C686-416L-ST

AIR TRAINING COMMAND

COMPUTER SYSTEMS DEPARTMENT

STUDENT TEXT

ABR30533-1

INTRODUCTION TO AN/FSQ-7

20 January 1966

RESPONSIBLE AGENCY OF ATC
Keesler Technical Training Center
Keesler AFB, Mississippi

ABOUT STUDENT STUDY GUIDES AND STUDENT WORKBOOKS

Student study guides and student workbooks are designed by the Air Training Command as student training publications for use in training situations peculiar to courses of this command. Each is prepared for the particular learning objective (s) of the plan of instruction.

The **STUDENT STUDY GUIDE** *contains the specific information required in the learning objectives(s) or it will refer to other publications which the student is required to read. It contains the necessary information which is not suitable for student study in other available sources. The material included or referred to is normally studied either outside the classroom or during supervised study periods in the classroom. Also included are thought-provoking questions which permit self-evaluation by the student and which will stimulate classroom discussion.*

The **STUDENT WORKBOOK** *contains the specialized job procedures, important information about the job, questions to be answered, problems to be solved and/or work to be accomplished by the student during the classroom/laboratory, airplane/missile/equipment activity. It serves as a job sheet, operations sheet, mission card, check list or exercise to be performed during classroom or laboratory periods. Also included are questions which will aid the student in summarizing the main points of the learning objective(s).*

The **STUDENT STUDY GUIDE AND WORKBOOK** *is a training publication which contains both student study guide and student workbook material under one cover.*

Since this publication is DESIGNED FOR ATC COURSE USE ONLY and must not conflict with the information and/or procedures currently contained in Technical Orders or other official directives, it is updated frequently to keep abreast of changes in qualitative training requirements. Students who are authorized to retain this publication after graduation are cautioned not to use it in preference to Technical Orders or other authoritative documents.

Computer Systems Department
KTTC, Mississippi

Student Text
January 1966

INTRODUCTION TO AN/FSQ-7

This Student Text provides study material in support of POI for Course ABR30533-1.

CONTENTS

CHAPTER I - GENERAL INFORMATION

THE LEARNING PROCESS

The first steps in attaining your basic AFSC 30533 is the successful completion of the Electronic Computer Repairman Course in which you are now entered. To reach this objective, you must be taught the essentials of several different jobs. However, each of these jobs is dependent upon the others. It becomes your responsibility to combine the skills of each job into one smooth, coordinated operation. If you apply yourself only part-time, you will be lacking in the knowledge that is absolutely necessary for such a coordinated operation.

Not only will you have to apply yourself in the classroom, but it will be necessary for you to review or study the classroom material as well as this and other manuals in your off-duty time. In addition, you will have assignments given to you by your instructor. When you are given an assignment, or when your instructor is presenting a lecture, always ask yourself "What am I supposed to gain from this material, and how will it aid me in my work?" Inevitably, the lecture material is going to contain coloring (facts which add to the interest, but are of minor value). However, the lecture material to be studied will contain one or two major points which will be emphasized. It will be your responsibility to pick out these major points and remember them to aid you in your future work.

TAKING NOTES FOR REFERENCE

It is not enough to be able to pick out the main points of a lecture. You must take notes and emphasize these main points for future reference. The notes you take will not only aid you in obtaining a good scholastic average, but will also be of value when you reach the field. By referring to the notes you took in school, you can more easily do the jobs to which you may be assigned as a Computer Repairman.

Don't try to put material in your notes that you do not understand. Your notes should be fully understandable by you, because you are the one who will be using them. How are you going to be sure that you understand all that you put down? Simply by re-wording the instructor's viewpoints so that they will be clear, concise, and in your own words. Do the same with your reading assignments. Don't copy word-for-word from the text. Restate the material in your own words, and then write it down. It will mean much more to <u>you</u>, the individual who is going to use the notes.

To get anything out of a lecture or assigned reading, you must focus your full attention on the material being presented. You have to concentrate on the subject at hand. Try to remove as many distractions as possible, and then apply yourself wholeheartedly to the task of studying.

STUDYING

When studying, it is necessary for you to recognize how the material is organized. The first thing to do is to try to get a general picture of just what the course is trying to put across to you. Once you get the overall picture, then fit the details in to complete the picture. This is comparable to working a jigsaw puzzle. It's practically impossible to work such a puzzle before you have seen the whole picture. After seeing the entire picture, then you may start putting in the small pieces or details.

Finally, to learn a subject fully, you must repeat and repeat. Review your material several times, not just by rereading your notes, but by trying to recall what you have included in your notes. Refer to your written material as a check on your memory.

One of the most effective ways of studying is the "Survey Q3R Method". Let us break this down into detail:

SURVEY - Take a general view of the subject matter

QUESTION - Ask in order to find out or to eliminate any doubts as to the contents of the information.

READ - To study, get the meaning of, and understand the material.

RECITE - To say part of the lesson, or give an account of it in detail.

REVIEW - To go over again to insure complete understanding of the material. Remember these, for you will be reminded of the "SURVEY Q3R METHOD" during the remainder of this course.

SECURITY

What is security? A correct definition is: "The protected condition of classified matter which prevents unauthorized persons from obtaining information of direct or indirect military value."

CLASSIFICATION

Official information which requires protection in the interest of national defense will be limited to three categories of classification: "TOP SECRET", "SECRET", or "CONFIDENTIAL". No other designation will be used to classify such information, including military information.

TOP SECRET: What is Top Secret matter? Information and material, the security of which is very important, and the unauthorized disclosure of which would cause exceptionally grave damage to the Nation.

Authority to classify: Matter such as this may be classified by authority of the Undersecretary, the Secretary, or an Assistant Secretary of the Air Force; the Chief of Staff, Commanding Generals of Major Air Commands, Inspector General, Comptroller of the Air Force, Assistant Chief of Staff of Guided Missiles, Intelligence, and Air Defense Systems.

SECRET: What is secret material? Information and matter, the unauthorized disclosure of which would endanger national security, cause serious injury to the interest or prestige of the Nation, or would be of great advantage to a foreign nation.

Authority to classify: Matter such as this may be classified only by authority of the Secretary, Undersecretary, or an Assistant Secretary of the Air Force, Chief of Staff, Commanding Generals of Major Air Commands, Independent Commands, Service Air Force Bases, Wings, Groups, or Depots, Chiefs of Air Missions, Air Attaches, Air Observers, or General Officers.

CONFIDENTIAL: What is confidential matter? Information and material (matter) the unauthorized disclosure of which would be injurious to the interest or prestige of the Nation or would cause unwarranted injury to an individual, or be of advantage to a foreign nation.

Authority to classify: Anyone who may classify Top Secret or Secret matter or by authority of same, or by any commissioned officer.

PROTECTING CLASSIFIED MATTER

You must be constantly aware of the fact that it is your responsibility to protect classified material at all times and to report immediately to your supervisor any breach of security which comes to your attention. Air Force Regulation 205-1 should be referred to, concerning Security and your responsibilities for the protection of classified material.

SEMI-AUTOMATIC GROUND ENVIRONMENT TRAINING (SAGE)

For most of you the ideas and facts presented in this text will be new. This is due to the fact that you are entering a relatively new and complex field where there are few if any carry-overs of skills from civilian or military life. As a result, many questions have probably entered your mind as you enter the sets portion of your training to become Computer Maintenance Technicians. You are asking, for example, "For what duties will I be prepared? What will be the extent and value of this training? How difficult is this course?" and the most common question of all is, "Where do I go from here?" In the next few weeks, most of these questions will be answered for you. The answer to the last question, "Where do I go from here?" can only be supplied by one person, You. The manner in which you apply yourself and adapt to new situations that you will encounter in this field will provide the answer.

TYPE OF TRAINING

In selecting each entry into the Electronic Digital Computer Repairman (SAGE-AN/FSQ-7) course, the Air Force has used the most advanced methods of career analysis and vocational guidance. This is to determine those who are potentially qualified to absorb the level of training and to develop the skills necessary to become good computer repairmen. The training in this school is aimed at providing the basic knowledge and skills necessary for you to embark upon an Air Force career, beginning with the fundamental assignment of computer repairman. Most of the training will be conducted in classrooms in the form of lectures and demonstrations. In addition, there will be periods of supervised practice on various pieces of equipment that will be part of your responsibility as a computer repairman. In the laboratory periods, you will learn to operate, and interpret the responses of, the equipment you will use in the field.

At the completion of your training, you will find that you have acquired a new vocabulary that would sound strange in conversation with your family and friends in civilian life, but which is the everyday speech of those concerned with this vital Air Force Mission.

So much for what you can expect from this course. Now, what does the school expect from you? It expects each student to apply himself honestly and diligently while in the course. Only by applying yourself can you hope to gain all that is possible in this career field. The school asks that you respect the equipment placed at your disposal during the training periods so that it can continue to fulfill its mission of training computer repairmen. The cost of the equipment with which you will be working runs into several hundred thousand dollars. <u>Use only the controls you are instructed to use. Use them as directed by your instructor.</u>

YOUR CAREER FIELD

When you finish the Electronic Computer Repairman (SAGE-AN/FSQ-7) Course, you will be assigned to duty as a computer repairman with a classification of AFSC30533. This classification is the Air Force method of designating your career field, the channel to which you are assigned in that career field, the skill and proficiency you have attained, and whether you are serving in a technical or supervisory capacity. How, you ask, can they determine all that information from a five digit number? Let's examine AFSC 30533, the Air Force Specialty for the Apprentice Electronic Computer Repairman:

AFSC 30533 APPRENTICE ELECTRONIC COMPUTER REPAIRMAN

30--- The first two digits indicate that you are now in the Airman Communications Electronic Systems Field.

--5-- The third digit designates the computer subdivision of the Airman Communications Electronic Systems Field. If the third digit is a zero (0), as in 30010, it indicates no specialization.

---3- The fourth digit indicates the degree of skill and proficiency which you have attained in your work. When the fourth digit is a three (3) in the AFSC 305X3, the AFSC denotes an <u>Apprentice</u> Digital Electronic Computer Repairman. The Electronic Computer Repairman (SAGE-AN/FSQ-7) Course is considered sufficient training for the award of AFSC 305<u>3</u>3. When you have successfully completed this course, 30533 will become your Air Force Specialty Code. After you have been awarded this AFSC, you will normally be placed in on-the-job-training status (OJT) for advancement to AFSC 30553. As your skill and proficiency increase, this fourth digit will change to a <u>5</u>, then to a <u>7</u>, and finally to a <u>9</u>. With a change in this digit, you will take on additional duties and responsibilities.

----3 The fifth digit, in combination with the other four digits, identifies the Air Force Specialty. In the Digital Computer Repairman AFSC, the fifth digit will always be a three (3).

What is the next step after the Apprentice Electronic Computer Repairman, AFSC 30533? In the following pages this question will be answered. The AFSC's which follow the Apprentice AFSC will be discussed. How to attain the next AFSC, what will be expected of you, the pay grades you will be eligible for, and similar questions will be answered.

AFSC 30553 Electronic Computer Repairman

Job Summary: Installs, maintains, and repairs high speed, general purpose, and special electronic computer systems and related equipment.

Job Progression: To reach this AFSC, you will normally have had to progress from Apprentice Electronic Computer Repairman 30533 with the necessary on-the-job-training, and satisfactory completion of the skill level examination for the AFSC 30553.

After you have received this AFSC, you will be eligible for pay grades E-4 and E-5 in the Communications Electronic Career Field, provided that you have met all other requirements of the Command to which you are assigned.

Supervision: You will be expected, upon attainment of this AFSC, to exercise supervision over subordinate Electronic Computer Repairmen.

AFSC 30573 Electronic Computer Technician

Job Summary: Inspects, troubleshoots, repairs, overhauls, modifies, and installs high-speed general purpose and special electronic computer systems and related equipment, and supervises electronic computer maintenance activities.

Job Progression: To receive this AFSC, you will have to prove your proficiency as an Electronic Computer Repairman 30553, with necessary on-the-job-training as an Electronic Computer Repairman, satisfactorily complete the skill level examination for AFSC 30573, and be in pay grade E-5. This AFSC makes you eligible for pay grades E-6 and E-7 in the Communications Electronic Career Field.

Supervision: This AFSC includes general supervision over Electronic Computer Repairmen.

AFSC 30590 Electronic Computer and Data Processing Superintendent

Job Summary: Superintends installation, maintenance, repair, overhaul and modification of high-speed general purpose and special electronic computer and data processing systems.

Job Progression: To receive this AFSC, you have to demonstrate your proficiency as an Electronic Computer Technician and pass the supervisory examination.

This AFSC may be held by pay grades E-7, E-8 and E-9 in the Electronic Computer and Data Processing subdivision of the Communications Electronic Systems Career Field.

Supervision: This AFSC includes general supervision over all Electronic Computer and Data Processing enlisted personnel.

Summary of Ratings and AFSC's

CMSgt	Electronic Computer and Data Processing Maintenance Sup't.	30590
SMSgt	Electronic Computer and Data Processing Maintenance Sup't.	30590
MSgt	Electronic Computer Technician	30573
TSgt	Electronic Computer Technician	30573
SSgt	Electronic Computer Repairman	30553
A1C	Electronic Computer Repairman	30553
A2C	Apprentice Electronic Computer Repairman	30533
A3C	Basic Computer Course	305XX
AB	Input from related fields - Basic Training	00010

JOB TRAINING STANDARD

The Job Training Standard is an official document which describes the Air Force Specialty in terms of task and/or knowledge which airmen in that specialty are required to perform or know on the job. The Job Training Standard is a document against which a man's performance is measured.

The Job Training Standard originates in the office of the course being offered. After it is prepared it is sent to Department, School Operations, Center Operations, Air Training Command, and the utilizing agency for review for adequacy, coordination, and approval.

The Job Training Standard is used in setting up the degree and type of instruction to be used in the course.

Through the use of a prescribed code key, this document also indicates the extent to which personnel should be trained on each task at a specified level.

The Job Training Standard (JTS) will also be used in the field OJT program. It will be the primary means for certification of qualification in upgrading. It will be to your advantage to understand the general description of the JTS, for it will be pertinent to you throughout your Air Force Career.

CHAPTER 2 - THE NEED FOR SAGE

AIR DEFENSE

In order to understand the Sage System, it is necessary to possess a general knowledge of the Air Defense System of the United States. When we discuss the SAGE System, we speak primarily of the geographical, organizational, and operational structure of the air defense network as it applies to the Semi-Automatic Ground Environment.

SAGE, itself is not a new system of air defense, but a new medium which is used to accomplish the air defense mission. It provides for the semi-automatic processing of data and for mid-course weapons control. Its computerized features have permitted many major changes in the system and have promoted revisions in the concepts of air defense.

In order to provide a comprehensive picture of the organization and operation of the SAGE System, this chapter contains a brief history of air defense after World War II. Also discussed are the operational concepts of the manual ACW System and the changes brought about by the SAGE System. This first section contains frequent references to the "manual" system. Such references are necessary to present a graphic picture of the evolution of the Air Defense System.

MISSION OF AIR DEFENSE

Any air defense system must fulfill the requirements of the mission regardless of its operational practice or theory. By its name alone, we know that air defense concerns ~~itself with~~ some form of aerial activity. Specifically, it must protect the nation's retaliatory forces, population, industrial potential, and natural resources from air attack.

In order to accomplish this mission, a requirement exists for an efficient method that permits no objective of the mission to be slighted. An effective air defense system must provide for the following:

(1) Detection of <u>all</u> aerial activity.

(2) Identification of air action as either friendly or hostile.

(3) Interception of all unknown or hostile aircraft.

(4) Destruction of hostile aircraft by guidance and control of defense air weapons.

The air defense mission is basic, and it is doubtful that any system, whether manual, semi-automatic, or automatic, will ever alter it in any manner.

The Problem is Staggering

The magnitude of this task demands a close-knit organization composed of segments of all the armed forces and civilian agencies capable of destroying or reducing the effectiveness of attacking forces. To provide such an organization is the mission of the Air Defense Command of which you, the Computer Repairman, are a key member.

Fortunately, air power as a weapon of such potent capability did not suddenly spring into being, and as airpower has developed there has been concurrent planning, programming, and development of the Air Defense System. As early as the closing phases of World War I, General Billy Mitchell had programmed an air organization that called for detection and interception as a concept of defense. However, an actual air defense system was not established until the years of World War II, (1941 - 1945).

During World War II the United States and Great Britain developed an air defense system which was the forerunner of the present system. To combat enemy air offenses, interceptor aircraft were controlled during the daylight hours from control centers equipped with interceptor plotting tables (map surfaced) on which the actions of the interceptors and their targets were depicted from information reported by search radar stations and ground observers. Interceptors were often pinpointed by very high frequency direction finding stations or by having them rendezvous over known check points. Enemy formations in Europe were customarily large - from 50 to over 100 aircraft. When their location and the location of the interceptors were both known and indicated on the intercept plotting table by the intercept controller in the control center, it was a relatively simple task to "talk" the interceptors near enough to the enemy for a visual approach and attack.

The enemy soon exploited the weakness of the system, however, by conducting night missions. Existing control procedures proved inadequate at night. If our defenses were to remain strong, new methods had to be found for tracking targets and controlling interceptors. At first various tactics were devised which depended on ground and airborne searchlights. These tactics provided interceptors with visual gunsighting once the enemy aircraft were located. Searchlight beams could be held on an incoming bomber while an interceptor moved in to shoot it down.

Perhaps area controlling as practiced with the use of plotting intercept tables and searchlights, would still be sufficient today if high speed aircraft and new control tactics hadn't been developed. But as aircraft flew faster and higher, the operational area of interceptions was expanded, and aircrew members became more concerned with flying duties and had less time to concentrate on intercept techniques. It was apparent that a more precise knowledge of the position of our interceptors in relation to enemy bombers would be highly advantageous.

The only alternative lay in aircraft control from the ground by personnel observing radar-scopes capable of covering considerable range and altitude. If a controller on the ground could watch both interceptor and target on a radar-scope, and if he were in constant radio-telephone communication with the interceptor pilot, he could rapidly direct the interceptor to the target. If this controller could also establish the intercept approach and the type of interception, leaving the pilot only the job of actually making the firing pass, the pilot would have more opportunity to concentrate on flying. The controller, not bothered with piloting duties, could set up a better interception. From this reasoning, our present Air Defense System was evolved.

SAGE IMPLEMENTATION

The advent of SAGE and its centralized control function created many problems for those responsible for integrating it into the present manual air defense system. At first, SAGE was considered as a computerized answer to all air defense problems, and not as a new medium of air defense. Consequently, strategists planned to install SAGE within the existing manual system boundaries and to continue normal operation. But, as with many advances in technology, difficulties were encountered. Three of these difficulties were as follows:

(1) Some of the sector boundaries were so small that a shift of weapons control to adjacent sectors frequently occurred.

(2) Irregular shapes of some sector boundaries were not adaptable to proper display on the SAGE Situation Displays (scopes).

(3) Existing boundaries were located poorly in relation to priority targets. Consequently, the targets were difficult to defend.

After numerous attempts to implement SAGE had ended in failure, a solution was reached. New SAGE boundaries were devised. This was coupled with a revised concept of air defense operation. The sector would be the heart of the system, and the direction center would command the sector. Emphasis on air defense control of weapons would shift downward from Division to the Direction Center. The ability of the SAGE system to satisfactorily handle a large number of tracks and simultaneous intercepts made it necessary for the air battle to be controlled at division level. In the manual air defense system, the Direction Center was responsible for a sub-sector, while the Division controlled the sector. Also, the responsibility for major tactical decisions rested with the commander at Division.

SAGE LONG RANGE PLANNING

The Air Defense System must be as invulnerable to attack as practicable. As SAGE replaced the manual system, numerous precautions were taken to insure that no weaknesses appeared within the air defense structure during the transition period. Some of these precautions dictated the sequence by which SAGE sectors replaced the manual sectors.

(1) It was realized that all SAGE sectors could not be completed simultaneously. Therefore, a completion priority system was established, based on the relative importance of the area of development.

(2) Each of the Direction Centers was placed in a strategic location within a sector. A Combat Center was located adjacent to one of the Direction Centers within the Division.

(3) The Direction Centers were duplexed -- that is, two computers -- one active and the other standby -- were located in the same building. The purpose of duplexing is obvious. To minimize vulnerability of the system, a backup is needed in case the original computer becomes non-operational. The two computers are identical

and use common input and output equipment. The active computer handles air defense problems while the standby computer maintains up-to-date summaries, performs maintenance checks on itself and other equipment, monitors the active computer, and provides simulated air defense situations for training personnel.

(4) Alternate communications facilities were provided with the installation of each computer.

(5) Direction Centers and Combat Centers were housed in shock-resistant, contamination proof buildings.

(6) In case SAGE should be incapacitated, the following emergency features were included in the planning:

(a) Each sector must be capable of absorbing some of the air defense responsibility of adjacent sectors.

(b) Local weapons defenses, Air Defense Artillery (ADA) for instance, must be permitted complete independence of control should SAGE control be destroyed.

(c) Limited manual air defense capability must be retained at each radar site. Thus, changeover to the manual system as an emergency measure could be implemented.

SAGE ORGANIZATIONAL STRUCTURE

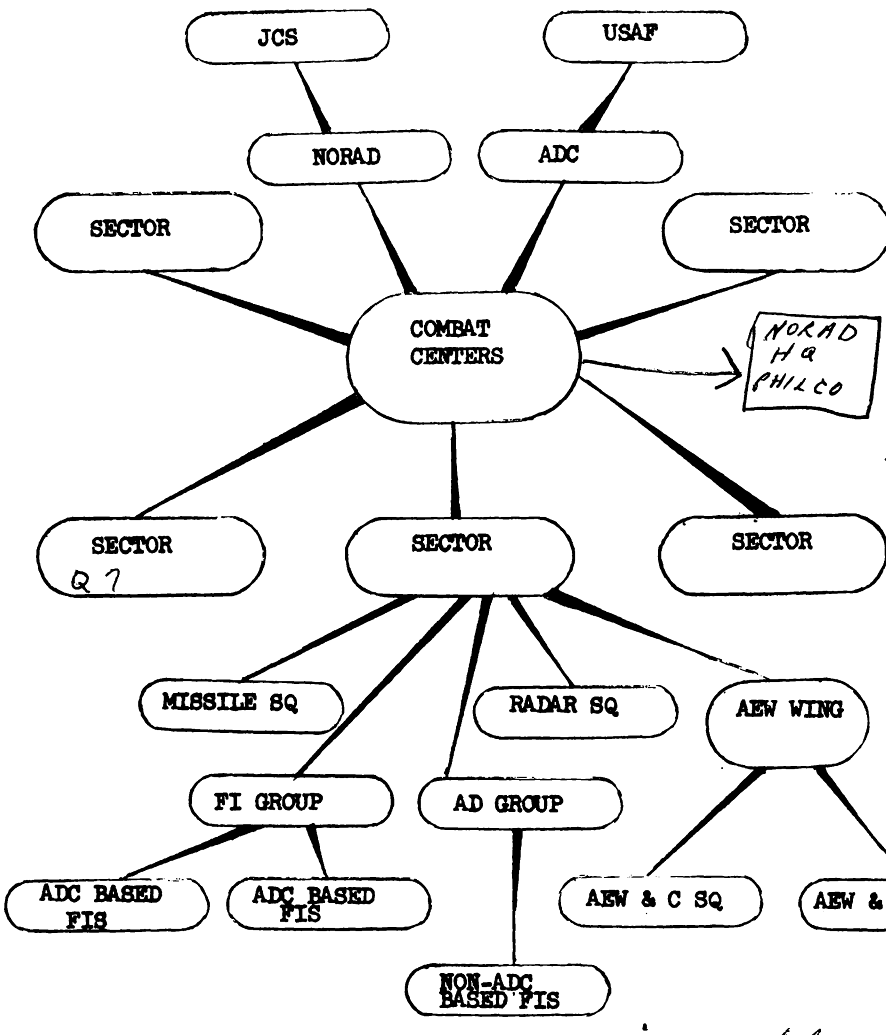
Air Defense Command (ADC) is the "organizational" head of the Air Defense System. It is responsible for manning, operating, and maintaining the system. However, it does not have command function so far as operational control of air defense is concerned. Decisive actions pertaining to all aspects of operational air defense have been delegated to North American Air Defense Command (NORAD).

Figure 2-1 outlines the organizational structure of Air Defense Command. SAGE has not changed the structure down through Force level. Division level changed only in respect to the geographical area assigned to its control. SAGE improved tactical control thereby eliminating the need for numerous divisions. Each division was given approximately three times the air defense responsibility that it had in the manual system.

SAGE introduced many new wings that were virtually non-existent in the manual system. Each wing controls the air defense area assigned to the sector. Wing and sector can be considered synonymous. In addition to the sector wing, on the same level is the AEW wing, which in turn supervises one or more AEW and C squadrons.

Below wing level are the various fighter groups, air defense groups, radar squadrons and air-ground missile squadrons. Fighter groups administer interceptor squadrons. Air defense groups concern themselves with interceptor squadrons located at non-ADC bases.

AN/FSQ-7 { 416L - DC A - directional center active
416L - DC S - " " standby



forward tell - lower to higher eschelon
backward tell - higher to lower eschelon
lateral tell - crosstell (cross of info ~~on~~ from sites of same level

Figure 2-1. Air Defense Command, Organizational Structure

SAGE OPERATIONAL STRUCTURE

The same urgency that created the requirement for SAGE dictated that all air defense agencies on the North American Continent be combined to provide a coordinated system for continental defenses. Thus, United States and Canadian forces were organized as the North American Air Defense Command (NORAD). In order to adequately understand the massive span of operational control of such a vast responsibility, more should be said about each echelon of the command and all of its subordinate levels. The following is an explanation of each, starting with the AC&W Squadron.

Radar Squadron

The radar squadron is essentially the same as the manual AC&W squadron, except that control of weapons and warning functions will normally not be affected at its location. These functions are now performed at the Direction Center. The radar squadron is responsible for providing: raw radar data, height readings, flight sizes, Mark X-IFF/SIF, long range mapping, and housing for emergency operation facilities should SAGE control become incapacitated and manual control become necessary.

Sector

The Direction Center is the primary operational unit of the sector. It is equipped with duplexed AN/FSQ-7 computers and associated communications systems. Within the Direction Center, the Sector Commander and his staff oversee the air defense activities within the sector area of responsibility. Located within this building is a tactical center called the Command Post. From here, the Sector Commander coordinates with adjacent Direction Centers and receives instructions from higher headquarters.

Division

The operational center of the Division is known as a Control Center. The Control Center consists of a building located adjacent to one of the Direction Centers within the division area of responsibility. The building houses a modified version of the AN/FSQ-7 (AN/FSQ-8) which is primarily used to store and display information. In other words, the AN/FSQ-8 is not used to control weapons.

The Control Center oversees the Directions Centers in its area and supervises weapons commitment in its sectors. The Division Commander and his staff are housed in the Control Center Command Post. Here, the commander evaluates threats and supervises air battles and force commitment. The Control Center is responsible for forward telling evaluated and summarized information to NORAD.

NORAD

The joint US-Canadian organization completes the operational control. NORAD, the operational head of the entire air defense system, is commanded by a four-star USAF General and a Royal Canadian Air Force (RCAF) Air Marshal, who is second-in-command. Specific assignments have been delegated to each of the military services directly controlled by NORAD:

(1) USAF -- ADC is responsible for interception of enemy air objects with assigned aircraft and/or surface-to-air missiles.

(2) US ARMY -- Army's Air Defense Command (USARADCOM) is responsible for point defense of cities and SAC bases. NIKE or associated missile systems are used in this defense.

