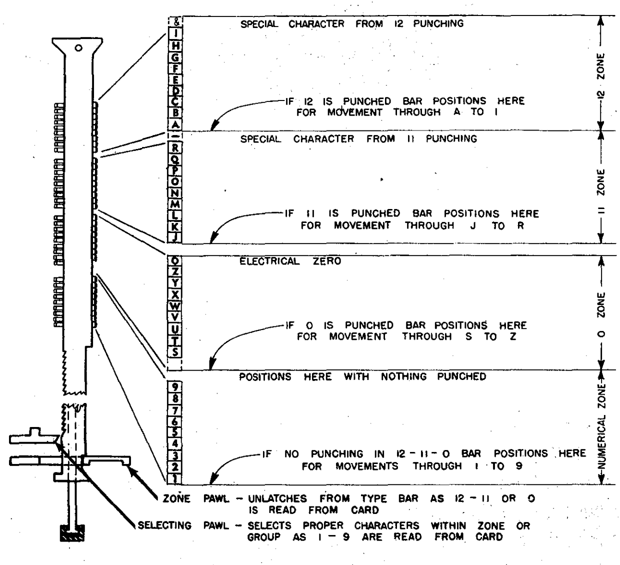
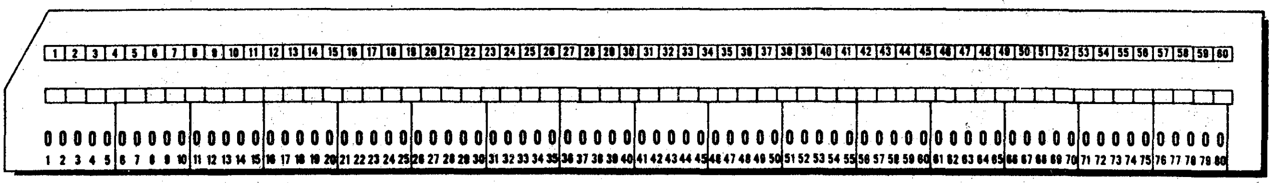
Figure 6-2.—Printing position knob.



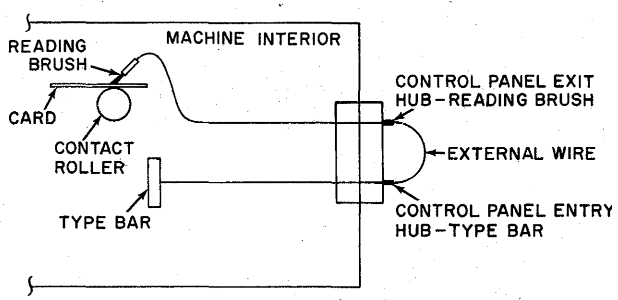
49.255X
Figure 6-3.—Layout of 548 typebar.



49.21X
Figure 6-4.—Interpreter printing positions.

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 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.

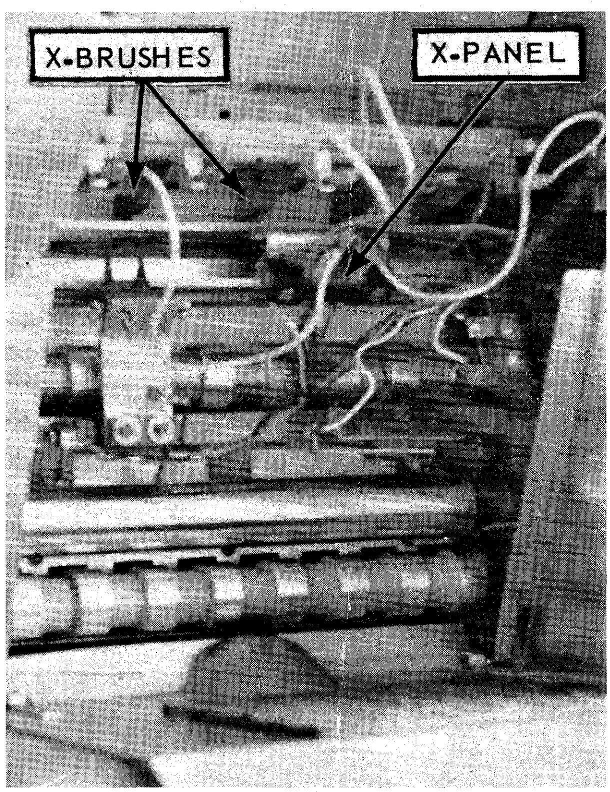


49.22X
Figure 6-5.—Principle of interpreter operation.

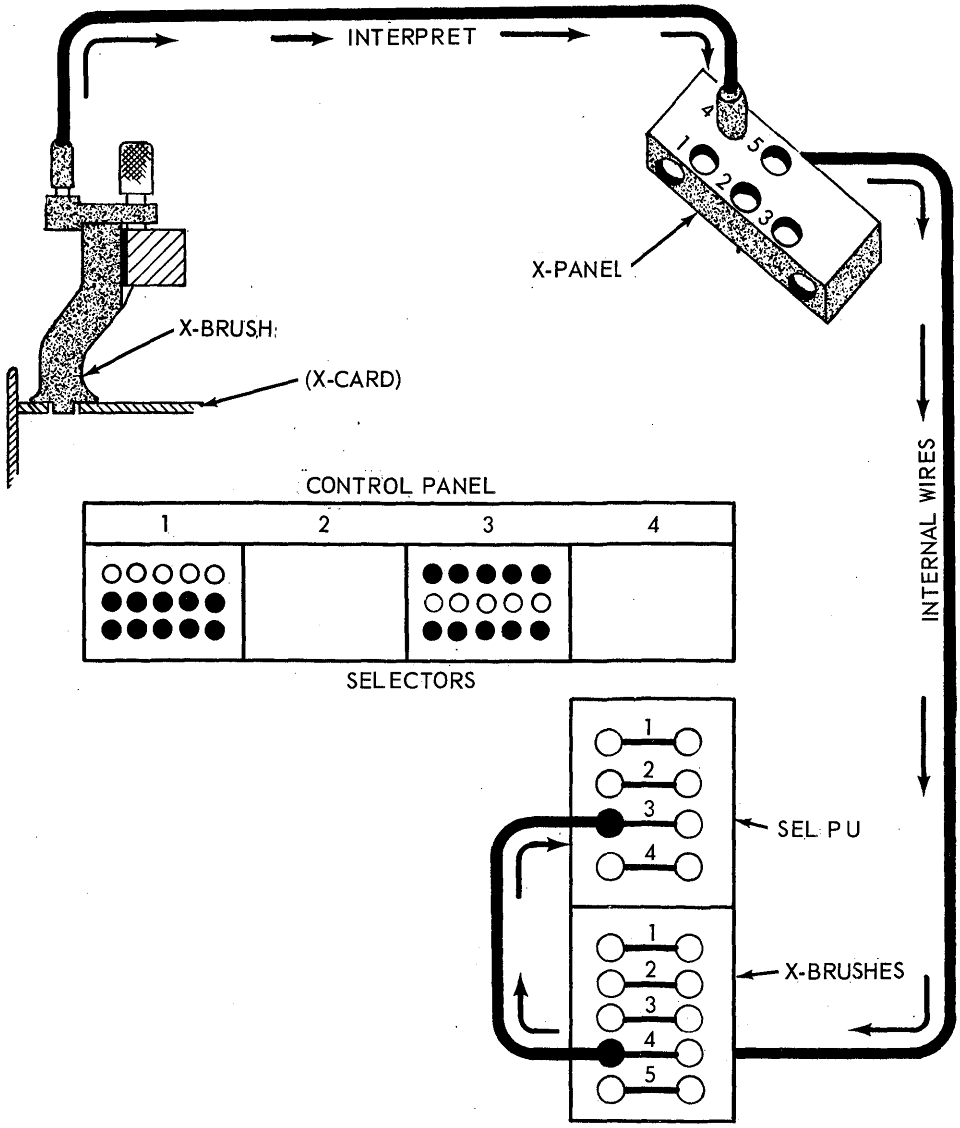
You should not tamper with the brush assembly or try to remove a card jam unless you have been properly instructed in the procedure and your supervisor is satisfied you can do the job.

X Brushes, X Panel

Five X brushes are located under the top cover, just to the left of the hopper. The 5 X brushes, as shown in figure 6-6, can be positioned to cover any 5 card columns and when



49.256X
Figure 6-6.—X-Brushes, X-Panel.



49.257

Figure 6-7.—The external, internal path of an X reading brush.

wired to the X panel, they control printing of X or NX cards.

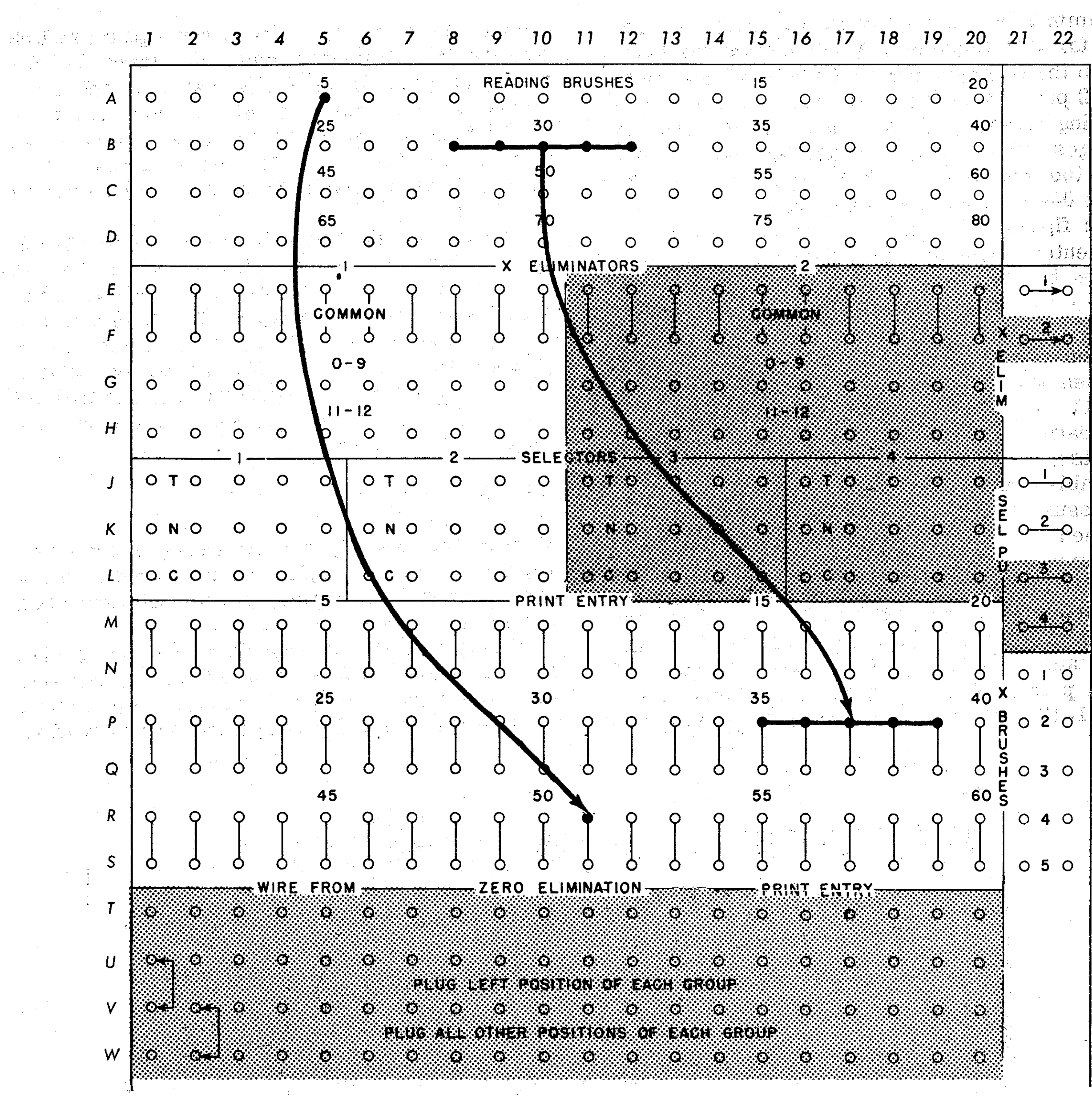
The internal function of the machine is illustrated in figure 6-7. When the X brush reads an X punch, the current is passed through the X panel and is available at the corresponding X brush hub on the control panel.

The X Brushes are timed to read only X-timed impulses and are normally used to pick up selectors, as illustrated in figure 6-7.

PRINCIPLES OF CONTROL PANEL WIRING

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



49.23

Figure 6-8.—Normal printing.

print positions 35 through 39, you would wire reading brush hub 28 to print entry hub 35, reading brush hub 29 to print entry hub 36, and so on. Figure 6-8 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 6-9 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.

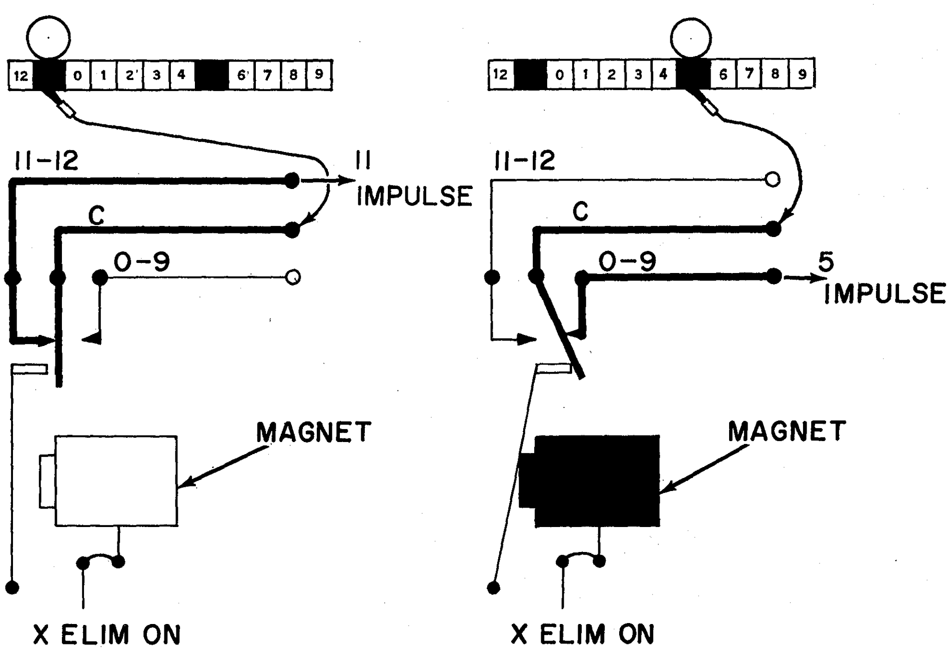
Assume you have the credit amount of 10327 punched in card columns 53 through 57, with an 11 punch in column 57 to identify the amount as being a credit. If you wired column 57 directly to a print entry hub, a P would print. However, if you wired it first to common of the X eliminator and out of the 0-9 hub to a typebar, a 7 would print. The 11 punch can be wired from the 11-12 hub to a 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 6-10 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

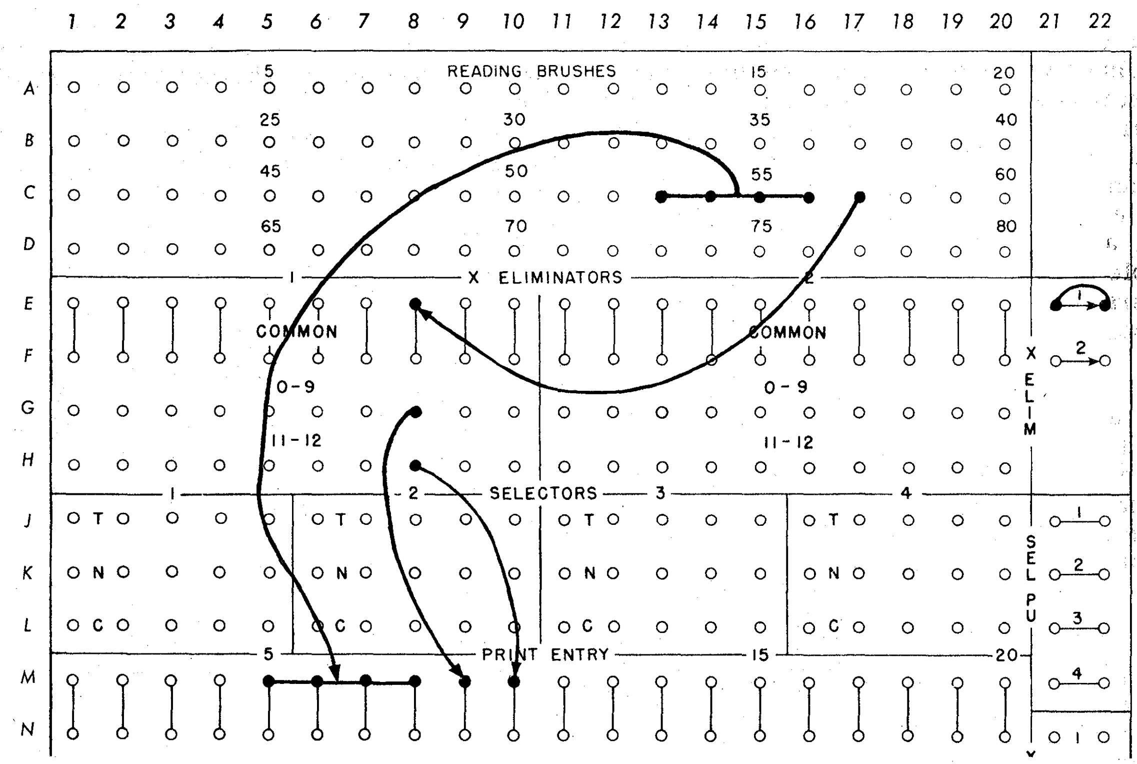
Selection usually means making a choice or decision. For example, you may decide to interpret data in one place on certain cards and in another place for others.

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



49.24

Figure 6-9.—X eliminator schematic.



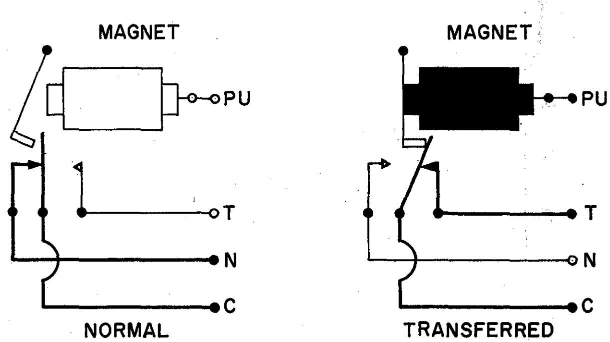
49.25

Figure 6-10.—X elimination.

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 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 6-11. 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.



49.26

Figure 6-11.—Selector schematic.

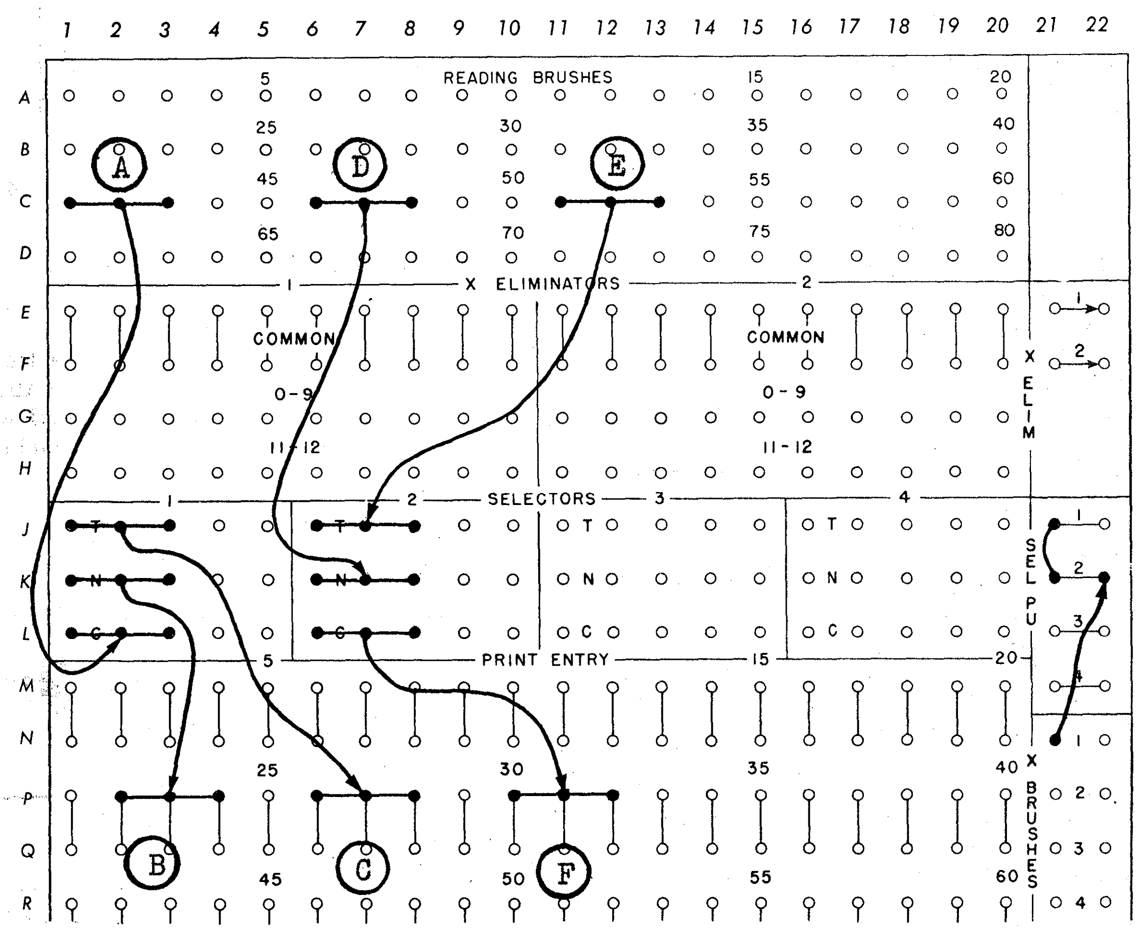
You can see then, how an impulse from a card column wired to the common hub of a selector becomes available out of normal when the selector is not picked up, and out of transferred when a selector is picked up. By the same token, any impulse wired to normal is available out of common if the selector 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 6-12. 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



49.27

Figure 6-12.—Class and field selection.

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. However, there are a few points you should remember about operating the interpreter.

1. Always use a test card or cards before starting an operation. This is necessary to determine if you have the right control panel, or if the panel you have just wired is wired correctly. 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 certain 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 toward the front. You must return the interpreted cards to the file in the same manner in which they were removed.
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 552

The type 552 interpreter is an earlier model machine than the 548. It is different in appearance and lacks some of the features of the 548. The operation of both machines and the functions of their control panels are essentially the same, except as noted below.

X Elimination

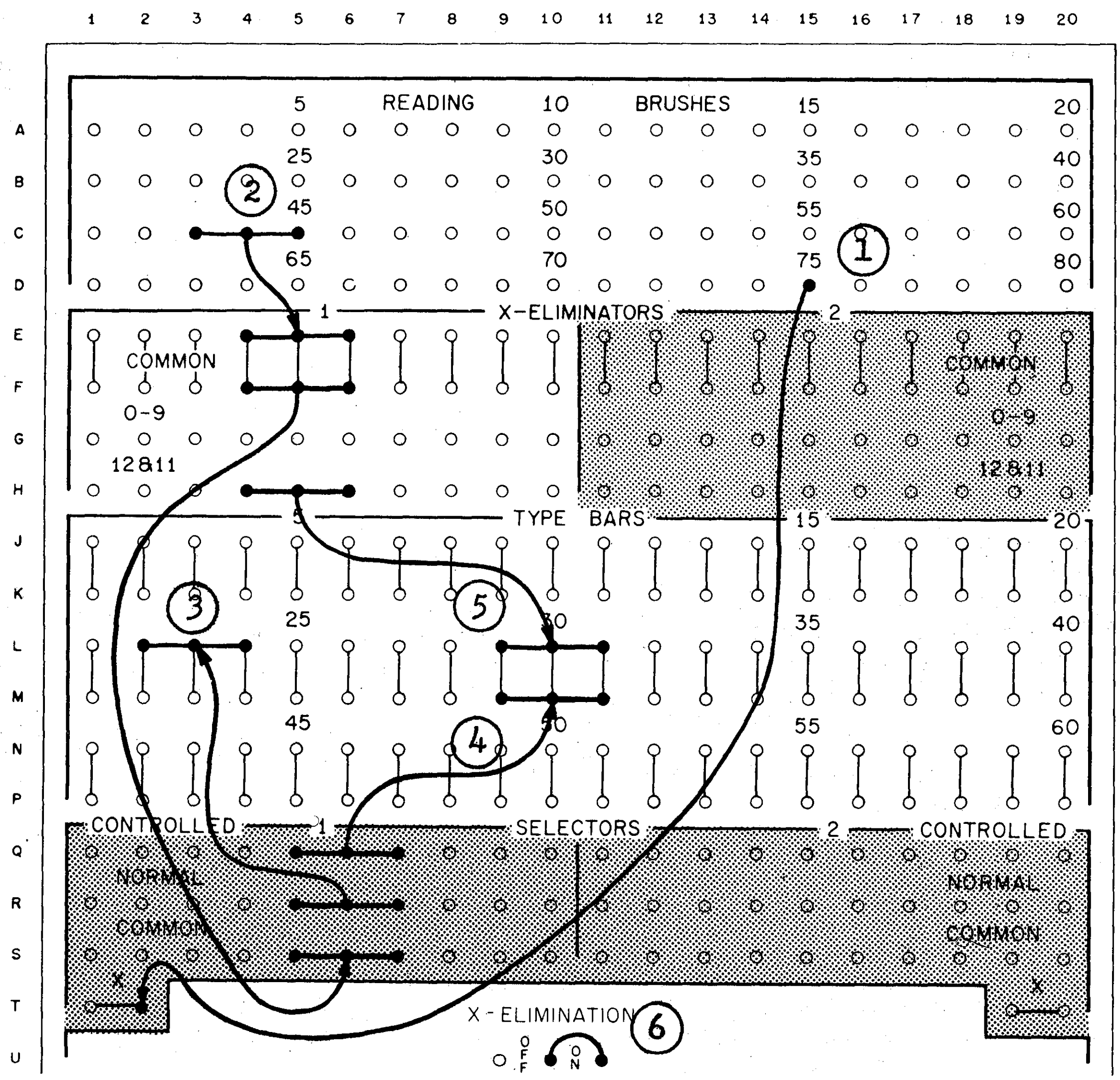
The X eliminator works on the same principle as the one in the type 548. The only difference is that the 552 X eliminator switch has an OFF position as well as an ON position. When this switch is wired OFF, it has the same effect as not being wired.

Selection

Selectors are installed only as an optional feature. The lack of X brushes requires controlling a selector by wiring the control X from the reading brushes to the selector X pickup hub. Because of this, wiring for selection of alphabetic information requires a method different than that required for numerical selection. Since the control X is read from the reading brushes, the selector cannot be picked up in time to control the 12 and 11 zones of alphabetic characters, so those zones must be wired directly to print. For this reason, alphabetic field selection is not possible. Alphabetic class selection is performed through the use of a selector and the X eliminator.

Wiring for alphabetic class selection is shown by the diagram in figure 6-13.

1. The control X, punched in column 75, is wired from reading brush hub 75 to the X pickup of a selector. If there are other punches in column 75, operation of the selector will not be affected since the selector pickup hub accepts 11 impulses only.
2. The alphabetic field, punched in columns 43-45, is wired to common of the X eliminator and through a set of common hubs to common of the selector. This allows both the numerical and zone punches to reach the selector.
3. The normal hubs of the selector are wired to typebars 22-24. As long as no impulse is received by the X pickup hub, all numerical and zone punches are allowed to pass through normal, and print as alphabetic characters.
4. The transferred hubs are wired to typebars 29-31. Since the 12 and 11 punching



49.28

Figure 6-13.—Alphabetic class selection, type 552.

positions have already passed the reading brushes when the selector transfers, they are directed through the normal side of the selector to typebars 22-24. They will print as special characters provided these typebars are equipped with special characters actuated by a single 11 or 12 punch.

Only the zero through 9 punches can be directed through the transferred hubs of the selector to typebars 29-31. This permits selecting all letters punched with a zero zone, along with the numerical punches in letters containing 12 and 11 zones.

5. The 12 and 11 zone punches reach typebars 29-31 by wiring the 12-11 hubs of the X eliminator directly to the typebars. This permits these zones to be combined with the numerical punches from the transferred side of the selector to cause alphabetic printing. When the selector is normal, 12 and 11 punches wired to typebars 29-31 will cause special characters to print, if these typebars are equipped for printing them.

6. The X elimination switch must be wired ON for this operation to prevent 0-9 impulses from traveling through the 12-11 hubs.

INTERPRETER TYPE 557

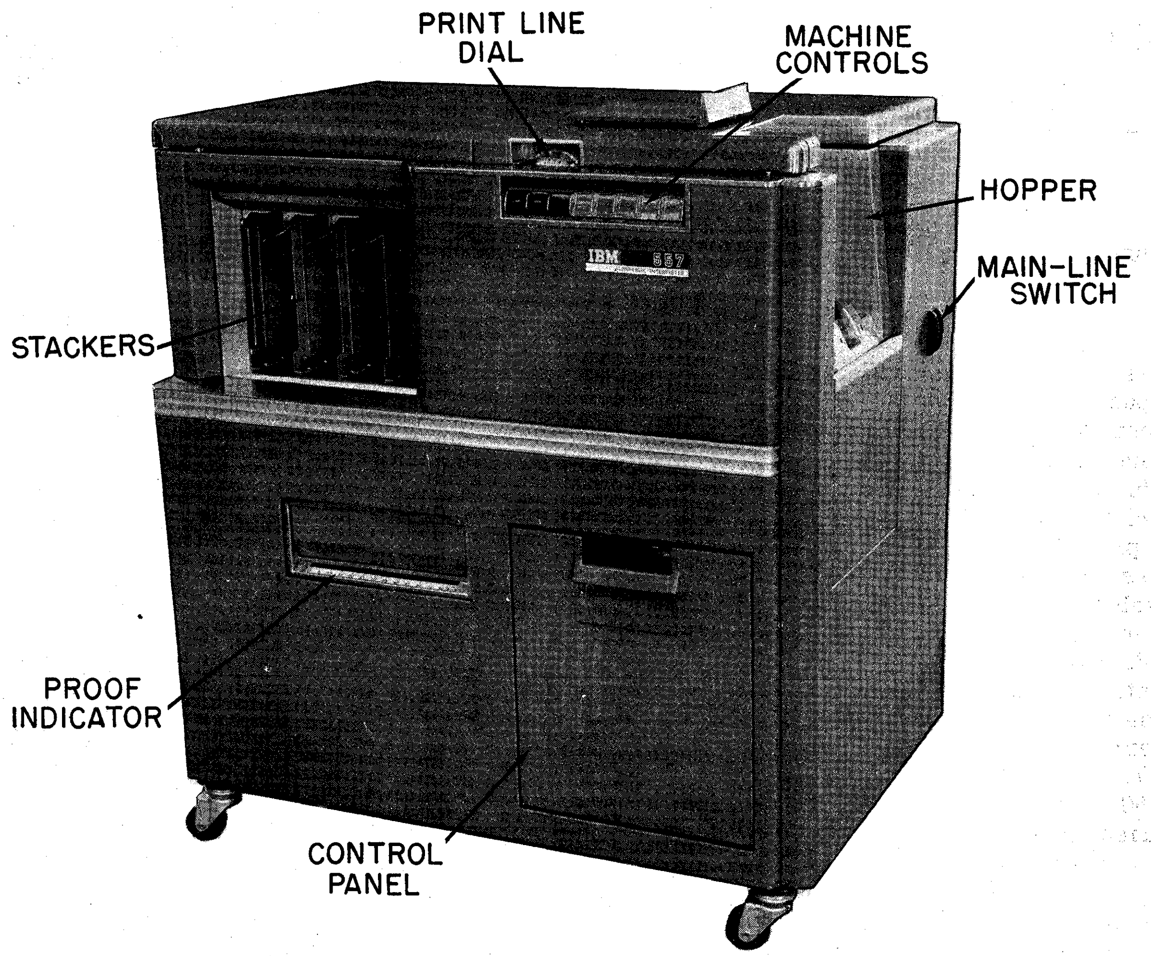
We usually think of interpreting as no more than the printing of punched card data across the face of the card so that the contents can be easily read by the human eye. However, in addition to the usual interpreting operations, the type 557 interpreter, shown in figure 6-14, can be equipped with several special devices which broaden the range of applications that may be performed.

Although only the basic features and operations will be analyzed in this chapter, 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.

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.

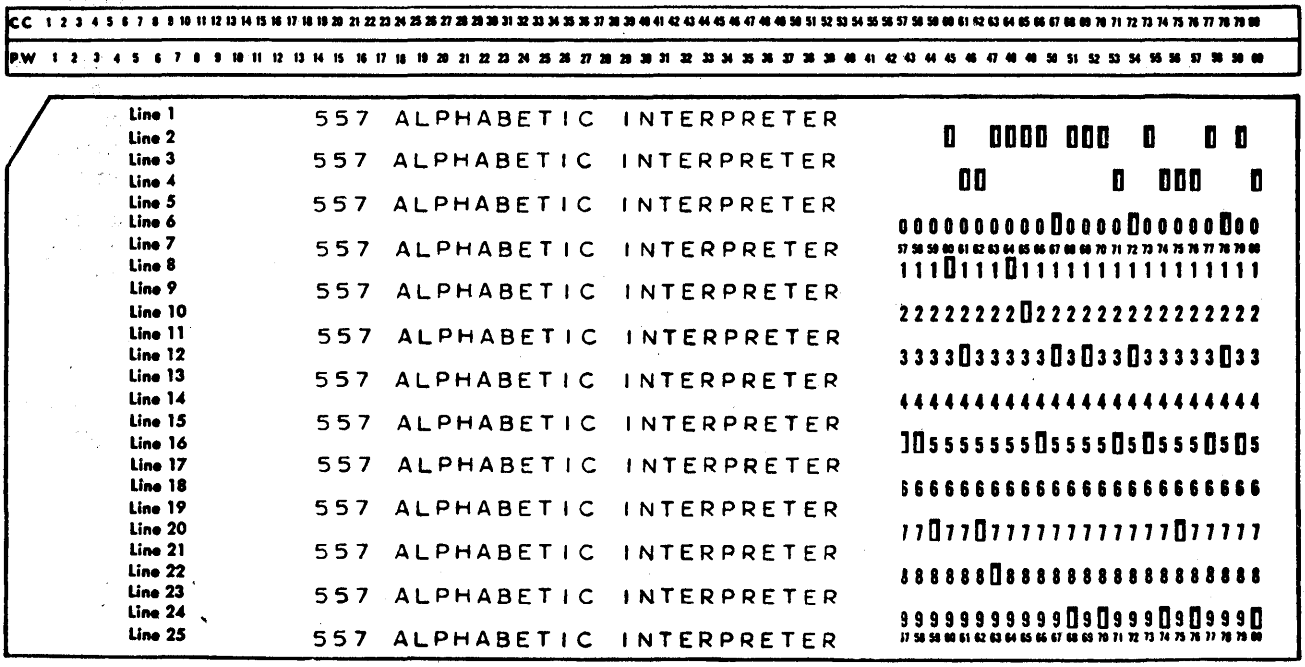
2. SELECTIVE STACKERS. Cards can be directed to four selective stackers by proper control panel wiring. Duplicate master or detail cards, unmatched cards, cards preceding unmatched or duplicate cards, and cards containing a control punch can be selected.

3. SELECTIVE LINE PRINTING. Cards can be controlled to print on each of 25 printing lines, as shown in figure 6-15.



49.29X

Figure 6-14.—Type 557 interpreter.



49.258X

Figure 6-15.—Interpreted card.

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

4. INTERPRET EMITTER. This device emits 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 type 557 interpreter reads data punched in a card and prints that data across the card at the rate of 100 cards 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 print line. Cards must be passed through the machine one time for each line to be printed.

Machine Controls

The MAIN LINE SWITCH supplies power to the machine. The START and STOP keys are used to control card feeding. 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 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. 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.

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.

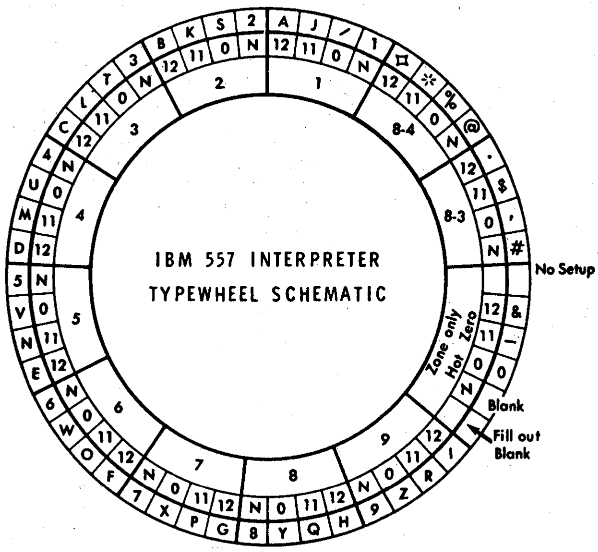
Notice the difference between card feeding in the type 557 and other interpreters. This is the only interpreter which requires that cards be fed face down, and from the front of the file.

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 6-16, can print numerical, alphabetic, 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.



49.30X
Figure 6-16.—Type 557 type wheel schematic.

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, such as proofreading, proof entry, and the digit emitter. Since this chapter discusses only those features which are standard only the left section of the control panel is shown in figure 6-17.

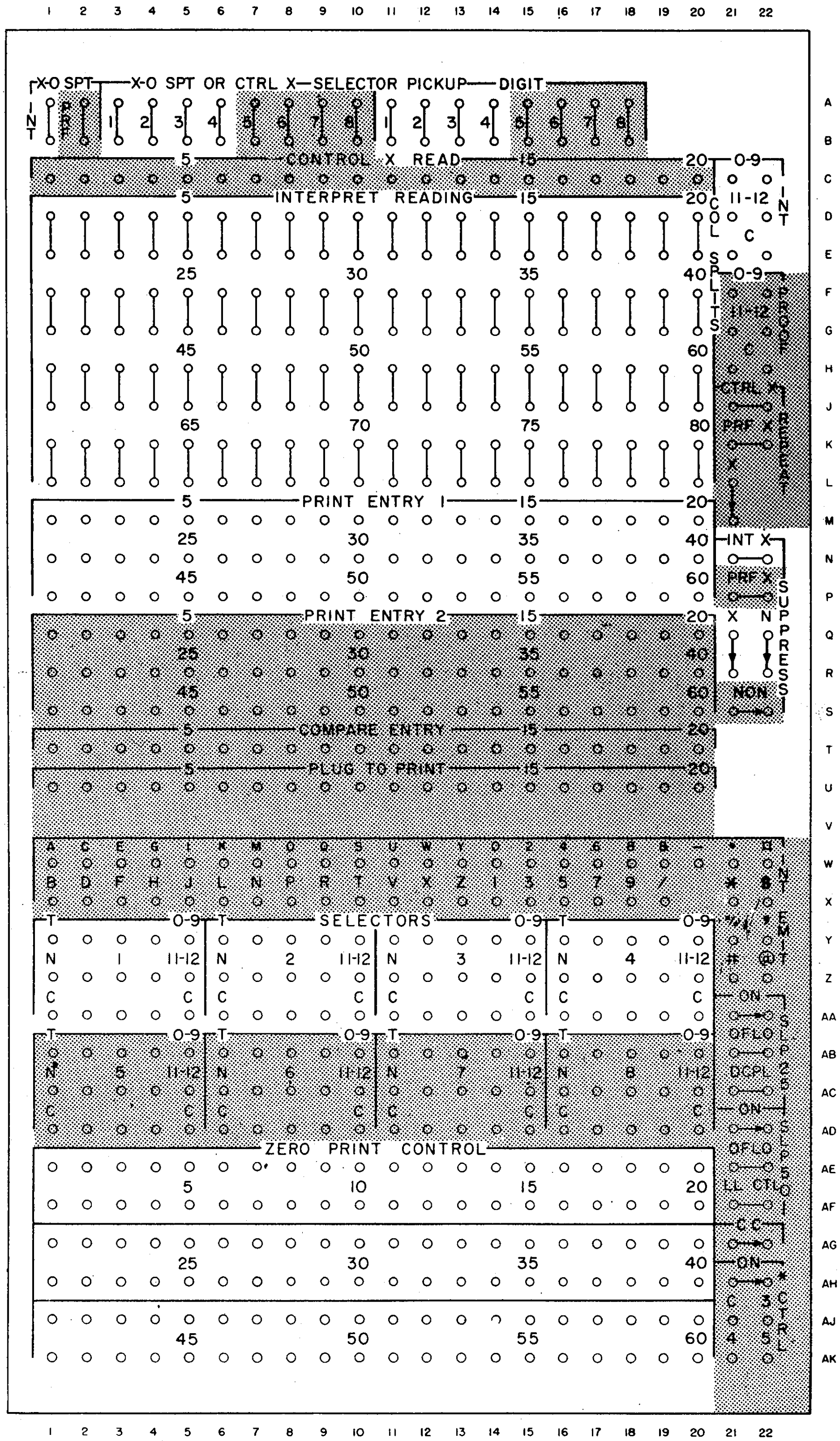
Normal Printing

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 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



49.31

Figure 6-17.—Left section of type 557 control panel.

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 6-17 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 6-18. 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 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.

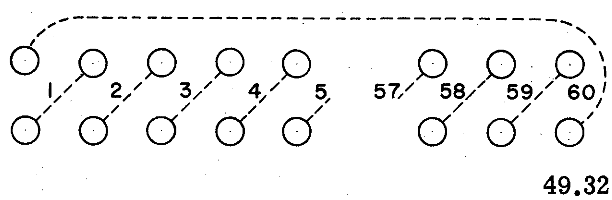


Figure 6-18.—Zero print control hubs.

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.

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

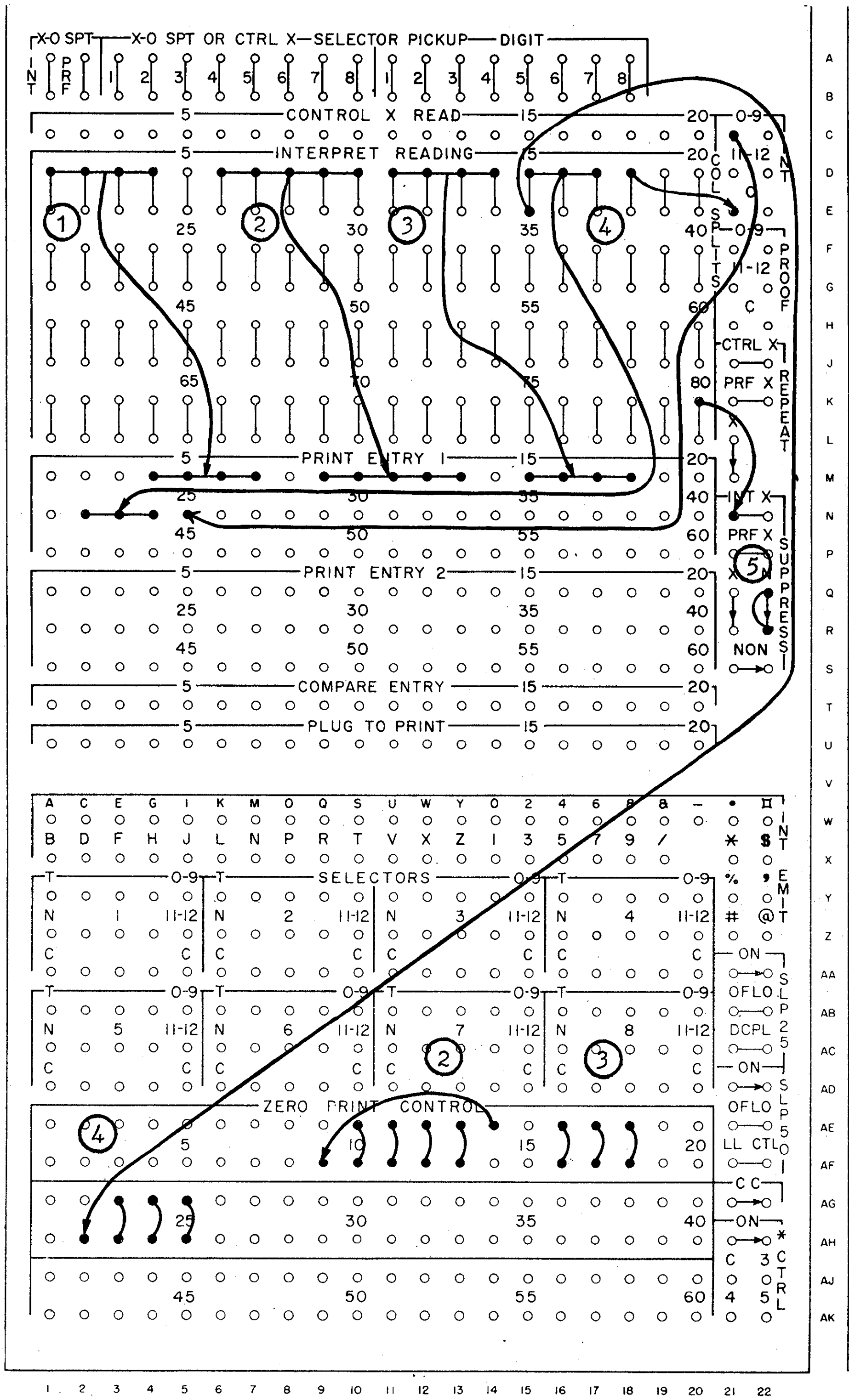
Selective printing of an entire card can be performed under the control of an X or NX condition. This permits you to interpret all cards of one type without separating the file or printing on the other cards in file. Either an 11 or 12 punch can be used for control.

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

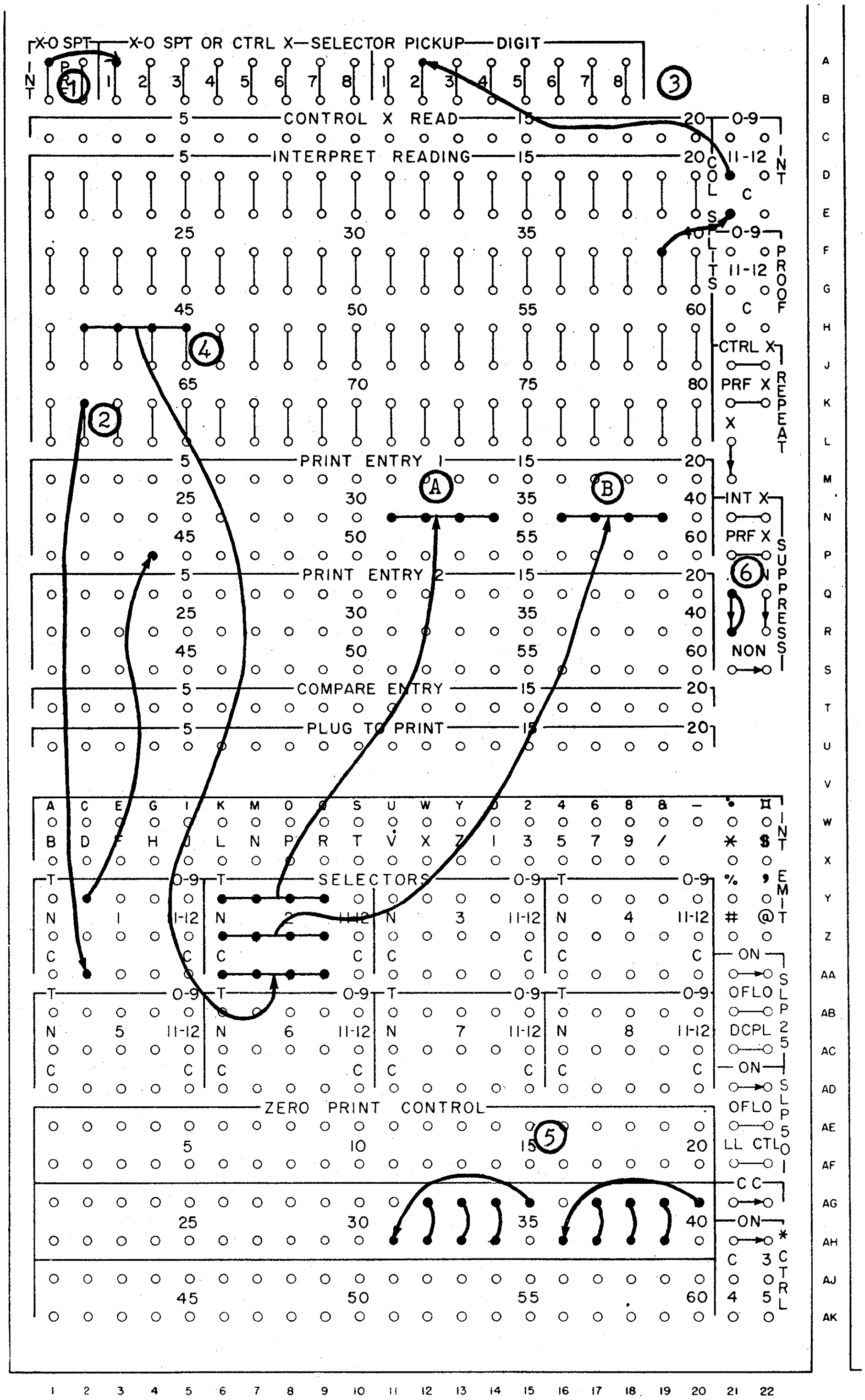
Figure 6-19 illustrates the wiring necessary for normal printing, zero print control, X elimination, and print suppression.

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



49.33

Figure 6-19.—Normal printing, zero print control, X elimination, and print suppress.



49.34

Figure 6-20.—Numeric class selection and X elimination.

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 exist 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.

The wiring diagram in figure 6-20 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.

CARD COLUMN—One of the 80 vertical divisions of a card.

CARD COUNTER—A device that counts each card as it is processed.

COLUMN SPLIT—Comparable to the X-eliminator, but operates automatically with each machine cycle.

DETAIL CARD—A term applied to a card to distinguish it from a master or heading card.

EMITTER—A device that emits an impulse for each punchable character.

INTERPRETER—A machine that will transcribe characters from punched holes.

INTERPRETING—Printing information from punched holes on the same card in which it is punched.

MACHINE ERROR—A deviation from correctness in data resulting from an equipment failure.

MASTER CARD—The first card of a group containing fixed or indicative information for that group.

PRESENSING—A device to read control punches to control repeat print and selectors for alphabetic selection.

PRINT ENTRY—Entries for impulses to activate the typebars and printwheels.

PRINT SUPPRESS—Allow suppression of printing for either X or NX cards.

PRINT WHEELS—Wheels embossed with letters, digits, and special characters for printing on forms and cards.

PRINTING POSITION KNOB—A device used for controlling the printing lines on a card.

PROOF—The editing feature of an interpreter for checking the printing operation.

PROOF INDICATOR—A device which displays or announces that an error has been made or a failure has occurred.

REPEAT PRINT—Information read from a master card and printed on any number of following detail cards.

RUNOUT—Moving the last card in the machine to the stacker.

SELECTIVE LINE PRINTING—More than one print line with the option of being selectable.

SELECTIVE STACKERS—More than one stacker with the option to select the desired one.

SELECTOR—A device capable of having two paths.

STACKER—A receptacle for cards that have passed through the machine.

TRANSCRIBING—Printing information punched in one card onto another card.

X BRUSHES—Adjustable reading brushes for reading control punches.

X ELIMINATION—Elimination of 11 and 12 zones of a given column.

X ELIMINATOR—A device for separating the reading between 0 and 11 time of any given column.

X ELIMINATOR SWITCH—A switch used to control the off-on feature of the X eliminator device.

X PANEL—A device whereby a reading by the X brushes can be made available on the control panel.

ZERO PRINT CONTROL—Provides electrical control of the printing of zeros and characters represented by only an 11 or 12 punch.

CHAPTER 7

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 dairy, 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 machine 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

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 7-1, contains two feed units; the reading unit and the punching unit. Cards may be fed from either or both units, depending upon

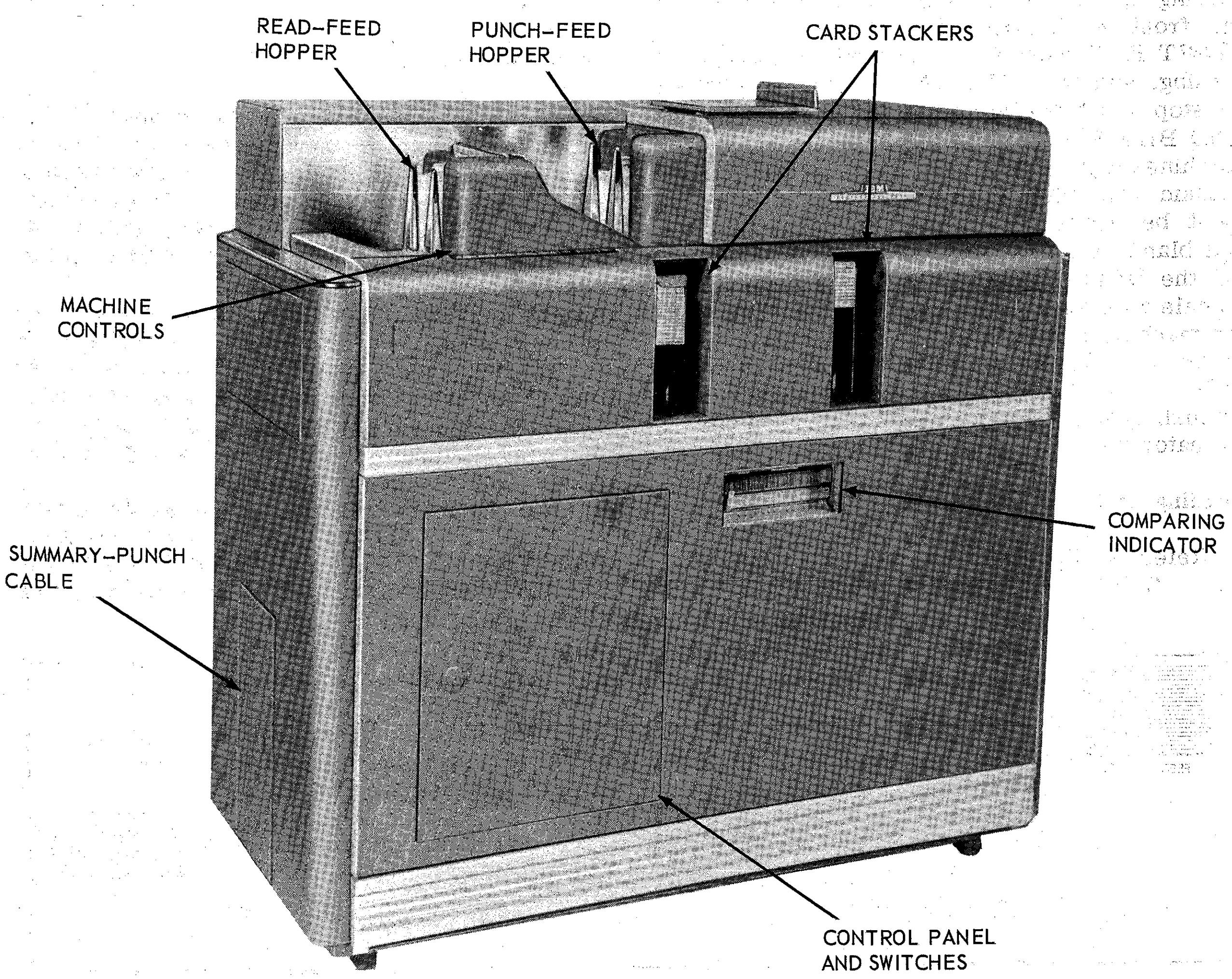


Figure 7-1.—IBM Type 514 reproducing punch.

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

Machine Controls

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 7-1. 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 7-2. 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.

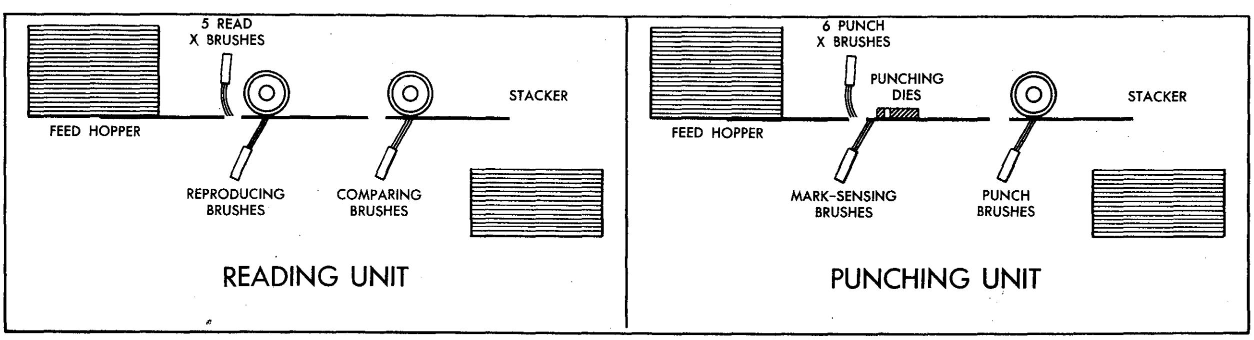
After cards pass the reproducing brushes, they are read by 80 comparing brushes. These brushes may be wired to the comparing unit to compare the card reproduced on the preceding cycle, or to check the accuracy of a gangpunching operation.

Punching Unit

A schematic diagram of the punching unit also is included in figure 7-2. 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



49.36X

Figure 7-2.—Card feed schematic diagram.

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 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 7-3, 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 pushed.

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 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 7-4.

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:

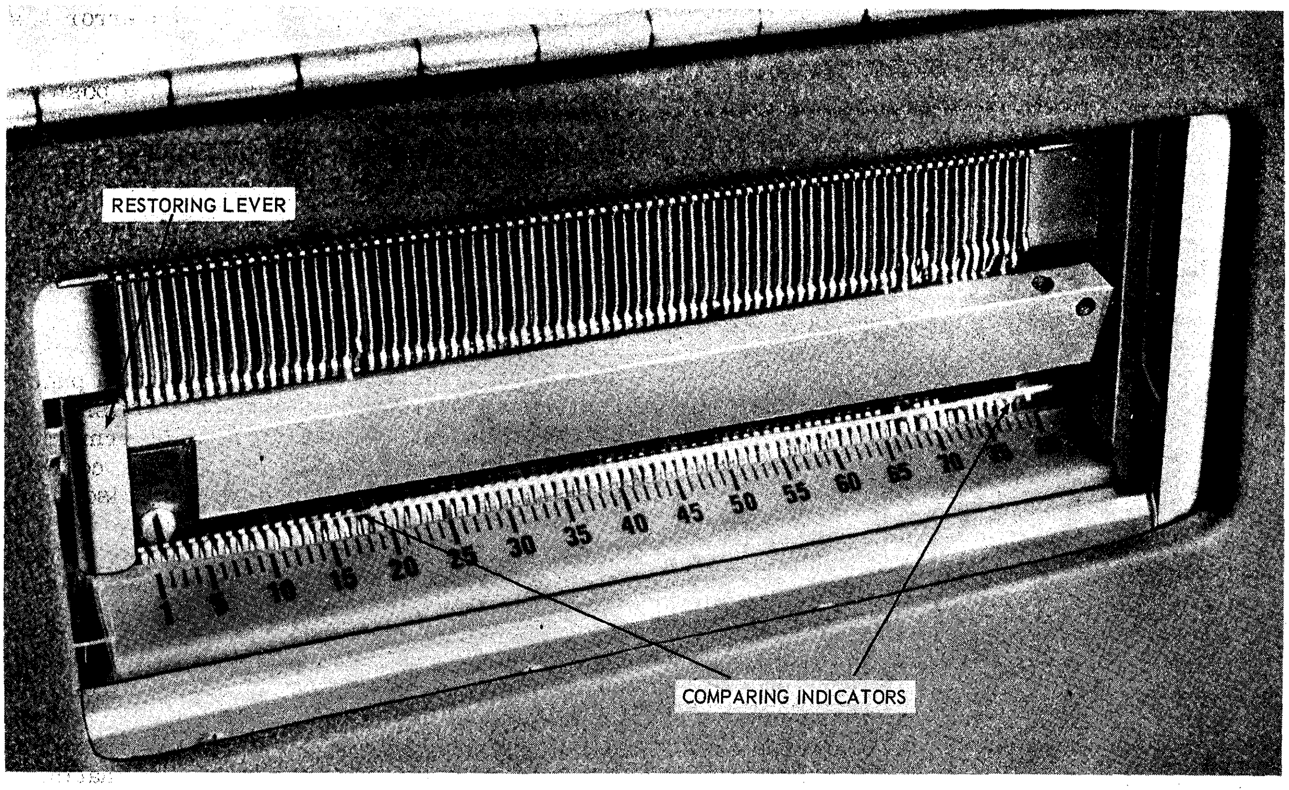
Reproducing Switch.—This switch synchronizes the reading and punching unit, so that they work together for any given operation. When this switch is OFF each unit may be used independently to perform separate operations.

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



49.37X

Figure 7-3.—Comparing indicator unit.

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.

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.

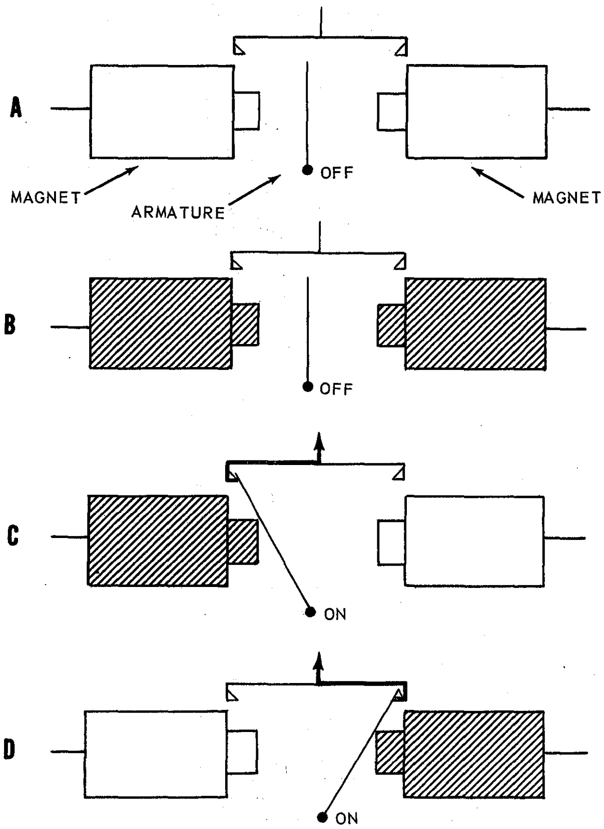
PRINCIPLES OF CONTROL PANEL WIRING

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 7-2 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 7-5 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.



49.38X
Figure 7-4.—Comparing position schematic.

2. Both cards then feed simultaneously past the next station in their respective unit. At this 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 is 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 7-6.

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:

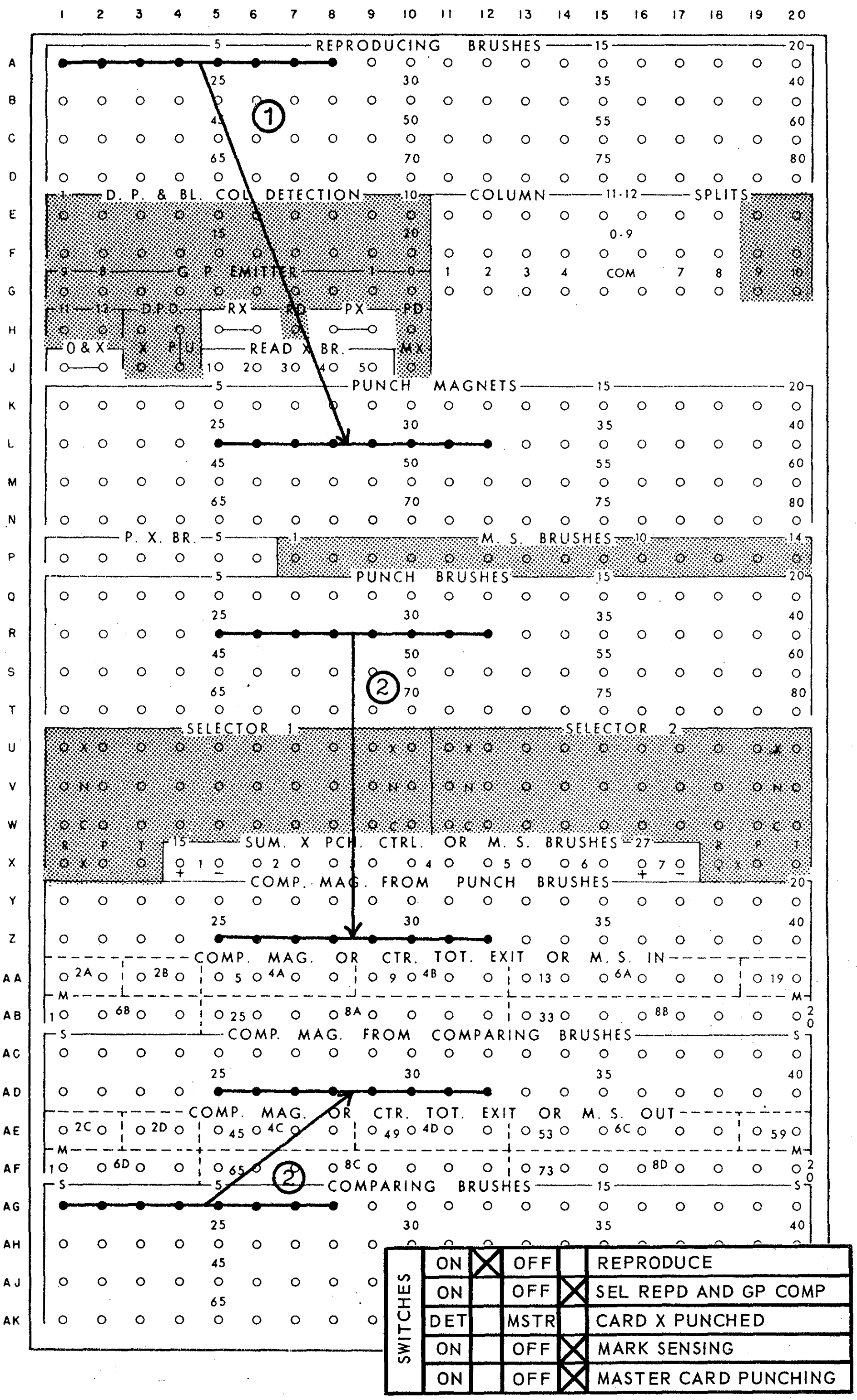
a. When the detail-master switch is set to MASTER, punching is suspended when X punched cards pass the reproducing brushes. All NX cards will be reproduced. Comparing is suspended when the X punched cards pass the comparing brushes. NX cards will be compared.

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 or Transfer

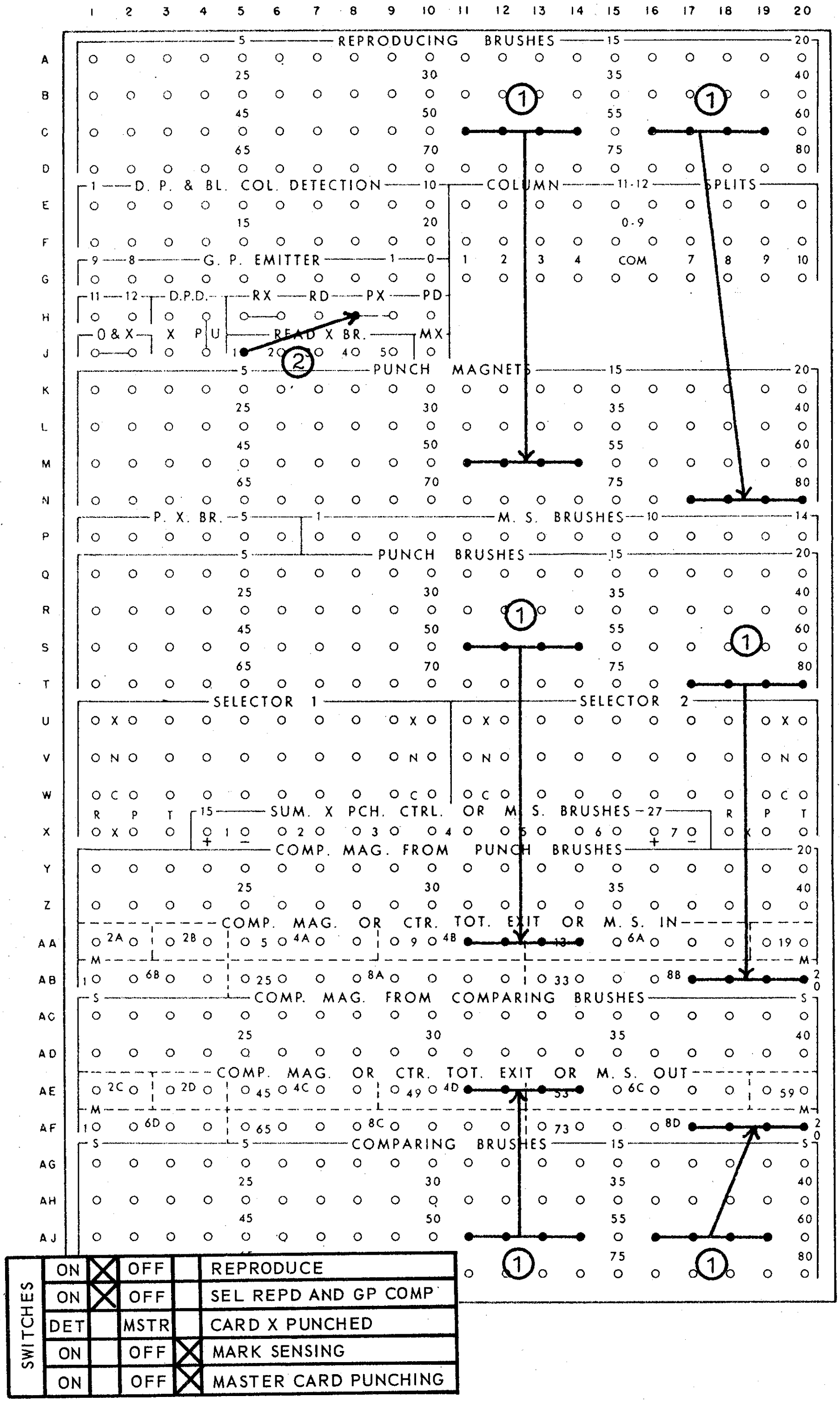
Column splits operate on the same principle as those in the type 557 interpreter. They allow the reading of a column to be divided between the zero and 11 punching positions in order to separate the reading of control punches from digit punches, or to combine these punches from different columns into one column. Figure 7-7 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



49.39

Figure 7-5.—Straight reproducing and comparing.



49.40

Figure 7-6.—Selective reproducing and comparing.

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

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 7-8 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 brushes to the other side. The wiring allows information punched in one card to be compared with the information in the following card. If

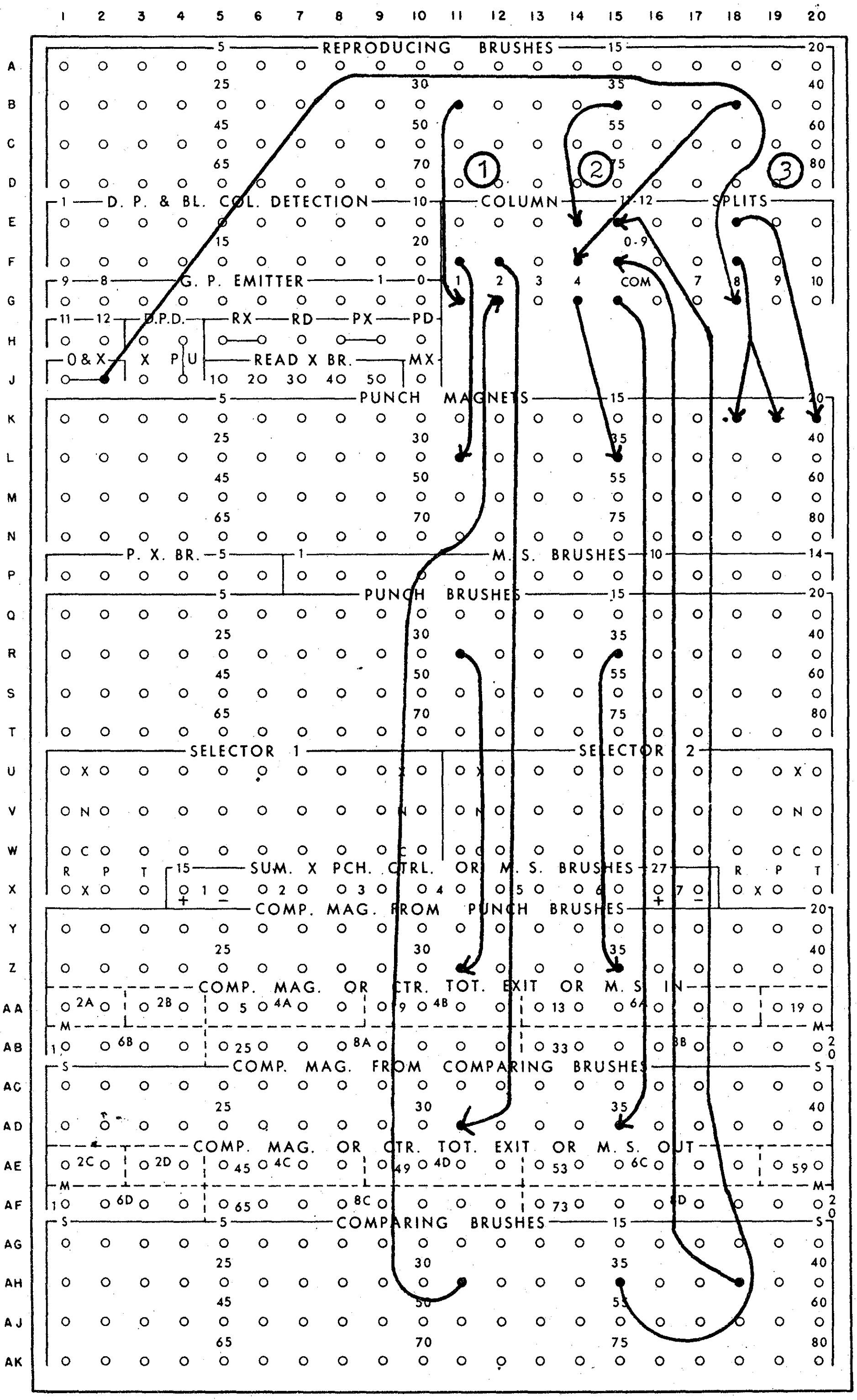
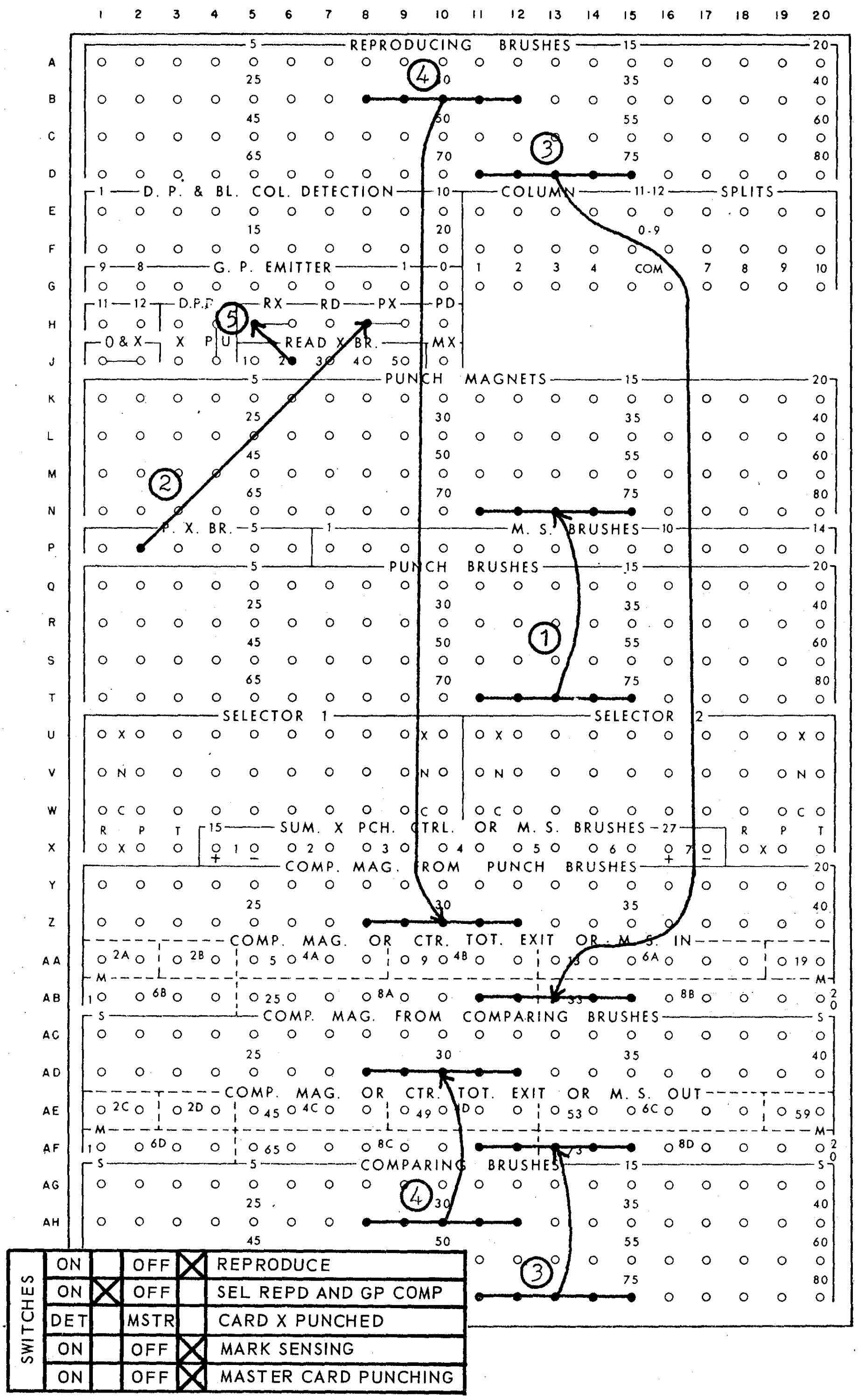


Figure 7-7.—Using the column splits. 49.41



49.42

Figure 7-8.—Interspersed master card gangpunching and comparing.

