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# BASIC DATA PROCESSING

Prepared by the Bureau of Naval Personnel

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# PREFACE

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

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## CHAPTER 1

# ADVANCEMENT

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

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

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

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

### THE ENLISTED RATING STRUCTURE

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

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

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

### THE DATA PROCESSING TECHNICIAN RATING

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

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

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

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

#### DP Assignments

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

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

#### The DP As A Leader

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

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

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

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

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

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

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

### ADVANCEMENT IN RATE

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

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

### HOW TO QUALIFY FOR ADVANCEMENT

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

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

consider you capable of performing the duties of the next higher rate.

5. Demonstrate your KNOWLEDGE by passing written examinations on the occupational and military qualification standards for advancement.

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

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

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

Merit rating system  
Personnel testing system  
Longevity, or seniority system

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

The following factors are considered in computing the final multiple:

Factor	Maximum Credit
Examination score	80
Performance factor (Performance evaluation)	50
Length of service (years x 1)	20
Service in pay grade (years x 2)	20
Medals and awards	15
	185

## ACTIVE DUTY ADVANCEMENT REQUIREMENTS

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

\* All advancements require commanding officer's recommendation.

† 1 year obligated service required for E-5 and E-6; 2 years for E-6, E-7, E-8 and E-9.

# Military leadership exam required for E-4 and E-5.

\*\* For E-2 to E-3, NAVEXAMCEN exams or locally prepared tests may be used.

Figure 1-1.—Active duty advancement requirements.



**INACTIVE DUTY ADVANCEMENT REQUIREMENTS**

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

\* Recommendation by commanding officer required for all advancements.

† Active duty periods may be substituted for training duty.

Figure 1-2.—Inactive duty advancement requirements.



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

## HOW TO PREPARE FOR ADVANCEMENT

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

### Quals Manual

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

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

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

Both the military requirements and the occupational qualification standards are divided

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

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

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

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

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

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

### Record of Practical Factors

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

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

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

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

#### NavPers 10052

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

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

If extensive changes in qualifications occur in any rating between the annual revisions of

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

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

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

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

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

#### Rate Training Manuals

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### PUBLICATIONS YOU SHOULD KNOW ABOUT

Each different type of data processing installation where Data Processing Technicians

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

### Technical Manuals

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

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

### TRAINING FILMS

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

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

## CHAPTER 2

# AUTOMATIC DATA PROCESSING

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

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

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

## THE REVOLUTION IN RECORD KEEPING

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

### Pencil and Paper Accounting

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

### Key-driven Accounting

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



R49.178X

Figure 2-1.—Pencil and paper accounting.



R49.179X

Figure 2-2.—Key driven accounting.

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

#### Punched Card Accounting

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

The punched card idea disappeared until the latter 1800s when Dr. Herman Hollerith adapted the theory to a smaller, more convenient card in which information could be punched (fig. 2-4). This was probably the most profound advance in data processing, for it introduced a system which employed for the first time the concept of

mechanically stored information. By 1900, Hollerith had developed an automatic electric sorting machine (fig. 2-5), a semiautomatic tabulator, and a keypunch machine. These were forerunners of our present electric punched card data processing equipment which can automatically code, sort, store input, perform calculations, and print output. The only required manual control is classifying data preparatory to punching, starting and stopping machines, and moving cards from one machine in a system to another.

#### Electronic Data Processing

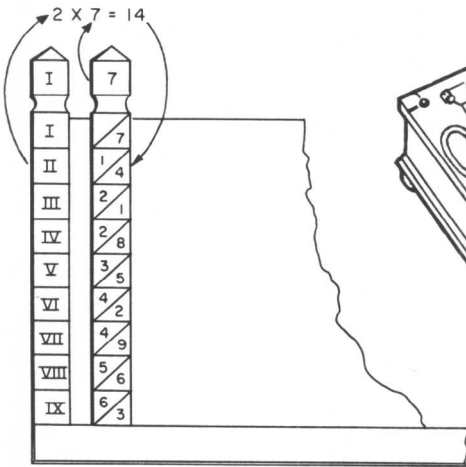
Electronic data processing (EDP) (fig. 2-6) is accomplished through principles of electronics rather than those of a mechanical or electromechanical nature. The first attempt to build a computer largely independent of operator action was in England in 1830 by Charles Babbage. Though the machine was a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