(3) US NAVY -- Naval forces of the North American Air Defense Command (NAVFOR) are responsible for providing early warning from picket ships and AEW.

(4) Canada -- RCAFADC is responsible for control of aircraft and missiles for Canadian home defense.

NORAD's component heads report directly to their own chiefs-of-staff at Washington, D.C. and Ottawa.

ORGANIZATION OF DIRECTION CENTER

The organization of the Direction Center (see Figures 2-2 and 2-3) will be discussed as regards the functions of the Branches. As it has already been pointed out, the mission of air defense is accomplished by:

(1) Detection of all air action.

(2) Identification of the air action as friendly or hostile.

(3) Interception of hostile air action.

(4) Destruction of hostile air action.

The first three parts of this mission are accomplished within the Direction Center. This is the basis for the following discussion.

Command Post

The Command Post exercises command and over-all supervisions of the air defense activities within the sector.

The Director of Operations (D/O), the senior Battle Staff member, is responsible for operation of the Command Post. Battle Staff personnel are responsible to the Sector Commander (SC), through the D/O.

Liaison personnel serve in an advisory capacity, exchanging relevant air defense information with Battle Staff personnel and the Sector Commander. Command Post personnel are required to have a general knowledge of the functions, systems equipment, weapons, and agencies for which they are responsible. Furthermore, they are required to keep informed of the latest developments that affect their individual areas of responsibility.

FPX

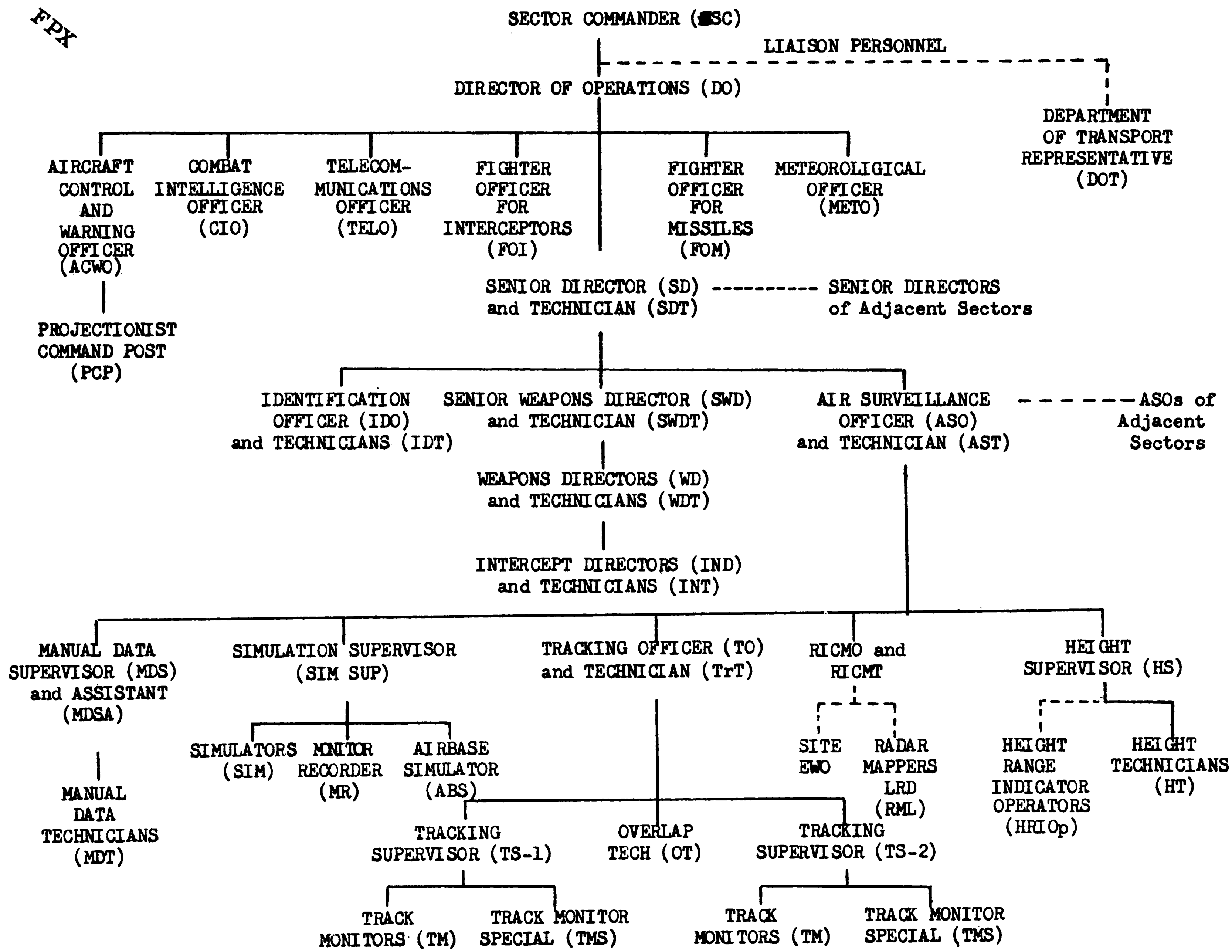


Figure 2-2. Directional Center Organizational Chart (Combined)

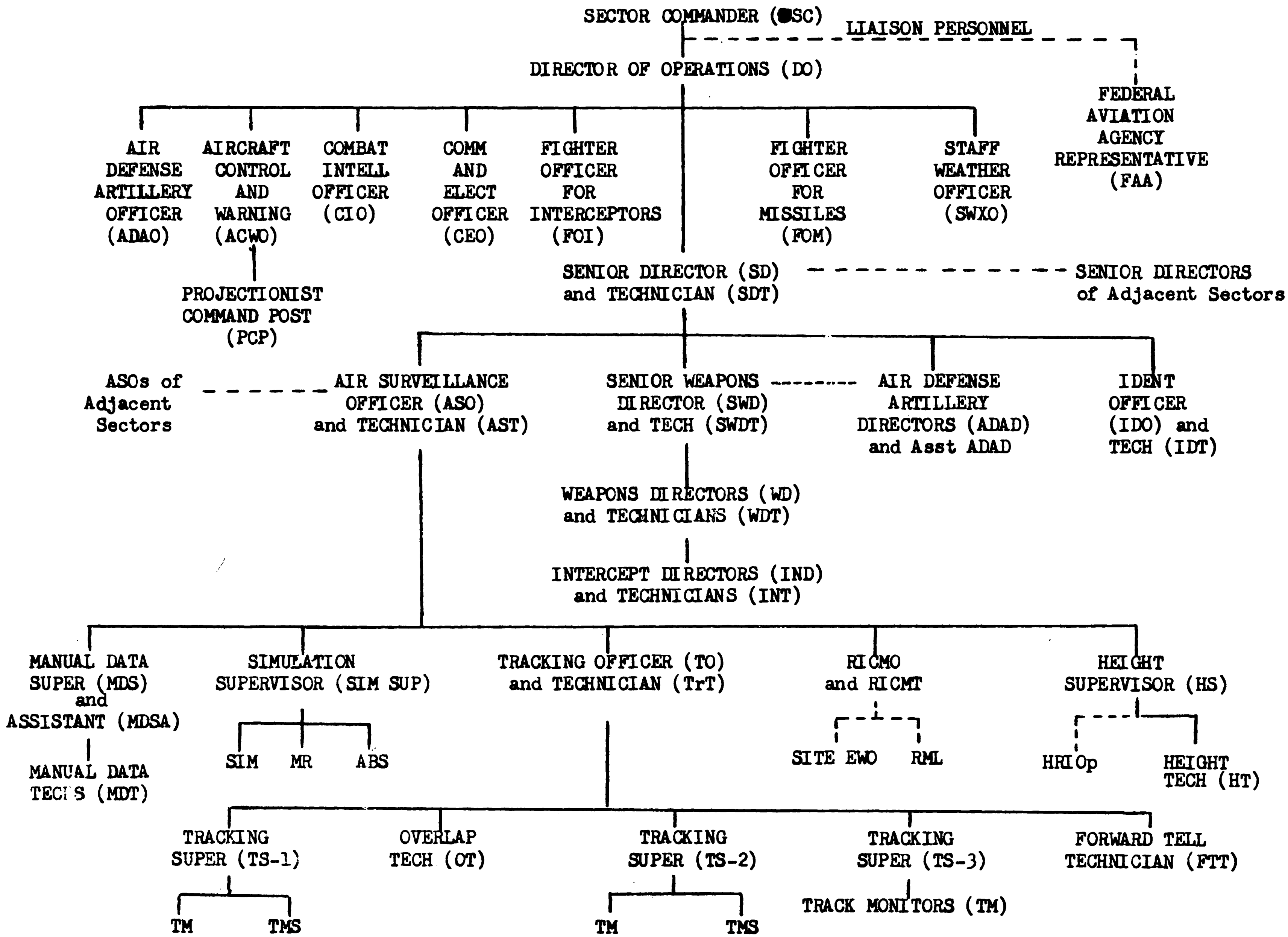


Figure 2-3. Directional Center Organizational Chart (Standard-Remote)

Senior Director

The Senior Director is the officer in charge of the Direction Center (DC). He has supervisory responsibility over all of its operational branches -- Air Surveillance, Identification, and Weapons.

AIR SURVEILLANCE BRANCH

SAGE does not simplify the surveillance process. On the contrary, the introduction of a computerized system complicates the process, even though the human error factor is virtually eliminated. Air Surveillance remains the most important element in air defense at the beginning of an air defense situation. As in the manual system, SAGE Air Surveillance also has related functions: detection, establishment, and monitoring of tracks (Tracking Element); filtering of undesirable radar returns (Mapping Element); processing information from sources not equipped for suitable entry of data into the computer (Manual Inputs); and processing of altitude information (Height Element).

The Air Surveillance function will be outlined in the following pages. A breakdown of each element and its complicated switch actions will not be attempted because knowledge of such details are not of immediate concern to the reader. However, additional information can be obtained in ADC SAGE Positional Handbooks associated with the particular job element concerned.

Air Surveillance Officer (ASO)

The ASO supervises the activities of the Air Surveillance Branch of the Sector Direction Center. He ensures that accurate data on the current and predicted air situation are gathered and maintained by surveillance personnel. He is responsible for ensuring that the best possible radar coverage is obtained and that equipment associated with air-surveillance functions is kept in good operating condition. Furthermore, he is responsible for ensuring that the most significant types of data are gathered and that the system count is kept as low as possible, while still enabling a high rate of useful data to be accepted.

A wide range of functions within the Direction Center are under the ASO's direction. These functions are of two types.

1. Functions that are the exclusive responsibility of the Air Surveillance Branch. This group includes radar inputs and counter-countermeasures, manual data inputs, tracking, and height finding.

2. Functions in which surveillance personnel have specific responsibilities, but whose operations are carried on jointly with other DC branches and/or the CC. This group includes information transfer, master operational tape (MORT) recording, start-over and switchover, and Mode II. The ASO is responsible to the Senior Director (SD) for the operation of the Air Surveillance Branch. He coordinates with the SD and the Senior Air Surveillance Officer (SASO) at the Region Combat Center. He also coordinates with ASO's in adjacent Sectors to resolve those air-surveillance problems that cannot be solved on subordinate levels within his own branch.

The facilities with which the ASO is provided include a Situation Display (SID) Console with a Digital Display (DD) scope, an Input Data Selection Control (wing) Panel attached to the ASO SID console, a Light Gun, a Radar Input Monitor (RIM) console, and telephone and radio equipment for communication with airborne radar platforms (ARP). The ASO is assisted in carrying out his duties by the Air Surveillance Technician (AST), who is provided with an auxiliary console that contains a DID scope.

Manual Data Supervisor

The Manual Data Section receives, records, verifies, and processes all manual data, for both the Direction and Combat Center, that arrives by teletype or voice telephones.

The major functions of the MDSA are to assist the MDS in the performance of his functions and to assume command of the Manual Data Section in the absence of the MDS.

The major functions of the Manual Data Technicians are to receive, transcribe, and insert manual data into the computer, and to assist the MDS and MDSA in reconstructing the air situation with minimum delay during startover and/or switchover.

Height Supervisor (HS) Position

The function of the Height Section in the SAGE System of air defense is to provide accurate and up-to-date height and flight-size information on all airborne objects within coverage of the Sector's height finders and being tracked at the DC.

Tracking Section

The tracking section is responsible to the ASO for track detection, track initiation, and track monitoring functions.

IDENTIFICATION BRANCH

Identification Officer

The Identification Officer is directly responsible to the Senior Director for the operation of the Identification Branch, consisting of the IDO and two Identification Technicians. The Identification branch is responsible for determining the identification of all airborne objects being tracked within the area of responsibility of the SAGE sector.

Senior Weapons Director

Coordination of weapons employment, supervision of Weapons Directors (WD) and assisting the Senior Director are responsibilities of the Senior Weapons Director (SWD).

The SWD observes the air situation and assists the SD in the threat evaluation. The SWD also confers with the SD concerning the adequacy of available weapons, verbally allocates weapons to weapons direction teams, and monitors and supervises the commitment of weapons against HUK tracks.

WEAPONS BRANCH

Weapons Director (WD)

Air-situation monitoring weapons commitment and the assignment and supervision of the Intercept Directors (5 Maximum) on his weapons direction team are the primary functions of the Weapons Director (WD). He maintains the operational efficiency and discipline of his team of Intercept Directors (IND's) and their Intercept Technicians (INT's). He initiates and coordinates weapons assignment actions taken on all tracks referred to his team, and he relays information on observed situations affecting other positions in the DC and CC.

AN/FSQ-7 SYSTEM BREAKDOWN

The huge data-processing computers that make up the principal equipments of the AN/FSQ-7 Combat Direction Central and the AN/FSQ-8 Combat Control Central are broken down into seven major systems through which all data is processed. They are:

a. Input System

b. Drum System

c. Central Computer System

d. Display System

e. Output System

f. Power Supply and Marginal Checking System

g. Warning Light System

The first five systems listed above are integral parts of the data-processing operations of the AN/FSQ-7 and the AN/FSQ-8 and execute functions within themselves which contribute to the overall operational solution of the air defense problem. The latter two systems listed above are not directly concerned with the defense functions of either Central.

For purposes of uniformity in design, production, and maintenance, the AN/FSQ-8 equipment installed at the Control Central is almost identical to its counterpart, the AN/FSQ-7, at the Direction Center. However, because of functional differences, certain portions of the equipment at the Control Center are either made inoperative or entirely omitted.

The Combat Control Central requires fewer operating personnel and has fewer display consoles than the Combat Direction Central. The Combat Control Central does not process raw radar data; therefore, the equipment required for receiving and processing radar is unnecessary at these installations. Likewise, the amount of manual data input equipment is reduced. It follows logically that the computing capacity of the AN/FSQ-8 will not be as heavily committed as that of the AN/FSQ-7. Therefore, the Combat Control Central is able to assume additional activities in the future as the needs arise.

REVIEW QUESTIONS:

1. What functions does the standby computer perform?

2. What is the primary operational unit of the SAGE sector?

3. What is the mission of the air defense?

4. What are the major systems of the Central computers?

Direction central
Control "

CHAPTER 3 - PHYSICAL LOCATION CODING

GENERAL

In order to maintain highly complex equipment such as the AN/FSQ-7 and -8, it is essential that each component part, from the largest unit to the smallest terminal be easily located. To that end, a simple and effective coding system is employed, which is consistent within the equipment and standard to every equipment site.

Modular Unit

The coding begins logically with the largest unit and proceeds in progressive breakdown steps to the smallest component or terminal. A pictorial layout of the second floor of a site is shown in Figure 3-1. Each block pictured is a modular unit; as such, it is the largest unit and, therefore, the first designated. Figure 3-2 illustrates the modular unit, its division into modules, and pluggable-unit assemblies.

Modules

The modules are the second largest unit and are marked from A to Z. The module on the extreme right is always the "Z" or power module. Right and left-hand, as used here, is viewed from the rear of the modular unit facing the wiring side. Figure 3-3 shows the detailed coding breakdown of the "standard" module. A representative site will have different types of units. Physically, the units fall into two broad categories: standard modules, made up of pluggable units, and assorted nonstandard modules, consoles and combinations of the two. The following progressive coding rules and the examples given for each step will make possible the location of any component or terminal, as previously stated.

Pluggable Unit

a. A unit is designated by a number (four digits maximum).

b. A module within a unit will be designated by a capital letter.

c. A pluggable unit assembly location is assigned the capital letter that designates the row area.

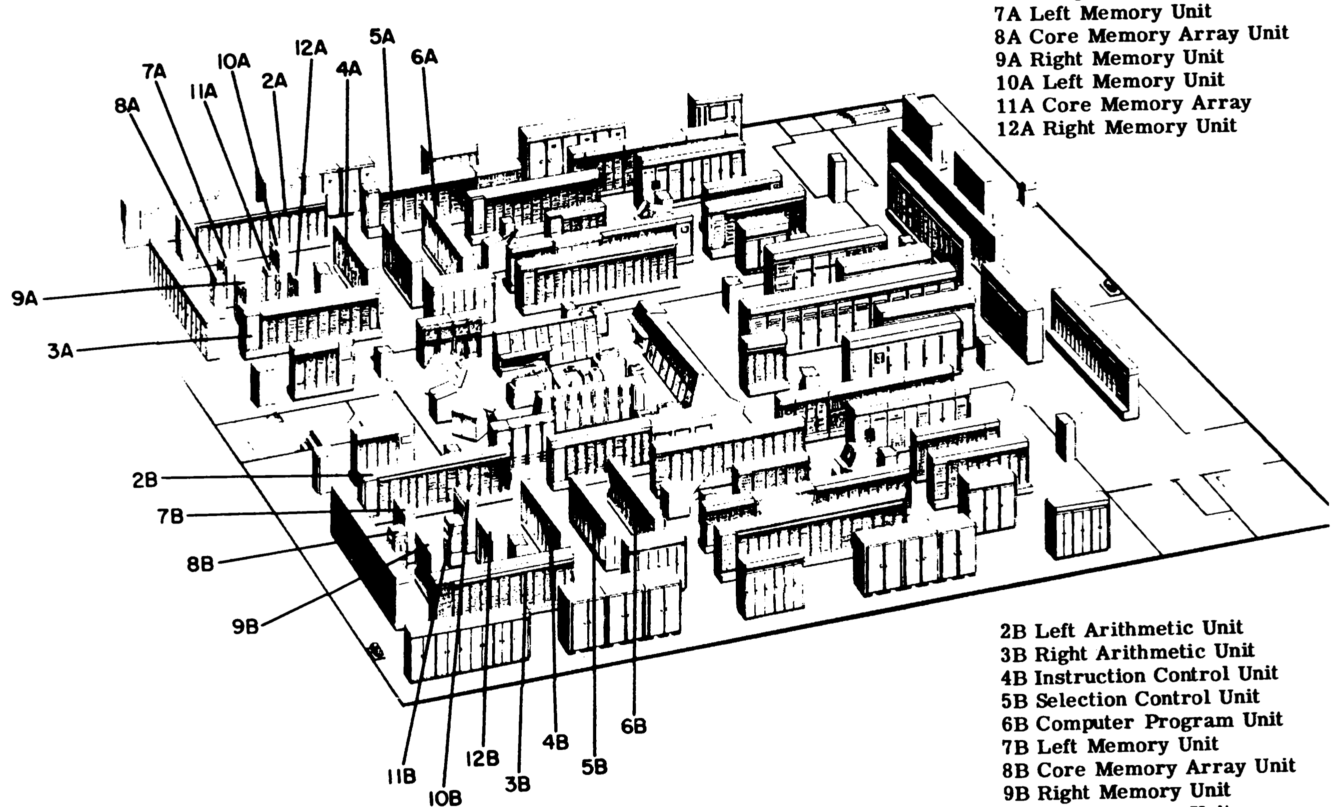
d. Each terminal group is designated by a capital letter.

e. Each terminal pin will be designated by a number.

Example: Standard pluggable unit assembly connector termination code.

a	b	c	d	e
34	C	E	B	2

2A Left Arithmetic Unit
3A Right Arithmetic Unit
4A Instruction Control Unit
5A Selection Control Unit
6A Computer Program Unit
7A Left Memory Unit
8A Core Memory Array Unit
9A Right Memory Unit
10A Left Memory Unit
11A Core Memory Array
12A Right Memory Unit



2B Left Arithmetic Unit
3B Right Arithmetic Unit
4B Instruction Control Unit
5B Selection Control Unit
6B Computer Program Unit
7B Left Memory Unit
8B Core Memory Array Unit
9B Right Memory Unit
10B Left Memory Unit
11B Core Memory Array Unit
12B Right Memory Unit

Figure 3-1

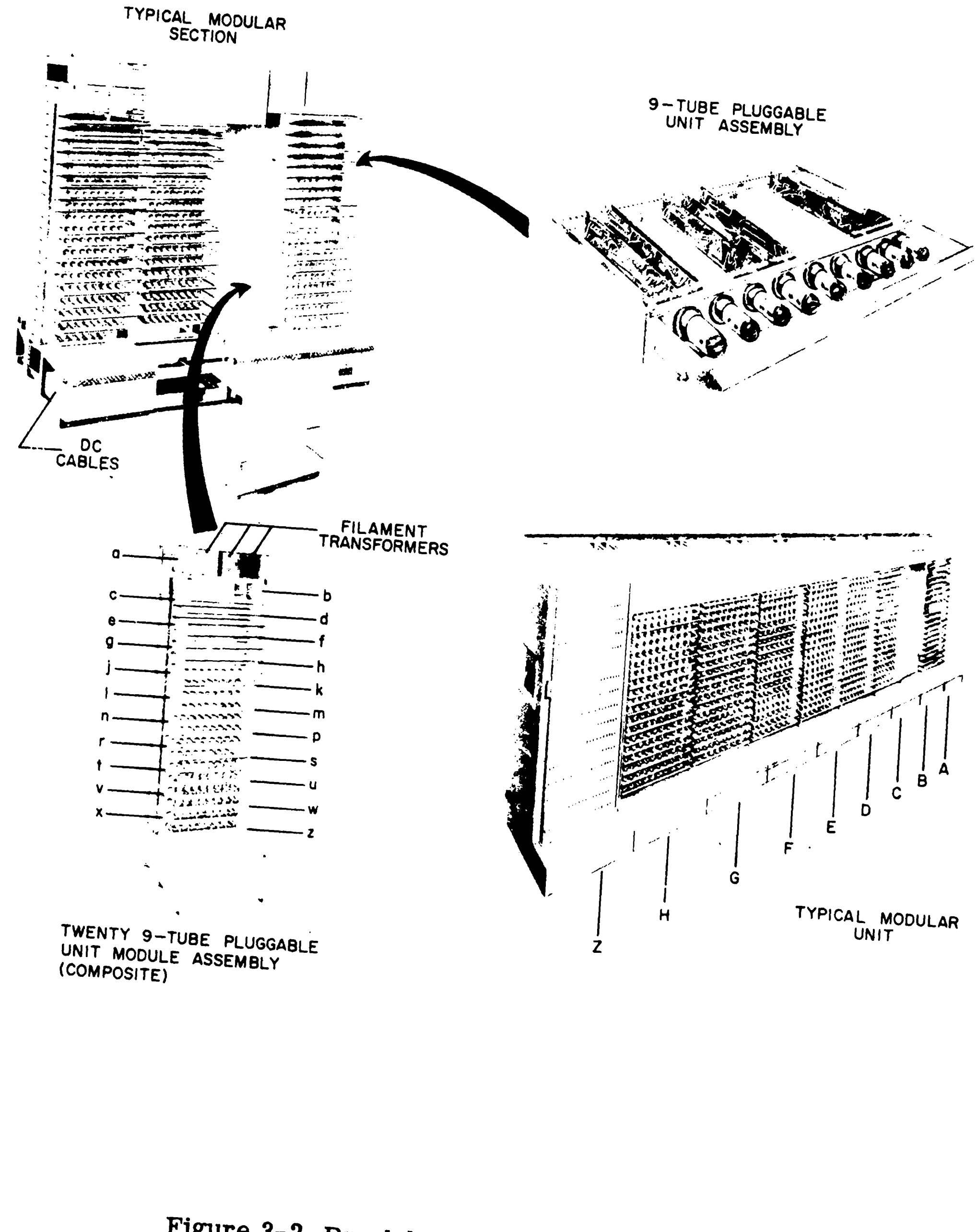


Figure 3-2. Breakdown of Typical Modular Unit

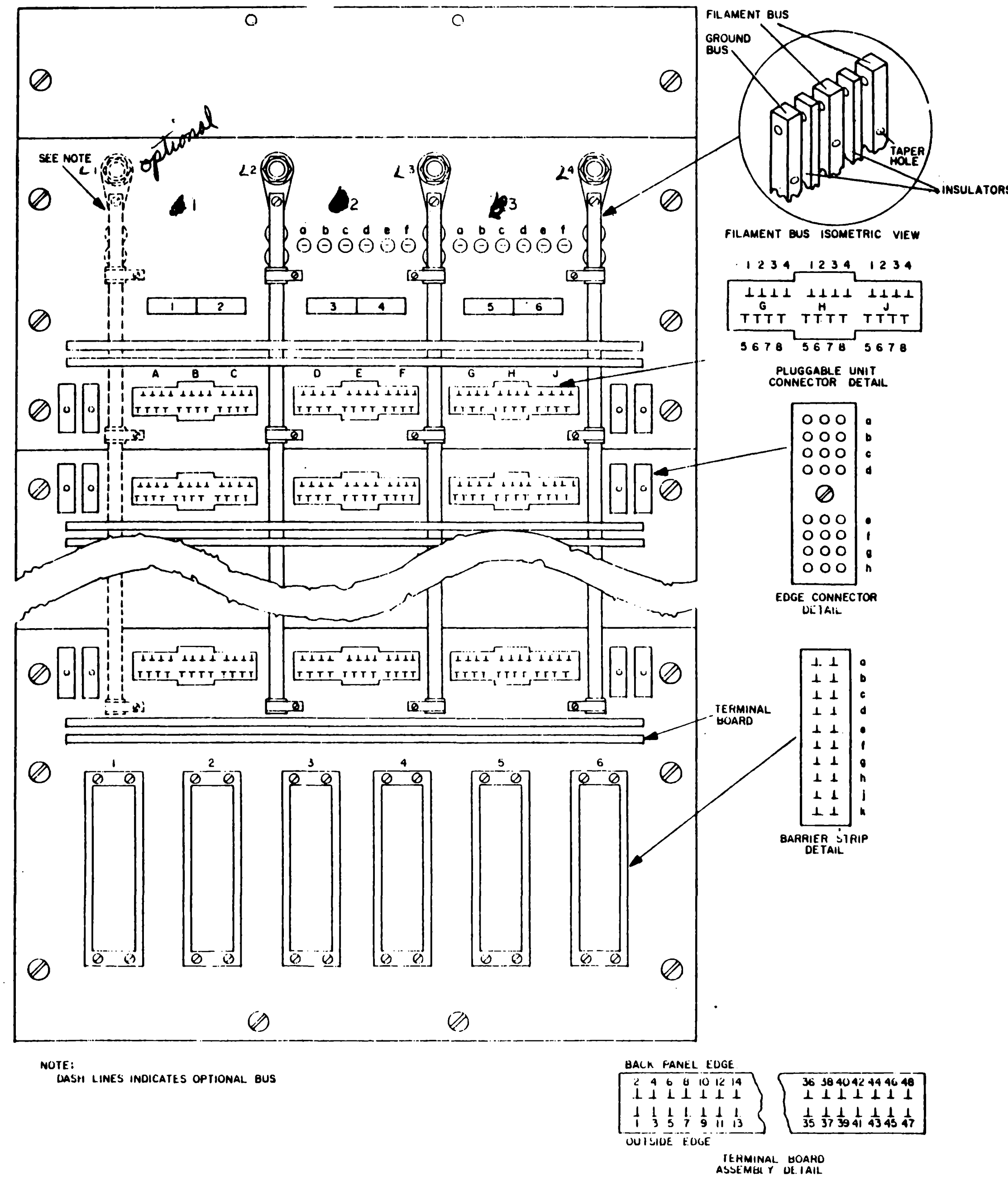


Figure 3-3. Pluggable Unit Assembly, Connector Termination Code

Edge Connector and Barrier Strip

a. A unit is designated by a number.

b. A module within a unit will be designated by a capital letter.

c. Each row location is assigned the capital letter that designates the row area.

d. Each column is designated by a number.

e. Each terminal will be designated by a lower case letter.