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. 7-9).

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 7-9.

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. 7-9).

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.

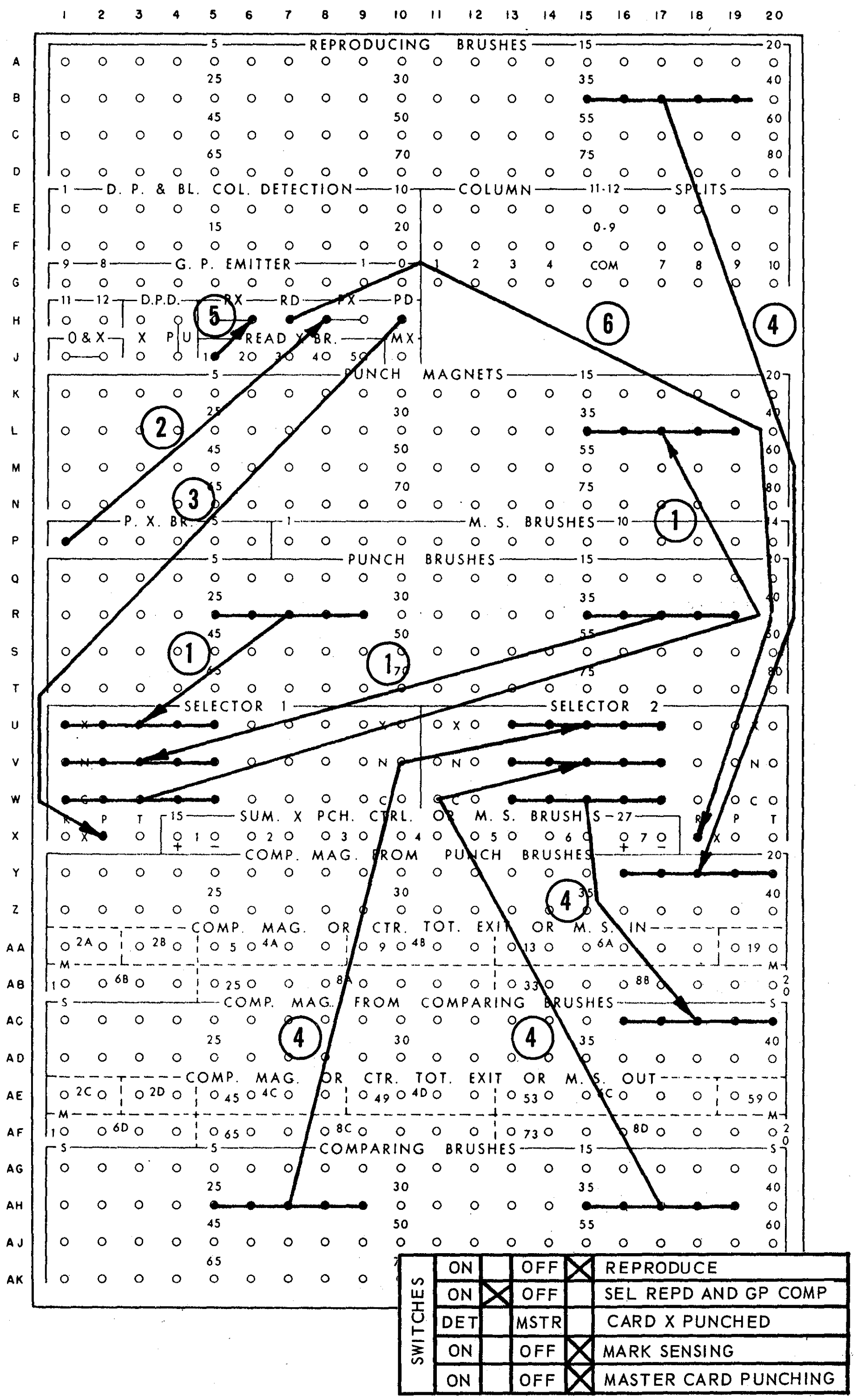
5. To prevent the master card from being compared with the last detail card of the preceding group, a read X brush is placed on the proper column to pick up the master X punches, and the outlet hub that corresponds to that particular read X brush is wired to the RX hub.

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 summary card is punched, the accounting machine continues feeding cards to accumulate totals for the next control group.



49.259

Figure 7-9.—Offset intersperse gangpunch and comparing.

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 exit 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

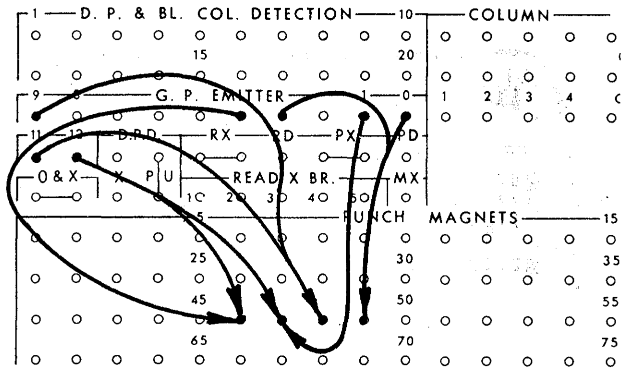
The gangpunch emitter is a special device which may be installed to supply punching impulses identical to those obtained from punches in the card. By reference to figure 7-8, G 1-10 and H 1-2, you will notice a hub for each punching position in a card. Each hub in turn emits an impulse whenever the corresponding punching position of the card is passing under the punch magnets. When wired to the punch magnets as seen in figure 7-10, 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.

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



49.260X

Figure 7-10.—Punching DART using the gangpunch emitter.

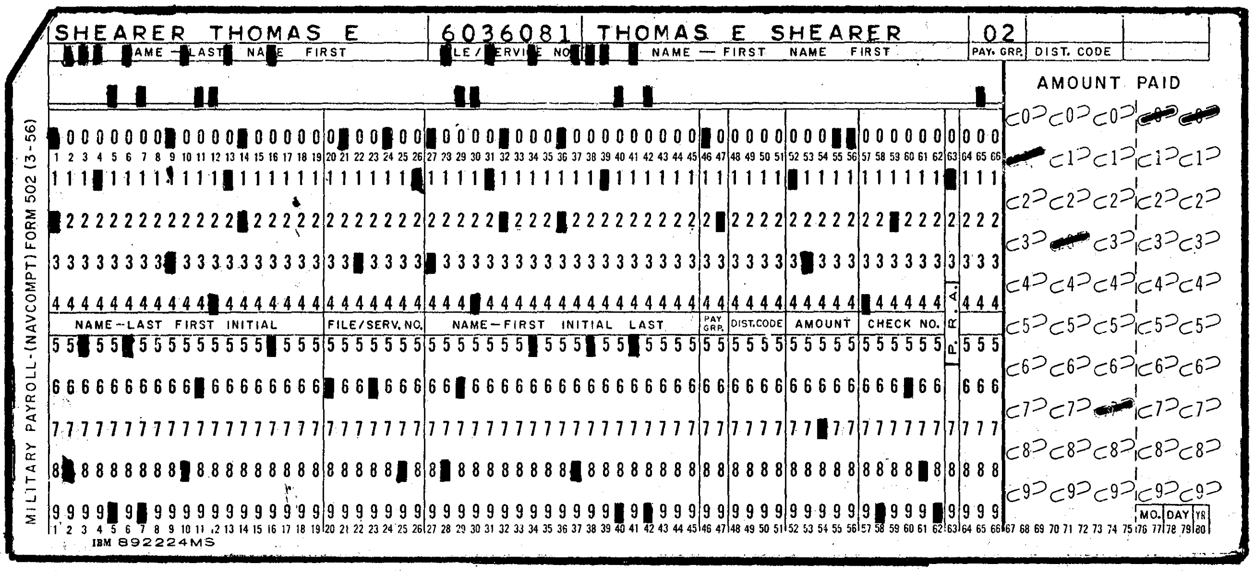
convert pencil marks on a card to punched holes. To make these marks electrically conductive, pencils with special leads containing a high graphite content must be used for marking.

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.

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 7-11 shows a mark sense card used for a military payroll. The data processing



49.43

Figure 7-11.—Sample mark sense cards.

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 7-12.

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.

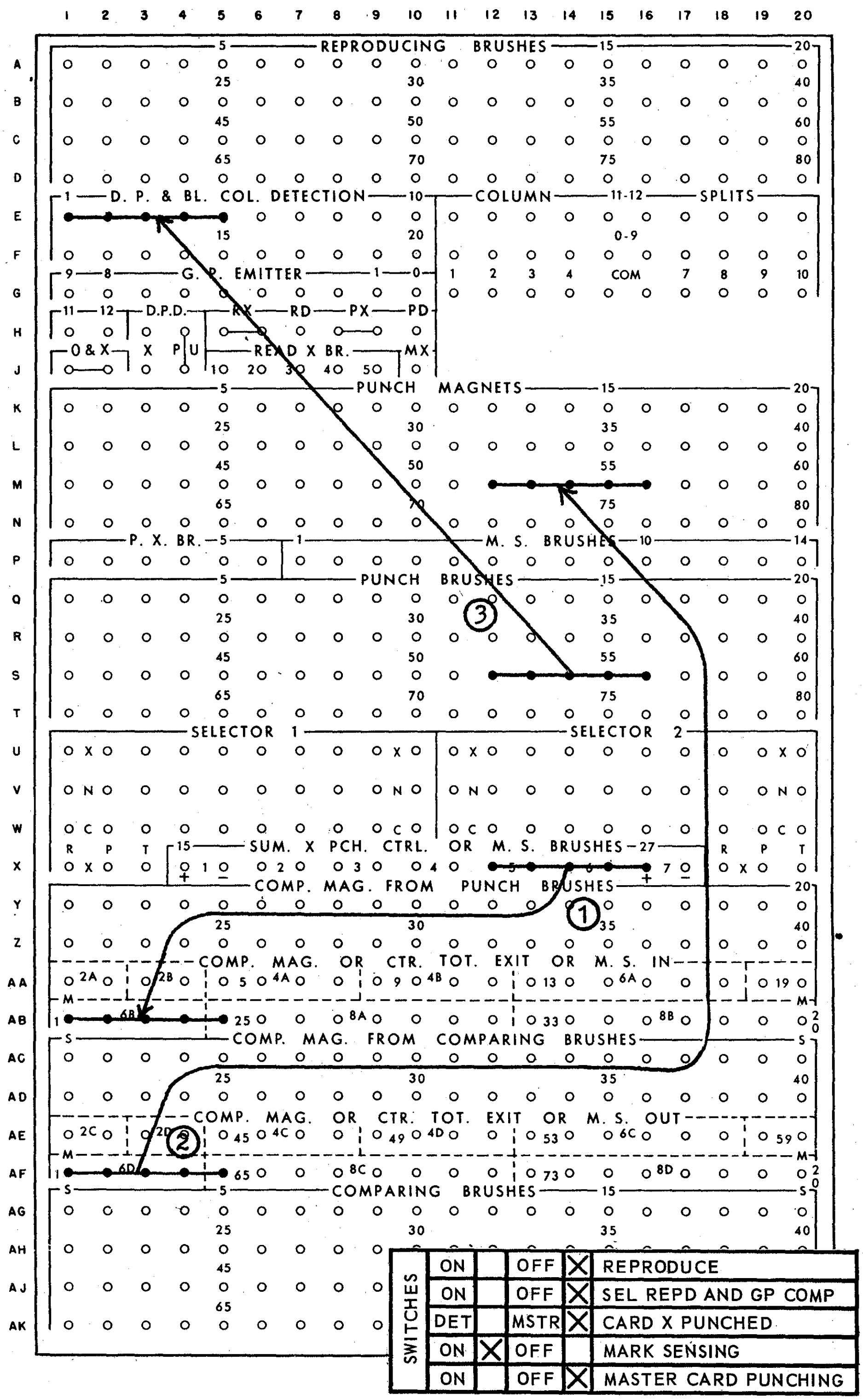
To test a gangpunch operation, the test card must contain information in every column to be gangpunched. The test card should then be placed in front of a few blank cards and fed through the punch unit. The results can be checked visually to see if gangpunching is performed correctly. At least two master 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.

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,



49.44

Figure 7-12.—Mark sense punching.

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 7-13 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.

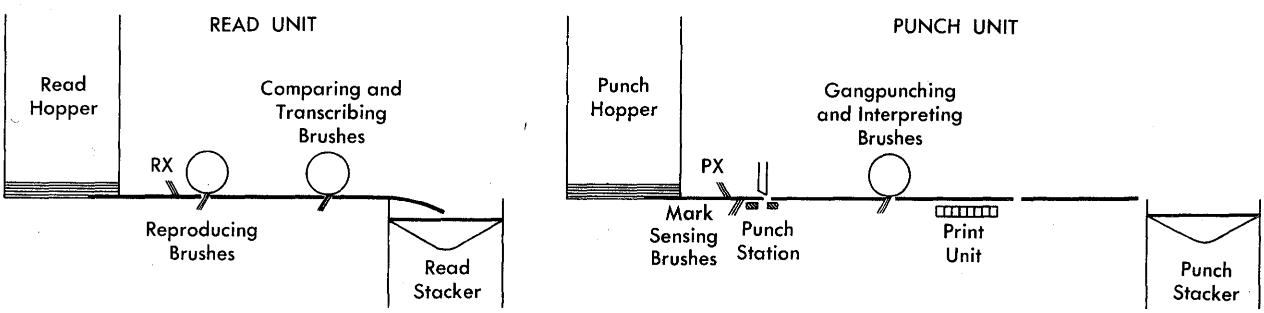


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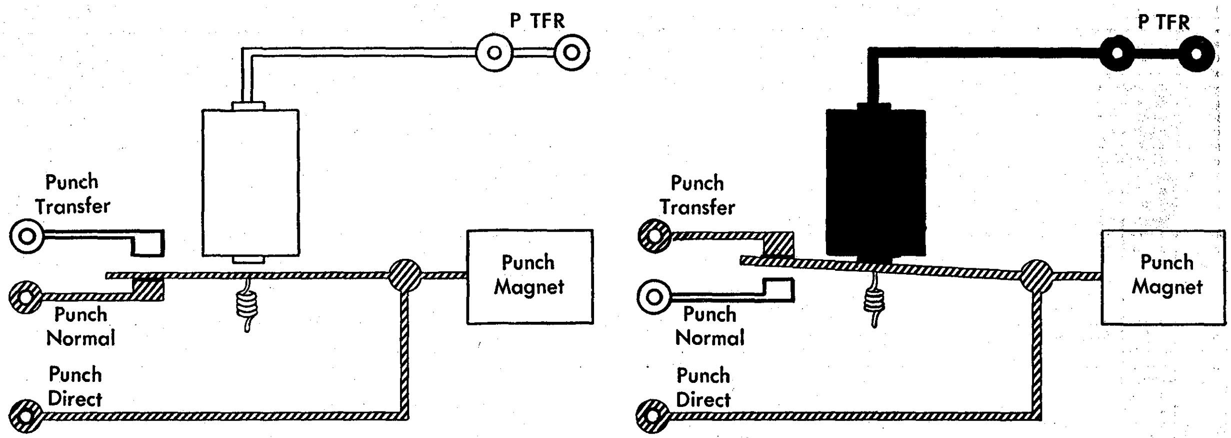
Figure 7-13.—Card feed schematic diagram.



49.46X

Figure 7-14.—Operation of the punch transfer feature.

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 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 7-14. The particular punch entry used depends upon the job being performed, as you will see in the following examples.

Figure 7-15 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.

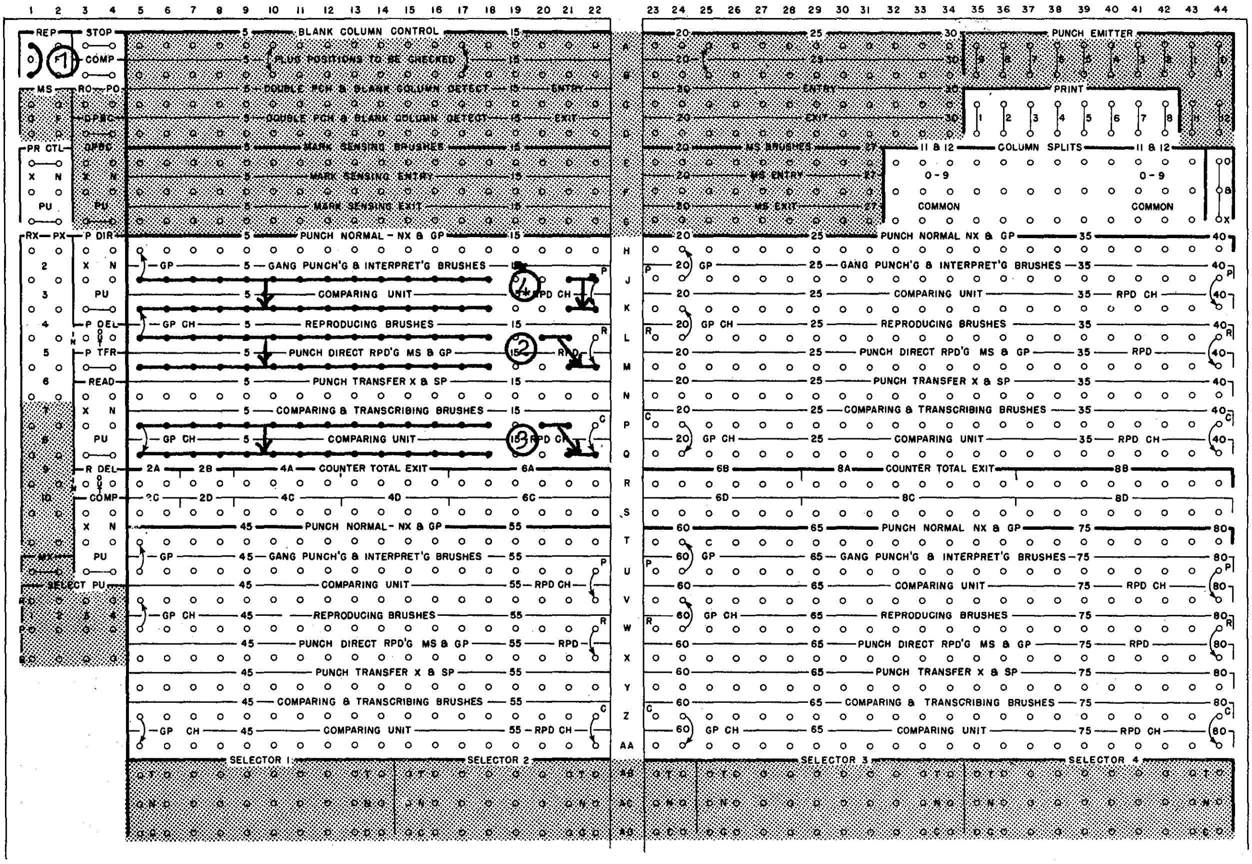
Punching can be controlled so that only one type of card, X or NX, will be reproduced. Figure 7-16 illustrates the punch transfer method for selective reproducing and comparing.

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



49.47

Figure 7-15.—Normal reproducing and comparing.

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.

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 7-15.

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

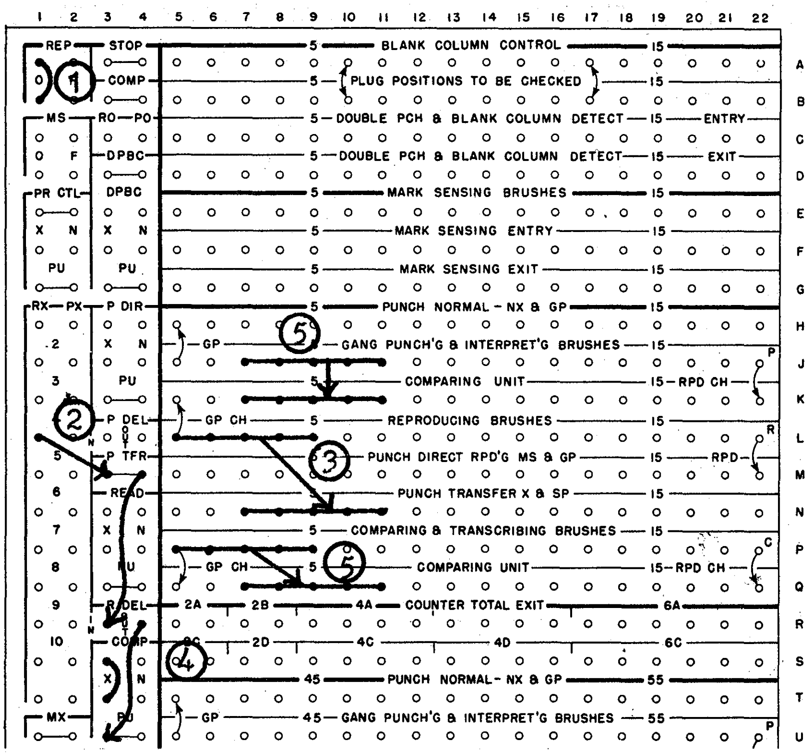


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Figure 7-16.—Selective reproducing and comparing.

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 endprint 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 suspended, depending upon the type of card which contains the control X.

In figure 7-17 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.

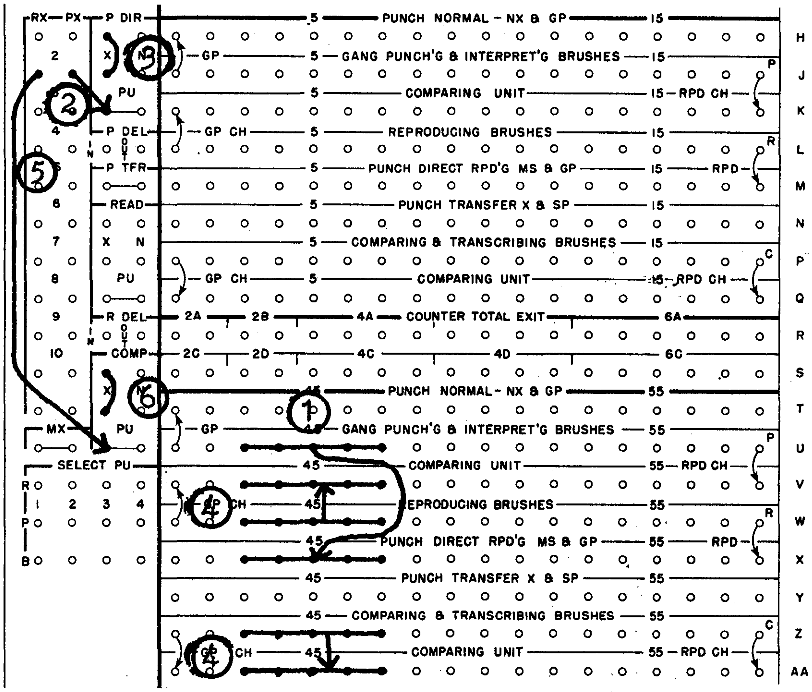
3. Because the X detail cards are to be punched, the punch direct X hubs are jack-plugged. This causes punching to be suspended whenever NX master cards are under the punch magnets. If the master cards contain the control X punch, the punch direct N hubs would be jack-plugged or left unwired to cause 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



49.49

Figure 7-17.—Interspersed gangpunching, punch direct.

in figure 7-18. 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

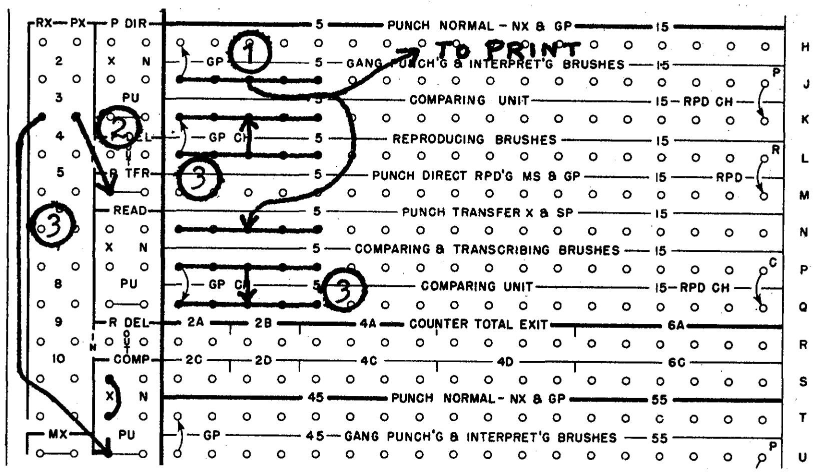


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Figure 7-18.—Interspersed gangpunching, punch transfer.

the punch transfer hubs when X punched detail cards are sensed by the PX brush.

3. Comparing is controlled in the same manner as previously described for the punch direct method.

End Printing

The print unit consists of eight print wheels capable of printing all digits zero through 9. A maximum of eight digits can be printed across the column 1 end of a card passing through the punch unit. Either one of two printing lines can be selected, or the print unit disengaged, by manual setting of the unit.

The print unit can be wired to print every card, or only certain cards, during reproducing, gangpunching, or combined operations. The wiring shown in figure 7-19 combines the operation of reproducing, gangpunching from a single master card, and selective end printing.

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.

Special Devices

The type 519 can be equipped with additional features to perform other operations not previously described. Figure 7-20 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. For 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

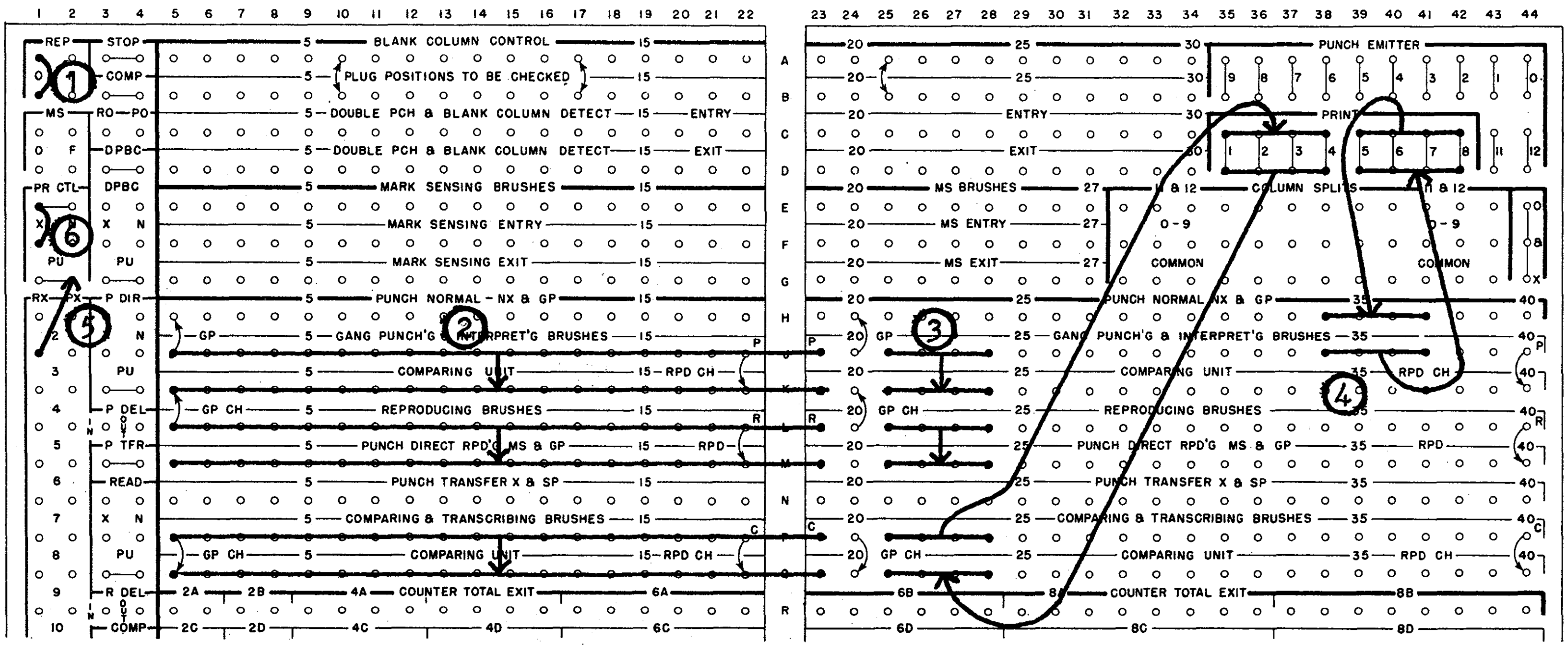

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Figure 7-19.—End printing.

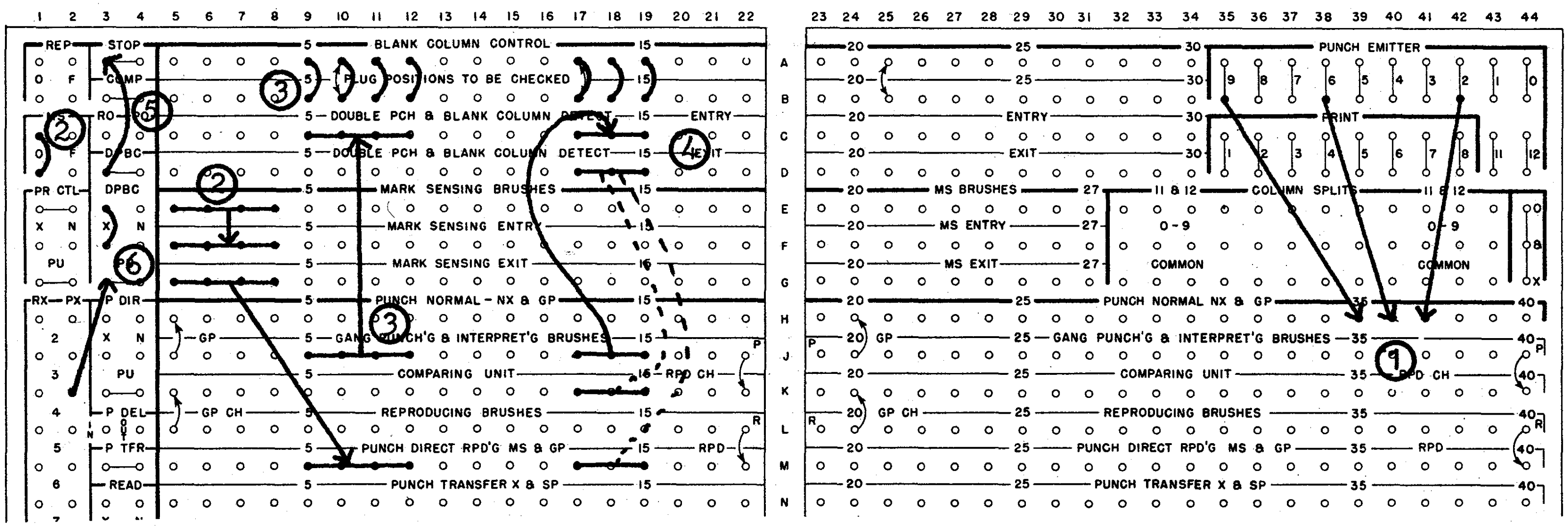

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Figure 7-20.—Special devices.

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 jack-plugged. 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.

BL COL DETECTION SWITCH—Used to verify summary punching and gangpunching operations.

COMPARING INDICATOR—A feature of the comparing unit that points out comparing positions that do not agree.

COMPARING UNIT—A device capable of examining two pieces of data and determining if they are equal or unequal.

DETAIL-MASTERSWITCH—Controls the effectiveness of the PX and RX circuits.

END PRINTING—Printing up to 8 digits across the end of a card.

FUNCTIONAL SWITCHES—Switches for varying machine operations.

GANGPUNCHING—The operation in which information contained in a master card is punched into succeeding detail cards.

MACHINE CONTROLS—Switches, keys, and lights that control card feeding and machine operations.

MARK SENSE BRUSHES—Brushes used for reading pencil marks on cards.

MARK SENSE SWITCH—When ON, converts the last 20 comparing positions to an amplifying unit; should only be on for a mark sensing operation.

MARK SENSING—Conversion of pencil marks to punched holes.

MASTER CARD PUNCHING SWITCH—Permits punching of mark sense data into the master card.

REPRODUCING—Taking all or any part of recorded data, and making an identical duplication.

REPRODUCING SWITCH—Synchronizes the reading and punching units.

RESET—To clear or return a unit to its normal starting position.

SEL REPD AND G.P. COMP SWITCH—Permits continuous feeding in the read unit; only ON for selective reproducing and gangpunch compare operation.

SELECTIVE REPRODUCING—Reproduction of only and X or NX card.

SUMMARY PUNCHING—Punching of accumulative information by a controlling factor.

X TRANSFER—Allows the reading of a column to be split between the 0 and 11 position, and directed to two different places.

CHAPTER 8

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 type 87, can process either numerical or alphabetic data. However, all collators, with the exception of the type 88, 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 type 88 collator differs considerably from others, it will be discussed separately.

COLLATOR, TYPE 85

The type 85 collator, shown in figure 8-1, is designed to perform all the functions previously mentioned. In addition, it has the

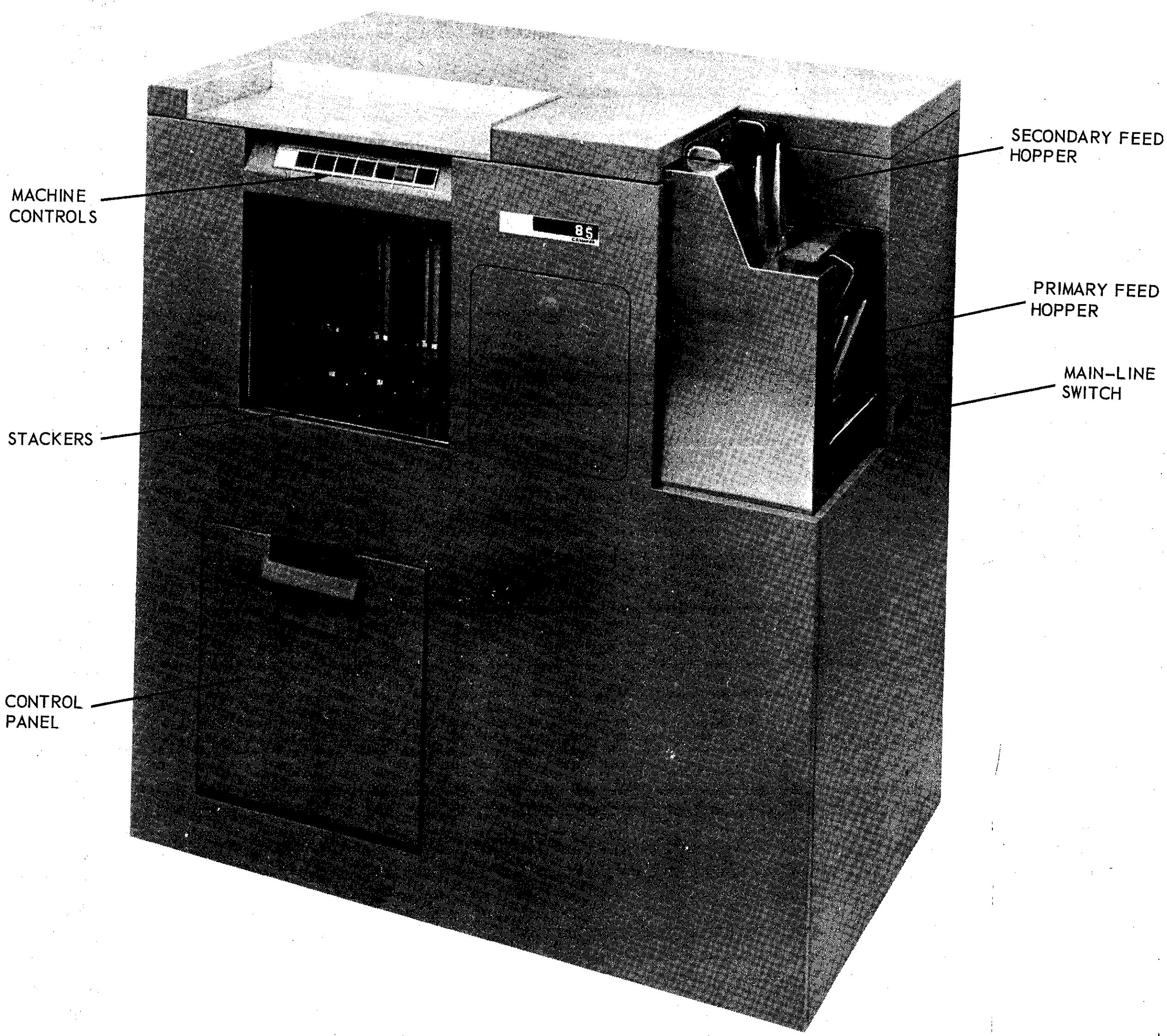

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Figure 8-1.—IBM Type 85 collator.

capacity for checking blank columns in cards fed from either hopper. Blank column detection can be performed separately or in conjunction with any other operation.

OPERATING FEATURES

Machine Controls

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 8-2.

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.

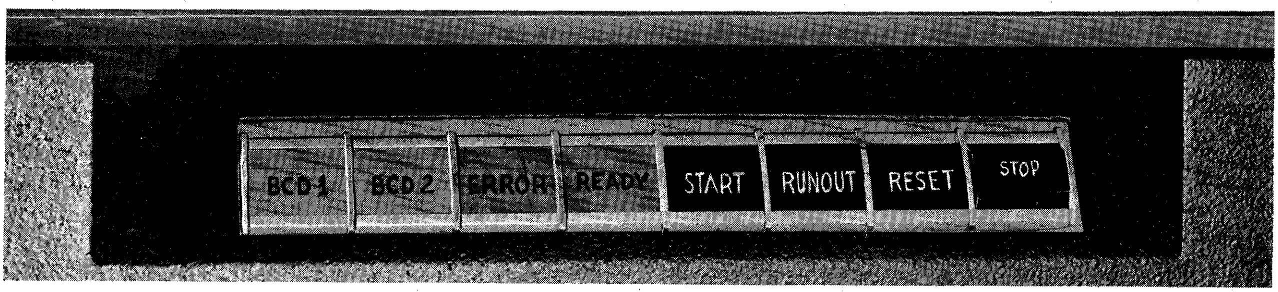

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Figure 8-2.—Machine controls.

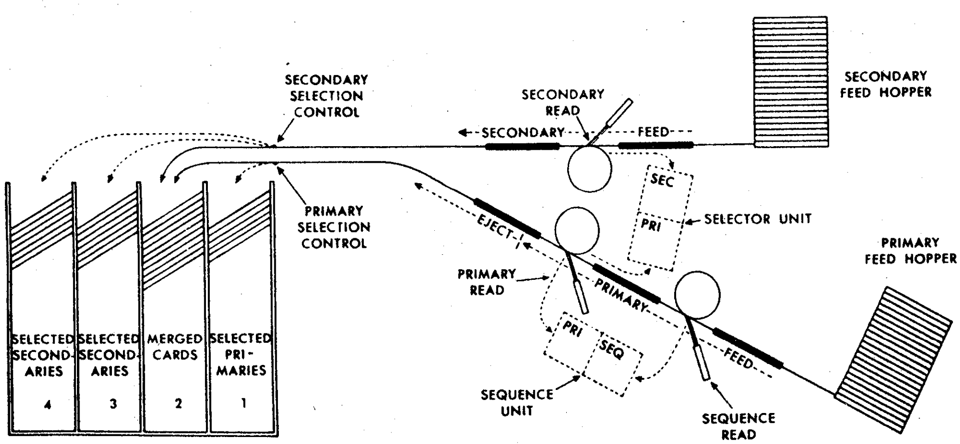

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Figure 8-3.—Card feed schematic diagram.

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 can be wired to read any columns of the card desired. 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.

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.

Schematic Diagram

Refer to figure 8-3. 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 the 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 8-4 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 8-4 and locate the particular hubs as they are described below.

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.

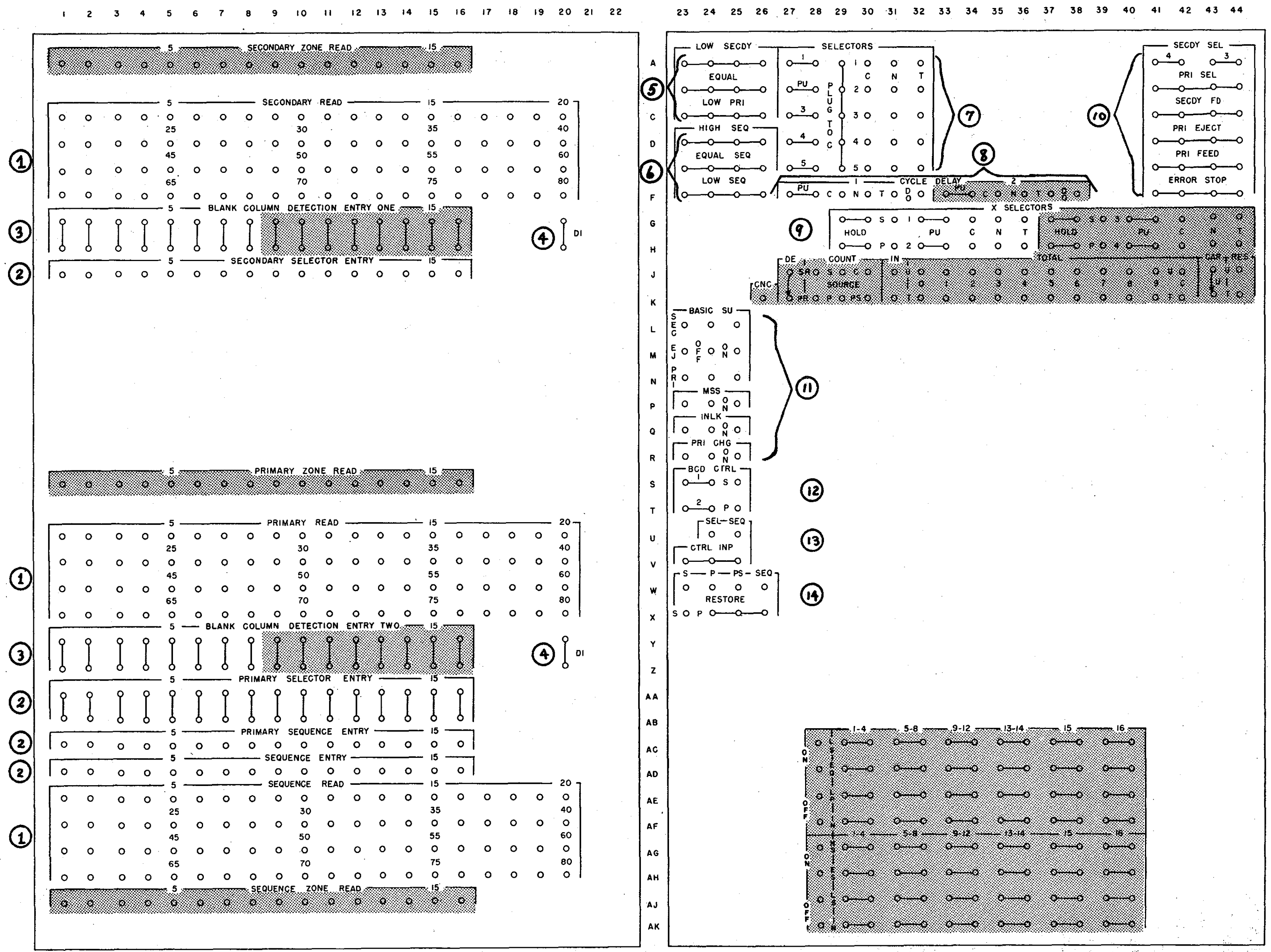

Figure 8-4. —Type 85 control panel.

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 de-activate 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 to 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 inpulse 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.

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.

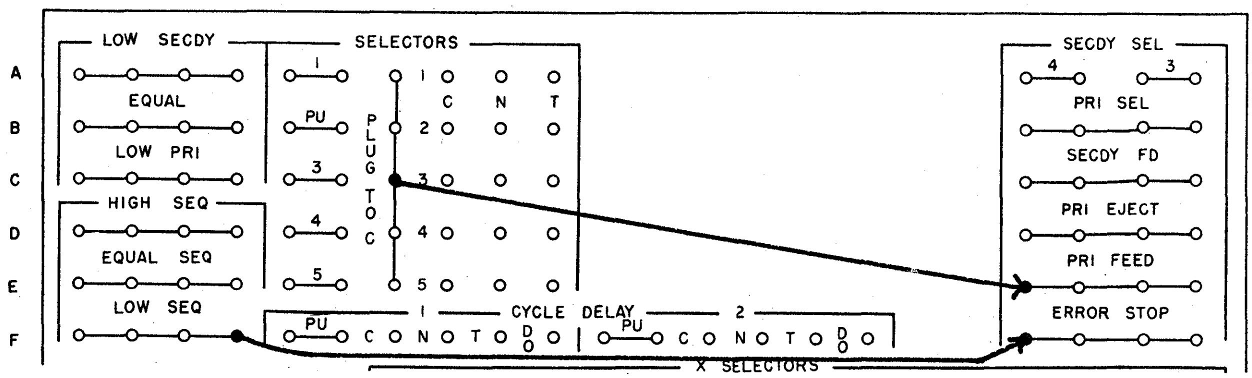

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Figure 8-5.—Checking sequence.

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 8-3, so that two cards feeding through the primary feed can be compared with each other. In operations such as merging or matching, secondary read

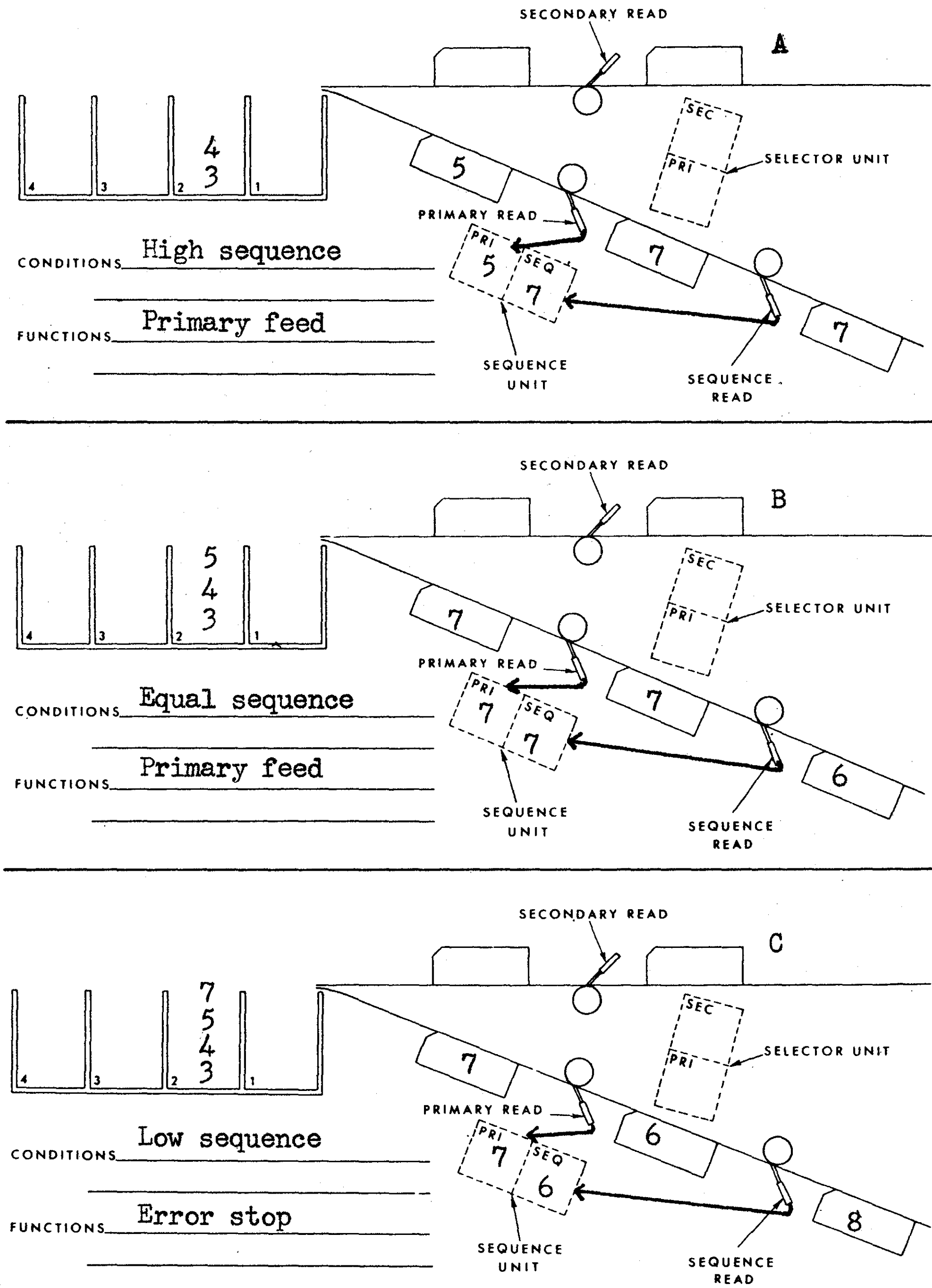

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Figure 8-6.—Checking sequence.

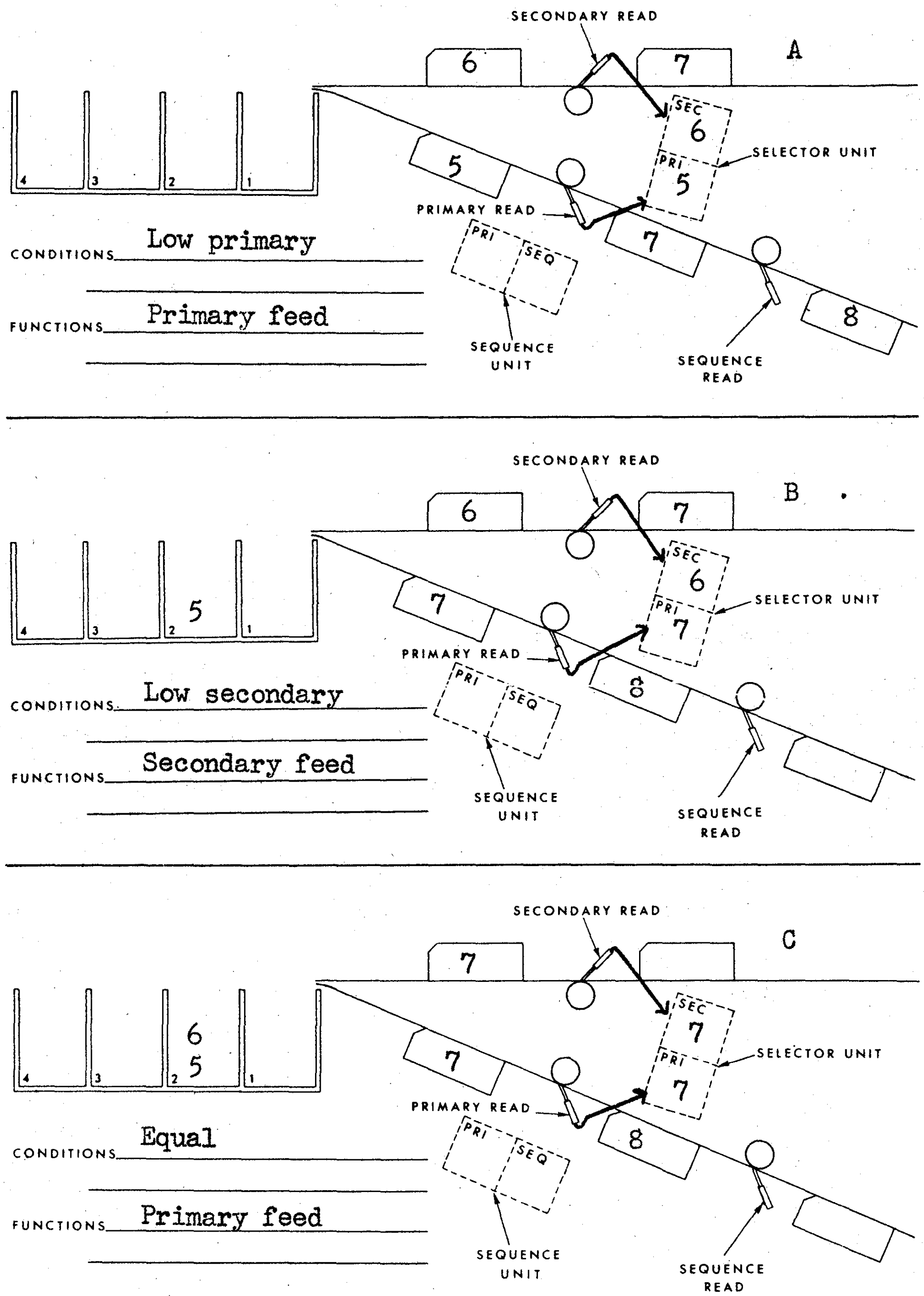

Figure 8-7.—Merging, feeding from one feed at a time. 49.59

is usually wired to secondary selector entry, and primary read is wired to primary selector entry. The selector unit, as illustrated in figure 8-3, 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 comparing units. Split wiring is avoided by wiring primary read to primary selector entry,

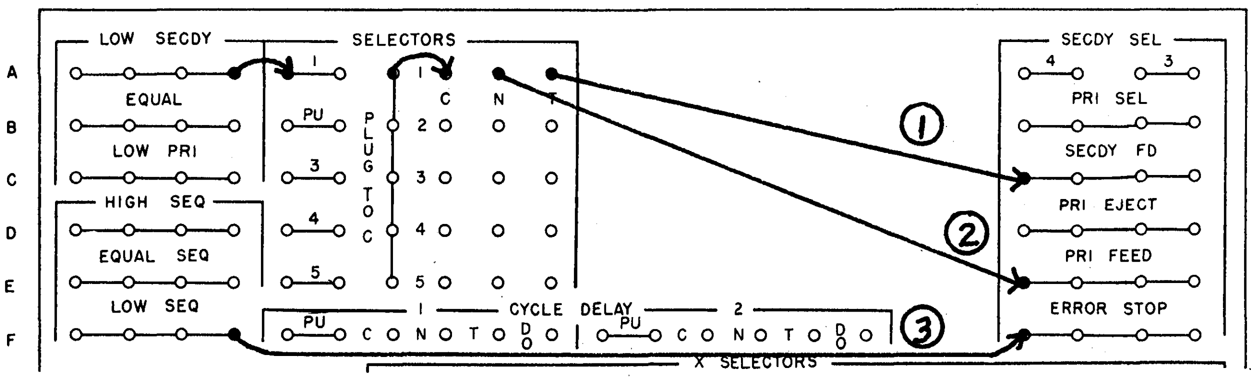

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Figure 8-8.—Merging, feeding from one feed at a time.

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 8-5, 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 8-6. 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 8-7 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.

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

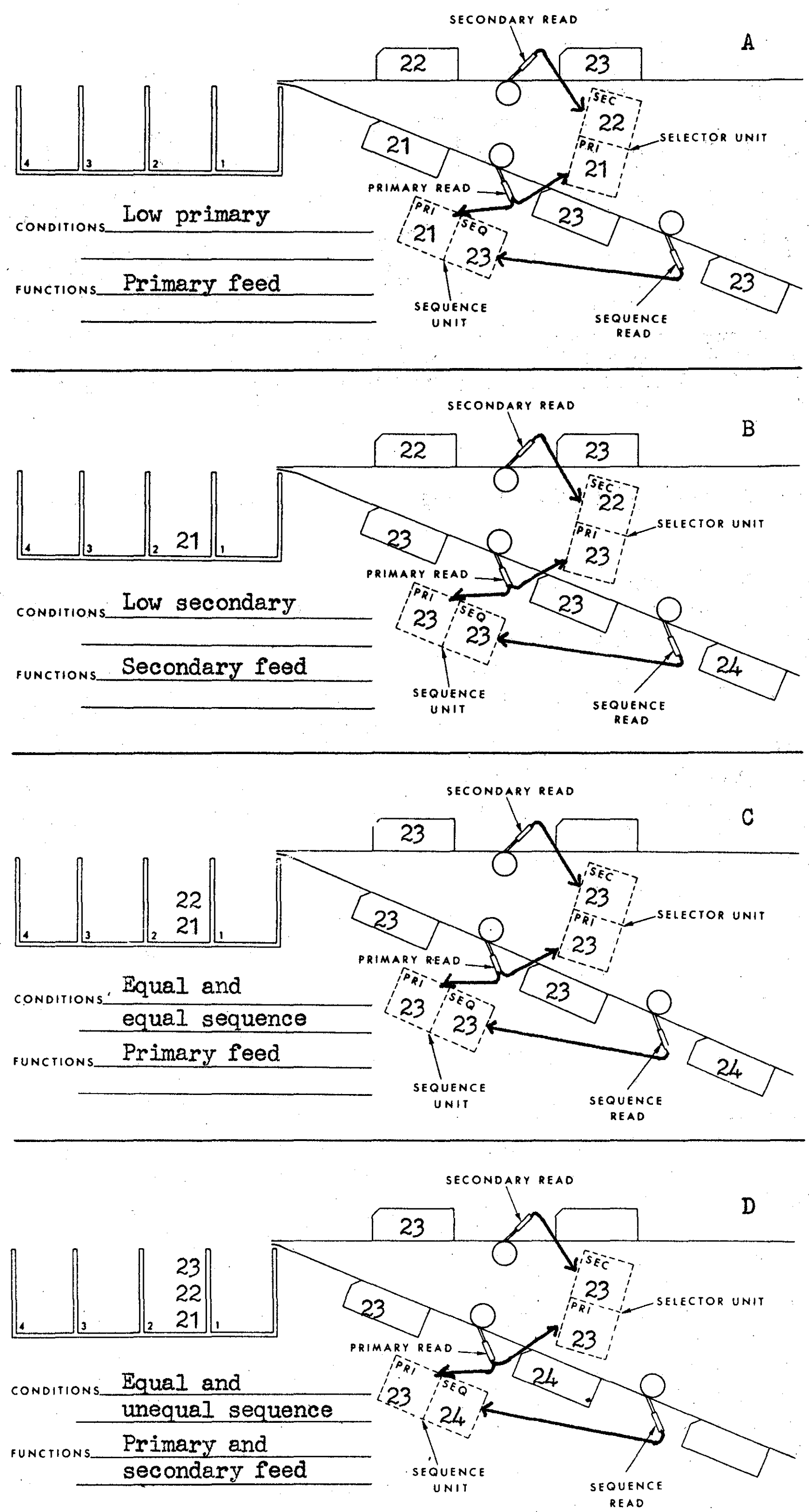

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Figure 8-9.—Merging, feeding from both feeds simultaneously.

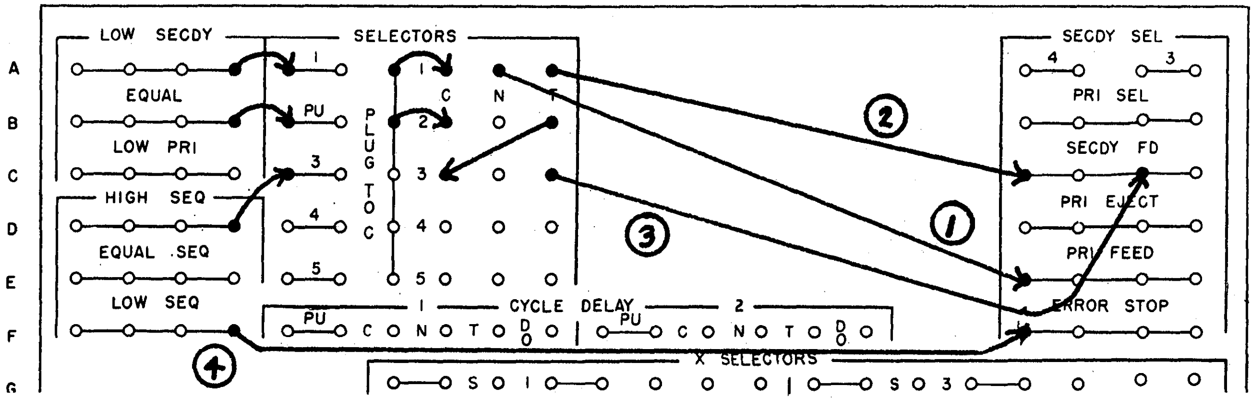

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Figure 8-10.—Merging, feeding from both feeds simultaneously.

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 8-7. One method is illustrated in figure 8-8.

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 8-9 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 8-10.

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

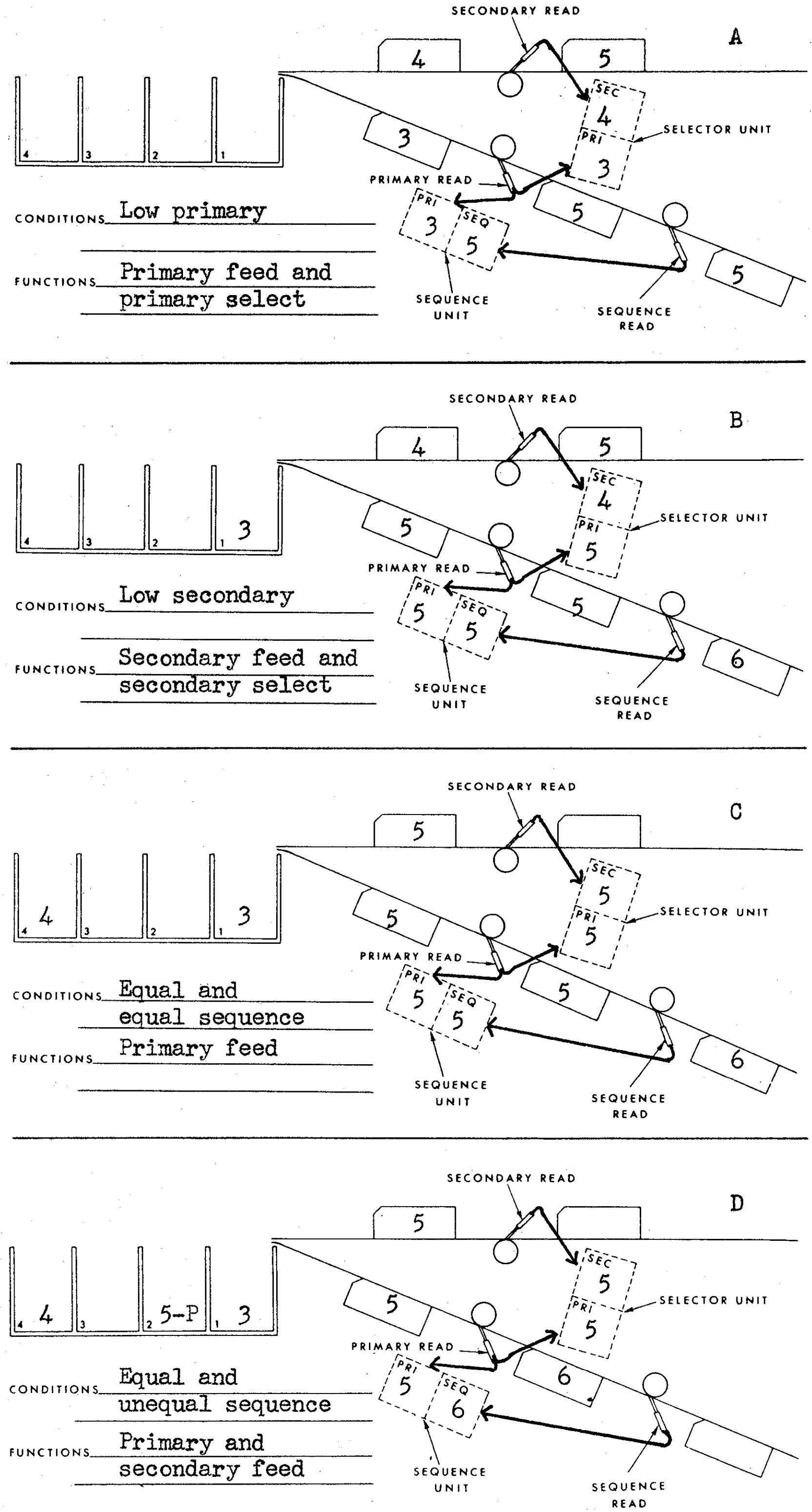

Figure 8-11.—Merging with selection, single secondaries. 49.63

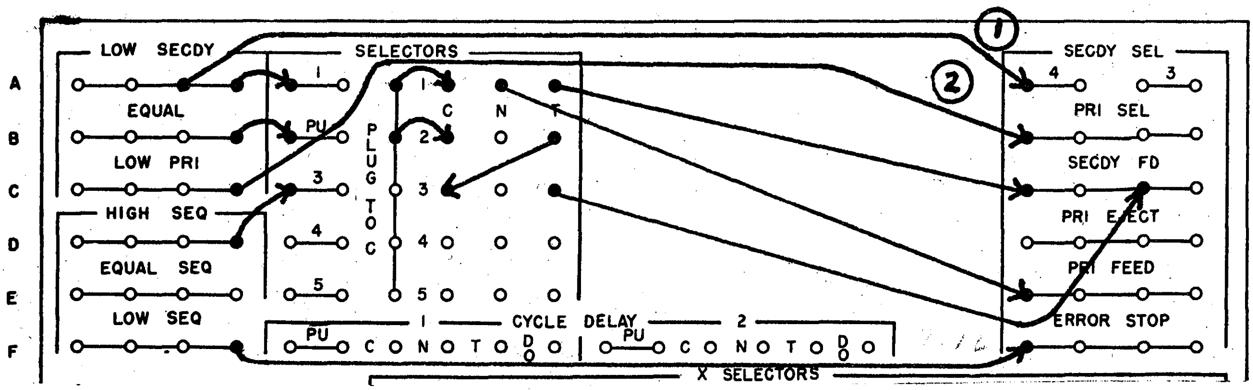

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Figure 8-12.—Merging with selection, single secondaries.

transferred sides of selectors 2 and 3 to secondary feed. This causes a secondary card to feed on an equal condition in the selector 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 8-11 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 8-12. 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 read 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 8-13 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

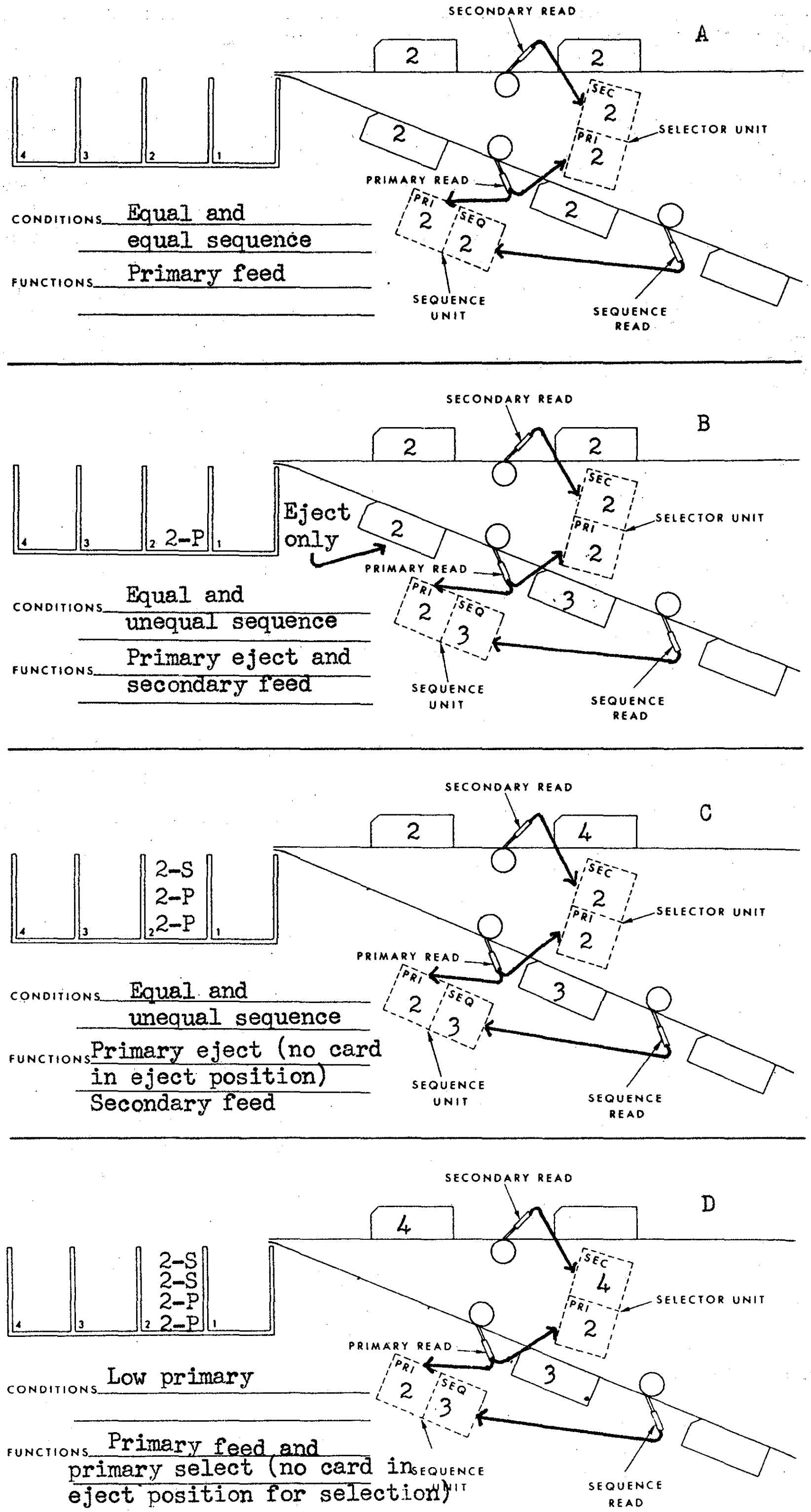

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Figure 8-13.—Merging with selection, multiple secondaries.

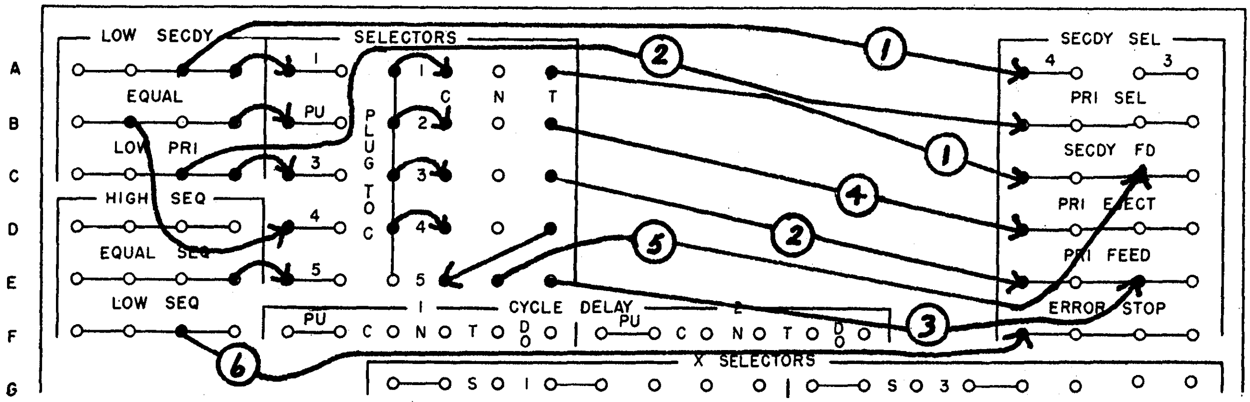

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Figure 8-14.—Merging with selection, multiple secondaries.

primary eject causes the last equal card from 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 8-14.

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 8-14 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 figures 8-12 and 8-14 can be adapted for matching by adding a wire from equal to secondary select 3. Thus, matched secondary cards will fall into 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. 8-4, 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 8-15, 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.

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

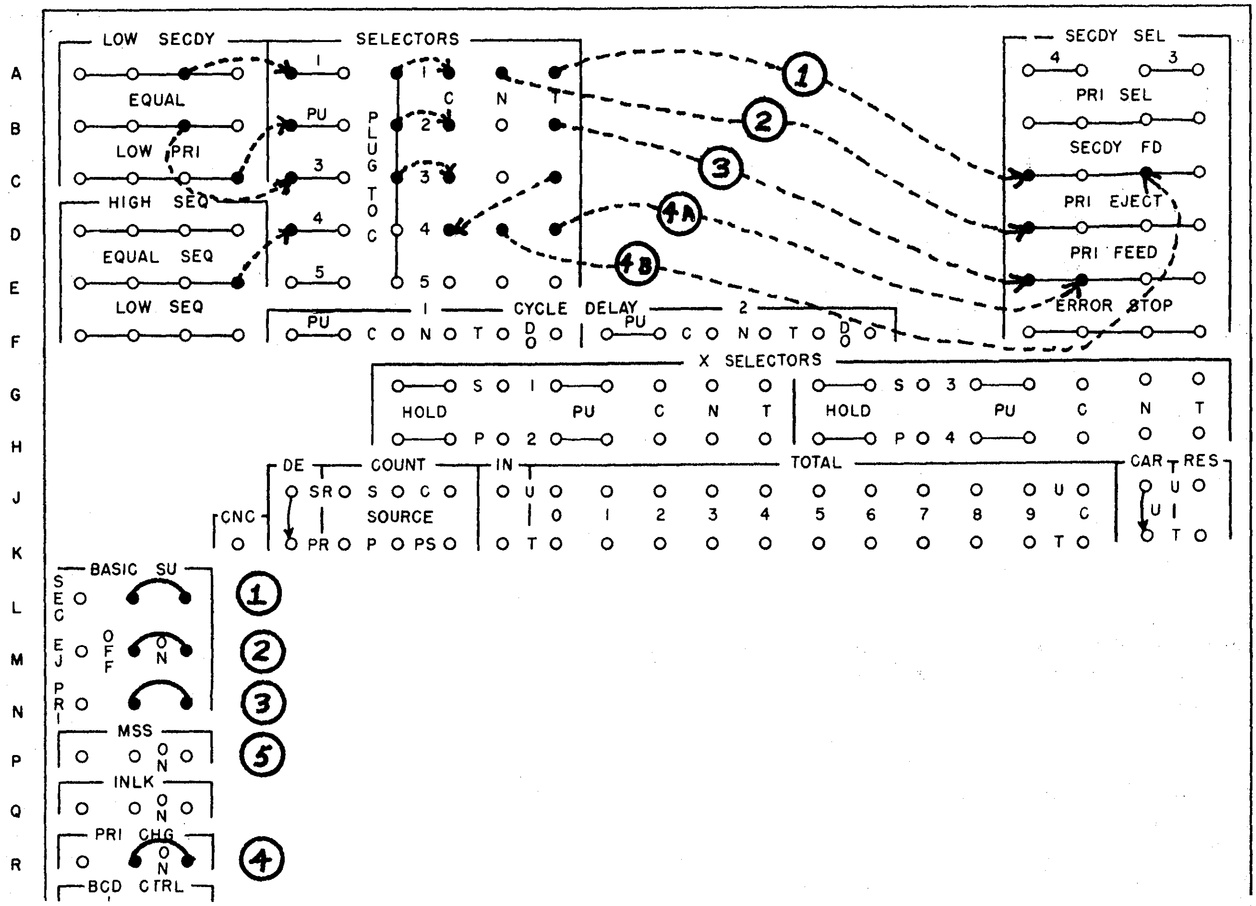

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Figure 8-15.—Basic setup.

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 8-16.

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 pocket 1, and NX-80 primary cards will merge 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

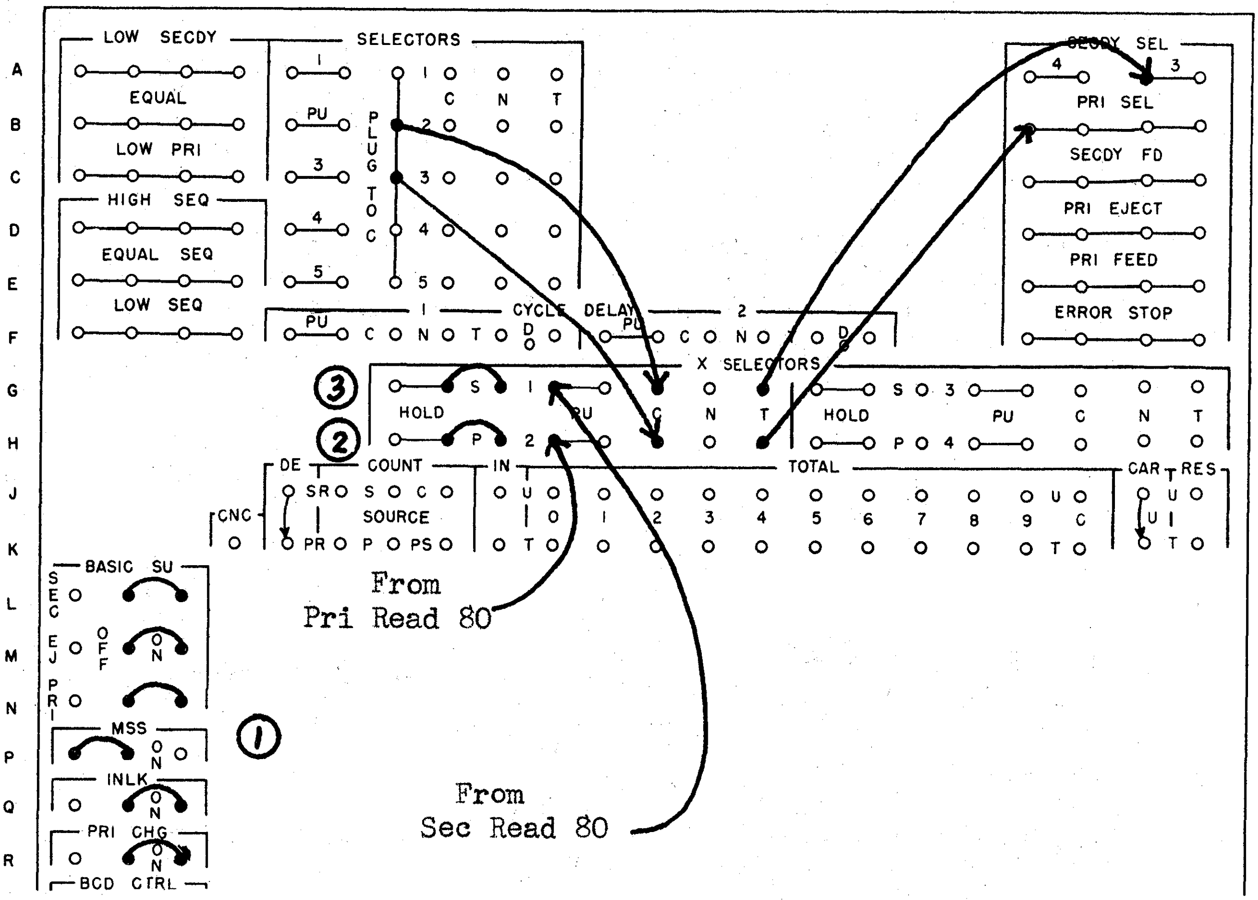

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Figure 8-16.—X selection.