#### PUNCHED CARD ACCOUNTING

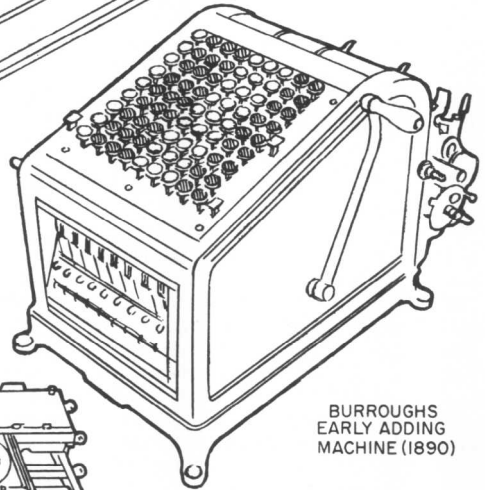
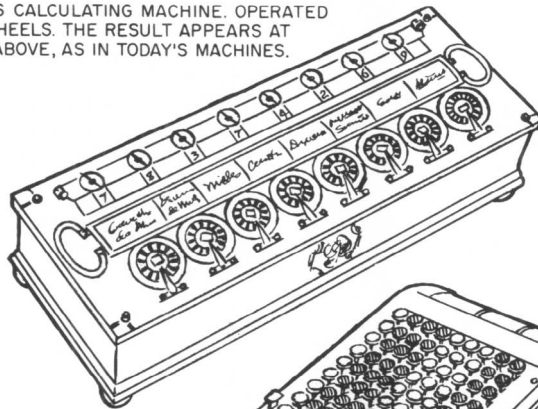
In the census of 1880, data for each person were handwritten on large cards. The cards were then hand-sorted by classifications and manually tallied over and over to produce facts. This cumbersome task was costly and provided no means for checking accuracy. Seven and one-half years were required for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

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

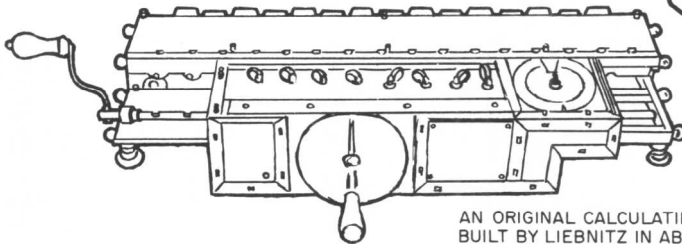
1642: PASCAL'S CALCULATING MACHINE. OPERATED BY TURNING WHEELS. THE RESULT APPEARS AT SIGHT HOLES ABOVE, AS IN TODAY'S MACHINES.



NAPIER'S BONES, INVENTED IN 1617, SHOWING THE MULTIPLE OF  $2 \times 7 = 14$ .



BURROUGHS  
EARLY ADDING  
MACHINE (1890)



AN ORIGINAL CALCULATING MACHINE  
BUILT BY LIEBNITZ IN ABOUT 1694.

Figure 2-3.—Advancement of calculating devices.

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

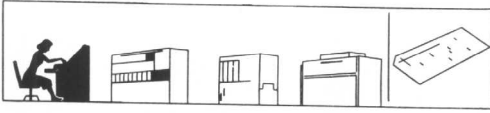
For the ease of handling and durability, these paper strips eventually were replaced by cards

of a standard size and shape. Following the purchase of Hollerith's Tabulating Machine Company in the early 1900s by the International Business Machine Corporation, further modifications to the card resulted in the one we now recognize as the 80-column card.

#### Data Processing by EAM

Despite the vast recent increase in the use of electronics, certain areas remain in which the employment of electronic data processing





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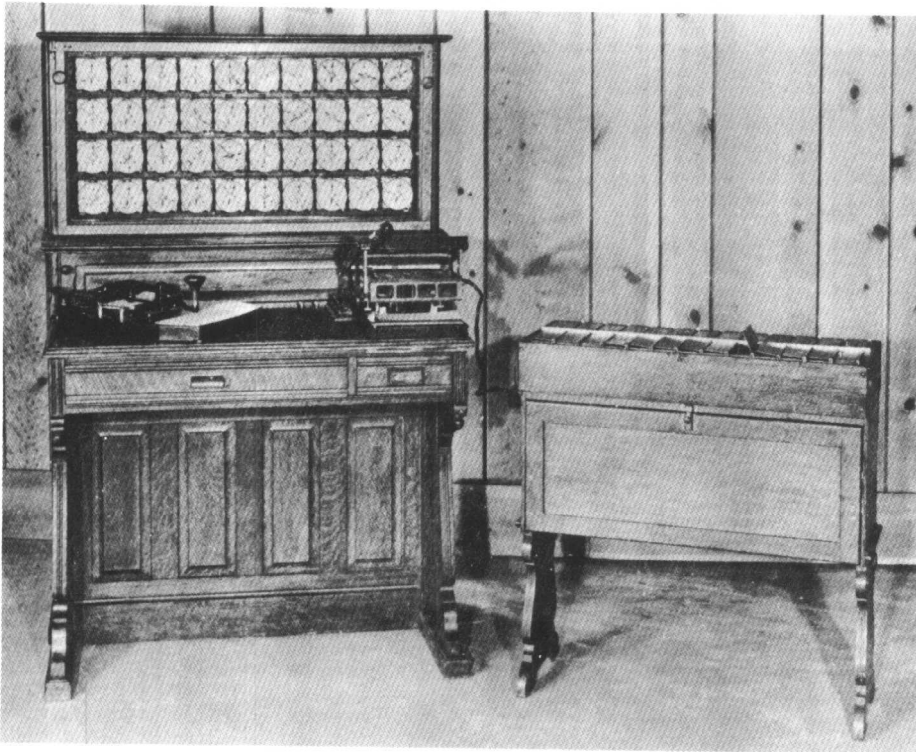
Figure 2-4.—Punched card accounting.