Example: Standard edge connector assembly code and standard barrier assembly code.

a	b	c	d	e
34	E	C	2	b

Resistor Board

a. A unit is designated by a number.

b. A module will be designated by a capital letter.

c. Each row will be designated by a capital letter.

d. A lower case u or l is used to designate the board as upper or lower, respectively.

e. A number will be used to designate each terminal.

a	b	c	d	e
34	F	E	u	4

Power Module Code

Power modules attached to each unit are designated module Z. This immediately identifies the power module in all physical location and reference coding, since the letter Z is reserved for power distribution exclusively. The three panels involved shall be numbered 1, 2 and 3, from left to right, from the service side of the module where the back access door will be panel 1. Panel 2 would be the resistor panel side of the module; the relay circuit breaker panel will be panel 3.

Example 1: Circuit breaker located on panel 3.

UNIT	MODULE	PANEL	ROW	COLUMN	TERMINAL
2	Z	3	F	14	b

Example 2: Power resistor located on panel 2.

UNIT	MODULE	PANEL	ROW	COLUMN	TERMINAL
2	Z	2	AA*	3	b

*Two digits will be used if the number of rows exceeds 23.

Multi-Turn Potentiometer

Multi-turn potentiometers are coded, as shown in Figure 3-4.

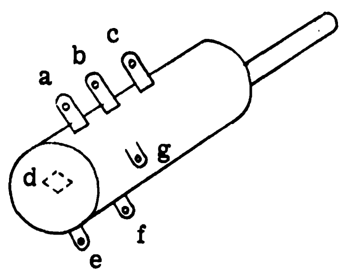


Figure 3-4

Relay Definitions

a. A single coil relay is energized or de-energized

b. A multi-coil relay is picked (when energized by a pick coil) and is held (when energized by a hold coil). The relay drops when the hold circuit is broken.

c. A latch-type relay is latched (when the latch coil is energized) and unlatched (when the latch trip coil is energized).

Note: In this type of relay, the armature has a mechanical link maintaining the armature in its energized position after the latch coil is de-energized.

d. Relay contacts are normally open (NO) or normally closed (NC) as determined by the de-energized or unlatched armature position of the relay.

e. Relay pickup and drop out time refers to the time lag between energizing or de-energizing the relay coil and the actual making or breaking of the contacts.

Relay Rack Coding

The relays are mounted in vertical racks with K numbers assigned to the mounting locations. The numbers are assigned sequentially from front to back when facing the back panel. The numbers are first assigned to the left-hand rack and then continued on the right-hand rack.

One of the following combinations of IBM relays can be mounted symmetrically on the rack and will be designated as indicated.

IBM Relay	Quantity per rack	Designation locations on rack
4 contact	6	K-1 - K-6
6 contact	4	K-1 - K-2, K-4, K-5
12 contact	2	K-1, K-4

In addition to the IBM relays it is possible to mount two plug-in type relays on the extreme ends of the rack. These mounting locations are designated K7 and K8, left and right, as viewed from the wiring side.

Example:

UNIT	MODULE	ROW	RELAY	TERMINAL
41	E	E	(K4)	C3

Wire Contact Relays (used to replace several smaller relays plug-in type for easy cleaning + replacement)

In relay gates when IBM wire contact relays are mounted in rows and columns, a grid coding system is used. The example given here is of a 6-position wire contact relay where the diagram is viewed from the contact side of the relay.

Example: Identifying and coding IBM wire contact relays.

1	A	C	3	B	4
UNIT	SECTION OR MODULE	ROW	COL	ROW	COL
		RELAY		TERMINAL	

The encircled pin in the diagram is that pin called out by the sample code.

The rows called out on this relay refer to the standard symbols for relays; (a) being common, (b) normally closed, and (c) normally open. The (d) row is for coil connections, with the two outside pins as the "pick" and the two inner contacts as "hold."

On occasion it may become necessary to group together more than one type of relay. The symbol K is therefore assigned to this and all other relays. The numbers assigned will run sequentially, in accordance with the standard practice of left to right and top to bottom on the particular sub-portion of equipment.

Figure 3-6 is a representation of this relay for wiring diagrams and logical drawings.

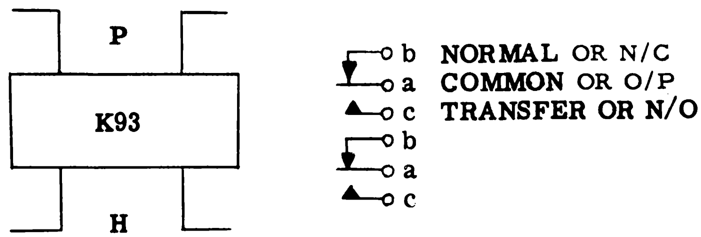


Figure 3-5

Clare Relays

heavy duty control over several circuits simultaneously

Three systems of position identification for Clare relays will be used: the grid, the sequential, and the graphic.

a. Grid system: This shall be used only when component parts are in clearly defined rows and colums.

1	A	C	3	B	3
UNIT	SECTION MODULE	ROW	COLUMN	TERMINAL	ASSEMBLY

b. Sequential system: This shall be used when the rows and columns are not clearly defined. This system assigns to each relay a K number, K being the approved symbol for relay, and a number in the conventional manner of left to right and top to bottom.

1	A	(K40)	C	3
UNIT	SECTION MODULE	RELAY NUMBER	TERMINAL	ASSEMBLY

c. Graphic system: This shall be used in all wiring diagrams and logical drawings. It shows the actual operation of each terminal.

The contact assemblies of the Clare relay are assigned consecutive numbers from left to right, top to bottom, with the relay held in its reference position. The reference position shall be as viewed from the wiring side with the coil to the bottom, as shown in Figure 3-7. The relay terminal designations will be as follows:

y - signal side of "pick" coil

z - return side of pick coil

y' - signal side of "hold" coil

z' - return side of hold coil

a - common arm

b - normally closed contact

c - normally open or transfer contact

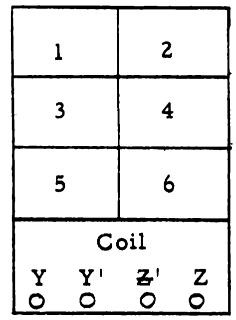


Figure 3-6

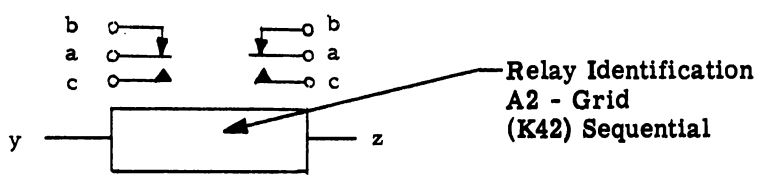


Figure 3-7

Relay Coil Identification

The symbol LP will be used to identify the pickup coil of a latching relay which is energized. The fact that the relay contacts remain transferred when the pickup coil is de-energized is shown by a dotted bar. The symbol LT is used to identify the trip coil.

a. 4-position relay

pins 1 and 4 - "pick" coil

pins 2 and 3 - "hold" coil

b. 6-position relay

pins 1 and 6 - "pick" coil

pins 2 and 5 - "hold" coil

c. 12-position relay

pins 1 and 12 - "pick" coil

pins 2 and 11 - "hold" coil

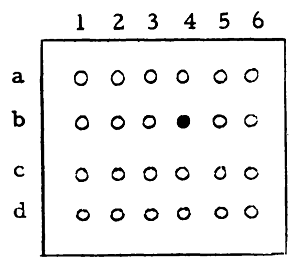


Figure 3-8

to sequence actions of more than 1 step or to increase volts in sequence

Step Relay

Step relays are coded, using the coil and screwheads as points of reference.

a. Sections

With the relay held so that the screwheads are to the right and the end of the coil is viewed, the switch sections (vertical columns of terminals) will be coded from right to left with capital letters. (See Figure 3-9A).

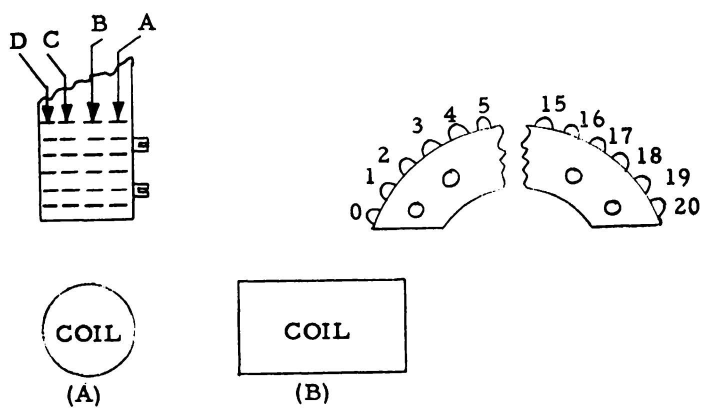


Figure 3-9

b. Terminals

With the relay held so that the screwheads are faced and the coil is to the left, wiper or transfer arms will be coded with lower case letters starting from the extreme counter clockwise position.

The terminals are then coded consecutively with numerals starting with the terminal next to the transfer arm and proceeding in a clockwise direction (See Figure 3-9(B).

Example: (sequential system)

1	A	3	(K7)	A	3
UNIT	MODULE	PANEL	RELAY	SECTION	TERMINAL

Delay Units

Delay units mounted on back panel boards will be located by the following code:

UNIT	MODULE	ROW	DELAY UNIT POSITION	TERMINAL
11	B	C	B	0.1

The delay units may be mounted in three positions on the resistor board with the location code reflecting the proper delay unit position (B, E, H) designation, as shown in Figure 3-10.

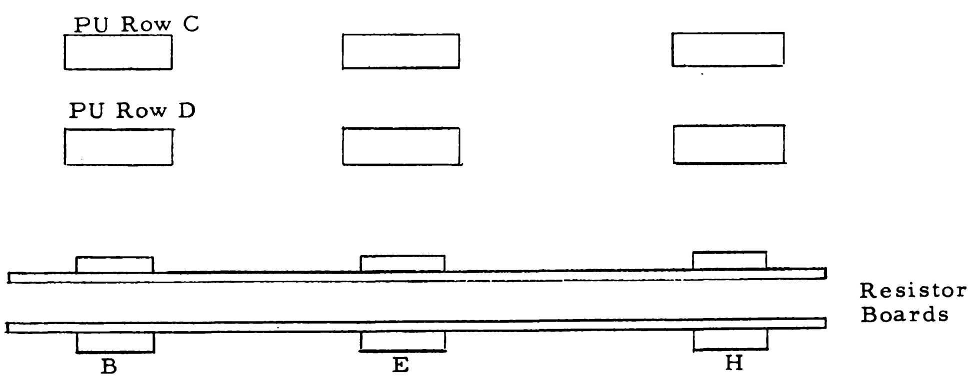


Figure 3-10

Coding of Panels and Doors

Panels within a module are coded with arabic numerals. The panel on the extreme left, when viewing the wiring side of the module, will be designated 1. The coding proceeds in a clockwise direction with the numerals 2, 3, 4, etc., as required. Doors are coded in the same way as panels.

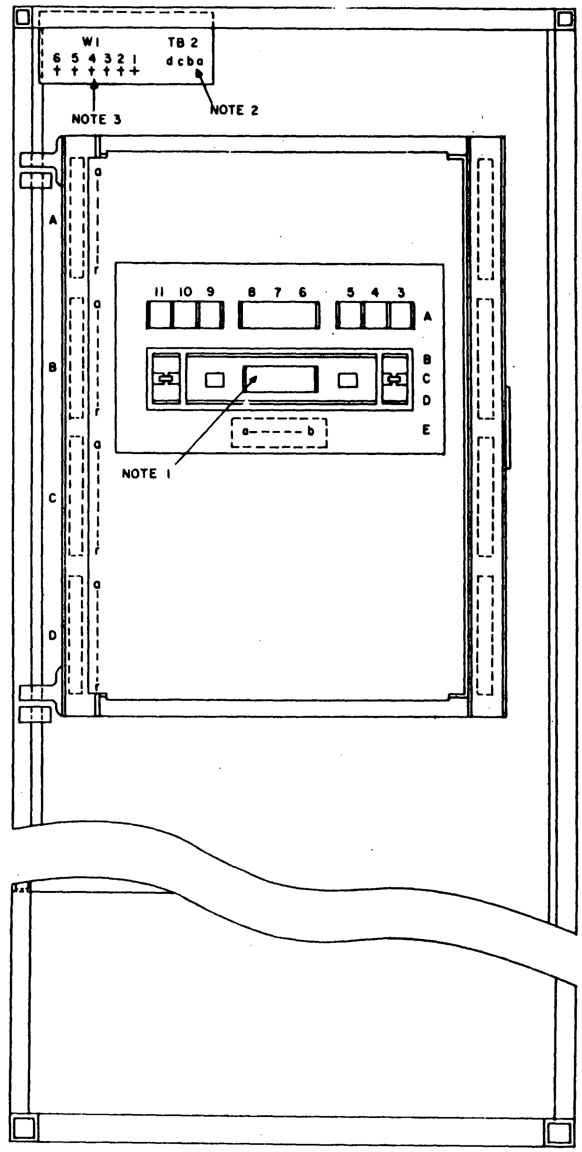
a. General Summary of Coding Rules

1) The letters I, O, Q, i, o, q are omitted from alphabetic coding.

2) All coding shall be referenced to the wiring side of the panels.

3) Coding for panels shall be lettered from front to back, top to bottom, left to right, when viewing the wiring side.

4) Module Z of a modular unit will refer to the power module.



NOTE:

1.	UNIT 2	MODULE Z	PANEL 1	ROW C	COLUMN 7	TERMINAL a OR b
2.	UNIT 2	MODULE Z	PANEL 1	COMPONENT (TB2)A		
3.	UNIT 2	MODULE Z	PANEL 1	COMPONENT (W1) 3		

IDENTIFICATION CODE, PANEL 1, Z MODULE

Figure 3-11

b. Panel 1, Z Module

Figure 3-11 illustrates three examples of coding for Panel 1, of the Z Module.

c. Test Doors

Test doors will be considered as panels and coded as such. Either the grid or sequential system of location coding may be used within the test doors.

	a	b	c	d	e	f
Example:	-	-	-	-	-	-
	42	E	1	B	4	a1

a) Unit

b) Module

c) Panel

d) Row

e) Column

f) Terminal

Filament Wiring

The illustration Figure 3-12 is a composite schematic of the filament load distribution and bias. There are up to three filament transformers per module, and are located at PU rows A & B. Generally, two transformers are required for the 6-tube modules and three for the 9-tube modules. Each transformer on a module is connected to a different phase of the 3-phase 208/120 VAC-System. This is done by running the filament power lines from the Z module across the top of the modular unit to the individual module circuit breaker and then to the filament transformers. Four wires are thus brought from the Z module. Three of the wires are the three 208-volt phase to phase legs; the other wire is a ground bus and is common to all three phases for 120-volt primary connections.

This ground bus serves as the ground return for all modules. No ground connection is made at individual module frames. Providing a ground connector at only the Z module prevents the possibility of ground loops within a modular unit. Ground loops are difficult to isolate when troubleshooting equipment for faulty operation.

The filament transformers used in the 3-phase distribution have a tapped primary and two secondary center-tapped windings.

The six primary winding taps are used to compensate for load effects on line voltage. The two center taps of the secondary windings are used to provide filament voltage biasing for different circuit conditions and to prevent an overvolting differential between tube cathode and filaments.

The electrostatic shield which exists between primary and secondary windings is brought out to a terminal connection, as indicated in the schematic drawing.

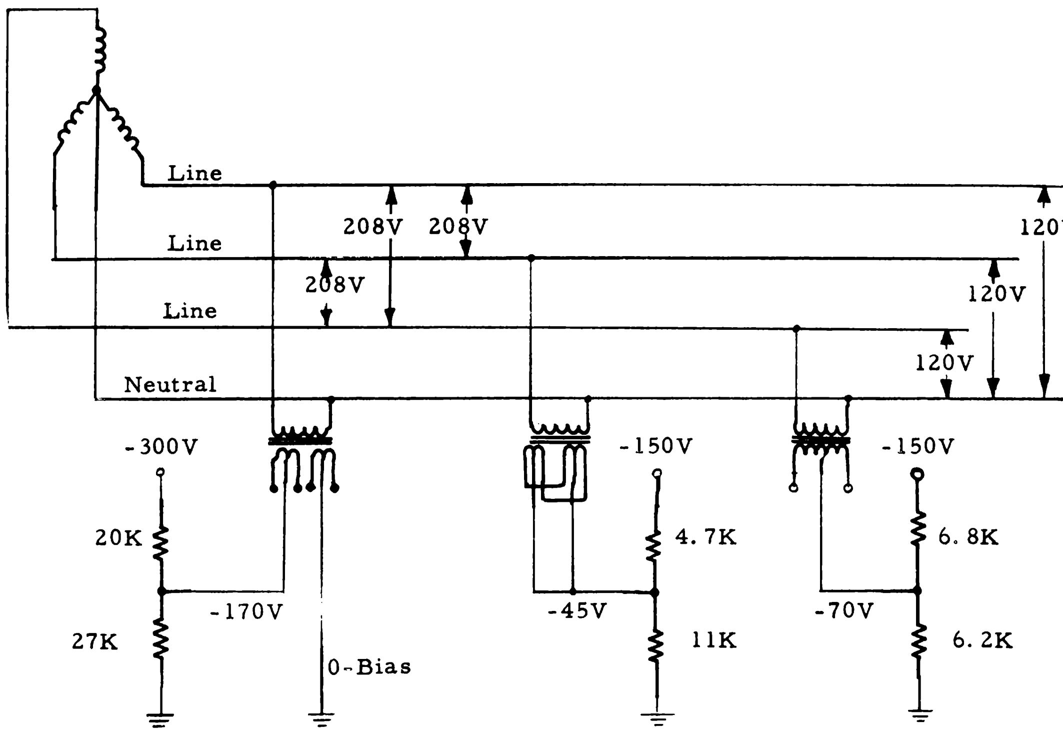


Figure 3-12

COMPONENT CODES AND SYMBOLS

Wire Color Code

This section establishes the color code to be used in coding equipment wiring with regard to its voltage and use. The applicability and/or application of the code in special cases is also included. Wire color code shall be considered as an aid to wire identification. A component color code (Figure 3-13) is included as an aid to the physical identification of components.

Color Code.

Code Number	Color	Voltage and Use
None	Yellow	Signal
None	Yellow, twisted pair	Signal
None	Yellow and black pair, Shielded	Signal

Code Number	Color	Voltage and Use
X or Y	Brown	Heater voltage at -70V DC bias.
X or Y	White with brown tracer.	Heater voltage at other than -70V DC bias.
0	Black	Ground or common
2	Red	+91 to +150V DC
3	Orange	+150 to +250V DC
5	Green	-31 to -150V DC, except -48V DC relay voltage.
6	Blue	-16 to -30V DC
7	Violet	-150 to -300V DC
8	Gray	+73 to +90V DC
9	White	-1 to 15V DC
24	Red with yellow tracer	High voltage cable shielded, 600V to 10KV.
	Red with white & white tracers	High voltage cable unshielded, 600 to 10 KV
25	Red with green tracer	High voltage shielded over 10 KV
92	White with red tracer	+150V DC marginal check
93	White with orange tracer	+250V DC marginal check
94	White with yellow tracer	-150V DC reset
95	White with green tracer	-150V DC marginal check
96	White with blue tracer	+150V DC relay
97	White with violet tracer	-300V DC marginal check In test equipment, a lead common to several marginal check voltages.
98	White with gray tracer	+90V DC marginal check
901	White with black and brown tracers	28V AC

Code Number	Color	Voltage and Use
905	White with black and green tracers	Display console input to wing boxes
906	White with black and blue tracers	12V AC, other than heaters
915	White with brown and green tracers	-150V DC, decoupled, DC Heater 200 amps.
920	White with red and red tracers	120V AC, unregulated
923	White with red and orange tracers	-300 to -450V DC
926	White with red and blue tracers	-450 to 600V DC
935	White with blue and orange tracers	-48V DC, relay
936	White with orange and green tracers	+10 to +72V DC
965	White with blue and green tracers	208V AC, regulated
971	White with violet and brown tracers	+600 driver, situation display
984	White with gray and yellow tracers	115V AC, regulated

Multi-Conductor Cables

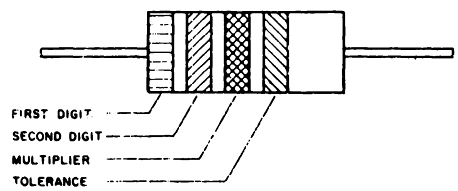
Multiconductor cables connecting modules and protected throughout their length by sleeving may be color-coded for wire identification only.

Color Coding "Change" Points

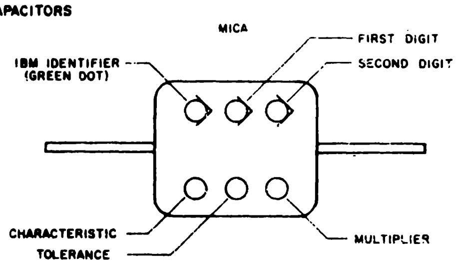
The "change" point for service voltage color-coding of wiring between power distribution and electronic chassis shall be at the circuit breakers of the load unit Z module and at the circuit breakers associated with simplex input and display equipment.

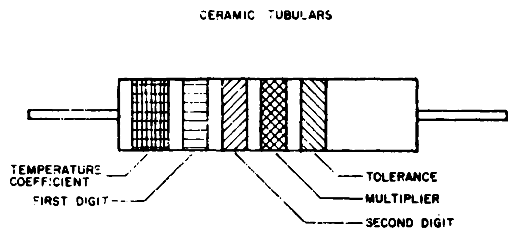
In load units which do not have a Z module, the change point for service voltage color-coding shall be at the first terminal to which the service voltage connects after entering the unit.

RESISTOR



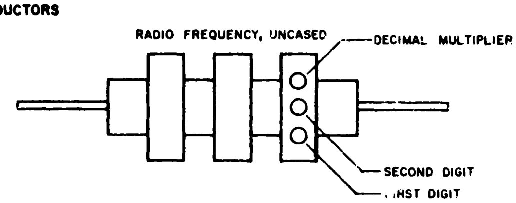
CAPACITORS

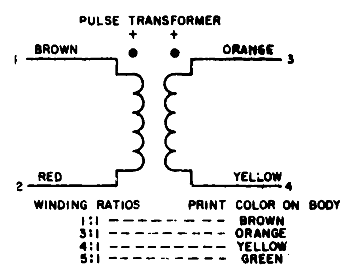




COLOR	FIRST AND SECOND DIGITS	DECIMAL MULTIPLIER	TOLERANCE PERCENT	VOLTAGE	CHAR.
BLACK	0	1			A
BROWN	1	10	1	100	B
RED	2	100	2	200	C
ORANGE	3	1000	3	300	D
YELLOW	4	10000	4	400	E
GREEN	5	100000	5	500	F
BLUE	6	1000000	6	600	G
VIOLET	7	10000000	7	700	
GRAY	8	100000000	8	800	
WHITE	9	1000000000	9	900	
GOLD		0.1	5 (J)	1000	
SILVER		.01	10(K)		

INDUCTORS





SEMICONDUCTOR DIODE

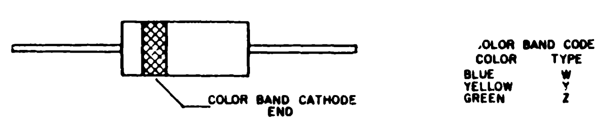


Figure 3-13. Component Color Code

External Wiring

Wire color-coding within cables between units shall be for wire identification only and shall not denote voltage levels or use.

Internal Wiring of Power Distribution and Marginal Checking Units.

The internal wiring of these units shall be coded, using black for voltage distribution and white for ground, common or neutral.

Marginal check wiring from the load unit Z module to the barrier strips shall be either black or black with a tracer for wire identification. When a load unit has no Z module, the marginal check wiring from the distribution unit to the load unit shall be black with a tracer for wire identification.

Convenience Outlets and Filament Transformer Primaries

Wiring to convenience outlets and filament transformer primaries in the load modules shall be coded, using black for voltage distribution and white for ground, common, or neutral.

CHAPTER 4 - BASIC CIRCUITS AND LOGIC SYMBOLOGY

GENERAL

In a large scale computer such as the AN/FSQ-7, the complexity of its overall operation and function makes it necessary to present circuit analysis in block form known as logic. This chapter will establish the basic circuits involved in each of these blocks along with the terms and conventions necessary for understanding of the AN/FSQ-7 SAGE computer, and in addition, lay the ground work for understanding of other computers.

A thorough understanding of the material presented here is necessary before you can expect to gain sufficient knowledge of succeeding material presented in this course of study. Failure to apply yourself and establish a firm knowledge of this material will only cause hardship and possible failure in later blocks of instruction.

The circuits presented in this text are simple and straightforward but, when combined into the logic circuits that make up the AN/FSQ-7 computer, form highly complex circuits that perform the multitude of high complex functions necessary to perform the air defense mission.

COMMON CIRCUIT CHARACTERISTICS

Standard and Non-Standard Signals

Standard Pulses: The standard pulse (Figure 4-1) is a +30 volt pulse (nominal) with a tolerance of ± 10 volts. The pulse shape approaches that of the positive half of a sine wave, with a negative tail of indefinite value.

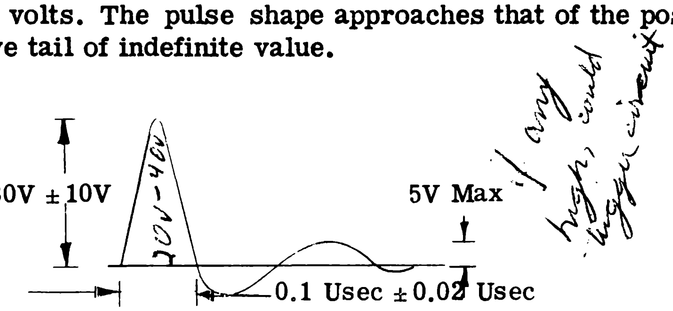


Figure 4-1. Standard Pulse

The pulse width measured at the base has a nominal value of 0.1 microsecond and a tolerance of ± 0.02 microsecond. It is evident that a standard pulse is defined by its amplitude, pulse width, and shape.

Standard Levels

There are two standard levels (Figure 4-2): the up level is a d-c potential of +10 volts (nominal); the down level is a d-c potential of -30 volts nominal. Rise time T_r is the period during which the potential climbs 40 volts from a down level to an up level. Fall time T_f is the period during which the potential drops 40 volts from an up level to a

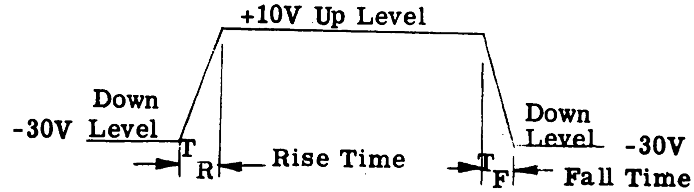


Figure 4-2. Standard Levels

down level. The standard signals just discussed are represented as logic lines with characteristic terminating symbols (Figure 4-3).