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, and NX-80 secondary cards will merge into 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 8-17, 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 8-18. 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

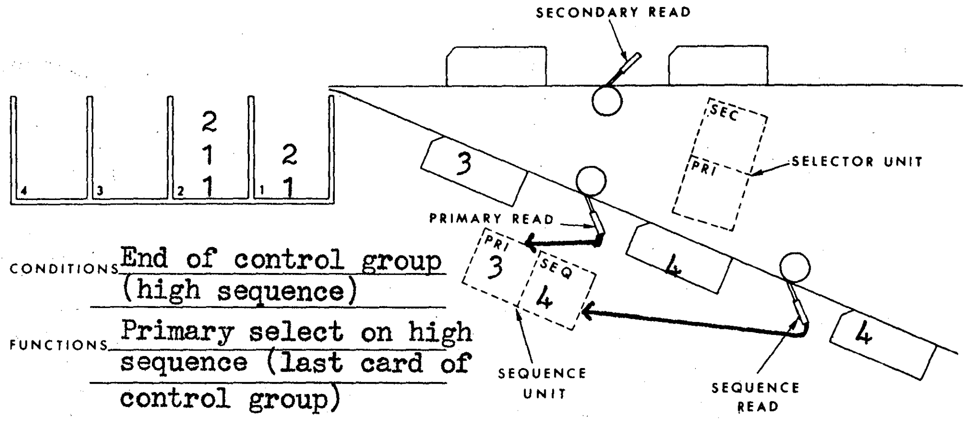

Figure 8-17.—Selecting the last card of a group.

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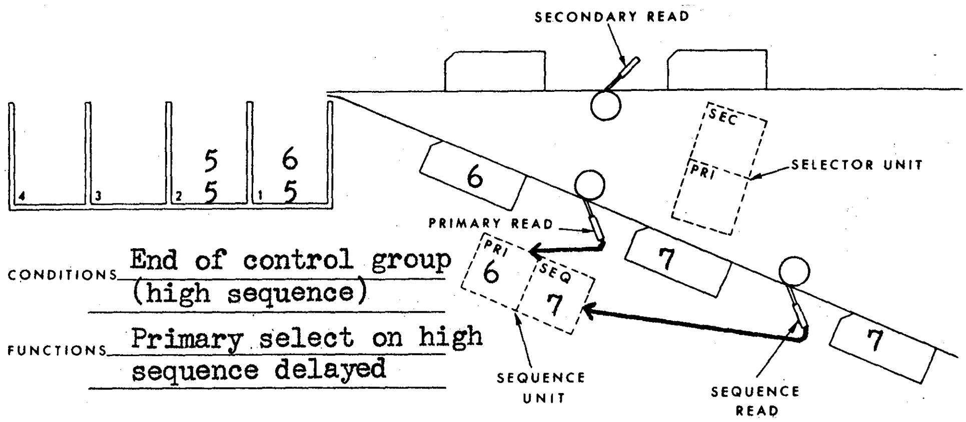

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Figure 8-18.—Selecting the first card of a group.

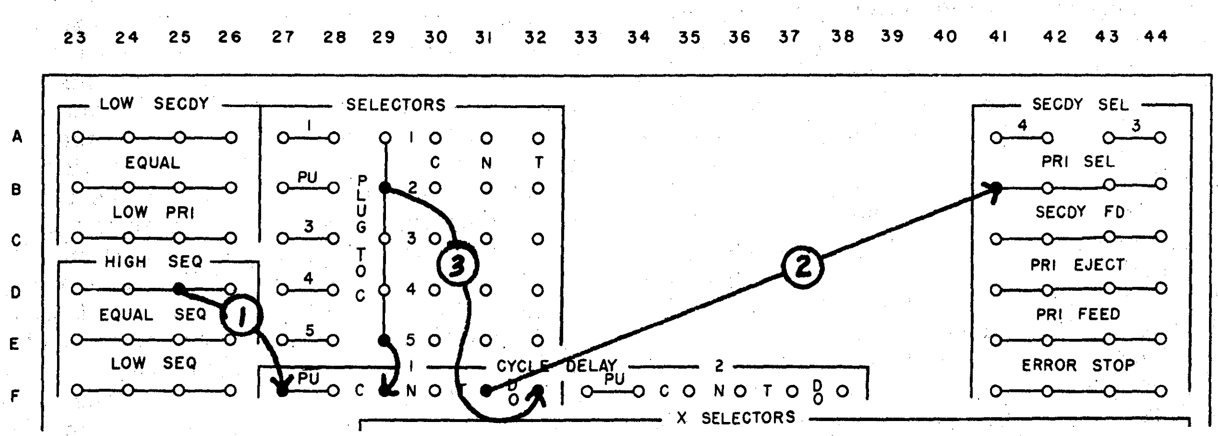

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Figure 8-19.—Selecting the first card of a group.

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 8-19.

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.

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 8-20, 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 8-21.

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 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 wired to the BCD pickup hub to hold that unit between primary feed cycles.

In figure 8-22, 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.

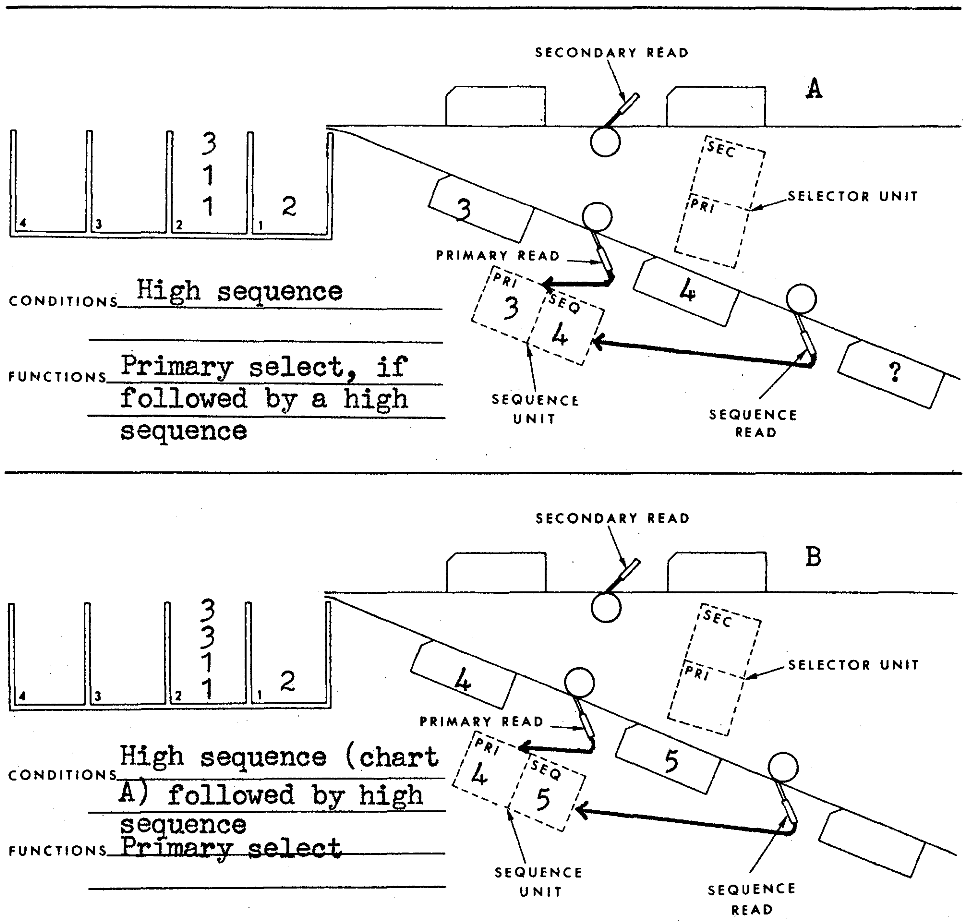

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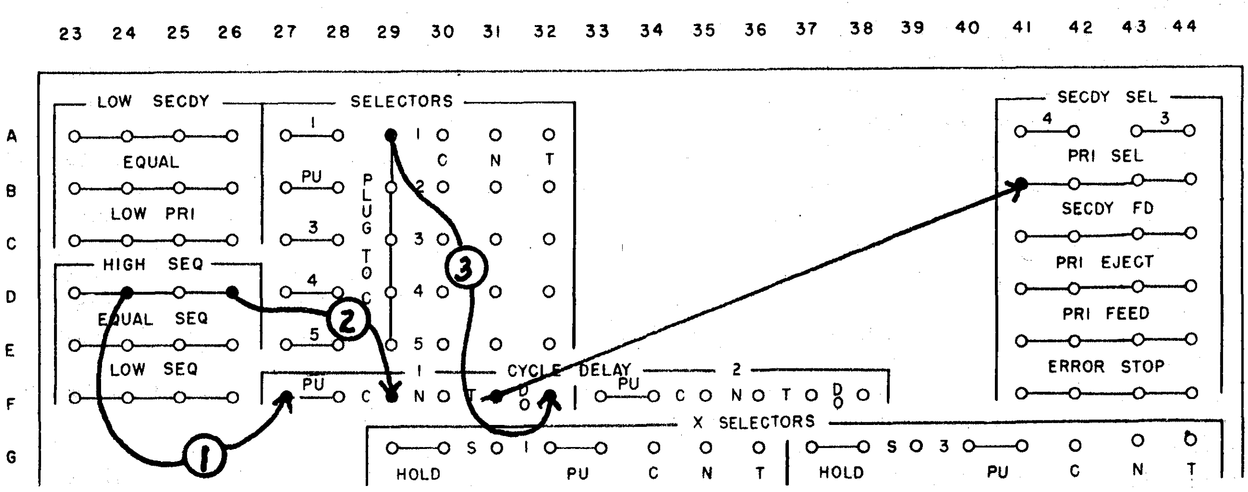
Figure 8-20.—Selecting single card groups.



49.73

Figure 8-21.—Selecting single card groups.

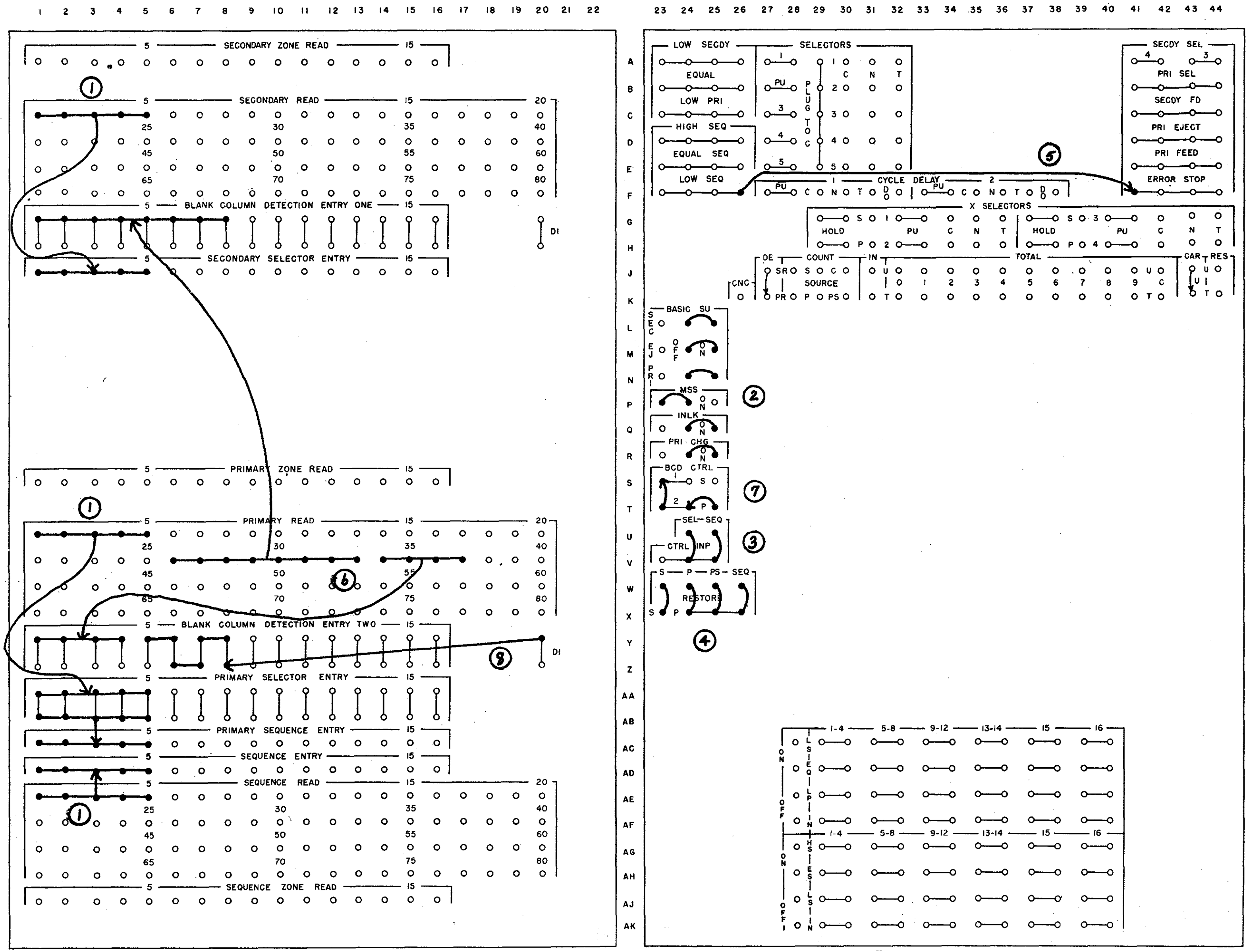


Figure 8-22.—Merging and blank column detection.

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 operation 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 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:

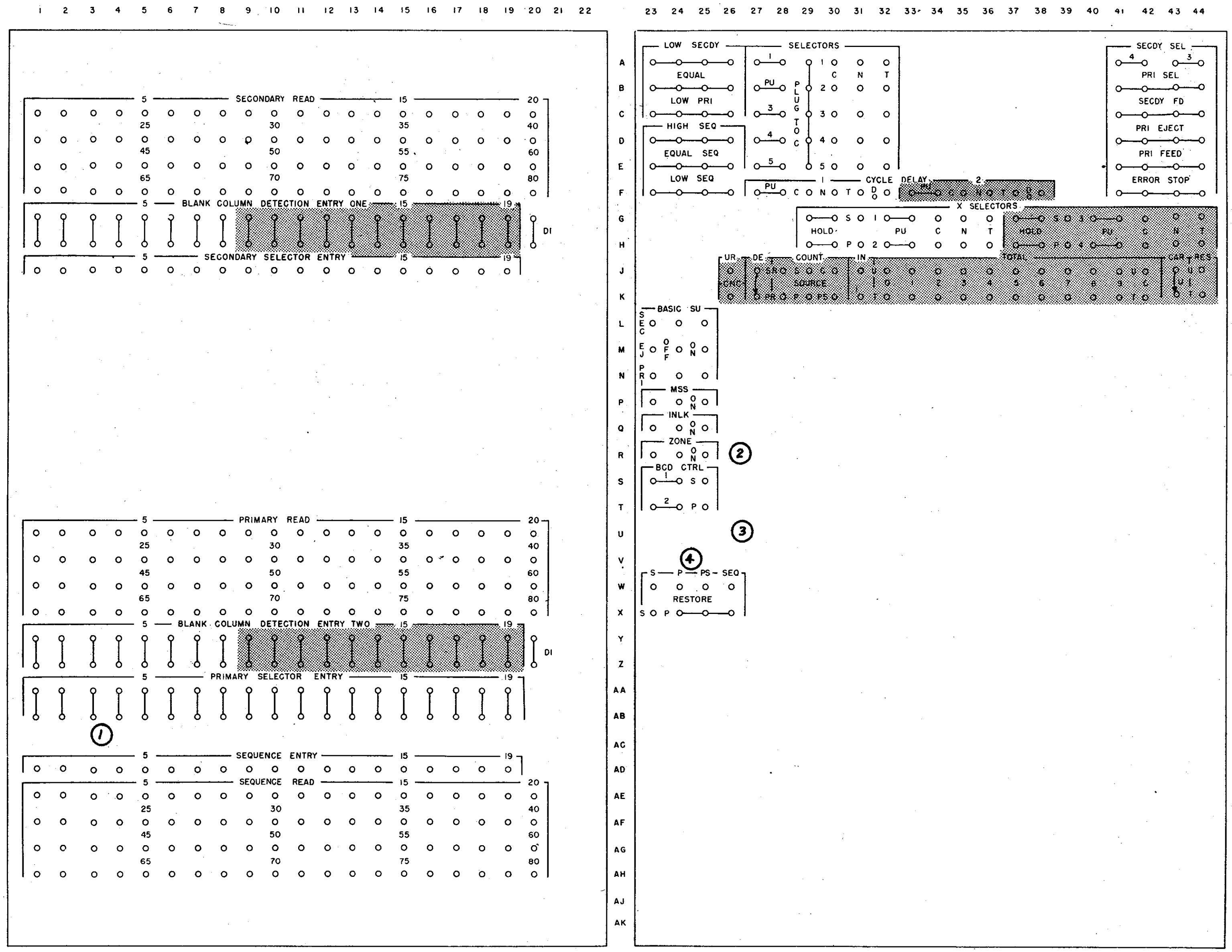
1. Blank column
2. Special characters in the following order:

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 8-23. 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.



49.75X

Figure 8-23. —Type 87 control panel.

4. The PS hub is inactive. Primary selector magnets and primary sequence magnets are restored when the restore P hub impulsed.

COLLATOR, TYPE 88

The IBM type 88 collator, pictured in figure 8-24, performs all operations previously de-

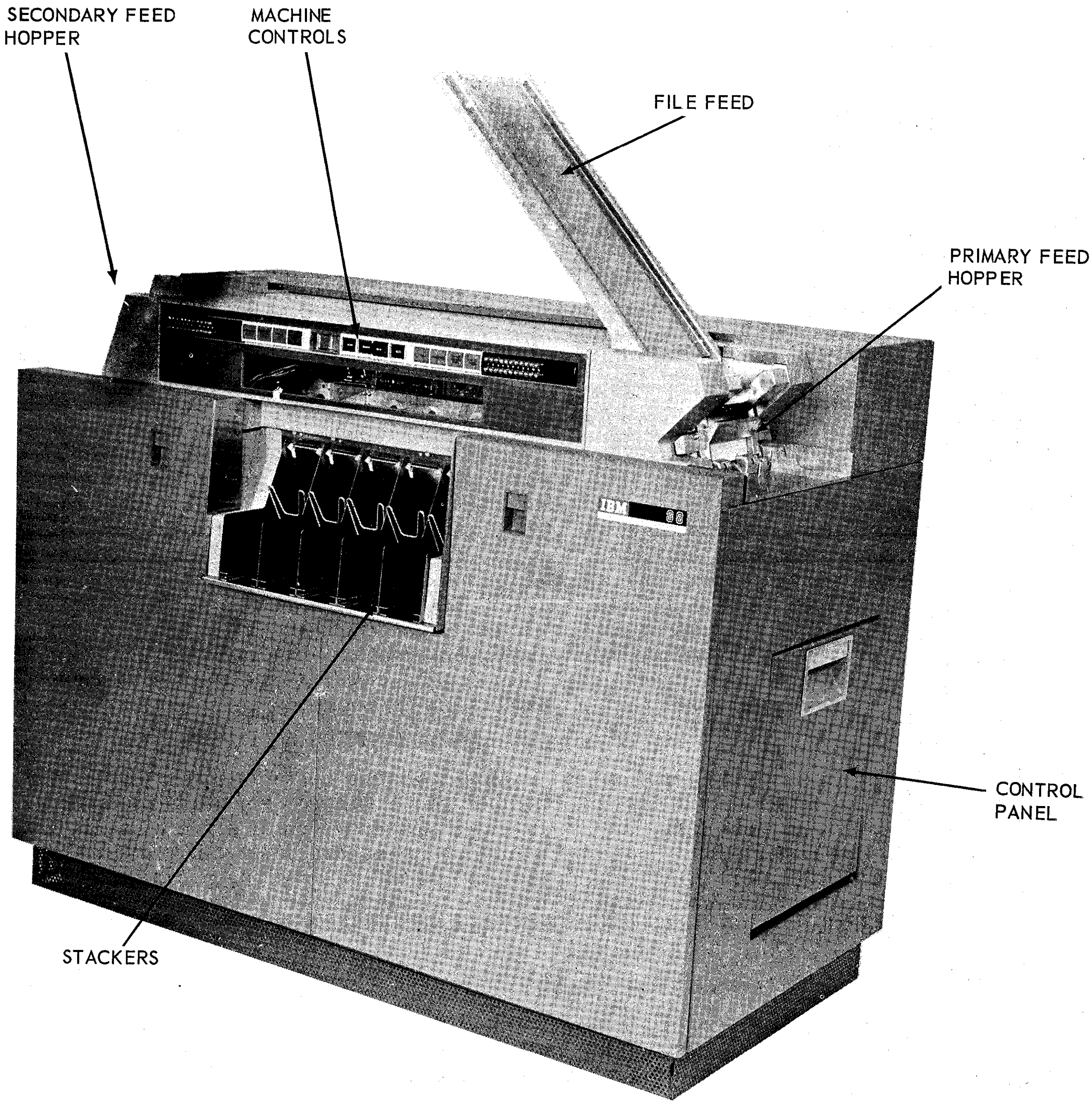


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Figure 8-24.—IBM Type 88 collator.

scribed 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

Machine Controls

The switches and keys perform the same functions as described for the type 85 collator. The lights differ somewhat, as indicated in figure 8-25, 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 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.

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 throgh 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

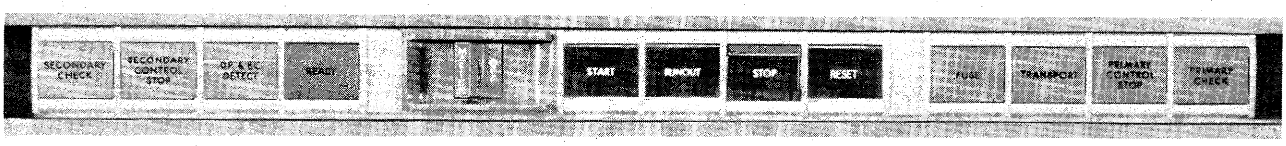

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Figure 8-25.—Machine controls.

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 8-26 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 8-27 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 ae essentially involved. These hubs can be located by reference to figure 8-27. 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.

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

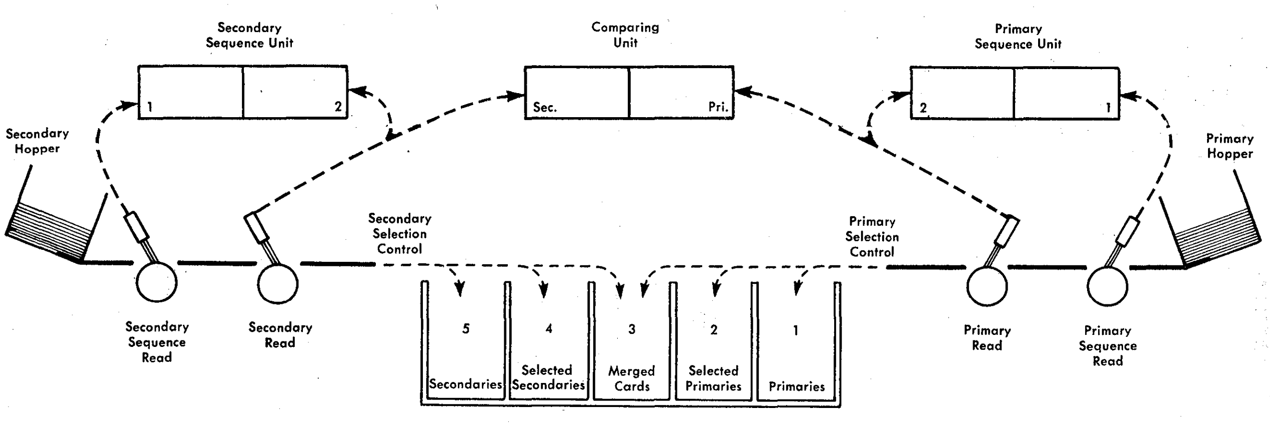

Figure 8-26.—Card feed schematic diagram.

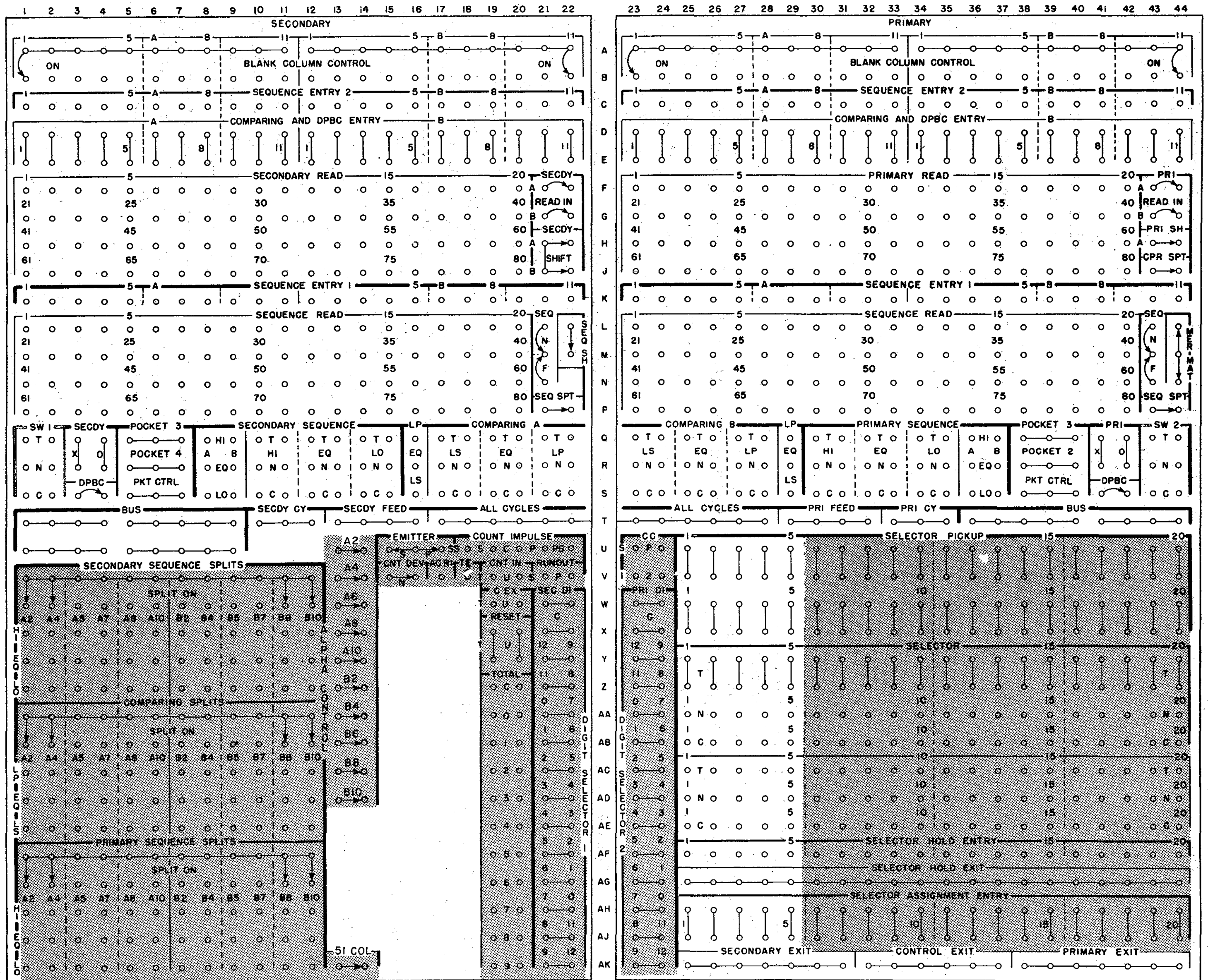

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Figure 8-27. —Type 88 control panel.

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 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 8-28, 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 8-26, 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.

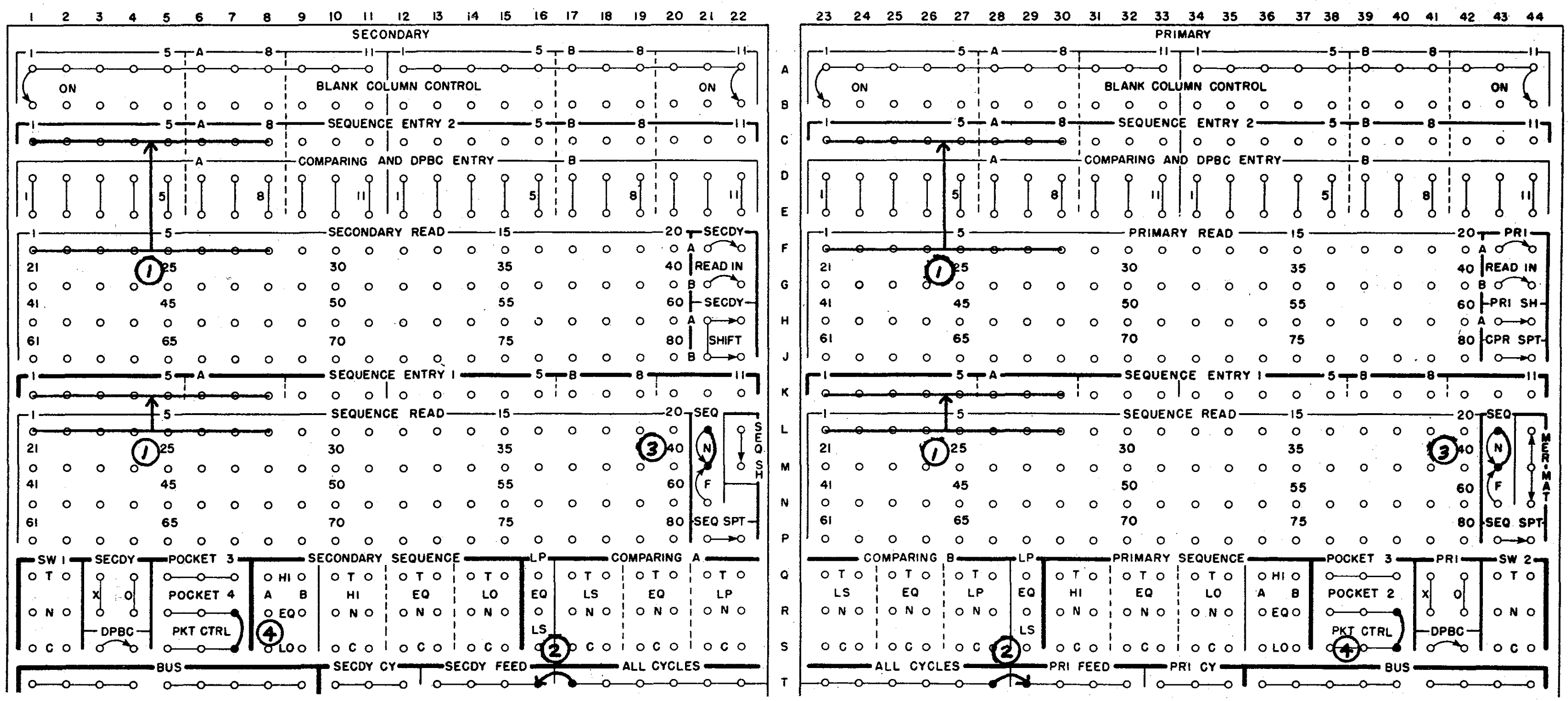

Figure 8-28. —Checking sequence.

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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 8-29 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 8-30.

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 8-31.

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 directed 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

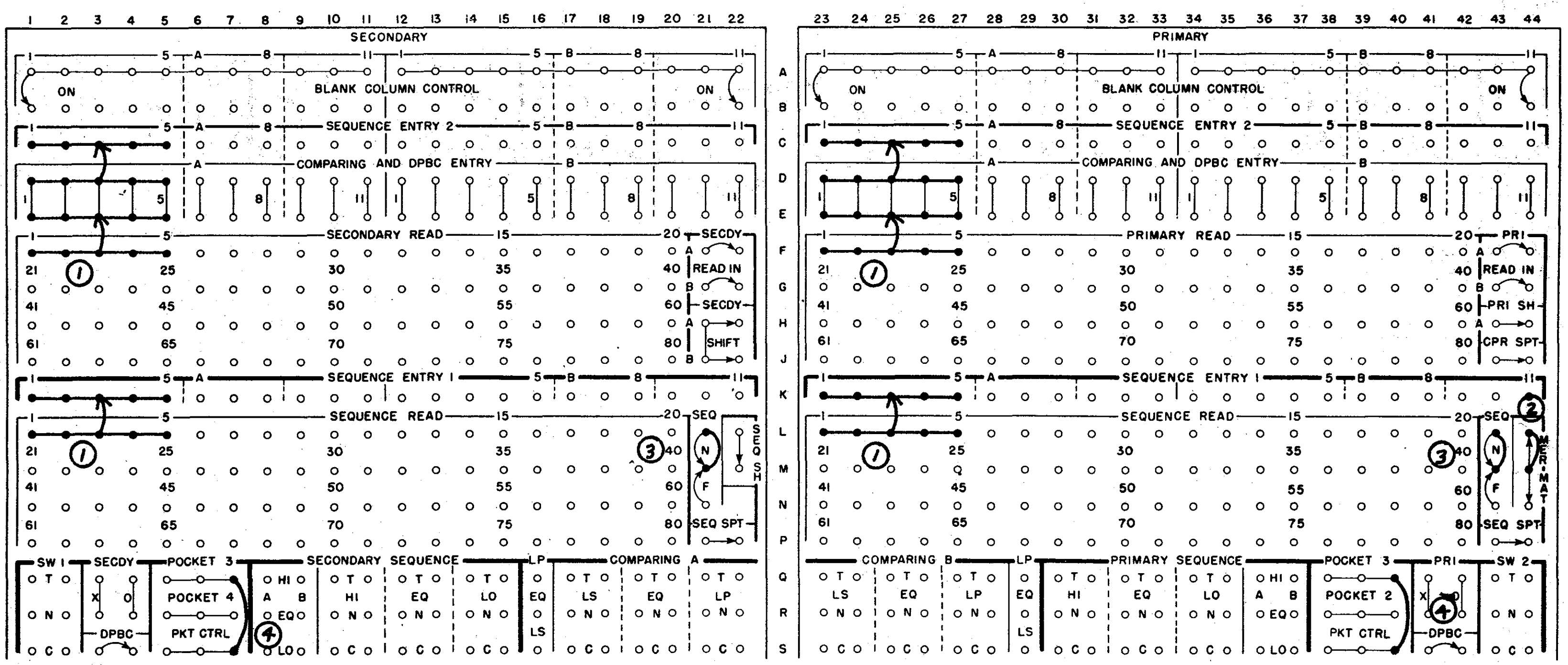

Figure 8-29. —Merging.

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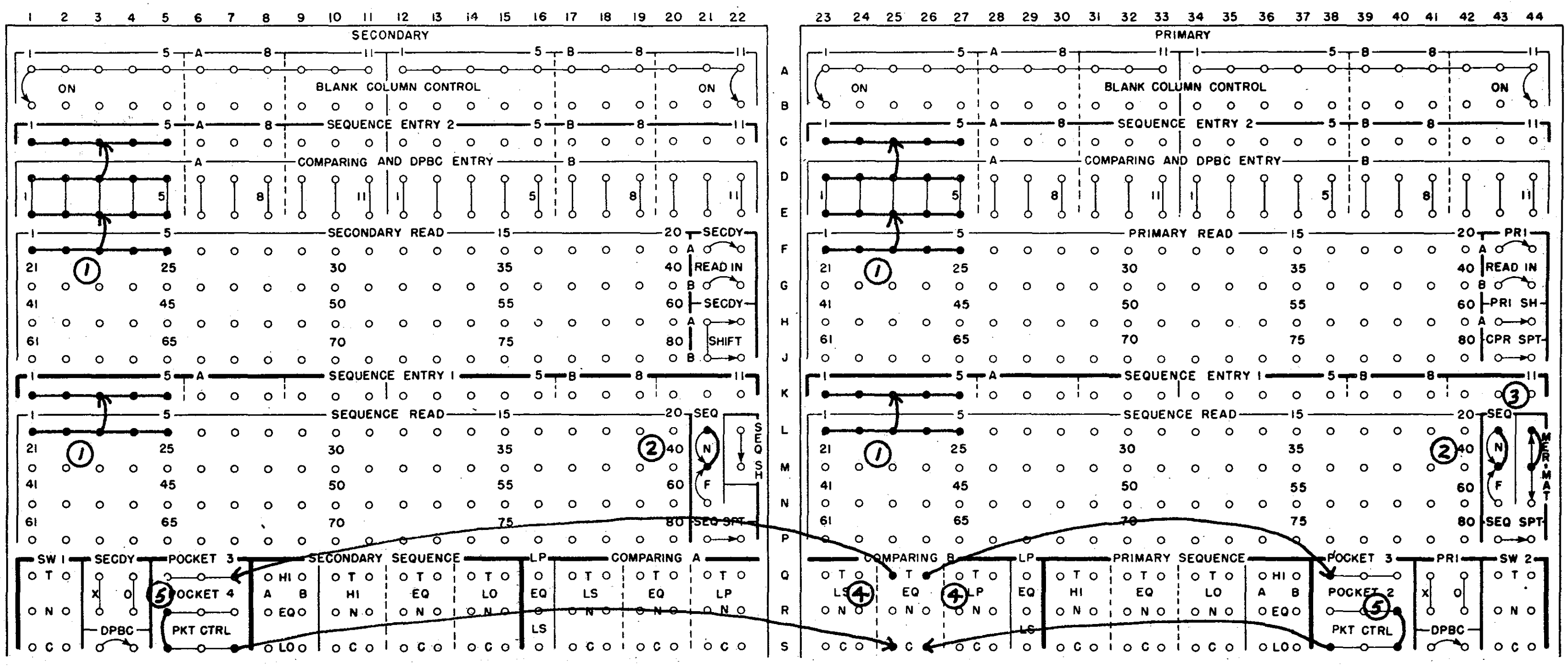

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Figure 8-30. —Merging with selection.

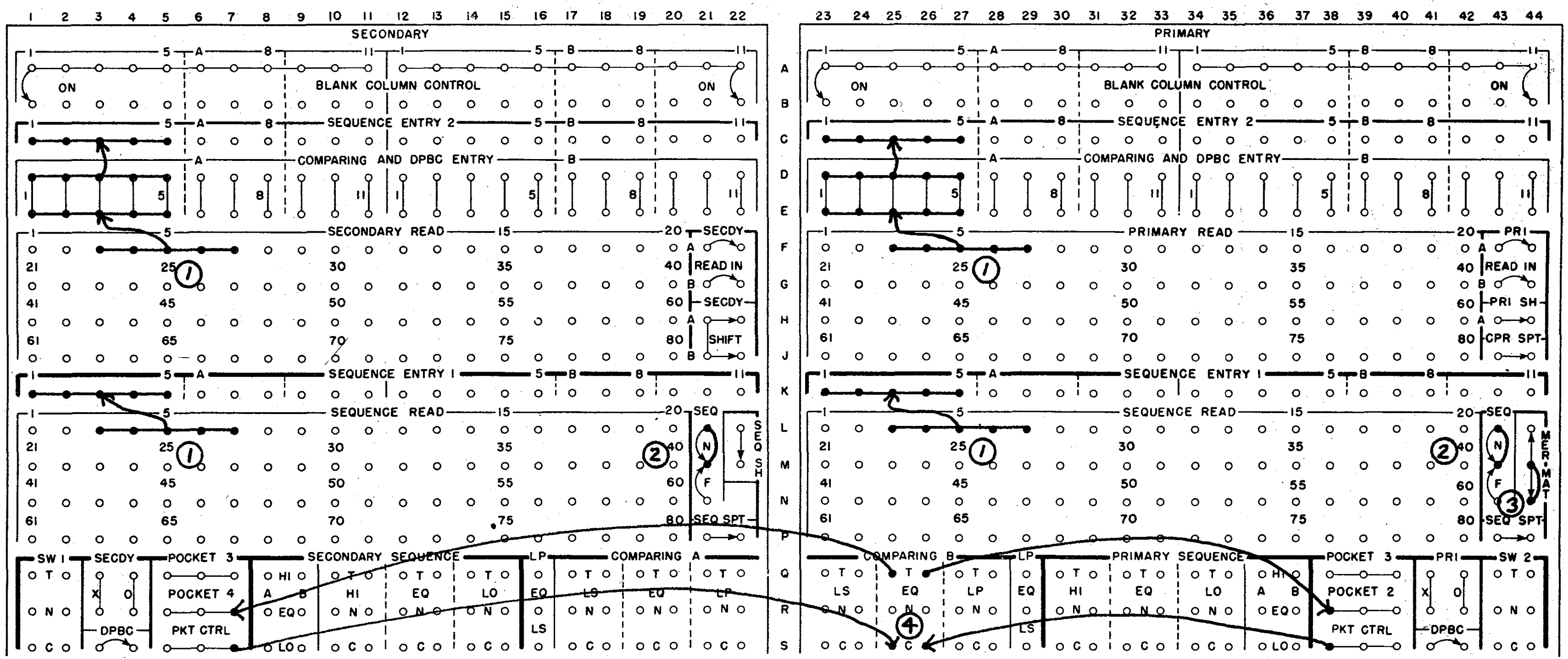

Figure 8-31. —Matching.

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of selectors. Control panel hubs which are used to control selectors are illustrated in figure 8-32.

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.

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 8-33 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 8-26, 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.

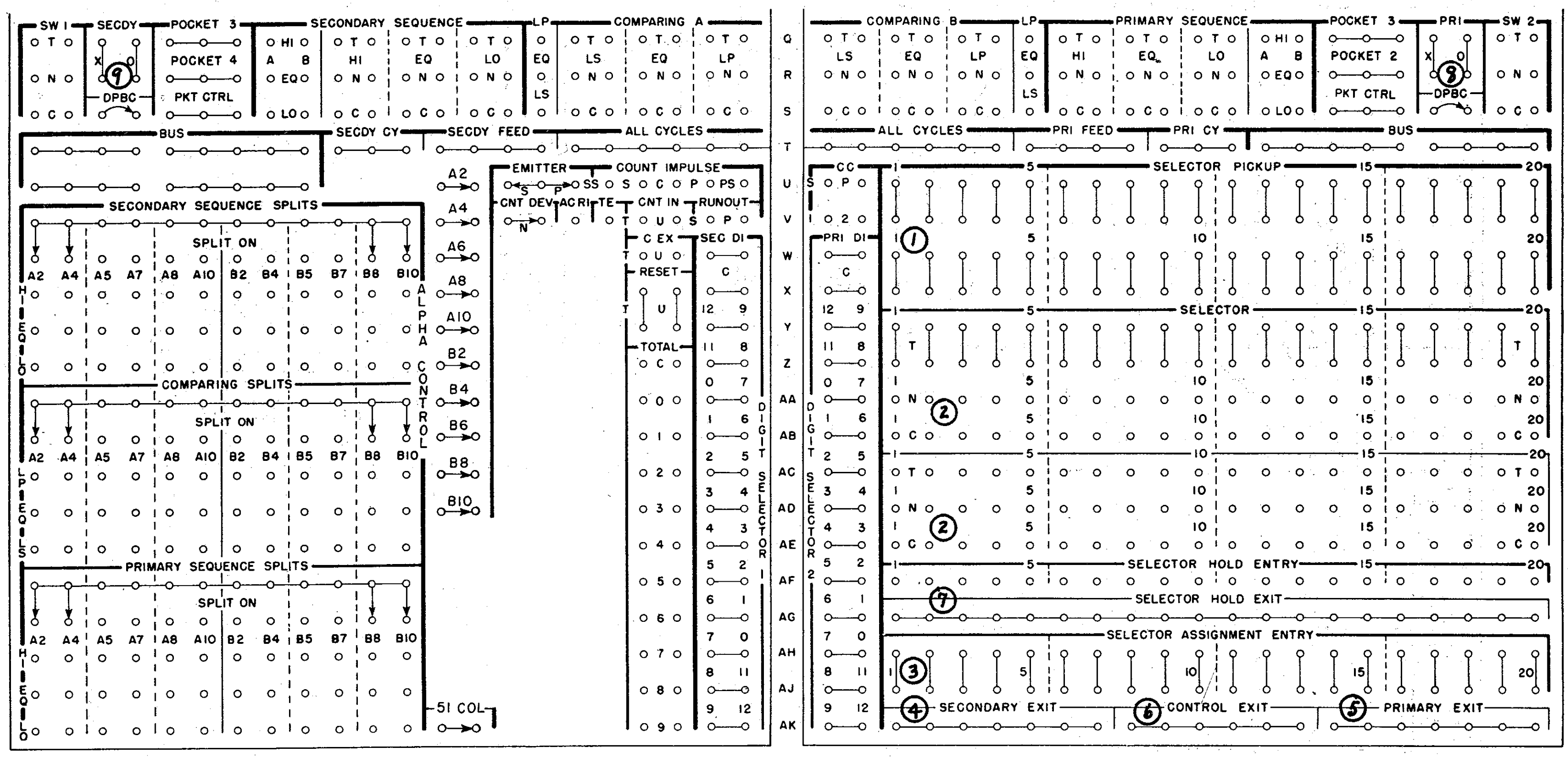

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Figure 8-32.—Hubs used for card selection.

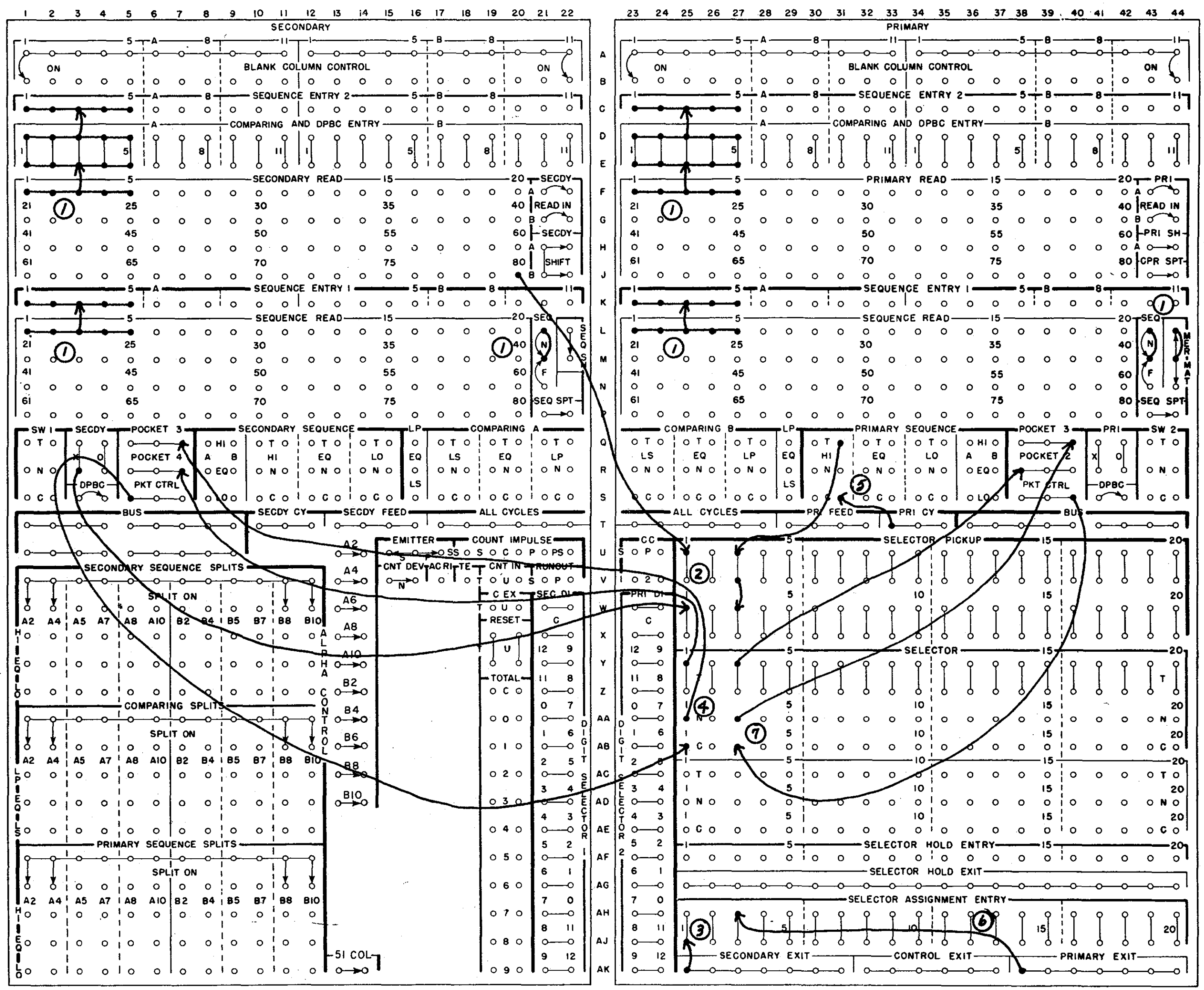

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Figure 8-33. —Card selection.

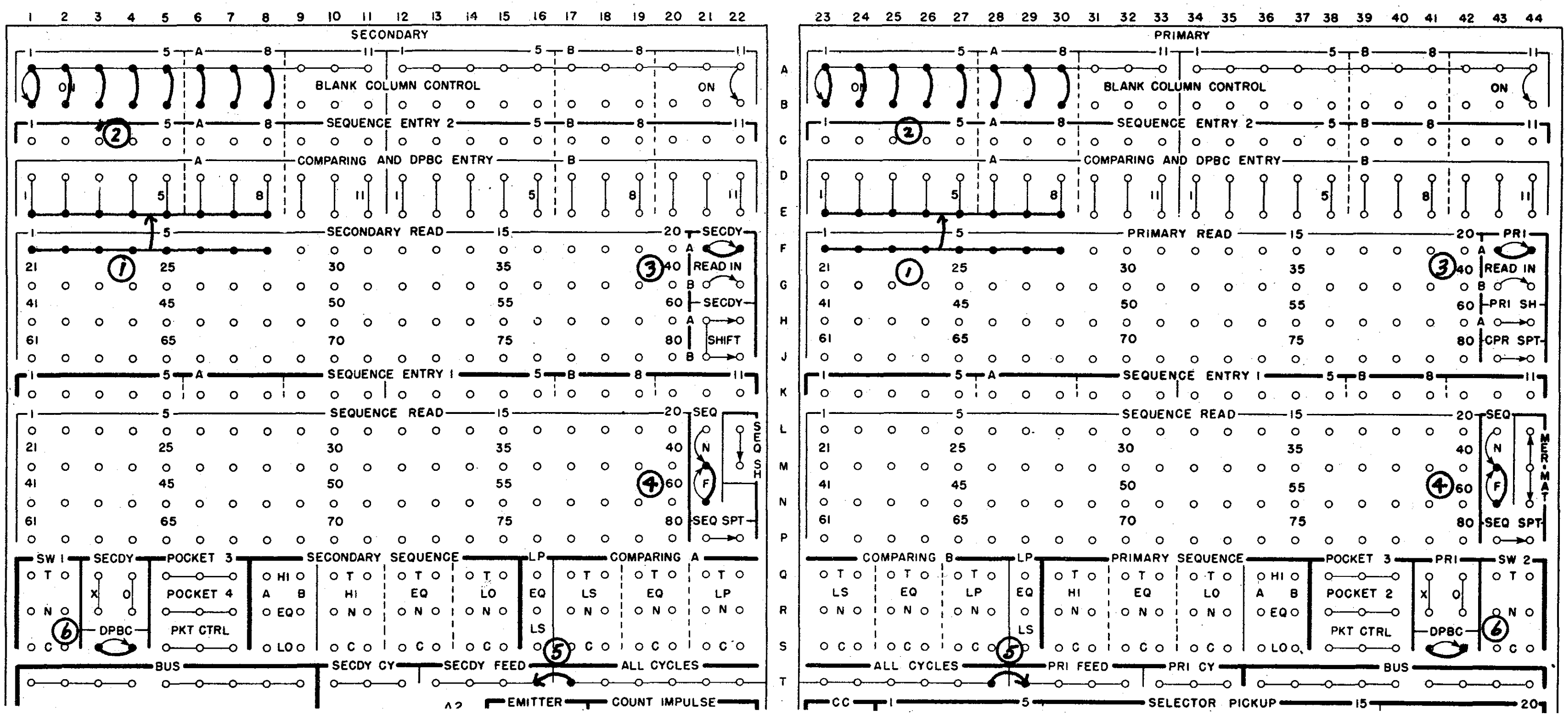

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Figure 8-34. —Editing.

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 conjuncton 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 8-34.

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.

ALL CYCLES—An impulse that is emitted on each machine cycle, except when the machine is in an error mode.

ALPHABETIC COLLATING DEVICE—Permits comparison of alphabetic characters as well as numeric characters.

BASIC SETUP SWITCHES—Switches that when wired, replace functional wiring for card feeding under certain conditions.

BLANK COLUMN DETECTION—A device capable of determining if a particular card column is punched or blank.

CARD SELECTION—The process of identifying certain cards and removing them from the file without disturbing the sequence of the others.

COLLATOR—A machine designed to compare two sources of data to determine if they are identical; if sources are dissimilar, the collator will determine which is lower.

COMPARING SPLIT SWITCH—A means of using the primary and secondary comparing units together as one unit.

CONTROL INPUTS—Allow test impulses to enter the comparing unit to determine the reading of the unit.

CYCLE DELAY—A type of selector unit that operates only on the cycle following the one on which it is picked up and that once transferred, does not return to normal until an impulse is received by the dropout hub.

DIRECT IMPULSE—An impulse used to deactivate the unused blank column detection entry hubs.

FUNCTIONAL ENTRIES—Entry for impulses to control card feeding, selection, and ejection.

HIGH SEQUENCE—A condition indicating that the reading in the sequence side of the sequence unit is higher than the reading in the primary side of the sequence unit.

INTERLOCK SWITCH—Insures proper selection on run out of either feed.

LOW PRIMARY—The reading in the primary side of the selector unit is lower than the reading in the secondary side of the selector unit.

LOW SECONDARY—The reading in the secondary side of the selector unit is lower than the reading in the primary side of the selector unit.

LOW SEQUENCE—A condition indicating that the reading in the sequence side of the sequence unit is lower than the reading in the primary side of the sequence unit.

MATCHING—Searching two files of cards for corresponding information; selecting those that agree from those that disagree.

MERGING—Combining two files of cards that have already been arranged in sequence.

MERGING WITH SELECTION—Combining two files of cards with the option of selecting certain cards.

PLUG TO C—An impulse available during each machine cycle; used for feeding and selection of cards.

PRIMARY CHANGE SWITCH—Conditions the primary and secondary feed switches depending on primary card control change.

PRIMARY CHECK LIGHT—Identifies a feed failure in the primary feed of the 88 collator.

RESTORE—Permits the clearing of either the primary or secondary comparing unit to allow new readings to enter.

SECONDARY CHECK LIGHT—Identifies a feed failure in the secondary feed of the 88 collator.

SELECTOR HOLD—A means of holding the selector in a transferred state.

SELECTOR UNIT—Normally used to compare the reading of a card in the secondary feed unit with the reading of a card in the primary feed unit.

SEQUENCE CHECKING—Determining if numbers run consecutively in ascending or descending order.

SEQUENCE UNIT—Normally used to compare the reading of two cards in the primary feed unit.

TRANSPORTLIGHT—Identifies a card jam in the transport area of the 88 collator.

X AND O HUBS—Emit an impulse corresponding to the X and O punching positions during each feed cycle.

CHAPTER 9

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 ranging from 80 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 types 407 and 402 are discussed in this chapter, since they are the accounting machines you will most likely be required to operate. These two machines perform many functions similarly. For this reason, certain operations covered in detail for the type 407 will be condensed later when the same operation is discussed for the 402. You will notice also 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 how a machine tells the difference 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. However, 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.

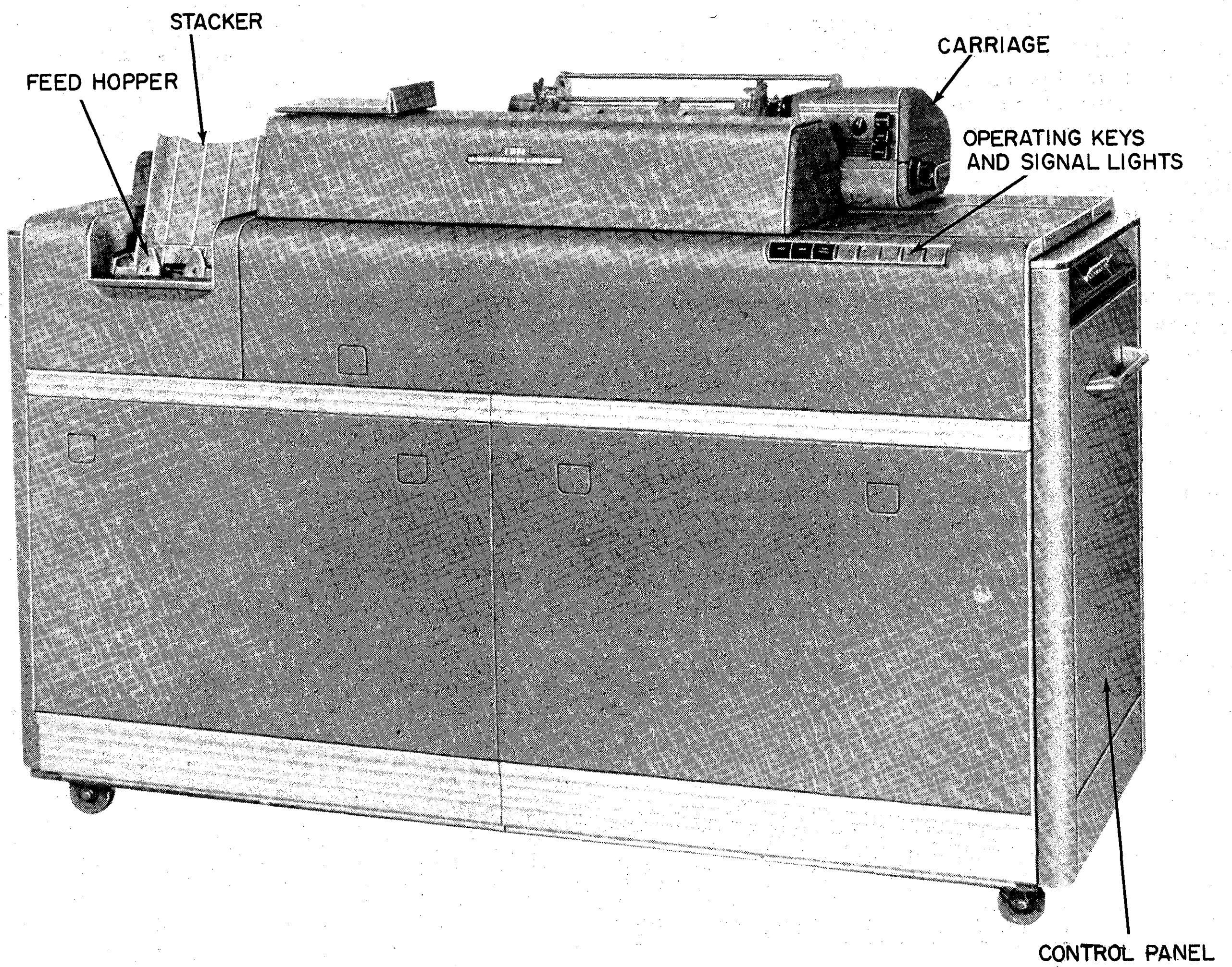
ACCOUNTING MACHINE, TYPE 407

The IBM type 407 accounting machine, shown in figure 9-1, can perform all operations previously listed at the beginning of this chapter. In addition, it is equipped with storage units for storing information to be used later in the operation, such as for overflow sheet identification, summary punching, or group indication. Detail printing (listing) or group printing (tabulating) can be performed at the rate of 150 cards per minute.

OPERATING FEATURES

Machine Controls

The MAIN LINE SWITCH, located on the left end of the machine, must be ON for all machine operations. 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.



49.106X

Figure 9-1.—IBM Type 407 accounting machine.

The keys for controlling machine operations, and lights for indicating certain conditions, are illustrated in figure 9-2.

The START KEY must be depressed to start cards feeding through the machine. When the STOP KEY is depressed, card feeding stops before the next card is fed. The FINAL TOTAL KEY provides for manual control of total printing. Final totals can be printed when this key is depressed if the FINAL TOTAL SWITCH is ON, the last card has been run out of the machine, and the machine is idling.

When the automatic stop hub on the control panel is impulsed, a STOP LIGHT (auto stop) goes on and card feeding stops. This light goes off and card feeding resumes when the start key is depressed.

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 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 checkswitch 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.

The FORM LIGHT goes on and the machine stops when the last form has passed the form stops, provided the FORM STOP SWITCH is ON. This light can be turned off by inserting a new form and depressing the start key.

The CARD FEED STOP 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.

If a fuse burns out, the FUSE LIGHT goes on. This light goes out when the bad fuse has been replaced.

Hopper and Stacker

Cards are placed in the feed hopper face down, with the 9-edge toward the throat. The capacity of the hopper is approximately 1000 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.

The stacker is located above and behind the hopper. A stacker stop switch 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.

Print Unit

Printing is performed by 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 9-3, contains the 26 alphabetic characters, digits 0 through 9, and 11 special characters.

Only one wire is required to position a printwheel for printing any number, letter, or special character. When the digit punched in a card is read, one of the 12 sections in a printwheel is selected. One of the four parts within that section is selected when the zone punch is read. Printwheels which are not impulsed remain stationary.

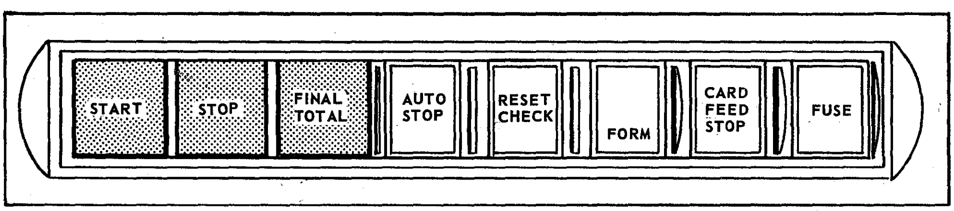


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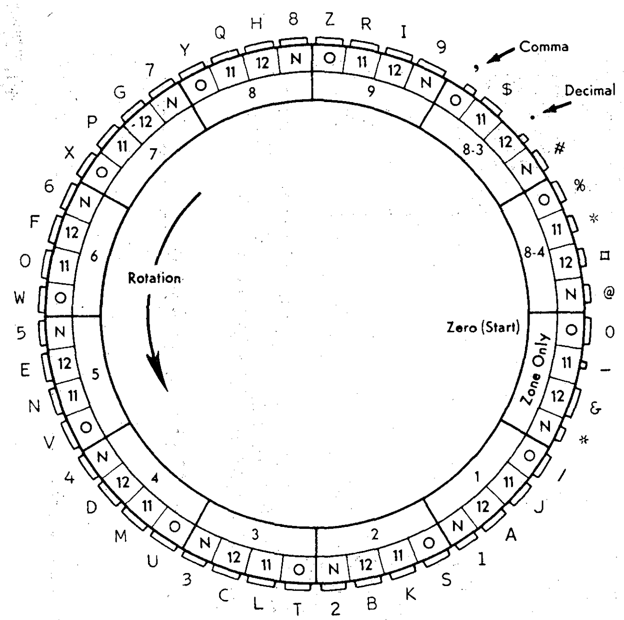
Figure 9-2.—Machine controls.



49.108X
Figure 9-3.—Printwheel schematic.

Functional Switches

The functional control switches, located on the right end of the machine, can be seen in figure 9-1. The functions of the FINAL TOTAL, FORM STOP, and RESET CHECK switches are described under MACHINE CONTROLS. The INVERTED switch is turned on only when inverted forms (detail cards printed before heading cards) are used. It is turned off for normal operations.

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.

PRINCIPLES OF CONTROL PANEL WIRING

The control panel illustrated in figure 9-4 is used with the types 407, 408, and 409 accounting machines. Hubs enclosed in heavy lines are used with the types 408 and 409. Hubs outlined with cross-hatching are used with the type 409 only. Discussion of control panel hubs will be limited to those which are standard for the type 407.

Printing

As cards feed through the accounting machine, they pass two reading stations, illustrated in figure 9-5. 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 first reading. The 407 is basically a detail printing machine, if cards are to be group printed, the LIST switch (E-F, 80) must be wired off.

Normal Printing.—Normal printing can be performed as illustrated by item 1 in figure 9-6.

1. Card columns 6-10 of second read are wired into card columns 10-14 of normal print, and this wiring will perform printing of every card.

Transfer Printing.—Printing can be controlled so that one type of card prints on one print cycle and other types on other print cycles. This is made possible by two sets of entries to the print wheels; 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 provides entrance to the printwheels at all other times. The transfer print entry hubs are active for only the duration of the impulse wired to TR PR. For this reason, it is not practical to impulse TR PR from digit punches. TR PR should be wired from a cycles impulse, such as a FIRST CARD impulse. First card impulses are explained later, under PROGRAM CONTROL. Items 2—4 in figure 9-6 illustrate one method of printing using the transfer print method.

2. Card columns 15-19 of second read are wired into card columns 16-20 of transferred

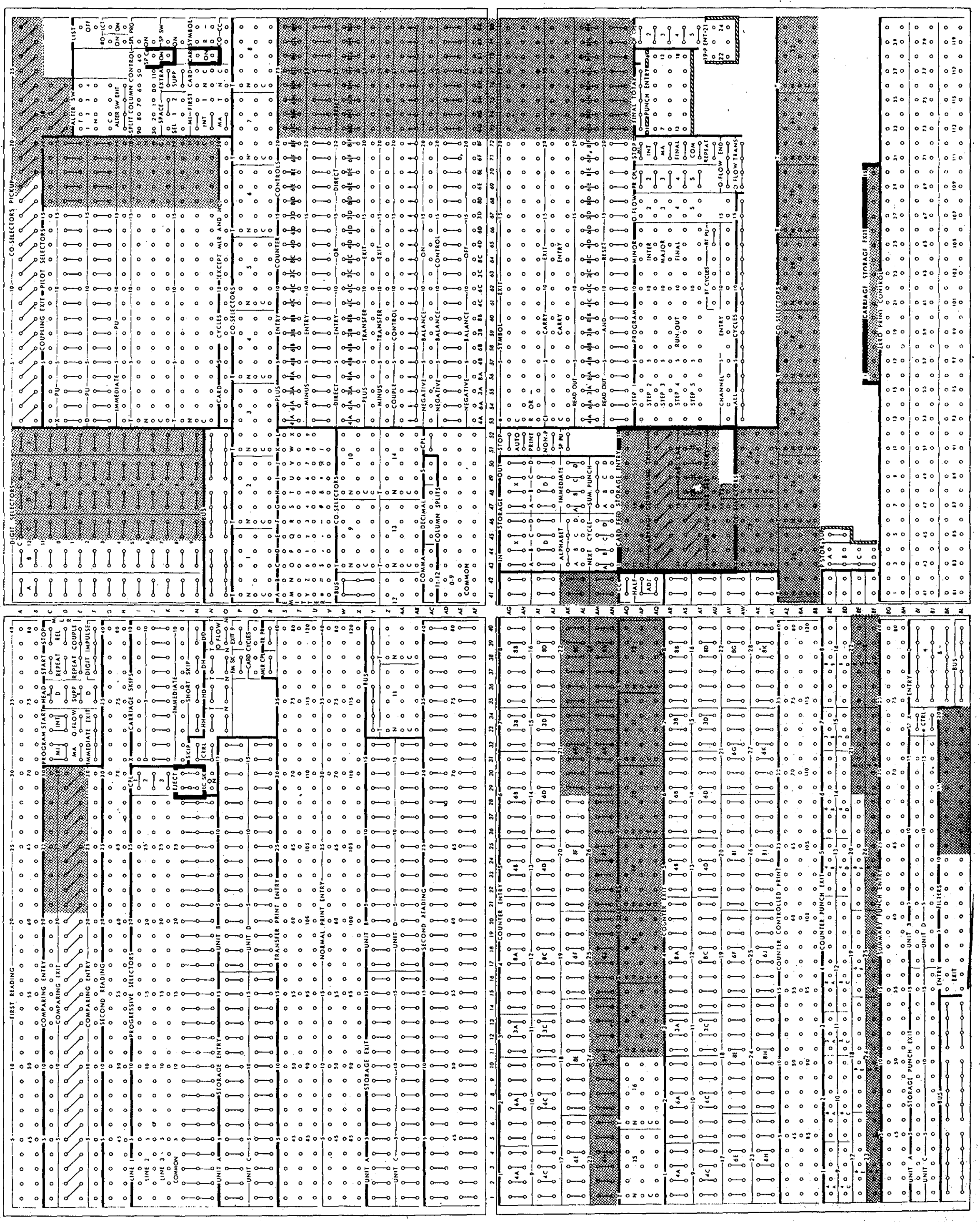


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Figure 9-4.—Type 407 control panel.

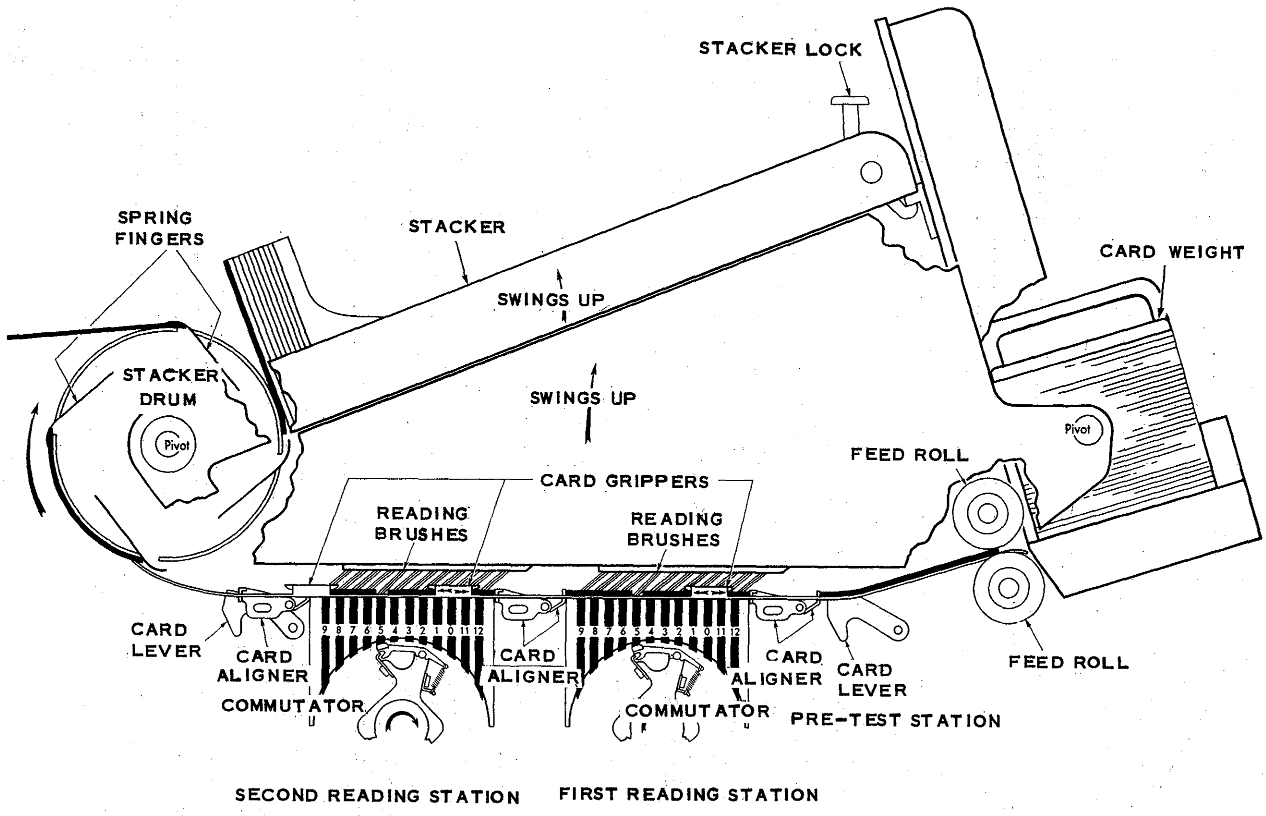


Figure 9-5.—Card feed schematic. 49.110X

print. 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 control will be initiated.

4. Whenever a minor program control is initiated, the first card minor hubs will 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.—This is one of the three entries to the printwheel, which is internally connected to NORMAL or TRANSFER PRINT, whichever is active. 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 exists and sets up the printwheels for printing. On the second half of the cycle the information that is printed is returned to the counter exit from which it originated. If the counter is wired to reset, the returned 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 9-6 (items 5—12) depicts a method of wiring for counter controlled printing.

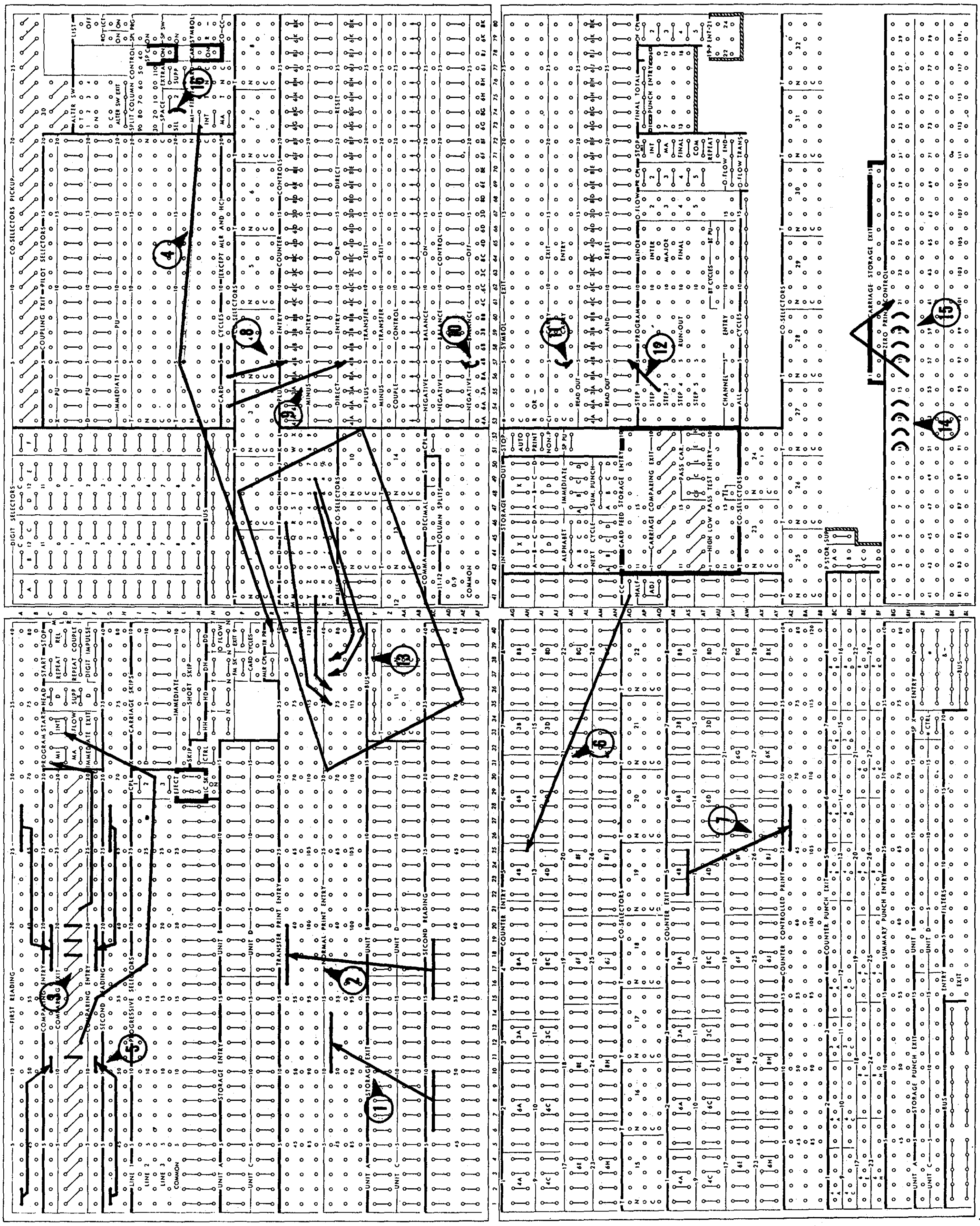
Assume that we want to count each card of a particular control group as it passes through the machine, but we only want to print the total number of cards when there is a difference in card columns 1-2.

5. Card columns 1-2 of first and second read are wired to comparing positions 10-11. When 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.



49.261

Figure 9-6.—Printing.

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 9-6 shows in the enclosed box the character emitter wired to print FY 65 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 9-6.

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 9-6.

Zeros can be printed only if they actually reach print entry. For example, if a field wired to print entry contains blank columns, 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 of printed reports usually is controlled by the SPACE hubs (fig. 9-4, 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 the 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 9-6.

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, 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 in 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 or D pickup hubs receive an impulse, the selector will transfer at the end of the 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 that card reaches second reading. The selector will remain transferred until the controlling card has been read at second reading.

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 cycle.

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 8 through 12 at the same reading station.

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 9-7 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.

Program Control

Program control is the process by which the accounting machine distinguishes cards of one group from those of another. The hubs used for wiring program control can be located by reference to figure 9-4, C-F, 1-20. The control field from first reading is wired to one set of comparing entry hubs and from second reading to the corresponding positions in the other set. An impulse is emitted from the comparing exit hub of each comparing position that recognizes a difference in card comparing.