systems is not practicable. In these areas, electric accounting machine (EAM) systems function effectively and provide the answer to mechanized data handling processes. Systems which process data entirely from punched cards are normally referred to as PUNCHED CARD or EAM DATA PROCESSING SYSTEMS. Electrically powered machines so designed that each

performs certain processing functions as directed by externally wired control panels (except key-driven and most sorting machines) are classified as ELECTRIC ACCOUNTING MACHINES (EAM). The optimum use of this equipment under precise rules of procedure can minimize clerical operations, standardize methods, and speed up output of records and reports.

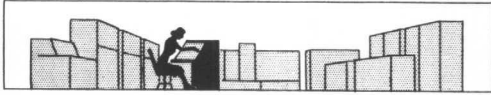
#### The Unit Record

Transferring information from a source document, such as a Personnel Diary or supply requisition into cards, produces individual records of hundreds and thousands of transactions. Once holes have been correctly punched into a



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Figure 2-5.—Hollerith's early model tabulating machine and sorting box.



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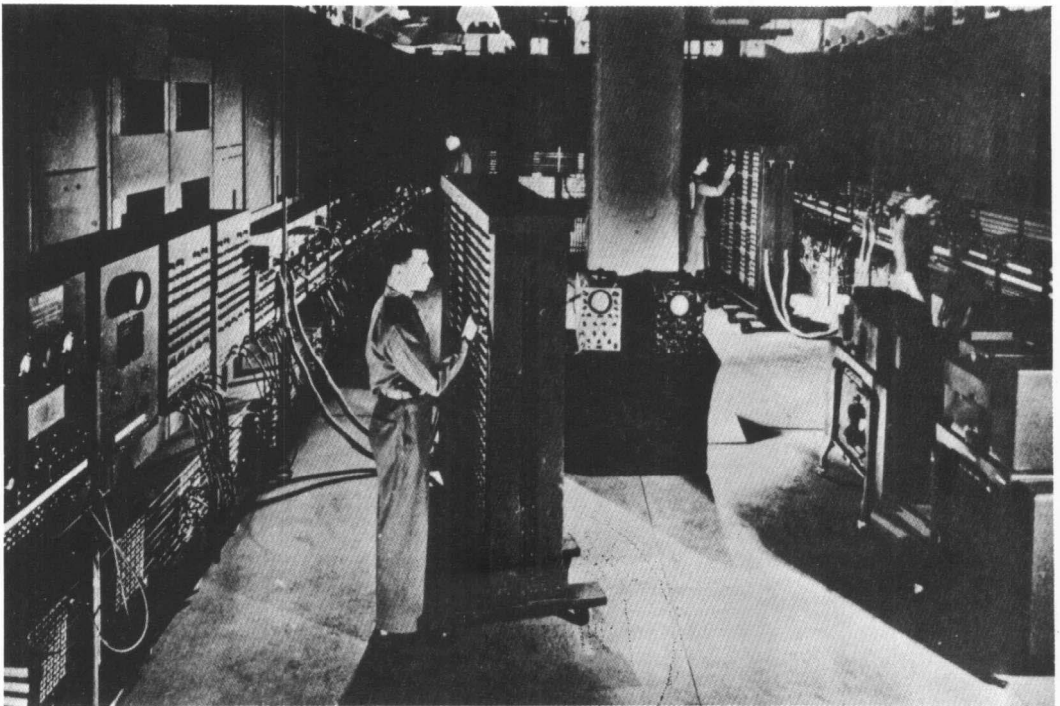
Figure 2-6.—Electronic data processing.

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

### THE PUNCHED CARD

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

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



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