The standard pulse is indicated by a line terminated in a solid arrowhead. The standard level, either up or down, is indicated by a line terminated in a solid diamond.

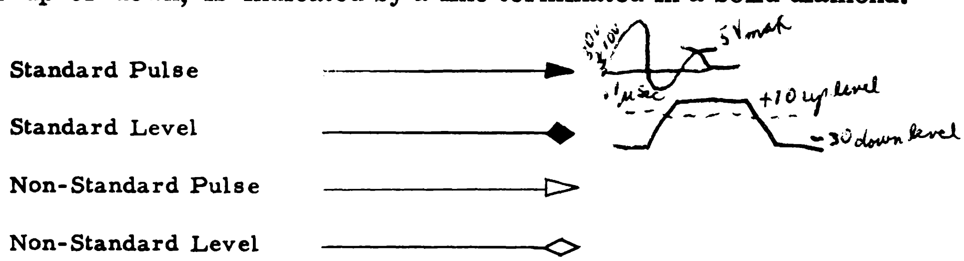


Figure 4-3. Logic Representation of Pulses and Levels

Non Standard Signals

A nonstandard pulse is indicated by a line terminated in an open arrowhead. Any other nonstandard signal will be indicated by a line terminated in an open diamond.

PHYSICAL CHARACTERISTICS

Several electrical circuit refinements are dictated by the physical layout and by the techniques employed in the packaging of the circuits in the AN/FSQ-7 and AN/FSQ-8 Systems. To appreciate the necessity of the electrical requirements peculiar to this equipment, it would be advantageous to become acquainted with the physical characteristics of the machine.

A basic circuit consists of one or more card assemblies, together with other detail parts and wiring. The card assembly consists of a card detail upon which parts are automatically mounted and dip-soldered. Figure 4-4 presents front and rear views of a typical card detail. The card is composed of a phenolic base tooled as indicated in this figure. Both sides of the card contain printed circuitry which interconnects the appropriate lands. A typical card assembly, depicted in Figure 4-5, has the detail parts and lugs mounted. A number of these cards are then mounted in a mechanical assembly and electrically connected to various detail parts, such as vacuum-tubes sockets, individual resistors, capacitors, and electrical connectors. This complete assembly is called a pluggable unit. The pluggable unit may consist of several basic and special circuits which are electrically connected.

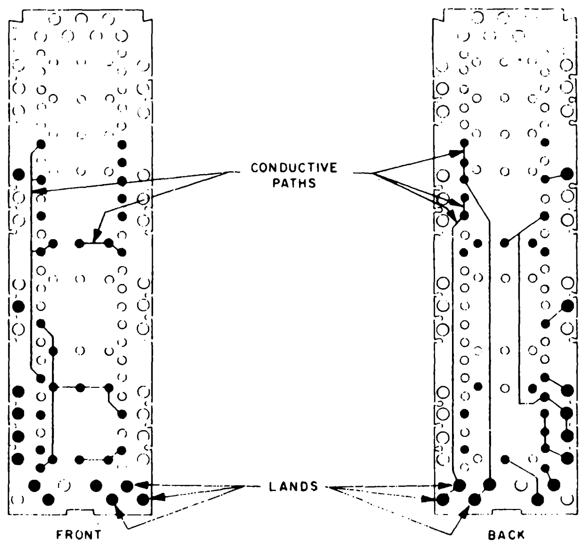


Figure 4-4

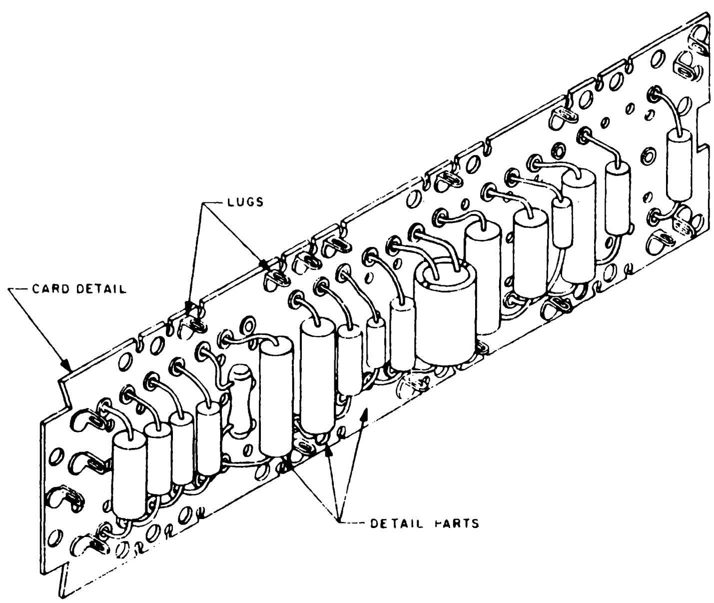


Figure 4-5

This method of physical construction makes possible the automatic manufacture of the card assemblies and easy removal and replacement of the pluggable unit. There are two standard types of pluggable units: one accommodates a maximum of nine vacuum tubes; the other, a maximum of six tubes. The electrical connectors mounted along the bottom of the pluggable unit provide a means of supplying service voltages and inputs to the unit. Outputs are also taken from these points.

PARASITIC SUPPRESSION

The manufacturing and packaging techniques just discussed result in lead lengths longer than those in common use.

The basic circuits, for the most part, include vacuum tubes. In circuits of this type, where long leads are prevalent, parasitic oscillations result. Parasitic oscillations are undesirable, self-generated, cyclic voltages, produced by unplanned resonant circuits appearing in the grid, plate, and screen circuits of a vacuum tube.

To eliminate parasitic oscillations, parasitic suppressing resistors are used. Such resistors add loss into an undesirable resonant circuit, reducing the circuit's efficiency to such a degree that parasitic oscillation is no longer possible. For maximum effectiveness, resistors are mounted at the vacuum-tube socket. They will be found in all the plate and control grid leads of the vacuum tubes employed in the basic circuits and also where necessary, in basic circuit vacuum-tube cathode and screen leads.

RC DECOUPLING

The various circuits that constitute the AN/FSQ-7 and AN/FSQ-8 Systems, derive their service voltages from common power supplies. For this reason, numerous vacuum-tube circuits have their plate, control grid, cathode, and screen grid circuits returned through common leads (See Figure 4-6). Long power leads and the fact that a large number of circuits share a common return contribute to the generation of undesired signals. Because these signals would affect machine dependability, resistance-capacitance (RC) decoupling circuits are employed in all the vacuum tube returns to attenuate them.

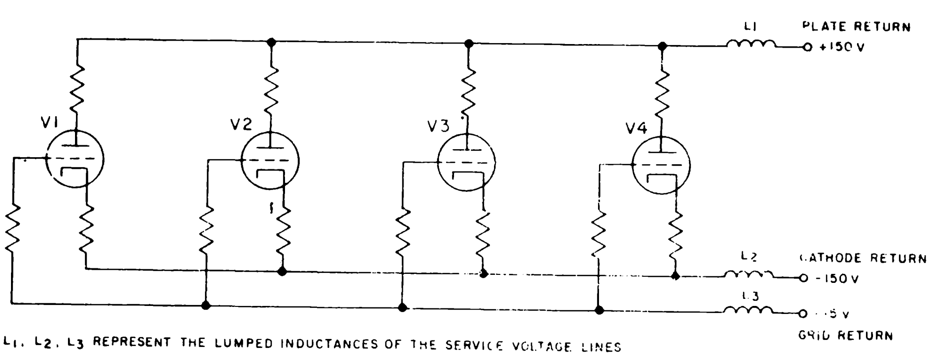


Figure 4-6. Common Return Paths, Simplified Schematic Diagram

Figure 4-7 is a simplified schematic of one vacuum-tube circuit employing an RC decoupling filter in each of its return paths. These RC filters attenuate undesirable signals appearing at the plate, cathode, control grid, and screen grid return circuits to such a degree that dependability is no longer threatened.

COMMON CIRCUITS FOR CLAMPING AND COUPLING LEVELS

There are a number of circuit techniques dictated by the functional requirements of the equipments. Two of these techniques, diode clamping and d-c coupling, are repeated in several of the basic circuits and are treated therefore, as a general circuit consideration.

Diode Clamping

Diode clamping is treated by considering this function in the output circuit of a flip-flop. Figure 4-8 shows the output circuit and the associated triode section of a flip-flop. For the purpose of this discussion, two states of conduction are assumed: The unclamped output is either more positive than +10 volts or more negative than -30 volts.

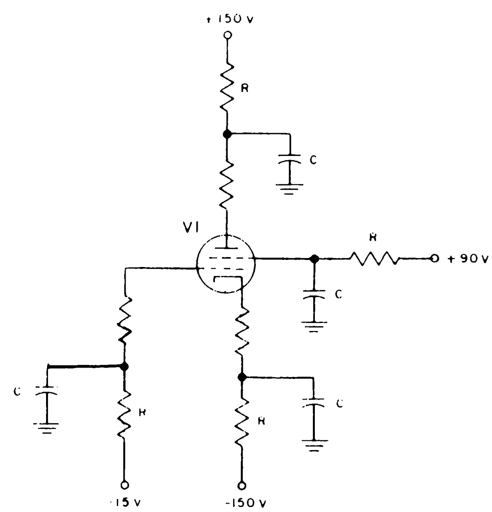


Figure 4-7. RC Decoupled Returns, Simplified Schematic Diagram

The cathode of diode CR-1 is biased at +10 volts. When the output voltage is less positive than +10 volts, diode CR-1 is cutoff. When the output rises slightly above +10 volts, diode CR1 conducts. The current through R-1 (I1 + I2) increases, lower the potential at the output to +10 volts. When output falls slightly below -30 volts, diode CR2 conducts. Current through R2 (I2 + I3) increases, raising the potential at the output to

-30 volts. In this manner, the output of the flip-flop is limited to an up level of +10 volts and a down level of -30 volts.

Varying loads and aging of components could produce undesirable variations of level at the output if they were not clamped as indicated. Clamping either one or both standard levels is a technique employed in certain applications of cathode followers, level setters, inverters, and flip-flops.

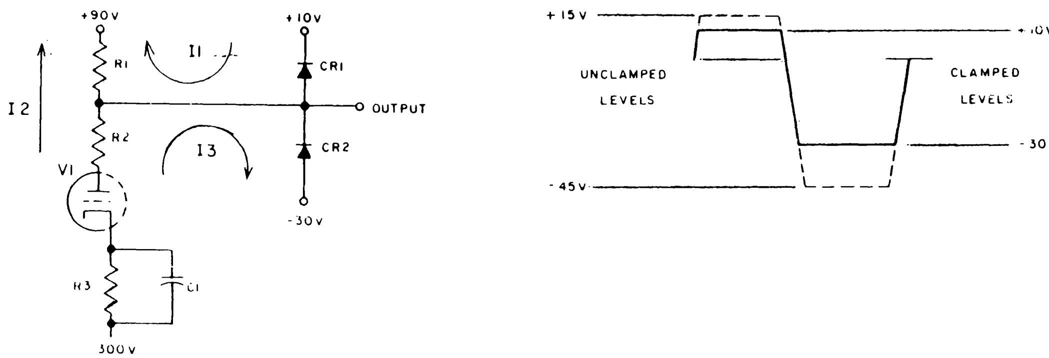


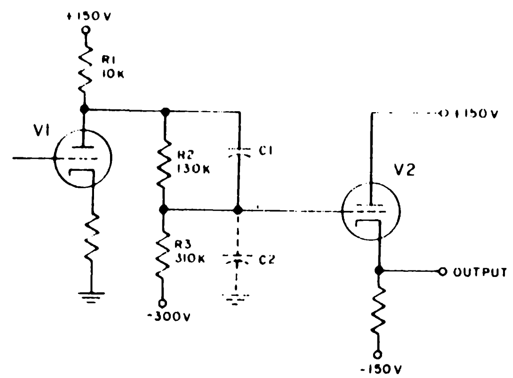
Figure 4-8. Diode Clamped Output Levels, Simplified Schematic Diagram

SPEEDUP CIRCUITS

Machine operation frequently depends on the speed at which levels shift. This makes rise and fall time an important characteristic of level outputs. The speed up of rise and fall time is a requirement satisfied by circuit configurations in certain of the basic circuits which produce levels. Flip-flops, d-c inverters, and d-c level setters are compensated to speed up the rise and fall of the level outputs.

Voltage Divider Compensation

One of the routine methods employed to effect the shortening of rise and fall time is voltage divider compensation. Figure 4-9 is a simplified schematic diagram of a compensated d-c coupling network. Capacitor C1 is a compensating capacitor, the capacitor C2 is the input capacity of V2. This input capacity, which must be compensated for, consists of stray capacity plus the effective grid-to-ground capacity of V2. Were it not for compensation, the capacity of C2 would result in a slow rise and fall at the output of V2 (Figure 4-11). It can be seen that, in the compensated output, there is considerable curvature at the corners of the waveform. This is caused by the attenuation of the high-frequency components of which level shifts are composed. The level itself is not affected because it consists of low-frequency and d-c components, which are not attenuated by C2 capacitance.



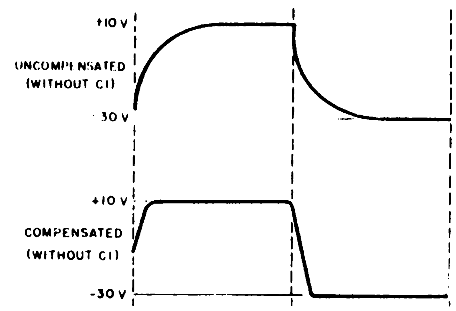


Figure 4-9. Compensated D-C coupling Network, Simplified Schematic Diagram

Figure 4-10. Output Waveform (V2 in Figure 4-9.)

Capacitor C-2 bypasses R-2 (Figure 4-9), increasing the amplitude of high-frequency components at the grid of V2 by the same amount that they are attenuated by capacitor C2. This results in a compensated (speed-up) output (shown in Figure 4-10).

General Diode Information

Due to size and power considerations, vacuum tube diodes are not used in the computer. Instead crystal diodes are used extensively.

General Diode Characteristics.

a. Allowable diode current - 20 to 60 ma.

b. Allowable surge current - 100 to 600 ma.

c. Allowable reverse voltage - 25 to 250 volts.

d. Minimum current with 1 volt forward bias - 2.5 to 15 ma.

e. Maximum reverse current with 50 volts reverse bias - 40 to 1660 micro amp.

f. Capacitance - 0.8 to 3.0 mmf.

There are three main types of diodes used in the AN/FSQ-7 system, with each type being characterized by a color band at the cathode end of the diode.

a. Type Y - used for d-c level switching, matrix switching, and d-c clamping.

b. Type W - used for mixing and clamping standard pulse circuits. Low forward impedance.

c. Type Z - used for switching where d-c bias and pulse conditions both occur (drums). heavy duty

Characteristics

	Type Y	Type W	Type Z
Min. back R	500 K	500 K	500 K
Max. Back E	60 V	60 V	90 V
Max. peak I	45 ma	150 ma	150 ma
Max. rms I	16 ma	60 ma	60 ma
Color band	Yellow	Blue	Green

Band to cathode end

Ckts designed to tolerate min. reverse R of 100 K ohms.

DIODE AND CIRCUITS

Definition and Description

Figure 4-11 is a logic block symbol of a diode AND circuit.

A diode AND circuit is a logic circuit which develops a positive level output, provided all inputs are positive levels. If any input is a negative level, the output level will be negative. The AND circuit may have several inputs.

The crystal diode is an essential part of the diode AND circuit. It is therefore important to become acquainted with the electrical characteristics of the crystal diode to better understand the theory of operation of the diode AND circuit.

The crystal diode is 0.75 inch long and 0.25 inch in diameter. It has two pigtails, one attached to the anode and one to the cathode. To guard against the harmful effects of humidity, it is hermetically sealed. See Figure 4-12.

The crystal diode has a unidirectional electrical characteristic utilized in the AND circuit. When the anode of a diode is positive with respect to the cathode, the diode will conduct. When the anode of a diode is negative with respect to the cathode, the diode will not conduct.

When a diode is conducting, its forward resistance is 50 ohms. (See Figure 4-13).

When a diode is cut off, its backward resistance is approximately 500,000 ohms (see Figure 4-14).

This property of high resistance for one polarity and low resistance for the opposite polarity is employed in AND circuitry.

Principles of Operation of the AND Circuit

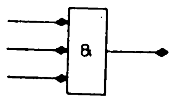


Figure 4-11. Diode AND Circuit
Logic Block Symbol

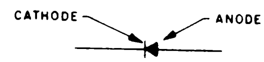


Figure 4-12. Crystal Diode
Electrical Symbol

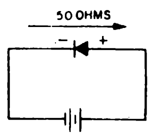


Figure 4-13. Forward Resistance of
Crystal Diode, Schematic Diagram

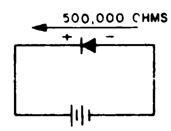


Figure 4-14. Backward Resistance of
Crystal Diode, Schematic Diagram

Figure 4-15 is a simplified schematic diagram of a diode AND circuit. With -30 volts applied to the cathode of CR1, the diode conducts. Because of the low forward resistance of a crystal diode, the voltage drop in the circuit will occur across R_{AND}. The voltage at point C is then -30 volts. With +10 volts applied to the cathode of CR2 and -30 volts on its anode, CR2 is cut off. Point C remains at -30 volts. The high backward resistance of crystal diode CR2 isolates one input circuit point B from the output circuit (point C). If both crystal diodes CR1 and CR2 have +10 volts applied to their cathodes, both will stop conducting, and the potential at point C will be +10 volts.

It can be seen that, to make point C positive, inputs A and B must be positive and that, to make point C negative, either one or both of the inputs must be negative. Figure 4-16 is a schematic diagram of a diode AND circuit.

Crystal diode CR3 is a protective feature of the circuit. It clamps point C at +10 volts, limiting the positive level at point C to +10 volts. This prevents the grid of a

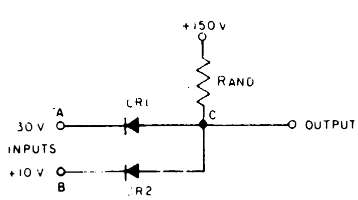


Figure 4-15. Two Way AND Circuit
Simplified Circuit Diagram

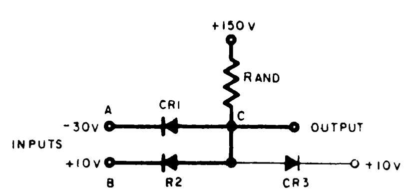


Figure 4-16. Two Way AND Circuit
Schematic Diagram

vacuum tube in a following stage from being driven so positive that destruction of the tube might result.

DIODE OR CIRCUITS

Definition and Description

Figure 4-17 is a logic block symbol of a diode OR circuit.

A diode OR circuit is a logic circuit which develops a negative level output, provided that all inputs are negative levels. If any input is a positive level, the OR circuit develops a positive level output. This type of circuit may have several inputs.

Principles of Operation

Figure 4-18 is a schematic diagram of a diode OR circuit. With +10 volts applied to the anode of CR1, the diode conducts. Because of the low forward resistance of the crystal diode, the voltage drop in the circuit will be across resistor R_{OR}. The voltage at Point C is then +10 volts. With +10 volts applied to the cathode of CR2 and -30 volts on its anode, CR2 is cut off. Point C remains at +10 volts. The high back resistance of crystal CR2 isolates one input circuit (point B) from the output Circuit (point C).

If both crystal diodes CR1 and CR2 have -30 volts applied to their anodes both will conduct, and the potential at point C will be -30 volts. It can be seen that, to make point C negative, A and B must be negative and, to make point C positive, either one or both of the inputs (A and B) must be positive. Crystal Diode CR3 is a -30 volt clamp.

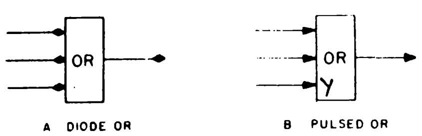


Figure 4-17. Diode OR Circuit, Logic Block Symbols

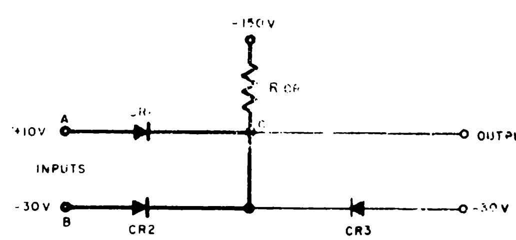


Figure 4-18. Two-Way OR Circuit, Schematic Diagram

If all the OR circuit inputs are fed from the AND circuits, there is nothing to prevent the output from going extremely negative should the +150 volt power supply fail. A protection diode clamping the circuit to -30 volts is connected to the outputs of all OR circuits of this category.

The fast rise time of the OR circuit permits a pulse input. This is not possible with the AND circuit because of the load capacitance giving the circuit a slow rise time. Figure 4-19 shows a pulsed OR circuit. In order for this circuit to function with pulse inputs, the fall time must be speeded up. This is accomplished by replacing resistor R_{OR} with an inductor, L. Resistor R_L is used to prevent oscillation between L and C (stray capacitance). Resistor R_L is of low ohmic value.

It can be seen that any positive pulse applied to either input will appear at the output. The cathodes of the diodes are grounded through inductor L and resistor R_L. When a positive pulse appears at the input, the diode involved will conduct, and the pulse will appear at the output.

Operation of Y_{OR}

When the output of a pulsed OR is applied to a pulse transformer, the Y_{OR} circuit shown in Figure 4-20 is used.

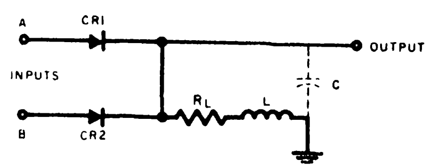


Figure 4-19. Pulsed OR Circuit Schematic Diagram

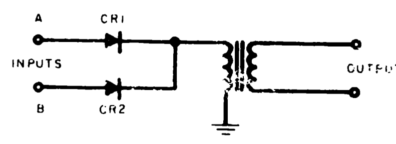


Figure 4-20. Y_{OR} Circuit Schematic Diagram

GATE TUBE, MODEL A

Definition and Description

The model A gate ($_A$GT) is a logic coincidence circuit. Figure 4-21 is the logic block symbol. A standard pulse applied to the input of the $_A$GT will appear at the output only when the $_A$GT is conditioned by a positive standard level.

Principles of Operation

Figure 4-23 is a schematic diagram of the $_A$GT.

A standard pulse input is applied to the control grid of pentode V1, and a standard level is applied to its suppressor grid. Pentode V1 is biased past cutoff by a fixed -15 volts applied to the control grid.

The $_A$GT has two states: conditioned and non-conditioned (Figure 4-22). In the non-conditioned state, a -30 volt level is applied to the suppressor grid (input B). In this state, although a standard pulse is applied to input A, overcoming the -15 volt bias, no current will flow through V2 because the -30 volts level is sufficient to hold this pentode at cutoff.

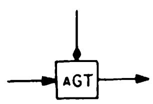


Figure 4-21. Gate Tube, Model A, Logic Block Symbol

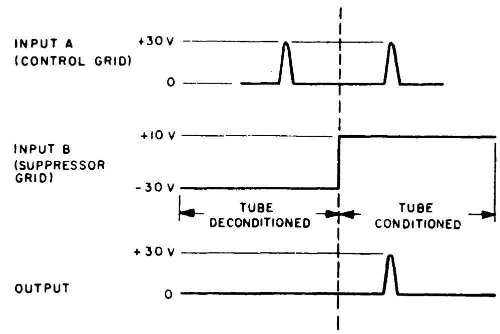


Figure 4-22. Gate Tube, Model A, Input-Output Relationship

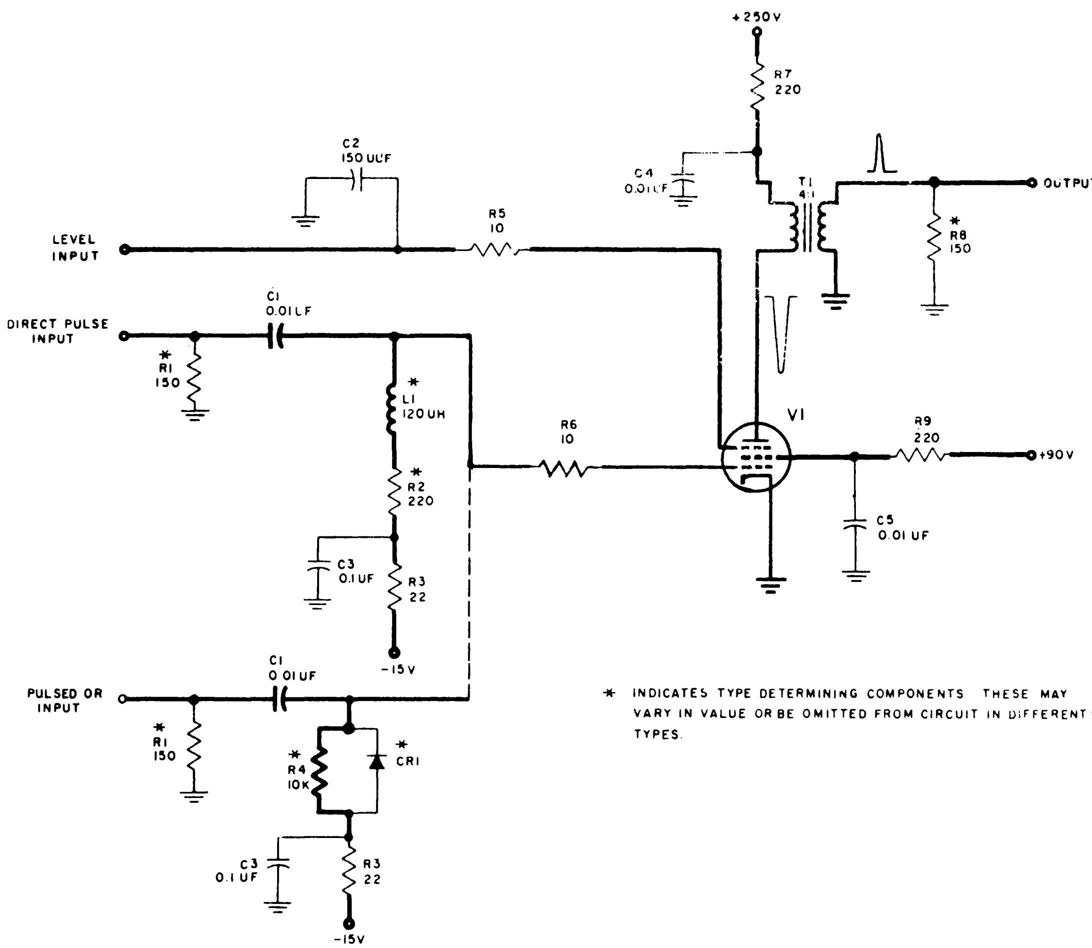


Figure 4-23. Gate Tube, Model A, Schematic Diagram

The $_{A}$GT is conditioned by the application of a +10 volt level on the suppressor grid of V1. In this state, the application of a standard pulse at input A overcomes the -15 volt grid bias, and the pentode conducts, producing a standard pulse at the output.