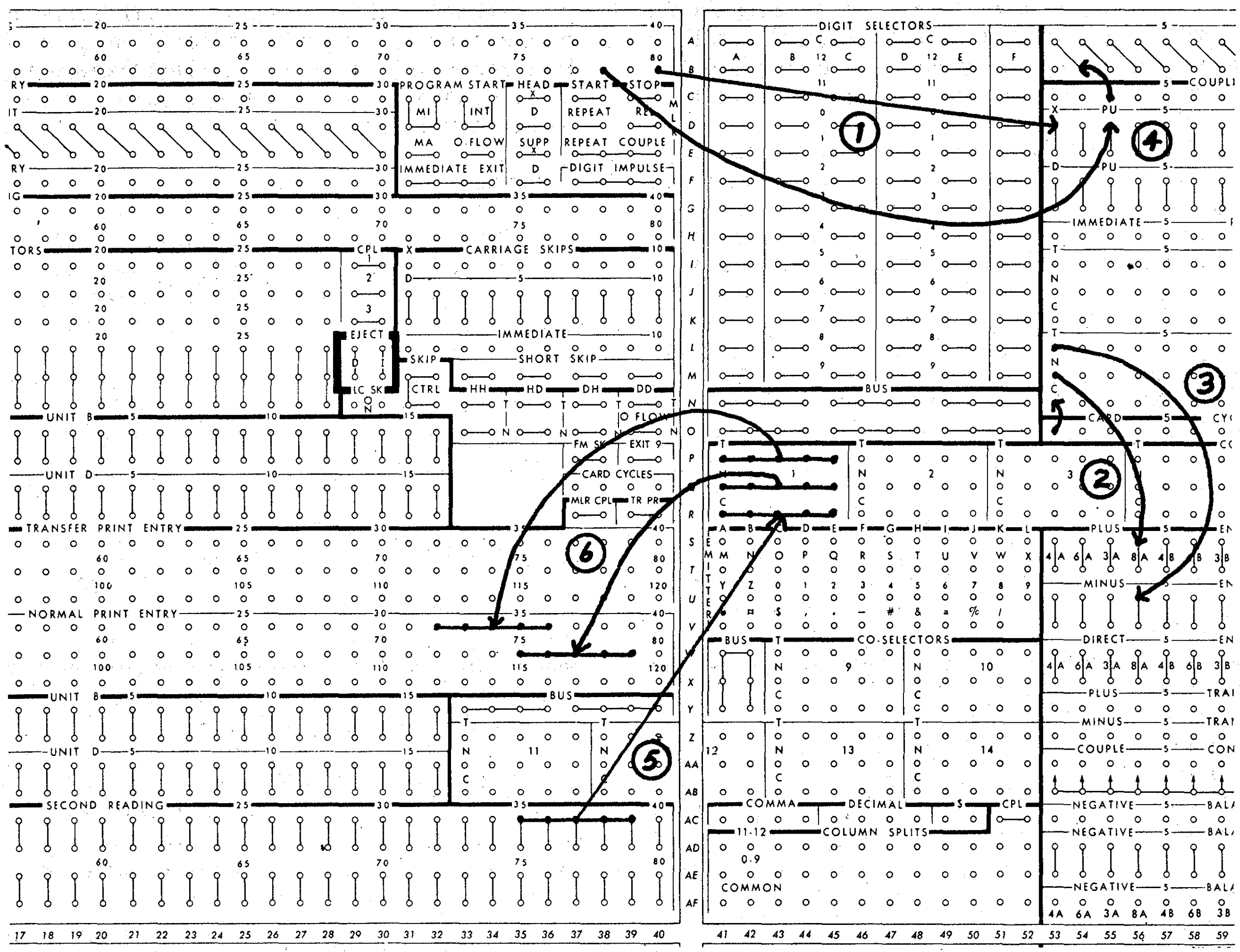


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Figure 9-7. —Selection.

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 usually 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.

If a column contains more than one digit 1 through 9 punch, the comparing magnet will recognize only the first digit read. For example, if a card at second reading is punched with a 6 only, and the card at first reading is punched with a 6 and 3, no unequal condition will be indicated since both comparing magnets for that position received an impulse at the same time.

However, if the card at second reading should contain a 3 in place of a 6, an unequal condition would be recognized when the 6 at first reading is read, causing the comparing exit to emit an impulse.

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.

Automatic totals obtained on the 407 accounting machine generally are classified as MINOR, INTERMEDIATE, and MAJOR. A total cycle for each type of total is usually started by wiring a comparing exit from a control field wired for comparing to the appropriate PROGRAM START hub (fig. 9-4, C-D, 31-34, and E, 31-32). 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 wired but minor is not, a minor program is forced before the intermediate. If program start major is wired 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 9-4, M-O, 73-77, you will notice a group of FIRST CARD hubs. The common hubs on the left, labeled MINOR, INTERMEDIATE, and 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. If head control is wired, the first card minor hub will also emit an impulse during the print cycle of the first detail card following a heading card, regardless of program change or whether the program change is minor, intermediate, or major. 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 cycles impulses, cycle count impulses, or single card columns to be group indicated.

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 card 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.

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. What information is to be added? (Counter entry.)

2. Which cards are to be added? (Counter control.)

3. When should the total be printed? (Counter read-out and reset.)

4. Where should the total 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. However, 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 indicate 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 for each of these classifications. Wiring for this type of report is illustrated in figure 9-8.

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 start 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 total.