Name	Logic Block Symbol	Load Driving Capabilities
Pulse amplifier, model A	aPA	Constant light load (2 to 8 units)
Pulse amplifier, model B	bPA	Constant heavy load (5-11 units)
Pulse amplifier, model C	cPA	Varying light load (0 -3 units)

Table 4-1. Pulse Amplifier, Logic Block Symbols and Load-Driving Capabilities

PULSE AMPLIFIERS, MODELS A, B, AND C

Definition and Description

The pulse amplifier's (PA's) are nonlogic circuits and are represented in complete logic schematics by the logic block symbols in table 4-1. Pulse amplifiers are employed

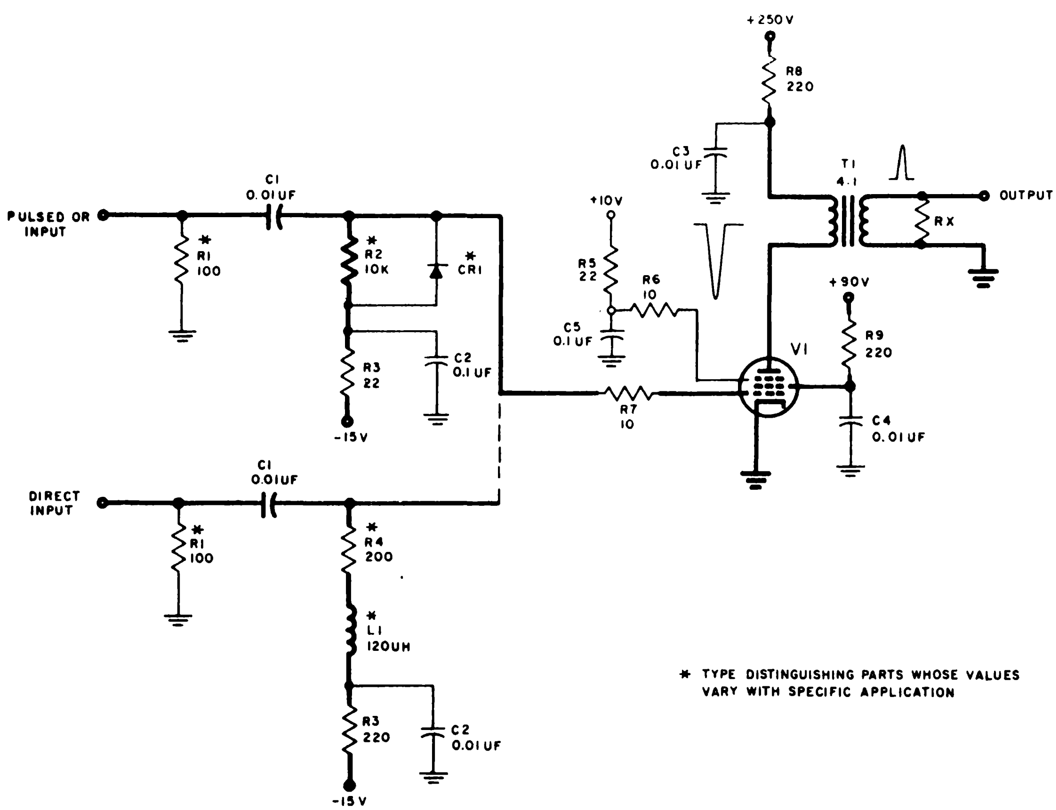


Figure 4-24. Pulse Amplifier, Model A, Schematic Diagram

to increase the load-driving capabilities (to amplify power) of a standard pulse. Three models of this circuit are employed to cover the range of loads that must be driven and are used separately or in combination, depending upon the specific load to be driven.

The differences between the models are in the point of connection of the suppressor grid and the value of the plate voltage applied. In the $_{a}$PA, the suppressor is tied to +10 volts. This connection limits the maximum value of current through the pentode. Current carrying capacity is increased in the $_{b}$PA by connecting the suppressor grid to the plate of the pentode and operating the tube as a tetrode-connected pentode. In the $_{c}$PA, a tetrode pentode is employed, and the plate supply voltage is either +250 volts or +150 volts. Although the plate supply voltage is reduced by 100 volts, the tetrode connection of the $_{c}$PA provides sufficient current to drive loads below the capabilities of the $_{a}$PA. When greater output is required, the +250 volt plate return is employed. One major difference between the $_{c}$PA and the others ($_{a}$PA and $_{b}$PA) is in the termination

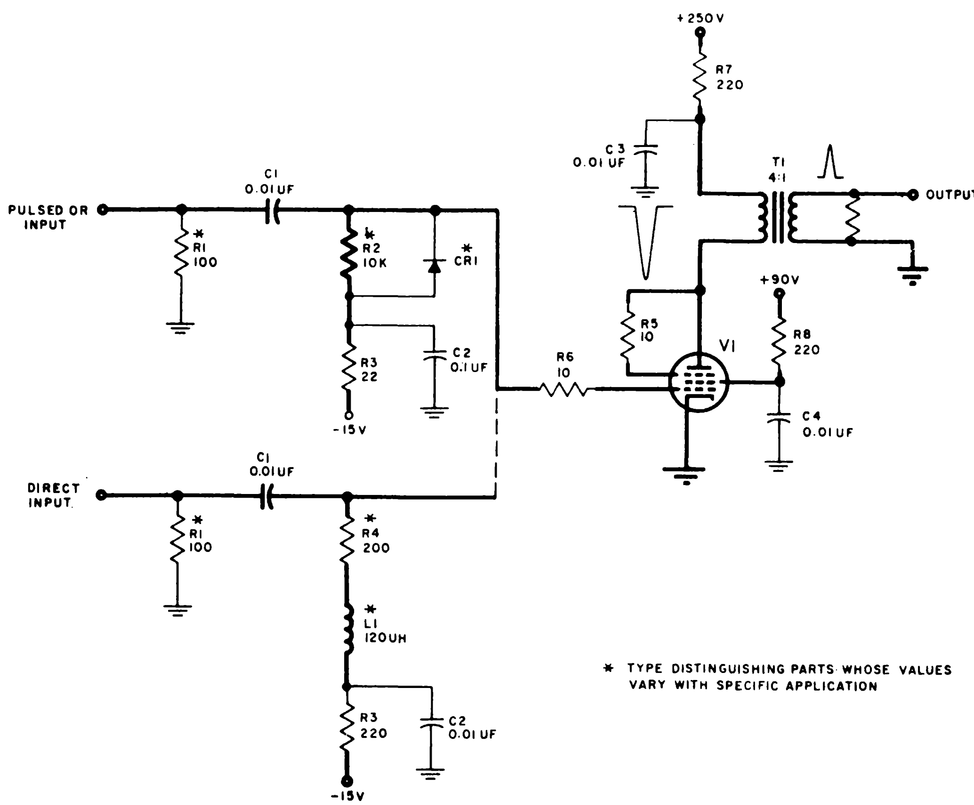


Figure 4-25. Pulse Amplifier, Model B, Schematic Diagram

requirements. The $_a$PA and the $_b$PA drive constant loads. The terminating resistor satisfies the minimum load requirements for each load the circuit drives and will be different for each load. The $_c$PA can satisfy termination requirements for a varying load (no load to maximum load in any one application) while using only one value of terminating resistor. Thus, the three PA circuits are a versatile group, capable of driving a wide range of loads. Refer to the discussion of the register drivers for further modifications of this basic circuit which have increased the load carrying capacity to 34 loads units.

Just as each model of the pulse amplifier is used to meet a specific range of load requirements, each model has variations (types) which are designed to meet specific input requirements for a given loading. These type-distinguishing features are detailed in the input circuits in Figures 4-24, 4-25, and 4-26.

Principles of Operation

The basic parts of the pulse amplifier are a pentode vacuum tube and a transformer. The pentode serves a power-amplifying function. The transformer provides the proper phase relationship at the output and, at the same time, serves an impedance matching function. This is accomplished by so connecting the transformer that a negative pulse at the plate of the pentode produces a positive pulse at the output. The transformer turns ratio of 4 to 1 provides an impedance step down of 16 to 1.

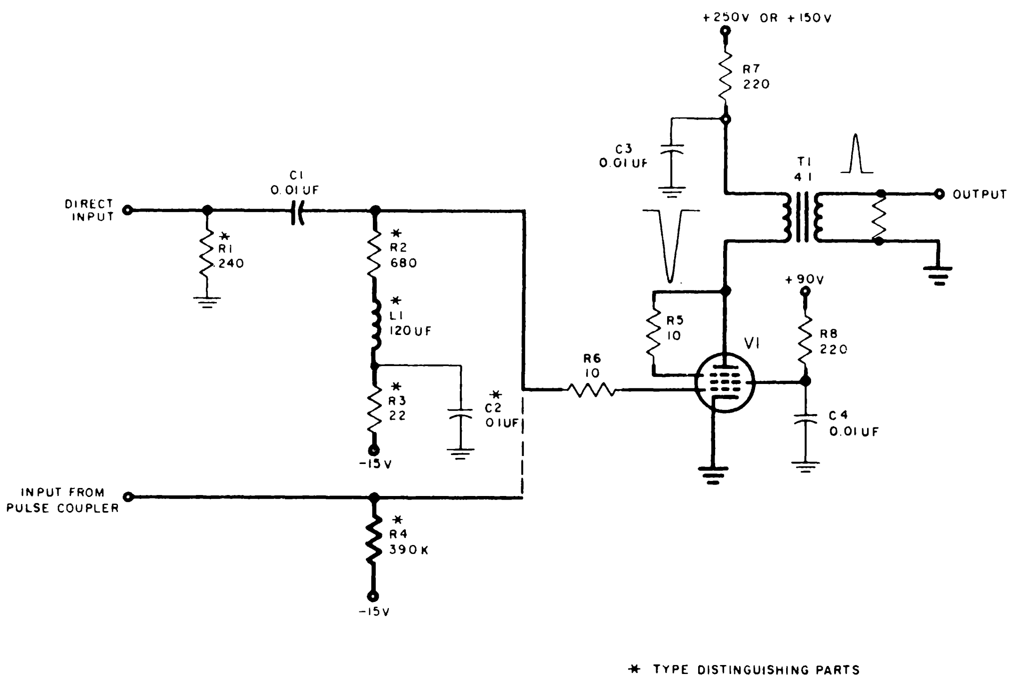


Figure 4-26. Pulse Amplifier, Model C, Schematic Diagram

Input Circuit Variations

Figures 4-24, 4-25, and 4-26, illustrate the input circuit variations for each model. A comparison of the figures reveals the close similarity between the type-distinguishing parts for each model. Therefore, only the input circuits to the $_a$PA will be discussed.

The input circuits are classified in two groups: the pulsed OR and the direct input. Consider the network used for the pulsed OR input, and note that this network has the same configuration in each schematic. The parallel combination of R2 and CR2 serves two functions: resistor R2 provides a high resistance load for the input pulse, and CR1 provides a low-resistance discharge path for capacitor C1, preventing bias buildup on the control grid. The series connection of R4 and L1 used with the direct input type $_a$PA ensures the return of the control grid to -15 volts shortly after the standard pulse at the input returns to 0. Inductor L1 presents a high impedance to a rapidly changing voltage, ensuring an undistorted coupling of the input pulse to the grid. Thus the high impedance to pulses and the low impedance to dc of L1 ensures a rapid response of the control grid to input pulses and quick recovery to the control grid bias level to prepare the circuit for the next pulse.

Resistor R1 connected across the input is not properly a part of the pulse amplifier circuit. It terminates coaxial lines connected between the driver and the pulse amplifier. The requirement for a close physical proximity to the pulse amplifier dictates its inclusion in the pulse amplifier assembly.

REGISTER DRIVERS, MODELS A AND B

Definition and Description

The register drivers ($_x$RD) are nonlogic circuits used to increase the load driving capabilities (to amplify power) to a standard pulse. Table 4-2 lists the models by name with their logic block symbols and load-driving capabilities. The register drivers are essentially model B pulse amplifiers with extended load-driving capabilities. There are two models: the $_a$RD is a $_b$PA with a transformer input circuit; the $_b$RD is a parallel input combination of two $_b$PA's with a single transformer feeding the inputs.

Principles of Operation

Figure 4-27 is a circuit schematic for both models of the register driver. As indicated the $_a$RD is converted into a $_b$RD by connecting two identical pentode circuits to the output terminal of input transformer T1. The $_b$RD connection is shown by the dashed line. As with the pulse amplifier, a standard pulse input produces a standard pulse output. Transformer T2 is connected to produce a positive pulse output three times the amplitude of a standard pulse input. As a result a standard pulse impressed on the primary appears as a positive potential at the control grid of V1. Tube V1 produces a pulse of current, and transformer T2 delivers a standard output. With

NAME	LOGIC BLOCK	LOAD-DRIVING CAPABILITIES
Register driver, model A	→ $_A$RD →	1–17 flip-flops or gate tubes with suitable termination resistor.
Register driver, Model B	→ $_B$RD →	17–34 flip-flops or gate tubes with suitable termination resistor.

Table 4-2. Register Drivers, Logic Block Symbols and Load-Driving Capabilities

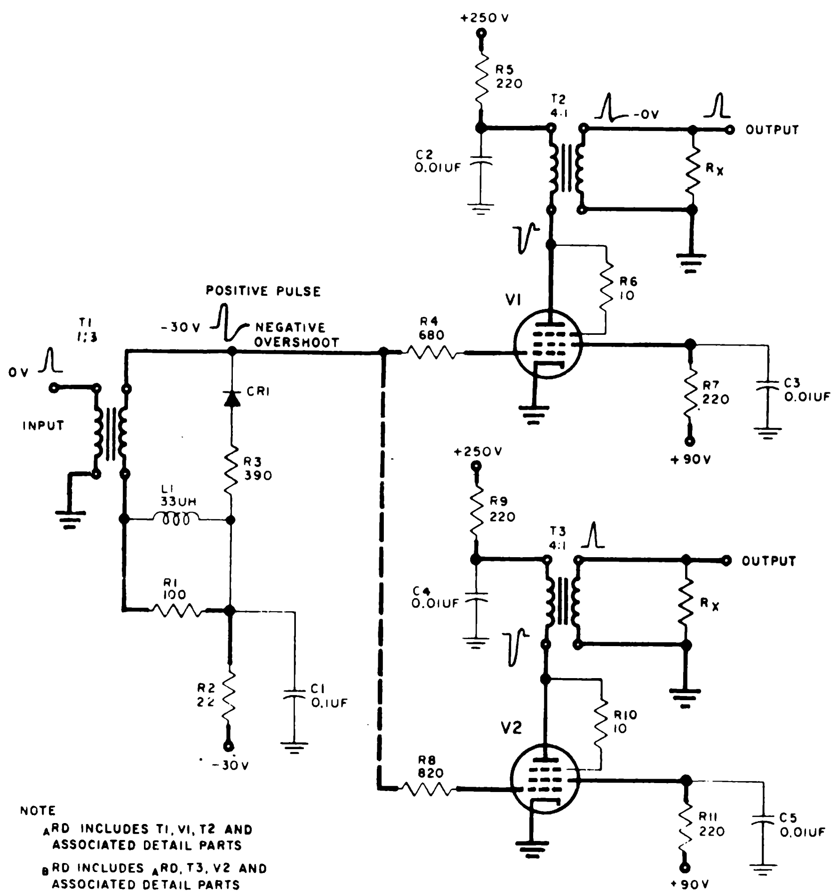


Figure 4-27. Register Driver, Models A and B, Schematic Diagram

proper termination, this standard pulse has much greater drive capabilities (power). Thus the register driver, a nonlogic circuit, power-amplifies standard pulses.

Variations

The $_b$RD, Figure 4-27, consists of the basic input circuit of the $_a$RD except for the addition of pentode V2 and associated parts in parallel with V1. The output circuit of the $_b$RD is identical with two $_a$RD's enabling the driving of twice the load of an $_a$RD (split).

Although the function of the $_a$RD is comparable with the $_b$PA, certain marked differences exist. The $_a$RD has much greater drive capabilities. This is accomplished by increased grid drive. To accommodate this increased drive and to limit noise the grid bias is increased to -30 volts as compared with the -15 volt bias on the $_b$PA.

CATHODE FOLLOWER

Definition and Description

The cathode follower (CF) is a non logic circuit which amplifies power. It has a voltage gain approaching 1. Since the cathode follower has high input and low output impedance, it is particularly useful as an isolating device. There are eight basic cathode follower models, identified by the letters B through H and J. Each model contains two $_x$CF circuits. When two circuits of different models are paired, the designations B and F, D and G, etc. are used. The representative cathode follower logic block symbol appears in Figure 4-28.

Principles of Operation

Figure 4-29 is a simplified circuit schematic diagram of a cathode follower. The cathode follower output is produced across load resistor R_k, which is returned to the -150 volt supply.

A +10 volt level applied to the cathode follower grid causes a rise in plate current flowing through R_k. The increased voltage drop across R_k makes the cathode (Output) more positive. A -30 volt level applied to the grid causes a decrease in plate current through R_k, making the output less positive. Although the cathode follower output voltage approaches the input voltage, the voltage gain is always less than 1. The level shift caused by cathode buildup, inherent in cathode followers, produces an output level more positive than the input level (see input and output waveforms in Figure 4-29). However, because of its large input and small output impedance, the cathode follower produces a power gain.

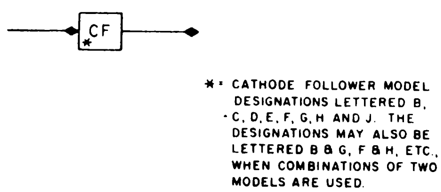


Figure 4-28. Cathode Follower, Logic Block Symbol

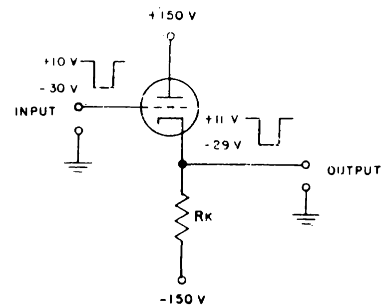


Figure 4-29. Cathode Follower, Simplified Schematic Diagram

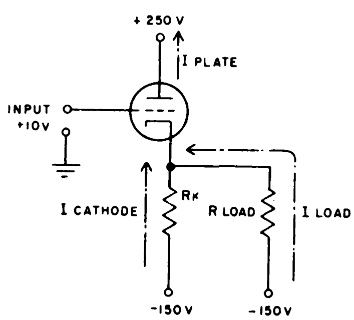


Figure 4-30. Cathode Follower with Resistive Load, Simplified Schematic Diagram

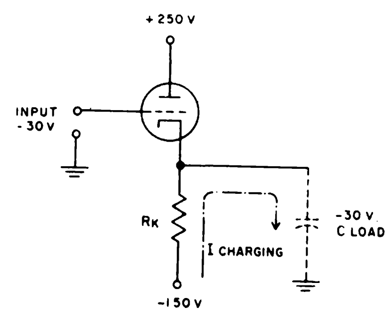


Figure 4-31. Cathode Follower with Capacitive Load, Simplified Schematic Diagram

Variations

The eight cathode follower models differ basically in the value of R_k for each model. The models, model combinations, and associated types must meet certain load requirements, the load in many cases being resistive and capacitive. Figure 4-30 is a simplified circuit schematic diagram of a cathode follower and of a representative resistance load. The plate current is the sum of cathode and load currents; therefore, the load current equals the plate current minus the cathode current.

A circuit schematic of the $_c$CF is shown in Figure 4-32. The basic operation of a $_c$CF is the same as that of the simplified cathode follower discussed previously.

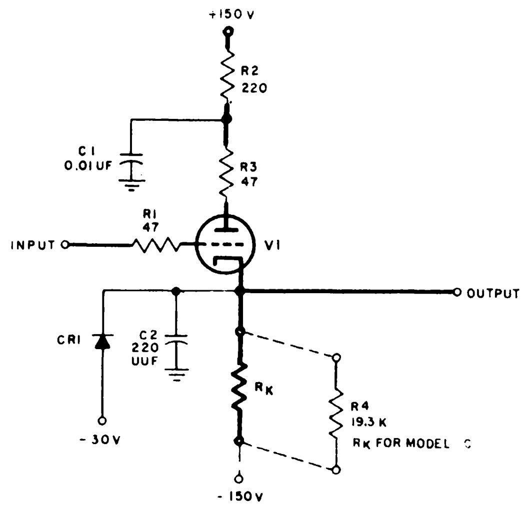


Figure 4-32. Cathode Follower Model C

The $_{c}$CF circuitry shown in the diagram contains all the components found in a particular cathode follower model. A general discussion of these components follows.

For a particular cathode-follower model, there is a definite value of R_k the reference symbol being R4.

The components CR1 and C2 may be present in the cathode-follower circuitry, depending upon the particular cathode follower model and type. Catcher diode CR1 has a safety function: it "catches" the cathode at -30 volts, thereby preventing it from becoming more negative than this potential if the vacuum tube filament should open or the plate supply voltage fail. Capacitor C2 is used only when a delay in fall time is required. Parasitic suppressor resistors R1 and R3 and decoupling networks C1 and R2 are common to most circuits.

Although there are many cathode-follower models and types, only the $_{c}$CF was discussed because it contains all the components found in the other models.

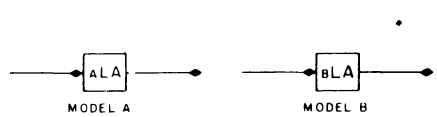


Figure 4-33. D-C Level Setters, Logic Block Symbols

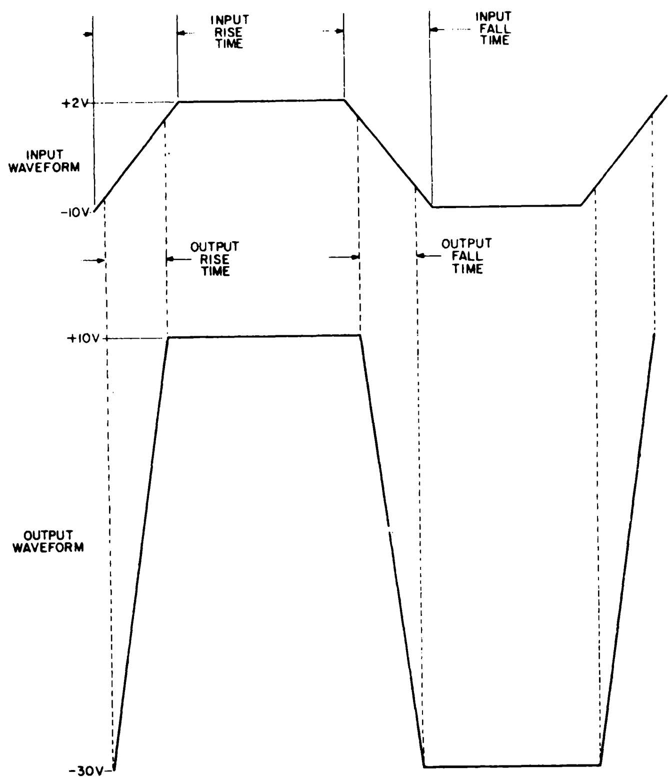


Figure 4-34. Input and Output Levels of a D-C Level Setter

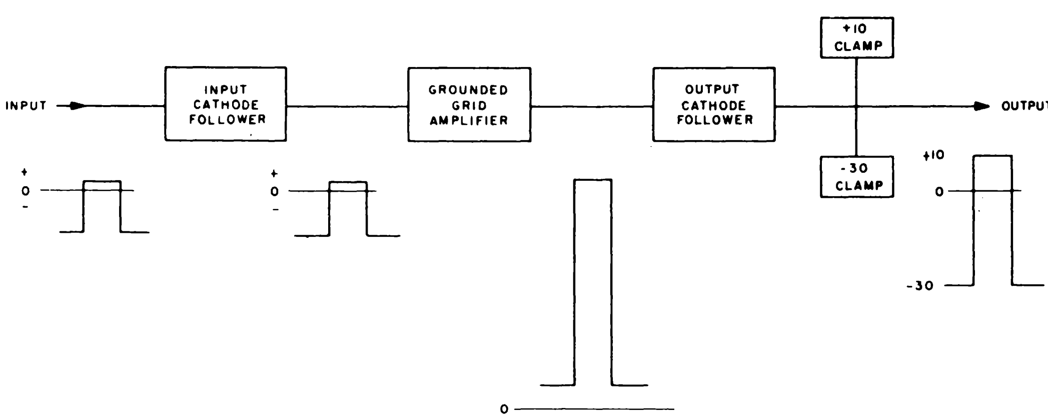


Figure 4-35. D-C Level Setter, Block Diagram

D-C LEVEL SETTER

Definition and Description

The models A and B d-c level setters, ($_{x}$LA), shown in logic block symbols in Figure 4-33 are non-logic circuits which restore signal levels to their nominal +10- and -30-volt upper and lower limits. Figure 4-34 is a graphic presentation of the typical input and output levels of a level setter.

	MODEL			
	$_{A}$LA		$_{B}$LA	
LEVEL	MAX	MIN	MAX	MIN
Upper	+12 volts	0 volt	+12 volts	+6 volts
Lower	—30 volts	—8 volts	—30 volts	—11 volts

Table 4-3. Maximum and Minimum Input Levels for D-C Level Setter Models A and B

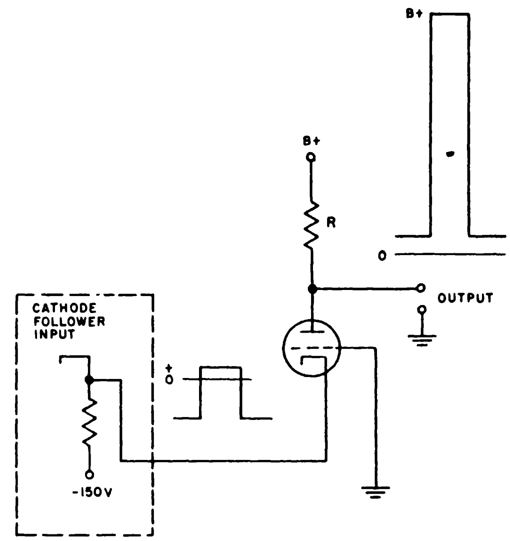


Figure 4-36. Grounded Grid Amplifier, Simplified Schematic Diagram

The inputs are plotted to the same time base as the restored output level. In addition to level restoration, the rise and fall times have been shortened. Incorrect levels are the results of level variations as the signal passes through various circuits. Level setters are introduced at points where levels deviate markedly from their +10- and -30 volt levels, eliminating the possibility of logic failure due to improper levels.

The two models of level setters differ in the minimum input level requirements and rise and fall time restoration. Table 4-3 presents the maximum and minimum input level requirements. It will be seen that the $_{a}$LA operates over a wider range of input levels and that the $_{b}$LA has the advantage of producing a faster rise and fall time.

Principles of Operation

Figure 4-35 is a block diagram of a d-c level setter. It consists of two cathode followers and a grounded grid amplifier. Figure 4-36 is a simplified circuit schematic of a grounded grid amplifier. An input level is applied to the cathode, and the grid is grounded. When the input level is positive with respect to ground, the grid (maintained at ground potential) is effectively negative with respect to the cathode. This causes the plate current flowing through R to decrease, raising the plate potential to a value approaching B+. When the input drops to a negative potential, the grid is effectively positive with respect to the cathode. Plate current increases, dropping the plate potential in a negative direction.

A positive input results in a more positive output, and a negative input results in a less positive output. Thus the output of a grounded grid amplifier is amplified and in phase with the input.

A level applied to the level setter input cathode follower is matched to the input of the grounded grid amplifier. The grounded grid amplifier amplifies this level and, in turn, drives the output cathode follower, which is alternately clamped at +10- and -30 volt levels. (See Figure 4-35).

THYRATRON RELAY DRIVERS, MODELS A AND B

Definition and Description

The thyratron relay drivers (RYD's) identified by the logic block symbols in Table 4-4, are nonlogic circuits. They are used to provide the current necessary to energize duo-relays, print and punch magnets, and wire contact relays. The thyratron relay drivers are essentially current switches which are triggered to pass current by a positive shift in standard level from -30 to +10 volts.

There are two models of the thyratron relay driver, A and B. Model A performs its function when one positive level shift is applied to its input. Model B performs its function with the application of a positive level shift, after the second input is conditioned with a positive level. Thus, when the logic requires that a specific relay be energized on every occurrence of a positive level shift, the $_a$RYD circuit is used between the source of the standard level shift and the specific relay. When the logic requires that a specific relay or magnet be energized each time a positive level shift occurs some time after a conditioning level the $_b$RYD circuit is used. In this application, the $_b$RYD includes the function of a gate circuit. These examples of one application for each circuit point out the specific difference between the two models: the $_a$RYD is controlled by one input; the $_b$RYD is controlled by two inputs.

In addition, each model on the thyratron relay driver occurs as one of two types: cathode-loaded ($_a$RYD, circuit 1, and $_b$RYD, circuit 1) and plate-loaded ($_a$RYD, circuit 2, and $_b$RYD, circuit 2). This designation, according to type, specifies the location of the relay or magnet in the thyratron circuit.

NAME	LOGIC BLOCK SYMBOL	FUNCTIONAL DESCRIPTION
Thyratron relay driver, model A	$_A$RYD	A current switch which permits passage of current through a relay or magnet coil when triggered by a positive level ~~shift from −30 volts to +10 volts.~~
Thyratron relay driver, model B	$_B$RYD	A current switch which permits passage of current through a relay or magnet each time a level shift from −30 volts to +10 volts is applied to one input, while the other input is conditioned with a +10-volt level.

Table 4-4. Thyratron Relay Drivers, Logic Block Symbol and Functional Description

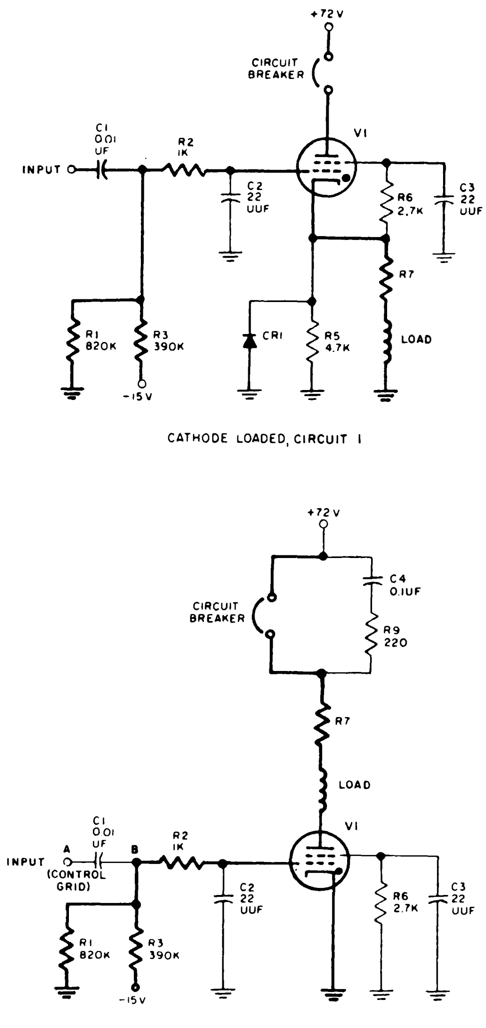


Figure 4-37. Thyratron Relay Driver, Model A, Schematic Diagram

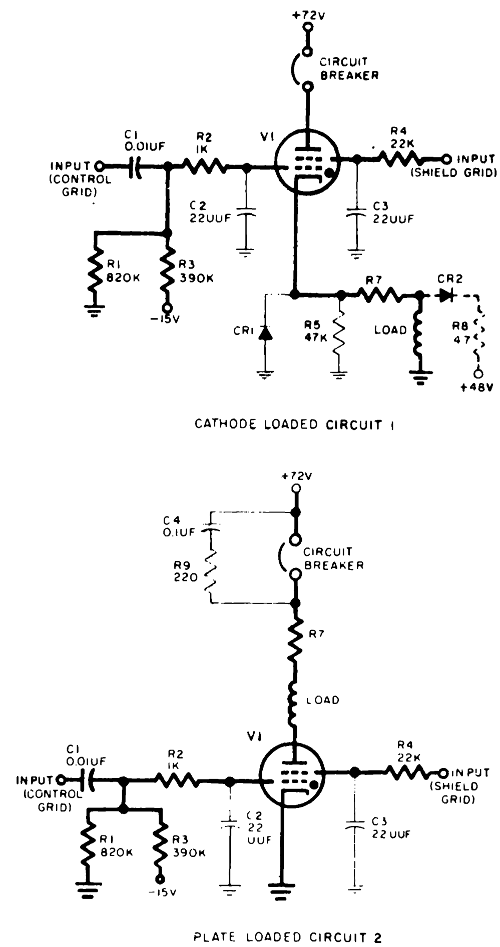


Figure 4-38. Thyratron Relay Driver, Model B, Schematic Diagram

Principles of Operation

Two basic considerations are involved in the operation of a thyratron circuit: the start of current and the extinction of current through the thyratron. For this reason, the RYD circuits are functionally divisible into the basic thyratron circuit and circuit refinements. The basic thyratron circuits consist of the thyratron and those parts that control the operation of the thyratron. The circuit refinements include those parts that serve a protective, isolating, and reliability function. The $_a$RYD and $_b$RYD schematic diagrams (Figures 4-37 and 4-38) indicate this distinction between the basic circuitry and its refinements by the difference in line weight. The heavy lines are reserved for basic circuit elements.

The thyratron used in the $_a$RYD and $_b$RYD is a gas-filled tetrode, containing a plate, cathode, control grid, and shield grid. The shield grid serves the function of a second control or input grid. The other three elements are similar in function to their counterparts in a vacuum tube, except that the control grid loses control of plate current through the thyratron once conduction is started.

The two states of operation of the thyratron conducting and nonconducting are termed ionized and deionized respectively. Ionization occurs when the potential between the anode and the cathode in a gas-filled thyratron is large enough to cause electrons to leave the cathode with sufficient energy to convert a gas molecule into an ion on impact. Such a potential between anode and cathode is termed the ionizing potential. Ionization occurs in a thyratron whenever the anode voltage is equal to, or greater than, the ionizing potential, and the control grid voltage is equal to, or greater than a specified value termed the critical grid voltage. Once the thyratron is ionized, positive ions form a sheath around the control grid and cause this grid to lose control of current through the thyratron. The magnitude of the current, then depends on the load in the anode or cathode circuit of the thyratron. The thyratron may be de-ionized only by reducing the ionizing potential below a value termed the extinction voltage.

In its application in the $_a$RYD and $_b$RYD circuits, the thyratron is ionized by an appropriate rise in the control grid voltage (well above critical grid voltage) and deionized by opening a circuit breaker (manually or automatically) in the anode circuit, reducing anode to cathode voltage well below extinction voltage.

VACUUM-TUBE RELAY DRIVER, MODEL B

Definition and Description

The logic block symbol for the model B vacuum-tube relay driver ($_b$VRD) circuit is shown in Figure 4-39. This is a nonlogic circuit and is used to energize a sensitive relay each time a positive standard level (+10 volts) is applied to its input terminal (left input). The input and output levels shown on the right side of the logic block symbol indicates inputs and outputs of the relay which is a part of the $_b$VRD. Figure 4-39 shows the relation of these levels and the state of the relay being driven. An input

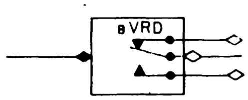


Figure 4-39. Vacuum Tube Relay Driver, Model B, Logic Block Symbol

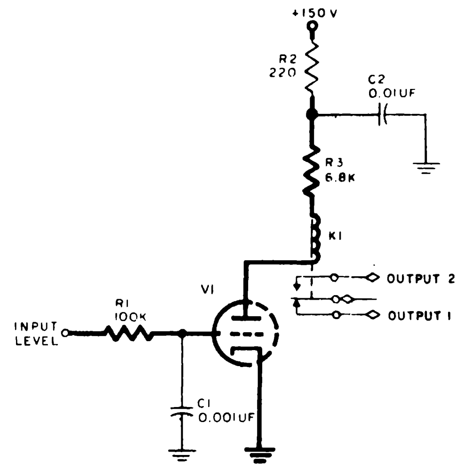


Figure 4-40. Vacuum-Tube Relay Driver, Model B, Schematic Diagram

level is applied to the movable arm or armature of the relay. The state of the relay (energized or de-energized) will determine at which output this level will appear. Thus, although two outputs are shown in the logic block symbol, they occur one at a time. The function of the $_b$VRD can now be stated more completely as follows: the $_b$VRD is a nonlogic circuit which applies a nonstandard level to one of two outputs. A standard down level produces a nonstandard level at output 1; a standard up level produces a nonstandard level at output 2.

Principles of Operation

Figure 4-40 is a schematic diagram of the $_b$VRD. The circuit consists of a triode, a relay and the circuit elements required to provide decoupling and plate current limiting and to satisfy input requirements.

Triode V1 has two states of operation in this circuit, conducting and nonconducting. When the standard level input to the grid is +10 volts, V1 conducts. When the standard level input to the control grid is -30 volts, V1 is cut off. Assume the input level is at -30 volts, with capacitor C1 charged negatively to this voltage. In this state, a level is being applied to channel 1 through relay K1. A shift of input level from -30 volts to +10 volts, does not immediately appear at the grid of V1. The negative charge on C1 maintains the grid at -30 volts. The value of R1 is chosen to translate the rapid shift at the input (0.5 usec) into a slower and more gradual rise of voltage (100 usec at the grid). Capacitor C1 discharges toward the +10 volt input level through R1. Plate current starts when the point of grid cutoff voltage is passed and increases as the grid voltage continues to rise. Grid current flows when the grid becomes more positive than the cathode. The grid limiting action of R2 maintains the grid at ground level (cathode potential) and V1 assumes its alternate state of conduction. In this state, plate current energizes relay K1, and a level is switched to channel 2. Note that with the grid at ground potential, C1 is completely discharged. A rapid shift of voltage at the input to the -30 volt standard level again appears as a gradual change at the grid as a result of the slow charging time of C1 through R1. The gradual fall in grid voltage causes a decrease in plate current until cutoff voltage is reached. At this point, the tube becomes nonconducting, and the relay reverts to its former state. Capacitor C1 continues to charge through R1 to the -30 volt level.

D-C INVERTER

Definition and Description

The model A d-c inverter ($_{a}$I), shown in logic symbol form in Figure 4-41 is a logic circuit. The $_{a}$I produces a -30 volt level when the input level is positive and +10 volt level when the input level is negative. The $_{a}$I is the only inverter model and is used when logic requires a level reversal.

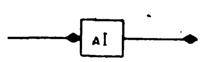


Figure 4-41. D-C Inverter, Model A, Logic Block Symbol

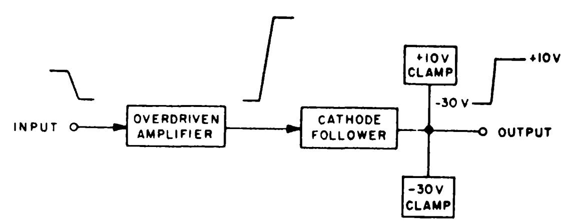


Figure 4-42. D-C Inverter, Simplified Block Diagram

Principles of Operation

Figure 4-42 is a simplified block diagram of the $_{a}$I. The circuit consists of an overdriven amplifier (driven to grid-limiting or cutoff) and a cathode follower whose output is clamped at levels of +10 and -30 volts.

A positive level between 0 and +12 volts applied to the overdriven amplifier input is amplified and inverted and fed to the cathode follower, whose output circuit clamps the inverted level to -30 volts. Similarly, a negative level between -8 and -30 volts applied to the overdriven amplifier is amplified inverted, and clamped at +10 volts at the cathode follower output.

FLIP FLOPS

Definition and Description

The flip-flops are logic circuits capable of storing a binary digit. The model A flip-flop ($_{a}$FF) produces d-c output levels only when the input is a standard pulse. The $_{b}$FF and $_{c}$FF produce standard d-c output levels when the input is either a standard

FLIP-FLOP MODEL	LOGIC BLOCK SYMBOL		CHARACTERISTICS	
	PULSE INPUT	LEVEL INPUT	SPEED	DRIVE
A	1 0 $_A$FF		High speed	Can drive load directly
B	1 0 $_B$FF	1 0 $_B$FF	Low speed	Cannot drive load directly
C	1 0 $_C$FF	1 0 $_C$FF	Low speed (lower than BFF)	Can drive load directly

Table 4-5. Flip-Flops, Logic Block Symbols and Characteristics

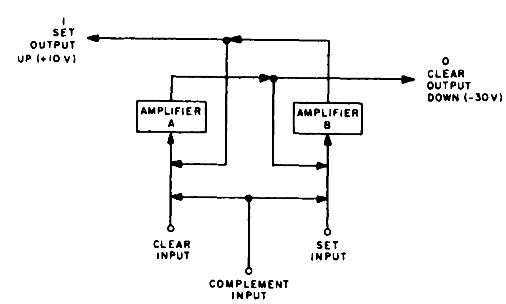


Figure 4-43. Flip-Flop, Block Diagram

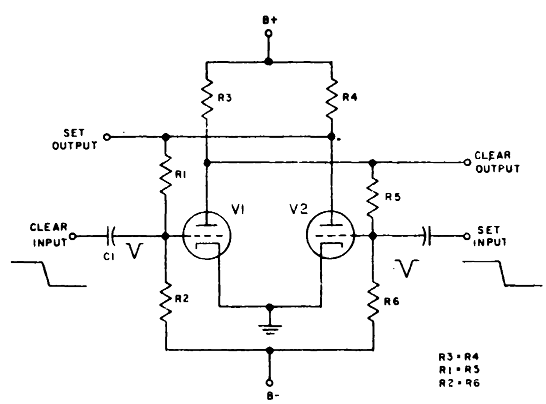


Figure 4-44. Flip-Flop, Simplified Schematic Diagram

pulse or a negative d-c level shift. Table 4-5 depicts the logic block symbols for the three flip-flop models and indicated generally the speed and drive characteristics of each. As indicated, the $_b$FF and $_c$FF operate with either standard pulses or standard level inputs.

Principles of Operation

Figure 4-43 is a simplified block diagram of a flip-flop; it consists of two amplifiers, designated A and B. The output of each amplifier feeds the input of the other. Circuits of this type are called multivibrators. The flip-flop itself is a form of multivibrator having two stable states and, for this reason, is called a bistable multivibrator.

By definition, the output of amplifier B (see Figure 4-43) is the set or 1 output of the flip-flop, and the output of amplifier A is the clear or 0 output. When the set output is up (+10 volt level), the clear output is down (-30 volt level), and the flip flop is in the set state. Conversely, the flip-flop is in the clear state when the clear output is up and the set output is down. The flip-flop is always in one of these two states.

Applying an appropriate signal to the clear input ensures that the clear output will be up. Likewise, the set output is up when an appropriate signal is applied to the set input. By applying signals to both inputs simultaneously the state of the flip-flop is changed. This process is known as complementing.

Figure 4-44 is a simplified schematic diagram of a flip-flop. The following should be noted:

a. Resistors R3, R1 and R2 are equal to resistors R4, R5, and R6, respectively.

b. An increase in plate current through plate load resistor R3 lowers the plate potential of V1. Conversely, a decrease in plate current raises the V1 plate potential. The same is true of V2 and associated plate load resistor R4.

c. The voltage divider formed by resistor R4, R1, and R2 between B+ and B- serves several functions. When V1 is conducting V2 is cut off, the voltage divider provides the proper up level at the set output and, at the same time, keeps the grid of V1 sufficiently positive to ensure full conduction. When V2 is conducting and V1 is cut off, the divider provides sufficient bias to keep V1 cut off and provides a proper down level at the set output. The voltage divider formed by R3, R5, and R6 between B+ and B- serves the same function at the opposite side of the flip-flop.

When the flip flop is in its set state, V1 is conducting and V2 is cutoff. A negative-going level applied to the clear input is changed to a negative pulse (Figure 4-44) by the combination of coupling capacitor C1 and resistor R2. This negative pulse at the grid of V1 decreases the plate current, which, in turn, increases the plate potential of V-1. The voltage divider formed by resistors R5 and R6 between the plate of V1 and B minus presents a positive rise of voltage at the grid of V2. This increases the plate current through V2 and, in turn, reduces the plate potential. The voltage divider formed by resistors R1 and R2 between the plate of V2 and B minus presents a negative fall in voltage at the grid of V1. This further decreases plate current through V1. The resultant

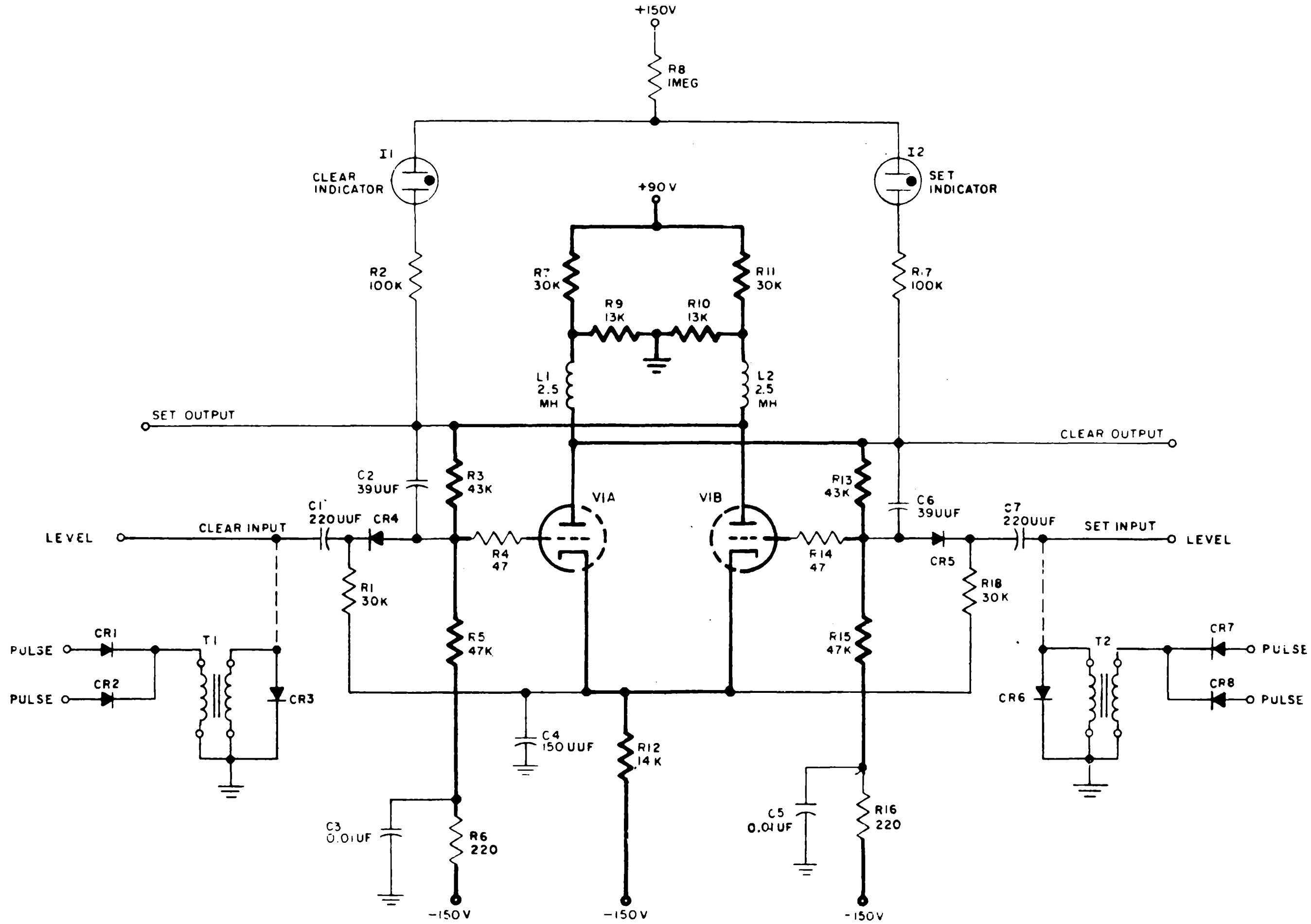


Figure 4-45. Flip-Flop, Model B, Schematic Diagram

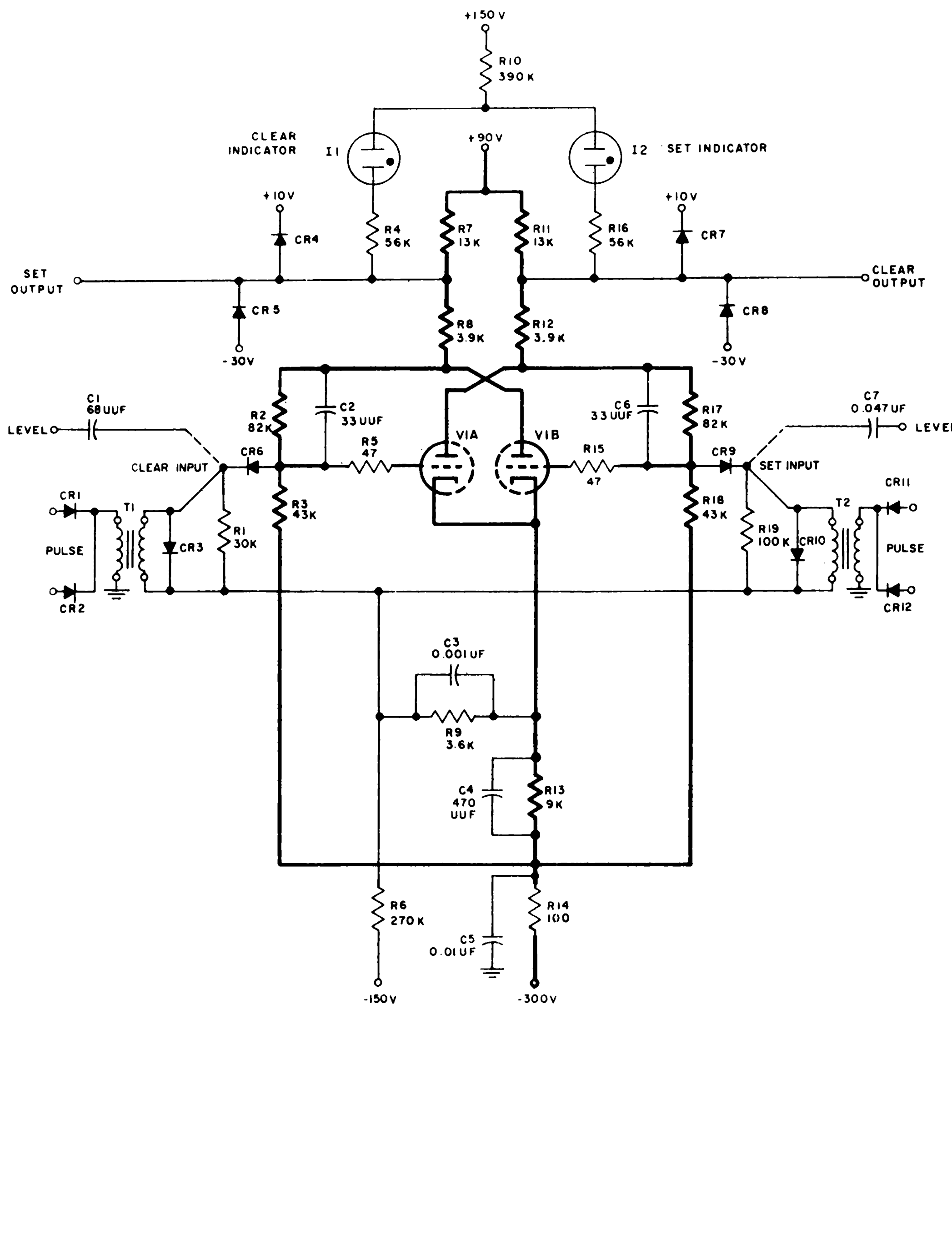


Figure 4-46. Flip-Flop, Model C, Schematic Diagram

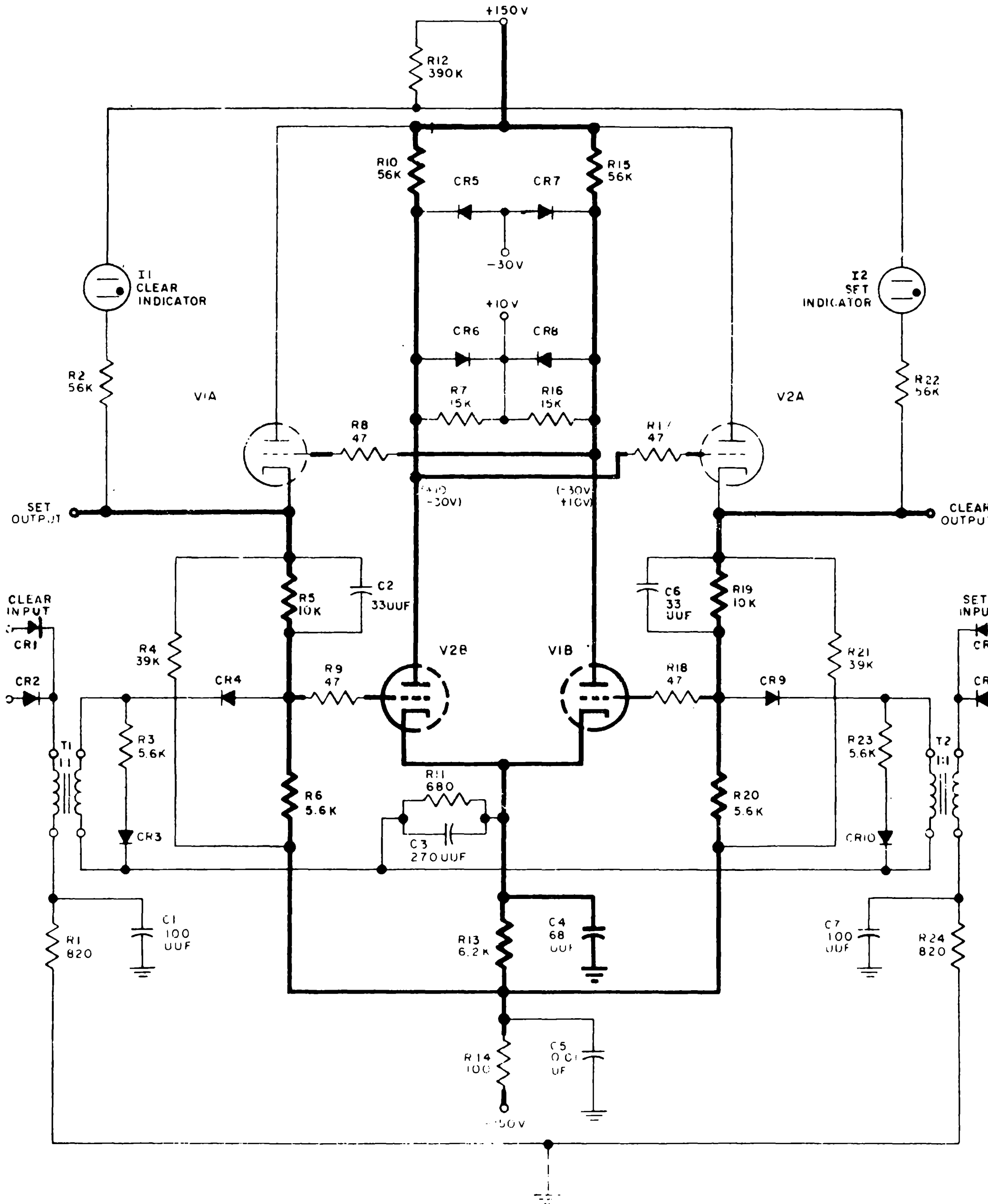


Figure 4-47. Flip-Flop, Model A, Schematic Diagram

rise of voltage at the V1 plate leads to the increase of V2 plate current, causing a further drop in plate potential. This action is cumulative and continues until V1 is cut off and V2 is conducting fully. Since V1 and V2 amplify the potential changes appearing at their respective grids, regeneration results and the process of changing state is very rapid. The flip-flop is now in a clear state, with an up level at the clear output and a down level at the set output.