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 would 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  (before subtraction
  +9995  (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 CI to C of that counter, resulting in the following:

```
 9994
+   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

49.113

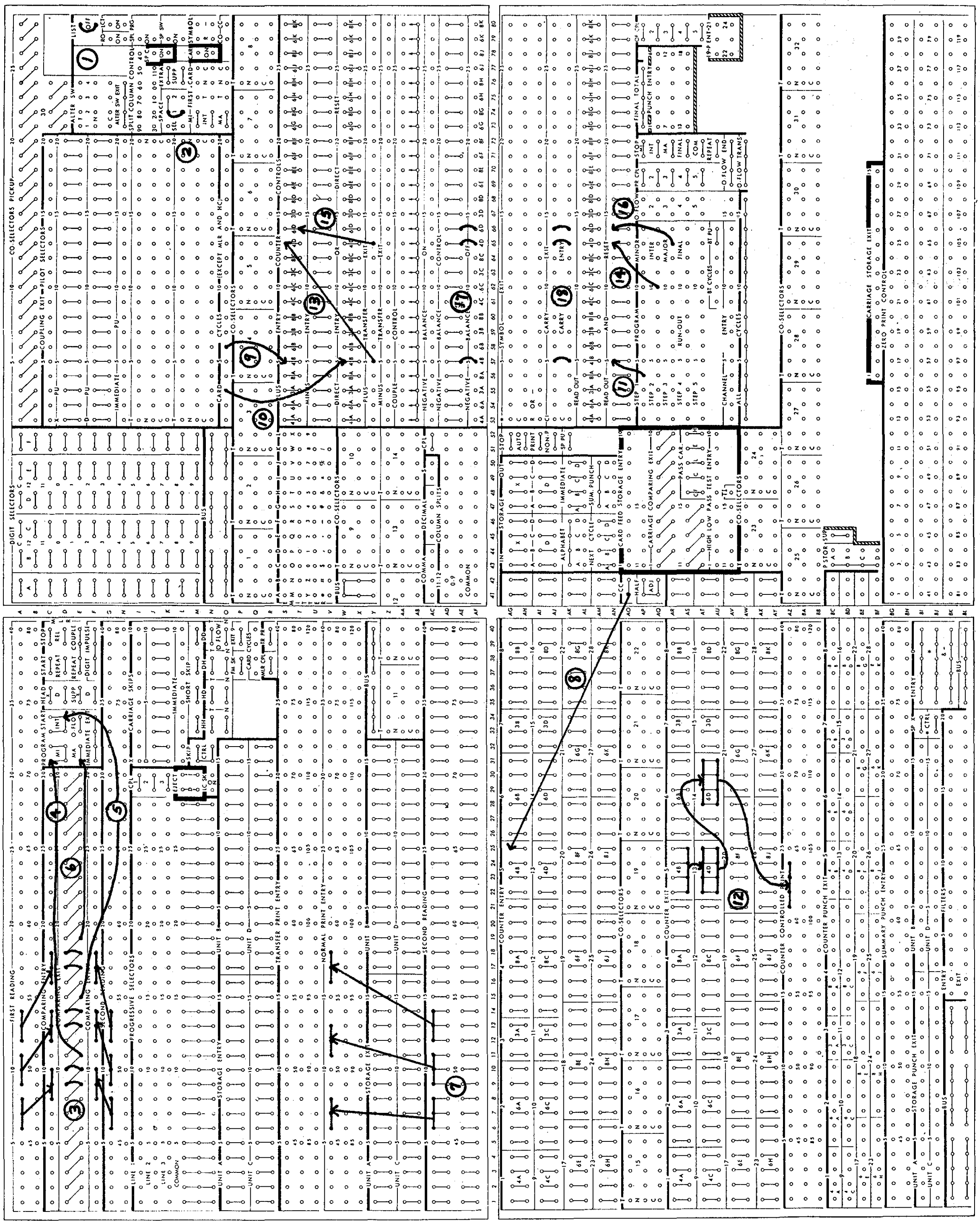


Figure 9-8.—Addition.

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 (fig. 9-4, 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 9-9 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.

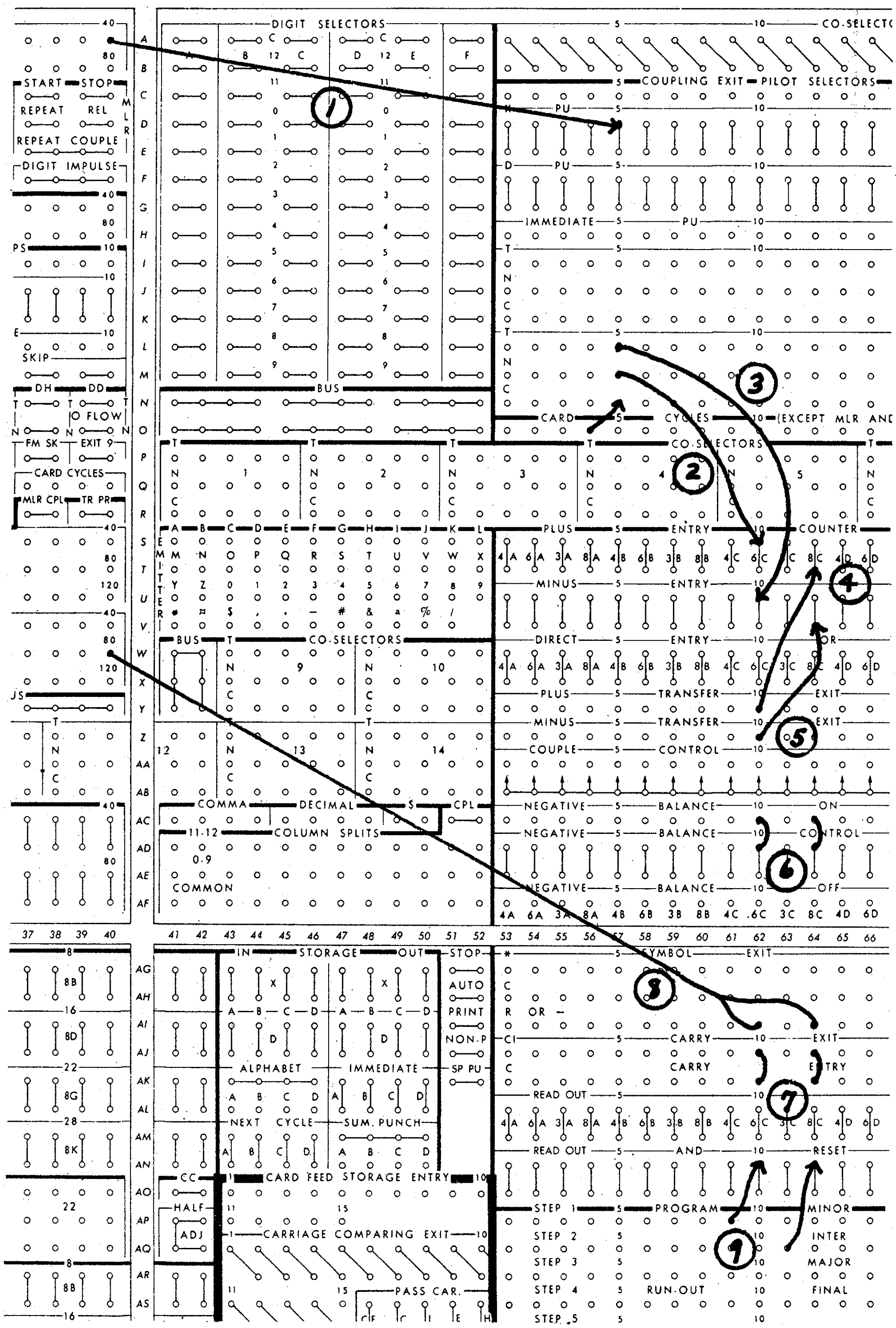
Storage Units

Storage units provide a means of storing information which is to be used later in an operation. Data can be read into or out of storage units at almost any time under the control of a digit, an X punch, a card cycles impulse, a program exit, and certain types of carriage impulses. Once information has been read into a storage unit, it remains there until replaced by a later reading and can be read out as often as desired.

Each storage unit will accept a maximum of 16 positions of numerical data or eight positions of alphabetic data. When alphabetic data is stored, it must be wired to the lefthand eight positions of a storage unit, since an alphabetic character needs one position for storing the zone punch and another for storing the numerical punch. Alphabetic data can be stored only if the alphabet switch for the corresponding storage unit is wired ON.

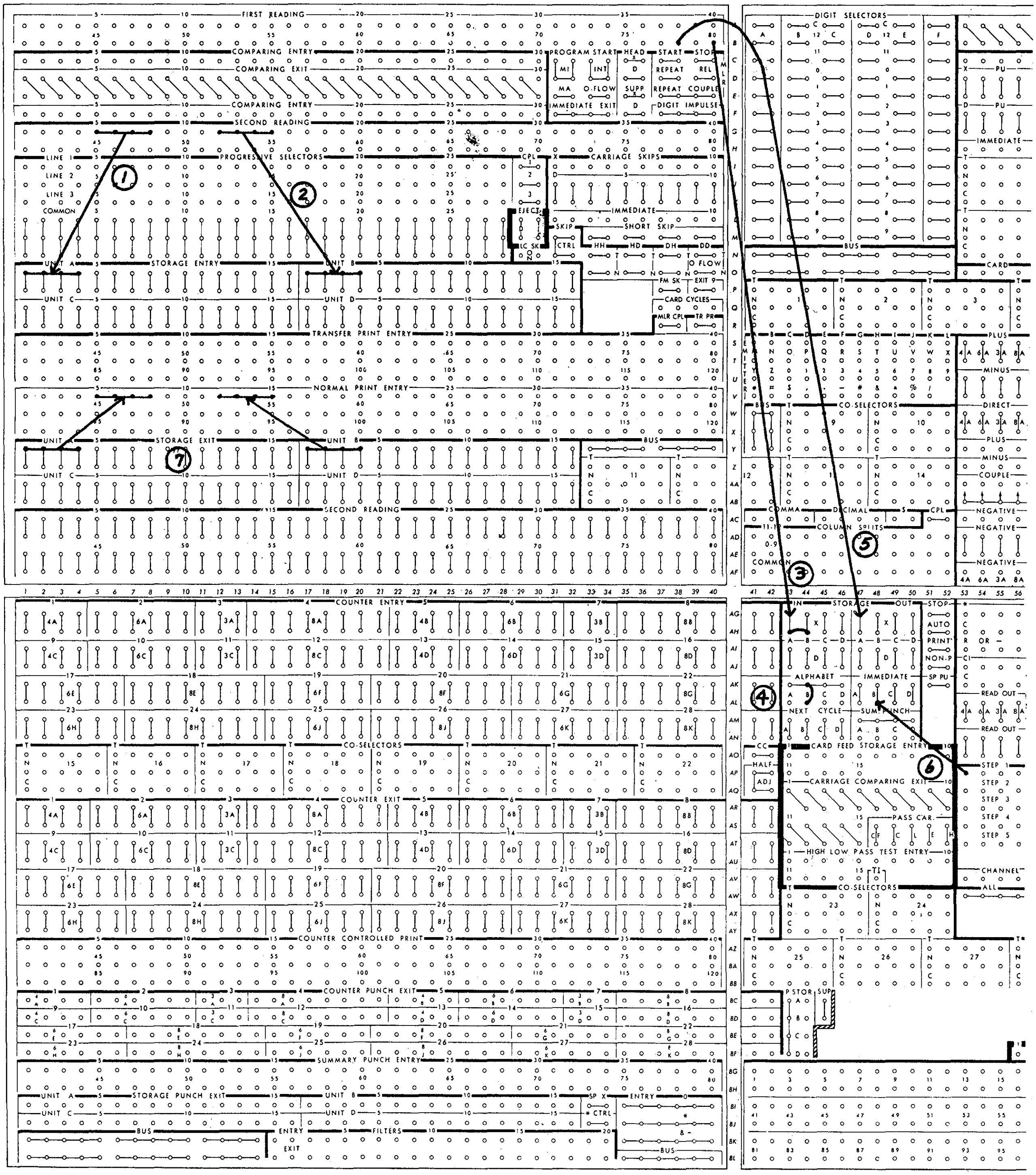
Figure 9-10 is used to illustrate the basic principles involved in wiring for storage, since it is impractical to show all the different methods of wiring. In this illustration, storage units A and B are told what information to store, when to store, when to read out, and where to print.

1. A numerical field is wired from second reading to storage entry A.
2. An alphabetic field is wired from second reading to storage entry B.
3. Both units are to accept information from an X-80 card. First reading 80 is wired to the X STORAGE IN hubs of both units to cause the units to accept information on the following card feed cycle. The D STORAGE IN hub could be wired if a digit were used to control read in.
4. Since storage unit B is to store alphabetic data, the alphabet switch is wired ON.
5. Storage unit A is to read out when X-78 cards are printed. First reading 78 is wired to the X STORAGE OUT hub of unit A to cause that unit to read out on the following card feed



49.114

Figure 9-9.—Subtraction.



49.115

Figure 9-10.—Storage units.

cycle. The D STORAGE OUT hub could be wired if a digit were used to control read out.

6. Storage unit B is to read out on a minor program cycle. A minor program exit is wired to the IMMEDIATE storage out hub to cause that unit to read out immediately on a minor program cycle.

7. Storage exit hubs become exits for stored information when the storage out hubs are impulsed. Both units are wired to normal print entry. Storage exit hubs can also be wired to transfer print entry, but they should not be wired to counter controlled print, since the counter controlled print hubs emit impulses during the second half of the cycle.

Summary Punching

Summary punching can be accomplished, either from counters or from storage units, 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 9-11 illustrates the wiring required for summary punching. It is to be assumed that all other wiring, such as program start, counters, and storage units, has been accomplished.

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.

4. Information in storage units can be summary punched by wiring STORAGE PUNCH EXIT to the appropriate summary punch entry hubs.

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. This carriage is controlled by punches in a narrow paper tape which is inserted in the carriage, as shown in figure 9-12. The tape corresponds to the exact length of one or more forms, and is punched with holes which are 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

Carriage Controls

Several of the carriage operating features can be seen by reference to figure 9-12.

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 for 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.

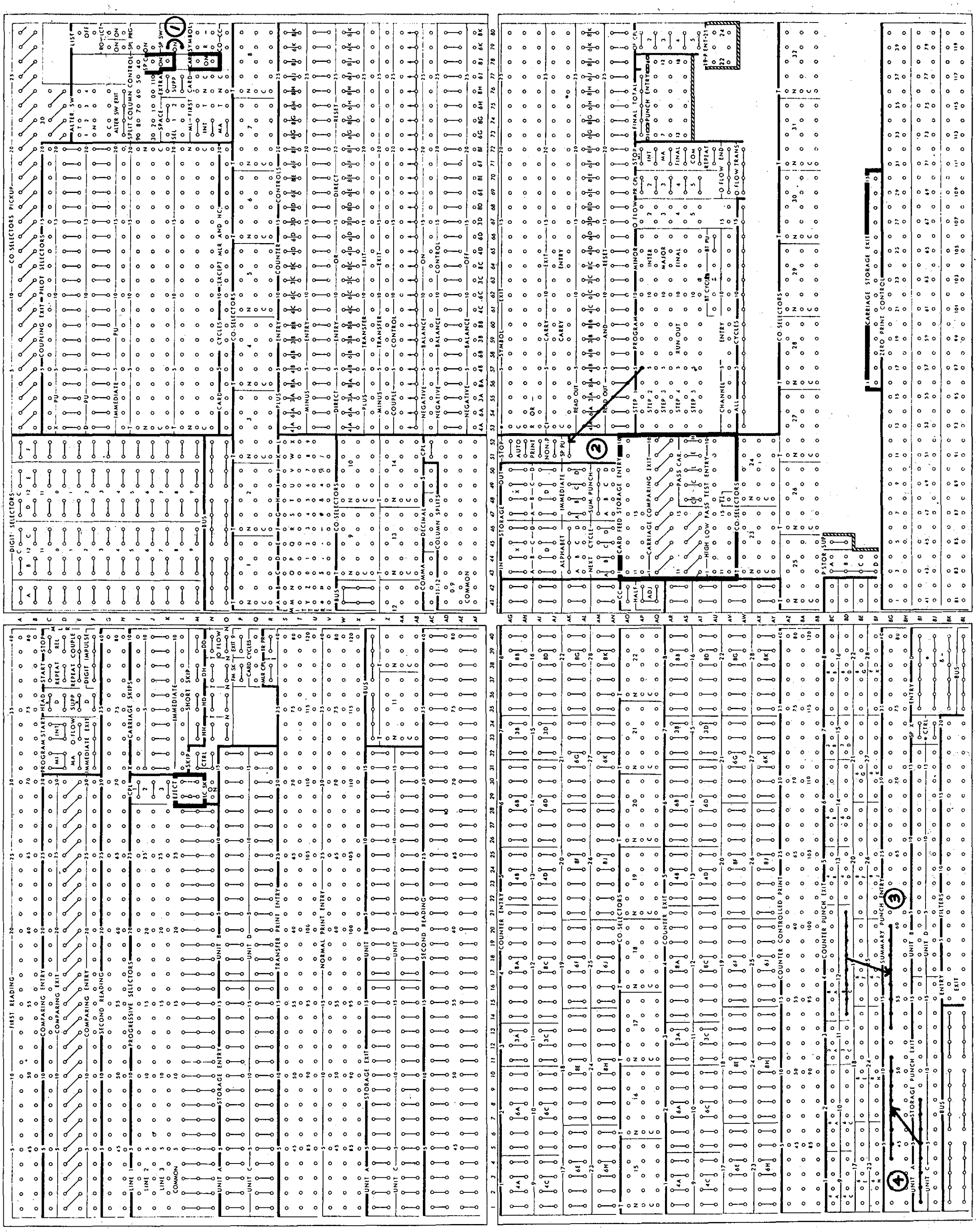
The RESTORE KEY must be depressed before an operation is started in order to set the carriage tape for the first printing line on the form. The platen should be disengaged when the restore key is depressed if skipping from one form to another is not desired.

When the STOP KEY is depressed, carriage operation stops immediately and card feeding stops at the end of the cycle. This key is normally used only when testing a new tape 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.

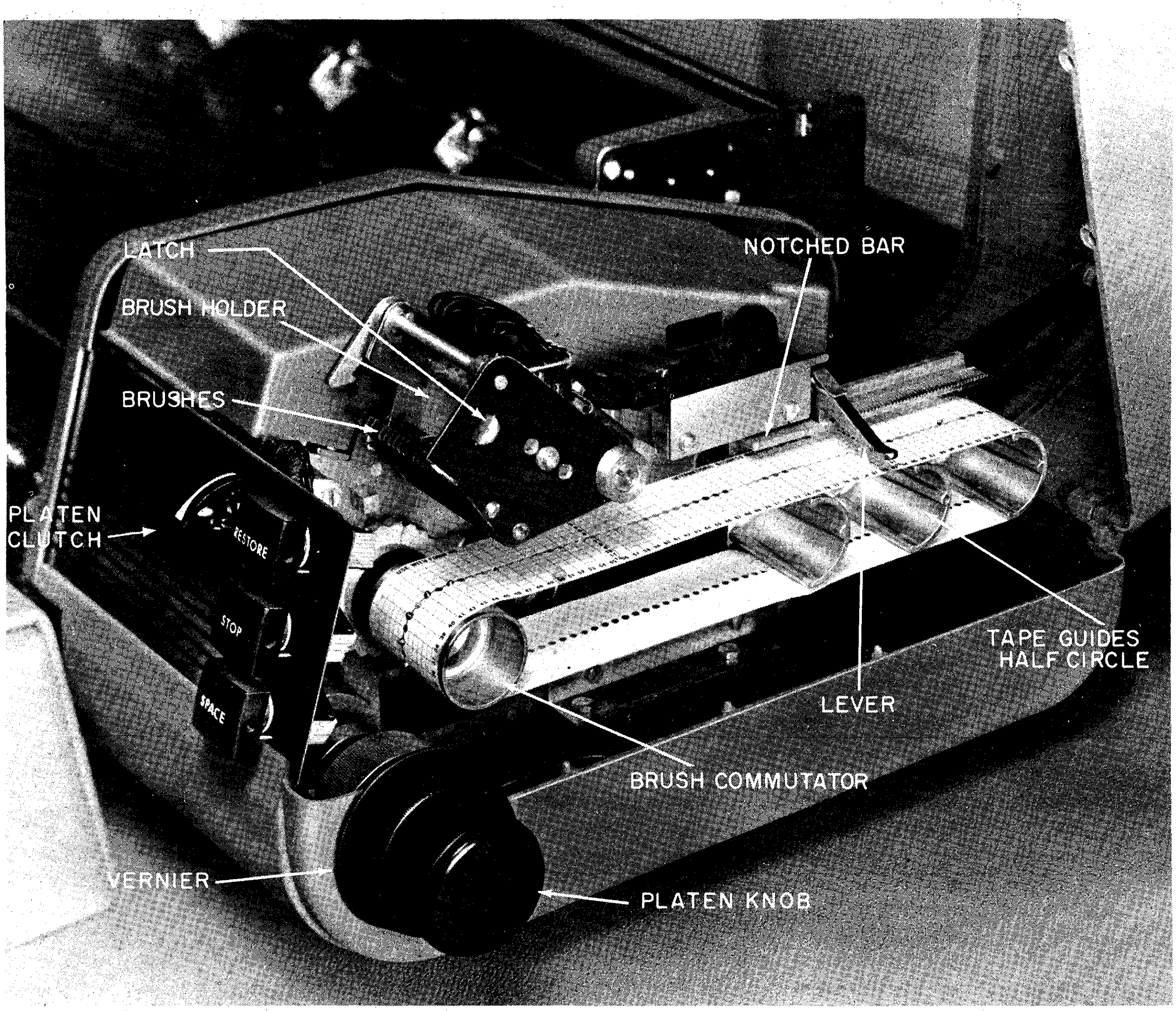
Control Tape

The carriage control tape, shown in figure 9-13, has 12 channel punching positions, represented by a numbered vertical line for each 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



49.116

Figure 9-11.—Summary punching.



49.117X

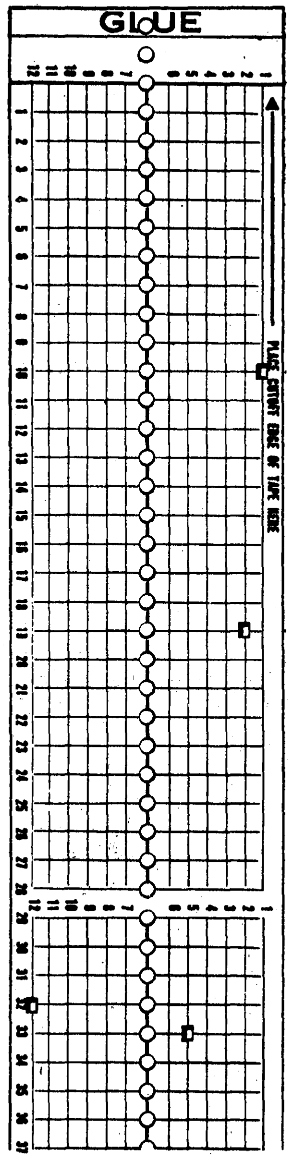
Figure 9-12.—Tape controlled carriage.

pin feed drive that advances the tape as the printed form moves through the carriage.

The following functions are controlled by punches in the tape channels:

1. 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.

2. 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 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.



49.118X

Figure 9-13.—Control tape.

3. 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 punching 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.

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.

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 the tape punch 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.

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, can be set at one of seven positions. It should be set at the position where best printing results are obtained.

Form Stops

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.

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.

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.

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 9-4, I-L, 31-40.

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 9-4, 0, 39-40. A punch in 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 formskipping. 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.

ACCOUNTING MACHINE, TYPE 402

The IBM type 402 accounting machine, shown in figure 9-14, performs all operations described at the beginning of this chapter. It is similar to the type 407 in that operations are controlled by control panel wiring and a tape controlled carriage. Much of the control panel wiring is performed in a manner similar to the type 407. Differences are discussed later in this chapter.

The list/tabulate speed of this machine may be one of three different speed combinations. That is, the number of cards per minute that can be listed (detail printed) or tabulated (group printed) can be either 80/80, 80/150, or 100/150. The Series 50 machine, which is a modified version of the standard type 402, has two speed combinations; 50/50 or 50/100.

OPERATING FEATURES

Machine Controls

The operating switches, keys, and lights are essentially the same as for the type 407, with the exception of the reset check light. Since the type 402 is not equipped with a reset check circuit, an unlabeled light is installed which goes on when the main line switch is turned on. Final totals can be taken manually by depressing both the final total and start keys at the same time, provided the last card has been run into the stacker and the machine is idling.

Print Unit

The print unit can be seen by reference to figure 9-15. Printing is performed by a variable number of typebars, depending upon the model of the machine. The maximum number of typebars obtainable is 88, of which 43 will print both alphabetic and numerical data, and 45 will print numerical data only. The typebars that print both alphabetic and numerical data are called ALPHAMERICAL typebars, and are located to the left of the NUMERICAL typebars. A space equivalent to one typebar separates the alphamerical from the numerical typebars.

Each alphamerical typebar contains the 26 alphabetic characters, digits 0 through 9, and a

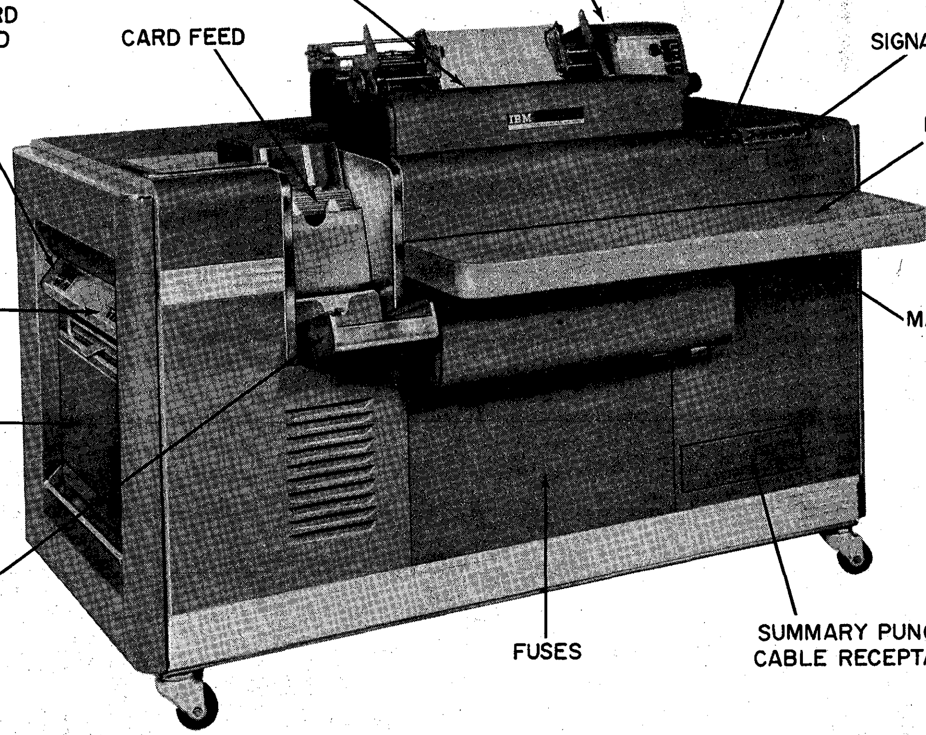


Figure 9-14.—IBM Type 402 accounting machine.

special character position consisting of an ampersand (&). Each numerical typebar has the digits 0 through 9 and one symbol. This symbol is an asterisk (*) on odd numbered typebars, and a credit (CR) on even numbered typebars.

Hammerlock Levers

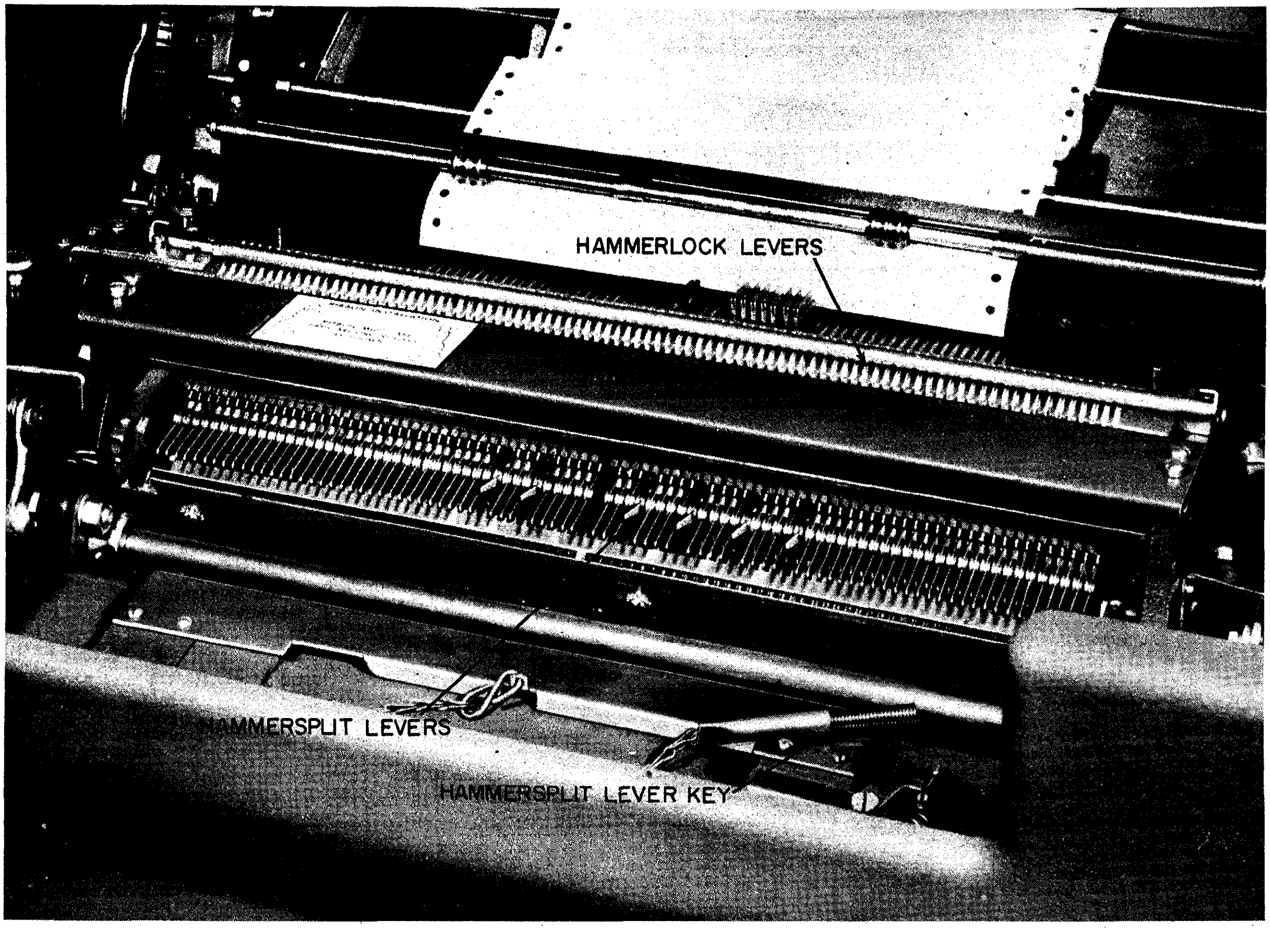
Printing can be controlled through the use of hammerlock levers, visible in figure 9-15. Each typebar is equipped with two levers; a short lever and a long lever. The purpose of these levers, when raised, is to lock the hammers to prevent them from firing against the typebars. When a short hammerlock for a particular typebar is raised, that typebar is prevented from printing at all times. When a long hammerlock is raised, printing from that typebar is under the control of control panel wiring.

Hammersplit Levers

Printing of zeros can be controlled by hammersplit levers, often called zero suppression levers, shown in figure 9-15. When one of these levers is raised, printing of zeros to the right, up to the next significant digit, is suppressed. A hammersplit lever can be raised by placing the hammersplit lever key, visible in figure 9-15, on the lever to be raised and exerting a slight upward motion.

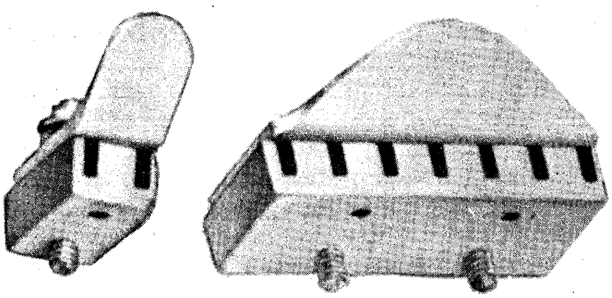
Zeros will print from alphamerical typebars under normal conditions only if they are punched in cards or present in a counter, the typebars are wired on the control panel, and a significant digit is printing to the left. Mechanical zeros will print from unwired numerical typebars to the right of a significant digit. These mechanical zeros can be eliminated by raising the hammersplit lever corresponding to the typebar which is printing the significant digit.

Zeros can be forced to print to the left of a significant digit by using a left zero carry clip, shown in figure 9-16. This clip, which comes in various sizes, can be placed on the hammersplit lever of a typebar printing the units position and on the hammersplit levers



49.120X

Figure 9-15.—Print unit.



49.121X
Figure 9-16.—Left zero carry clips.

of as many as six typebars to the left of this position to cause zero printing.

Functional Controls

Additional switches and buttons are located on the left end of the machine, and can be used to control various machine operations.

The three SETUP CHANGE SWITCHES enable you to perform several different operations with the same control panel without changing the wiring. Each switch has an exit hub on the control panel which emits an impulse when the corresponding switch is turned on. These switches can be used to change from a listed report to a tabulated report while using the same control panel. They may be used also to control selectors so that machine functions can be changed according to the setting of the setup change switches.

The GANG PUNCH SWITCH is used only with the types 517 or 523 gang summary punch machines when these machines do not operate under their own power. The accounting machine will not operate when this switch is turned on, but the gang summary punch will, provided the cable between the two machines is connected.

The NONPRINT RUNOUT BUTTON can be depressed at any time, other than a card feed failure, to run cards out of the machine without printing on the report. The hopper must be empty in order for the cards to be run out.

The FEED INTERLOCK START BUTTON provides a method for re-starting card feeding after a card feed failure occurs. Failure of a card to feed causes the machine to stop and the card feed stop light to turn on. The card feed hopper should be emptied and the feed interlock start button depressed in order to run cards remaining in the machine into the stacker. When the feed interlock start button is depressed, the last card to feed into the stacker performs all normal functions with the exception of comparing. The card that failed to feed from the hopper must be corrected and placed behind the last card to stack. Then, both these cards must be placed in front of the rest of the file and inserted in the hopper. The feed interlock start button must be depressed to start card feeding. On this second run-through, the last card removed from the stacker and re-fed performs only the function of comparing. Normal operation will be resumed for the following cards.

The LAST CARD AUTOMATIC TOTAL SWITCH provides for printing automatic last card totals without the use of the final total key, provided the counter total hubs are wired to clear. When this switch is ON, the comparing exits are inactive and a major program control change is forced, both on run-in and run-out, regardless of control panel wiring.

PRINCIPLES OF CONTROL PANEL WIRING

Automatic operation of the accounting machine is made possible by the control panel, illustrated by the diagram in figure 9-17. Areas enclosed in heavy lines represent hubs that are used only for the type 403 multiple line printing (MLP) machine. Shaded areas represent special devices or optional features. Operations described herein are limited to those features standard for the type 402.

There are many operations that can be performed on the type 402 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 shown in figure 9-18. Refer to figure 9-18 for the appropriate wiring illustration as each wiring step is mentioned.

Printing

The type 402 is basically a group printing machine. It will not detail print unless the LIST hub is impulsed. When an ALL CYCLES impulse is wired to the LIST hub, the typebars rise on each card cycle and print whatever is wired to print entry, resulting in a detail printed report. Detail printing is performed at the rate of 80 or 100 cards per minute, depending upon the speed combination of the particular machine. If the LIST hub is not impulsed and none of the program start hubs are wired, the typebars rise only when the final total key is depressed. If program start is wired but the LIST hub is not, the typebars rise for the first card of a group so that identifying information for each group can be printed, and on the total cycle for printing totals, resulting in a group printed report. Group printing is performed at the rate of 80 or 150 cards per minute, depending upon the speed combination of the particular machine. Wiring step 1 in figure 9-18 illustrates wiring the LIST hub for a detail printed report.

Printing From a Card

As cards pass through the machine, they are read at two reading stations, each containing 80 reading brushes. These stations are called SECOND READING and THIRD READING. FIRST READING is used only in the type 403 multiple line printing accounting machine.

Readings from the second reading station are used primarily to condition typebars for printing alphabetic data and to control various machine functions, such as adding, subtracting, and selecting. Readings from the third reading station can be used to position a typebar for printing alphabetic or numerical data, or to send amounts punched in a card to a counter for adding or subtracting.

An alphamerical typebar must receive two impulses if it is to print an alphabetic character; a zone punch and a digit punch. The zone punch is read at the second reading station and is wired from SECOND READING TO NORMAL

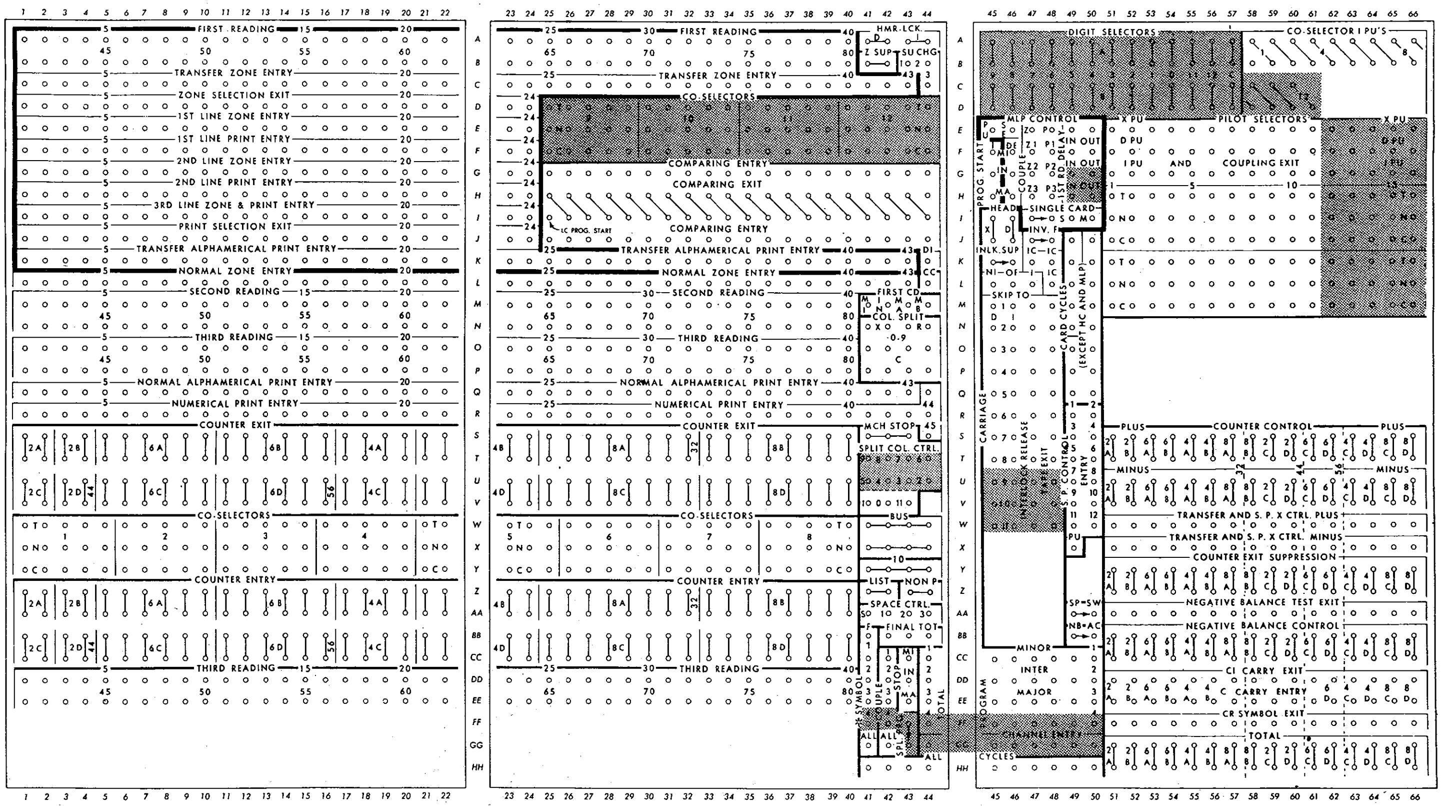


Figure 9-17.—Type 402 control panel.

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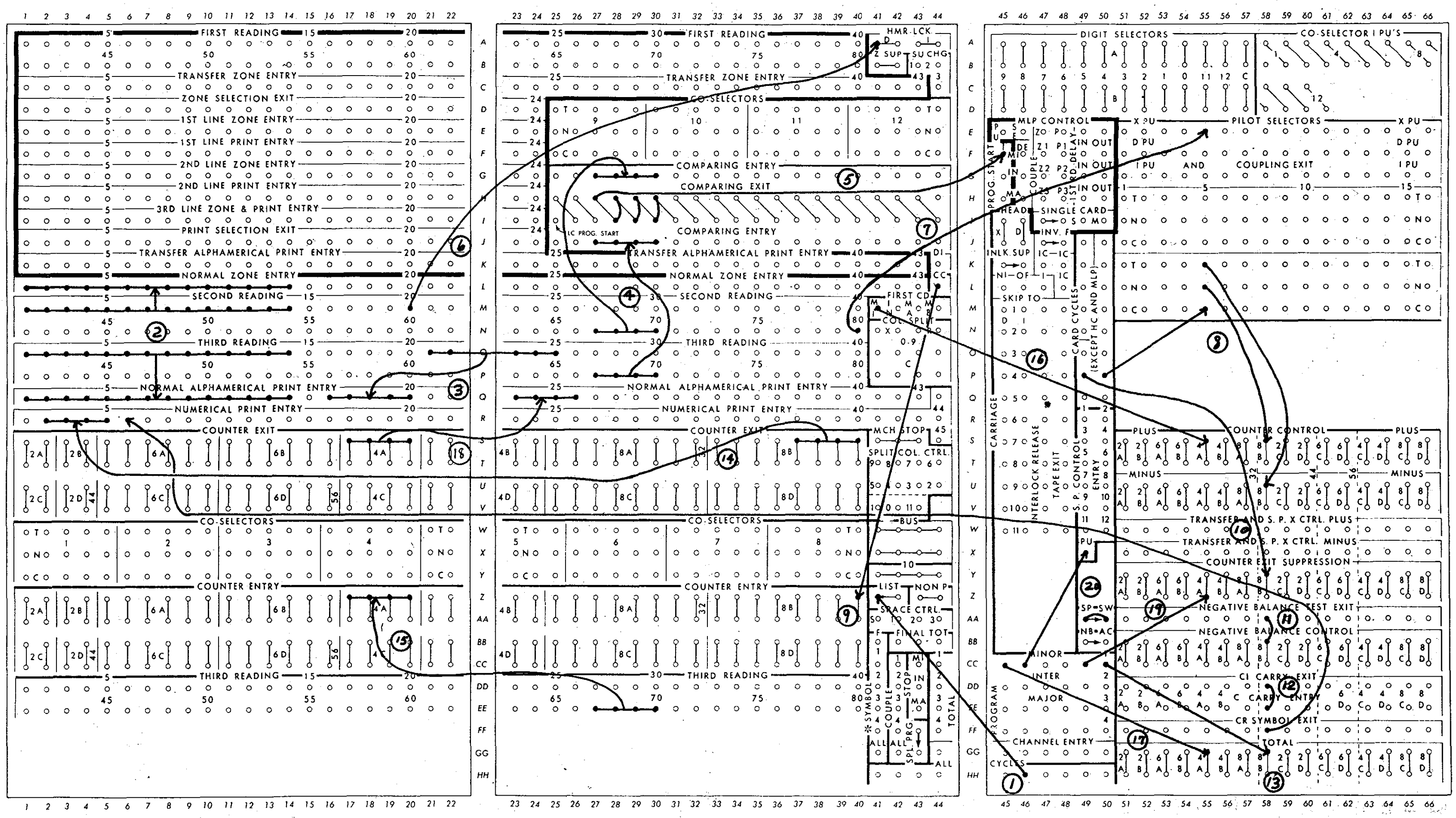

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Figure 9-18.—Wiring.

ZONE ENTRY. This "zones" the typebar so that the proper letter will print on the following cycle when the digit punch is read at third reading. Although all digits 9 through 12 are read at second reading, normal zone entry will accept only zone punches. The digit punch is read at the third reading station and is wired from THIRD READING TO NORMAL ALPHAMERICAL PRINT ENTRY. This completes the positioning of the typebar for printing the alphabetic character represented by the combined zone and digit punch. Wiring for alphabetic printing is shown in wiring step 2 in figure 9-18.

A numerical digit can be printed by wiring from THIRD READING to either NORMAL ALPHAMERICAL PRINT ENTRY or to NUMERICAL PRINT ENTRY. Control X or 12 punches in the numerical field wired to normal alphamerical print entry will not affect the printing of numerical data provided normal zone entry is not wired, since alphamerical print entry will not accept X or 12 zone punches. Wiring for numerical printing is illustrated in figure 9-18, wiring step 3.

Program Control

The type 402 accomplishes program control in the same manner as the type 407. Also, there is a FIRST CARD hub for each class of automatic total. However, these hubs do not emit impulses when head control is wired, since wiring of head control suspends all programming during printing of heading cards. An additional hub called the MB (minor body) emits an impulse for the first minor group following heading cards when head control is wired. When head control is not wired, the MB functions the same as the first card minor hub. The type 402 is not equipped with first card selectors. Wiring for program control is illustrated in figure 9-18, wiring step 4. Wiring step 5 illustrates the use of an impulse from the comparing exits, available when an unequal condition exists in the control field wired to the comparing entries, to start a minor program.

Hammerlock Control

Hammerlock control provides a means for suppressing the printing of certain fields wired to print, either at all times or under a particular condition. Each typebar is equipped with a short and a long hammerlock lever. When a short hammerlock lever is raised, it pushes down a metal tab. The hammer for that typebar will hit this metal tab in place of the typebar, thereby preventing that typebar from printing at all times. When a long hammerlock lever is raised, it pushes down the metal tab, but not as far as a short hammerlock. This allows the hammer to pass under the metal tab and strike the typebar unless one of the hammerlock hubs has been impulsed. If one of these hubs is impulsed, the hammerlock support bar tilts just enough to cause the hammer to strike the metal tab, and prevents printing.

The hammerlock D (digit) hub will accept any impulse 9 through 12 to cause hammerlocking to be effective for the following cycle. The hammerlock I (immediate) hub will accept ANY impulse, and causes hammerlocking on the SAME cycle. If neither hub receives an impulse, hammerlocking through the use of long hammerlocks is not effective.

Wiring step 6 in figure 9-18 illustrates the wiring for hammerlock control. In this example, column 20 is wired from second reading to the hammerlock D hub so that hammerlocking will be effective when a card that contains a punch in column 20 reaches third reading. The long hammerlock levers for alphamerical typebars 16-20 are raised so that printing from columns 21-25 is suppressed whenever column 20 contains a punch.

Selection

Pilot selectors and co-selectors operate on the same principle as those in the type 407. The only difference in their construction lies in the fact that each pilot selector in the type 407 is provided with a separate I pickup hub and coupling exit when the corresponding pilot selector transfers. Wiring step 7 in figure 9-18 illustrates a pilot selector picked up from an X punch in column 80. The remainder of the selector wiring shown is discussed under ACCUMULATION.

Accumulation

The same basic steps required for accumulation in the type 407 are needed in the type 402. That is, a counter must be told what information to add or subtract, which cards to add or subtract, when to print the total, and where to print the total. However, counters in the type 402 reset to zero in place of 9, so wiring CI to C is not required for counters which are wired for adding only. If a counter is wired to subtract, then CI must be wired to C, because subtraction is performed by adding the 9s complement of the number, and provision must be made for returning the carryover from the high order counter position to the units position.

Type 402 accounting machines may be either net balance or non-net balance. They are so called because of the method required for converting complement totals to true figures before totals print. Since you are not likely to be concerned with non-net balance subtraction, net balance subtraction only is discussed.

Net balance machines perform net balance subtraction automatically when a counter negative balance test exit is wired to the corresponding counter negative balance control hub. The negative balance test exit hub for each counter emits an impulse when a 9 is recognized in the high order position of the respective counter on a program cycle. If this impulse is wired to negative balance control, complement totals will be converted to true totals just before the print cycle occurs.

The CR symbol exit for each counter emits an impulse when an amount is subtracted in the corresponding counter, and when a counter prints a converted complement total. This impulse can be wired to an even-numbered numerical typebar to print a CR, or to an odd-numbered numerical typebar to print an asterisk, in order to identify negative amounts.

Amounts which are being accumulated are normally available from the counter exit hubs each time an amount is added. They will print for each card cycle during a detail print operation and for the first card of a control group during a group print operation unless suppressed by control panel wiring. If these amounts are not to be printed on a card cycle, a card cycles impulse can be wired to counter exit suppression to prevent printing except on total cycles. Card cycles impulses are active only on card cycles.

An example of accumulation is shown in figure 9-18, wiring steps 8 through 14. In this illustration, NX-80 cards are to be added in counter 8B, and X-80 cards are to be subtracted. Second reading 80 is wired to the X pickup of pilot selector 5 so that adding and subtracting can be controlled.

Wiring Step 8.—A card cycles impulse is wired through the normal side of pilot selector 5 to COUNTER CONTROL PLUS to add NX-80 cards, and through the transferred side to COUNTER CONTROL MINUS to subtract X-80 cards.

Wiring Step 9.—COUNTER ENTRY 8B is wired from CARD COUNT to cause a 1 impulse to enter the counter for each card.

Wiring Step 10.—A card cycles impulse is wired to COUNTER EXIT SUPPRESSION of counter 8B to prevent the 1 impulse, entered into counter entry, from printing on a card feed cycle.

Wiring Step 11.—Since subtraction is being performed in counter 8B, NEGATIVE BALANCE TEST EXIT is wired to NEGATIVE BALANCE CONTROL so that complement totals can be converted to true totals.

Wiring Step 12.—CI of counter 8B is wired to C so that carryover is provided for when the counter subtracts.

Wiring Step 13.—Counter 8B is wired to read out and reset on a minor program by wiring MINOR PROGRAM to TOTAL of 8B.

Wiring Step 14.—The COUNTER EXIT hubs of counter 8B are wired to PRINT. Credit totals are identified with a CR symbol by wiring the SYMBOL EXIT of 8B to numerical print entry 6.

Summary Punching

Summary punching on the type 402 differs from the type 407 in only one respect. Since the type 402 does not have counter punch exits and summary punch entries, all counters wired for summary punching must be wired on the automatic punch control panel from the appropriate counter total exits to punch magnets. All other wiring is essentially the same. Wiring for summary punching is illustrated in figure 9-18, wiring steps 15 through 20.

Wiring Step 15.—Columns 67-70 are wired to counter entry 4A so that the controlling information can be summary punched.

Wiring Step 16.—Counter 4A is impulsed to add only the first card of a minor control group.

Wiring Step 17.—Counter 4A is wired to read out and reset on a minor program.

Wiring Step 18.—Counter exit 4A is wired to print. The time at which printing will occur is controlled by the impulse wired to COUNTER EXIT SUPPRESSION.

Wiring Step 19.—Counter 4A is suppressed from printing on a minor program. It will print for the first card of a control group, since printing is not suppressed for a card feed cycle.

Wiring Step 20.—The SUMMARY PUNCH SWITCH is wired ON, and the SUMMARY PUNCH PICKUP hub is impulsed from minor program. The summary punch cable from the automatic punch must be connected to the accounting machine in order for summary punching to be effective.

Wiring for Automatic Punch.—Control panel wiring for the automatic punch is not shown. However, the only wiring required is from the counter total exit hubs of counters 4A and 8B to the appropriate punch magnets.

TAPE CONTROLLED CARRIAGE

The tape controlled carriage controls the automatic feeding and spacing of continuous forms in essentially the same manner as the carriage on the type 407. For this reason, only the major differences are noted herein.

OPERATING FEATURES

The operating features of the carriage used with the type 402 are the same as the carriage used with the 407, except for the following differences.

Paper Brake and Form Stop

A paper brake device is located behind the platen for manual adjustment of the drag or tension on the paper. Both the paper brake and form stops are controlled by a lever at the left side of the carriage. When the lever is in the top notch, both paper brake and form stop control are in effect. When the lever is set to the middle notch, the paper brake device is OFF and form control is ON. When set to the bottom notch, both paper brake and form control are OFF.

Platen Shift Wheel

The platen shift wheel can be turned to shift the platen laterally a total of 5 3/4 inches.

Form Thickness Adjustment

The form thickness adjustment device is located under the machine cover between the reading brushes and the print unit. It is used for the same purpose as for the type 407.

FORM CONTROL

All printing is normally single spaced, six lines to the inch. Double and triple spacing can be controlled by normal control panel wiring. Any other spacing must be controlled by the tape. Spaces up to 3 2/3 inches between lines can be skipped at the same speed as normal spacing, and printing can be performed at the normal speed. Card feeding is normally stopped for all skips in excess of 3 2/3 inches to prevent printing during the skip.

Carriage Skips

Each carriage channel has two SKIP TO hubs, labeled D (digit) and I (immediate). These hubs can be located by reference to figure 9-17, M-T, 45-46. The D hub accepts impulses on one cycle to cause skipping before printing occurs on the next cycle. The I hub accepts impulses to cause skipping immediately.

When an impulse is wired to a carriage SKIP TO D or I hub, the corresponding tape channel must be punched on the appropriate line to stop the skip.

Impulses which are available at card reading time, such as digits 9-12 or a comparing exit, are normally wired to the D hub to cause skipping on the following cycle. The I hub is normally wired from impulses which are available at other than card reading time, such as first card, total program, card cycles or all cycles impulses to cause skipping immediately.

Form to Form Skipping

When a skip is made from one form to another, such as at the end of a control group, after a total has printed, or after a card with a specific punch has printed, it is customary for card feeding to stop during the skip to avoid printing in flight. Card feeding resumes after the skip is completed. This process of stopping and restarting is called INTERLOCKING. However, if all skipping is to be 3 2/3 inches or less, this interlocking can be prevented by wiring the INTERLOCK SUPPRESS switch, located in figure 9-17, K, 45-46. When this switch is wired on, printing occurs at the normal rate of speed without stopping for each skip.

Overflow Skipping

Overflow skipping from one completed form to the next is usually controlled by the OVERFLOW hubs, shown in figure 9-17, L, 45-47.

A punch in channel 12 signals that the last printing line of a form has been reached, and causes the OF (overflow) hub to emit an impulse, which is normally used to cause skipping to the next form. Skipping can be made to either the first printing line of the next form, identified by a punch in channel 1, or to the first body line, identified by a punch in channel 2, depending upon the wiring of head control and the overflow hub.

When OF is wired to NI (non-indicate) and head control is not wired, overflow skipping will be to the first printing line of the next form. This causes printing to start on the line identified by the punch in channel 1 and continue until the last printing line of the form is reached. If head control is wired, overflow skipping will be to the first body line so that the portion of the form set aside for printing heading information will be skipped over. In this case printing starts on the line identified by the punch in channel 2 and continues until the last printing line of the form is reached.

When OF is wired to I (indicate) overflow skipping will be to the first printing line of the next form, whether or not head control is wired. When skipping is completed, the accounting machine takes an automatic cycle to allow information stored in counters for sheet identification to be printed. If head control is not wired, normal printing then continues for the rest of the form. If head control is wired, an automatic skip to channel 2 is made after sheet identification is printed, and normal printing starts on the line identified by the punch in channel 2.

Program Skipping

Skipping to any predetermined line in the body of a form can be made by starting a skip from a total program exit when a program start is initiated, and stopping the skip by a punch in one of the channels 3 through 8. Channels 9 through 11 may be used for normal skip stops when installed as a special feature.

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.

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 (and start key on the type 402) 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 absolutely necessary that you 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 immediately and call your supervisor. 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 9-12 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 pin-feed 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 kep 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.

ACCUMULATION.—The adding of a 1 timed impulse per card; or the adding of actual numbers punched in cards.

ALTERATION SWITCHES.—Allows a control panel to be wired for more than one operation.

AUTO STOP.—When impulsed for a certain specific condition, it causes the machine to stop.

CARD FEED STOP LIGHT.—Lights if a summary punch cycle is started, and stays lighted until the cycle is completed; also lights if a card fails to feed.

COUNTER CONTROLLED PRINT.—One of the three entries to the printwheels. Provides the only means of resetting the counters on the 407 as totals are printed.

COUNTER EXIT SUPPRESSIONS.—When properly wired, suppresses the reading out of counters.

CYCLE COUNT.—A 1 timed impulse, emitted each machine cycle.

D - STORAGE IN.—Accepts impulses to condition the storage unit to accept information on the following card feed cycle.

D - STORAGE OUT.—Accepts impulses to condition the storage unit to read out on the following card feed cycle, except when the unit is picked up on an MLR card.

FEED INTERLOCK START BUTTON.—Used to run cards out of the 402 when a card feed failure occurs.

FORM LIGHT.—A light which, when lighted, indicates that the machine is out of paper forms.

FORM STOP LIGHT.—When ON causes the machine to stop and the form light to come on when the last piece of form has passed the sensing device.

FORM THICKNESS ADJUSTMENT DIAL.—Used to increase or decrease the distance between the platen and printwheels.

FUSE LIGHT.—When on indicates that a fuse is burned out.

HAMMERLOCK LEVERS.—Designed to prevent the hammers from firing against the 402 typebars.

HAMMERSPLIT LEVERS.—Designed to control zero printing on the 402.

LAST CARD AUTOMATIC TOTAL SWITCH.—Provides a total cycle for the first and last card that passes through the machine.

LEFT ZERO CARRY CLIPS.—Is used to print up to six zeros to the left of a significant digit.

NEGATIVE BALANCE CONTROL.—Suppresses zero balances and converts 9s complement to true figures.

NEGATIVE BALANCE OFF HUBS.—Emits an impulse when the corresponding counter contain all 9s.

NEGATIVE BALANCE ON HUBS.—Emits an impulse when the corresponding counter contains a nine in the high order position.

NONPRINT RUNOUT BUTTON.—Prevents printing on the report while cards are being run out of the 402, except for card feed failures.

NORMAL PRINT.—Print entry that is normally used for detail and group printing.

PAPER BRAKE.—A device used for adjusting the drag on the paper as it moves through the machine.

PLATEN CLUTCH KNOB.—Used for selection of desired printing line on the report.

PLATEN SHIFT WHEEL.—Used to shift the platen right or left, thus altering the horizontal printing on the report.

RESET CHECK SWITCH.—When on, reset check light comes on and machine stops when a counter fails to reset correctly; when off, the light flashes off and on for all machine operations.

RESTORE KEY.—Used to restore the carriage tape to the first print line.

SETUP CHANGE SWITCHES.—These switches on the 402 are comparable to the alteration switches on the 407.

TAPE CONTROLLED CARRIAGE.—A device to control automatic spacing and feeding of continuous form for report preparations.

TRANSFER PRINT.—One of the three print entries, normally used for printing only selected cards.

VERNIER KNOB.—Used for correct positioning of forms in relation to horizontal lines.

X - STORAGE IN HUBS.—Same function as D - STORAGE IN HUBS.

X - STORAGE OUT HUBS.—Same function as D - STORAGE OUT HUBS.

CHAPTER 10

CALCULATING PUNCHES

One of the machines which may be less familiar to you than those previously discussed is the calculating punch. This machine is used in installations that have a need for computing a result by multiplication or division as well as addition and subtraction. A typical example of such computations concerns the amount of net pay to which an individual is entitled after all withholdings have been calculated and subtracted from the gross pay. In order for a result to be calculated and punched, a card must contain certain items of information, called FACTORS. For example, in payroll applications, some of the basic factors required are hours worked, hourly rate, and number of dependents. These factors, plus other known or standard factors such as percentage of pay which must be deducted as Federal Income Tax and amount of pay which must be contributed to the Federal Insurance Contribution Act, are read into the calculating punch and used by the machine to calculate the net pay. The result, net pay, is then punched in the same card that contains the basic factors.

In addition to calculating amounts punched in a card and punching the result in the same card, calculations can be made for several detail cards and the result punched into a trailer card. The trailer card can then be used as a summary card representing the overall result for that particular group of detail cards.

Several types of calculating punches have been developed which are capable of performing the arithmetical computations of addition, subtraction, multiplication, and division. This chapter discusses one of these machines, the IBM type 602 calculating punch.

The basic principles of machine operation and control panel wiring for this machine are included in this chapter, and no attempt is made to cover the machine in complete detail. For further information concerning calculating punches, including the limitations placed on the type 602 Series 50, it is recommended you consult the appropriate machine reference manual, printed by the manufacturer.

CALCULATING PUNCH, TYPE 602

The IBM type 602 calculating punch, pictured in figure 10-1, performs all calculations and punching in one unit. When multiplying, a 22-digit multiplicand can be multiplied by an 8-digit multiplier to obtain a 30-digit product. When dividing, a 15-digit dividend can be divided by an 8-digit divisor to obtain an 8-digit quotient. Results obtained from calculations can be punched in the card or retained for later use.

The operating speed of the type 602 is based on the number of machine cycles required for calculation and punching. These cycles occur at the rate of 200 per minute. At least four machine cycles are required to get a card from the hopper to the stacker. This includes reading the card, performing some basic calculation, and punching of not more than two columns. Thus, a maximum of 50 cards can be calculated and punched per minute. The processing speed is reduced in proportion to the number of cycles required for calculation and the number of columns to be punched. Punching is performed serially (column by column) at the rate of four columns in one machine cycle. Addition or subtraction requires one machine cycle. The number of machine cycles required for multiplication and division is dependent upon the size of the factors used in these operations.

OPERATING FEATURES

Machine Controls

The MAIN LINE SWITCH, located at the right end of the machine, must be ON to supply power to the machine. An unlabeled light turns on when the main line switch is on and the machine is ready for operation. This light remains on when the machine is idling, but goes off while cards are feeding.

The START KEY must be depressed to start card feeding and calculating. The STOP KEY can be depressed to stop card feeding, even though the machine may be in the middle of a calculation.

The COMPARE LIGHT turns on when an error is detected during a checking operation. This light may also indicate an error in control panel wiring, a card feed failure, a card jam, improper counter reset, improper storage punching, or a burned out fuse. The RESET KEY must be depressed to turn out the compare light and to permit card feeding to be restarted. In some cases when the compare

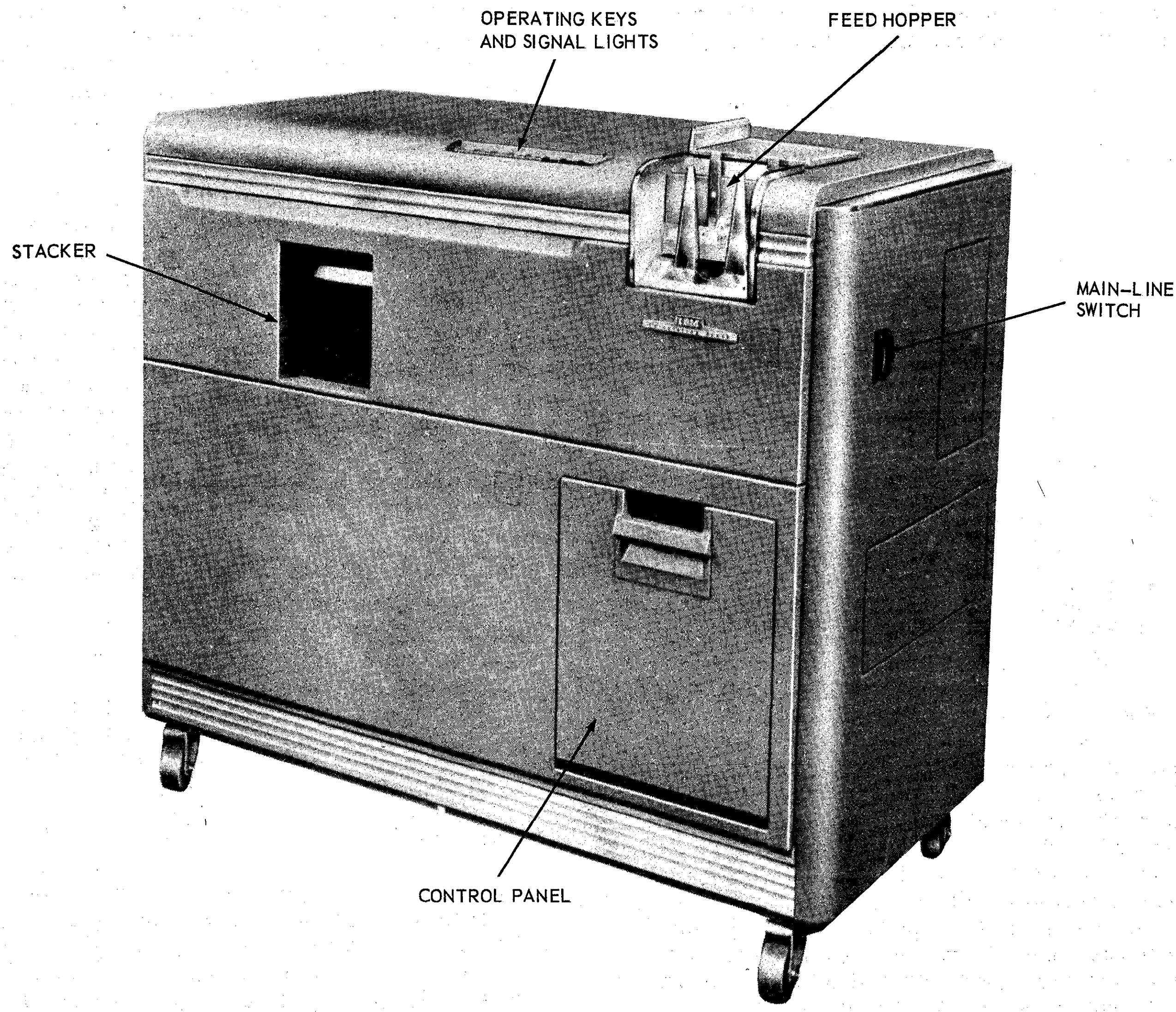

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Figure 10-1. —IBM Type 602 calculating punch.

light is on, it may be necessary to release the control panel before card feeding can be resumed.

Card Feeding and Punching

The card feed schematic diagram in figure 10-2 shows the path of cards through the machine. Cards are placed in the feed hopper face down with the 9-edge toward the throat. When the start key is depressed, the first card moves past a set of 20 control brushes which may be used to read control punches in the card. At this point, card feeding stops until all instructions wired in the control panel are executed, but no calculation is performed since

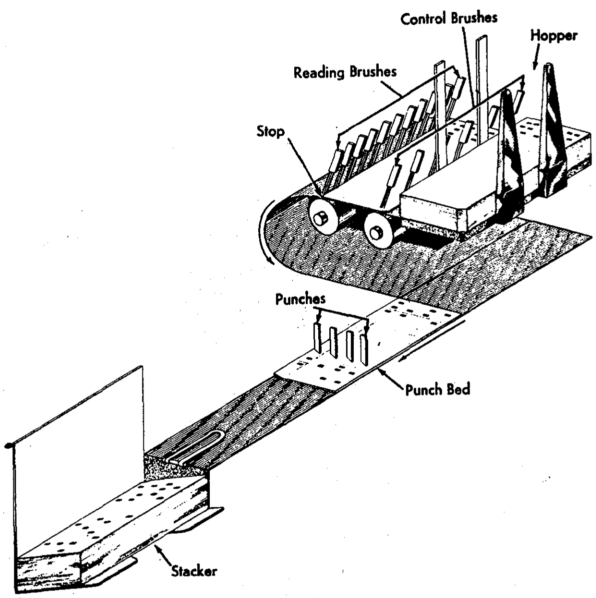

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Figure 10-2.—Card feed schematic diagram.

factors have not yet been read from the card. The purpose of this delay in card feeding is to permit the machine to clear out all units which are used with this control panel prior to calculating the first card. The remaining cards are fed without this delay.

Cards then feed past a set of 80 reading brushes, one brush for each card column. Factors are normally read at this station and entered into storage units or counters.

After passing the reading brushes, cards continue to feed in a semicircular path until they reach the punch entry station. At this point, they are face up with the column 1 edge to the left. If no previous card is being punched, the card passes directly to the punch bed and is skipped into position for punching the first column of the first result field. If a previous card is being punched, the next card waits at the punch entry station until the preceding card has been punched and ejected. The third card cannot be read until the first card is punched and ejected and the second card is in the punching station. Thus, during proper operation, it is not possible to have more than three cards in the feed unit; one in the punch bed, a second waiting at the punch entry station, and a third between the two sets of reading brushes.

After cards have been punched and released from the punch bed, they are ejected into the stacker face down and stacked in the same sequence as they were placed in the hopper.

Adjustable Skip Bar

Since punching occurs one column at a time, and there may be columns intervening before punching is to begin or between fields to be punched, the speed of an operation can be increased by skipping to the first column of each field to be punched. Skipping of a card while in the punch bed is started by control panel wiring and stopped by inserts placed in an adjustable skip bar. This bar, shown in figure 10-3, contains one position for each column of a card. A small insert must be placed in the position corresponding to the first column of each field to be punched after a skip. The skip bar is then inserted in the machine, just behind the punch bed.

PRINCIPLES OF OPERATION

Calculation in the type 602 is performed through the use of three basic units; storage units, counters (arithmetic unit), and the program unit.

Storage Units

Storage units can be used for storing factors read from a card, for storing calculated results, and to supply results to the punching mechanism. The standard machine is equipped with six 12-position storage units which are divided into a right and left section for each unit. Each section in a unit can be used to hold separate factors. These factors can be

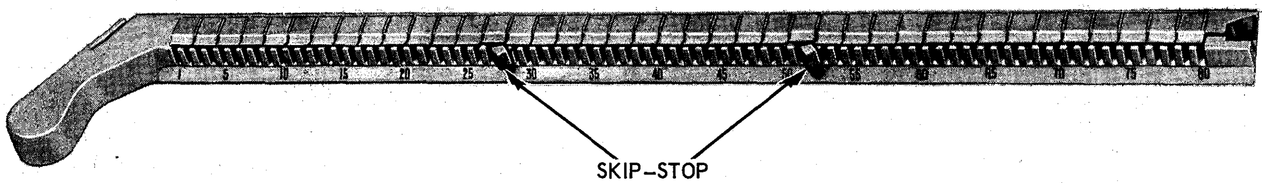

Figure 10-3. —Adjustable skip bar.

49.137X

read out of either section independently of the other, but both sections of a unit must be controlled to read in at the same time to avoid erasing the contents of one section when the other is being read into. All storage units can be used as input for storing calculated results, but only two can be used as output for punching results.

Counters

Counters are used to perform all addition, subtraction, multiplication, and division. The standard machine has three 6-position and three 4-position counters, which may be used separately or coupled together for greater capacity. All counters can be combined to produce one 30-position counter if desired. These counters can also be used as storage units because factors can be read into them directly from a card. These factors can be held during part or all of the calculation. Results cannot be punched directly from the counters.

Program Unit

The program unit supplies a series of 12 program steps which are used to instruct the machine to calculate a given set of factors. These steps are taken in sequence from 1 through 12, and as many may be used as are required to complete the calculation. Steps that are not needed can be eliminated by control panel wiring.

Diagram of Information Flow

The schematic diagram in figure 10-4 shows the flow of information from the time a card is read until punching takes place. This diagram, which is made from sections of the control panel, shows the entry of information from a card (input), the flow of information in making a calculation, and the punching of results (output).

Factors can be read from a card and entered into any storage units or counters by wiring the reading hubs to the appropriate entry hubs. Factors used for some operations must always be wired to a particular unit. The multiplier or divisor must be entered into storage unit 1R, the dividend must be entered into coupled counters 1, 2, and 3, and results must be punched from storage units 6 and 7. Storage units and counters are provided with exit hubs from which information can be transferred to other storage units or counters. Entry into and exit from any particular storage unit or counter cannot be made on the same program step.

Results can be transferred from counters or storage units to the entry hubs of storage units 6 and 7 for punching. Storage units 6 and 7 have special storage punch exit hubs which can be wired to the punching hubs for punching. Results to be punched can be entered into these units and punched immediately, or they may be held for punching later. It is possible to start punching some results into a card while other factors in that card are being calculated. When this is done, all fields to be punched must be arranged in logical order from left to right in the card so that punching can be performed in the proper sequence.

PRINCIPLES OF CONTROL PANEL WIRING

The control panel illustrated in figure 10-5 is used to direct all card reading, calculating, and punching in the type 602. Transfer of information must be accomplished by control panel wiring. Most of the hubs discussed in this section are illustrated in figure 10-4. Additional hubs are described as the need arises.

Planning the Operation

The first step in performing a calculation is planning the operation. Once the operation has been planned on a planning chart, such as the one shown in figure 10-6, the chart can be used as a guide for wiring the control panel. This planning chart is provided with a column for each of the operating features shown in figure 10-4 except card reading and punching. A line is provided for indicating the operation to be performed on each of the 12 program steps.

Due to the complexity of control panel wiring for combined operations, the operations of crossfooting, multiplication, and division are discussed and planned separately in this chapter.

Crossfooting

Crossfooting is the term applied to the process of adding or subtracting two or more factors to produce an answer. If the total results in a negative amount, it can be converted to a true figure and identified with an X punch through proper control panel wiring. The wiring required for identifying negative totals is discussed later in this chapter. In the example for crossfooting described below, it is to be assumed that totals will always be positive.

Suppose you are required to add two 4-position fields and subtract one 3-position field to obtain an answer with a maximum of five positions. The formula for this problem can be stated as A + B - C = D.

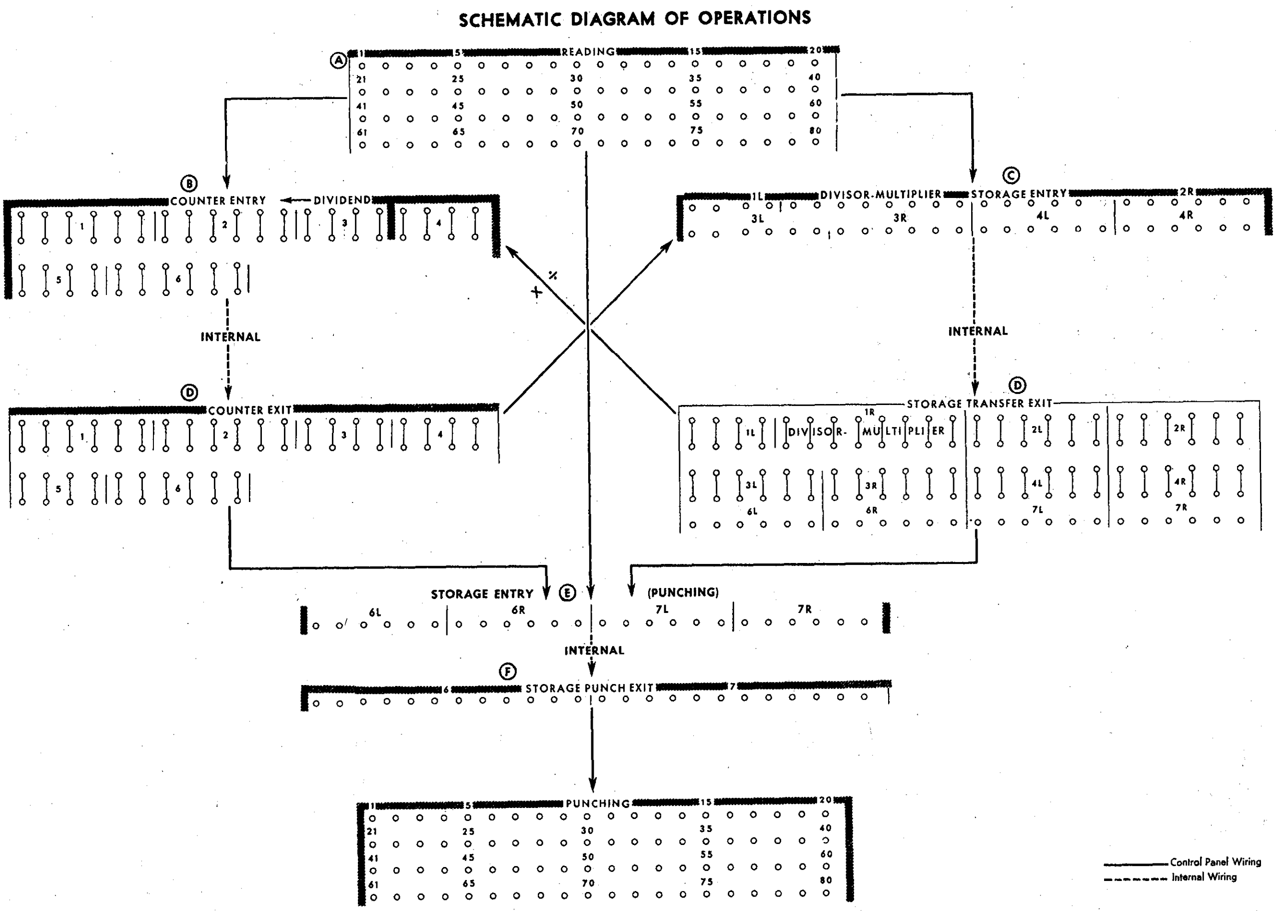

Figure 10-4. —Diagram of information flow.

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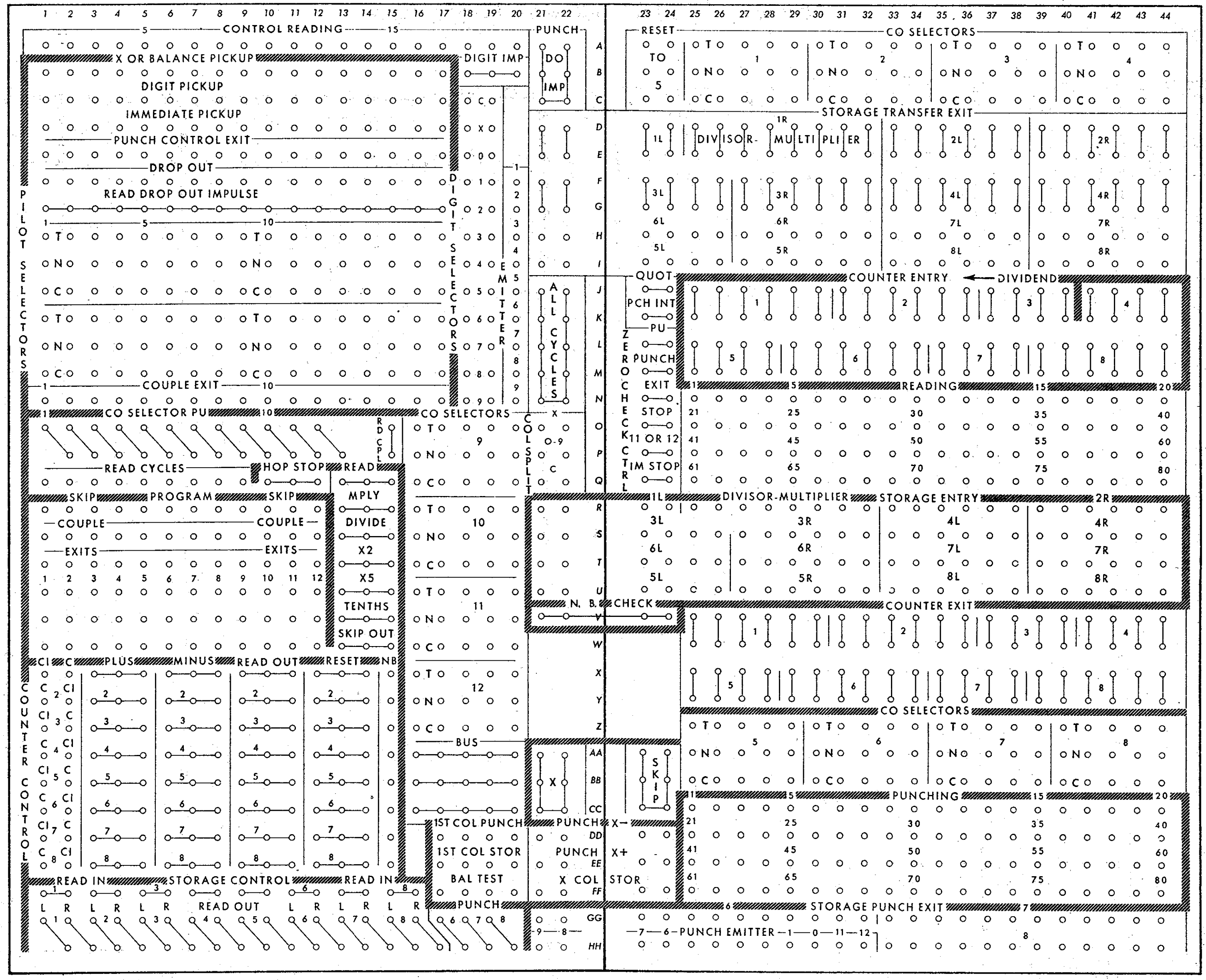

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Figure 10-5.—Type 602 control panel.

PROGRAM SUPPRESS	PROGRAM STEP	OPERATION	STORAGE UNIT		COUNTER						STORAGE UNITS									
				DIVR.-MULT.	DIVIDEND												PUNCH UNITS *UNITS POSITION MUST BE WIRED TO PUNCH			
			1L	1R	1	2	3	4	5	6	2L	2R	3L	3R	4L	4R	6L	6R *	7L	7R *
		READ CYCLE																		
	1																			
	2																			
	3																			
	4																			
	5																			
	6																			
	7																			
	8																			
	9																			
	10																			
	11																			
	12																			

49.140X

Figure 10-6.—Planning chart for type 602.

Planning for this operation is shown in figure 10-7. The first step is to assign the factors from the card to storage units or counters. Since counters will accept factors read from a card, one program step can be saved by entering one factor directly into a counter. In this example, factor A is entered into counter 6, factor B into storage unit 2L and factor C into storage unit 2R.

Program step 1 is used to complete the first part of the formula, which is A + B. Since A is already in counter 6, B can be added to it by reading out storage unit 2L and reading into counter 6 plus.

On the second program step, factor C is read out of storage unit 2R and read into counter 6 minus. The answer D is now developed.

On the third program step, counter 6 is directed to read out and reset so that factor A from the next card can be entered. Both sides of storage unit 2 clear automatically when a new factor is entered into either side. The answer D is transferred from the counter to storage unit 6R for punching. The arrow under the answer D indicates that punching is to be performed on this program step. Programming for this operation is now completed.

Wiring for this operation is shown in figure 10-8. You must remember that all transferring of information between storage units and counters must be accomplished by control panel wiring.

1. The READING hubs are wired to counter entry 6 for storing factor A, and wired to storage entry 2L and 2R for storing factors B and C.

2. Each READ CYCLES hub emits an impulse when a card passes the reading brushes. Factor A is added by wiring a read cycles impulse to the plus hub of counter 6. Notice that CI is wired to C of counter 6. This is necessary because counters in the type 602 reset to 9 instead of zero, and the carryover which emerges from the high order counter position when an amount is added or subtracted must be brought to the units position in order for results to be shown correctly. CI to C must be wired for all counters used, regardless of the operation.

3. Factors B and C are entered into storage by wiring a read cycles impulse to the STORAGE CONTROL READ IN hub of storage unit 2.

4. Factors B and C are wired from the exit hubs of storage unit 2L and 2R to the entry hubs of counter 6 in order to provide a path for these factors from storage to counter. The use of split wires is avoided by wiring factor B through the common hubs of 2R.

5. The exit hubs of counter 6 are wired to storage entry 6R so that the answer D can be stored for punching.

6. The punch exit hubs of storage unit 6 are wired to the punching hubs for punching.

7. Skipping is started when one of the common SKIP hubs receives an impulse, and is stopped by an insert in the skip bar. In this example, punching hub 33 is wired to SKIP so that skipping can be started after the units column of the field has been punched. An insert must be placed in position 28 of the skip bar so that the skip will be stopped when the first column to be punched in the following card

Program Suppress	Program Step	Operation	Storage Unit 1L	Storage Unit Divr.-Mult. 1R	Counter Dividend 1	Counter Dividend 2	Counter Dividend 3	Counter 4	Counter 5	Counter 6	Storage Units 2L	Storage Units 2R	Storage Units 3L	Storage Units 3R	Storage Units 4L	Storage Units 4R	Punch Units 6L	Punch Units 6R *	Punch Units 7L	Punch Units 7R *
		READ CYCLE								+A 14725	READ IN B 247	READ IN C 264								
	1	Add B to A								RI + 14972	RO 247									
	2	Subtract C								RI − 14708		RO 264								
	3	Store and Punch D								R&R								RI (D) 14708 ↓		

*UNITS POSITION MUST BE WIRED TO PUNCH

49.141

Figure 10-7. —Planning for crossfooting.

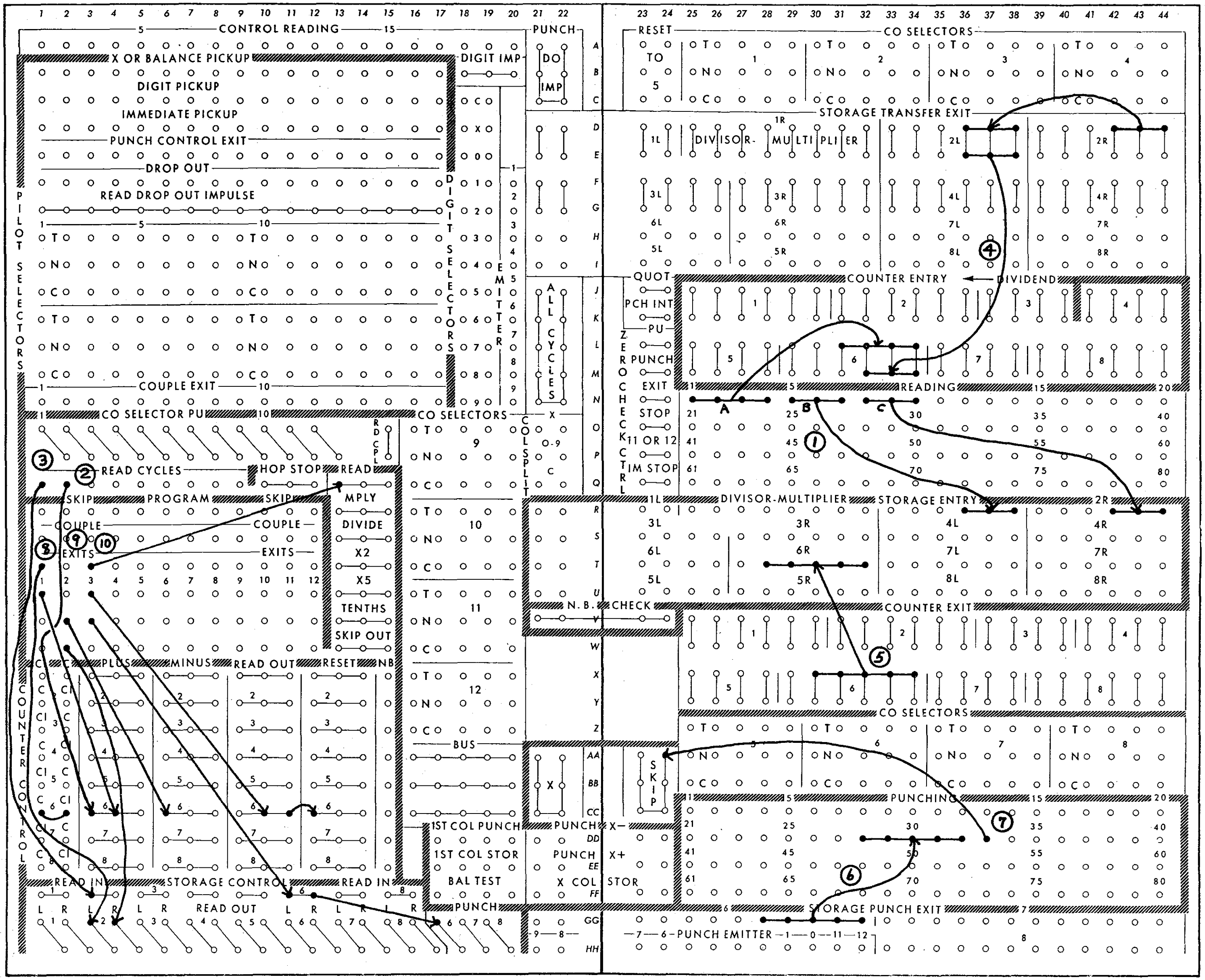

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Figure 10-8.—Wiring for crossfooting.

reaches the punching station. While the PUNCHING hubs are normally thought of as entry hubs to the punch magnets (and can be used as such) they are actually EXIT hubs, and each hub emits an impulse when the corresponding column of the card is in punching position.

8. The first program step in the planning chart requires factor B to be read out of storage and added to factor A. This is accomplished by wiring one exit from program step 1 to storage control READ OUT of storage unit 2L, and a second program exit to the plus hub of counter 6.

9. On the second program step, factor C is subtracted by wiring one exit from program step 2 to storage control read out of storage unit 2R, and a second exit to the minus hub of counter 6. The answer D is now developed.

10. On program step 3, counter 6 is read out and reset by wiring a program exit to one of the READ OUT hubs, and from a common read out hub to RESET. The answer D is read into storage by wiring another program exit to the storage control read in hub of unit 6. Since punching is to occur on this step, the program exit is further wired to the PUNCH hub of storage unit 6. A third program exit is wired to READ to cause the machine to feed the next card, since no further program steps are to be taken.

Balance Conversion

In some operations involving addition and subtraction, the total of the factors subtracted may be greater than the total of the factors added, resulting in a negative total. In order to convert these totals to true figures and identify them as negative amounts, balance conversion must be used. This can be done provided the counter used for developing the result contains at least one more position than there are digits in the result. If the result in a counter is negative, each counter position to the left of the result will contain a 9. Any one of these positions can be wired to a storage unit position to the left of the result in storage to start the balance conversion process. However, you must be sure that the counter position used for balance conversion will never be needed for actual accumulation.

Figure 10-9 illustrates only the wiring required for balance conversion. All other wiring is the same as shown in figure 10-8 except for the first and last positions wired from storage punch exit to the punching hubs. Arrows indicate the direction of the impulses used in balance conversion as an aid to you in understanding the balance conversion process. Negative totals are to be identified with an X over the units punching position of the amount field.

1. The high order position of counter 6 is wired to a free position in storage unit 6R for signaling a negative total.

2. When the first column in the field to be punched is positioned at the punching station, the punching hub for that column emits an impulse which is directed by control panel wiring to 1ST COLUMN PUNCH. This impulse is then directed by an internal circuit to the BALANCE TEST hub.

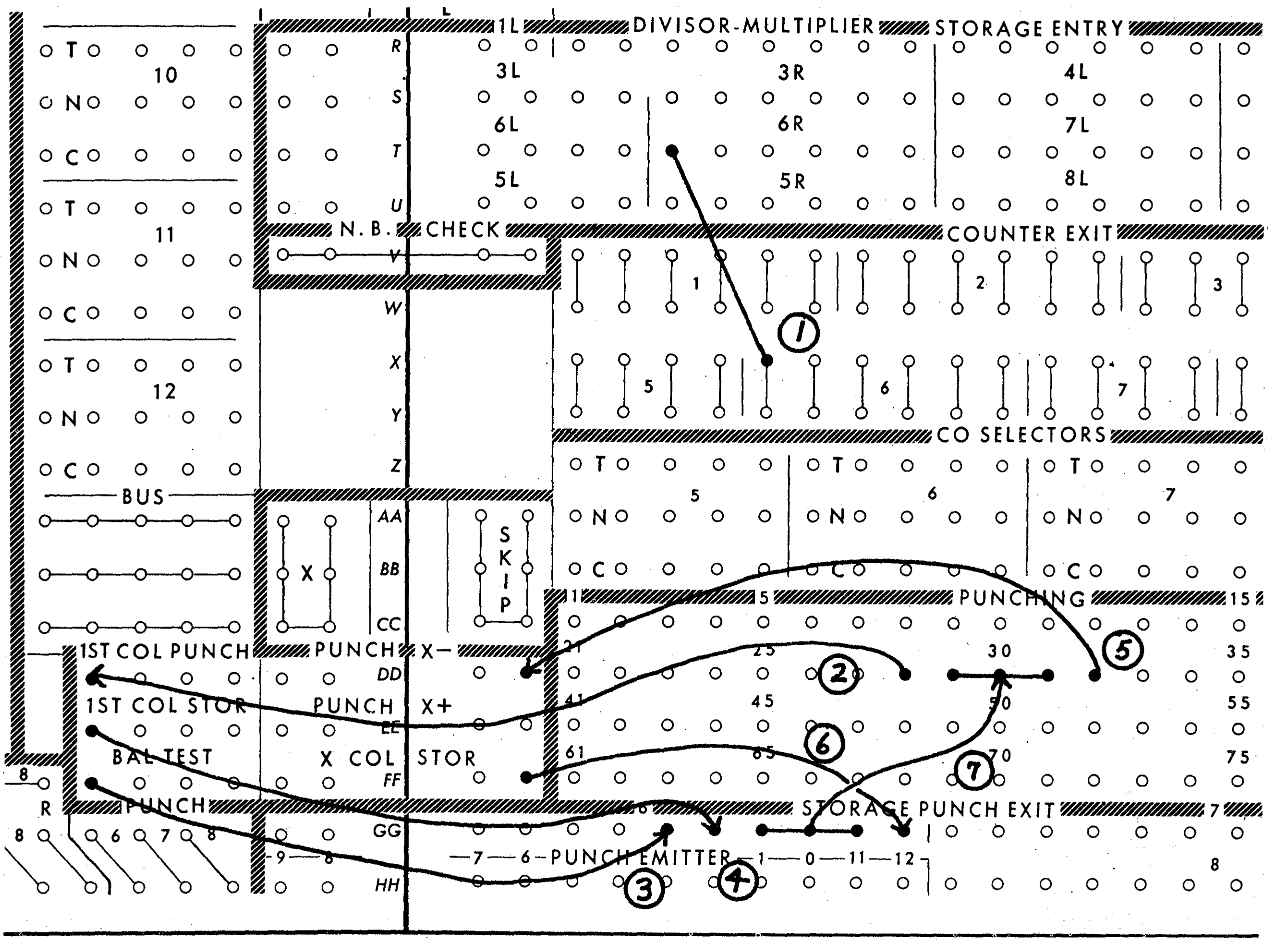
3. The balance test hub is wired to the storage punch exit corresponding to the storage entry position wired from the high order counter position. If the storage test position contains a 9, indicating a negative total in the counter, the machine converts the total to a true figure. If the storage test position contains a zero, indicating a plus total in the counter, no conversion takes place. In either event, the impulse from PUNCHING is then switched from BALANCE TEST to 1ST COLUMN STORAGE.

4. The first position to be punched is wired from 1st column storage to the storage punch exit hub representing the high order digit of the amount wired to punch. The storage punch exit hubs are actually ENTRIES, although they are normally thought of and used as exits from storage to punching.

5. The punching hub representing the column to be punched with an X for identifying negative totals must be wired to the PUNCH X MINUS hub. If a negative total is present in the counter, an emitted X is available from the X COLUMN STORAGE hub. Any digit in the amount field wired from the punching hub to punch X minus is available from X column storage whether negative or true totals are present in the counter.

6. Digit punches in the units column are made available for punching by wiring X column storage to storage punch exit. An X impulse is made available for punching by this same wire if the counter contains a negative total.

7. The remaining columns in the field to be punched are wired in the normal manner.



49.143

Figure 10-9.—Wiring for balance conversion.

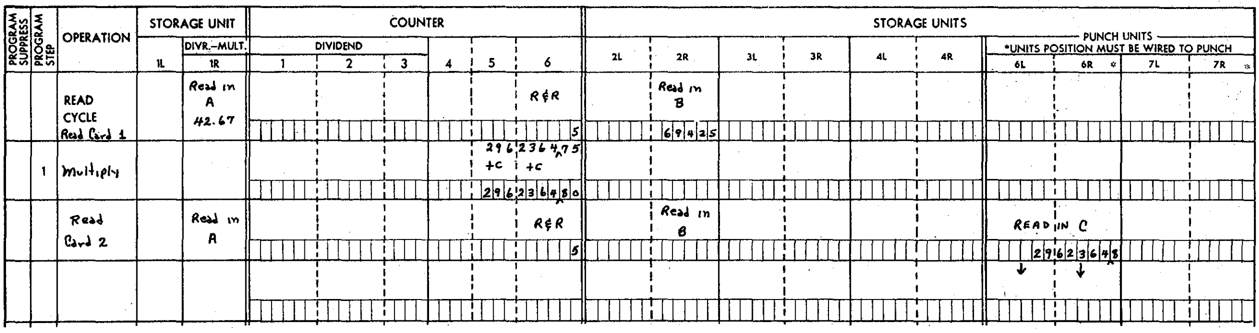
Multiplication

Multiplication requires the use of storage unit 1R for storing the multiplier, a counter or storage unit for storing the multiplicand, and a counter for developing the product. Multiplication is performed on a single program step, but the number of machine cycles required for this step depends upon the number of digits in the multiplier. For this reason, the factor with the smaller number of digits should be used as the multiplier.

The number of decimal positions in the product is equal to the total number of decimal positions in the multiplicand and the multiplier. If some of these positions in the product are to be dropped, the last position retained can be adjusted to the nearest whole number by adding a 5 to the left hand decimal position to be dropped. This 5 is entered into the counter before multiplication begins by impulsing the counter to reset to 5 instead of the normal reset.

Planning for a multiplying operation, in which A x B = C, is shown in figure 10-10.

The multiplier, containing two decimal positions, is stored in storage unit 1R. The multiplicand, with no decimal positions, is stored in storage unit 2R. This means that the product developed in coupled counters 5 and 6 will have two decimal positions. Suppose we wish to have only one decimal position in the product, adjusted to the nearest whole number. This can be accomplished by directing the units



49.144

Figure 10-10.—Planning for multiplication.

position of counter 6 to reset to 5 on the card feed cycle instead of normal reset. This 5 will be added to the product automatically when the machine is directed to multiply.

Only one program step is required for multiplication. Factor B is read out of storage and automatically multiplied by factor A to develop the product C in counters 5 and 6. The product is transferred to storage unit 6R and punched while the next card is being read.

Control panel wiring for this operation is illustrated in figure 10-11.

1. Four functions take place when each card is read by wiring READ CYCLES impulses as follows:

a. To the READ IN hubs of storage units 1 and 2 for storing factors A and B.

b. To the READ OUT and RESET hubs of counters 5 and 6 for clearing those counters each card cycle.

c. To the READ IN hub of storage unit 6 for storing the product.

d. To the PUNCH hub of storage unit 6 for punching the product C.

2. Factor A is read into the multiplier unit and factor B into storage unit 2R.

3. Factor B is wired from the exit hubs of storage unit 2R to the entry hubs of counter 6, where the product is to be developed.

4. Only one of the two decimal positions in the product is to be retained. Therefore, a RESET TO 5 impulse is wired to the units position of counter entry 6, since this is the decimal position to be dropped and the remaining position is to be adjusted to the nearest whole number.

5. The product, with one position dropped, is wired to storage unit 6 for punching. The units position of storage unit 6R must be wired to punch.

6. The product is wired from storage punch exit 6 to the punching hubs.

7. Skipping is started after the units position of the field has been punched. A skip insert must be placed in position 28 of the skip bar to stop skipping when the first column to be punched is in punching position.

8. Only one program step is required in this example. Four functions take place by wiring the exits for program step 1 as follows:

a. To the READ OUT hub of storage unit 2R for reading out the multiplicand.

b. To the MULTIPLY hub for multiplying.

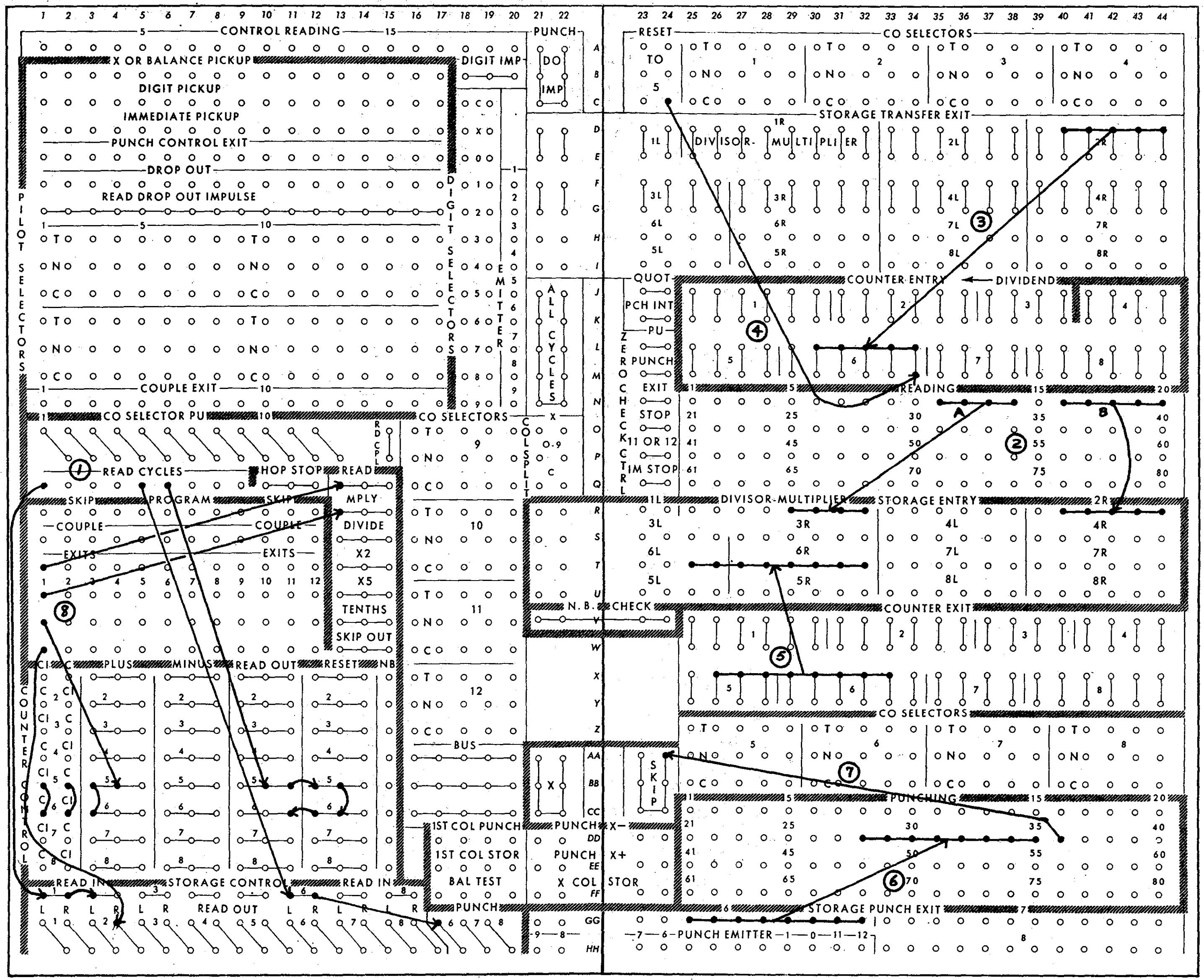
c. To the PLUS hubs of coupled counters 5 and 6 for adding the positive product as it is developed.

d. To the READ hub for reading another card, since no further program steps are required for this calculation.

Division

In order to divide, the dividend must be entered into coupled counters 1, 2, and 3 and the divisor into storage unit 1R. When the machine is impulsed to divide, the divisor is repeatedly subtracted from the dividend until the remainder reaches zero or is less than the divisor. The quotient is developed in counters 4, 5, or 6 by counting the number of subtractions required to reduce the dividend to a number less than the divisor.

In divide operations involving decimals, care must be taken to position the dividend properly in the dividend counter. The placement of the decimal in the dividend counter is determined by adding the number of decimals in the divisor, plus the number of decimals desired in the quotient, plus another decimal position if the quotient is to be half-adjusted.



49.145

Figure 10-11.—Wiring for multiplication.

Planning for a divide operation, in which A ÷ B = C, is shown in figure 10-12.

The first thing to be determined is the placement of the decimal position in the dividend counter. In this example, the divisor has two positions, the quotient is to have two positions, and the quotient is to be half-adjusted, making a total of five positions that must be pointed off in the dividend counter. Since the dividend has two decimal positions, the units decimal position must be entered into the fourth position of the dividend counter.

The divisor must be placed in storage unit 1R. This is indicated by placing a B under 1R on the READ CYCLE line. The counter in which the quotient is to be developed can be indicated by Q. The dividend is placed in coupled counters 1, 2, and 3.

Two program steps are required for division. On the first step, division is accomplished by reading out the divisor and dividing. On the second program step, the remainder in the dividend counter is cleared, the quotient is transferred for punching, and the quotient counter is reset to 5 for half-adjusting the following quotient.

Control panel wiring for this operation is illustrated in figure 10-13.

1. The dividend A is stored from each card by wiring a READ CYCLES impulse to the PLUS hubs of coupled counters 1, 2, and 3. The divisor B is stored from each card by wiring a READ CYCLES impulse to the storage control READ IN hub of storage unit 1.
2. The dividend is wired from the reading hubs to the entry hubs of counters 2 and 3 in accordance with the decimal position alignment determined on the planning chart. The entry divisor is wired from the reading hubs to the hubs of storage unit 1R.
3. The divisor is wired from the exit hubs of storage unit 1R to the entry hubs of the dividend counter, starting with the units position, in order for the divisor to be subtracted from the dividend. The fact that the divisor and dividend, wired to the entry hubs of the dividend counter, do not overlap is purely coincidental. By reference to the planning chart, you will notice that the dividend actually has zeros in the counter positions to which the divisor is wired, because of the necessity for pointing off five decimal positions in the dividend counter.
4. The quotient is developed one position at a time as an internal machine test compares the size of the dividend with the size of the divisor. By wiring a QUOTIENT impulse to the units position of counter 6, the quotient digit is added as it develops from left to right. Although only one quotient impulse is wired, a quotient in excess of one position can be developed because of an internal shift that occurs as the divide cycles are taken.
5. The units position of counter 6 is wired from a RESET TO 5 impulse to provide for half-adjusting the quotient.
6. The quotient is transferred for punching by wiring the exit hubs of counter 6, with the units position dropped, to the entry hubs of storage unit 6R.
7. The quotient is wired to punch, and column 32 is wired to skip.
8. Two program steps are required in this example. On the first step, four functions take

PROGRAM SUPPRESS	PROGRAM STEP	OPERATION	STORAGE UNIT 1L	STORAGE UNIT DIVR.-MULT. 1R	COUNTER DIVIDEND 1	COUNTER DIVIDEND 2	COUNTER DIVIDEND 3	COUNTER 4	COUNTER 5	COUNTER 6	STORAGE UNITS 2L	2R	3L	3R	4L	4R	PUNCH UNITS 6L	6R*	7L	7R*
		READ CYCLE		Read in B 3.51	+A	+A	+A													
						457	6000													
	1	Divide		RO	–	–	–			+C										
							13			13042										
	2	Clear remainder and store quotient			RESET	RESET	RESET			R & R								Read in C		
										5								1304		

*UNITS POSITION MUST BE WIRED TO PUNCH

49.146

Figure 10-12.—Planning for division.

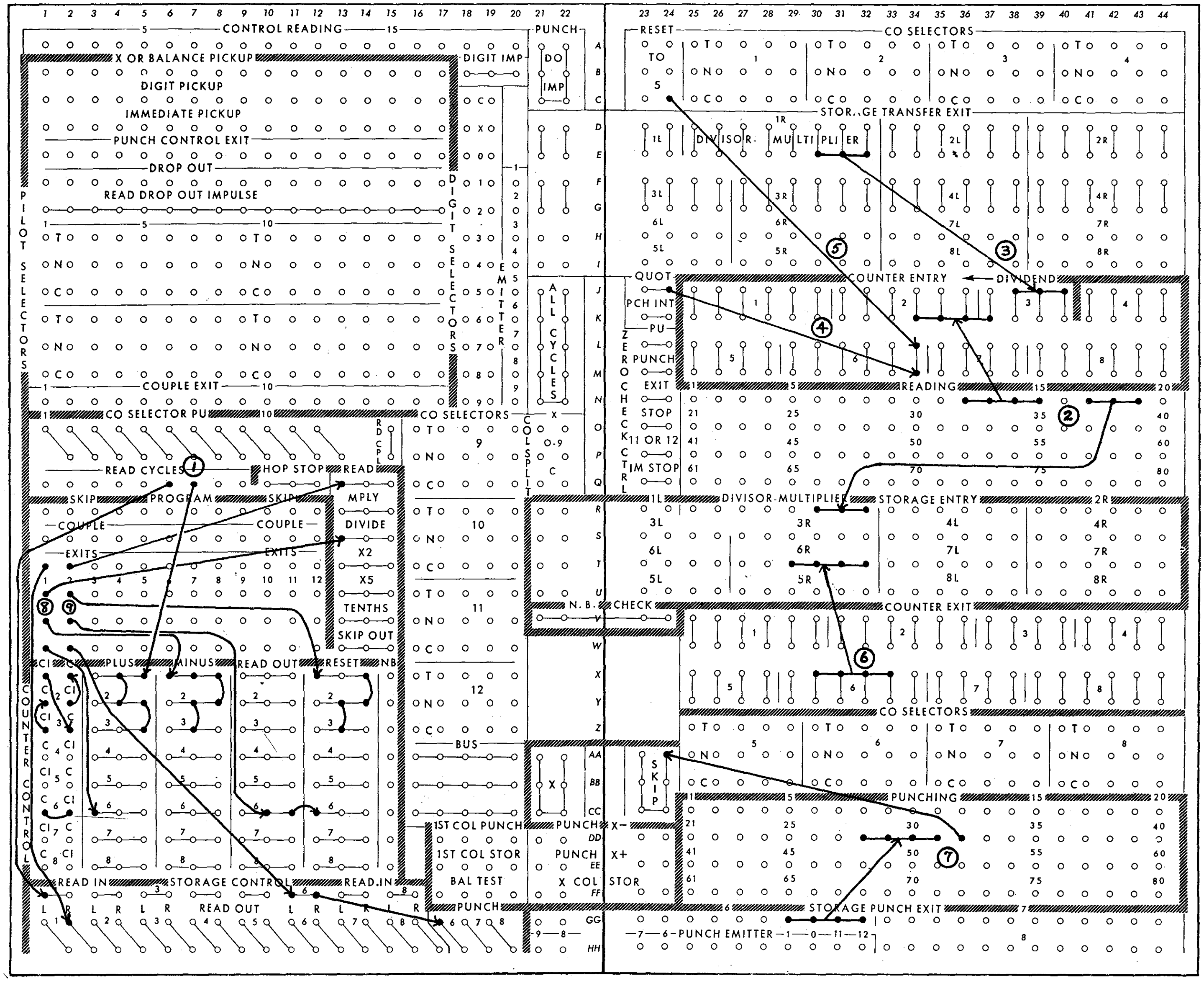


Figure 10-13.—Wiring for division.

place by wiring the exits for program step 1 as follows:

a. To the READ OUT hubs of storage unit 1R for reading out the divisor.
b. To the DIVIDE hub for dividing.
c. To the MINUS hubs of coupled counters 1, 2, and 3 for subtracting the divisor.
d. To the PLUS hub of counter 6 for adding the quotient.

9. The divide operation is completed on the second program step. Four functions take place when the exits for program step 2 are wired as follows:

a. To the RESET hubs of coupled counters 1, 2, and 3 for clearing the remainder from the dividend counter.
b. To the READ OUT and RESET hubs of counter 6 for transferring the quotient and for resetting the counter to 5. By resetting the units position to 5, the half-adjustment factor is entered for the following card. This factor is entered for the first card to be calculated when the machine stops after the first card passes the control brushes and goes through all program steps to be executed, as explained under CARD FEEDING AND PUNCHING.
c. To the READ IN and PUNCH hubs of storage unit 6 for storing and punching the quotient.
d. To the READ hub for feeding another card, since no further program steps are to be taken.

OPERATING SUGGESTIONS

Always conduct a test run of a few cards before starting any operation. Check these cards manually to make sure that calculations and punching are correct. If you find an error that you cannot resolve, notify your supervisor.

Make sure that skip stop inserts are placed in the proper positions in the skip bar before beginning an operation. Placing an insert in the wrong position will result in improper punching. If no insert is placed in the skip bar when results are to be punched, the machine will skip the card immediately to column 80, where it remains until the control panel cover is opened.

Do not turn off the main line switch during an operation. Card feeding should be stopped only by depressing the STOP key.

If card feeding stops for any reason, cards remaining in the machine can be run out automatically by emptying the feed hopper and opening the control panel cover. These cards will be ejected into the stacker without being calculated or punched.

ADJUSTABLE SKIP BAR - A metal bar that contains one position for each column of the card, and enables the 602 to skip over unpunched columns or fields.

BALANCE CONVERSION - A process whereby a negative total is converted to a true figure and identified as a negative amount.

CROSSFOOTING - Adding and subtracting of numbers left to right, as opposed to top to bottom.

FACTORS - Data used in calculations; hours worked, hourly rate, tax deductions, etc.

ONE HALF ADJUST - Resets the quotient counter to 5 for following quotient.

PLANNING CHART - Used to analyze a job by the logical use of storage units and the sequence of steps required; facilitates control panel wiring.

READ CYCLE - The time it takes a card to pass a reading station.

SIGN CONTROL - A special punch or impulse that indicates that the result of a calculation is negative or positive depending on its presence or absence.

SKIP-STOP INSERTS - These inserts are placed in the first column of a field to be punched to stop skipping.

STORAGE ASSIGNMENT - Provides a way to shift a storage unit internally to the left in order to make one unit operate in conjunction with another unit; assigning specific channels for transferring factors.

STORAGE UNIT - A device that will accept and retain data until called for.

ZERO CHECK - A method of checking a calculation to determine if the results are a zero balance.

CHAPTER 11

EAM PROCEDURE AND DATA FLOW

Many different jobs are performed by Machine Accountants in a data processing installation. In a broad sense, these jobs can be grouped in three general categories; clerical, machine operation, and administration. 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.

Chapters 4 through 10 cover the operation of various punched card data processing machines and the principles of wiring control panels for accomplishing a desired result. 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 flow charts; the meanings of different symbols and how they are used. Finally, but certainly not least, it provides you with some pointers on how to act as a team member.

PROCEDURE DEVELOPMENT

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 a 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. This is necessary if we are to accomplish the following objectives:

1. Enable machine operators to set up machines without assistance.
2. 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.
3. Enable the supervisor to regulate and coordinate the operations within his section or division.
4. Provide management with a tool for regulating and coordinating operations of the entire installation.

PLANNING THE PROCEDURE

Before any data processing job is performed, a procedure for doing the job should be established. 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.

Before you can start writing a procedure, you must know what the requirements are for the finished product, and when the source documents or cards which are required for producing the final result will be available. The procedure is then developed to bridge the gap between the source documents or cards (input) and the finished product (output).

Establishing 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 requests for punched card 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. You must find the answers to the following questions?

1. What information is needed in the report?
2. In what sequence should items of information appear?
3. What headings, types of totals, and controls are required?
4. Who will receive and use the report?
5. How often is the report desired?
6. What priority is to be assigned to the report compared to other reports?

A sample report can be prepared on the accounting machine or on a typewriter. Reference to the schedule of reports presently in use will normally indicate the best time for scheduling a new report. You are now ready to proceed with the next step in planning.

Determining Source Documents

Once the objectives have been established, the next step is to examine the source data that must be used in obtaining the information for the final report. If the required information is already contained in existing punched cards, so much the better. Sometimes it may be necessary to add fields to present cards for punching additional information required. If existing cards cannot be used, you must examine the present source documents to see if they contain the desired information. 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 the source documents for the easiest and most effective use in keypunching and other processing.

Source documents frequently are batched and transmitted with a control tape to provide for ease in handling and control. The size of batches is more or less up to you. However, if the control tapes contain totals of certain items in the batches, and these totals must be proven before the cards can be used, the size of a batch should be small enough to that if a batch does not balance, the error or errors can be located without spending too much time in research. After the procedure has been in effect for some time, size of batches or units can be more accurately determined with the following factors available for consideration:

1. Number of totals per batch to be balanced.
2. Average keypunching time per batch.
3. Number of errors experienced during a trial period.

Designing the Cards

New card layouts must be prepared if existing cards cannot be used in the new procedure. You may have to design detail cards for keypunching, or summary cards for summary punching. The types of cards to be prepared depend upon the requirements of the particular job.

Basic Types of Cards.—Cards are classified usually as one of four different types 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. A typical example of this type of card is the rotation data card, which is keypunched from data entered by the recording activity in the appropriate blocks of the card.
3. MARK SENSED cards are automatically punched from pencil marks placed on the card, such as cards used for a military payroll.
4. SUMMARY cards are automatically punched with totals accumulated in the accounting machine or calculating punch. These cards usually are prepared by tabulating groups of detail cards and obtaining totals for each group.

The design for dual and mark sensed cards must be prepared by using special layout forms and submitting these forms to a card manufacturer for printing. The method of designing these cards will not be a matter of discussion here, since you will not normally be concerned with their preparation. Your present concern is designing the layouts for transcript and summary cards. Standard stock cards can be used for punching these types of cards after the layout has been prepared. 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.

Card Data.—The first step in designing a card is to prepare a list of all information required for the established objective. This information usually is determined when the objective is established. You must then decide if all these data can be punched from available source documents, or if certain information must be gangpunched or reproduced from other card files. Once the list of information is prepared, you must decide on the best arrangement for punching.

Preliminary Work.—One of the most important factors that must be considered when assigning card fields is the alignment of control fields to correspond with the same columns previously assigned to other types of cards. For example, if service number is punched in columns 20-26 of all other personnel cards, then service number should be placed in the same columns of the new cards. This is extremely important if other types of cards are to be combined with the new cards for producing the final result, since data processing machines can perform the functions of automatic control most effectively when the control fields in all types of cards are assigned to the same columns.

Next in importance is the arrangement of data fields to provide for ease in keypunching. When possible, data fields should be set up in each card so that punching can be accomplished in the same sequence as the information appears on the source document. Consideration must be given to eliminating manual punching of repetitive information by using prepunched master cards for duplicating data which is common to all cards of a group. In some instances, repetitive information need not be entered at the time cards are keypunched, but can be gangpunched later by the automatic punch. In other situations, you may find that master card files can be used for intersperse gangpunching some of the information required in the detail cards.

Each field in the card layout should be identified as to the method by which it is to be punched; that is, keypunched, duplicated, summary punched, gangpunched, or calculated. All fields for each type of information, such as reference, classification, and quantitative information, should be grouped together whenever possible to simplify control panel wiring and to eliminate excessive skipping on the keypunch. Reference information is used to identify the original source, such as date, activity processing code, or invoice number. Classification information identifies a particular item on the source document, such as part number or service number. Quantitative information consists of totals punched in the card, such as quantity on hand or unit price.

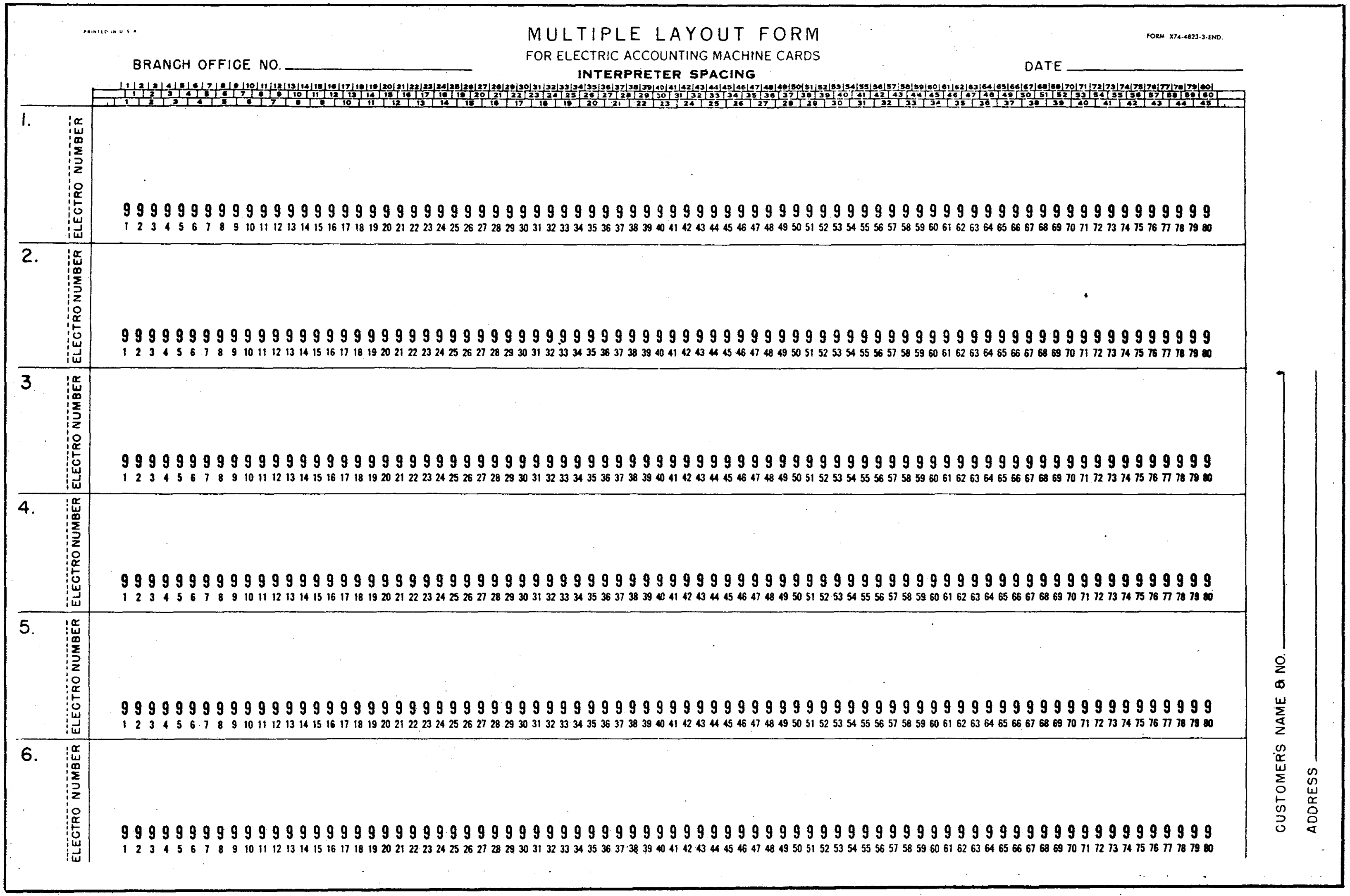
The size of fields is an important factor in designing the card. The number of columns needed for reference and classification of data can be readily established since they usually require the same number of positions for each card. A realistic assignment of columns for totals can be made only if you have a pretty good idea of the maximum size of totals to be expected. Total fields should be set up to take care of all but the unusual cases, and these should be 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.

If the new cards are to be identified by a specific control X or digit punch, consult the present list of X and digit assignments in the supervisor's manual to avoid establishing a control punch that conflicts with another type of card.

Preparing the Card Layout.—After you have completed the list of required data, arrangement of data, and the number of columns required for each field, prepare the card layout on a standard layout form. Draw vertical lines between the numbered columns for each field, and label each field according to its contents. Indicate the method of punching for each field. Be sure to identify the card by name, such as daily transaction card, labor distribution card, or daily production card. The card layout is now complete, and is ready to be included in the supervisor's manual.

STYLE OF THE PROCEDURE

There are several effective styles that can be used when writing a procedure, but as a general rule the best policy is to write procedures in the style adopted by your particular installation. Regardless of the style used, a procedure should be written in a simple, easily understood manner, with all information included which is necessary for a machine operator to perform



PRINTED IN U.S.A.

MULTIPLE LAYOUT FORM

FOR ELECTRIC ACCOUNTING MACHINE CARDS

FORM X74-4823-3-END.

BRANCH OFFICE NO. ______ DATE ______

INTERPRETER SPACING

1. ELECTRO NUMBER

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2. ELECTRO NUMBER

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3 ELECTRO NUMBER

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4. 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

5. ELECTRO NUMBER

9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9
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

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 ______

49.148X

Figure 11-1.—Multiple card layout form

the job without further assistance. The procedure should not be cluttered with details that will tend to slow down completion of the job without contributing any assistance to the operator.

The following sample procedure shows you one style of writing an effective procedure for accomplishing a job after cards have been keypunched and verified.

1. Interpret Daily Transaction cards, obtained from keypunch section, on upper line. Use type 548 control panel number 4.

2. Sort Daily Transaction cards from step 1 to Transaction Number (11-8).

3. Merge Daily Transaction cards from step 2 behind Cumulative Transaction cards, obtained from file. Wire type 85 control panel to control on Transaction Number (8-11).

4. Tabulate and summarize merged Daily and Cumulative Transaction cards from step 3 to prepare the Cumulative Transaction Report and to obtain updated Cumulative Transaction cards. Use type 407 control panel number 6 and type 519 control panel number 12. Use carriage control tape number 5. Single space on 4-part preprinted form, obtaining minor control totals by Transaction Number (8-11) and automatic final totals. Use standard stock cards for updated summaries.

   a. Forward report to supervisor for checking and distributing.
   b. Forward merged Daily and Cumulative Transaction cards to HOLD file for use in procedure 3.
   c. Forward updated Cumulative Transaction cards to step 5.

5. Interpret updated Cumulative Transaction cards from step 4c on upper line. Use type 548 control panel number 7. Forward cards to Cumulative Transaction card file.

From an analysis of the sample procedure shown above, we see that certain basic instructions have been established as follows:

1. Each step begins with an ACTION word. This alerts the operator to the type of operation that is to be performed.

2. The place from which cards are obtained is listed in each step.

3. Instructions for using permanently wired control panels or for wiring temporary panels are included.

4. The columns to be sorted or used for control are shown. Columns to be sorted are shown in the sorting sequence desired. For example, Transaction Number which is punched in columns 8-11 must be sorted on the units position (column 11) first, and then progressively sorted through the high order position (column 8). Thus, the sorting sequence desired is 11-8.

5. Disposition of each type of card and the report is shown.

6. The type of paper and the number of copies to be prepared are shown.

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 according to the manner previously established. 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.

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 such as sorting, interpreting, collating, reproducing, calculating, and tabulating. 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, type of paper to be used for preparing the report, and the number of copies to prepare.

MANUALS OF PROCEDURE

The objectives listed above can best be met by establishing a procedural manual for each functional level—operations, supervision, and management. These manuals usually are called an operator's manual, a supervisor's manual, and a general manual for management personnel. 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 detailed procedures for each job, wiring diagrams if control panels are to be wired, and sample copies of reports to be prepared. In addition, reference should be made in the operating procedures to test decks and carriage tapes which are to be used.

Operating Procedures.—The most important part of the operator's manual is the detailed operating procedures. Each operation to be performed should be written in a series of detailed operating steps to enable an operator to perform the job with no outside assistance. The actual method used in writing a procedure is discussed later in this chapter. A copy of each operating procedure which is to be used by the machine operators should be placed in a separate folder to allow several operators to use different procedures at the same time.

Wiring Diagrams.—If a job calls for the operator to wire a control panel, he should be provided with all necessary instructions, including, when required, a complete and legible wiring diagram. Wiring diagrams usually are prepared as enclosures to the operating procedure, and should be referenced in the procedure at the point where each panel is to be wired.

Test Decks.—In many situations a machine should be tested before beginning the actual operation to make sure everything is in order. This is especially true if the operator is required to wire a control panel. Test decks should include a card for each type of transaction that could exist to ensure that the control panel is wired correctly and the machine is in proper working order. It may be practical to place some test decks in the folder along, with the procedure. As a general rule however, it is better to label them and to place all test decks in a separate, convenient location. Such a practice keeps the procedural folder from becoming bulky, decreases the chance of losing test cards, and provides for ease in keeping test decks up-to-date.

Sample Reports.—Operators should be provided with a sample copy of each report which is to be prepared on the accounting machine. This enables the operator to compare the results of a test with the report as it should be. Sample reports usually are prepared as enclosures to the operating procedure, and should be referenced in the procedure at the point where the report is to be prepared. As test decks are prepared or revised, new sample reports should be run and placed in their respective places in the report enclosure.

Carriage Tapes.—All carriage tapes for accounting machines should be prepared in advance, labeled, and placed in one convenient location. In some instances several different operations require the use of the same tape. In this case it is advisable to prepare duplicate tapes if your installation has more than one accounting machine. The tape which is to be used for an accounting machine application should be referenced at the proper point in the operating procedures.

Setup Cards.—If a job calls for using control panels that are permanently wired, the title or number of each panel should be referenced in the operating procedure. A setup card should be placed in the slot provided on the cover of each control panel. This setup card should contain the number of the panel, title of the job for which it is wired, and instructions for setting switches. Additional data should be included for each type of machine to help the operator in setting up for the operation. For example, setup cards for the type IBM 402 accounting machine should show the settings of hammersplit and hammerlock levers if required. Setup cards for automatic punches (reproducers) should list the read X and punch X brushes used for an interspersed gang-punching and comparing operation. Proper use of setup cards reduces the amount of instructions that must be placed in the operating procedures for accomplishing a job.

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 supervisor 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. This manual usually contains the following items:

Schedule of Reports.—The schedule of reports is the foundation which is laid for constructing all data processing operations. It should include the title of each job or report prepared, and the due-in and due-out times for each job. This schedule clearly establishes the time limits within which the results must be accomplished.

Operational Flow Charts.—An operational flow chart contains individual, detailed steps which are required for each processing application. Such flow charts assist the supervisor in maintaining a better overall view of the jobs being processed. When a procedure must be changed, the flow chart can be used for locating the specific points in the procedure where steps must be added, changed, or deleted without reference to the detailed operating procedure. However, any change to the operational flow chart requires a change also to the corresponding operating procedure.

Evaluation Data.—Improvements in the operating efficiency of an installation often can be made by keeping records such as machine utilization, number of cards punched, number of errors made in keypunching, and the time required for performing different jobs. Through proper analysis of these records, it is possible to make improvements in procedures, workload assignments, and operating schedules.

Code Lists.—Codes frequently are used to represent actual data punched into cards. Lists of these codes and descriptions of what they represent are used to interpret the actual meaning of data shown on source documents, punched into cards, and printed on reports.

X and Digit Assignment Lists.—Certain types of cards usually are identified by a control X or digit punched in a specific column of the card. A list of these codes is necessary to revise existing procedures properly and to plan for new jobs.

Card Index.—A card layout for each different type of card used simplifies the process of changing the design of existing cards and of designing new cards.

Stationery Index.—Different preprinted forms often are used for preparing different reports. A sample of each different form should be maintained to assist in improving present form designs and in designing new forms.

General Manual

The general manual outlines the broad objectives of the data processing installation and summarizes all operations performed. This manual is used primarily for the following purpose:

1. To present the general picture of the purpose and operation of the installation to new personnel assigned.
2. 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.
3. 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. Sample copies of reports and source documents, together with general flow charts of major applications, provide a simple but complete picture of the results produced and the data handling involved. A general flow chart differs from an operational flow chart in that it covers only the high points in a procedure without going into detail for each step. Pictorial flow charts may be used in place of general flow charts if the material and time for preparing them are available. Pictorial flow charts are composed of actual illustrations of the documents, cards, machines, and reports involved in an operation.

DATA FLOW

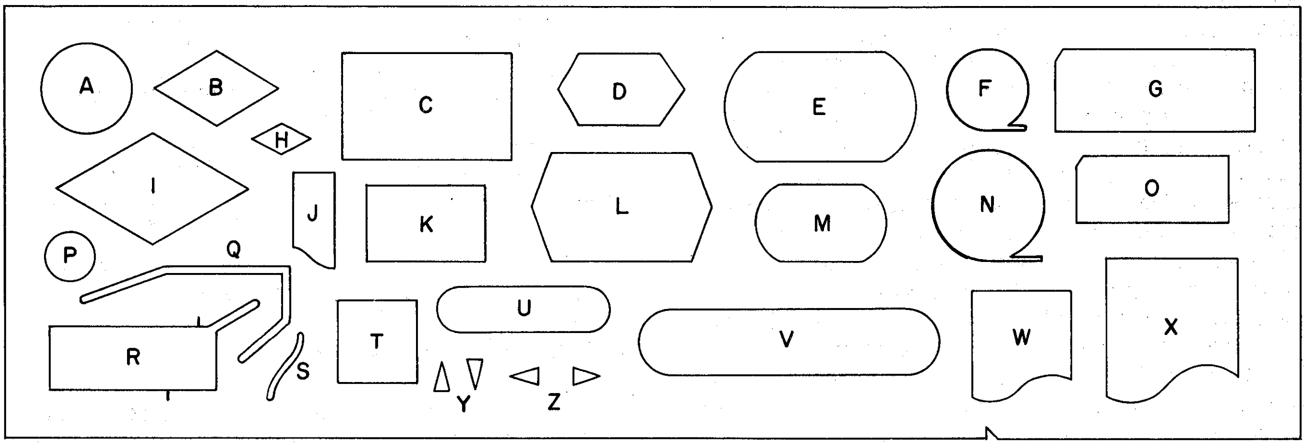
A flow chart can be defined as a graphic representation of the system by which information provided by source documents is converted to final documents. In a broad sense, a document is considered as any instrument conveying information. A flow chart then, provides a picture of the data processing application from the standpoint of what is to be accomplished. General flow charts present a general picture of the work to be accomplished and place primary emphasis on the documents involved in the operation. An operational flow chart shows the job steps required in the development of information as well as the documents themselves. All flow charts should be drawn in a standard manner by using special symbols designed especially for flow charting.

FLOW CHART SYMBOLS

Various symbols can be used in a flow chart for representing devices and functions. However, a standard set of symbols should be used when practicable to provide a meaningful flow chart for all personnel concerned. The charting and diagramming template shown in figure 11-2 contains a set of symbols which can be used to provide standardization in the use of flow chart and block diagram symbols. Variations of these symbols, and different symbols, can be used as the situation requires.

Notice in figure 11-2 that each symbol is lettered. This is done for reference purposes only, to assist you in locating the appropriate symbols as they are discussed. The procedures for developing a block diagram usually are connected with electronic data processing systems, and are not discussed in this chapter.

The symbols shown in figure 11-2 may have one meaning when applied to unit record machine operations and a different meaning when used in electronic data processing systems. Since punched cards are actually units of information, and are often referred to as UNIT RECORDS, the machines used to process these cards are often called UNIT RECORD MACHINES. Of



49.149

Figure 11-2.—Charting and diagramming template.

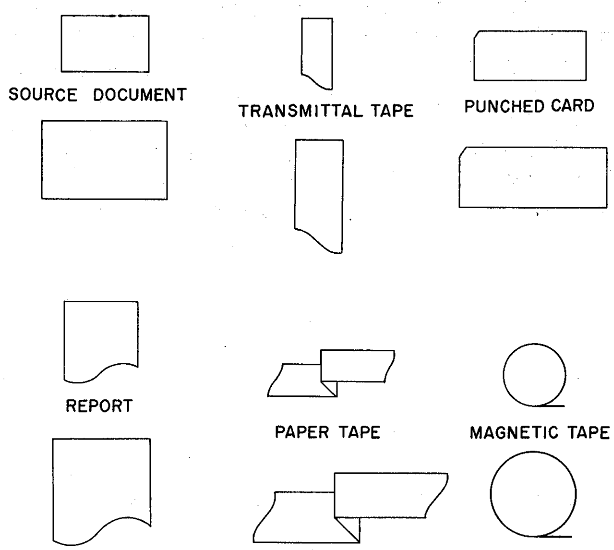
course, there are machines used in electronic data processing systems that can process cards as well as magnetic tape, but these machines normally are thought of as COMPONENTS of the data processing system. Symbols are used in this chapter only as they apply to unit record machines and procedures.

Direction of Flow

The basic element of the flow chart is the line and arrow, which are used to indicate the direction of the flow of work. Arrows are drawn by using symbols Y and Z, and the line drawn by using one edge of the template. Solid lines are used to show the physical movement of the work, and dotted lines indicate the transfer of information through the system, such as a source document moving from one stage of processing to the next.

Document Symbols

The symbols used for identifying different types of documents encountered in data processing applications are shown in figure 11-3. The source document symbols C and K indicate any paper document, such as a personnel diary, from which information is extracted during a process, and the report symbols W and X indicate a paper document prepared during a process, such as a BuPers report. When a document is used as both an input and output representation, the source document symbol is used.



49.150

Figure 11-3.—Document symbols.

Symbol J, and a combination of symbols R and S, are used to draw transmittal forms. The top portion of the large transmittal form can be constructed by drawing that part of symbol R marked off by dark lines, and can be completed by drawing symbol S for the bottom. The fold effect in the paper tape is obtained from the transmittal form symbol by rotating the template 180 degrees and connecting the lower corners of the two halves with a short diagonal line. The transmittal form normally is used to indicate an adding machine tape or some other type of batch control sheet accompanying other forms.

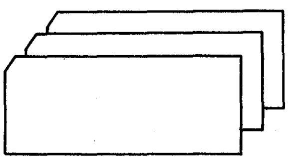
Punched cards are shown by symbols G and O, and magnetic tapes by symbols F and N.

Document symbols appearing in a flow chart usually are labeled to indicate the type of information they contain. If several different documents are involved in one application, one symbol can be drawn several times to give the impression of many documents by superimposing the drawings. Figure 11-4 illustrates the principle of drawing a symbol to represent several types of cards used in one processing step.

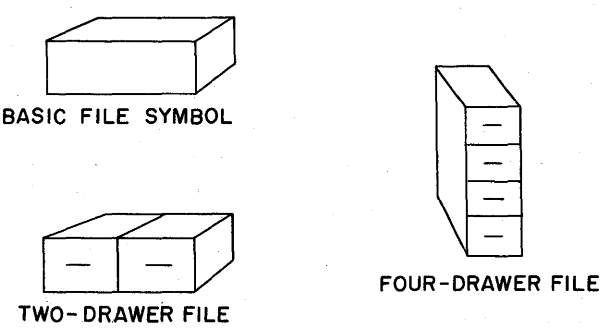
It often is necessary to represent files of documents as well as the documents themselves. Document files can be drawn in several different variations by using symbols Q and R, such as the files shown in figure 11-5.

Clerical Function Symbol

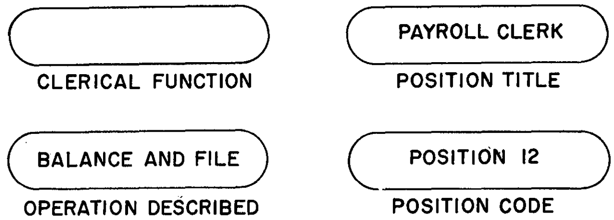
Clerical operations, such as recording, coding, and filing source documents, are indicated by the symbols U and V, as shown in figure 11-6 The actual operation to be performed is normally indicated in the symbol. Indicating a position title or code means that a job description found elsewhere provides the necessary information as to what occurs at that step.



49.151
Figure 11-4.—Symbol for different card types.



49.152
Figure 11-5.—Document file symbols.



49.153
Figure 11-6.—Clerical function symbol.

Unit Record Machine Symbols

The symbols used for showing unit record machine operations are illustrated in figure 11-7.

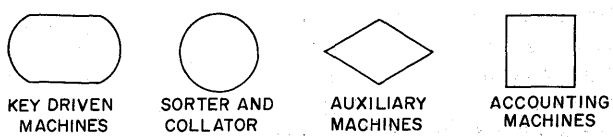
Card punching and card verifying operations are indicated by the card punch and card verifier symbol M. This symbol can be used also for indicating transceiver operations.

Sorting and collating operations, including electronic statistical and card proving machine operations, are identified by the symbol A. This symbol may have one or more card files leading into or leaving it, depending upon the type of operation being performed.

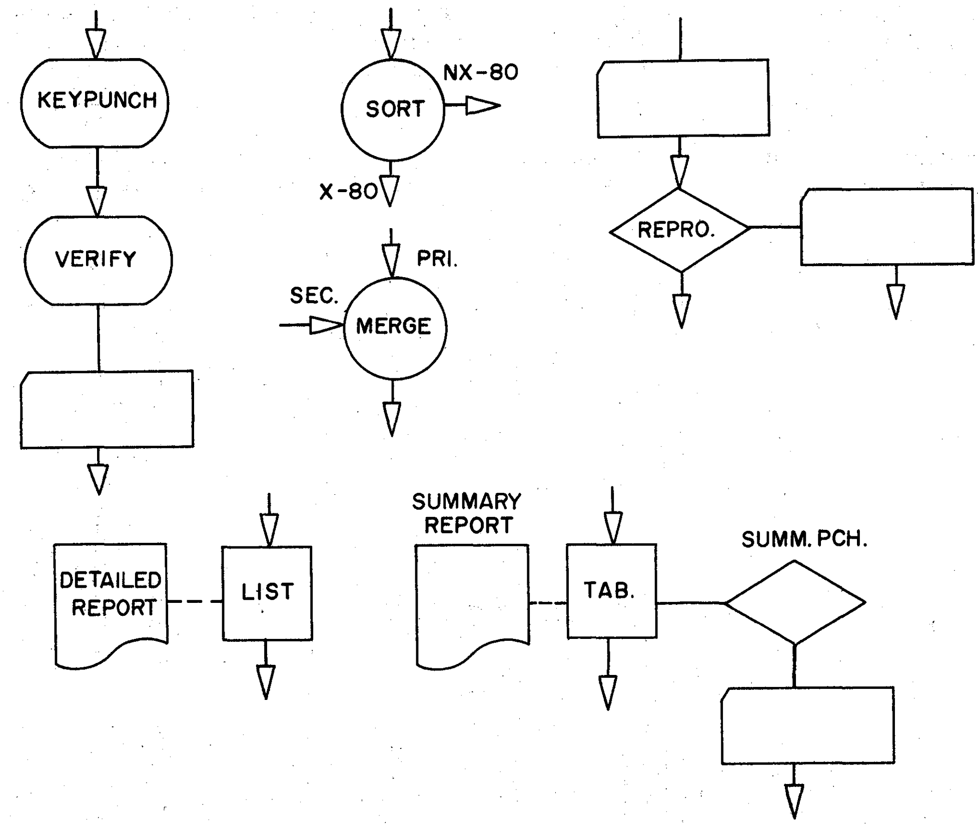
The auxiliary machine symbol B is used to show operations performed on automatic punches, interpreters, calculating punches, facsimile posting machines, and tape-to-card and card-to-tape punches.

The accounting machine symbol T is used to show operations performed on the accounting machine. This symbol usually is associated with the report symbol W or X, illustrating the result of an operation. Summary punching operations usually are shown by placing the accounting machine and auxiliary symbols side by side and connecting them with a straight line.

Figure 11-8 shows several methods for indicating typical machine operations. Note that documents produced as a result of an operation have a line leading to them but no arrow. This indicates that the symbol does not represent a



49.154
Figure 11-7.—Unit record machine symbols.



49.155

Figure 11-8.—Typical unit record machine operations.

separate job step, but is associated with the symbol to which it is connected. If a document is to be used in another job step, the line leading from the document to that step would have the arrow.

DEVELOPING THE FLOW CHART

The manner in which flow charts are developed is very similar to the way procedures are developed. In fact, flow charts often are developed first and used as a basis for establishing the procedure. All operating steps required for completing a job can be sketched in flow chart form without bothering with the details as to how each step is to be performed. Then, the flow chart can be used as a guide for developing the procedure. The first attempt at drawing a flow chart 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 flow chart first, and draw the smooth flow chart after the procedure has been developed and tested.

Before you begin constructing the flow chart for a given application, you must know the type and source of information to be used as input, and the results which the application is to produce. You may wish to sketch a general flow chart first to show what documents and cards are to be used in the application, and the reports that are to be produced. This type of flow chart is also called a data flow chart, since it shows only the flow of data through the operation. Such a flow chart is shown in figure 11-9.

The operational flow chart is an extension of the general flow chart in that it shows the job steps necessary to produce the final result. The operational flow chart shown in figure 11-10 represents the job steps required to produce the Cumulative Transaction Report outlined in figure 11-9. 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.

DATA CONTROL

Your first assignment as an MA striker may have been the coding or keypunching of source documents. Then, as you became more familiar with the work and operation of the installation, you moved on to become a machine operator. Somewhere along the line you probably advanced to MA3. Up to this point, you have been working more or less on an individual basis, performing your particular part of the overall operations. Now you are ready for advancement to MA2.

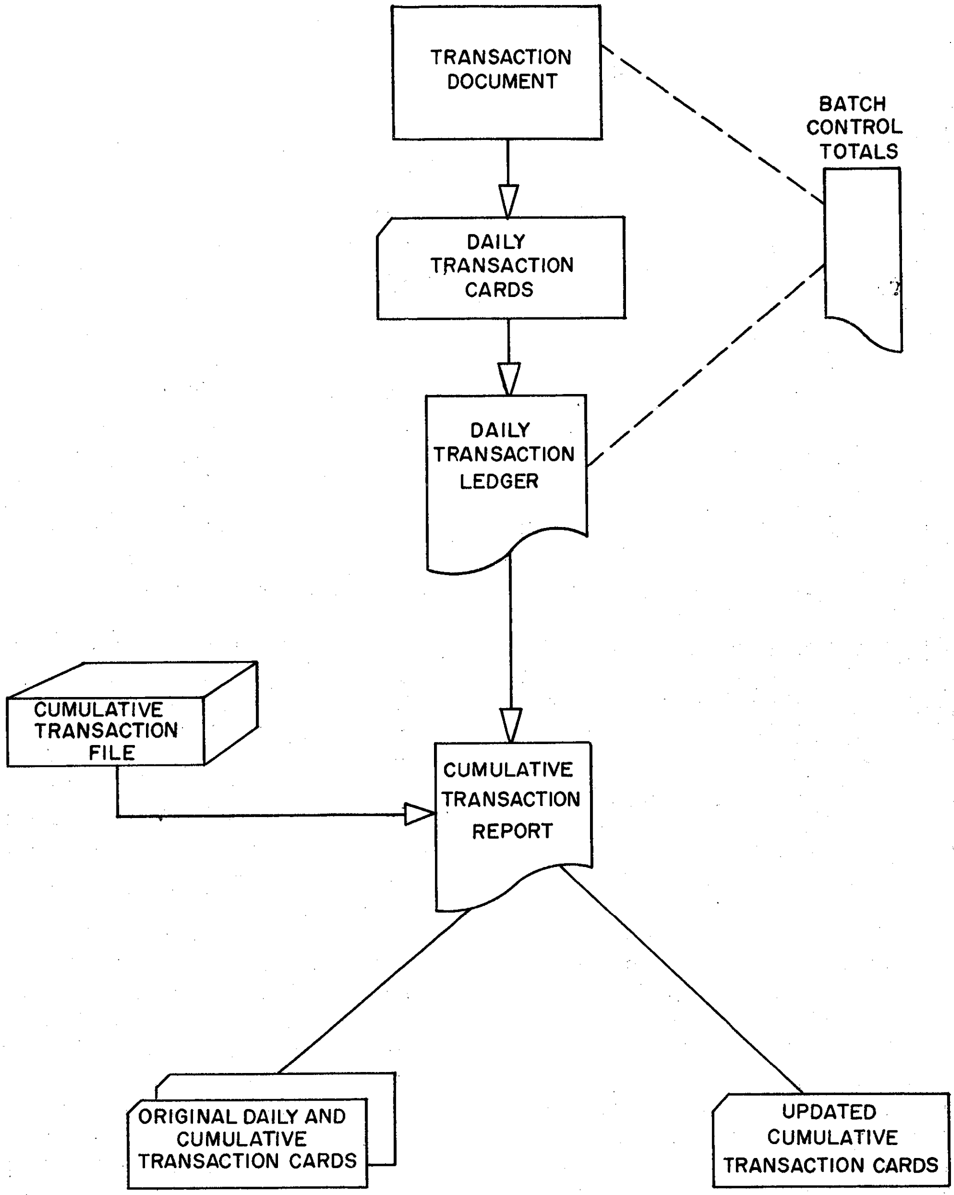


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Figure 11-9.—General Flow chart.

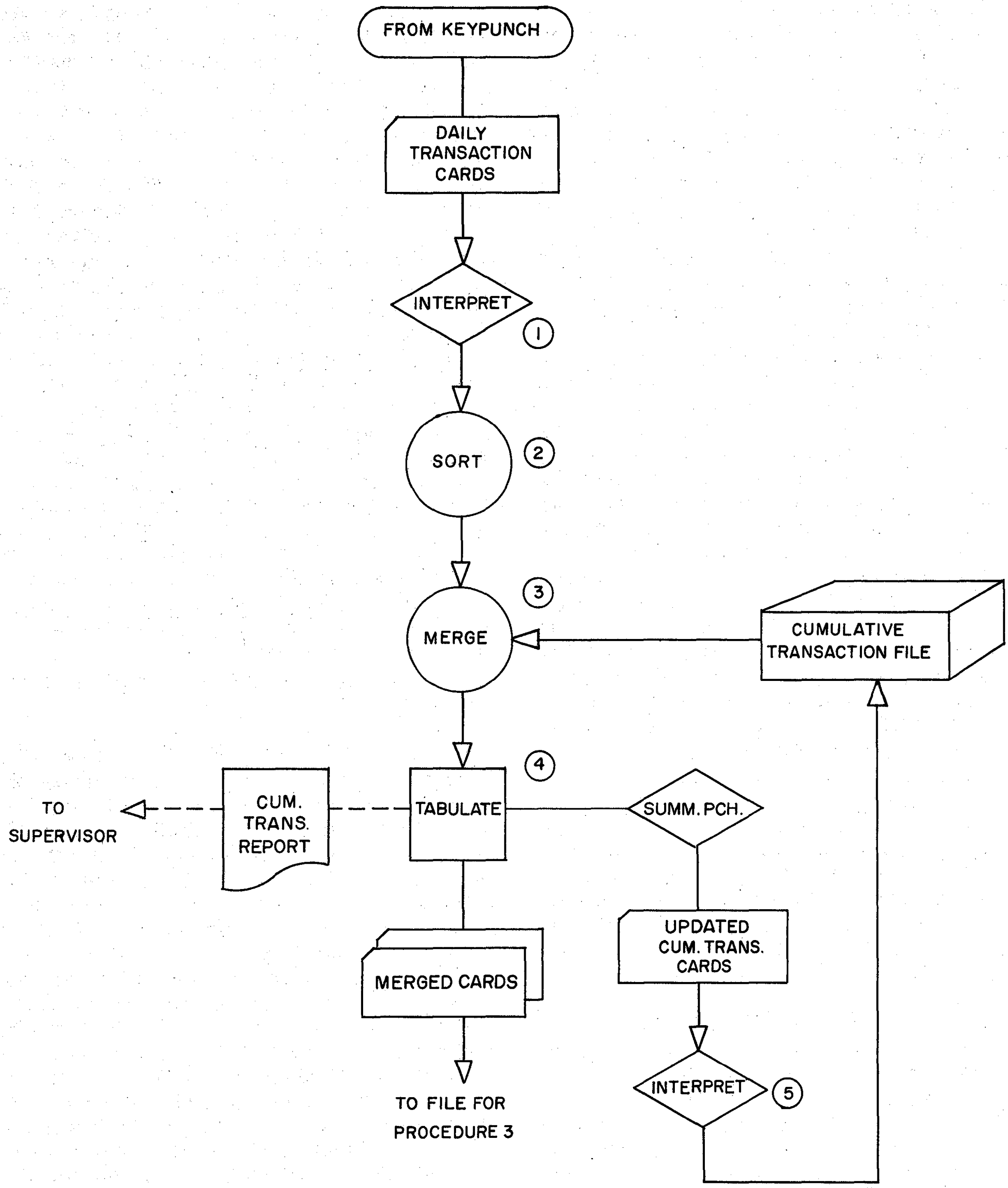

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Figure 11-10.—Operational flow chart.

Your duties as an MA2 may require that you continue as a machine operator, or you may be placed in charge of a particular section and be held responsible for seeing that all work required of that section is performed in an approved fashion and in a timely manner. The following numbered paragraphs list some of the things you need to know in order to administer the work in your section and to see that work is completed correctly and on time.

1. You must be able to organize your work so that it keeps moving in an orderly fashion and does not become bogged down at one point while other work piles up.

2. You must be able to control your work so that you know at all times what progress is being made, and if the work is being done properly.

3. You must be able to assist your operators in the performance of their duties, such as setting up for an operation, and answering questions concerning the operation. You must know your machines and their proper operation, including safety precautions which must be observed.

4. You must be able to perform clerical duties associated with your tasks. Your installation may have YNs, PNs, or strikers who perform clerical functions, such as correspondence and filing, but you may be required to prepare rough forms of correspondence. In the absence of qualified clerical personnel, you may be required to prepare the final correspondence. You should know the general contents of, and how to use, the Navy Correspondence Manual, SECNAVINST 5216.5 series, and the Navy-Marine Corps Standard Subject Classification System, SECNAVINST P5210.11 series. Refer to the chapters on correspondence and filing in the latest edition of the Navy Training Course for Yeoman 3 & 2, NavPers 10240, for general discussion of naval clerical procedures.

ORGANIZATION OF WORK

Data processing installations should have an established schedule showing when source documents are due in, when a processing application should begin, and when it should be completed. This is necessary if the work is to flow evenly through the installation and be completed on time. Each group of tasks performed in the installation can be referred to as a phase in the overall accounting application. For example, the first phase could include receiving, auditing, recording, and coding source documents. The next phase could involve keypunching and key verifying the source information. From that point, source documents normally are filed for future reference and the cards moved on to further processing. Phases of card processing include screening operations to prove the validity of data, applying the data to various card files, and preparation of final reports. It is your responsibility when placed in charge of one or more of these phases to see that all work assigned is accomplished within the allotted time. Your operators must have a clear understanding of what they are to do and how to do it. The work should be distributed as evenly as possible among the operators, so that each will be pulling his share of the load, and each can be accomplishing productive effort at the same time. Much work is done on an assembly line basis, which means that everyone cannot always be working with the job in process at the same time. However, you should plan the work so that as little time as possible is wasted from the beginning of a task until it is completed. You should have a good idea how much time is required to complete each job. This can be acquired best by careful analysis of past performances in the same or similar jobs, and in the case of machine operations, by the added method of estimations based upon card volume and the number and types of processing steps required.

When determining the time required for keypunching and key verifying operations, keep in mind the number of columns to be punched or verified in each card, legibility and arrangement of data on source documents, and the skill and experience of the operators. You could not expect a new keypunch operator to be as efficient as someone who has been on the job for some time. Therefore, you should assign work to new operators in accordance with their ability to produce. As they become more skilled, you can give them more work in keeping with their capabilities. Once you have determined the average keypunching speed of each operator, you can generally estimate the time required to complete a given job by multiplying the number of cards to be punched by the number of columns in each card, and dividing by the number of key strokes per hour. For example, if 12,000 cards are to be punched with 40 columns of information, and the average key strokes per hour is 7500, then total time can be determined as follows:

$$12{,}000 \times 40 \div 7500 = 64 \text{ hours.}$$

Three basic factors must be considered when determining time requirements for automatic machine operations. These are:

1. Setup Time.—This is the time it takes to place the correct control panel in a machine, bring the cards to the machine, make other necessary settings and adjustments, and run a few test cards through the machine to prove the accuracy of the operation. All such operational details performed before the job is actually started contribute to setup time.

2. Machine Time.—Essentially, machine time is determined from the volume of cards to be processed and the speed of the machine; that is, the number of cards to be processed, divided by the number of cards the machine can process per hour. This is the most important of the three time factors.

3. Handling Time.—After an operation begins, it is normal to expect short interruptions in the operation of the machine, caused by such details as placing more cards in the machine, spot checking results of the operation, operating another machine at the same time, checking or balancing results, and any other details which the operator must handle.

All three of these factors must be taken into consideration when determining the total machine time required for a job. Setup and machine time usually are easy to figure. Handling time, however, must be based on the particular machine used and the experience of the operator. Card sorters and electronic statistical machines require more card handling than other types of machines, so they should be accorded a greater percentage of handling time. It is up to you to determine the most realistic estimate of handling time involved in a particular job step.

Two common methods are used for expressing the percentage of handling time; as a percentage of MACHINE TIME, or as a percentage of the TOTAL TIME (less setup time) for the job. The method used is determined by the policies established in your particular installation. When expressed as a percentage of machine time, the calculation to determine the total time for a job is as follows: Total time is equal to machine time, plus percentage for handling multiplied by the machine time. For example, assume the machine time for a job is 4 hours, and the handling time is 20 percent. The total time is expressed in the following formula: $4 + (.20 \times 4) = 4.8$ hours. If handling time is expressed as a percentage of total time, then the calculation to determine total time would be the machine time, divided by 1 minus the percentage for handling. Stated as a formula in which machine time is 4 hours and handling time is 20 percent, we have the following:

$$4 \div (1.00 - .20) = \frac{4.00}{.80} = 5 \text{ hours.}$$

This calculation can be simplified by using only one factor in addition to machine time; the remainder after subtracting percentage of handling from 100 percent, such as .80 for the problem shown above. In this case, the factor is called OPERATIONAL EFFECTIVENESS, and the final result is the same, for 20 percent handling time is equivalent to 80 percent operational effectiveness.

CONTROL OF WORK

In any accounting system, there must be safeguards to ensure the accuracy of the data used in the system. These safeguards are known as CONTROLS. In each phase of a data processing application, there are certain controls which must be established if the finished product is to represent exactly what was intended. Some of these common controls are listed as follows.

Controls must be established to ensure that all source documents to be used in an application are actually received and correctly keypunched. If an error is made in keypunching, and that error is not detected, erroneous information may be placed in files, or printed on reports.

Certain information in cards must be screened prior to use in order to check the validity of the data. For example, in personnel accounting, cards containing a rate abbreviation must be checked against a master deck of rate cards to make sure that the rate is a valid one.

Certain predetermined totals must be maintained to make certain that, after processing has been completed to a file of cards, the file contains all the cards it is supposed to contain, or that totals in the cards balance to what they should be.

Reports must be checked to see that they contain the required information and that totals appearing in these reports are accurate. Reports must also be checked to ensure that the data are printed in the proper sequence.

Each type of accounting procedure has its own particular controls. It is your duty as an operator to see that sufficient controls are established and maintained to provide for accuracy and completeness of all jobs for which you are responsible.

ARRANGING—Documents filed to a prescribed order.

AUDITING—Checking for small or hidden errors during keypunching, balancing, and screening operations.

BATCHING—Batching of source documents into small groups, for ease in proving the contents of the documents.

CARD DATA—Data are contained in a card to meet the requirement of an established objective.

CARD DESIGN—Determining card fields to be used, to facilitate card punching and processing.

CARD LAYOUT—Determining the arrangement of data fields in a card and the required number of punching positions for each.

CODE LISTS—List of codes and description of what they represent.

CODING—The underlining, circling, or transcribing of data in preparation for punching.

CONTROL TOTALS—Predetermined totals recorded on invoices or control tape for balancing purposes.

DATA CONTROL—Seeing that all work required is performed in an approved manner and fashion, from the time of receipt to completion.

DUE DATES—Dates that source documents are due in and reports due out.

DUAL CARDS—Cards punched from information recorded in written form on the card itself; that is the card serves a dual purpose.

EVALUATION DATA—Recorded data which can be used in improving the operating efficiency of an installation.

FLOW CHART—Defines the conversion of sources documents to final documents of a system by a graphic representation.

FLOW CHART SYMBOLS—Symbol used to represent devices and functions.

GENERAL FLOW CHART—Presents a general picture of documents and the work to be accomplished.

GENERAL MANUAL—Prepared for management; outlines the broad objectives of an installation, provides for indoctrination of new personnel, illustrates to others the role of the installation, and shows visitors the nature and scope of the work performed.

HANDLING TIME—Time lost because of normal interruptions of the machine while performing a job.

MACHINE TIME—The time required for a machine to complete a given job, minus setup and handling time.

MARK SENSED CARDS—Cards designed to be marked with a special pencil so that the mark will activate the punch dies to punch the card.

OPERATIONAL FLOW CHART—A flow chart that contains individual detailed steps which are required for each processing application; assists the supervisor in maintaining an overall view of jobs being processed.

OPERATOR'S MANUAL—A manual set up to provide the operator with all the required information, to enable him to perform a job with no outside assistance.

PROCEDURE—A series of step-by-step functions required to accomplish an end result.

PROCEDURE CONSTRUCTION—Bringing together in written form all the required steps to bridge the gap between source documents and the finished product.

PROCEDURE DEVELOPMENT—Planning, style and construction of a procedure.

PROCEDURE PLANNING—Determining the requirements of source documents and the finished product, to bridge the gap between the input of source data and the output of the report.

PROCEDURE STYLE—Conversion of thoughts or planned steps to a distinct pattern of words easily understood by the operators.

SAMPLE REPORT—An enclosure to the operating procedure for comparison to the test report.

SCHEDULE OF REPORTS—Establishes the due-in time, the processing time, and the due-out time for all reports.

SETUP CARD—A card that provides instructions for the proper setup of a machine for any given job.

SETUP TIME—The time required to get a machine ready for a particular job, including insertion of the control panel, insertion of paper forms, and carriage tapes, and the machine test run.

SUMMARY CARDS—Cards that are automatically punched as the result of a calculation or accumulation.

SUPERVISOR'S MANUAL—A manual that serves as a basis for all plans, controls, and evaluations.

TRANSCRIPT CARDS—Cards punched from documents that have been previously recorded.

WIRING DIAGRAM—A drawn reproduction of a prewired and tested control panel.

WORK ORGANIZATION—A schedule showing when source documents are due in, when processing should begin, and when it should be completed; this applies to all work performed by an installation.

CHAPTER 12

ELECTRONIC DATA PROCESSING

One of the most significant characteristics of electronic data processing is that a whole 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 individual machines, we think of a data processing SYSTEM, which may involve several machines and devices. The three basic elements of all data processing are still present, however. They 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 source 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.

Chapters 3 through 11 discussed electric accounting machines used in the unit record data processing system. Chapter 2 discussed the concepts of electric and electronic data processing. This chapter presents the basic principles of an electronic data processing system (EDPS), including a discussion of the language of the system.

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 12-1. Notice that the heart of the system is the PROCESSING UNIT, which is a high speed electronic computer. 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 processing unit performs all arithmetical operations, makes comparisons 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 and processing 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 where measuring is of primary importance and an up-to-the-minute check of an entire system is required, as in a continuous check on 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 Machine Accountants 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 navigational 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

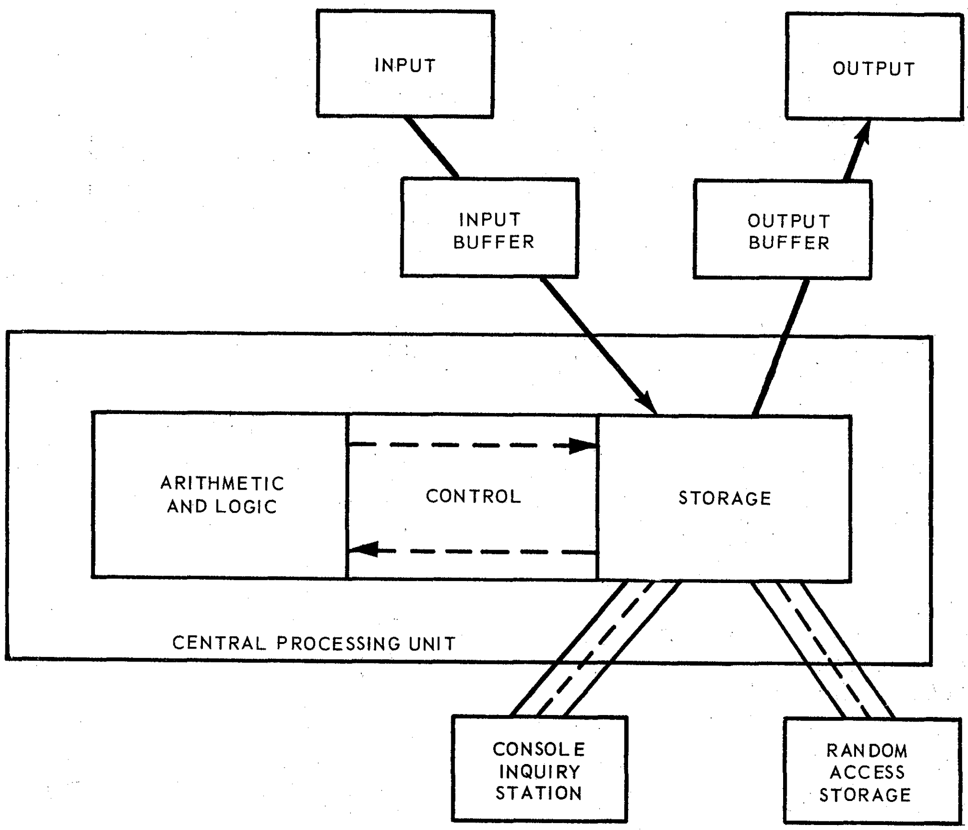

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Figure 12-1.—Organization of an EDPS.

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, Machine Accountants will work, in most cases, with general-purpose computers.

Type of Program Storage

Before a computer can perform its work, it must have a common language with its programmer. This common language 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. 12-2). 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.

Source Data.—Source data to be used with the computer system can be recorded on five media: punched cards, paper tape, magnetic tape, magnetic ink characters and optically recognizable characters (fig. 12-3). Data are represented on punched cards by the presence of small round or rectangular hales (fig. 12-4). 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 machine (fig. 12-5). The shape of the optical characters, together with the contrast with the background paper, permits the optical characters to be read by machine as well as by people (fig. 12-6). On magnetic tape small magnetized areas called spots or bits, arranged in a specific pattern, are the symbolic representation of data (fig. 12-7). The symbolic data on paper tape are small circular holes punched along the length of the tape (fig. 12-8).

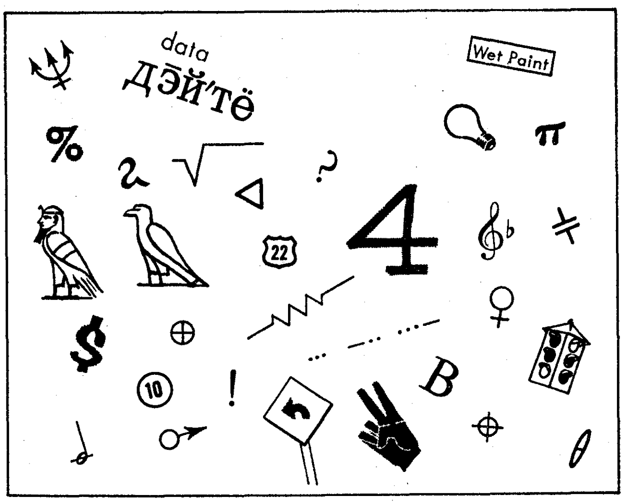

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Figure 12-2.—Communication symbols.

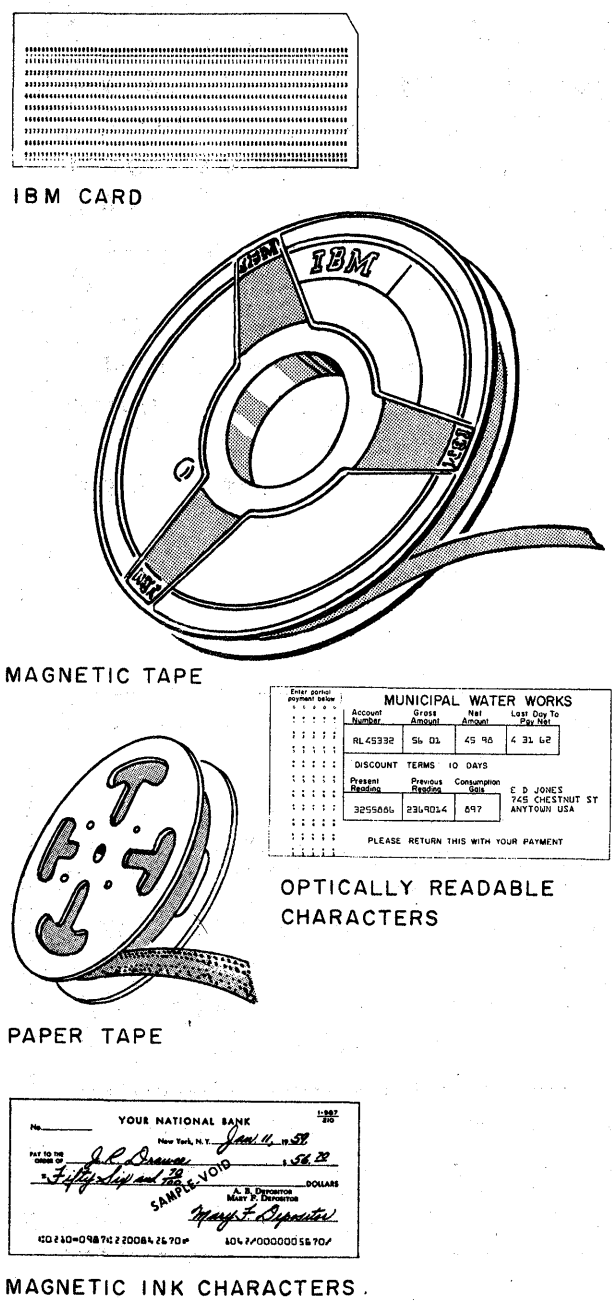

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Figure 12-3.—Source data.

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 are 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. 12-9). Thus, the combination of these internal component settings is the method by which data are represented inside the computer.

Data Types

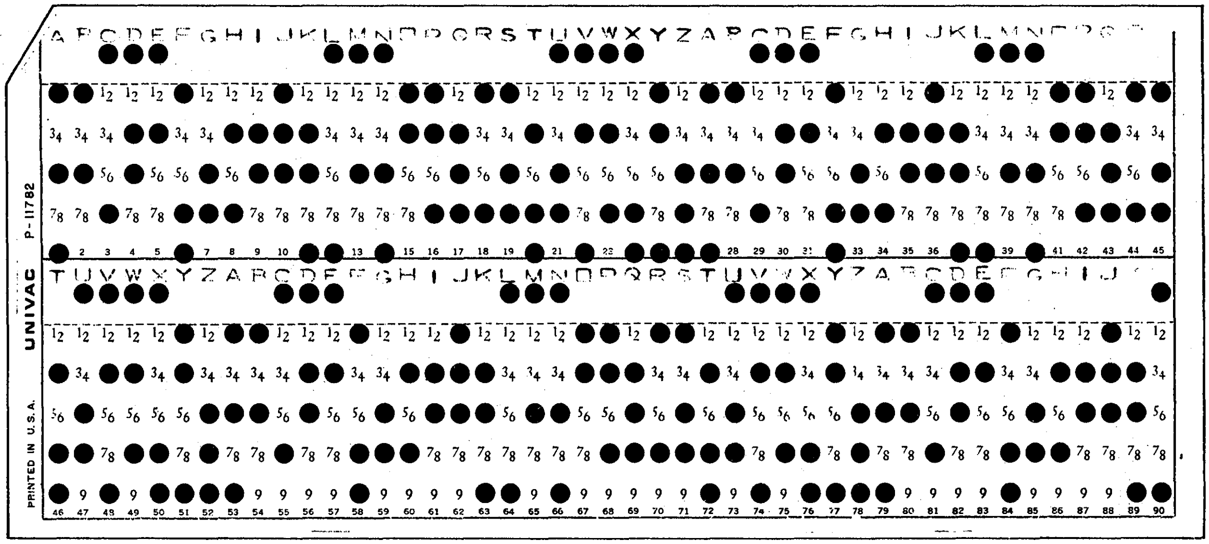
There are many types of data that can be used in data processing systems. However, the discussion of data types in the paragraphs that follow pertains only to computer acceptable data (fig. 12-10).

Direct Data.—Information may be presented directly to the computer in its original form; namely, right from the document or paper on which it is recorded. An example of this is the reading of personal checks by computers used in banks. This is made possible by a machine connected to the computer. Called a document handler or reader-sorter, this machine reads information printed in the form of magnetizable inked characters at the bottom of the check.

Various other optical scanning devices have been perfected, utilizing photosensitive techniques, then transferring the data from the original document directly to the computer input tape. At present, this process has limited application, but new developments are occurring almost daily to the extent that optical scanning by photosensitive processes will become a common means of data input into a computer.

Converted Data.—Some kinds of information must be converted for the computer's input device prior to reaching the computer. For instance, data on an invoice might be transferred into a punched card or punched paper tape so it can be read by the computer for an accounts payable program. This is an example of data conversion.

On-Line Data.—Data can be entered into a computer directly via long-distance teletype or telephone connections. By typing the information to be processed on a teletype, a clerk in a distant sales office can enter data to be pro-



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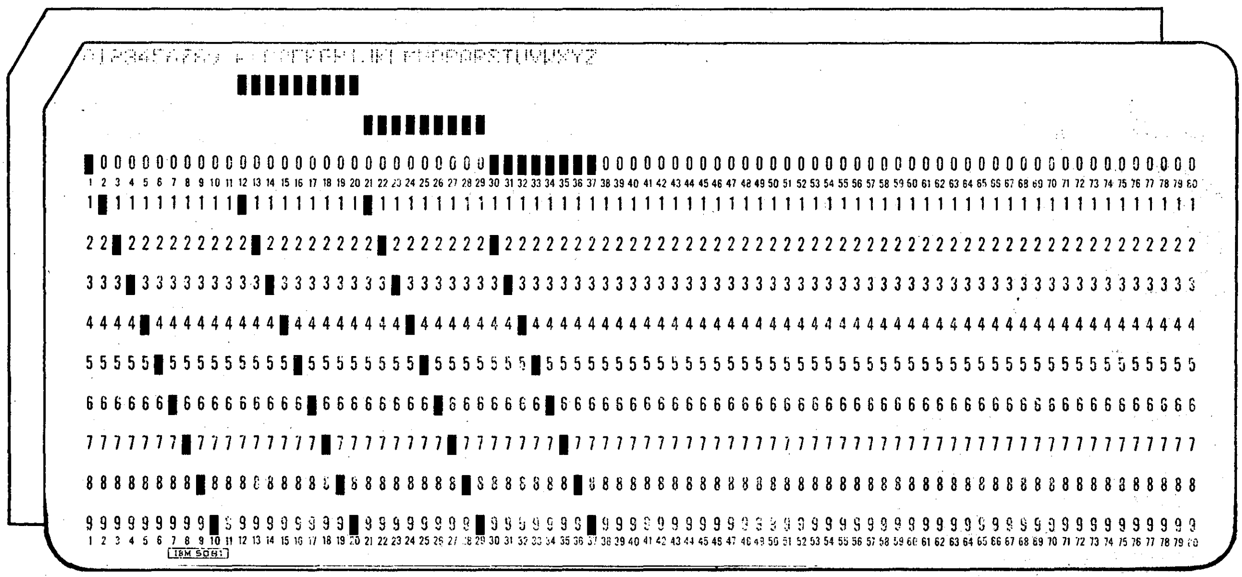

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Figure 12-4.—Punched cards.

cessed. This necessitates that the computer have a program operating at the time so the incoming information can be received and treated properly.

Circulating Data.—Data going into an operating computer run could have originated as output on the previous day's run. Typically, "yesterday's" answers placed on magnetic tape may go into "today's" computer run from the same tape. This is a circulating type of input; from and back into the same program on successive days.

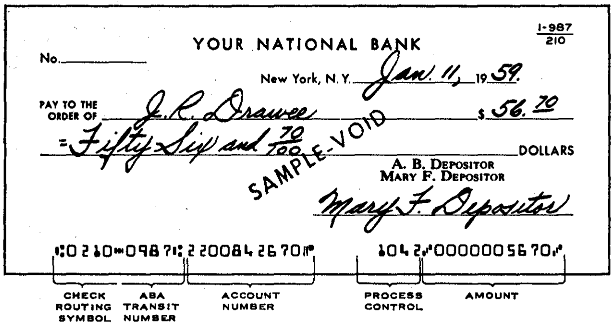

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Figure 12-5.—Magnetic ink characters.

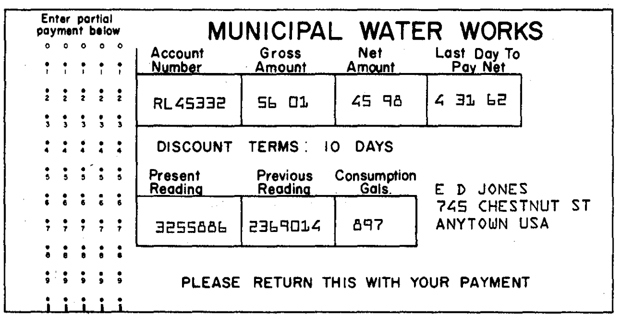

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Figure 12-6.—Optically readable characters.

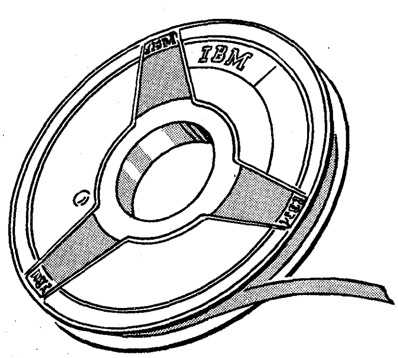

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Figure 12-7.—Magnetic tape.

External Data.—Data may originate as output from previous processing by another program of the data processing system or by a completely different system. For example, punched cards prepared from time sheets for input to a payroll system which produces checks, journal, F.I.C.A. reports, et cetera, could be re-sorted in a different sequence for introduction of other data into a run to produce different reports within the payroll accounting system.

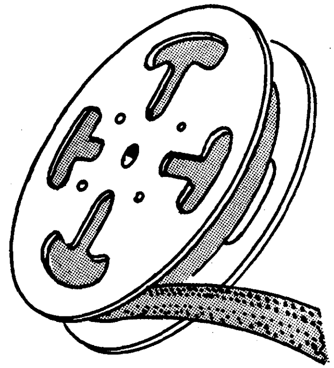

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Figure 12-8.—Paper tape.

Re-Prepared Data.—Data can originate too, when a technician chooses certain parts of outputs from several computer runs and re-prepares these for introduction into another run. For instance, totals from weekly payroll summary reports might be recorded on punched cards or otherwise entered at the end of the year as input data for a report to management giving a summary of the year's payroll.

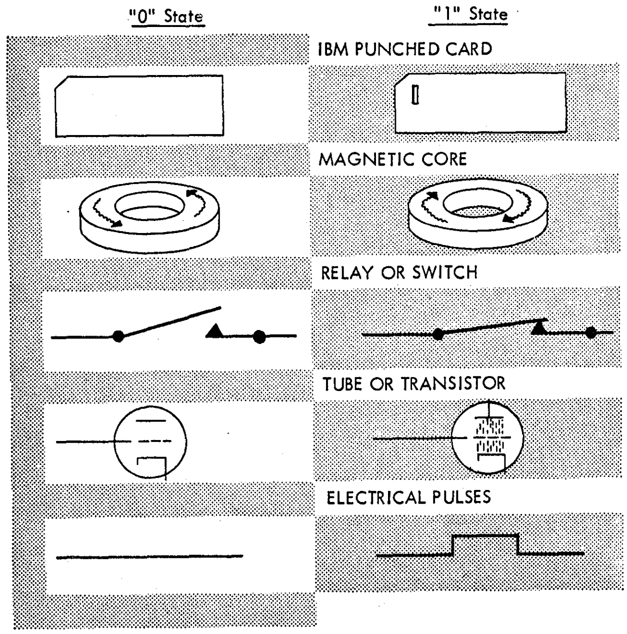

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Figure 12-9.—Representing binary data.

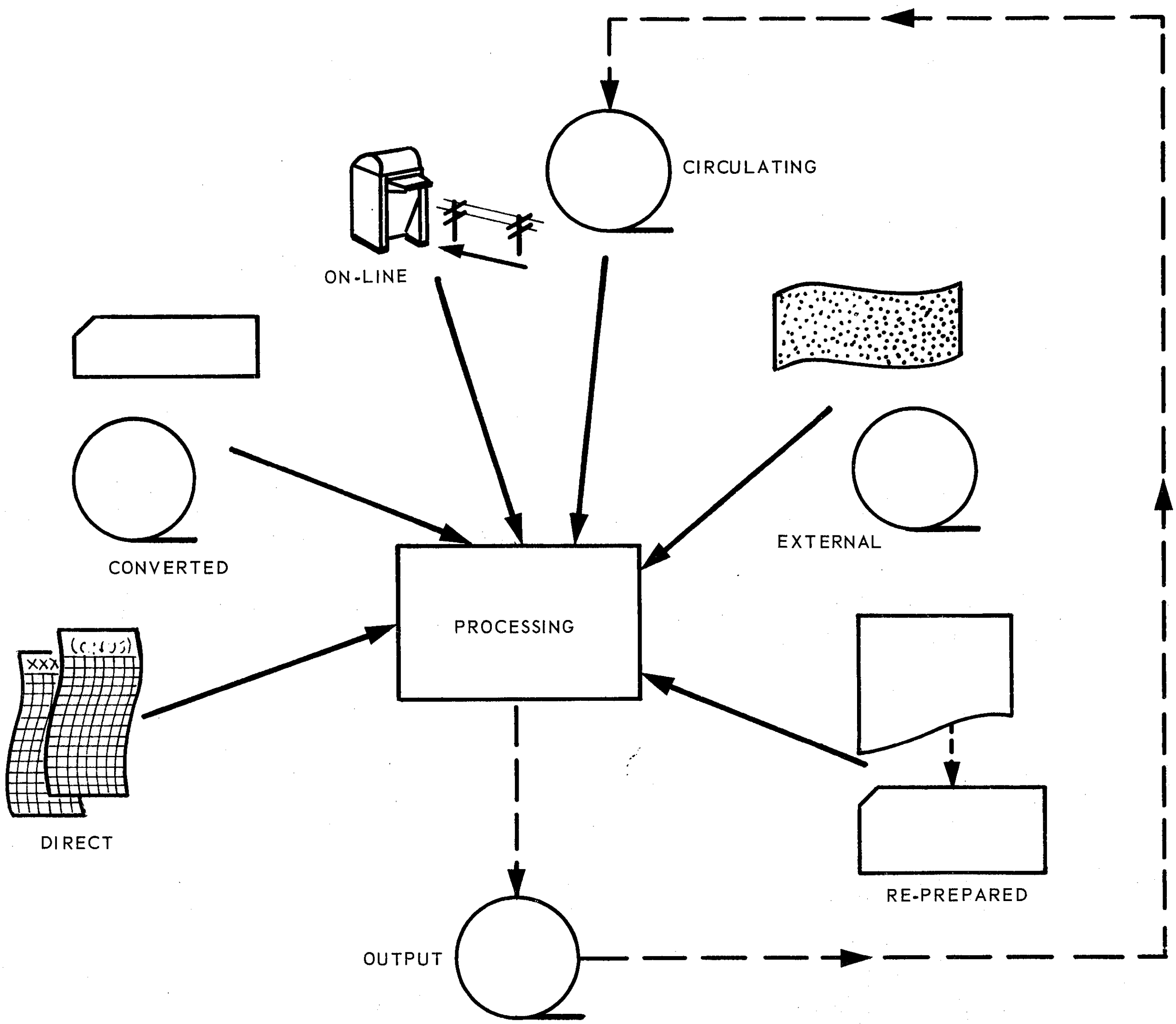

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Figure 12-10.—Data Types.

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:

6 x	1	=	6
4 x	10	=	40
3 x	100	=	300
7 x	1000	=	7000
			7346

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 12-11. 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 the decimal value for each binary position, going from right to left, as follows:

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
			217

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:

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0 with a 1 carried

The following example illustrates the principle of binary addition:

```
  011000111100
+ 010100101001
= 001100010101
+ 1   1 1        (Carry)
= 101101000101
+        1       (Carry)
= 101101100101
```

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:

```
  011000111100
- 010100101001
= 001100010101
-  1        1   (borrowed)
= 000100010111
            1   (borrowed)
= 000100010011
```

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. 12-12). 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. 12-13).

1024	512	256	128	64	32	16	8	4	2	1

49.272
Figure 12-11.—Place value of binary numbers.

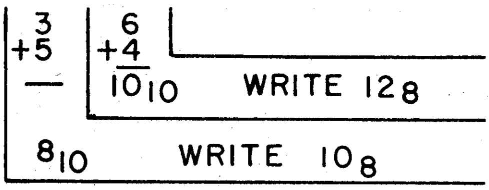
OCTAL	—	DECIMAL	OCTAL	—	DECIMAL
0	—	0	16	—	14
1	—	1	17	—	15
2	—	2	20	—	16
3	—	3	21	—	17
4	—	4	22	—	18
5	—	5	23	—	19
6	—	6	24	—	20
7	—	7	25	—	21
10	—	8	26	—	22
11	—	9	27	—	23
12	—	10	30	—	24
13	—	11	31	—	25
14	—	12	32	—	26
15	—	13	33	—	27

49.273
Figure 12-12.—Octal numbering system.

Octal Addition.—In octal, arithmetic follows 64 rules, but 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. 12-14.) Notice we never need to

100010111000110101100000011	BINARY
100 010 111 000 110 101 100 000 011	CONDENSED
4 2 7 0 6 5 4 0 3	OCTAL

49.274
Figure 12-13.—Condensing a binary representation to octal representation.



49.275

Figure 12-14.—Octal addition.

consider more than one digit-pair at a time.

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_{10} 00005
-00002_{10} → becomes $+99997$
     00002 Plus a carry
     1 which is added.
yielding 00003_{10} As an answer

In octal the same rules apply as in decimal with one exception: the nines complements are to be replaced by sevens complements as follows.

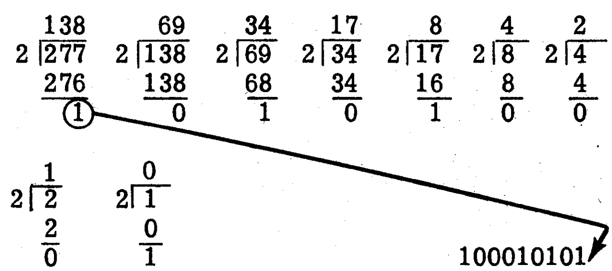
Octal

07301_8 07301_8
-02046_8 becomes 75731_8
     5232 Plus a carry
     1 which is added.
yielding 5233_8 As an answer

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.

Base 10 to Base 2.—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 (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:

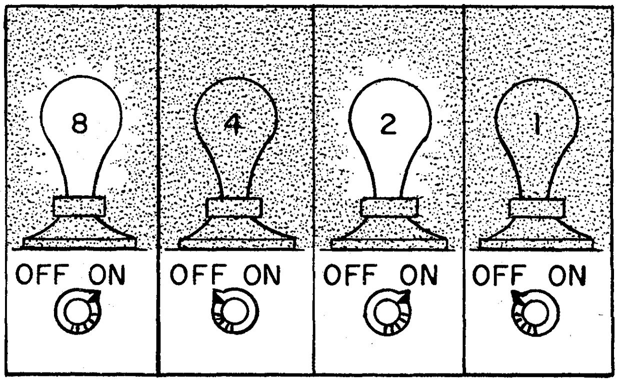


Verify the results as follows:

256	128	64	32	16	8	4	2	1	Place Value
1	0	0	0	1	0	1	0	1	Bits
= 277									Decimal

Base 2 to Base 10.—To convert binary to decimal, division is performed repeatedly by the binary representation of decimal 10, which is 1010 (fig. 12-15). 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
```



49.276X
Figure 12-15.—Representing decimal data.

Thus the remainders, reading from right to left are 277, which is the decimal equivalent of the binary number 100010101.

Base 10 to Base 8.—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.