When a negative-going level is applied to the set input, V2 is cut off and V1 conducts fully, changing the flip-flop to a set state. The action is similar to those in the previous discussions.

Variations

The variations of the flip-flop circuits used in the AN/FSQ-7 will be explained in the following manner. The ${}_{b}$FF is described first, followed by the ${}_{c}$FF and ${}_{a}$FF, in that order. The ${}_{b}$FF description includes a brief discussion of function and operating characteristics.

Operation of the Low-Speed, Model B Flip-Flop

The low-speed ${}_{b}$FF produces standard d-c level outputs for either a standard pulse or negative-going level shift input, depending upon the configuration of the input circuits. (See Figure 4-45).

The ${}_{b}$FF operates at a maximum pulse repetition frequency of 500 kc (400 kc for complement input).

There are two neon indicators, I1 and I2. Indicator I1 glows when the set output is down, indicating a clear state; I2 glows when the clear output is down, indicating a set state. These indicators are located at appropriate positions on the computer. Resistors R2 and R17 isolate each indicator circuit from its respective output.

Operation of Low-Speed, Model C Flip-Flop

Figure 4-46 is a schematic diagram of the ${}_{c}$FF, which operates with a maximum pulse repetition frequency of 200 kc. The ${}_{c}$FF is slower than the ${}_{b}$FF, however, it can drive a load directly.

Operation of High-Speed, Model A Flip-Flop

The high-speed ${}_{a}$FF, shown in Figure 4-47 operates with a maximum pulse repetition frequency of 2 megacycles. The input signal to the ${}_{a}$FF is a standard pulse. The use of cathode follower output circuits enables the ${}_{a}$FF to drive a load directly. Cathode follower V2A isolates the plate circuit of V2B from the grid circuit of V1B. Cathode follower V1A isolates the plate of V1B from the grid circuit of V2B. This permits faster flip-flop action.

The plate supply voltage for the $_{a}$FF is greater than that used on the $_{b}$FF and $_{c}$FF.

In order to minimize wiring capacitance which would slow down the $_{a}$FF, each of the twin triodes contains an amplifier and associated cathode follower in the same envelope.

The network consisting of Resistor R1 and capacitor C1 connected to the return of the primary of T1 prevents noise pulses from affecting the $_{a}$FF. Resistor R3, in series with diode CR3 across the secondary of T1, limits the current through CR3. Resistor R7 across diode CR6 (+10 volt clamp) prevents large positive potential from being applied to the grid of V2A should CR6 open. The $_{a}$FF may have numerous diode inputs accompanying diodes CR1 and CR2.

SINGLE SHOT MULTIVIBRATORS

Definition and Description

The single-shot multivibrator ($_{x}$SS) is a logic circuit which generates a level of predetermined duration when a standard pulse is applied to its input. Figure 4-48 depicts the logic block symbol of each multivibrator model with its associated outputs.

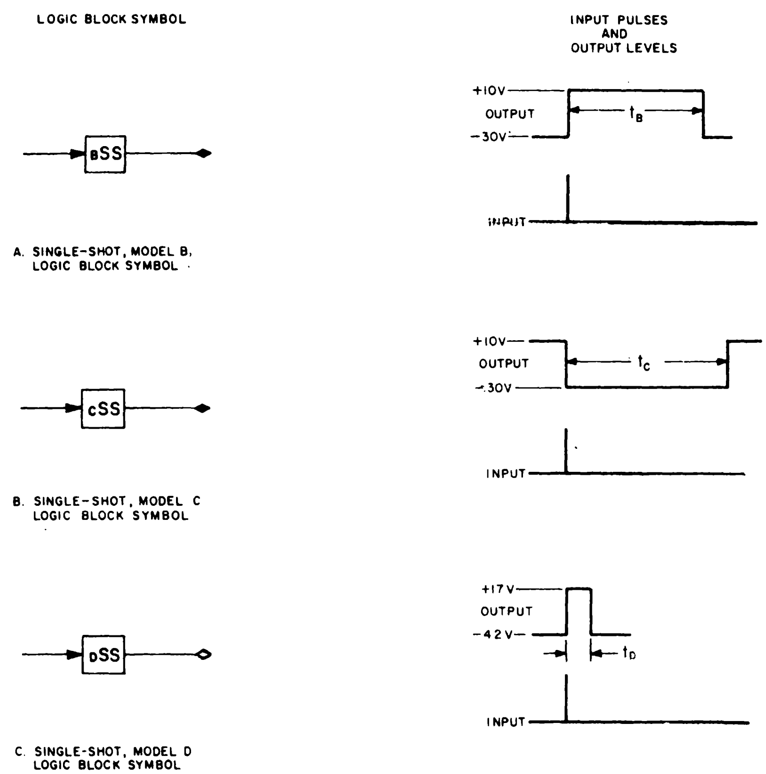


Figure 4-48. Single-Shot, Logic Block Symbols and Output Waveforms

Principles of Operations

The SS has one stable state; in this it differs from the flip-flop multivibrator, which has two stable states.

Figure 4-49 is a block diagram of an SS consisting of amplifiers A and B. Normally, amplifier B is conducting and amplifier A is cut off. This is the stable state of the SS.

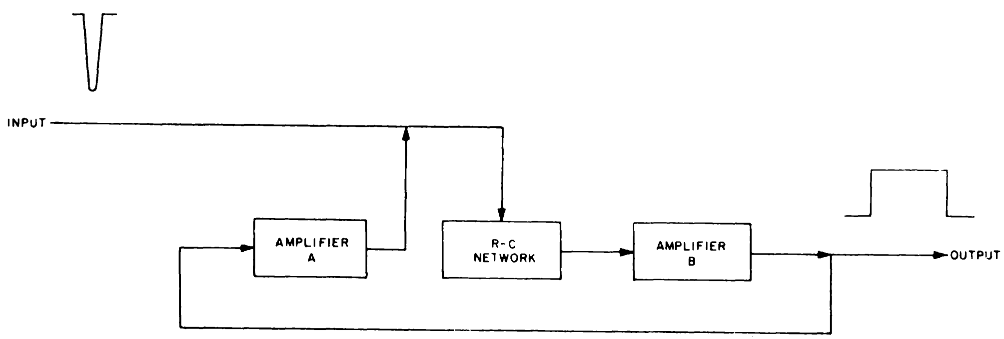


Figure 4-49. Single-Shot, Simplified Block Diagram

An appropriate signal applied to the input will cause amplifier B to cut off and amplifier A to conduct. This change of state is maintained, for a predetermined period of time, by the RC network. The SS then returns to its stable state. The output level of the SS is down in its stable state and up in its nonstable state.

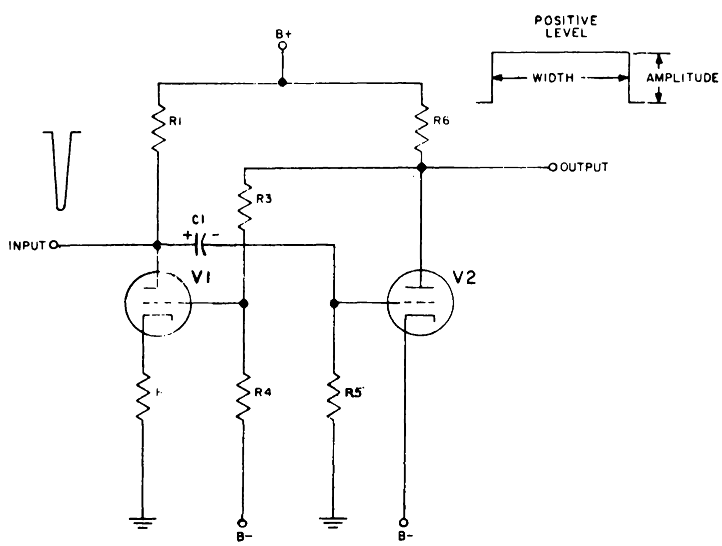


Figure 4-50. Single-Shot, Simplified Schematic Diagram

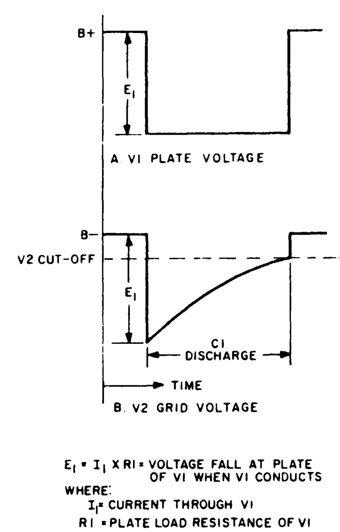


Figure 4-51. V1 Plate Voltage and V2 Grid Voltage

Figure 4-50 is a simplified diagram of the Single-Shot Multivibrator. Initially, V2 conducts because its cathode is at B- and its grid is at ground potential. Because of the conduction of V2, resistors R3 and R4 between the plate of V2, and B- apply a potential to the grid of V1 sufficiently negative to maintain V1 at cutoff. With V1 cut off and V1 conducting, capacitor C1 charges to (B+) - (B-) through the cathode to grid circuit of V1.

A negative pulse applied to the input is coupled by capacitor C1 to the grid of V2, reducing the plate current through R6.

The reduction in voltage drop across R6 results in a rise of potential at the plate of V2. This rise is coupled to the grid of V1 through the voltage divider consisting of Resistors R3 and R4. Tube V1 conducts, and its plate voltage falls. This negative shift in potential at the plate of V1 adds to the negative pulse input and is coupled by C1 to the grid of V1. The plate voltage of V2 rises and this action continues in a regenerative manner until V2 is cut off. At this time the plate potential of V1 is at maximum, the plate potential of V1 is at minimum, and the grid potential of V2 is below B-. As was previously indicated the initial charge across C1 is B+ - B-, with the potential at the grid of V2 at B- and the potential at the plate of V1 at B+. When the plate of V1 falls, the grid potential of V2 falls a like amount (Figure 4-51). This is accomplished by the coupling action of capacitor C1 (the charge across a capacitor cannot change instantaneously). At the instant V2 is cut off, a positive level shift occurs and the level is maintained until V2 resumes conduction. Tube V2 will remain cut off until the charge on C1 leaks off through R5. As the charge on C1 is decreased, the grid of V2 approaches B- and reaches the point where V2 conducts. Current through V2 causes a fall in voltage at the plate of V2. This fall is coupled to the grid of V1 through resistors R3 and R4.

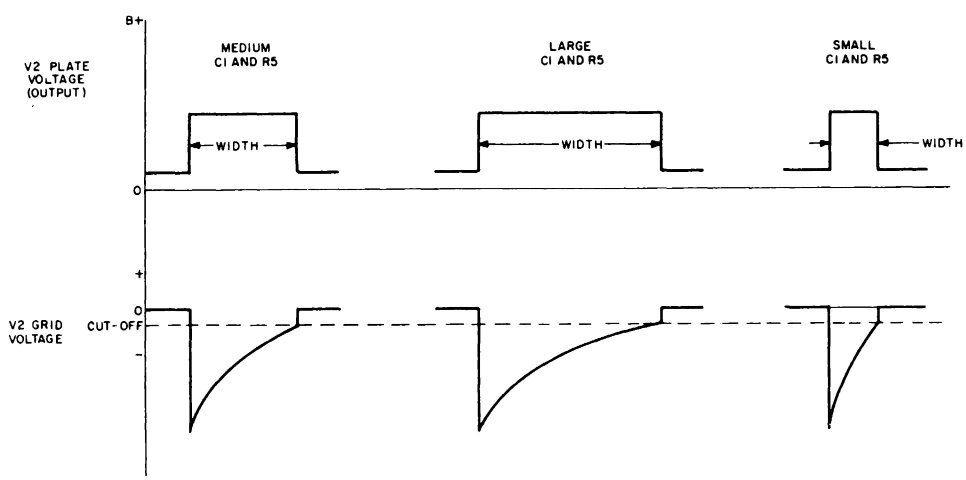


Figure 4-52. Plate and Grid Voltages of V2 for Varying Values of C1 and R5

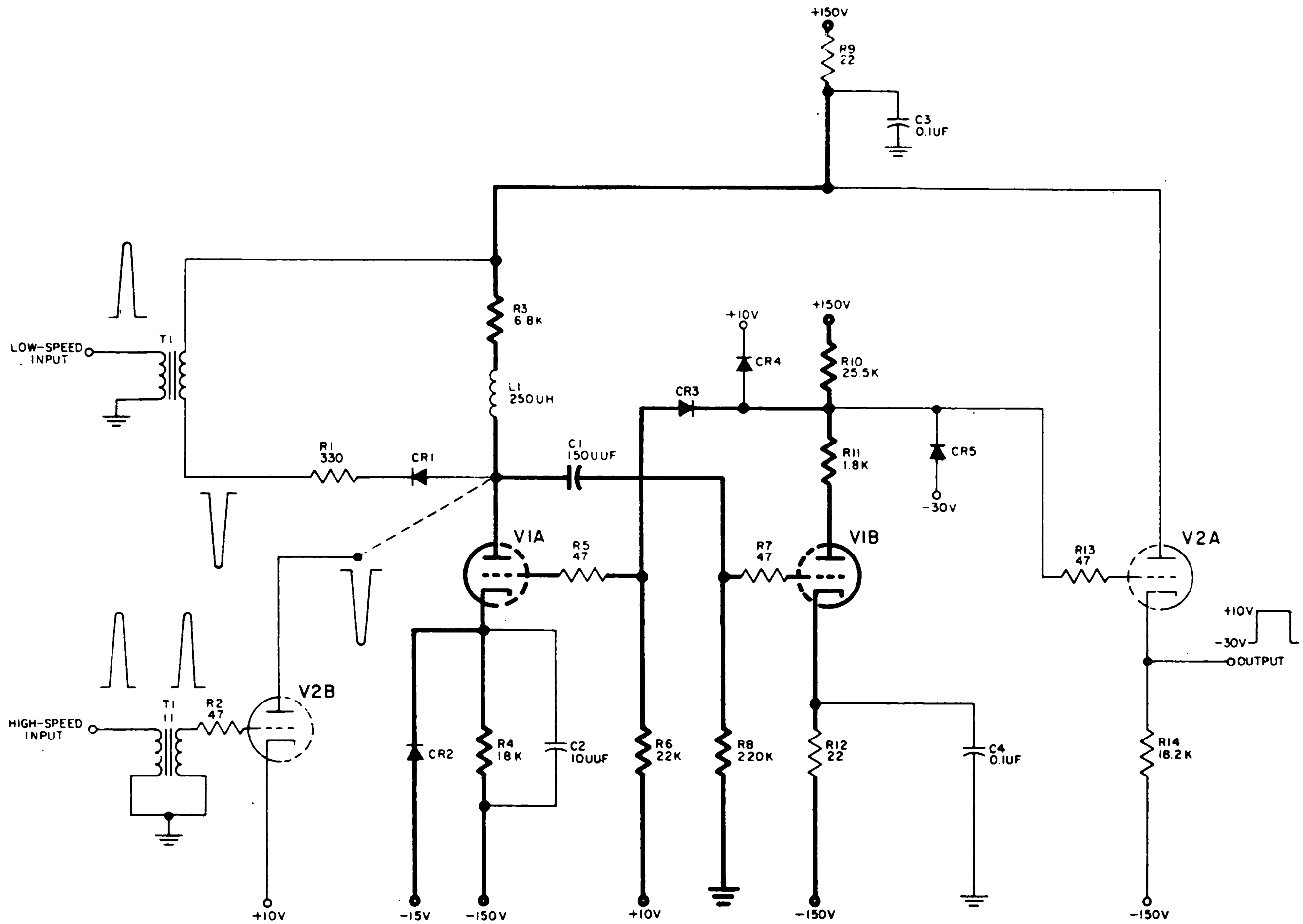


Figure 4-53. Single-Shot, Model B, Schematic Diagram

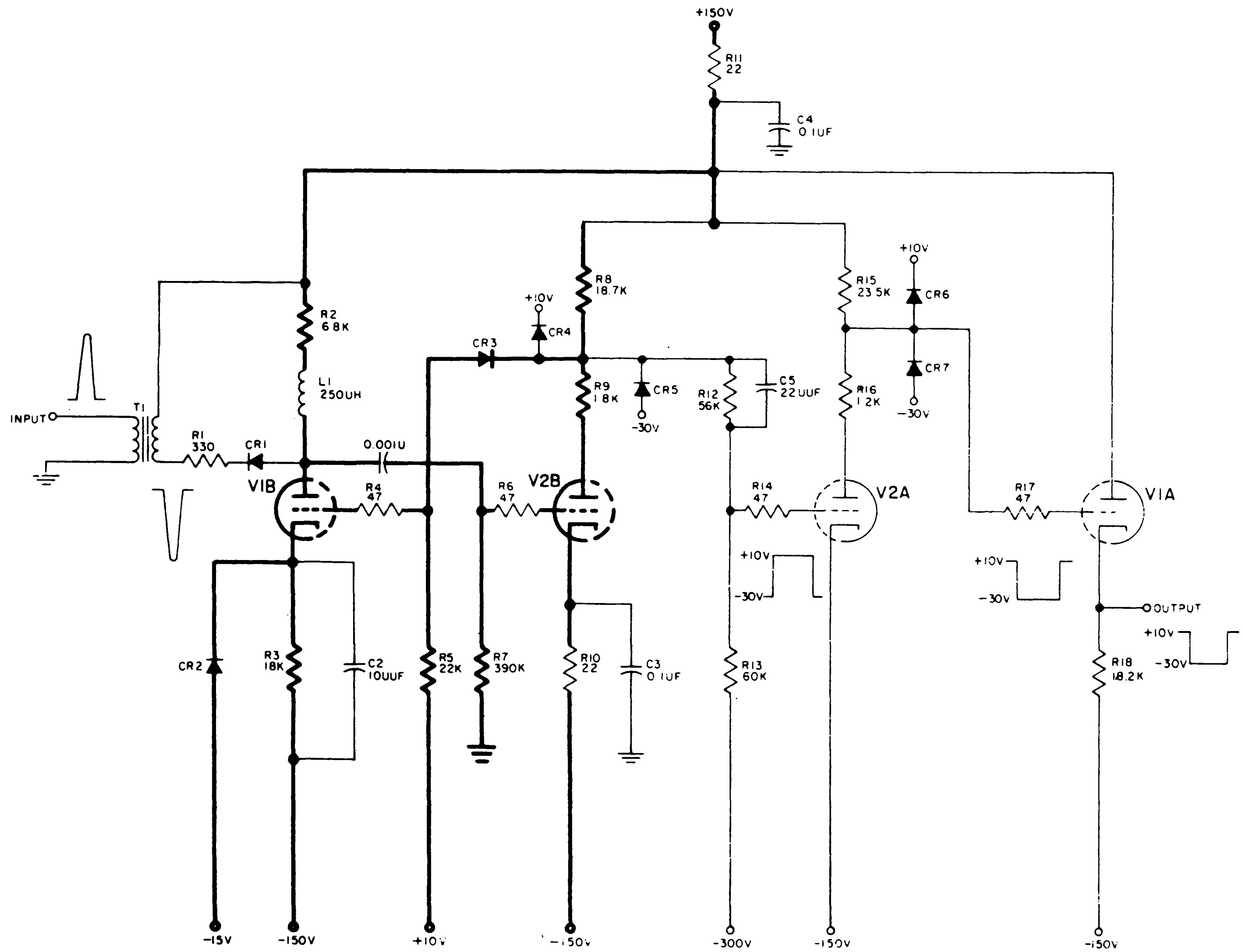


Figure 4-54. Single-Shot, Model C, Schematic Diagram

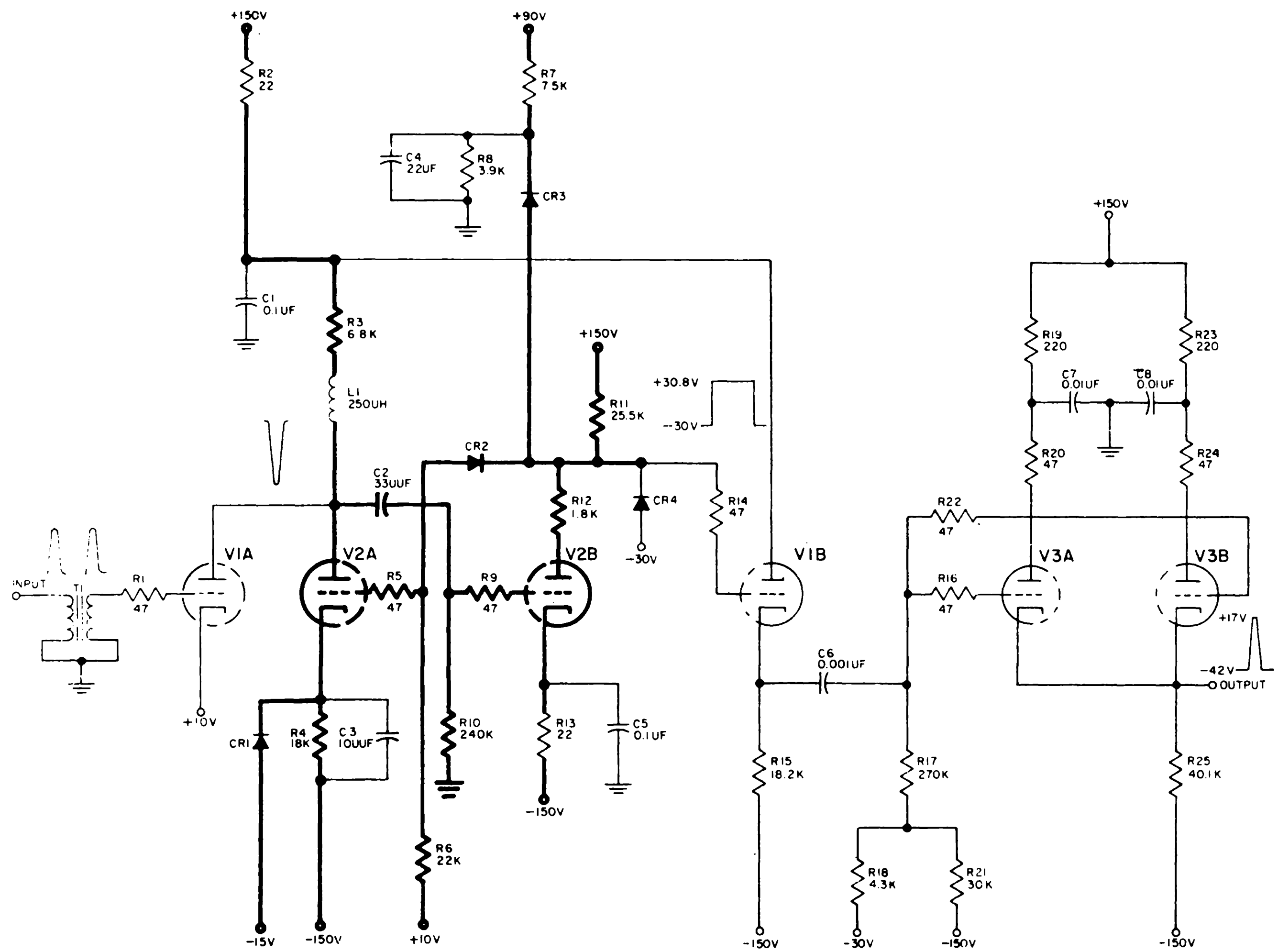


Figure 4-55. Single-Shot, Model D, Schematic Diagram

The plate of V1 rises, and regenerative action returns the SS to its stable state (V1 cut off and V2 conducting). In the stable state, the grid and cathode of V2 are at B-, and the plate potential of V2 is reduced to its minimum value hence, the output level falls (Figure 4-50). The width of the output waveform (the time required for capacitor C1 to discharge sufficiently to enable V2 to conduct) is determined by the capacity of C1 and the resistor R5. The duration of the up level output is predetermined by, and directly proportional to, the product of C1 and R5; and increase of either C1 or R5 increases the time; a decrease of either C1 or R5 decreases the time.

Figure 4-52 depicts the grid and plate voltage waveforms of C2 for varying values of C1 and R5. From this figure, it can be seen that the width of the positive level output is dependent upon values of C1 and R5.

Variations of $_{x}$SS

Figure 4-53 is a composite schematic diagram of the $_{b}$SS. The $_{b}$SS produces a +10 volt (up) level for a predetermined duration when a standard pulse is applied to its input. The range of duration of the up level is from 1 to 100,000 microseconds and is determined by the values of C1 and R8. Two input circuits are employed to cover the range. The high-speed input circuit is used for the range of 1 to 4 microseconds. The low-speed input circuit is used for a range of 4 to 100,000 microseconds. Cathode follower V2A increases the load driving capabilities of the B SS.

Figure 4-54 is a schematic diagram of the $_{c}$SS. This circuit produces a -30 volt level for a duration of from 4 to 100,000 microseconds for each standard pulse input. The output then returns to a +10 volts level (stable state).

The $_{c}$SS circuit is essentially the same as the $_{b}$SS; however, a modified inverter, V2A, precedes the cathode follower V1A to invert the level.

Figure 4-55 is a schematic diagram of the $_{d}$SS. The output of the $_{d}$SS in its stable state is a -42 volts. For each standard pulse applied to its input, the $_{d}$SS produces a +17 volts level of 2.2 microseconds duration.

The $_{d}$SS circuit is the same as the $_{b}$SS, utilizing a pullover tube input with the modifications that follow. The positive rise of output from V2B is clamped to +30.8 volts by diode CR3 during the 2.2 microseconds this tube is cut off, permitting the $_{d}$SS output to rise to +17 volts. This +30.8 volt bias is obtained from the junction of divider resistors R7 and R8 between +90 volts and ground. Capacitor C4 maintains the voltage across R8 constant. Because of the heavy load requirement, the $_{d}$SS output circuit consists of paralleled cathode followers V3A and V3B. Capacitor C6 couples the output of cathode follower V1B to the grids of V3A and V3B. Grid return resistor R17 is common to V3A and V3B and is tied to the junction of the voltage divider composed of resistors R18 and R21. This divider develops a potential of -45 volts at the junction of R18 and R21, enabling the $_{d}$SS output to fall to -42 volts during the stable state.