Base 8 to Base 10.—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)
```

Base 2 to Base 8 to Base 10.—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 left most 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 base 8 to base 10.

Base 8 to Base 2.—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 base 2 to base 8 by writing the binary equivalent of each octal digit. Thus 425 octal for example, becomes 100010101 binary.

COMPUTER BINARY CODING SYSTEMS

The system used for symbolizing data is known as a CODE. 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. Various codes are used in the many computers of today; some of the more common are described in the following paragraphs.

Binary Coded Decimal

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. 12-16.)

PLACE VALUE				DECIMAL VALUE
8	4	2	1	
			0	0
			1	1
		1	0	2
		1	1	3
	1	0	0	4
	1	0	1	5
	1	1	0	6
	1	1	1	7
1	0	0	0	8
1	0	0	1	9

49.158

Figure 12-16.—Binary coded decimal.

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 12-17.

Seven-Bit Alphameric Code (BCD)

The Seven-bit alphameric code is just an extension of BCD. Instead of using just the 8-4-2-1 scheme, this code uses seven positions of binary notation to represent all characters, as opposed to only numerical characters, (fig. 12-18).

3	2	4	6	DECIMAL DIGITS
0011	0010	0100	0110	BINARY VALUE
8421	8421	8421	8421	PLACE VALUE

49.277

Figure 12-17.—3246 in binary coded decimal.

CHECK BIT	ZONE BITS		NUMERIC BITS			
C	B	A	8	4	2	1

49.278

Figure 12-18.—Seven 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 Z 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 number, 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

PRINTS AS	DEFINED CHARACTER	CARD CODE	BCD CODE	PRINTS AS	DEFINED CHARACTER	CARD CODE	BCD CODE
	BLANK		C	G	G	12-7	BA 421
.	.	12-3-8	BA8 21	H	H	12-8	BA8
⌑	⌑	12-4-8	CBA84	I	I	12-9	CBA8 1
	(Left Parenthesis (Special Character)	12-5-8	BA84 1	—	! (Minus Zero)	11-0	B 8 2
	< Less Than (Special Character)	12-6-8	BA842	J	J	11-1	CB 1
	⧧ Group Mark	12-7-8	CBA8421	K	K	11-2	CB 2
&	&	12	CBA	L	L	11-3	B 21
$	$	11-3-8	CB 8 21	M	M	11-4	CB 4
*	*	11-4-8	B 84	N	N	11-5	B 4 1
	) Right Parenthesis (Special Char.)	11-5-8	CB 84 1	O	O	11-6	B 42
	; Semicolon (Special Character)	11-6-8	CB 842	P	P	11-7	CB 421
	Δ Delta (Mode Change)	11-7-8	B 8421	Q	Q	11-8	CB 8
—	—	11	B	R	R	11-9	B 8 1
/	/	0-1	C A 1	⧧	⧧ Record Mark	0-2-8	A8 2
,	,	0-3-8	C A8 21	S	S	0-2	C A 2
%	%	0-4-8	A84	T	T	0-3	A 21
	= Word Separator	0-5-8	C A84 1	U	U	0-4	C A 4
	' Apostrophe (Special Character)	0-6-8	C A842	V	V	0-5	A 4 1
	" Tape Segment Mark	0-7-8	A8421	W	W	0-6	A 42
⧧	¢ Cent (Special Character)		A	X	X	0-7	C A 421
#	#	3-8	8 21	Y	Y	0-8	C A8
@	@	4-8	C 84	Z	Z	0-9	A8 1
	: Colon (Special Character)	5-8	84 1	0	0	0	C 8 2
	> Greater Than (Special Character)	6-8	842	1	1	1	1
	√ Tape Mark	7-8	C 8421	2	2	2	2
&	? (Plus Zero)	12-0	CBA8 2	3	3	3	C 21
A	A	12-1	BA 1	4	4	4	4
B	B	12-2	BA 2	5	5	5	C 4 1
C	C	12-3	CBA 21	6	6	6	C 42
D	D	12-4	BA 4	7	7	7	421
E	E	12-5	CBA 4 1	8	8	8	8
F	F	12-6	CBA 42	9	9	9	C 8 1

78.10X

Figure 12-19.—Binary coded decimal chart.

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 an 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 12-19 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.

Two-Out-Of-Five Fixed Count Code

Two-out-of-five is another coded decimal system which uses five positions of binary notation, with the assigned values of 0, 1, 2, 3, and 6. In basic code, decimal values are represented by the presence of only two 1 bits, (no more, no less), of the five figure 12-20. The number of combinations total ten-one for each decimal digit. The digits 1 through 9 are each composed of two bits, the position value sum of which equals the number to be represented. Zero is indicated by the 1-2 bit combination.

DECIMAL DIGIT	PLACE VALUE				
	0	1	2	3	6
0	0	1	1	0	0
1	1	1	0	0	0
2	1	0	1	0	0
3	1	0	0	1	0
4	0	1	0	1	0
5	0	0	1	1	0
6	1	0	0	0	1
7	0	1	0	0	1
8	0	0	1	0	1
9	0	0	0	1	1

49.279X

Figure 12-20.—Two-out-of-five code.

Alphabetic and special characters are treated a little differently than decimal values 0 through 9. As stated earlier there are ten combinations provided in the two-out-of-five code. Decimal value 0 through 9 consumes all of these, as can be seen in figure 12-20. Alpha and special characters are represented as a 2-digit number. For example, the letter A is equal to the coded decimal value of 61 and is composed of the two coded decimal digits 6 and 1, figure 12-21.

ONE DIGIT					ONE DIGIT				
0	1	2	3	6	0	1	2	3	6
1	0	0	0	1	1	1	0	0	0

49.280X

Figure 12-21.—Letter A in two-out-of-five code.

Each digit that is moved in data processing operations is tested to assure that it has only two bits. This is a fixed count code.

Bi-Quinary Code

The bi-quinary code is basically a numeric code consisting of seven positions of binary notation, as shown in figure 12-22. The bi-quinary code for each decimal digit consists of two parts; a BINARY part, meaning TWO, and a QUINARY part, meaning FIVE. The two positions in the BINARY part are assigned the values of 0 and 5, while the five positions in the QUINARY part are assigned the values of 0, 1, 2, 3, and 4. Each decimal digit is composed of two bits; one binary bit and one quinary bit. The decimal digits 0 through 4 have bits in the 0 position of the binary part, indicating their value is less than five; their actual value is denoted by a bit in the appropriate quinary position. The decimal digits

DECIMAL DIGIT	BINARY POSITION		QUINARY POSITION				
	0	5	0	1	2	3	4
0	1	0	1	0	0	0	0
1	1	0	0	1	0	0	0
2	1	0	0	0	1	0	0
3	1	0	0	0	0	1	0
4	1	0	0	0	0	0	1
5	0	1	1	0	0	0	0
6	0	1	0	1	0	0	0
7	0	1	0	0	1	0	0
8	0	1	0	0	0	1	0
9	0	1	0	0	0	0	1

49.281X

Figure 12-22.—Bi-quinary code.

5 through 9 have bits in the 5 position of the binary part, indicating their value is five or greater; their actual value is indicated by a bit in the quinary position which, when added to five, equals the value of the digit.

The bi-quinary code affords a method for internal validity checking, since each digit must contain one binary bit and one quinary bit before it is considered a valid code. The absence of a bit, or the presence of more than one bit, in either the binary or the quinary part constitutes an error.

An alphabetic device may be installed in computers which operate with the bi-quinary code to permit the representation of alphabetic characters. When this device is installed, each character, including the digits 0 through 9, requires two bi-quinary codes; one code to represent the zone value and the other to represent the numeric value. A special character device may be installed as an addition to the alphabetic device to permit the use of special characters. A typical coding chart for alphabetic, numeric, and special character bi-quinary codes is shown in figure 12-23.

X-S3 (Excess Three Code)

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.

THE SYSTEMS CONCEPT

A system, as we know it in data processing, is a series of logical steps to be taken to do all the necessary work upon information to get desired results; for example, collecting time cards, calculating pay, preparing checks and journals. In data processing, a system typically means, a set of related input procedures and computer programs designed to do all the data processing defined within that system or communication network.

Data Collection

We know that data collection begins where the data originate. For example, an accounting department must get all the data necessary to pay all employees. Data may be collected on time cards, time reports, or on an automatic data collecting device that prepares a computer-acceptable tape for each employee as each "dials in" his hours worked, employee number, job order, clock station, and work center. In a payroll application the needed data may arrive from a variety of sources, such as work centers, clock stations, or personnel offices. It may be necessary then to design the form that carries the data so that the data can be removed swiftly and accurately. To obtain the source data rapidly and as required, some analysis and organization may be required.

Data Conversion

Remember that before data can be processed by a computer they must be converted into a format that can be accepted by the computer. For instance, data from payroll time cards or reports may be transferred to punch cards or to perforated paper tape. One computer may convert data for input into another computer. In a two-computer installation, one is a large, expensive, fast computer that uses only magnetic tape for input, processing, and output because tape inputing-outputing functions are much faster than using cards, or printers. The second is an auxiliary computer used for converting cards or paper tape to magnetic

CHARACTER		CARD CODE	BI-QUINARY CODE	CHARACTER	CARD CODE	BI-QUINARY CODE
Blank			0 0	M	11-4	7 4
Period	.	12-3-8	1 8	N	11-5	7 5
Lozenge	¤	12-4-8	1 9	O	11-6	7 6
Ampersand	&	12	2 0	P	11-7	7 7
Dollar Sign	$	11-3-8	2 8	Q	11-8	7 8
Asterisk	*	11-4-8	2 9	R	11-9	7 9
Dash	-	11	3 0	S	0-2	8 2
Diagonal	/	0-1	3 1	T	0-3	8 3
Comma	,	0-3-8	3 8	U	0-4	8 4
Per Cent	%	0-4-8	3 9	V	0-5	8 5
Pound	#	3-8	4 8	W	0-6	8 6
At	@	4-8	4 9	X	0-7	8 7
A		12-1	6 1	Y	0-8	8 8
B		12-2	6 2	Z	0-9	8 9
C		12-3	6 3	0	0	9 0
D		12-4	6 4	1	1	9 1
E		12-5	6 5	2	2	9 2
F		12-6	6 6	3	3	9 3
G		12-7	6 7	4	4	9 4
H		12-8	6 8	5	5	9 5
I		12-9	6 9	6	6	9 6
J		11-1	7 1	7	7	9 7
K		11-2	7 2	8	8	9 8
L		11-3	7 3	9	9	9 9

78.12

Figure 12-23.—Typical bi-quinary coding chart.

tape, and converting the magnetic output tape from the fast machine to print the results on the printer or convert it to paper tape.

Data Manipulation

Why is data manipulation necessary? Under the systems concept it means a time saver. More often than not we are forced to wait too long for information. Efficient data manipulation requires that the needed information be available on time to get the job done. To take again our example of computing pay, the information is "read" from the employee's punched time card. His hours worked must be multiplied by the hourly or weekly rate. All these data, plus name and year-to-date figures (probably on magnetic tape) must be brought together for printing on his check and check stub.

Data Presentation

Data should be presented in a orderly, easy-to-identify, visual manner. For instance, in check preparation, the name, date, and amount are not printed at random, or on a scratch piece of paper. A card must be designed that is flexible in processing, easy for the recipient to read, and negotiable as a check at a bank.

Data Feedback

Data feedback or circulated data allows for using the data more than once. In other words, data feedback consists of saving part of the output of a computer run for re-introduction into the computer on the same run or a different run at a later time. The purpose of this circulating data is two fold; re-adjustment and/or correction. For instance, in a supply inventory, the master tape is updated over and over, but it must be re-introduced into the computer for each update operation. For example, if the unit price change on an item on the master tape, the master tape as well as the source of the price change will have to be read into the computer together. Then, a comparison process takes place and the source data are compared to the master tape by Federal stock number until the comparison is equal, then the new unit price is inserted onto the tape, and this operation is repeated until the master tape has been completely updated.

ONE STEP FURTHER

Univac 1 became an antique after 12 1/2 years and was retired to the Smithsonian Institution. This is typical of the changes taking place today in data processing. Both private business and the Government are developing so many new uses for computers, and the systems are being improved so rapidly that future uses seem limitless. What we call "new developments" today may be obsolete in the very near future. Some fairly recent trends that are of interest to the Navy Machine Accountant are discussed below.

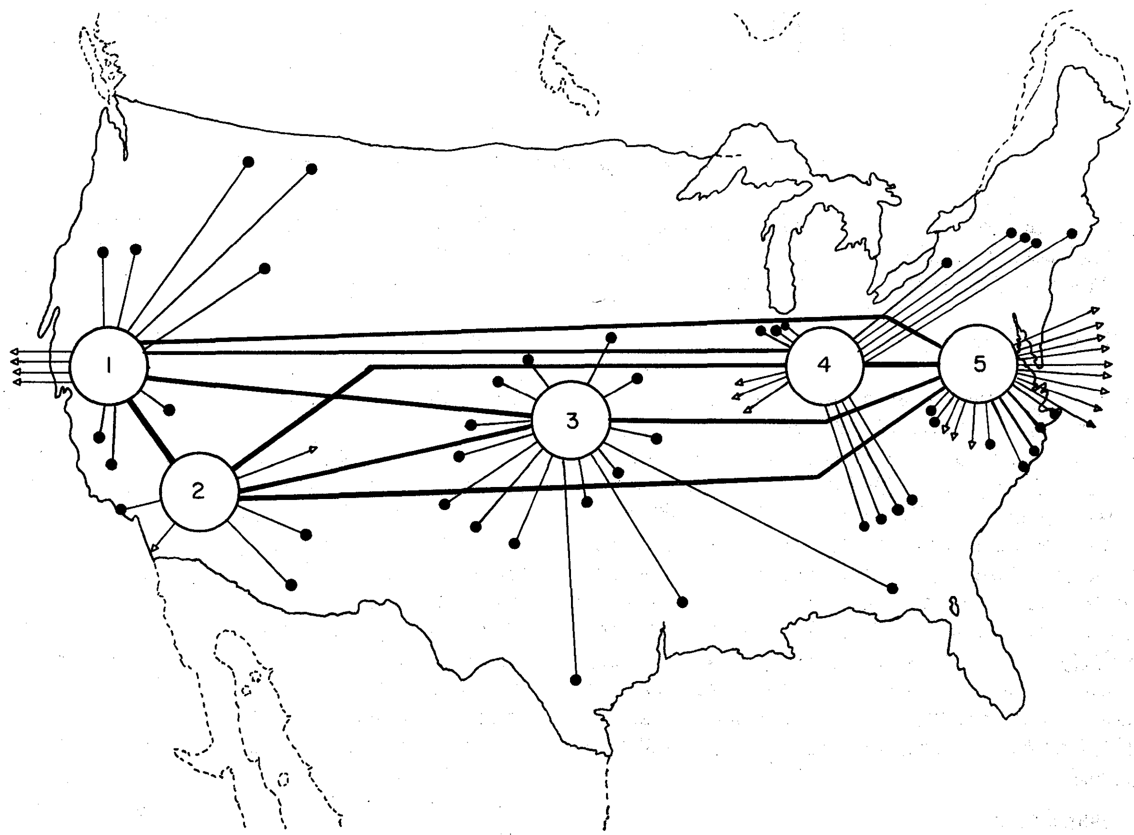
The "Total" Systems Concept

A rather simple way of defining total systems is: all major operating systems of a company or activity completely integrated through the medium of a centrally located computer. Every system, accounting, sales, inventory, et cetera, would be connected directly into the computer. Anything that happens to one system would affect all the others, and the computer, as the central repository of important data, would automatically make changes in all the other systems and print out the necessary reports.

The total systems concept truly encompasses an entire business.

Autodin

The AUTODIN (automatic digital network) system is a large communications network that provides service for the Department of Defense



49.282

Figure 12-24.—Autodin Switching Center in the U.S.

and some industrial plants that support certain weapons systems. It has terminals located in the "customers" offices (industrial plants and various military activities). These are connected by landline or microwave circuits to one of five transistorized, fully automatic, high speed, electronic switching centers. The switching centers, as indicated in the illustration in figure 12-24, are further interconnected by high speed lines, capable of handling messages at the rate of 3000 words per minute. Each switching center serves customers in its particular geographic area, quite the same as a city's telephone exchange serves its customers in that city's metropolitan area. This complex of terminals, circuits, and switching centers is now recognized as the world's largest computer controlled communications system designed exclusively for the transmission and processing of messages of various types, lengths, and formats which are exchanged between the many users of the system. Autodin may not use the largest computer in existence, but it is the largest and most advanced communications system which employs computers for control, storage, and relay of message traffic.

ACCESS TIME - The time required for a computer to locate and transfer data or an instruction word from storage. The time required to transfer and store data that has been processed.

ANALOG COMPUTER - A machine that represents data as physical quantities, and performs calculations in terms of physical analogies such as, flow, temperature, pressure, angular position, or voltage.

AUTODIN - The automatic digital network providing the world's largest, most advanced digital communications system, used throughout the Department of Defense.

BINARY NUMBER - A number, usually consisting of more than one figure, representing a sum, in which the individual quantity represented by each figure is based on a radix of two.

BIQUINARY CODE - A two part code in which each decimal digit is represented by the sum of the two parts, one of which has the decimal value of zero or five and the other the values zero through four.

BIT - An abbreviation of Binary Digit; a single character in a binary number, a single pulse in a group of pulses.

CIRCULATING DATA - Output from a computer run that is used again, in the same or different runs.

COMPUTER DATA - A system of symbols for representing data or instructions in a computer.

CONVERTED DATA - Data that has been changed from one form of representation to another; such as, punched card to magnetic tape or paper tape to punched card.

DATA COLLECTION - The act of collecting raw information and transforming it into a machine readable form.

DATA CONVERSION - The process of changing information from one form of representation to another; such as, from the language of one machine to another, tape to card, card to tape, et cetera.

DATA FEEDBACK - See circulating data.

DATA MANIPULATION - The handling of one or more pieces of data, by the computer, to provide a useful output such as, adding, shifting, and transferring.

DATA NUMBERING SYSTEM - A systematic method for representing numerical quantities in which any quantity is represented as the sequence of coefficients of the successive powers of a particular base with an appropriate point.

DATA PRESENTATION - The process whereby data is arranged and presented in an orderly, easy-to-identify, visual manner.

DATA REPRESENTATION - The symbolic forms used to represent data; card code, bit, paper tape, e.g.

DIGITAL COMPUTER - A machine capable of performing sequences of arithmetic and logical operations, not only on data but on its own program.

DIRECT DATA - Data that may be presented directly to the computer in its original form.

EVEN PARITY - A check which tests whether the number of one bits in a word is even.

EXCESS THREE CODE - A binary coded decimal code in which each digit is represented by the binary equivalent of that number plus three.

GENERAL PURPOSE COMPUTER - A computer designed to solve a large variety of problems; a stored program machine which may be adapted to any of a large class of applications.

NUMBER BASE CONVERSIONS - The process of changing information in one number base to another.

OCTAL NUMBER - A number of one or more figures, representing a sum in which the quantity represented by each figure is based on a radix of eight.

ODD PARITY - A check which tests whether the number of one bits in a word is odd.

ON-LINE-DATA - Data that is introduced into a computer via a machine that is under the control of the computer.

PARITY CHECK - A summation check in which the binary digits, in a character or word, are added, modulo 2, and the sum checked against a single, previously computed parity digit.

REPREPARED DATA - Data that is reconstructed from different outputs for a new input.

SOURCE DATA - Data that has been collected, converted, and is machine acceptable.

SPECIAL PURPOSE COMPUTER - A computer designed to solve a narrow range or specific class of problems.

STORED PROGRAM - A sequence of instructions, stored inside the computer in the same storage facilities as the computer data.

SYSTEM - An assembly of procedures, processes, methods, routines or techniques united by some form of regulated interaction to form an organized whole.

TOTAL SYSTEMS - All of a company's different systems integrated by a central computer.

VALIDITY CHECK - A check based upon known limits or upon given information or computer results.

CHAPTER 13

INPUT—OUTPUT

An electronic data processing system must have a means of receiving data (input), controlling and processing data, and releasing processed data (output). These functions are made possible through the combined use of several different types of data recording media and devices. This chapter deals with a number of recording media and devices used for getting information in and out of the computer.

DATA RECORDING MEDIA

Just as devices are needed to convert source code to computer code, there must exist a way of recording the information to be entered into, and received from, the computer. In this chapter we will cover several of the generally used data recording media and some of the methods and techniques employed to introduce data into, and receive data from, a computer system.

The Card

Punched cards are commonly used for input and output 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.

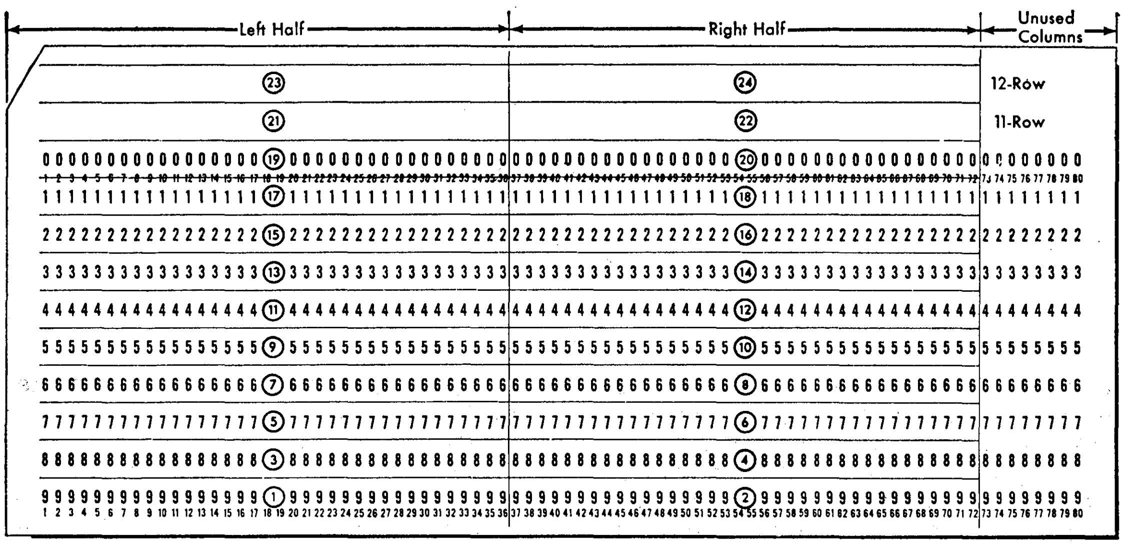
There are two types of punched cards in general use — the 80 column and the 90 column cards. Different equipment is required for handling the two types of cards. The 90 column card employs circular holes and is associated with the equipment of Sperry Rand. However, the most common is the Hollerith code that is used with IBM equipment.

Card Codes.—The physical placement of holes in a specific 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 Ch. 3) row binary, and column binary. In general there are 12 rows on the card and each row contains 80 columns.

In the row binary code, the first 72 columns of the card are used for recording binary data. The 72 columns are further divided, columns 1 through 36 represent the left half, and columns 37 through 72 represent the right half. The system that used 72 columns of the card for recording binary data normally uses 36 bits of binary information to represent one "word." As can be seen in figure 13-1, the information is arranged serially across each row of the card (left to right) starting at the 9 row, continuing to and including the 12 row. Each punched hole is regarded as a binary 1. No punching indicates a binary 0. Therefore, one full word of binary information (36 bits) can be punched in any half row, and 24 words may be punched in one card.

Referring to a system that uses a 36 bit word, we can see that it is also feasible to record binary information in parallel as well as in serial. This method of recording data on punched cards is known as column binary code. Using the columar fashion of recording binary information, each column (12 through 9) can represent 12 bits of information. Thus, one full 36 bit word will require three card columns. The entire card can contain twenty-six 36 bit words (fig. 13-2).

Card codes are almost identical to the codes that a computer uses. That is, 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



49.283X

Figure 13-1. —Row binary code.

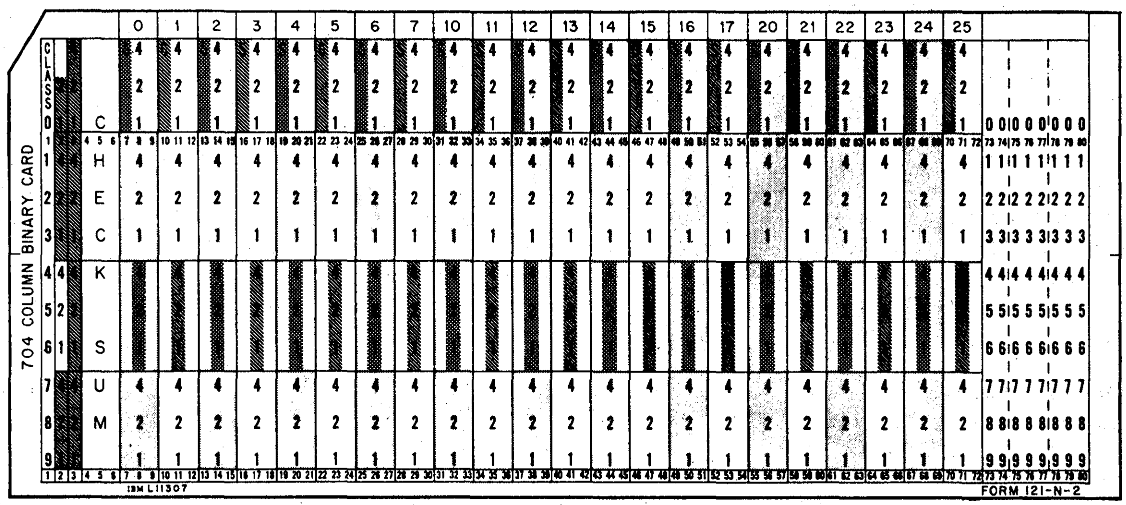


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Figure 13-2. —Column binary code.

computer originates from electrical contact of the punched holes.

Paper Tape

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 5/8 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 (figs. 13-3 and 13-4). Paper tape is a continuous recording medium and can be used to record data in records of

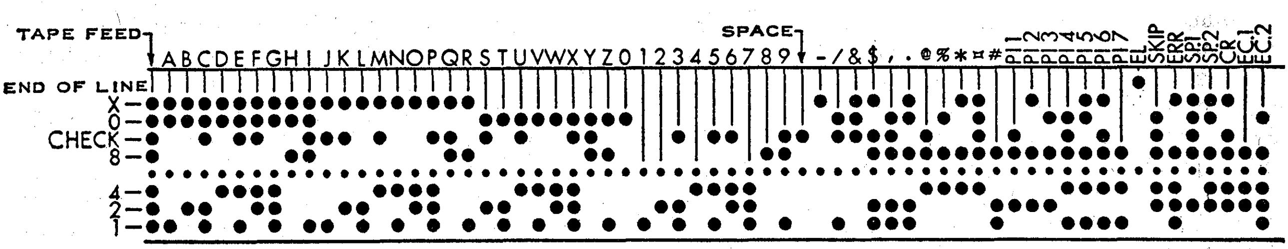

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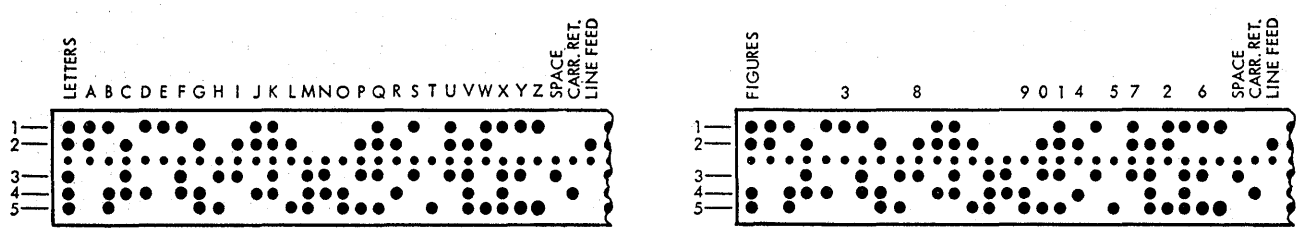
Figure 13-3. —Eight channel paper tape code.



49.286X

Figure 13-4. —Five channel paper tape code.

any length, the capacity of the storage medium 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.

Paper Tape Code.—There are two basic types of paper tapes, a five channel tape and an eight channel tape. The only difference in the two is that one can record all characters without reusing some of its coded combinations; whereas, the other cannot.

In an eight channel tape the data are recorded in eight parallel tracks along the tape. Figure 13-3 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 codings for alphabetic and special characters are shown in (fig. 13-3).

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, 0, 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, 0, 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.

As opposed to the eight channel tape, the five channel tape uses only five parallel channels along the tape for punching. 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 13-4 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. 13-4). When preceded by the letters (LTRS) code, a section of tape is interpreted as alphabetic characters (fig. 13-4).

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 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 the principal recording medium 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 spots called bits. The recording 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.

IBM tapes are wound on individual reels or in dust-resistant cartridges containing two reels so that they may be handled and processed easily. The cartridge-loaded tape is supplied in 1-inch width and up to 1800 feet in length and is called Hypertape. Tape on individual reels may run up to 2400 feet in length and 1/2 inch in width.

Data are recorded in parallel channels or tracks along the length of the tape. There are 10 tracks on Hypertape, and 7 tracks on the 1/2 inch tape.

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. Character densities as high as 1511 characters per inch are possible using hypertape and up to 800 characters per inch using the 1/2 inch tape.

A space that is longer than usual is used to indicate the end of one record and the start of another. This space is called the inter-record gap. Even though the Hypertape is 600 feet shorter, the recording capacity is about twice that of 1/2 inch tape due to the higher recording density and shorter inter-record gap.

Magnetic Tape Code.—Data for computers are normally coded on IBM magnetic tapes in two modes — binary coded decimal (BCD) or binary. The code used depends on the computer that originates the tape recorded data. Recording also varies within the two modes of tape coding, depending on whether Hypertape or 1/2 inch tape is used.

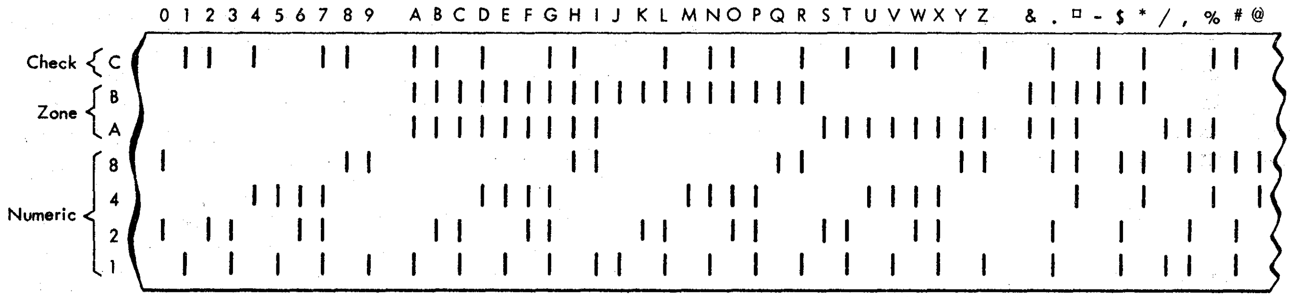
Binary coded decimal (BCD) coding may be used for recording decimal numbers and letters of the alphabet on magnetic tape. The BCD format also provides for coding punctuation marks as well as other special characters (fig. 13-5).

Hypertape will accept binary coded decimal data written in two modes: data compression (packed) mode and nondata compression (unpacked) mode. Character coding in unpacked mode is similar to that used for 1/2 inch BCD tape. The main exception is that the unpacked mode uses two check bits.

Packed mode may be used only to record decimal numbers, but this mode offers the advantage of recording two numbers in a single tape column, thus effectively doubling the reading and writing speed of numeric data in certain data processing systems. All ten tracks are used, eight for recording the packed data and two for checking.

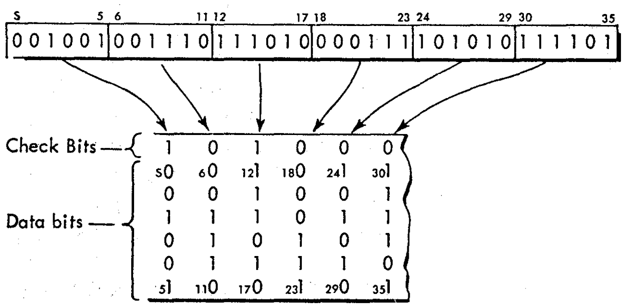
Binary code is used in some computers to record data on magnetic tape. The binary mode of tape recording can be used with both Hypertape and 1/2 inch tape. Figure 13-6 illustrates binary notation on seven track magnetic tape.

Binary data are recorded only in unpacked mode on Hypertape. Only six of the data tracks and the two check tracks are used.



78.25X

Figure 13-5. —BCD notation on seven track magnetic tape.



78.26X

Figure 13-6.—Binary notation on seven track magnetic tape.

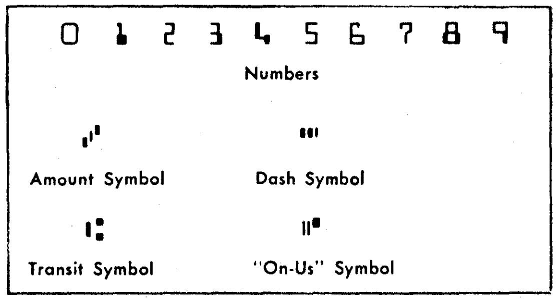
Just as the presence of pulses in a computer represents data, the presence of magnetized spots or bits on magnetic tape represents data.

Magnetic Ink Characters

A language readable by both man and machine is produced by printing magnetic ink characters on paper media for machine processing (see fig. 13-7). The magnetic property of the ink allows reading by the machine, and the shape of the characters permits visual interpretation.

The paper documents on which magnetic ink characters are inscribed may be random size paper or cards ranging from 2 3/4 inches to 3 2/3 inches wide, from 6 inches to 8 3/4 inches long, and from .003 inch to .007 inch thick.

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. At this point the information may be entered directly into the data processing system.

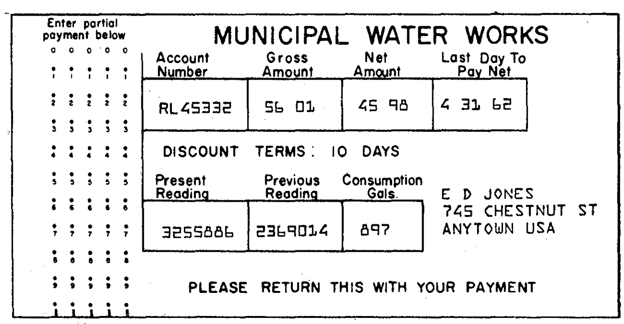


49.287

Figure 13-7.—Magnetic ink characters.

Optically Read Characters

A new method of input to a data processing system is optically readable characters on paper documents (fig. 13-8). Included in these characters are all letters of the alphabet, digits 0 through 9, decimal point, comma, and special characters. Ordinary pen or pencil marks placed in certain locations on the document can also be read.



49.288X

Figure 13-8.—Optically readable characters.

Documents for optical reading may vary in size up to 8 3/4 inches long, 3 2/3 inches wide, and .005 inch thick.

Optical characters are represented by the same computer code that is used to represent magnetic ink characters.

INPUT-OUTPUT DEVICES

In a data processing application the functions of input and output are performed by input-output devices linked directly to the data processing system. Each input-output device operates under the control of the central processor as directed by the stored program.

Input devices read (interpret) data from cards, magnetic tape, paper tape, and magnetic ink characters. The data are then made available to the main storage of the computer. Output devices receive data from main storage and record (write) information on cards, magnetic tape, paper tape, and printed reports.

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.

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. 13-9). The status of the devices is shown by the indicator lights: off, on, selected, ready, and so on. The primary functions of the operating key 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 (fig. 13-10) 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 chapter 3 should be consulted.

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. 13-11). 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

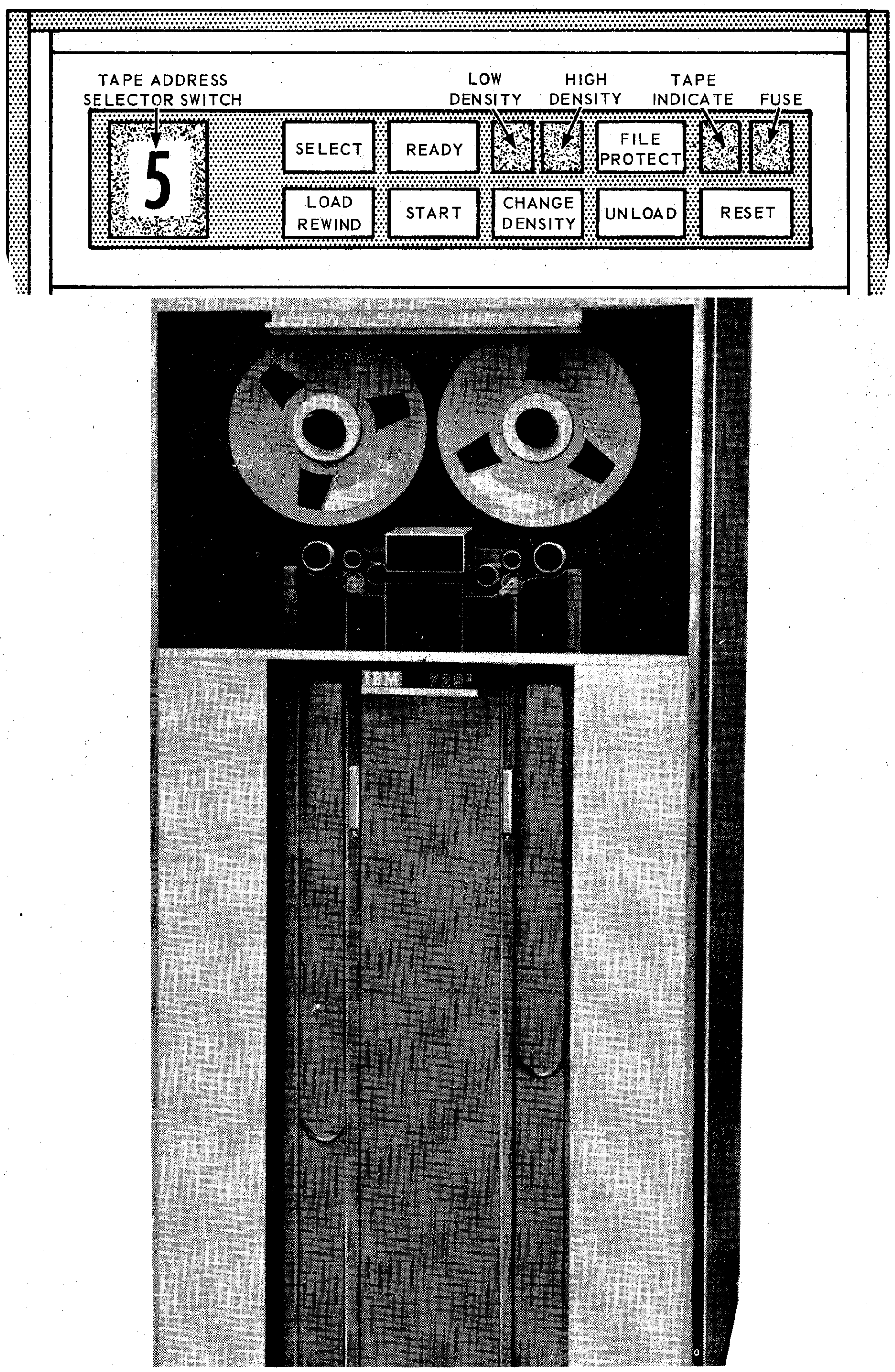


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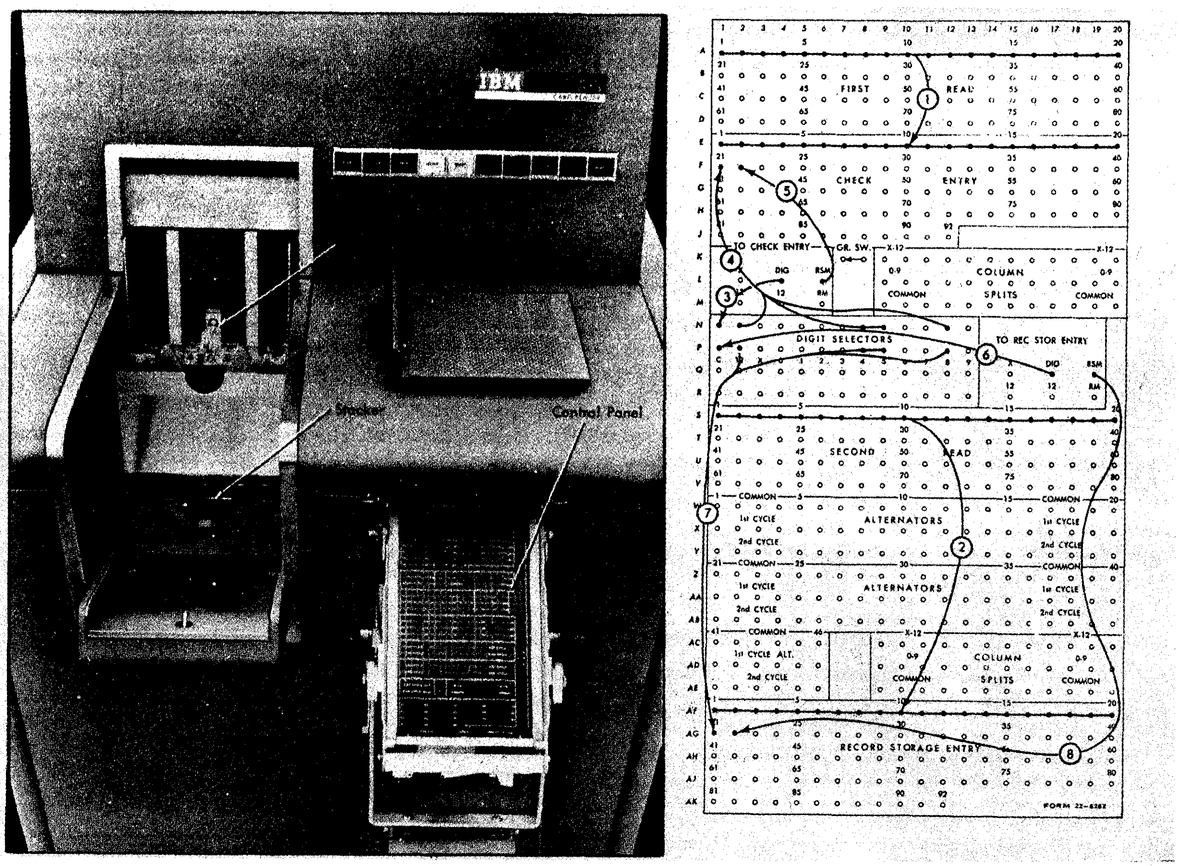
Figure 13-9. —Magnetic tape unit and indicators.



49.289X

Figure 13-10. —Card reader with control panel schematic.

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.

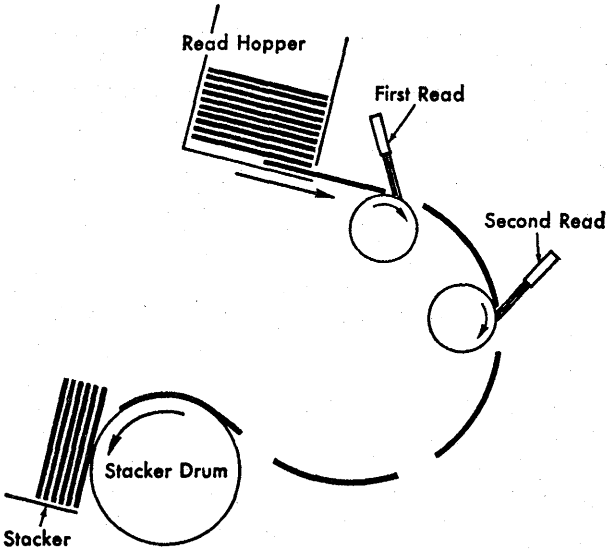
The photoelectric type card reader performs the same function as the brush type; the only difference is in the method of sensing the holes. Photoelectric card reading is performed by 12 photoelectric cells, one for each of the 12 columns of the card. Cards are passed between the photoelectric cells and the light source. If the cards are punched, the light will penetrate the holes and activate the photoelectric cells.

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

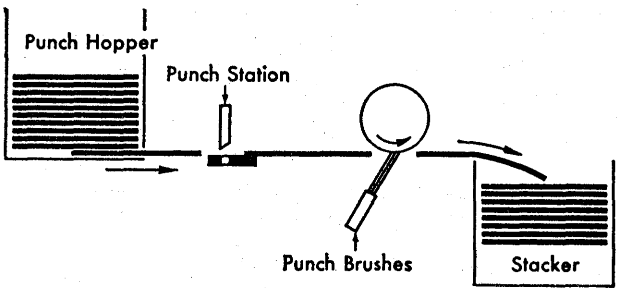
Card punching devices are used to punch results obtained within the computer system. The binary coded characters within the system are automatically converted to standard punched card codes before punching occurs. The card punch automatically moves blank cards, one at a time, from the card hopper, under a punching mechanism (PUNCH DIES) that punches data as it is received from storage of the computer system (fig. 13-12). 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



49.290X
Figure 13-11.—Brush reading.

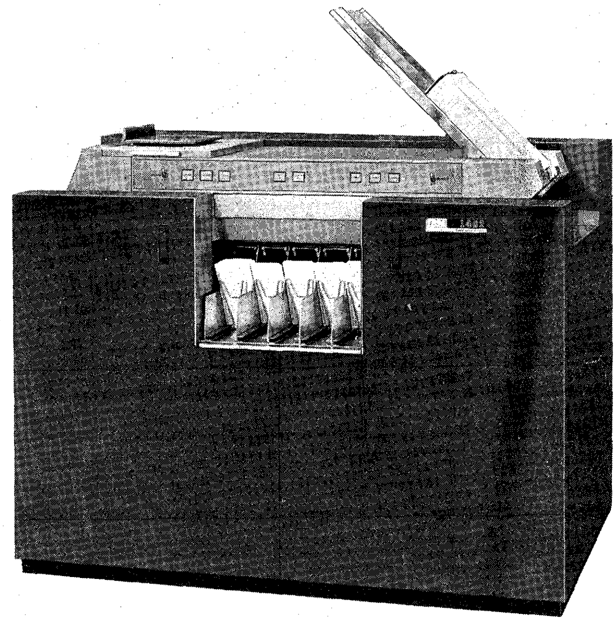
output from a tape system must be converted to punched card form for further processing or handling.



49.291X
Figure 13-12.—Card punch station.

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 1402 card read-punch shown in figure 13-13 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 gang-punched from the cards in the read unit into the cards in the punch unit must first pass through storage in the processing unit.



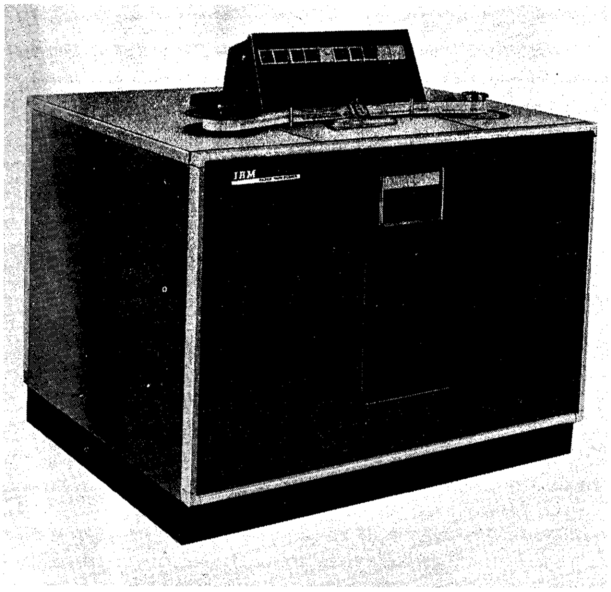
49.292X
Figure 13-13.—Type 1402 card read-punch.

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 (fig. 13-14) 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.

Paper Tape Punch

Information from the computer system can be recorded as punched holes in paper tape by an automatic tape punch (fig. 13-15). Information to be punched is converted from computer language to paper tape code before being punched. Paper tape usually is 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.



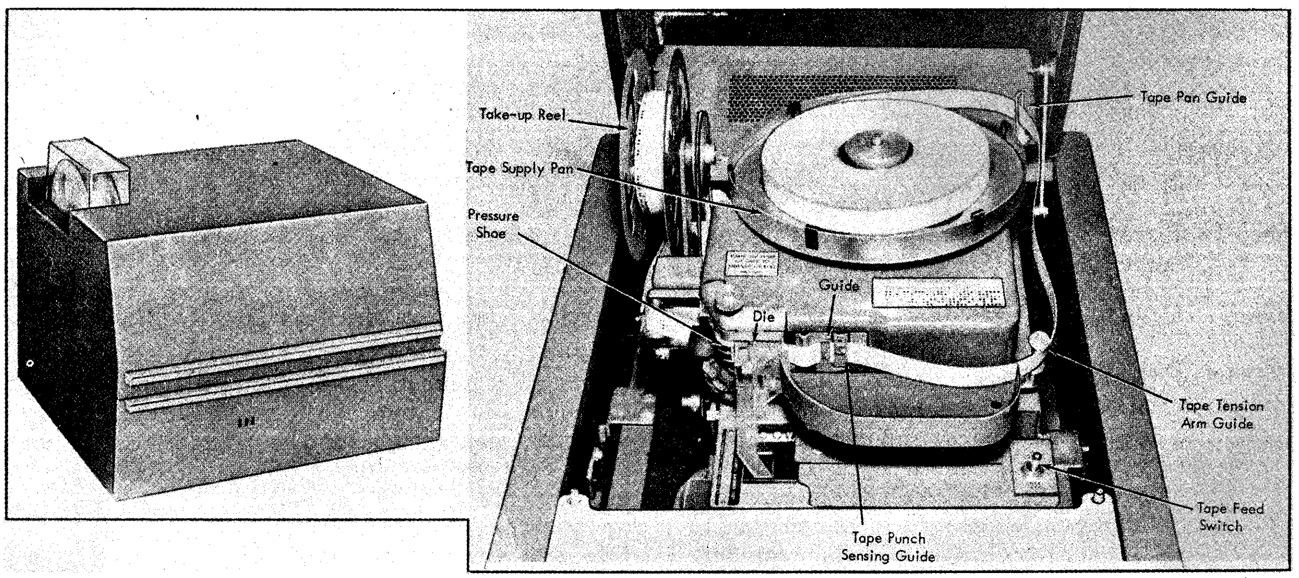
49.293X
Figure 13-14.—Paper tape reader.

Magnetic Character Reader

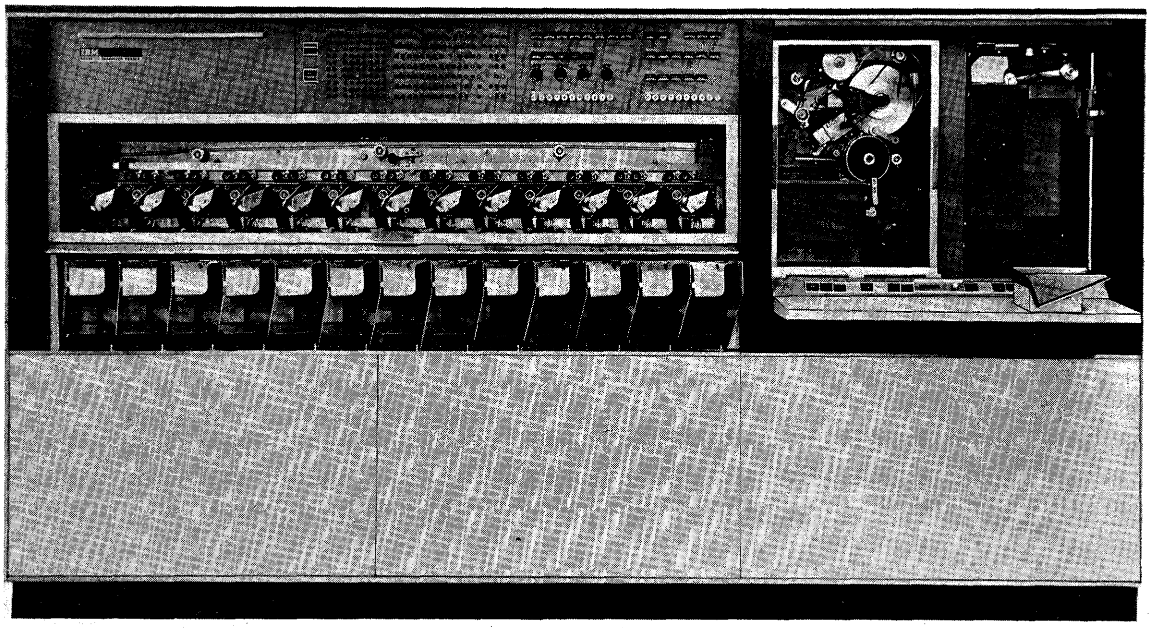
A magnetic character reader (fig. 13-16) provides a time-saving method of reading and processing large volumes of daily transactions. These machines read inscribed cards and paper documents and have the ability to sort the magnetically inscribed documents in an off-line operation.

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. 13-17). For each of 70 character segments, there is a storage location in the matrix, and as documents 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. 13-17). 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. 13-17). 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. 13-17). To verify accuracy of processed data, the reader automatically checks 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

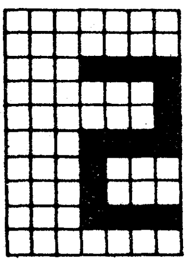


49.294X
Figure 13-15.—Paper tape punch.



49.295X
Figure 13-16. —Magnetic character reader.

invalid, the recognition circuits provide the machine with an error signal.



49.296X
Figure 13-17.—Character matrix.

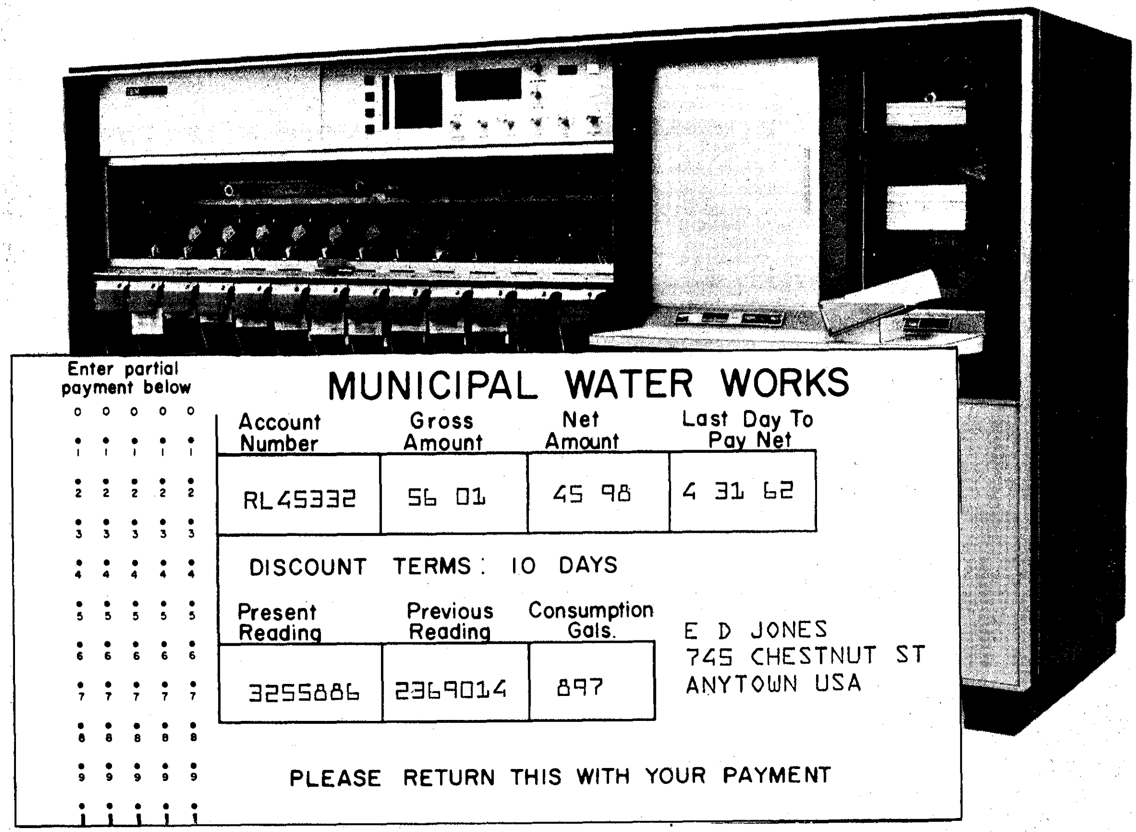
Optical Character Reader

The optical character reader (fig. 13-18) 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. The components of the scanner are: A powerful light source and a lens system that 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.

Consoles

A console normally consists of a keyboard, typewriter, and a line or a cluster of indicator lights on a pedestal base. The console such as the one illustrated in figure 13-19 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 displays. A typewriter provides limited input and output, such as keying in new instructions, modifying instructions, printing out



49.297X

Figure 13-18.—Alphameric optical reader and mark sensing document.

messages signaling the end of processing or an error condition. It may also print out information that will enable the operator to monitor and supervise the operation more efficiently.

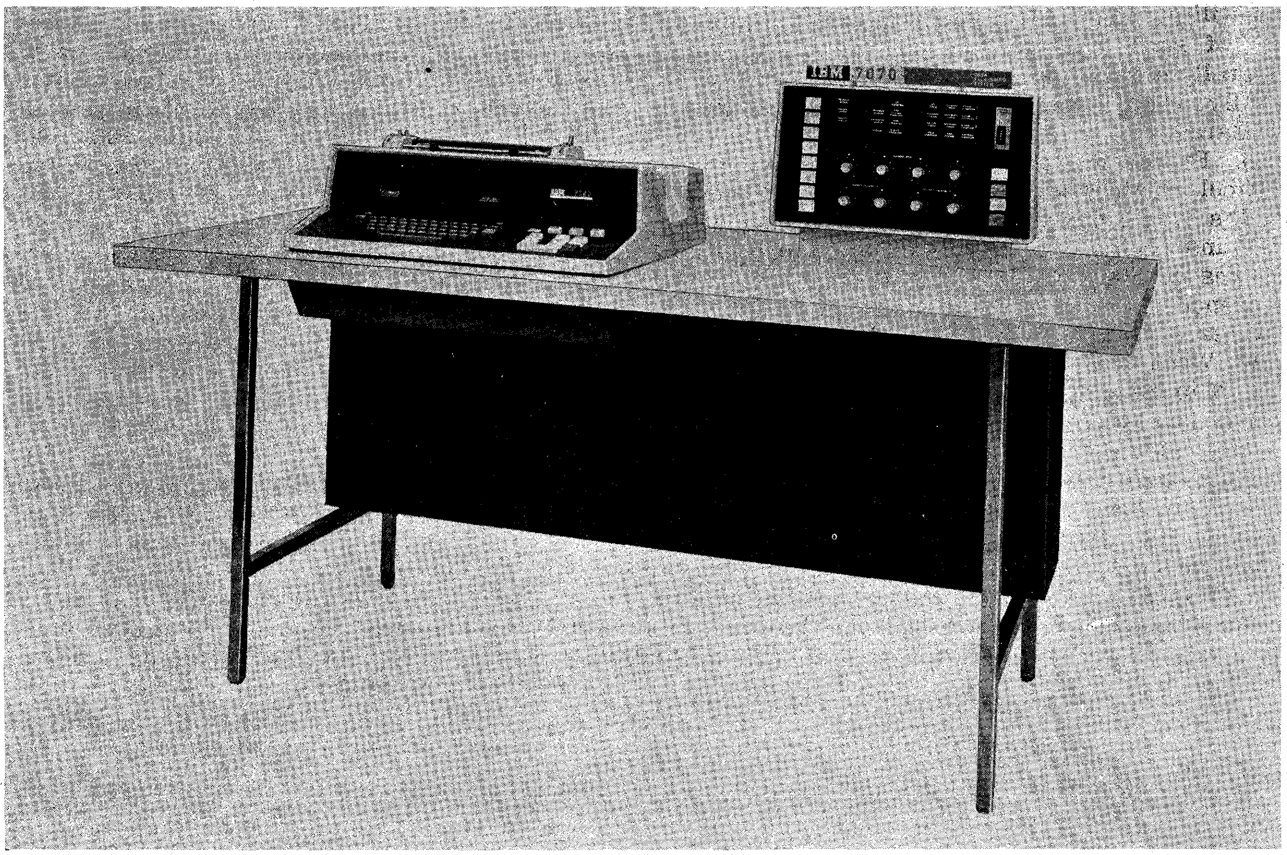
A remote console may be used at a remote location to provide duplicate operator controls for increased flexibility and efficiency.

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



49.298X

Figure 13-19. —7150 Console.

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 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 particular operation called for by the instruction must have the dial set to the number specified in the instruction.

Loading and Unloading Tape Units.—Each type of magnetic tape transport unit has its own set of operating keys and lights (see fig. 13-9), and routines 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. Excluding Hypertape, 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. A tape reel MUST have the file protection device INSERTED to permit writing on the tape.

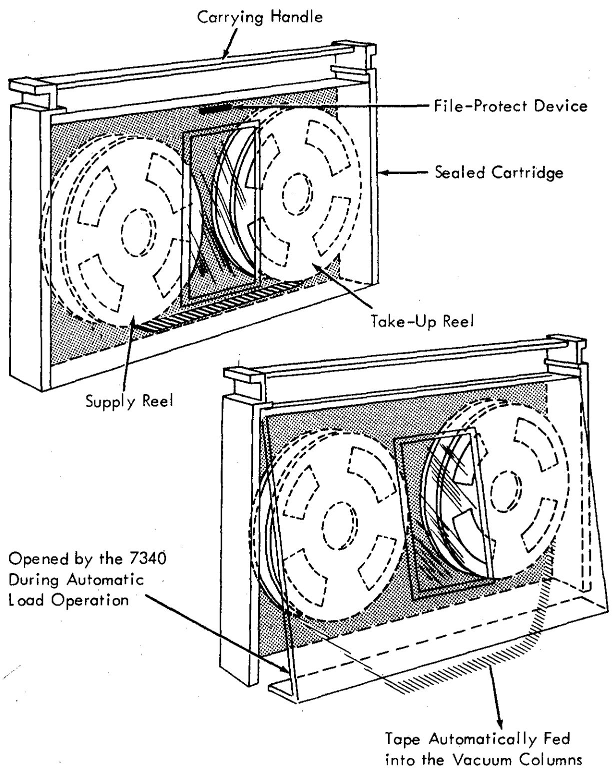
2. Exercise due caution to ensure the tape reel is properly mounted. Reels which are not mounted correctly may cause the edge of the tape to receive undue wear and become burred. Burring causes one edge of the tape to be slightly thicker than the other, and in time the edge of the tape will be permanently 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 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.

The loading of Hypertape is performed automatically after the dust-resistant cartridge is placed in the tape unit by the operator; the time-consuming manual threading in tape loading operations is eliminated (fig. 13-20).



The Hypertape cartridge houses the supply and take-up reels, which are equivalent to the file and machine reels of non-cartridge tape. The Hypertape Drive automatically loads the tape, protecting it from possible handling damage.

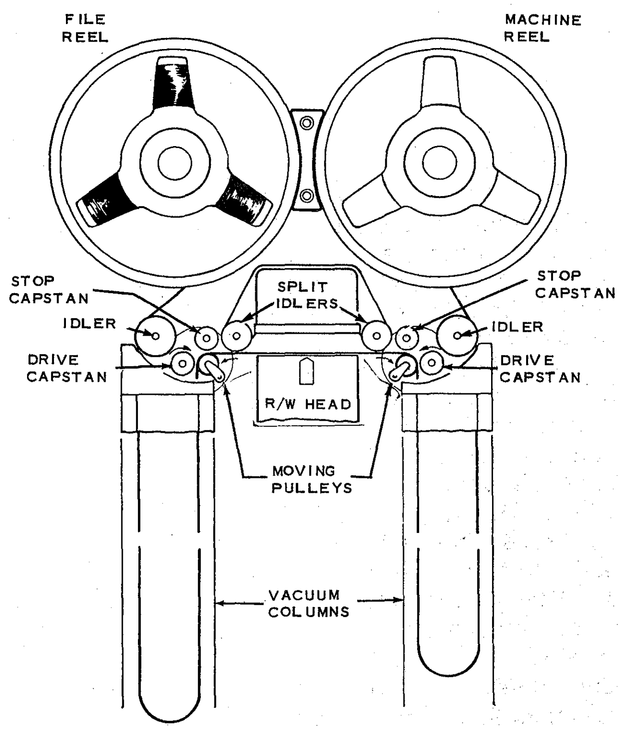
49.299X

Figure 13-20.—Hypertape cartridge operation.

Reading and Writing Magnetic Tape.—Information is recorded on and read from magnetic tape by a read-write head. The read-write head assembly is built in two sections and is located between the vacuum columns (fig. 13-21). The upper section can be raised and lowered, while the lower section is stationary. Some tape units open and close the head assembly automatically while some are manually opened and closed. When the head assembly is open, tape may be threaded. When closed, the tape is in close contact for reading and writing.

Notice that the file reel 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

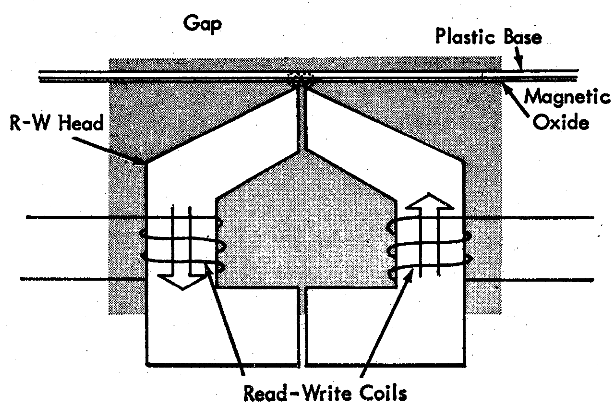


49.162X

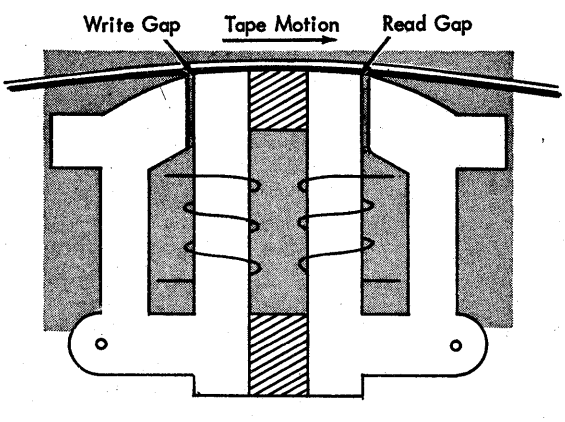
Figure 13-21.—Tape feed unit.

machine reel takes up tape, depending on which vacuum column has reached its maximum or minimum length. Tape may be backspaced over a record or rewound to the beginning of the reel. No writing may take place while the tape is moving in reverse.

Information is recorded on magnetic tape 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 13-22. 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.



ONE-GAP READ-WRITE HEAD



TWO-GAP READ-WRITE HEAD

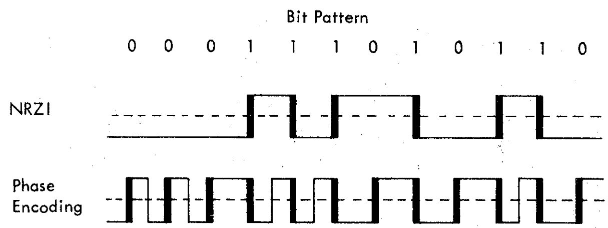
7.53.2aX

Figure 13-22.—Read-write heads.

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.

Due to the rapid current reversals in the write head coils, tapes can be written at a speed in excess of 100 inches per second.

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 in two ways: to ensure that the recorded data are of effective magnetic strength, and to verify that the recorded data are composed of valid characters. For instance, IBM uses two methods of recording data on magnetic tape. The non-return-to-zero-IBM (NRZI) method is used on all magnetic tape units except Hypertape. Hypertape uses what is called a phase encoding method. Figure 13-23 show the comparison of the two methods.



In the NRZI method of recording, a change in magnetic flux is interpreted as a 1 bit; lack of a flux change is interpreted as a 0 bit. The phase encoding method of recording used on Hypertape results in a continuous wave pattern, even when a record contains all zeros.

49.300X

Figure 13-23.—Comparison of NRZI and Phase Encoded bit patterns.

The NRZI data recording method is generally satisfactory, but after excessive runs through the tape unit, with accompanying tape wear and handling, magnetic bit strength is sometimes weakened. This weakened strength means that the bit may not be detected as a flux change during reading, therefore resulting in an unsatisfactory reading. Because of a more positive method of recording, using a flux change for both 0 and 1 bits, phase encoding avoids this condition.

Two types of errors are possible on NRZI tapes: reading a 0 bit for a 1 bit or reading a

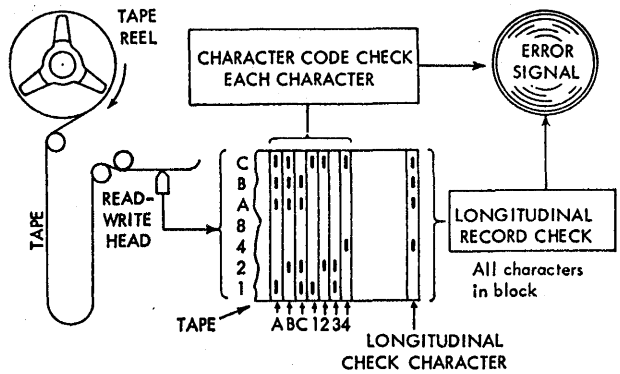
1 bit for a 0 bit. The error detection system, using the principle of simple parity checking, has the possibility of detecting and indicating virtually all errors, although the type of error is not indicated.

In contrast to the simple parity checking used by NRZI tapes, Hypertape uses a method known as dual parity checking. There is only one type of error using this system of checking. Either 1s or 0s are recorded or they are not. If unrecorded, an error is indicated. Detection of all errors is ensured using this system of error checking.

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.

In checking BCD tape, except Hypertape, 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. 13-24). 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.

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. 13-24).



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.

49.301X

Figure 13-24.—Seven track tape validity checks, BCD mode, even parity.

Checking Binary Code (except Hypertape).—In electronic data processing systems using the binary code for data representation, the basic 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.

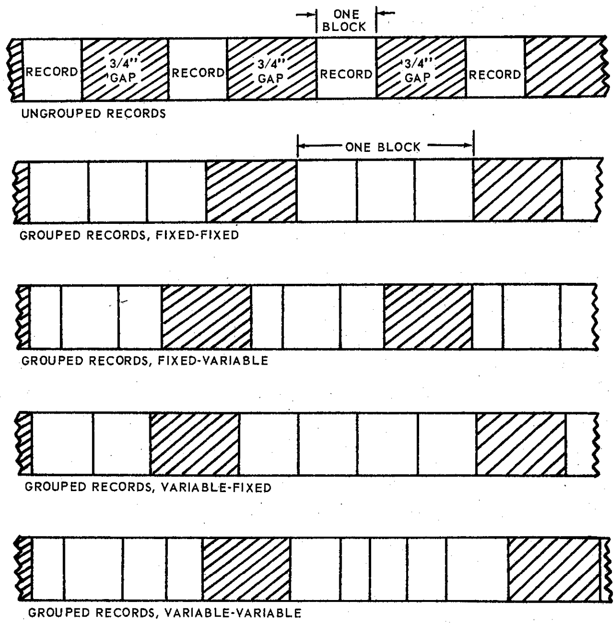
The difference in checking binary tape and BCD tape is that the vertical parity check including the check character must have an odd parity for binary coded data; whereas the horizontal parity check, including check character, for binary tape must be even. If these conditions are not met, an error condition is indicated.

Hypertape uses the method of dual parity checking, which provides detection of all errors. Using this method of parity checking, utilizing the two-gap read-write head, all information is read immediately after it is written. Specific signal strength is checked in each of the ten tracks. If the signal in one or more tracks does not meet the prescribed standard, an error is indicated. Corrective action will then be performed in accordance with the program.

Because of the two-check-bit system used during reading with Hypertape, all single bit errors and most double bit errors are not only detected but are corrected automatically. Uncorrectable double bit errors are dependent on the program for corrective action.

Tape Records, Density, and Inter-Record 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 inter-record 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 inter-record gap. During writing, the inter-record or inter-block 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 inter-record or inter-block 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 13-25, 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.



78.27

Figure 13-25.—Placing data records on magnetic tape.

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 inter-record 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. Record blocks and 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 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 typical example is illustrated in figure 13-26.

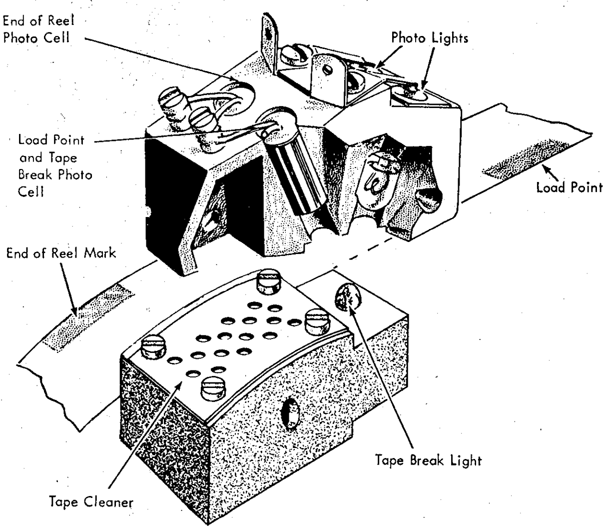
TAPE SPEED (INCHES/SEC)	DENSITY (CHAR/INCH)	CHARACTER TIME (MICROSECONDS)	CHARACTER RATE (CHAR/INCH)
36	200	139	7,200
	556	50	20,016
75	200	67	15,000
	556	24	41,667
112.5	200	44	22,500
	556	16	62,500

49.302X

Figure 13-26.—Character rate.

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 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 photo-electric cells in the tape transport unit, as illustrated in figure 13-27. 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.



78.30X
Figure 13-27.—Sensing of tape markers.

The load point marker is placed approximately ten 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 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. The end-of-reel marker is placed approximately 14 feet from the end of the tape to provide at least 10 feet of leader and enough space to hold a record of approximately 9600 characters after the end-of-reel marker has been sensed. This marker is placed 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.

Another method utilizes transparent windows in the tape for markers. Rays of light passing through these windows are detected by photosensing stations for initiating the various signals which control the motion of the tape, as illustrated in figure 13-28.

Approximately 50 feet of tape is used as a leader, prethreaded on the tape station to provide ease in loading a reel. Data are never recorded on this portion of the tape. During the loading routine, the leading end of tape on the file reel is spliced to the leader. A window in the leader, called a LEADER WINDOW, is used to stop the motion of the transport unit in a position which allows the operator easy access to the tape-to-leader splice. The leader window is followed by another window, called the BEGIN TAPE WINDOW (BT). When the BT is sensed, a BEGINNING OF TAPE LEVEL (BTL) is generated, which signals that the beginning of the usable portion of tape has been reached.

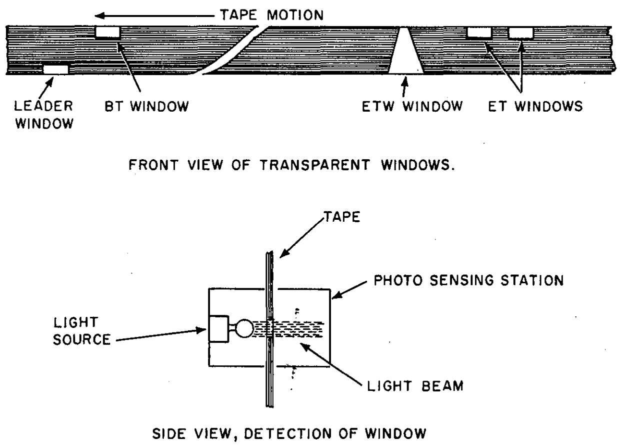
Another window, called the END OF TAPE WARNING (ETW), is located in the tape approximately 75 feet from the end of the tape. When this window is detected, an ETW level is generated and sent to the user equipment to warn that the usable portion of tape is almost exhausted and the operation should be terminated. A pair of windows known as an END OF TAPE (ET) is located approximately 50 feet from the end of the tape. The detection of these windows causes the transport unit to stop and prevent the tape from running off the reel.

Hypertape uses the same principle as reflective strips for tape markers. That is, photosensing the tape markers, such as the end of a reel and so on. In lieu of reflective strips, Hypertape uses a series of small holes in the tape to indicate specific areas of the tape.

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, other than Hypertape, have a circular groove molded in the back of the reel (fig. 13-29), which permits the insertion of a plastic file protection ring, or adapter rim (fig. 13-29). 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."

Since Hypertape is contained in a cartridge, it must have another means of file protection. This is accomplished by a mechanical slide on the cartridge (fig. 13-29). The slide may be actuated either manually or by program control.

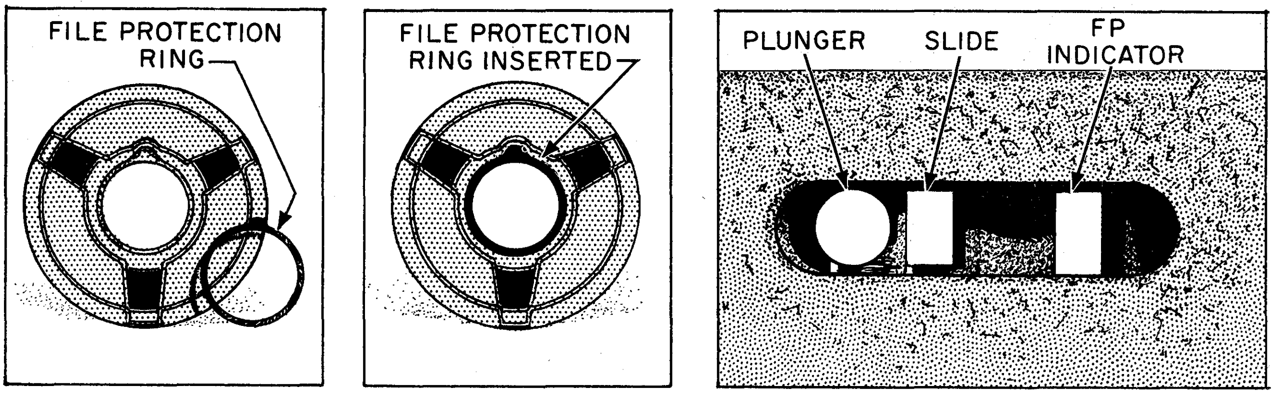


78.31

Figure 13-28.—Sensing of Marker windows.

An FP signal is displayed on the cartridge and an indicator is lighted on the Hypertape drive when the FILE PROTECT status is in effect.

Any tape reel which has been tagged with a file label should have the file protection device removed by the operator as soon as the tape is written. This prevents accidental destruction

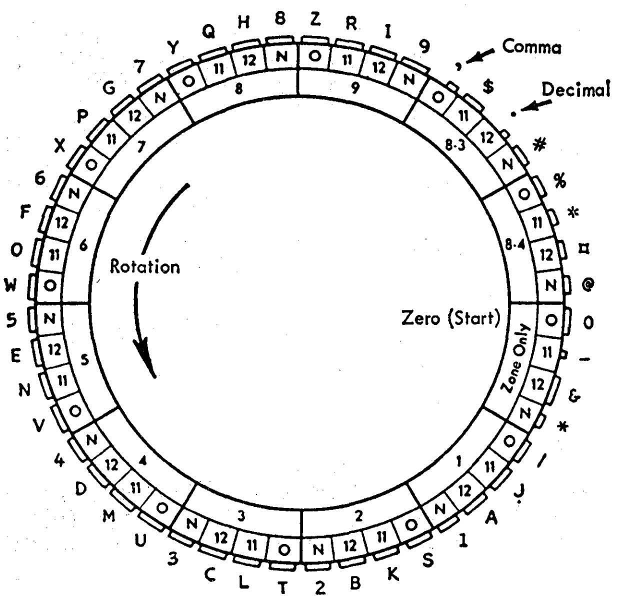


On non-cartridge tape, the file protection device is a plastic ring that fits into a round groove molded in the tape reel. When the ring is in place, either reading or writing can occur. When the ring is removed, writing is suppressed and only reading can take place; thus, the file is protected from accidental erasure.

On Hypertape, file protection is controlled by a mechanical slide on the cartridge. The slide may be actuated manually or under program control. When file protect status is in effect, an FP signal is displayed on the cartridge and an indicator is lighted on the Hypertape Drive.

49.303X

Figure 13-29.—File protection devices.



49.304X

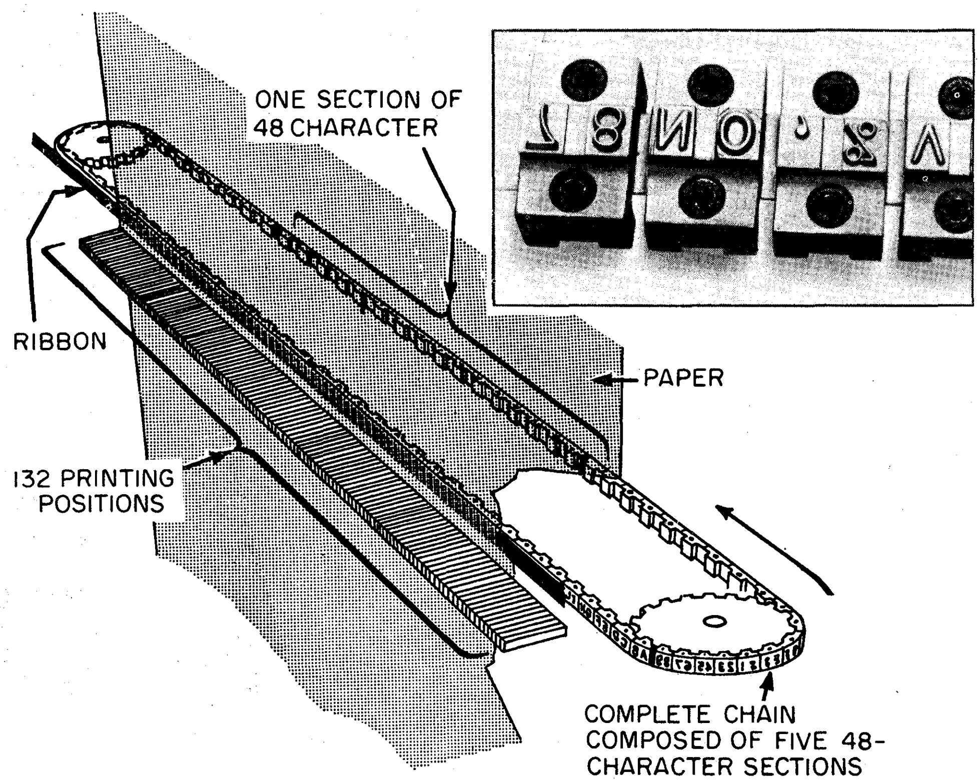
Figure 13-30. —Print Wheel.

of the information on the tape in the event a subsequent attempt is made to use the tape for recording output. If the tape librarian receives a newly created record tape bearing a file label and with the file protection device in effect, he should immediately take the necessary steps to prevent the tape from being written on.

Printers

Printing devices provide another means of outputing data from a computer. Data from the 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 DRUM, print wheel printer, 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 actuated the



49.305X

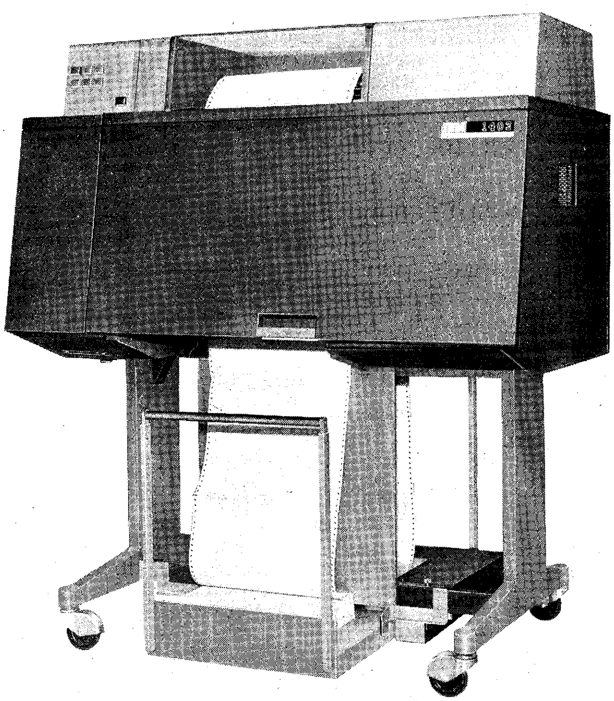
Figure 13-31. —Print chain

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 Drum.—Print drums are used with several printers manufactured by UNIVAC. Located around the print drum are 63 printable characters 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, and the print speed varies from 300 lines of alphanumeric data up to 400 lines of numeric data per minute. Printing speed is determined by the type of data being printed.

Print Wheel.—The print wheel printer prints all numeric numbers, alphabetic characters, and special characters, utilizing 120 rotary print wheels (fig. 13-30). 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 from 150 to 600 lines per minute, depending upon the type of printer.

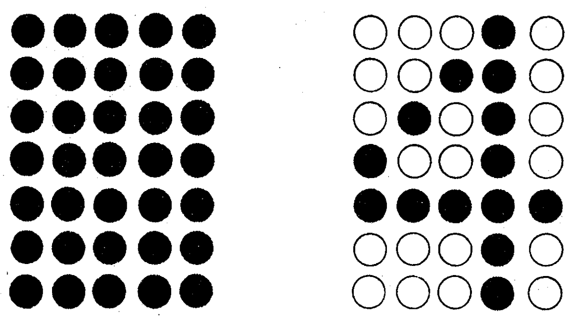


49.166X
Figure 13-32.—Type 1403 printer.

49.306X
Figure 13-33.—Typewriter.

Automatic printing and carriage spacing are under the control of the stored program.

Chain Printer.—The chain printer is an electromechanical line printer using engraved type. The information is printed from characters assembled in a chain (fig. 13-31). As the chain rotates in a horizontal path, each character to be printed is positioned opposite a magnetically actuated hammer 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 type 1403 printer shown in figure



49.307X
Figure 13-34.—Character matrix and 5 X 7 dot pattern of the numeral 4.

13-32, can print a maximum of 132 characters per line at a speed up to 1285 lines per minute. All printing and carriage spacing is determined and controlled by the stored program.

Typewriter.—A typewriter used as an output device (fig. 13-33) has a close resemblance to those used manually. The printing speed of this particular unit is 600 characters per minute. Unlike the manual typewriter, this unit is under the control of the stored program. Spacing and carriage returns are automatic.

Wire Matrix.—The wire matrix printer uses a different method of printing than the four previously described. 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. 13-34). Printing is accomplished 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 depends upon the printer. Speeds of 500 or 1000 lines (of 120 characters per line) per minute may be attained.

ADDRESS - An identification, represented by a name, label, or number, for a register or location in storage. Addresses are also a part of an instruction along with commands, tags, and other symbols. The part of an instruction which specifies an operand for the instruction.

BLOCKING - The combining of two or more records into one block.

CARD PUNCH - A machine which punches cards in designated locations to store data.

CARD READER - A device which can interpret the holes that have been punched by the card punch.

CARD READER-PUNCH - A machine that houses the facilities for reading and punching card data.

CHAIN PRINTER - A device that uses a horizontally rotating chain to print information.

CHARACTER MATRIX - An electronic storage device that holds the 0 and 1 bit segments of a character.

CHARACTER READER - A device which may operate optically or magnetically to convert data from one language to another.

COLUMN BINARY CODE - A code used with punch cards in which successive bits are represented by the presence or absence of punches on contiguous positions in successive columns as opposed to rows.

CONSOLE - A portion of the computer which may be used to manually control the machine, correct errors, determine the status of machine circuits, registers, and counters, determine the contents of storage and manually revise the contents of storage.

DATA FIELD - A specified area in a record. The term is generally used in connection with the designation of a specific area for the placing of certain items of information; for example assignment of the beginning of a record as the data field that will contain the name and service number.

DATA WORD - A word which may be primarily regarded as part of the information manipulated by a given program. A data word may be used to modify a program instruction or may be arithmetically combined with other data words.

DENSITY - The number of bits that can be stored per inch.

FIELD - Synonymous with data field.

FILE PROTECTION DEVICE - A device or method which prevents accidental erasure of operative data on magnetic tape reels.

FIXED LENGTH RECORD - A record whose number of characters is fixed.

GROUPED RECORDS - A combination of two or more records into one block of information on tape.

HYPERTAPE - A ten track magnetic tape.

INTER-RECORD GAP - An interval of space or time between recorded portions of data or records. Such spacing is used to prevent errors through loss of data or overwriting, and permits tape start-stop operations.

MAGNETIC CHARACTER READER - A device that can convert data represented in a form that is readable by human beings directly into machine language.

MAGNETIC INK CHARACTERS - Characters which are printed with special magnetic ink that can be interpreted by a character reader.

MAGNETIC TAPE - A tape or ribbon of any material impregnated or coated with magnetic or other material on which information may be placed in the form of magnetized spots.

MAGNETIC TAPE UNIT - A mechanism which handles magnetic tape and usually consists of a tape transport, reading or sensing and writing or recording heads, and associated electrical and electronic equipment.

OPTICAL CHARACTER READER - Synonymous with magnetic character reader.

PAPER TAPE - A strip of paper capable of storing or recording information and being read.

PAPER TAPE READER - A device capable of interpreting the holes punched in paper tape.

PAPER TAPE PUNCH - A device capable of recording, in the form of holes, the data recorded in paper tape.

PHASE ENCODING - A method of checking data using a flux change for both bits and no bits.

PRINT WHEEL PRINTER - A printing device that uses rotary print wheels. Each print wheel contains all printable characters for that specific printer, and the printer has one print wheel for each print position.

READ-WRITE HEAD - A small electromagnet used for reading, recording, or erasing polarized spots, which represent information.

READING GAP - The space between the reading head and the recording medium.

RECORD - A group of related facts or fields of information treated as a unit.

RECORD MARK - A special character used in some computers either to limit the number of characters in a data transfer or to separate blocked or grouped records in tape.

ROW BINARY CODE - A code used with punch cards in which successive bits are represented by the presence or absence of punches on contiguous positions in successive rows as opposed to columns.

TAPE MARK - The special character that is written on tape to signify the physical end of the recording on tape.

UNIT RECORD - A separate record that is similar in form and content to other records.

VARIABLE LENGTH RECORD - A record whose number of character is not fixed.

WIRE MATRIX PRINTER - A printing device that prints character-like configurations of dots through the proper selection of wire-ends from a matrix of wire-ends.

WRITING GAP - The space between the writing (recording) head and the recording medium.

CHAPTER 14

PROCESSING DATA

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 (internal storage) 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 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 this chapter we will describe data storage devices and their functions, we will show how the components of the central processing unit work during the execution of a program, and, finally, we will define in more detail what a program is and identify several methods of executing a program.

DATA STORAGE

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.

Access 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 in use today are MAGNETIC CORE, MAGNETIC DRUM, MAGNETIC DISK, and THIN FILM. 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 many tiny rings, or CORES, made of magnetic material. Normally, four wires pass through each core: two MAGNETIZING wires placed at right angles to each other for magnetizing a core in one direction or the other, a SENSE wire for sensing the magnetic state of the core, and an INHIBIT wire which ensures that the core remains in its original magnetic state after its contents have been read.

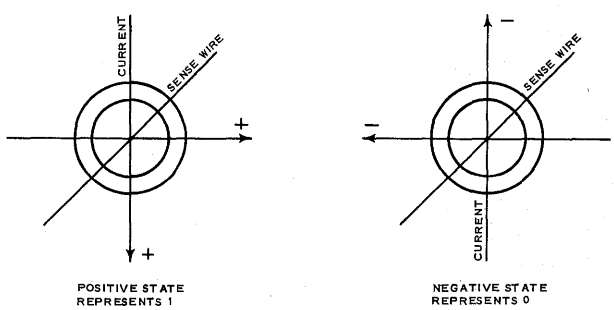
Every magnetic field has polarity. This can be demonstrated by the common horseshoe shaped magnets, which attract each other when turned one way, and repel each other when turned the other way. Similarly, a magnetic core has a magnetic field, and its polarity can be reversed by changing the direction of electrical current passing through the magnetizing wires. By sending the current through the wires in one direction, and then reversing the current flow, two magnetic states can be established. These magnetic states represent the binary digits 0 and 1, or NO BIT and BIT. Figure 14-1 illustrates the principle of reversing the polarity of the magnetic field in a magnetic core.

Magnetic 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 14-2 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. Core storage can be used in systems designed for either fixed or variable word lengths.

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.

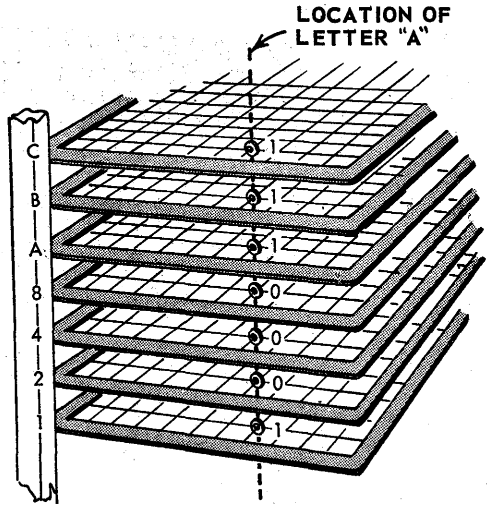
Magnetic Drum Storage.—The magnetic drum storage device consists of a rotating steel cylinder enclosed in a copper surface capable of being magnetized. Magnetized spots (bits) can be placed on the surface of the drum to represent data. These bits are placed in a series of parallel tracks running around the drum, as shown in figure 14-3. The seven bits forming one binary coded character are normally placed in seven adjacent, parallel tracks, and all seven bits are put onto or read off the drum simultaneously.

In drum storage, characters are usually grouped together in words which has the



49.167

Figure 14-1.—Reversing a magnetic core.



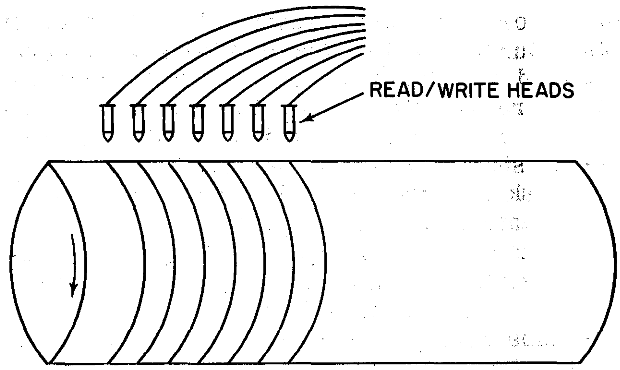
49.168X
Figure 14-2.—Representing a character in core storage.

possibility of being 200 characters in length. Each word has a specific location on the drum, thus allowing for storing on or reading from any desired portion of the drum surface.

Information is read from a magnetic drum by the sensing of magnetized spots on the drum surface by the read-write heads while the drum is rotating. Information is written on the drum by electrical impulses emitted from the read-write heads. Neither reading nor writing can occur until the particular location to be read or written is directly under the read-write heads. Thus, 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.—The magnetic disk storage device consists of a group of thin metal disks, similar in appearance to phonograph records. Each disk is coated on both sides with a material capable of being magnetized. The arrangement of the disks may vary from one disk storage device to another.

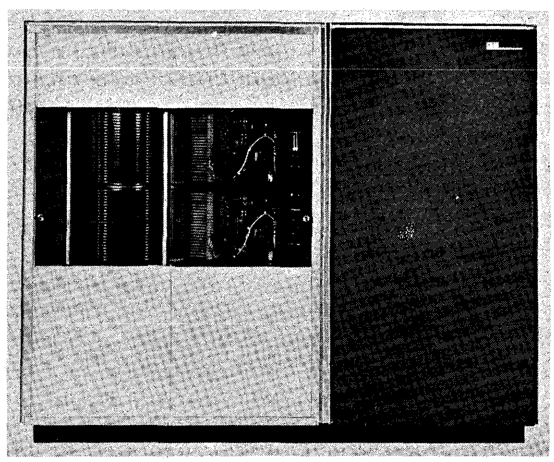
One disk arrangement, (fig. 14-4) has the disks mounted on a vertical shaft, with each disk separated from the adjacent one. As the shaft revolves, spinning the disks, magnetized spots can be placed in tracks on both sides of the disks to represent data. One or more access



49.169
Figure 14-3.—Schematic of magnetic drum.

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 has the disks mounted side by side in a storage basket, with each disk in a vertical position. When information is to be written on or read from a disk, a transfer arm selects the proper disk and transports it to the read-write station. A read-write head, mounted on a read-write transport arm,



49.308X
Figure 14-4.—1301 Disk storage.

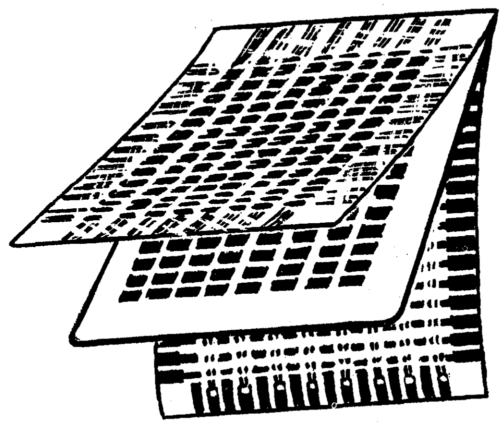
reads or writes as the disk revolves horizontally on a turntable. Reading or writing can be performed only on the upper side while the disk is at the read-write station. To read from or write on the reverse side, the disk must be returned to the storage basket and reselected.

Disk storage makes it possible to process information without having the source data in sequence. This is called RANDOM ACCESS processing (as contrasted with SEQUENTIAL or BATCH processing). For example, if a card or tape record is entered into the system as input, the stored record desired can be located without having to search through all disks. To illustrate further, 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 machine is looking for is reached.

Random 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 random access processing, only those master records affected by transactions need be read and written, thus saving considerable reading and writing time.

Thin Film Storage.—Thin film storage consists of small spots of magnetic material less than 1/16 of an inch in diameter, deposited on an insulating base, such as glass (fig. 14-5). 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 of the Univac 1107 thin film memory is 300 nanoseconds (.3 microseconds).

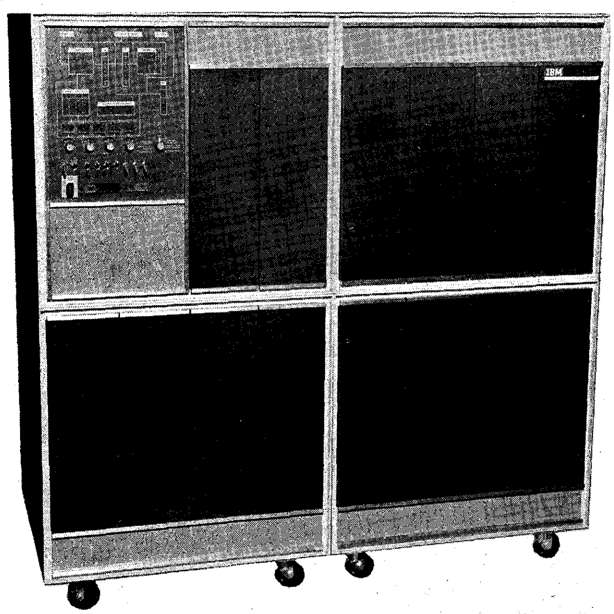
Whereas magnetic drums, disks, and tape use spots of magnetization, the magnetic material is continuous. In thin film the spots of magnetization and the spot of magnetic material are coextensive. The spots are made by evaporating the magnetic material in the presence of a magnetic field. Therefore, magnetization in the preferred direction or opposite direction can be easily made.



49.309
Figure 14-5.—Thin film memory.

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 14-6. It is in this unit that all arithmetic and



49.170X
Figure 14-6.—Type 1401 central processing unit.

logical operations are performed. From a functional standpoint, the processing unit consists of two sections; the control section and the arithmetic-logical section.

Control Section

The control section times and directs all operations called for by the instructions in the stored program. 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-logical section (fig. 14-7). Integrated 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 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

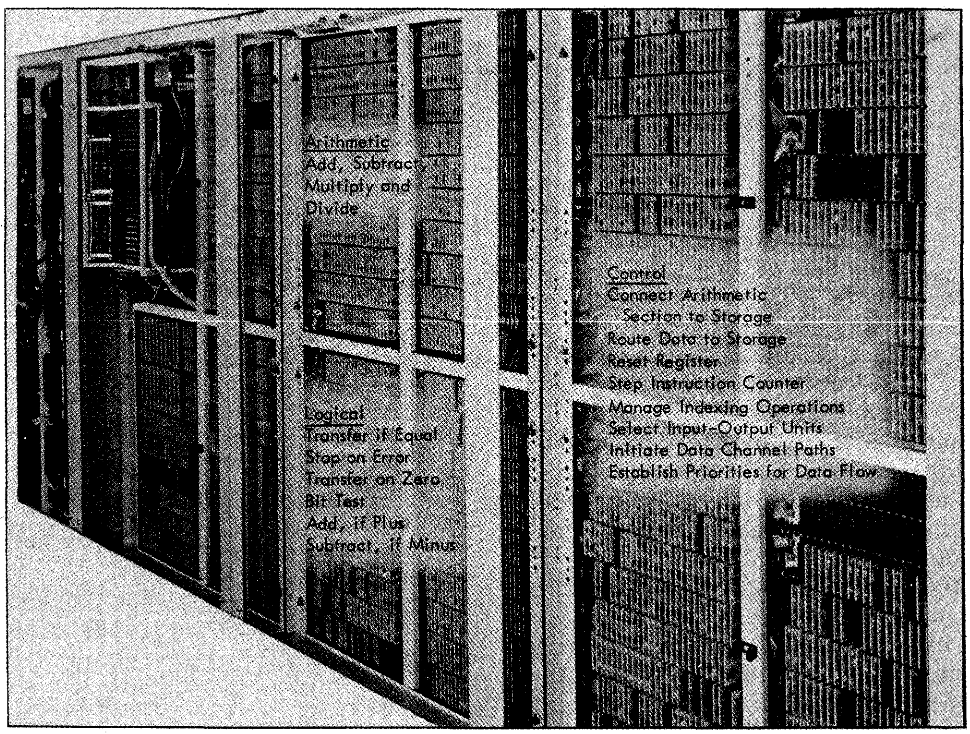


Figure 14-7.—Control and arithmetic-logical section. 49.310X

circuits. Registers are named according to their function. An accumulator is used to accumulate totals; 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 data register contains the data of the location specified in the data address. Some registers, 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 (fig. 14-8).

Counters

The counters are closely related to and usually perform the same function as a register. There is one notable difference, however; the contents of a counter can be incremented 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

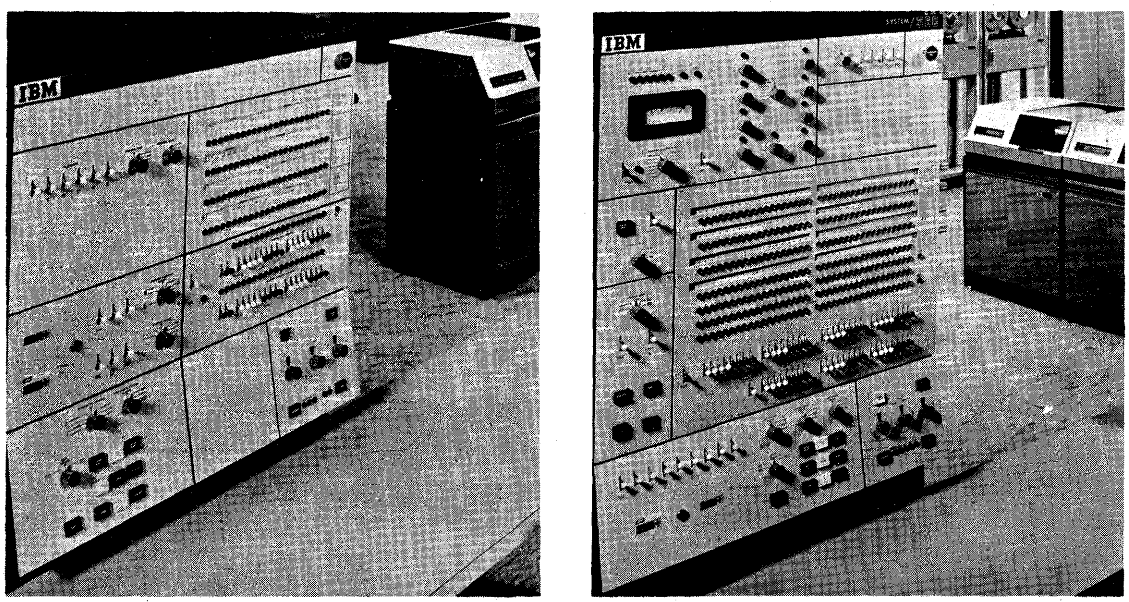
The adder receives the data from two or more sources (fig. 14-9), performs addition, and sends the answer to a receiving register. An adder acts upon one position of data at a time: the numbers in the units positions of the amount fields are brought to the adder where they are added and sent to the units position of the receiving register. Carryovers are placed in a "carry-box" for use with the next addition step. The number in the tens positions of the amount fields 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.

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 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 CODE (or OP CODE)



49.207

Figure 14-8.—Typical operator consoles control panels.

and the OPERAND. The operation code tells the machine which function to perform, such as READ, PUNCH, COMPARE, and ADD. 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 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 placed 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.

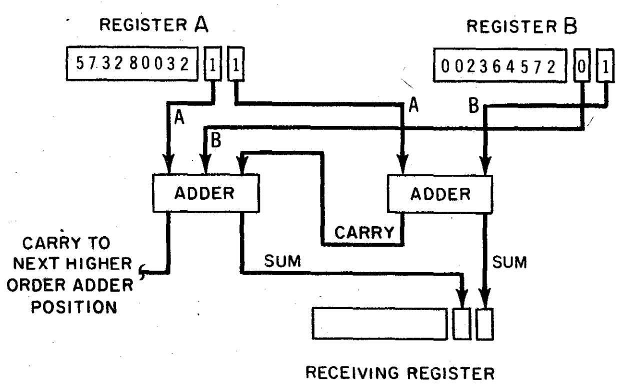
At the beginning of a program, an instruction counter is set to the address of the first program instruction. This instruction is brought from storage, and the counter automatically steps (advances) to the location of the next stored instruction, while the first instruction is being executed. The instruction 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 stops 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 14-10 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.

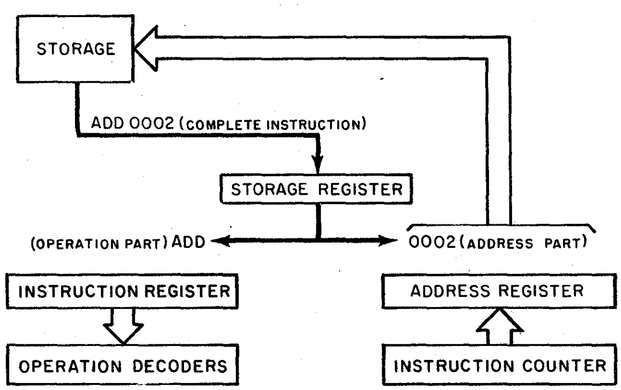
I-time begins when the address of the instruction is transferred to the address register. This instruction is selected from storage and placed in a storage register. From the storage register, the operand is routed to the address register and the operation part to the instruction register. Decoders then condition proper circuit paths to execute the instruction.

Execution

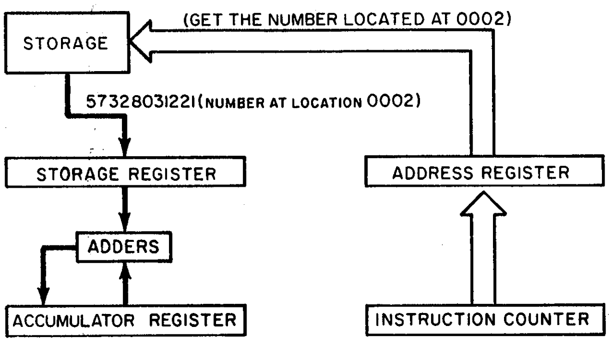
The EXECUTION TIME, or E-time, consists of one or more machine cycles normally following I-time. The instructions to be executed will determine the number of execution cycles required. Figure 14-11 illustrates the data flow following I-time as shown in figure 14-10.



49.312X
Figure 14-9.—Adders in a computer system.



49.313X
Figure 14-10.—Computer I cycle flow lines.



49.314X
Figure 14-11.—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. 14-11) 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 only a data address. 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

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. 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 random 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. Figure 14-12, depicts the idea behind both methods of processing data.

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 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.

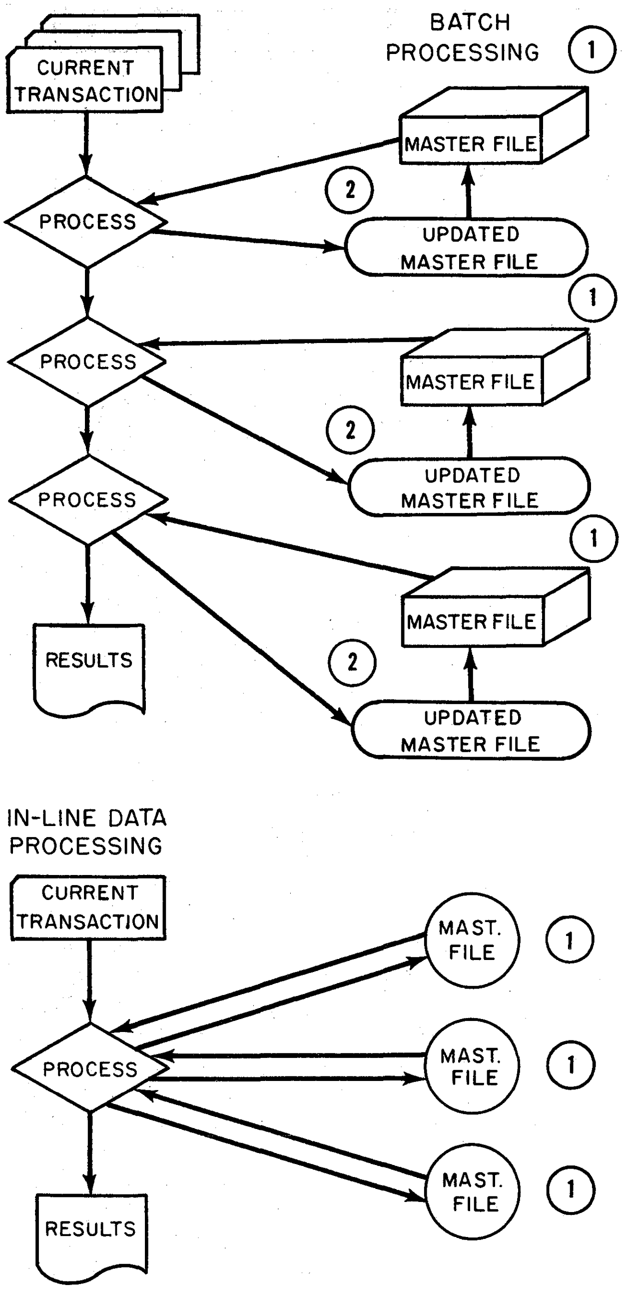


Figure 14-12.—Batch and in-line data processing.

The master file, together with the transaction file, now becomes input into the computer. One record, or a small group of records, 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 (Random access)

When processing by in-line, or random 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.

The computer accepts at random the transactions affecting the contents of the file. The computer locates the corresponding data or record in storage and adjusts the master record.

Due to the random 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 Parallel

The performance of a computer is measured, to some degree, by the method by which it performs 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, either separately or in combination and using words of either fixed or variable lengths or a combination of both. When speaking of computers, (a word is an ordered set of characters which occupies one storage location that is treated by the computer circuits as a unit and transferred as such.)

To illustrate the serial and parallel operations of a computer, let's assume that our problem deals with addition.

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 pencil and paper (fig. 14-13). To illustrate further, let's use an imaginary football squad, letting each man in the squad represent a bit. If the squad is marching in single file, it can be said to be marching in a serial-mode.

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 (fig. 14-14). To return to our football squad, if the squad marches abreast, it is in parallel-mode. Let's say that the squad is now formed in 11 ranks of 4 men each. As they march by, an observer sees 11 rows of 4 men pass in front of him; the squad is in the serial-parallel mode. If the squad is formed so that the observer sees 4 rows of 11 men pass in front of him, the squad is in parallel-serial mode.

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. 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.

	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

49.316X

Figure 14-13.—Serial addition.

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

	00564213
NUMBERS BEING ADDED	00000824
CARRY	1
FINAL RESULTS	00565037

49.317X

Figure 14-14.—Parallel addition.

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.

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 a 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 (fig. 14-15).

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 et cetera, 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

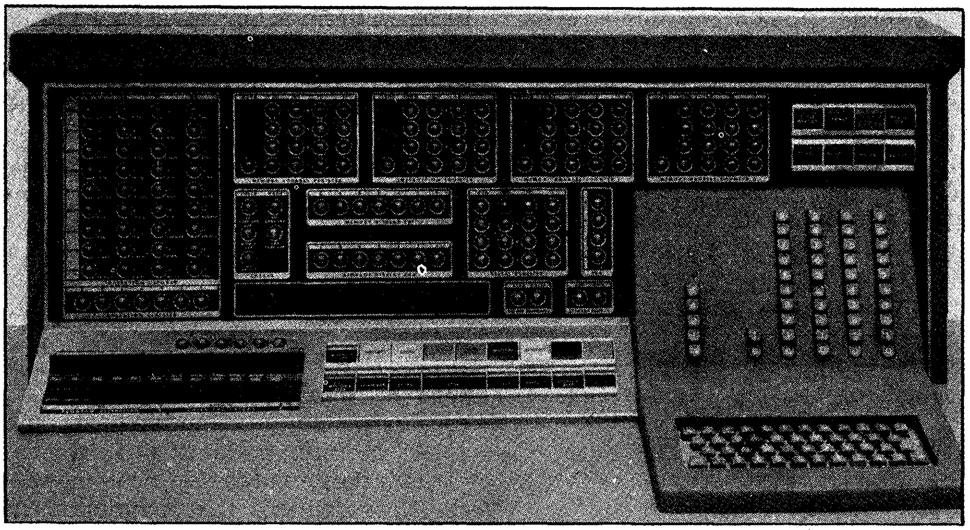


Figure 14-15.—Typical operators console.

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 mode switch can be set to allow the computer to operated 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.

ACCUMULATOR - A unit in a digital computer used for temporary storage, and for totaling (accumulating) numbers.

ADDER - A device capable of receiving two or more numbers as input and forming a sum as output.

ADDRESS REGISTER - A register that is used to store the address of the data to be operated on.

ALTERNATE INSTRUCTION - An instruction to take the place of another if certain circumstances are encountered; for example, a branching routine to change the sequence of instructions.

ARITHMETIC-LOGICAL UNIT - See arithmetic unit in chapter 2.

AUXILIARY STORAGE - A storage device in addition to the main storage of a computer. Auxiliary storage usually holds more information than the main storage, but the information is accessible less rapidly.

CENTRAL PROCESSOR - The portion of a computer system that contains the main storage, arithmetic unit, and special register groups. Synonymous with central processing unit (CPU). All portions of a computer exclusive of the input, output, peripheral, and in some instances, storage units.

CENTRAL PROCESSING UNIT - See central processor.

CONSOLE INQUIRY STATION - A remote or on-site device from which an inquiry into a data processing system can be made.

CONTROL UNIT - The portion of a computer which directs the sequence of operations, interprets the coded instructions, and initiates the proper commands to the computer circuits preparatory to execution.

COUNTER (EDP) - A device, register, or location in storage for storing numbers or number representations in a manner which permits these numbers to be increased or decreased by the value of another number, or to be changed or reset to zero or to an arbitrary value.

DATA REGISTER - A register that contains the data of the location specified in the data address.

E-TIME - The portion of an instruction cycle during which the actual work is performed or operation executed.

EXECUTE - To interpret a machine instruction and perform the indicated operation(s) on the operand(s) specified.

FIXED WORD LENGTH - Describes a machine word that always contains the same number of characters or digits.

I-TIME - The portion of an instruction cycle during which the control unit is analyzing the instruction and setting up to perform the indicated operation.

INSTRUCTIONS - (1) A set of characters which defines an operation together with one or more addresses, or no address, and which, as a unit, causes a computer to perform the operation on the indicated quantities. (2) The operation or command to be executed by a computer, together with associated addresses, tags, and indices.

INSTRUCTION COUNTER - A register in which the address of the current instruction is recorded.

INSTRUCTION REGISTER - A register in which the current instruction of the program is stored.

MAGNETIC CORE STORAGE - A storage device in which binary data are represented by the direction of magnetization in each unit of an array of magnetic material, usually in the shape of toroidal rings.

MAGNETIC DISK STORAGE - A storage device or system consisting of magnetically coated disks, on the surface of which information is stored in the form of magnetic spots arranged in a manner to represent binary data.

MAGNETIC DRUM STORAGE - The storage of data on the surface of magnetic drums.

MAGNETIC STORAGE - A device or combination of devices which utilizes the magnetic properties of materials to store information.

MEMORY - See storage.

OP CODE - The part of a computer instruction word which specifies, in coded form, the operation to be performed.

OPERAND - The part of a computer instruction word which specifies, in coded form, the address of the data the computer is to work with in carrying out the OP CODE.

PARALLEL OPERATION - The performance of several actions, usually of a similar nature, simultaneously through provision of individual similar or identical devices for each such action.

RANDOM ACCESS - The process of obtaining information from or placing information into storage where the time required for such access is independent of the location of the information most recently obtained or placed in storage. A device by which random access can be achieved without effective penalty in time.

REGISTER - A hardware device used to store a certain amount of bits or characters. A register usually is constructed of elements such as transistors or tubes and usually contains approximately one word of information.

SERIAL OPERATION - The flow of information through a computer in time sequence, using only one digit, word, line, or channel at a time.

STORAGE DEVICE - A device consisting of electronic, electrostatic, or electrical, hardware or other elements into which data may be entered or retrieved.

THIN FILM MEMORY - A storage device that is made by deposition of magnetic alloys under high vacuum in layers so thin that magnetization can be switched by rotation within time intervals of several nanoseconds.

TRANSACTION FILE - Synonymous with detail file.

VARIABLE WORD LENGTH - The property (of a machine word) of having a variable number of characters. It may be applied either to a single entry whose information content may be changed from time to time, or to a group of functionally similar entries whose corresponding components are of different lengths.

CHAPTER 15

OPERATION AND CONTROL

This chapter on electronic data processing deals with 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. 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 preparation to the final output. In addition they also provide the computer with the means of performing certain checks on itself.

YOU AS AN EDP OPERATOR

There are several areas of concern for an operator of an EDP system. In addition to being familiar with the various methods employed in controlling data and procedures, he must be thoroughly familiar with the operating procedure of a given system, as dictated by the activity.

Operating the Console

Operation of a data processing system is an important business in the Navy. 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:

1. Knowing the system's emergency power, keys, and switches.
2. Knowing the bit configuration of the particular system.
3. 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 should have the ability to:

1. Display the contents of accumulators, registers, or any particular position of storage.
2. Trace the path of data, or instructions, within the central processing unit.
3. Give the status of the system at any given moment.

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 storage can prolong the usable life of magnetic tape.

Cleaning Tapes and Containers.—Magnetic tape can be cleaned by gently wiping it with a clean, lint-free cloth, moistened with an approved tape transport cleaner. The use of carbon tetrachloride and vythene for cleaning magnetic tape should be avoided under all circumstances. A certain kind of tape, such as the IBM H-D magnetic tape, should never be cleaned with tape transport cleaner because of an interaction with tape and cleaner.

Tape containers should be inspected under an established schedule. Dust accumulation can be removed by washing the container with a common household detergent.

Handling Tape Reels.—Information is recorded on magnetic tape to within .024 of an 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. Always follow the rules and procedures as established by your activity or installation.

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 handling be exercised by all operators.

Wavy Edge.—An appearance of wavy edges on magnetic tape is normally due to two conditions; curvature is one - if a short length of tape is laid flat on a clean surface, its edge will show a slight curvature. This curvature, in 36 inches of tape, should not exceed 3/16 inch. If more than 3/16 inch the tape will tend to turn in the vacuum columns.

Improper mounting of the tape reel is another reason for a wavy edge. (See the section in chapter 13 on the loading and unloading of tapes.)

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.

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 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:

$$\Sigma(\text{qty} \times \text{cost}) + \Sigma(\text{qty} \times \text{proof cost}) = \Sigma(\text{qty} \times X)$$

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 Labels.—Tape labels usually consist of information recorded at the beginning or ending of a reel of magnetic tape 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.

As an added control, to ensure that the proper records have been processed, tape labels are read into storage at the beginning and/or end of a program. Tape 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 system 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.

Check Points 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 check point. Once a check point 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 check point is reached.

Check point 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 check point 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 check point. This may include reloading the program itself, re-setting 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 check point. Card units and printers must be manually adjusted; tape files are rewound or backspaced automatically.

The proper use of check point 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 check points).

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.

KNOW YOUR TAPE LIBRARY

Each data processing installation that utilizes magnetic tape records should have a tape library for proper control and storage of magnetic tapes. A tape librarian, as designated, is the custodian of all tape reels in the library.

As the tape librarian you should be thoroughly familiar with the procedures in maintaining a tape library. A tape library may contain a hundred reels to several thousand reels of magnetic tape. These reels contain vital records, and an adequate system of control is essential in the filing and maintenance of tape records.

Before the types of records and controls are discussed let's get an idea of the tape designations that may be assigned to tape reels. The following definitions are not considered mandatory for tape reels, but could be used in maintaining a magnetic tape library:

- Nonrecord tape—this term applies to new tapes and tapes that have been used and released for re-use.
- Record tape—this term applies to any tape containing valid data.
- Tape file—a term that applies to a body of information recorded on one or more reels of tape, identified as a specific record file or program.
- Tape serial—a term that applies to identification numbers permanently assigned to each tape on receipt from procurement. A typical nine-digit serial number may be constructed as follows:

a. First two digits—installation number.

b. Digits three through five—numeric month (two digits) and year (one digit) received.

c. Digits six through nine—tape serial number (0001--9999).

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 means for quickly locating any reel of tape in the library. Each reel should be identified with file number and reel number, since there may be more than one reel per tape file.
- Identifying the person to whom a reel or file is issued.
- Identifying scratch date expirations so that tape reels may be released for re-use. 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 Records

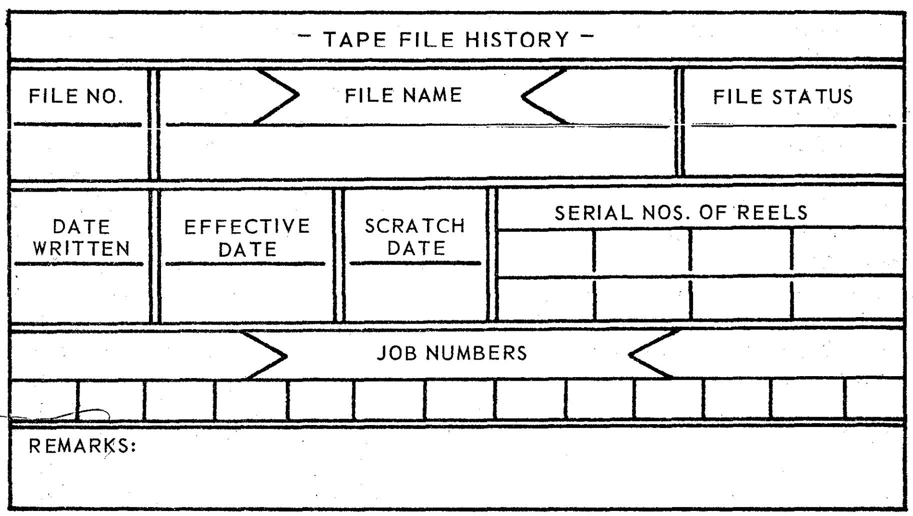
Library records for magnetic tapes may be set up in various ways, as long as they provide the proper control of all tape reels in the data processing installation. However, it must be remembered that each time the tape status changes, all records pertaining to that tape must be changed accordingly. Following are examples of records which may be used to meet these requirements.

File History.—The file history record, as shown in figure 15-1, could provide information pertinent to all tape reels within each tape file. In addition to name and file number, the following information is shown:

- Date written—pertains to the actual date the file was written.
- Effective date—this date indicates the date through which the file data are updated.
- Scratch date—indicates the date that the file reels may be re-issued as nonrecord tapes.
- Job numbers—represent the job or program numbers with which the file is used.
- Remarks—column for responses pertaining to additional information pertinent to the tape file.

Reel History.—The reel history record, as shown in figure 15-2, could provide a history of each tape reel. If required, additional pages can be used for recording usage of the tape reel throughout its life span or until a new reel history tape is created.

Tape Log.—Effective controls require knowing at all times the physical location of a given reel when it is not in the tape library. A sample tape log, shown in figure 15-3, provides this control. When a request is made for a particular reel or file, the tape librarian causes appropriate entries to be made in the log, and issues the tapes along with nonrecord tapes, as required, for creating a new or updated file. When reels are returned, the librarian notes the time of return and initials the log. In the case where nonrecord



78.32

Figure 15-1.—Sample magnetic tape file history record.

– TAPE REEL HISTORY –

SERIAL NO.	DATE RECEIVED	PRESENT LENGTH	CONDITION	PAGE NO.

FILE NO.	REEL	OF	DATE WRITTEN	SCRATCH DATE	DATE SCRATCHED

78.33

Figure 15-2.—Sample magnetic tape reel history.

– MAGNETIC TAPE LOG –

FILE NO.	SERIAL NO.	JOB NO.	TIME ISSUED	ISSUED TO	TIME RETURNED	INIT.

78.34

Figure 15-3.—Sample magnetic tape log.

tapes have been issued for creating or updating a record file, the librarian is informed of the current status of the tape when it is returned. This information pertains to:

- Applicable job and file number
- Description
- Reel number within the file
- Any other appropriate information

When this information is received the librarian ensures that appropriate entries are made in the file and reel history records, and that the reels are affixed with the appropriate labels. The librarian should also ensure that redesignations required as a result of file updating are accomplished.

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. 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 tapes is to be assured. Of the many ways that this may be accomplished, three are mentioned below.

One method of controlling available tapes for writing operations involves setting up the tape reel history records on 3'' X 5'' cards, and maintaining all cards representing record tapes in one file and all cards for scratch tapes in a separate file. Each time a record is changed from record to scratch, or from scratch to record, the corresponding card is shifted to the appropriate file.

Another method utilizes card index files, with each tape reel history recorded on a separate pocket card. Indicator tabs at the bottom of each card index could be set in one direction to indicate that the tape is a record, and in the opposite direction to indicate a scratch tape.

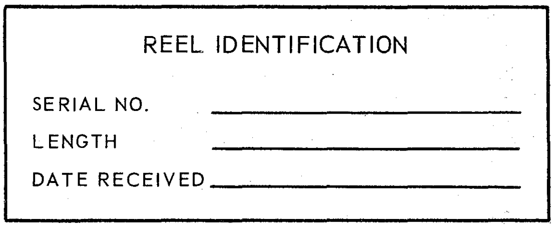
A third method is to set up a status of tapes sheet, as illustrated in figure 15-4. This sheet contains a listing of all magnetic tape reels in serial number order, and contains a number of segments across the sheet, with two blocks in each segment for indicating whether a given tape is a record (R) or scratch (S). When the tape is written, an X is placed in the next succeeding R block. Thus, a quick glance at the status sheet will indicate which tapes are available and which are in use.

External Labeling of Tapes

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.

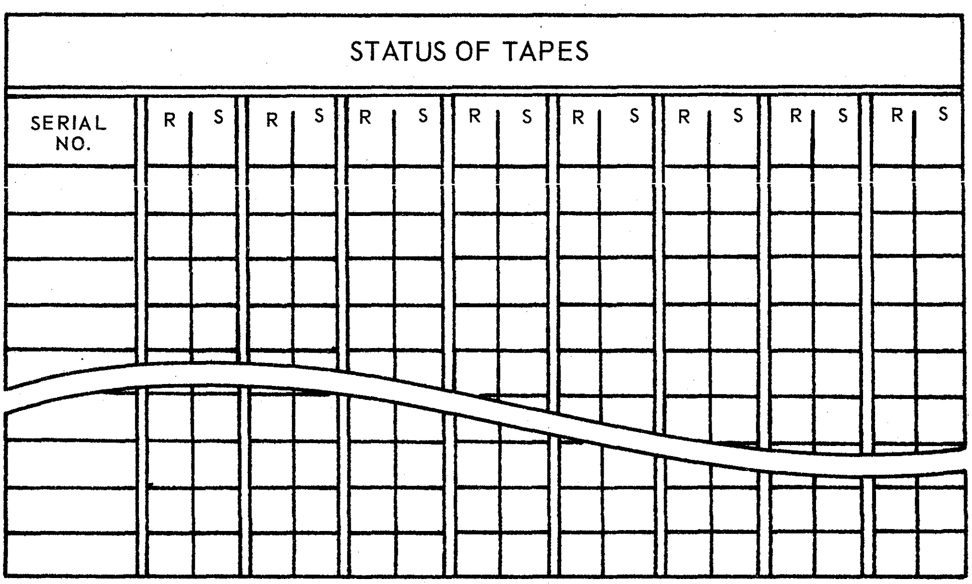
Permanent Reel Label.—The permanent reel label, in this case, is a card (fig. 15-5) inserted in a small pocket on the side of new reels. Information included on this card is: serial number of the reel, date received from manufacturer, and current length of the tape on the reel. This card is never removed from the reel.

Temporary File Labels.—The temporary file label (fig. 15-6) may be color-coded for different applications. For instance, files pertaining to



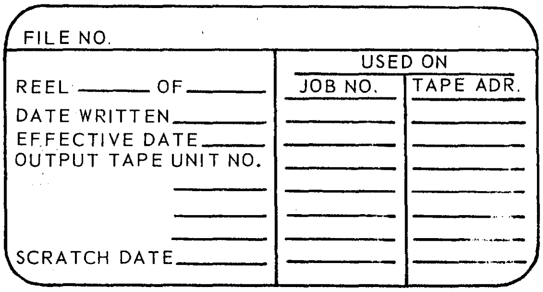
49.319

Figure 15-5.—Permanent reel label.



49.319

Figure 15-4.—Sample status of tapes sheet.



49.320
Figure 15-6.—Temporary file label.

inventory may have green labels, while payroll files may have red labels. In addition to being color-coded, labels used with certain systems, have adhesive backing that is reusable. When a file is written, the label is prepared and may be stuck on the tape unit door frame. Before any reel is unloaded from the tape unit the label is placed on the side of the real.

Information contained on these labels includes:

- Effective date—indicates the date or period to which the file pertains.
- Output tape unit number—pertains to the address of the tape unit on which the file is written.
- Scratch date—indicated the date on or after which the reel may be released for a record tape.

The number of jobs on which the tape may be used as an input, and the corresponding tape address it should have on each may be entered on the right side of the label in the spaces provided.

EDP INSTALLATION MAINTENANCE

Although every installation has certain individual maintenance procedures, some procedures are common to all, such as those concerned with cleanliness and dust prevention.

Daily Cleaning

Vacuuming is the standard method of cleaning in an operational EDPS. Vacuuming the entire room every 24 hours is recommended. To minimize the possibility of an electrical shock it is recommended that a nonconductor type nozzle be used for vacuuming under various machine components. Only a well sealed or filtered container should be used within the room. An external vacuum is preferred.

Every day the entire floor should be thoroughly cleaned with a damp mop. Under no circumstances can dry mops, dust cloths, sweeping, and such be tolerated.

Floor Waxing

Waxing should be kept to a minimum. Efficient equipment operation can be seriously jeopardized by dust resulting from the improper application of wax that tends to flake when carelessly applied. Only light applications of floor waxes should be used. The floor should be machine buffed to remove excessive amounts of wax. Finally the floor should be rebuffed, when dry, after the wax has been hardened by damp mopping. No metal abrasives, such as steel wool, should ever be used for buffing.

Smoking

Smoking is normally not permitted while operating EDP equipment. As was explained earlier, smoking is never permitted while working with magnetic tapes. However, the rules that are to be observed are normally implemented by the activity concerned.

EQUIPMENT MAINTENANCE

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. Maintenance programs are closely tied in with the operating schedule. Each should be set up so as to avoid conflict between operation and maintenance, or at least to keep such conflicts to the minimum.

AUDIT TRAIL—A system of providing a means for tracing items of data from processing step to processing step, particularly from a machine produced report or other machine output back to the original source data.

BIT CONFIGURATION—Pertains to the type of language used by the data processing system. Such as, binary BCD, or octal.

CHECKPOINT—A point in time in a machine run at which processing is momentarily halted to make a magnetic tape record of the condition of all variables of the machine run, such as the position in input and output tapes and a copy of working storage. Checkpoints are used in conjunction with a restart routine to minimize reprocessing time occasioned by functional failures.

CHECK INDICATOR—A device which displays or announces that an error has been made or that a checking operation has determined that a failure has occurred.

DATA CONTROL CHECKS—Any check designed to control data, manually or automatically, from inception to output.

FILE HISTORY RECORD—A record designed to provide all necessary information pertaining to all tape files.

LIBRARY CONTROLS—All controls designed for the efficient operation of a magnetic tape library.

NONRECORD TAPE—See scratch tape.

RECORD TAPE—A tape containing valid data contrasted to scratch tape.

REEL HISTORY RECORD—Library records designed to provide all necessary information pertaining to each individual magnetic tape reel.

RESTART PROCEDURE—To go back to a specific planned point in a routine, usually in the case of machine malfunction, for the purpose of rerunning the portion of the routine in which the error occurs.

SCRATCH DATE—The date that recorded data on magnetic tape becomes obsolete or outdated, permitting the tape to be issued as a non-record tape.

SCRATCH TAPE—A tape containing obsolete or outdated data. Contrasted to record tape.

SYSTEM CHECK—A check on the overall performance of the system, usually not made by built-in computer check circuits; control totals and record counts.

CHAPTER 16

DATA FLOW, PROGRAMMING AND DOCUMENTATION

Before any new data processing application is started, there must exist 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 procedure 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 Machine Accountant 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 entire new system. In either case he must do the following:

1. Determine what information the system should produce and in what form it is needed.
2. Analyze the types and format of input data.
3. Determine the machines required for processing, and the most effective flow of the data through the system.
4. Describe this flow by constructing a system flow chart.

The PROGRAMMER is directly concerned with the detailed steps of processing information in the computerized segment of the system. He takes the general directions described by the analyst in the system flow chart and from them develops a general program flow chart and then a detailed program flow chart which enables him to write the operating instructions in a language acceptable to the computer. This step, the preparation of computer acceptable instructions, is sometime called CODING and if a separate person does it he is called the CODER.

CHARTING DATA FLOW

When the programmer has determined the most effective way of performing the job, he must represent each step by an appropriate symbol in the general program flow chart. The programmers knowledge of the capabilities, limitations, and functions of the computer should be enough to enable him to write a program for that computer, as defined by the system flow chart developed by the analyst. Since the programmer's work depends upon his correctly interpreting the system flow chart developed by the analyst, there must exist a common language between analysts and programmers. This common language is provided by the use of graphics or a standard set of symbols in the system flow chart.

System Flow Chart

A system flow chart depicts the flow of data through all parts of a data processing system and includes the operations performed in the system and the sequence in which they are performed. Often such a chart is composed solely of symbols that represent only the form in which data appear at various stages of processing. In all instances the system flow chart can be extended to an operational flow chart to show the job steps involved in the development of information as well as the documents themselves.

Overall, system flow charts show what is to be accomplished. Here the main emphasis is on the documents involved, and secondary emphasis is on the work stations through which they pass.

Figure 16-1 illustrates the symbols used in preparing system flow charts. The explanation

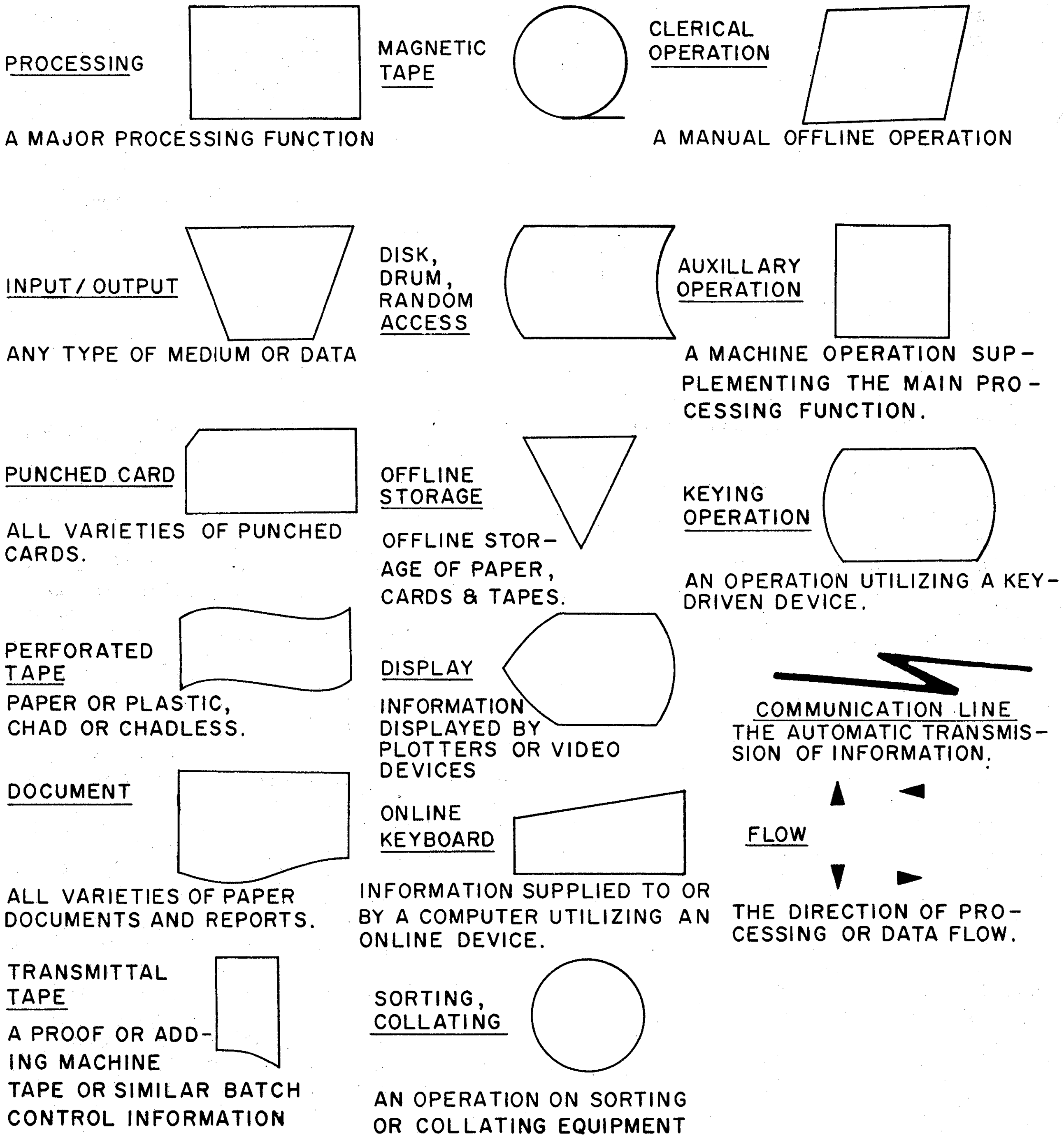


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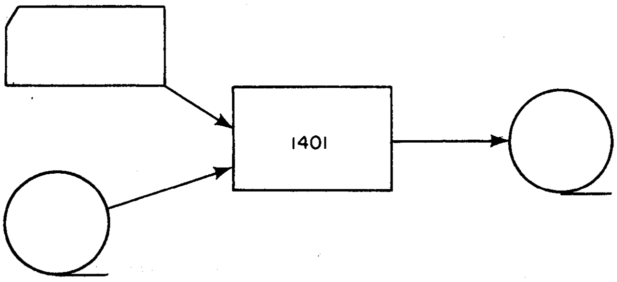
Figure 16-1.—System flow chart symbols.

with these symbols needs no clarification, except for the rectangle labeled "central processing unit." This symbol is used to represent the basic system, including main storage, the arithmetic unit, and the basic controls.

Figure 16-2 illustrates a typical flow chart for a data processing system "operation." The symbol for the CPU should be labeled with the type number to identify the system.



49.322
Figure 16-2.—Typical system flow chart.

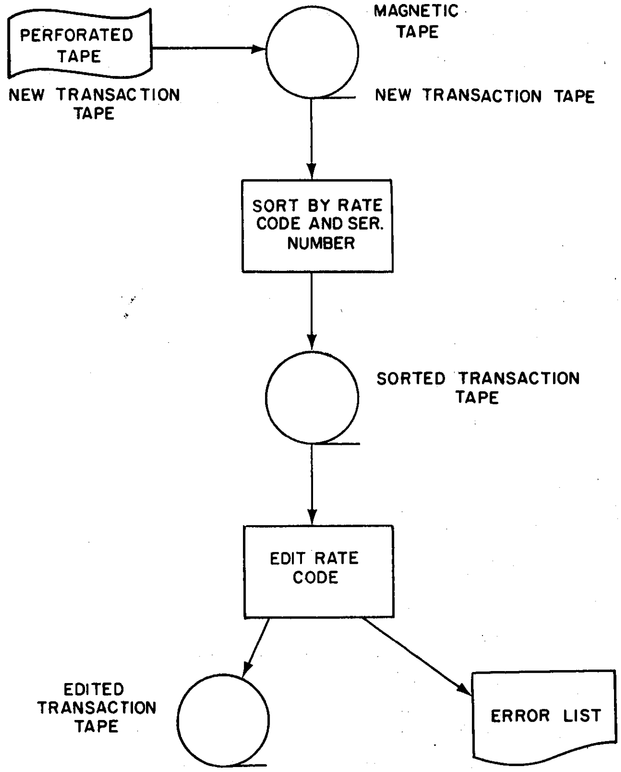
Figure 16-3 illustrates an extended system flow chart, hereafter known as an operational flow chart. Note that the "application" flow is from the top to the bottom of the page. Secondary functions are shown to one side. The operational flow chart depicts the "application" of a data processing system and serves as a guide to programming and operating. Therefore, the correct labeling of the operational flow chart is essential.

All references to flow charts in the remainder of this text will pertain to PROGRAM flow charts.

Program Flow Charts

Program flow charts are prepared utilizing the symbols illustrated in figure 16-4. These symbols depict what takes place in the stored program. In a program flow chart the emphasis is on the operations and decisions necessary to complete the specified process. The program flow chart has many important uses, one of which is to provide the programmer a means of visualizing, during the development of the program, 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 flow chart determines the amount of detail to be included in it. The primary purpose of the chart, during early stages of program development, is to experiment



49.323
Figure 16-3.—Typical operational flow chart.

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.

Of all the important uses of a program flow chart, the three most important are: as an aid to program development, as a guide to coding, and as documentation of a program.

General Program Flow Chart.—A general program flow chart depicts the major steps required during a data processing application and shows what is to be done without regard to the specifics of how it is to be done. It presents the best logical solution to the problem, using the information provided, and indicates the processing thereof. It is in no way restricted by specific machine limitations or characteristics. It is developed as an aid to understanding the problem, and supplements the detailed specifications. The general program flow chart provides the basis for developing detailed program flow charts.

Detailed Program Flow Chart.—Detailed program flow charts are an extension of a general

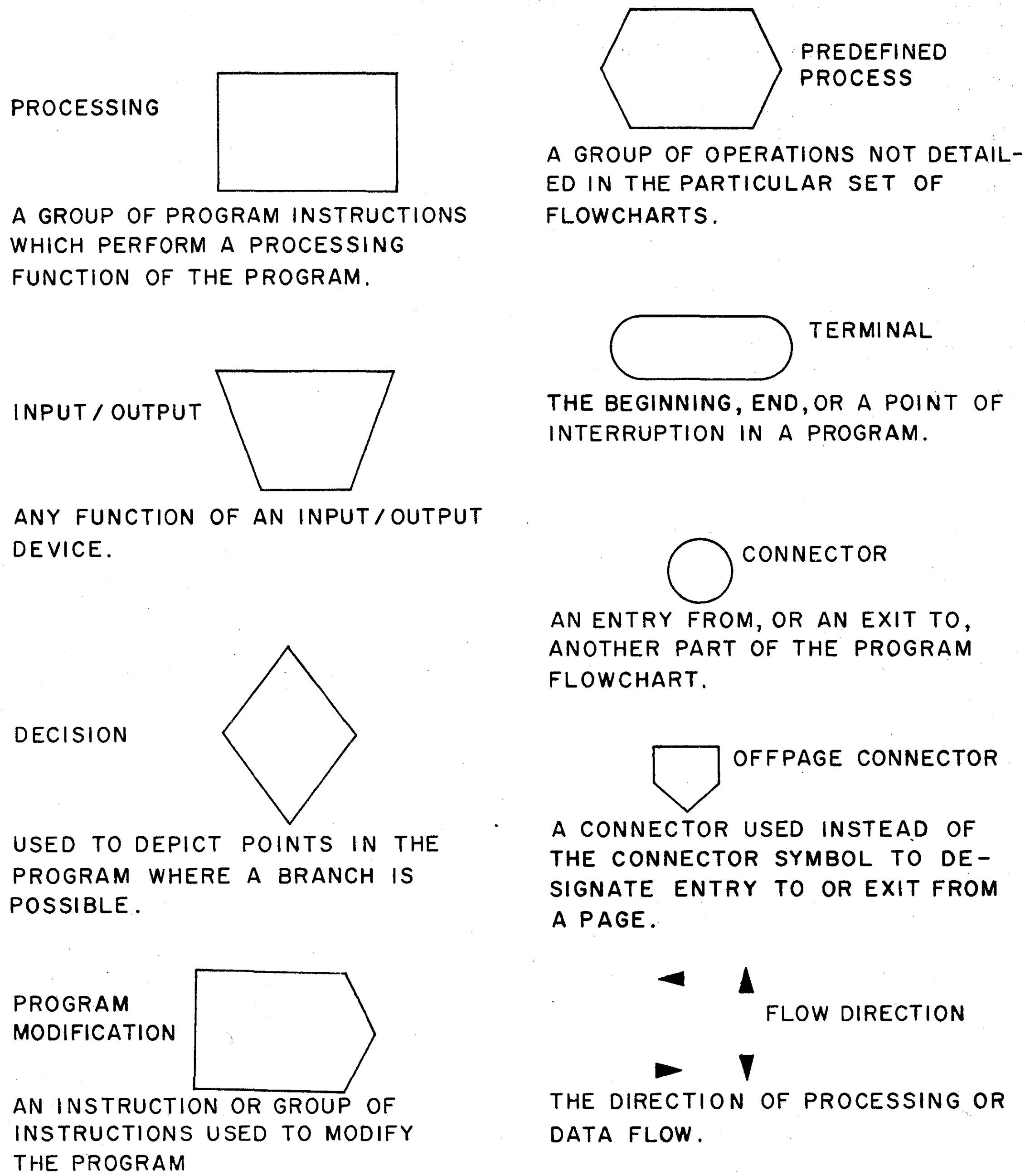


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Figure 16-4.—Program flow chart symbols.

program flow chart, showing in detail how each major function indicated in the general program flow chart is to be accomplished. They are designed to present a detailed solution to the problem in terms of the logic, or built-in characteristics of a specific machine.

The amount of detail shown in a detailed program flow chart and the method of construction may vary from one installation to another, depending upon the scope and complexity of jobs and the particular techniques employed. The general guideline used to indicate the extent to which detailed program flow charts should be drawn is: they must be specific enough for a coder who is completely unfamiliar with the operation to write accurate machine instructions to accomplish the job. Every processing step, every decision point, and every contingency must be set down.

Standardization of flow charting and programming techniques is a desirable aspect of data processing which, has not yet been fully realized. While it is not the intent of this manual to establish a standarized procedure for developing program flow charts, the illustrations in this chapter do utilize the latest and most generally accepted flow charting symbols and techniques.

The "Common Language" of Flow Charting

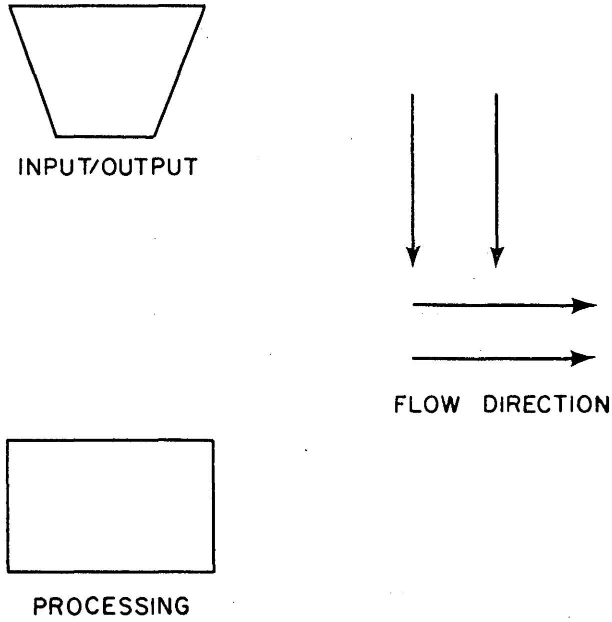
The language of flow charting is composed of many symbols. These symbols represent devices and functions, and their arrangement shows the direction of data flow. A given symbol should always portray the same general meaning wherever it appears. For example, it would not be logical to represent a COMPARE 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 flow chart, and increases the possibility of error during the preparation of machine programs.

The most standard symbols for program flow charts are shown in figure 16-4, and their functions are explained in the following paragraphs. Other symbols and variations of the symbols shown can be used as the situation requires.

Basic Symbols.—All general program flow charts may be constructed using only the basic symbols of input-output, processing and flow direction symbols (fig. 16-5).

The general direction of data flow for all flow charts should be from the top of the page to the bottom, or from left to right. The direction of data flow symbols for all flow charts is a straight line (fig. 16-5) and may or may not use arrowheads to indicate the direction of data flow. For identification purposes only, arrowheads are used in all illustrations of data flow in this chapter. In actual practice, arrowheads must be used on all lines that oppose the general direction of data flow.

In complex program flow charts an arrow should be used at any point where the direction of data flow is not immediately clear. Violation of the basic rules of the processing flow is often encountered during looping in the program—that is, repeating an instruction sequence.



49.325

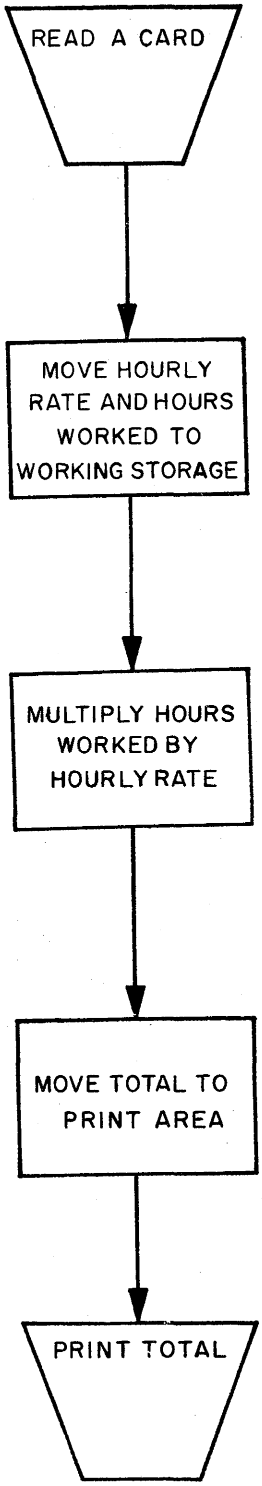
Figure 16-5.—Basic symbols.

The rules for flow charting the direction of data flow are:

1. Flow lines should not cross each other.
2. Arrowheads may be used on all lines; when used, they should be placed at the point of entry to a connector or functional symbol.

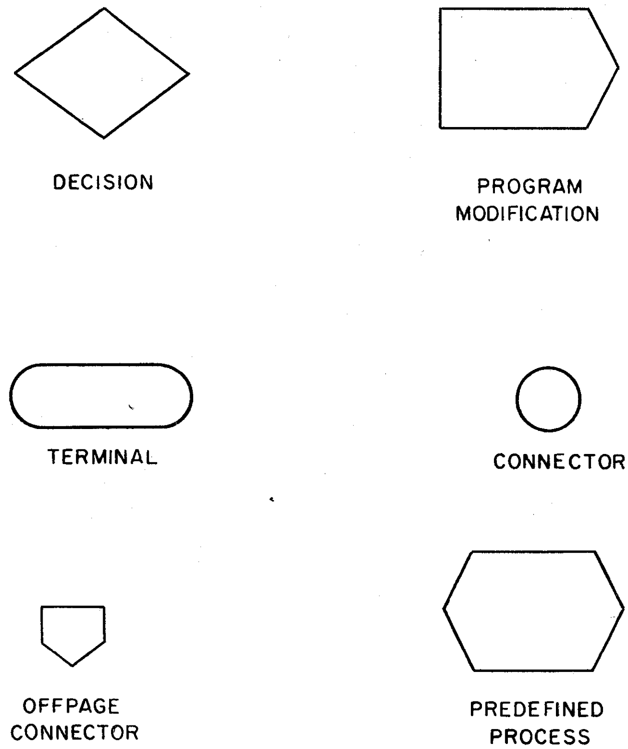
The processing symbol (see fig 16-5) for a program flow chart is defined as the symbol that represents general processing functions not represented by other symbols. In program flow charting these operations are concerned with the actual processing operations of the stored program.

The input-output symbol for a program flow chart (fig. 16-5) is used to denote any input-output (I/O) device or function. Introducing data into the central processing unit is an input function. Recording data received from the central processing unit is an output function. The I/O category includes reading, writing, rewind, backspace of magnetic tape, I/O functions of readers, printers, and punches. I/O operations involving communication between the main and random access storage units are also in this category. An example of a general program flow chart utilizing the previously mentioned symbols is illustrated in figure 16-6.



49.326
Figure 16-6.—General program flow chart using only the basic symbols.

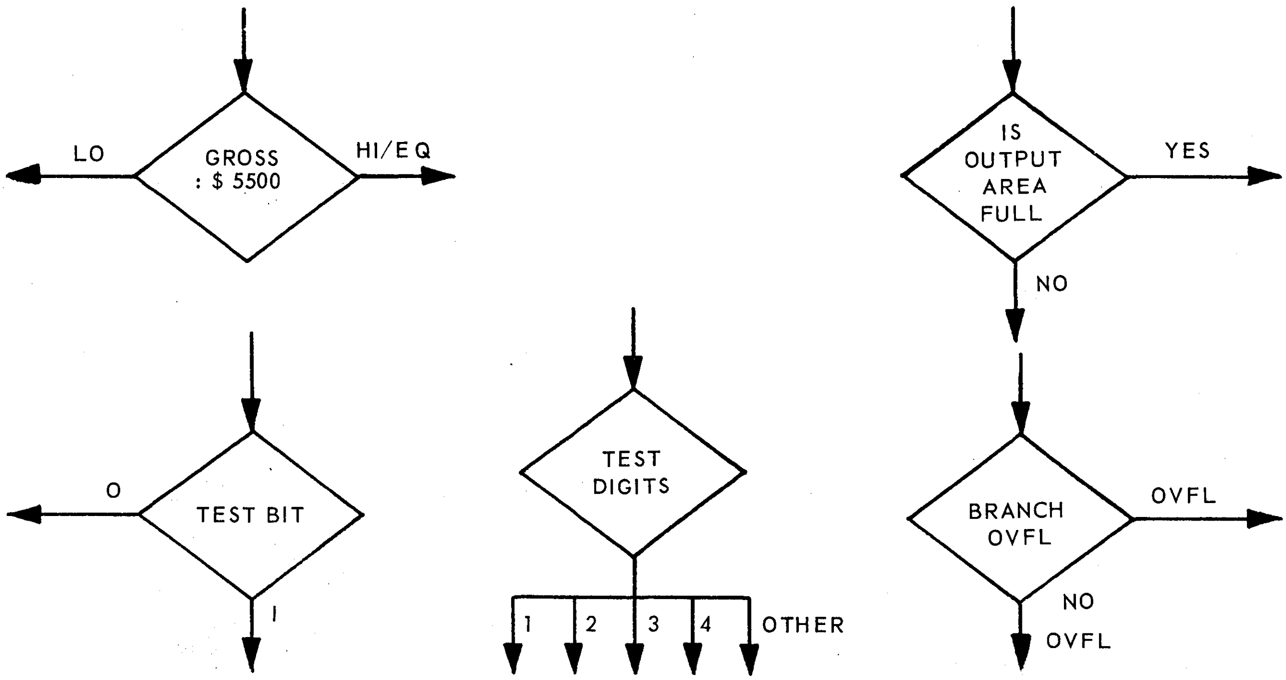
Special processing symbols.—A detailed program flow chart uses input-output and flow direction symbols in the same manner as a general program flow chart. But the basic processing symbol is replaced by the use of six special processing symbols which make a program flow chart more meaningful. These symbols are shown in figure 16-7 and explained in the following paragraphs.



49.327
Figure 16-7.—Special processing symbols.

The DECISION symbol is used to depict a point in a program at which a branch to one of two or more alternate paths is possible. The manner in which the decision is made should be indicated. There are several bases for decisions, such as: comparisons, testing of an indicator, the sign of an arithmetical operation, and many more. All possible conditions should be accounted for and the condition upon which each of the possible alternate paths is accepted should be identified (fig. 16-8).

Program modifications, as directed by an instruction or group of instructions, are indicated by the PROGRAM MODIFICATION symbol (fig. 16-7). This symbol is used to indicate



ENLISH STATEMENT	SHORTHAND STATEMENT
COMPARE A WITH B (WHERE B IS THE COMMON FACTOR OR CONSTANT VALUE)	A : B
A IS GREATER THAN B	A > B
A IS LESS THAN B	A < B
A IS EQUAL TO B	A = B
A IS NOT GREATER THAN B	A ≤ B
A IS NOT LESS THAN B	A ≥ B
A IS NOT EQUAL TO B	A ≠ B
COMPARE INDICATOR SETTINGS	HI LO EQ
CHECK INDICATOR SETTINGS	ON OFF

49.328

Figure 16-8.—Examples of decision techniques.

address changes, op code changes, index register changes, setting and clearing of word marks, and initializing (resetting to zero or other starting values). The purpose for all modifications should be indicated by the text inside the symbol.

Any point at which a program originates or terminates should be indicated by a TERMINAL symbol. That is, at the beginning or ending of a job, or at a programmed halt.

The CONNECTOR symbol is used to indicate a continued flow process when the flow lines are precluded by the limitations of the flow chart. The entries and exits are represented by a set of two connector symbols. Connector identification should be placed within the symbol.

The OFFPAGE CONNECTOR symbol serves the same purpose as the connector symbol, but as the name implies, it serves as reference points for exits from one page to the entry of another. The point of the offpage connector should be placed so as to indicate the direction of flow. Connector identification should be placed within the symbol.

A group of operations not detailed on the particular flow chart being used is depicted by the PREDEFINED PROCESS symbol. An example of its use would be to indicate the use of a library subroutine.

An example of a detailed program flow chart utilizing the above mentioned symbol(s) is shown in figure 16-9.

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.

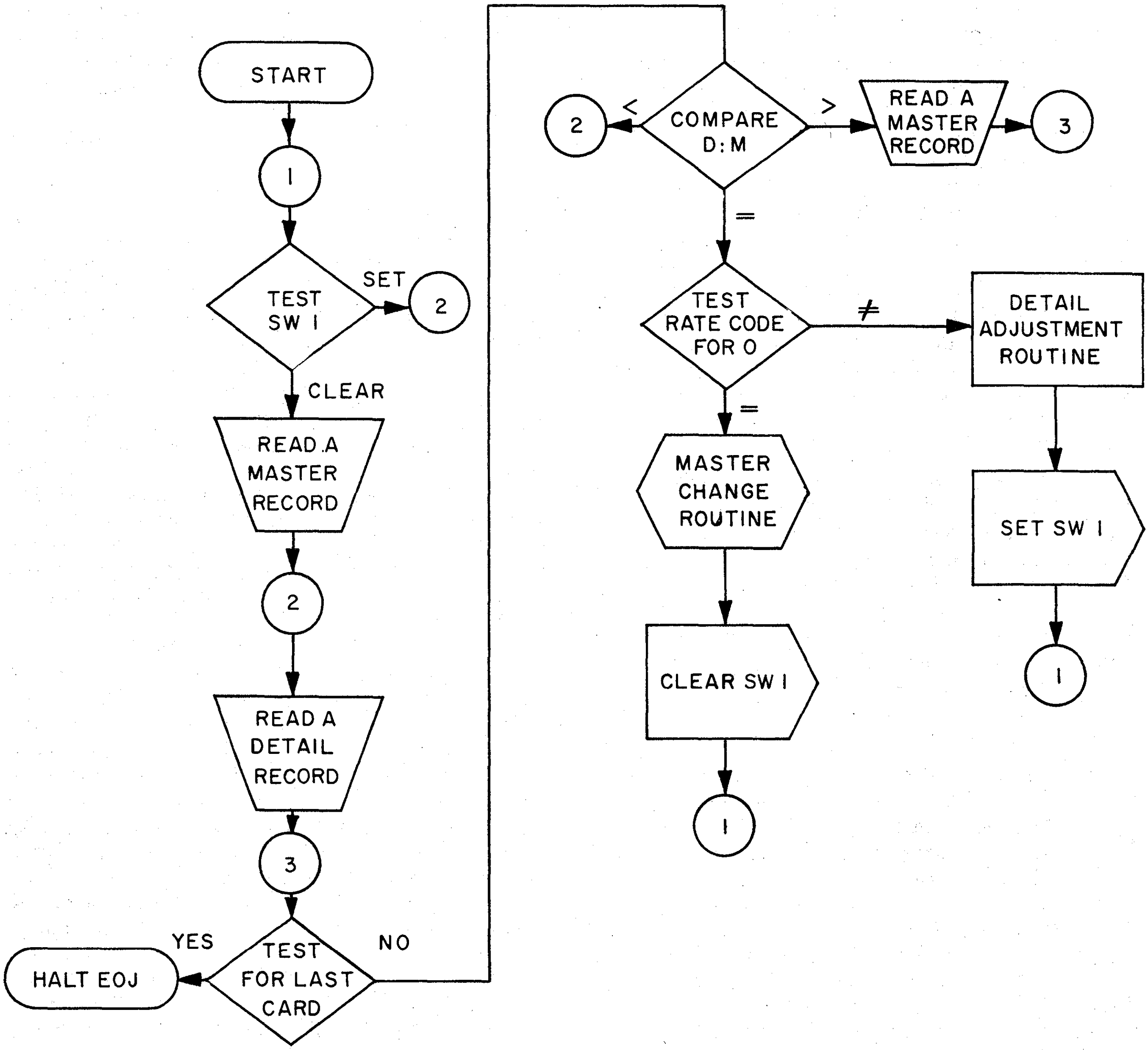


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Figure 16-9.—Typical detailed program flow chart.

Program Development

To develop a program requires more than just developing the flow charts. 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. Completeness of detail is of utmost importance here 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 principal 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.
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 card files.
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 control punches or dates.
4. The disposition of punched output.

Specifications for magnetic tape output should be essentially 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:
    a. Heading and identifying information to be printed.
    b. Horizontal placement of data, and vertical line spacing (single, double, or other).
    c. First and last printing lines and overflow data to be printed.
    d. 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.
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

A computer must be commanded to carry out a data processing function. 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. The commands are in the form of instructions, which 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, 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 16-10 illustrates a typical storage assignment specified by wired circuitry; all unassigned storage is termed working storage.

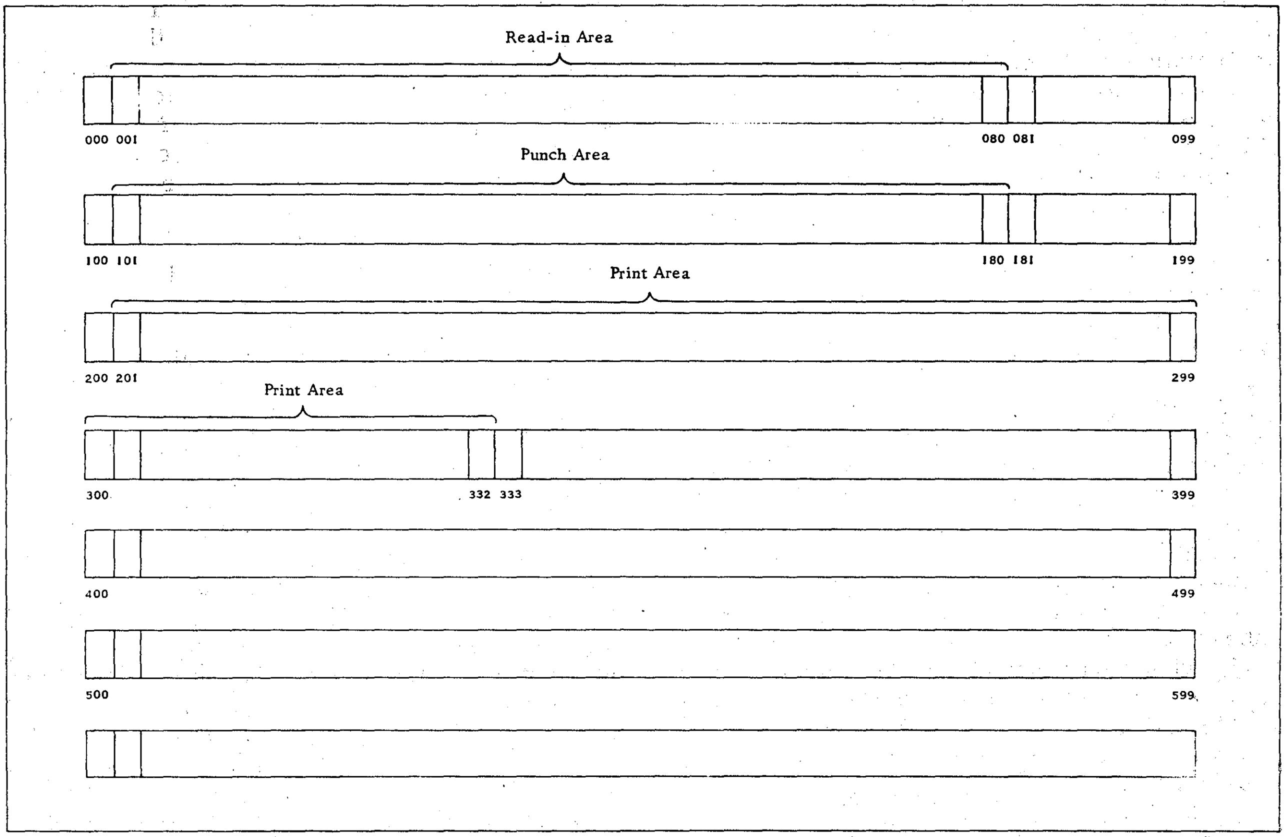

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Figure 16-10.—Example of internal storage areas for IBM 1401.

To illustrate the purpose of data movement instructions, let us examine the chart illustrated in figure 16-10 a little more closely. When a card is read, the 80 columns of card data are automatically placed in storage positions 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 or 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 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 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, zero, or non-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 HOUSEKEEPING 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. 16-11).

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.

OP CODE	A/I ADDRESS			B ADDRESS			DIGIT MODIFIER
X	X	X	X	X	X	X	X

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Figure 16-11.—Instruction format.

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 the 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. However, they must be stored in an area which will not be used for data storage during the processing routine, since data and instructions cannot be stored in the same location at the same time.

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 may 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. 16-12). 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.

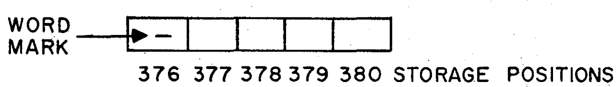

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Figure 16-12.—Word mark identification.

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. 16-13) represent an instruction, the address of the field is 376. Included as part of the instruction are the remaining positions through 380.

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, (fig. 16-13) 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.

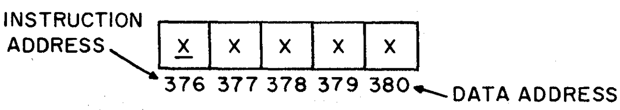

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Figure 16-13.—Identifying the instruction and data address.

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 16-14. Two types of registers are shown in this illustration: an instruction address register, and an instruction register.

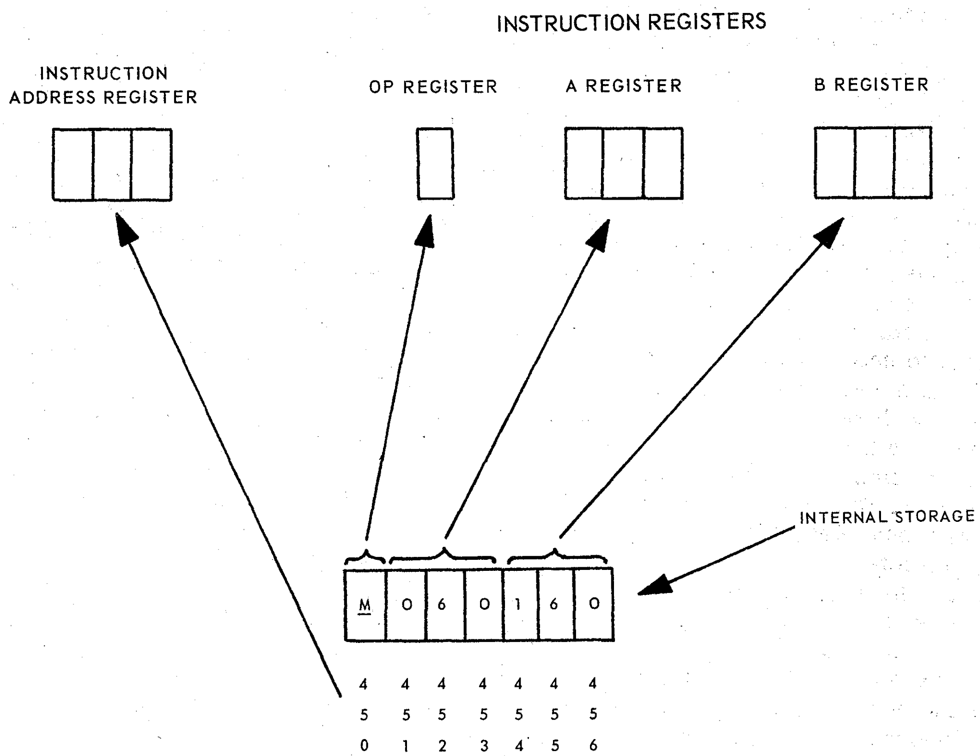

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Figure 16-14.—Storing an instruction in registers.

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.

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: "M 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 M 060 160 is read; M 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: M060160M050150M040140M030-130M020120. 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 M060160MMMM, and 24 positions of storage can be saved.

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 appriate.
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 printouts, 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 verified 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.

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 general program flowchart for the subroutine just mentioned is illustrated in figure 16-15. In the majority of cases, perhaps even in all cases, each record will be read correctly throughout an entire data processing

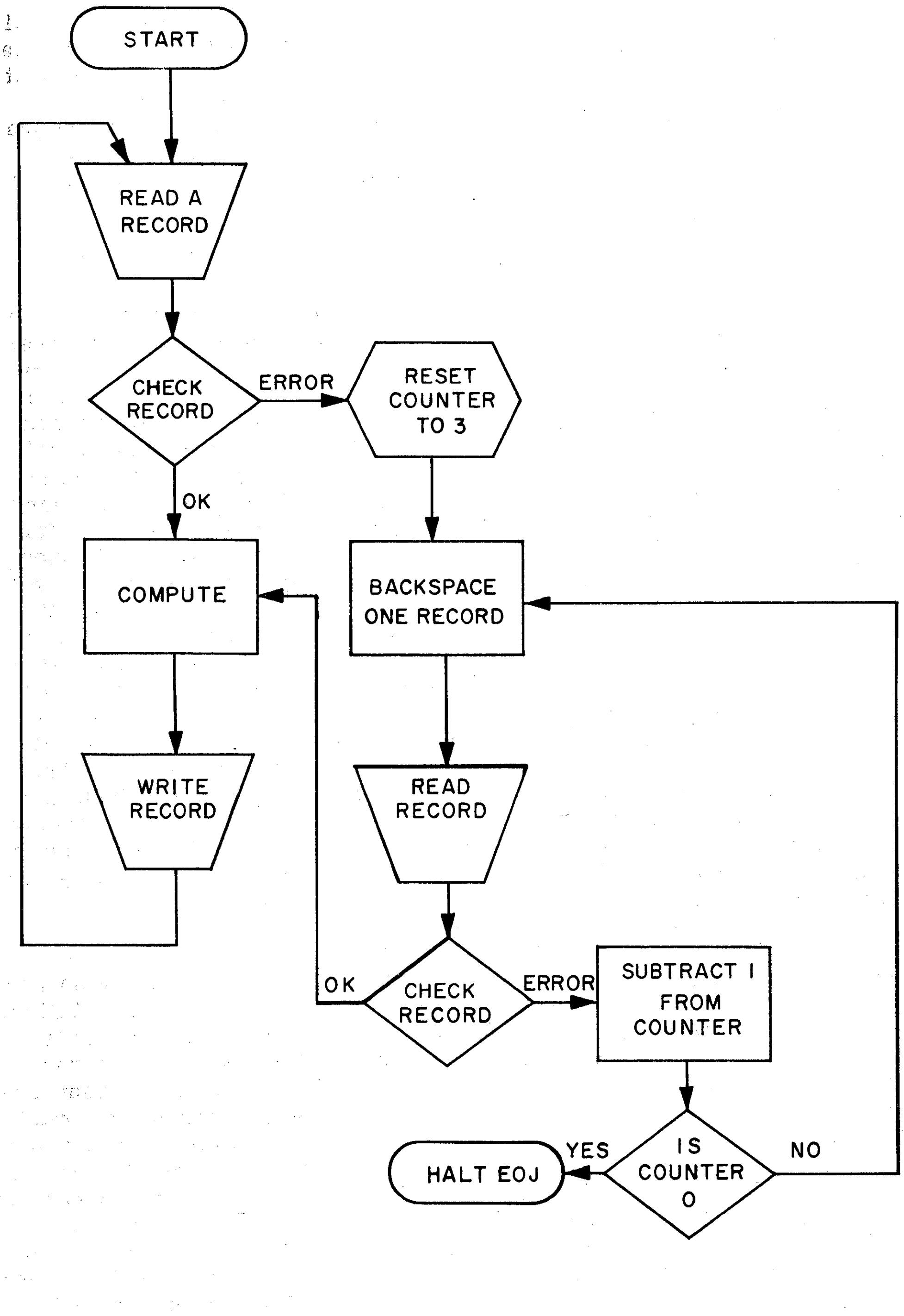

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Figure 16-15.—Typical subroutine.

application. Thus, the 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 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.

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 Language

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 Programming.—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 assignment 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.

Procedure-machine Oriented.—A programming system's language may be either procedure or machine oriented. The type of data processing system in use usually determines what type of language is to be used. Procedure-oriented language closely approximates the everyday language of the user and is independent of the computer; it can be translated into a number of different machine languages by using appropriate processors. If machine-oriented, the language generally relates to one specific data processing system.

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 stroage, 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.

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.

SPS.—The symbolic 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 scienfific 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 availability, 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 programed 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 placed in production, and description of all changes made.

ADDRESS - Usually used to identify a data field location from which data are to be extracted.

ASSEMBLE - To integrate subroutines that are supplied, selected, or generated into the main routine by means of present parameters, by adapting, or changing relative and symbolic addresses to absolute form, or by placing them in storage.

ASSEMBLER - A computer program which operates on symbolic input data to produce machine instructions by carrying out such functions as: translation of symbolic operation codes into computer operating instructions; assigning locations in storage for successive instructions; or computation of absolute addresses from symbolic addresses. An assembler generally translates input symbolic codes into machine instructions item for item, and instructions or constants as were defined in the symbolic input codes.

ASSEMBLY PROGRAM - Same as assembler

ADDRESS - Usually used to identify a data field location to which data are to be sent.

CHAINING INSTRUCTIONS - Any series of instructions linked together.

CLOSED SUBROUTINE - A subroutine not stored in the main path of the routine. Such a subroutine is entered by a branch operation, and provision is made to return control to the main routine at the end of the operation. The instructions related to the entry and reentry function constitute a linkage.

COBOL - A specific language by which business data processing procedures may be precisely described in a standard form. The language is intended not only as a means for directly presenting any business program to any suitable computer, for which a compiler exists, but also as a means of communicating such procedures among individuals.

COMPILE - To produce a machine language routine from a routine written in source language by selecting appropriate subroutines from a subroutine library, as directed by the instructions or other symbols of the original routine supplying the linkage which combines the subroutines into a workable routine and translating the subroutines and linkage into machine language. The compiled routine is then ready to be loaded into storage and run.

COMPILER - A computer program more powerful than an assembler. In addition to its translating function, which is generally the the same process as that used in an assembler, it is able to replace certain items of input with series of instructions, usually called subroutines. Thus, where an assembler translates item for item and produces as output the same number of instructions or constants as were put into it, a compiler will do more. The program which results from compiling is a translated and expanded version of the original.

CONSTANTS - The quantities or messages which will be present in the machine and available as data for the program and which, usually, are not subject to change with time.

DATA FLOW - The sequence of an application execution, as symbolized on a flow chart.

DEBUG - (1) To locate and correct any errors in a computer program. (2) To detect and correct malfunctions in the computer itself.

DECISION - The computer operation of determining if a certain relationship exists between words in storage or registers, and taking alternative courses of action.

DECISION, LOGICAL - The choice, or ability to choose, between alternatives. Basically, this amounts to an ability to answer yes or no with respect to certain fundamental questions involving equality and relative magnitude.

DETAIL PROGRAM FLOW CHART - An extension of a general program flow chart. Should be in enough detail to allow a coder to write all necessary instructions without guidance.

DOCUMENTATION - The group of techniques necessary for the orderly presentation, organization, and communication of recorded specialized knowledge, in order to maintain a complete record of reasons for changes in variables. Documentation is necessary not so much to give maximum utility as to give an unquestionable historical reference record.

FLOWLINES - Lines on a flow chart that may, or may not, use arrowheads to indicate the sequence of operations.

FORTRAN - A programming language designed for problems which can be expressed in algebraic notation.

GENERAL PROGRAM FLOWCHART - A flowchart, prepared by a programmer, that depicts, the major steps of a data processing application and presents the best logical solution to the problem.

GROUP MARK - A special charcter used to designate the end of a record in storge for a write instruction.

HOUSEKEEPING ROUTINE - The initial instructions in a program which usually are executed only one time.

I ADDRESS - Usually used to identify an instruction location from which an instruction is to be extracted.

I/O FUNCTION - Any function pertaining to input or output.

INDEX REGISTER - A register that contains a quantity which may be used to modify addresses.

INSTRUCTION FORMAT - The breakdown of an instruction such as, OP register, A register, B register.

INTERRUPT ROUTINE - A routine used to disrupt temporarily the normal operation of a routine by a special signal from the computer. Usually, the normal operation can be resumed from that point at a later time.

JUMP - Synonymous with branch (see Chapter 14).

LABEL - A set of symbols used to identify or describe an item, record, message, or file. Occasionally it may be the same as the address in storage.

LANGUAGE - A system for representing and communicating information or data between people, or between people and machines. Such a system consists of a carefully defined set of characters and rules for combining them into larger units, such as words or expressions, and rules for word arrangement or usage to achieve specific meanings.

LIBRARY - (1) A collection of information available to a computer, usually on magnetic tape. (2) A file of magnetic tapes.

LIBRARY ROUTINE - A collection of standard, proven routines and subroutines by which problems and parts of problems may be solved.

LOAD - (1) To put data into a register or storage. (2) To put a magnetic tape on a tape drive, or to put cards into a card reader.

LOADING ROUTINE - A routine which, once it is itself in storage, is able to bring other information into storage from cards or tape.

LOOP - A self-contained series of instructions in which the last instruction can modify and repeat itself until a terminal condition is reached.

MACHINE-ORIENTED LANGUAGE—A language designed for interpretation and use by a machine without translation.

MACRO INSTRUCTION - (1) An instruction consisting of a sequence of micro instructions which are inserted into the object routine for performing a specific operation. (2) The more powerful instructions which combine several operations into one instruction.

MARK - A sign or symbol used to signify or indicate an event in time or space; for example, end of word or message mark, a file mark, an end of tape mark.

MNEMONIC - Pertaining to the assisting, or intending to assist, human menary; thus, a mnemonic term, usually an abbreviation that is easy to remember.

MNEMONIC OPERATION CODE - An operation code in which the names of operations are abbreviated and expressed mnemonically to facilitate remembering the operations they represent. A mnemonic code normally needs to be converted to an actual operation code by an assembler before execution by the computer.

MODIFIER - A quantity used to alter the normal interpretation and execution of an instruction; for example, an index tag or indirect address tag.

MODIFY - (1) To alter a portion of an instruction so its interpretation and execution will be other than normal. The modification may permanently change the instruction or leave it unchanged and affect only the current execution. The most frequent modification is that of the effective address through use of index registers. (2) To alter a subroutine according to a defined parameter.

OBJECT PROGRAM - A program which is the output of an automatic coding system.

OPEN SUBROUTINE - A subroutine inserted directly into the linear operational sequence, not entered by a branch. Such a subroutine must be recopied at each point that it is needed in a routine.

OPERATIONAL FLOWCHART - A flowchart prepared by the system analyst, which is merely an extension of a system flowchart.

PROBLEM DEFINITION - The art of compiling logic in the form of general flow charts and logic diagrams which clearly explain and present the problem to the programmer in such a way that all requirements involved in the run are presented.

PROCEDURE - ORIENTED LANGUAGE - A machine-independent language which describes how the process of solving the problem is to be carried out.

PROCESSOR - (1) A generic term which includes assembly, compiling, and generation; (2) A shorter term for automatic data processor or arithmetic unit.

PROGRAM DOCUMENTATION - Synonymous with documentation.

PROGRAM LANGUAGE - A language which is used by programmers to write computer routines.

ROUTINE - A set of coded instructions arranged in proper sequence to direct the computer to perform a desired operation or sequence of operations, that is, a program. Also, a subdivision of a program consisting of two or more instructions that are functionally related.

SOURCE LANGUAGE - The original form in which a program is prepared before processing by the machine.

SOURCE PROGRAM - A computer program written in a language designed for ease of expression of a class of problems or procedures by human beings. A generator, assembler, translator, or compiler routine is used to perform the mechanics of translating the source program into an object program in machine language.

STORAGE ALLOCATION - The process of reserving blocks of storage for specified blocks of information.

SUBROUTINE - A portion of a routine that causes a computer to carry out a well-defined mathematical or logical operation.

SYMBOLIC ADDRESS - A label, alphabetic or alphanumeric, used to specify a storage location in the context of a particular program. Often, programs are first written using symbolic addresses in some convenient code, which are translated into absolute (machine code) addresses by an assembly program.

SYMBOLIC CODE - A code which expresses programs in source language by referring to storage locations and machine operations by symbolic names and addresses which are independent of their hardware-determined names and addresses.

SYMBOLIC INSTRUCTION - An instruction in an assembly language directly translatable into a machine code.

SYMBOLIC NOTATION - A method of representing a storage location by one or more figures.

SYMBOLIC PROGRAMMING - The use of arbitary symbols to represent addresses in order to facilitate programming.

SYSTEMS ANALYSIS - The examination of an activity, procedure, method, technique, or a business to determine what must be accomplished and how the necessary operations may best be accomplished.

SYSTEMS ANALYST - A person skilled in the definition of and the development of techniques for the solving of a data processing problem, especially those techniques for solutions on a computer.

SYSTEMS FLOWCHART - Flowcharts prepared by the systems analyst to depict the overall picture of a data processing application.

TEST DATA - A set of data developed specifically to test the adequacy of a computer run or system. The data may be actual data that has been taken from previous operations, or artificial data created for this purpose.

TRANSLATOR - A program whose input is a sequence of statements in one language and whose output is an equivalent sequence of statements in another language.

UTILITY PROGRAM - Synonymous with utility routine.

UTILITY ROUTINE - A standard routine used to assist in the operation of the computer.

WORD MARK - An indicator to signal the beginning or ending of a word.

CHAPTER 17

COMPUTERS IN THE NAVY

Chapters 12 through 16 of this book have been devoted to a discussion of the characteristics of automatic electronic digital computers and of the documentation, particularly flow charts and programs, necessary to the operation of these computers. We have not described in detail any particular model or line but have discussed some of the basic hardware functions common to all digital computers; nor have we attempted to instruct you in how to prepare programs, but have confined ourselves to describing some of the most important characteristics of programs and how programs are used to control computer operations.

In this chapter we will describe the uses of computers in both industry and the Armed Forces and how the Navy uses computers to carry out its supply and personnel support functions.

Computer Uses

Electronic digital computers are used to execute all of the following types of application: (1) model manipulation, (2) computation, (3) file updating, and (4) report and action document preparation.

A single EDP system is rarely committed to just one of these applications, but is used to carry out combinations of applications (integrated operations). The most common combination, however, is file updating with report and action document preparation, and it is with this combination that you, as a Machine Accountant, will have the most to do. The EDP systems used by the Navy to facilitate its personnel and supply support functions are committed to the maintenance of supply and personnel files and to the preparation of reports and action documents. Before we discuss these applications, however, let us briefly consider how computer systems differ in the manner in which transactions are grouped before loading, how they differ in the time demands placed upon them, and how computers are used in model manipulation and in computation.

Solo and Batched Grouping of Transactions

Data, in the form of an individual report or transaction, may be loaded and processed immediately upon receipt, or they may be held until a certain number of reports or transactions are received and then loaded into the computer, either in the order in which they were received (time- or random-batching) or in some new order. The first grouping of transactions is called solo grouping; the second is called batched grouping.

Real Time and Delayed Time

Real time processing, according to the Bureau of the Budget Glossary, is "the processing of information or data in a sufficiently rapid manner so that results of the processing are available in time to influence the process being monitored or controlled." Data describing some aspect or aspects of an operation are transmitted to a computer, processed, and output while the operation is still going on and in time to enable the persons or equipment controlling or monitoring this operation either to modify the operation itself or to effect a response to it. Data regarding changes in the position of a satellite, for example, are entered from a radar or inertial guidance system into a computer which determines vehicle position and velocity and then gives steering commands to the control system. Similar data regarding changes in the velocity of missiles or in the path of unmanned satellites are transmitted from radar screens or from inertial guidance systems and processed by computers in time to enable monitoring personnel to take appropriate action: destruct, retaliation, etcetera.

The decision to call a computer system a real time system is sometimes based not on its ability to enable the timely control of, or response to, an operation, but on how data are grouped before they are loaded into the computer and on how fast they are input, processed, and communicated. The computer systems used in Navy supply and personnel data processing are often called real time systems because they permit immediate loading and processing of individual transactions and immediate communication of results to remote terminals.

Model Manipulation

A model describes a real process or situation in mathematical (digital and analog) language; it is a set of variable quantities and dimensions which represent the factors, functions, and relationships constituting the process or situation together with the factors, functions, and relationships constituting the set of external influences (environment) to which the process or situation is subject. A model is constructed to be used for one of two possible purposes: (1) the control of a process (automation), or (2) the analysis of a situation (operations research). For both purposes, hybrid computer systems are used. (A hybrid computer system is a computer system consisting of both analog and digital computers.)

For the control of processes, the computer system operates in real time and processes transactions solo or in order received.

For the analysis of situations, the computer system operates in delayed time and processes transactions batched.

Automation output is the physical control of the process or, more precisely, signals to equipment controlling the process. Operations research output is a series of short reports summarizing the performance of the model.

In operations research selected variables and dimensions of the model are changed and consequences described with a view to (1) aiding in the setting of objectives for a unit, (2) improving decision-making, and (3) improving the organization of the unit.

Computation

Computation is a delayed time application with batched transactions. Most computational applications involve a great deal of internal processing with little input and little output. Computation is a primary application in scientific and engineering research.

Files, Action Documents, and Reports

Information stored in a computer is organized into records which are combined to form files. When a high proportion of records in a file requires frequent updating, the file is said to be active; when little updating is required to keep the file current, the file is said to be relatively inactive.

At least four files are encountered in a file maintenance operation: first, the master file, which contains permanent data; second, the transaction or detail file which, with the master file, is input to the computer; third, the updated master file; and, fourth, the error or could-not-process file. (In a computer system using random-access storage, a master file need not be inscribed in sequence nor does a transaction file have to be sequenced before loading.)

Computers increase the ability of an information system to collect information, to detect errors in it, to store it, to combine it, to break it down, and to convert it into reports and action documents.

A report can range in form from a short response (to an unscheduled inquiry) to a lengthier scheduled summary or digest of transactions. Reports describe operations and thereby let management know if its objectives are being realized.

An action document—such as a material order document or an assignment card—is used to effect some specific prescribed action in a series of such actions leading to some change in the allocation of men, money, or materials.

Most reports are prepared from batched transactions processed in delayed time. Responses to inquiries, on the other hand, are often the output of solo-grouped transactions in real time.

In order to perform effectively as a member of a computer team, you will have to learn (1) what information is contained in the various files that are loaded for processing into the storage of the computer you are assigned to, (2) what supply, personnel, or other functions are carried out automatically by this computer, and (3) under what conditions these functions are so carried out.

AUTOMATIC DATA PROCESSING IN NAVY SUPPLY

For an organization as large, as diverse, and as wide-spread as the Navy, the problems of ordering, receiving, warehousing, shipping, and recording stock, and of doing all this efficiently, are big ones. Automatic data processing has not only helped the Navy to improve its control and accounting of the continuous movement of stock through its supply system; it has enabled the Navy to reduce the time an activity has to wait before it receives an item of stock it has requisitioned. A ship's supply officer, wanting a certain repair part, submits a requisition to the nearest supply activity. If this supply activity does not have the requested item in stock, it transmits the requisition to the appropriate inventory control point (ICP). The ICP then selects the stock point which is nearest the activity and which has this item warehoused, and transmits to that stock point a material release order. If the item is a priority item, the entire processing takes place in 2 hours.

The computers at the ICPs not only store inventory files, which must be continually updated to reflect changes in inventory due to requisitions by Navy activities and Navy purchases from civilian suppliers; the computers also store programs which enable the computers to produce regular and special reports, together with responses to inquiries, that show Navy supply managers how the supply system is performing. A weak point in the supply system can be quickly detected and quickly corrected.

Action documents to effect corrective action may be originated automatically when a special condition is reflected in the files, when another action document is input into the system, when a regular report is being compiled, or when an inquiry is made. A daily demand review, for example, may show that an item of stock at a given stock point is in short supply and result in the automatic production of a stock replenishment request or, if the item is on hand elsewhere, a redistribution order.

UNIVAC 490As are now installed at the three ICPs (SPCC Mechanicsburg, ESO Great Lakes, and ASO Philadelphia). Because of the random-access capability of these computers, daily changes in stock status reported by the stock points can be entered into the computer system and processed as they come in, instead of being batched and sequenced for processing at longer intervals.

The UNIVAC 490A is also a time-sharing system and may be queried simultaneously from a number of remote inquiry stations located in the operating divisions of the ICP.

Automatic Data Processing at Navy Stock Points

When stock point operations were first computerized, each stock point was assigned responsibility for analyzing its own files and functions and for preparing its own programs. Later, for reasons of increased efficiency and lower cost, it was decided to set up a central maintenance organization that would analyze, write, and maintain all principal stock point programs. This organization, the Data System Support Office at NSD Mechanicsburg, is under the direction of the Naval Supply Systems Command (formerly the Bureau of Supplies and Accounts) and maintains the stock point program library.

The computer systems at each of these stock points are IBM 1410/7010 systems. They are random-access systems that produce and process action documents (expenditure, receipt, and material movement documents), receive and answer inquiries from remote terminal devices, maintain files up to date, and prepare reports.

Because they are modular, stock point computer systems can be expanded and modified as required.

The principal stock point files loaded for random accessing are the master stock item record, the receipt/due file, the in-process issue file, the back-order file, the requisition status file, the name and address file, and the financial inventory control ledger file.

The master stock item record file contains such information as stock quantities on-hand, warehouse locations of stock, restriction codes, weights, and substitute items.

The receipt/due file contains records that identify material that has been received within the last specified number of days and records that identify material due to be received.

The in-process issue file contains routine requisitions held in suspense.

The back-order file contains back-orders of items not in inventory but ordered.

The requisition status file contains requisitions in the process of being filled or back-ordered.

The name and address file contains the names and addresses of all customers that normally do business with the stock point.

The financial inventory control ledger file contains data from which financial reports are generated.

Communications between remote terminals in the customer service area and in the stock point warehouse permit rapid action on a priority requisition.

Routine requisitions are merged into the in-process issue file and held there until a release program decides whether issue action should be taken. (The criteria which govern the release program's decision are stated in uniform priority processing rules promulgated by the Department of Defense.)

Information in a requisition together with pertinent information in the master stock item record is printed out in the warehouse—name and address of the customer, warehouse location of the item, and other applicable management or shipping data. When the material has been shipped, the warehouse feeds back information to the central computer.

When material is received at a stock point warehouse, receipt data is input into the computer, which sends back to the warehouse receiving area a receipt location card indicating where this material should be stored in the warehouse. When the material is properly located, the receipt location card is input into the computer and data referring to this material is transferred from the in-process to the on-hand field of the master stock item record.

If the computer does not receive this card back within a given period, it automatically prints a delayed receipt notice which alerts management that action should be taken.

When a receipt quantity is taken up as on hand and the master stock item record shows that back orders are being held, the back order file is automatically scanned and requisitions for the material in question released.

Any of these files may be interrogated online. The master stock item record file is the one most queried, usually to find out how much of an item is on hand and where it is in the warehouse.

At the end of each day, a tape showing every transaction that has taken place during the day is closed and used to update the financial inventory control ledger file and other relevant files.

Other Navy Computerized Supply Systems

Automatic data processing is used for supply and accounting (and maintenance history) functions on tenders, repair ships, and aircraft carriers of the Navy; it is also used at naval air stations and public works centers for these functions. Automatic data processing systems are, in fact, being introduced throughout the Navy wherever they might serve to improve reporting and administrative procedures.

THE NAVY MANPOWER INFORMATION SYSTEM

Stored in the vaults of the Bureau of Naval Personnel and the Navy's three Personnel Accounting Machine Installations (PAMIs) are magnetic tapes containing detailed information on the personnel histories and status of all the officers, men, and activities of the Navy. These tapes comprise the data banks of the Naval Manpower Information System (NMIS), a Navy-wide service designed to gather, process, and display or disseminate information required for personnel administration.

The data contained in the NMIS banks are updated regularly by inputs in the form of personnel change reports or diaries from every activity and by inputs from the Bureau of Naval Personnel and from other bureaus, systems commands, and offices taking actions which affect the data.

Studies are continually underway to find new information of value in Navy personnel administration that might be added to the information arrays inscribed on these tapes. (One of the most recent additions is a monthly input from the U. S. Armed Forces Institute (USAFI) of data showing USAFI credits gained by individuals.)

Studies are also continually underway to find better ways to collect, verify, symbolize, transmit, store, process, read out, and use personnel information.

The NMIS data banks are the source of information for about 2400 monthly regular and special reports for the use of manpower managers at all Defense Department and Navy levels.

The NMIS is currently undergoing redesign and new equipment has been selected. The new system (NMIS II) will eliminate the need to maintain master files at each PAMI, which will in turn eliminate the need to reconcile files, always a difficult and time-consuming process and one that delays the production of needed information. Moreover, by substituting random-access processing for the sequential processing of magnetic tapes, the new system will enable the application of operations research techniques to personnel data files.

The hardware for the new information system will consist of five medium-scale third-generation computers with associated peripheral gear. Two of the five computers will be installed at the Bureau of Naval Personnel, the remaining at the three PAMIs.

The new system will maintain a central data bank at the Bureau of Naval Personnel in on-line mass storage rather than in tape vaults. Each PAMI will maintain a replica of that portion of the central data banks covering the activities for which it is responsible.

Daily transactions entering the system through the PAMIs will be relayed to the Bureau of Naval Personnel via a data communication network, batch-processed to the central data banks no less frequently than daily, and returned via the data network to update the PAMI replica or image files. Only during the period of transmission back to the PAMIs, therefore, will the central data banks and the PAMI images contain discrepant data.

The enlisted distribution system is also under current study. While there are no plans for computerizing distribution, further automation of the information available to distribution activities is being designed with a view to improving the Navy's ability to get the right man into the right job.

The revised NMIS will enable users to get summary statistical reports on demand through the use of on-line inquiry stations located at the console or at remote points. It will also encourage the use of brief exception reports rather than voluminous regularly scheduled reports. (An exception report is a report that presents data concerning some condition in a material or information system that needs looking into and possible corrective action by management and that is generated only when this condition comes into being.)

The new system will employ visual scanners to eliminate manual transcription of information, thereby speeding up input and reducing errors.

Other personnel information systems planned will draw from the new NMIS data banks. These systems will access personnel information needed in such fields as financial management, mobilization planning, inventory projection, and curriculum planning.

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 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 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.

AUTOMATION—The investigation, design, development, and application of methods of rendering processes automatic, self-moving, or self-controlling.

DELAYED TIME OPERATIONS—Batch-processing operations.

EXCEPTION REPORT—A report presenting data that describe some condition of a material or information system that management should look into.

HYBRID COMPUTER SYSTEM—A computer system made up of both analog and digital computers.

MODEL—A mathematical description of a real situation or process.

OPERATIONS RESEARCH—The devising and analysis of models of real situations with a view to clarifying objectives and to improving organization and decision-making.

RANDOM-ACCESS PROCESSING—Processing in which the storage and accessing of information is not sequential.

SOLO TRANSACTION—An individual transaction processed without being batched with other transactions.

TIME-SHARING—The use of a computer for two or more purposes during a given unit of time, accomplished by interspersing component actions.

APPENDIX 1

TRAINING FILM LIST

Training films that are related to the information presented in chapters 12 through 17 of this training course are listed below. The training films are identified by navy number and title. All films listed have sound and are unclassified. Other training films that may be of interest are listed in the United States Navy Film Catalog, NavWeps 10-1-777.

MN 8969-A Digital Computer Techniques—Introduction. (20 min.—Color—1962)

MN 8969-B Digital Computer Techniques—Computer Logic—Part I—Binary Numbers. (20 min.—Color—1962.)

MN 8969-C Digital Computer Techniques—Computer Logic—Part II—Logic Symbology. (15 min.—Color—1962.)

MN 8969-D Digital Computer Techniques—Computer Units. (24 min.—Color—1962.)

MN 8969-E Digital Computer Techniques—Logic Element Circuits. (16 min.—Color—1962.)

MN 8969-F Digital Computer Techniques—Programming. (14 min.—Color—1962.)

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