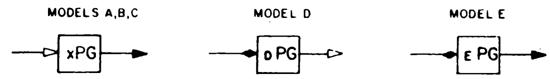


Figure 4-56. Pulse Generators, Logic Block Symbols

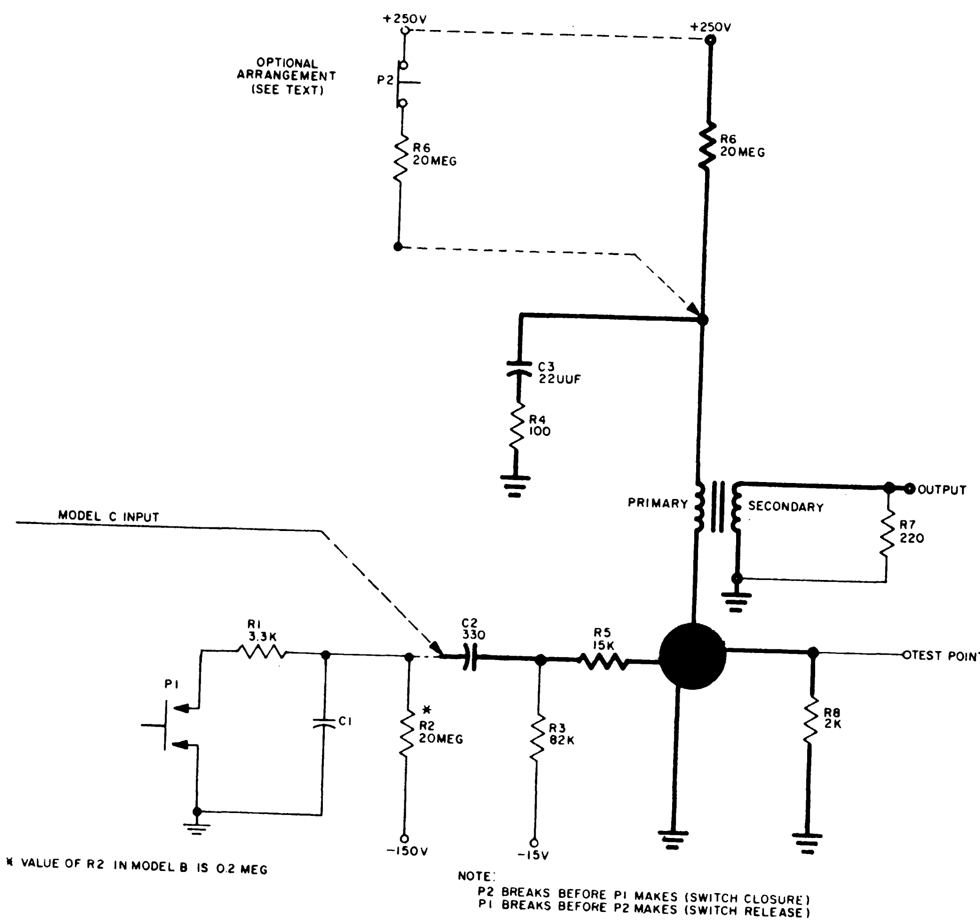


Figure 4-57. Pulse Generators, Models A, B, and C, Schematic Diagram

PULSE GENERATORS, MODELS A, B, C, D, AND E

Definition and Description

Pulse generators (PG's) are logic circuits which provide standard pulse outputs for appropriate inputs. Figure 4-56 is a logic block symbol of the several model groups. Pulse generators, models A, B, and C are essentially the same circuit, the only difference being the means of input. Model A is actuated by hand-operated switching at a maximum repetition rate of 240 pulses per minute; model B, by a cam-operated switch at a maximum rate of 3,600 pulses per minute; model C by a positive level shift at a maximum rate of 30,000 shifts per minute. The output of each is a standard pulse. The model D input is a rapid shift in standard level from -30 to +10 volts. The output is a non-standard pulse. The model E input is a standard level shift from +10 to -30 volts. The ouput is a standard pulse.

Principles of Operation

Models A, B, and C consist basically of an input circuit, a tetrode thyratron, and an output transformer. These pulse generators produce standard pulses whenever a switch is actuated in the input grid circuit or, as in model C, a positive shift in voltage is applied to the input.

Circuit Refinements, Model A, B, and C

While the thyratron is conducting, the shield grid draws current, and a representative pulse appears across current limiting resistor R8, for testing purposes.

The only difference between Model B and model A is the value of resistor R2. In model B, the value of resistor R2 is 0.2 megohm. The reduction in the resistance of R2 decreases the charging time for capacitor C1, permitting the circuit to be actuated at a higher repetition rate by a cam-operated switch.

Model C is triggered by a positive level shift at capacitor C2. Resistor R3 and Capacitor C2 convert the positive level shift into a positive trigger at the grid side of C2. Capacitor C2 discharges through the now conducting grid and resistors R5 and R3. The trigger generating components, R1, C1 and P1 and P2, are not used. A composite schematic diagram of models A, B, and C, is shown in Figure 4-57.

An optional arrangement in the form of a special switch (P2) is incorporated in the circuit as shown in Figure 4-57. This switch eliminates the possibility of multiple output pulses caused by switch (P1 bounce). Removing the +250 volt plate supply before P1 is closed prevents capacitor C1 from charging during the bounce period and eliminates the possibility of accidental triggering of thyratron V1.

Principles of Operation, Model D

This blocking oscillator type pulse generator consists of a plate pullover triode, a tetrode-connected oscillator, and a pulse-shaping transformer. A shift from the down to the up level at the input is necessary to trigger the circuit. The output is a non-standard pulse. Figure 4-58 is a schematic diagram of the $_d$PG.

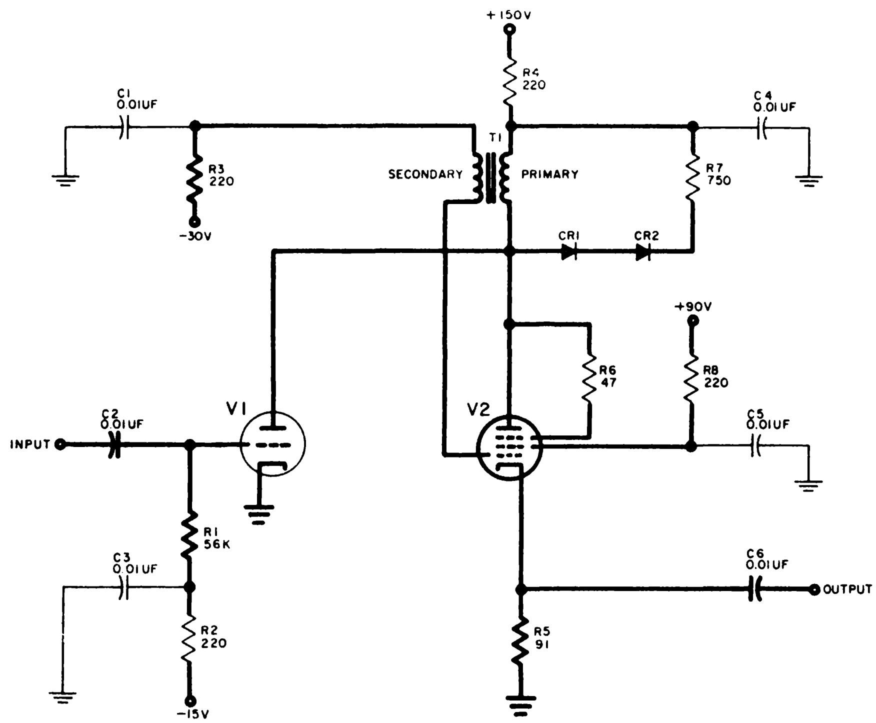


Figure 4-58. Pulse Generator, Model D, Schematic Diagram

DELAY UNIT GROUP

Definition and Description

Delay unit, model C ($_{C}D$), is a logic circuit consisting of a delay line and a delay line driver. Table 4-6 shows the logic blocks for the delay unit and its component parts. The purpose of the delay unit is to delay information (a standard pulse) for a fixed length of time. The standard pulse is fed to the delay line by the delay line driver. It appears at the output of the delay line a fixed time after the initial pulse is applied to the input.

Principles of Operation

The delay line consists of a series of LC filter sections (see Figure 4-59). A standard pulse applied to the input of the delay line charges C1 in a finite period of time. The voltage developed across C1 causes current to flow through L1 charging C2. The process continues with L2 and C3, L3 and C4, and L4 and C5. Finally, C5 discharges through terminating resistor R1, producing a voltage pulse. This pulse will appear a fixed time after the standard pulse is applied to the input. The time difference between these pulses (the delay) is determined by the values of L and C and the number of LC sections. The nominal time difference of a delay unit is 0.5 microsecond. When a smaller delay is needed, the delay line may be tapped at one of the LC sections. For greater delays, lines are cascaded (connected in series).

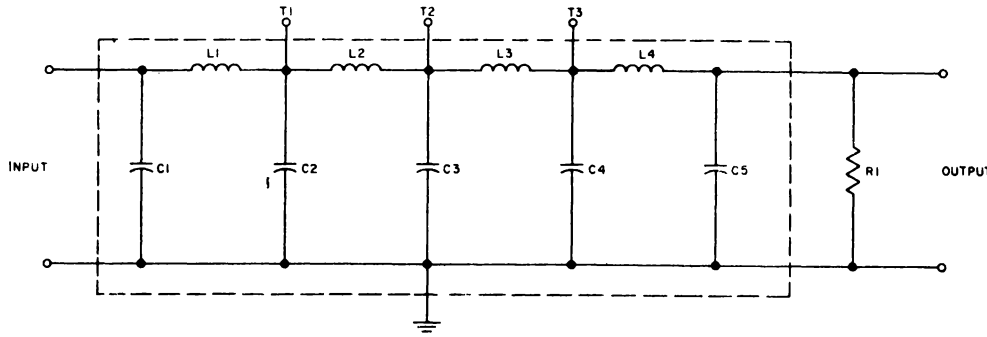


Figure 4-59. Typical Delay Line

NAME	LOGIC BLOCK SYMBOL	FUNCTION
Delay unit, model C ($_C$D)	$_C$D 0.5 usec	Delays information for a fixed period of time. Composed of delay line and driver.
Delay line	0.5 usec	Provides necessary delay.
Delay driver, model A ($_A$DD)	$_A$DD	Provides power amplification necessary to drive delay line.

Table 4-6. Delay Unit, Logic Block Symbols and Functions

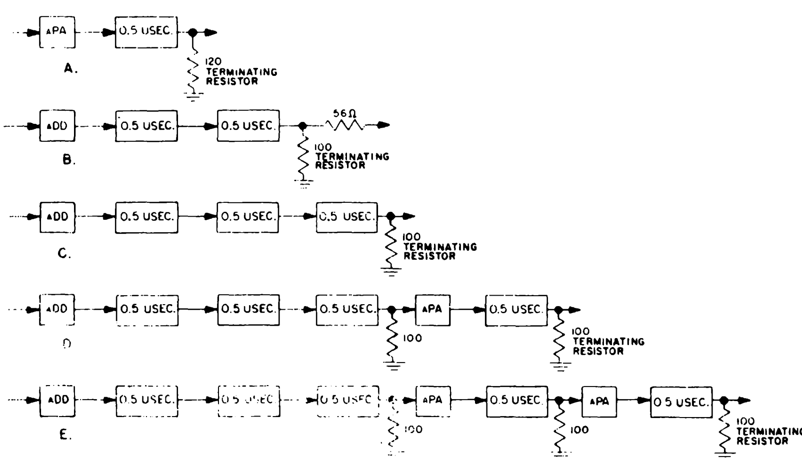


Figure 4-60. Typical Arrangements of Delay Units

Operation of Model A Delay Line Driver

Figure 4-61 is a schematic diagram of the Model A delay line driver. Pulse power is required to drive the delay line because a 40 volt standard pulse is being fed to a 100 ohm load (the impedance of the delay line). The Model A delay line driver provides this power. It is basically composed of an input transformer, a tetrode-connected pentode, and an output transformer. A standard pulse is applied to the input transformer. The output of the transformer is a positive pulse amplified by a factor of 3. This pulse is applied to the control grid of vacuum tube V1. Bias considerably below cutoff is provided by a fixed -30 volts on the control grid. The pulse at the secondary of the input transformer overcomes this bias and causes V1 to conduct heavily. The resulting plate current through the primary of the output transformer, T1, causing a positive pulse to be fed to the delay line. Transformer T1 matches the high impedance of the plate to the low impedance of the delay line. It also steps down the voltage by a factor of 4, thereby increasing the current by four times.

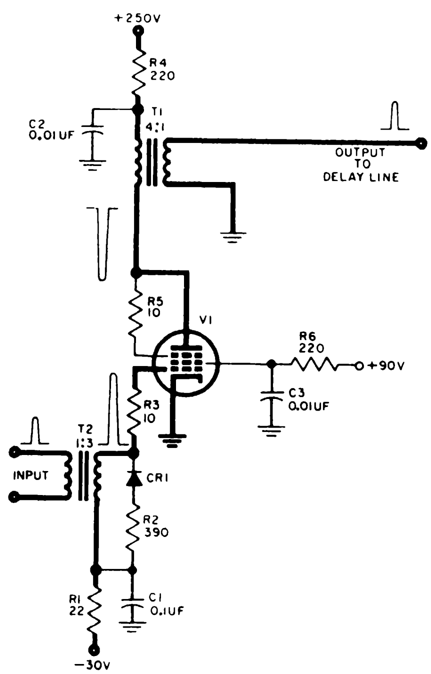


Figure 4-61. Delay Line Driver, Model A

When it is necessary to cascade delay lines for longer delays, the standard pulse is distorted beyond acceptable limits. To correct this condition, $_{a}$PA is used instead of an $_{a}$DD to drive each additional delay line. Arrangements of delay lines and driving sources are shown in Figure 4-60. When tapped delay lines are used for delays shortened to less than 0.5 microsecond, series limiting resistors are used to limit the pulse amplitude. The values of these resistors depend on the load and on the position of the tap in the delay line.

Diode-Capacitor Gates, Models A and B

A diode-capacitor gate (DCG) is a logic circuit which passes a signal when conditioned by a level. The logic block symbols for the Two DCG's utilized in the AN/FSQ-7 and 8 equipments are shown in Figure 4-62. The difference between the models are accounted for by the changes in detail components in the circuits and by the different type of signals received and transmitted by each model.

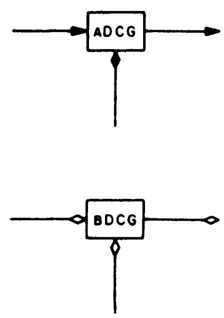


Figure 4-62. Diode Capacitor Gate, Models A and B, Logic Block Symbols

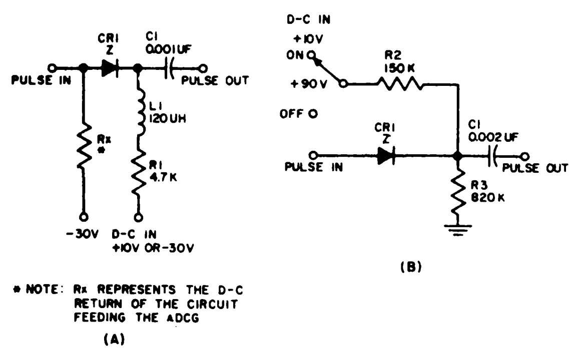


Figure 4-63. Diode Capacitor Gates, Models A and B, Schematic Diagrams

Principles of Operation

Figure 4-63 contains the schematic diagrams of the two models of the DCG.

First consider the model $_a$DCG. The circuit consists of a diode, a choke, a capacitor, and a resistor. The PULSE IN terminal is returned to -30V. With DC IN at +10V, the anode of diode CR1 is biased at a -40V with respect to the cathode. A standard pulse (40V maximum) cannot pass through CR1. With DC IN a 30V, the anode and cathode of CR1 are at the same potential. A standard pulse applied to PULSE IN develops a 40V pulse across L1 and R1 and is coupled to PULSE OUT by C1.

Now consider the model $_b$DCG (Figure 4-64, B). This circuit consists of a diode, a capacitor, a voltage divider, and a BIT SELECTION Switch. A 1 pulse (approximately +30V) is applied to the anode of CR1 through PULSE IN. The voltage divider biases CR1, this bias depends on the position of S1 in the DC IN circuit. When S1 is in the OFF position, +90 volts is applied across the voltage divider and a resulting +76 volts is applied to the cathode of CR1. The +30V pulse on the anode of CR1 makes the anode of CR1 negative with respect to the cathode and, as a result, this pulse is prevented from passing through. When S1 is in the ON position, a +10 V potential is applied across the voltage divider, resulting in a bias of +8.5V on the cathode of CR1. The +30V pulse on the anode is now sufficient to overcome this bias and, as a result, is coupled to PULSE OUT by capacitor C1.

CAPACITOR-DIODE GATES, MODELS A, B, C, AND E

Definition and Description

The capacitor-diode gates (CDG) are logic circuits which pass a standard pulse when conditioned by a +10V standard level. Figure 4-65 shows the logic block symbol for these circuits.

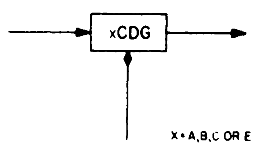


Figure 4-64. Capacitor-Diode Gate, Logic Block Symbol

There are four models of the CDG. Three models (A, B, and C) are identical in form. Changes, in value or type, of several parts in the circuit account for the differences between the three models. Model E is a combination of a pulse coupler and a CDG.

Principles of Operation

Figure 4-65 shows the schematic diagrams of the four models of the CDG. The output terminal of CR1 is returned to +10V in the circuit it feeds. With -30V applied to the D-C IN terminal, CR1 is biased beyond cutoff by 40V. A standard pulse applied to the PULSE IN terminal raises the plate of CR1 to a maximum of 40V to +10V. As a result, no pulse appears at the output terminal. With D-C IN voltage at +10V, the diode anode and cathode are at the same potential. A standard pulse applied to the PULSE IN terminal appears as a standard pulse at the output terminal. Inductor L1 presents a high impedance to the input pulse, ensuring relatively unloaded coupling to the succeeding circuit. Inductor L1 also presents a low d-c impedance for the discharge of C1 and prevents a bias buildup at the anode of CR1.

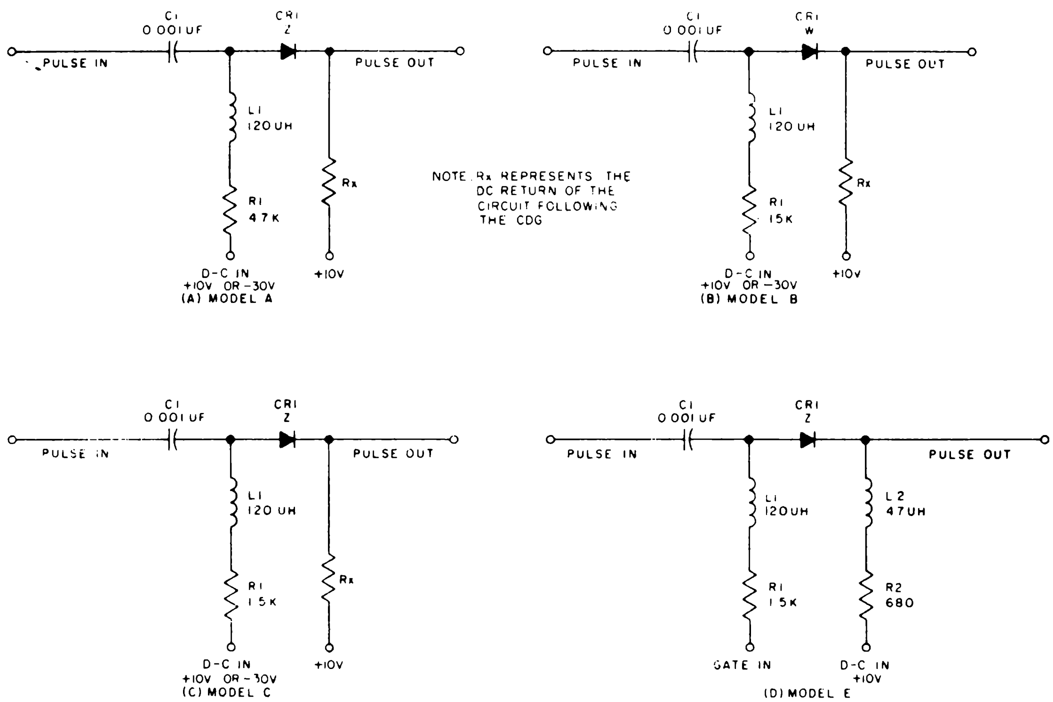


Figure 4-65. Capacitor-Diode Gate, Models A, B, C, and E, Schematic Diagrams

The $_b$CDG and $_c$CDG operate in a similar manner. In model B, the type of diode (CR1) is changed to adapt the model C to specific application requirements. In models B and C, R1 is changed in value to reduce the input impedance (DC) of the CDG to meet specific application requirements.

The $_e$CDG has a pulse coupler segment which provides the +10V cathode bias voltage for CR1. This arrangement permits pulse gating into circuits lacking +10V returns in their inputs.

CHAPTER 5 - LOGIC FUNDAMENTALS

A. Basic Logic Rules and Coding

1. The circuitry involved in a computer such as the AN/FSQ-7 is of such complexity, that it is presented in block schematic form. This is termed logic.

2. The overall computer logic is divided into logic systems; namely, logic drawings grouped together with regard to their particular equipment areas. (A system of logic may require 3 or 4 logic books for all its drawings). In turn each of these logic systems is further divided into logical function, section of function, etc.

3. A special four digit coding is used in the logic book for ready reference to the system, function, section and circuit.

a) The first digit indicates system. 0-7

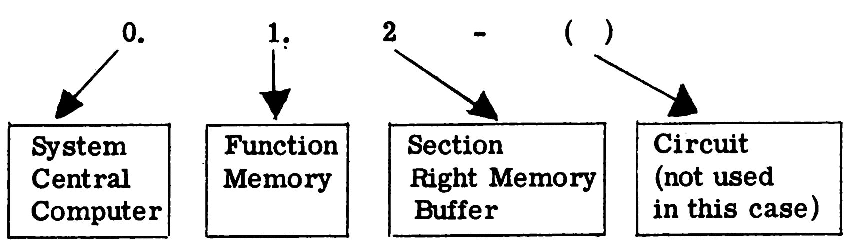
0. -Central computer
1. -Drums
2. -Inputs
3. -Outputs
4. -Displays
5. -Power
6. -Warning lights
7. -Duplex and simplex maintenance console switches.

b) The second digit indicates logical function - such as memory is part of central computer.

c) The third digit indicates section - such as the memory buffers are a section of memory.

d) The fourth digit indicates circuit designation. (Used only if necessary for further break-down of section.)

Example of Four digit Coding.



4. The four digit number, that is applicable to a certain page in a logic book, appears in the upper right hand corner of the page. (The number or numbers appearing directly under this number pertains to the marginal check group (S) for this page.)

5. Other information concerning logic symbology will be covered at this time with references made to Figure 5-1. This figure is representative of a pluggable unit as it would appear with other pluggable units on a logic page.

a) Item Nr. 1 Refers to origin of signal appearing at this point.
b) Item Nr. 2 Refers to point to point wiring of signal output.
c) Item Nr. 3 Refers to simultaneous signal application.
d) Item Nr. 4 Refers to marginal check information for a particular circuit. (Ex) FF circuit.
e) Item Nr. 5 Refers to the tube positions in the P. U. for a particular circuit (Ex) FF circuit.
f) Item Nr. 6 Refers to the pluggable unit designation.
g) Item Nr. 7 Refers to destination in logic of a signal.
h) Item Nr. 8 Refers to line crossovers.
i) Item Nr. 9 Refers to P. U. pins this P. U.
j) Item Nr. 10 Indicates this not complete circuitry in P. U. - other portions appear else where.

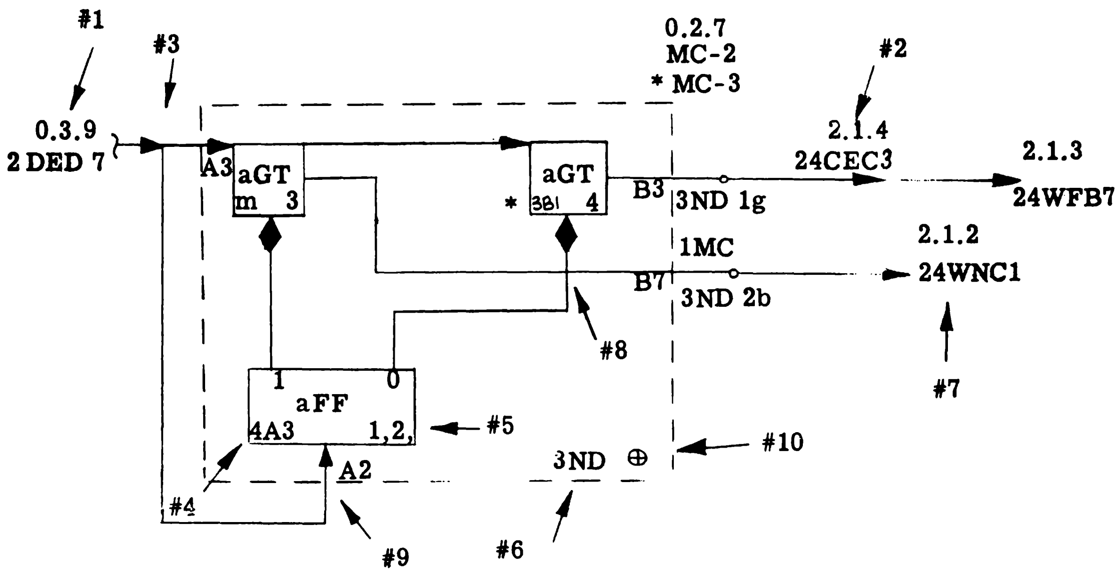
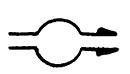
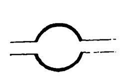


Figure 5-1

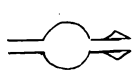
STANDARD-LINE CONVENTIONS



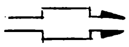
Multiple signal lines (pulsed at the same time pulse not necessarily in the same machine cycle)



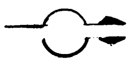
Power distribution

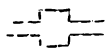


Marginal checking distribution

 Multiple signal lines (pulsed at different time pulse)

 Multiple signal lines (signal levels up at different times)

 Multiple signal lines (signal levels all up at the same time)

 Multiple mechanical connections activated at different times

 Multiple mechanical connections activated at the same time

DEFINITION LIST FOR BASIC CIRCUITS

AND (circuit)- A circuit which provides an output when and only when all inputs are energized simultaneously and with the same polarity. The output is of the same polarity as the inputs.

AND (gate)- A circuit logically similar to the AND circuit except that the output is of opposite polarity to the inputs. This circuit performs the function of a logical NOT AND.

Back panel- The side of the module that is opposite to the side in which the pluggable units are inserted; e.g., the wiring side.

Basic circuit- A circuit which, without modification, is used in several units.

Block schematic- A diagram representing a logical division of the AN/FSQ-7 equipment. A block schematic shows circuits as blocks.

Blocking oscillator- A vacuum tube circuit used for the generation of pulses from a rapid rise in d-c voltage.

Bus- One or more conductors which are used for the distribution of power or information from any of several sources to any of several destinations.

Card circuit- A circuit that has been produced using etched-card techniques. The conductors are etched on the surface of the card by means of etching, and the components are then mounted or printed on the card.

Cathode follower- A vacuum tube circuit in which the output appears between the cathode and ground, thereby giving high input impedance, low output impedance, and a voltage gain approaching one.

Clear-	To restore a counter or memory device to the zero state. (see: set.)
Component-	A device which is used in the construction of a larger device and which is constructed in such a manner that it is usually replaced as a whole since it is not economical to disassemble it.
Core memory-	A memory device which stores bits by magnetizing cores in a direction corresponding to the values of the bits.
Delay line-	A circuit which may be used to delay a signal. Delay lines usually have the characteristics of low-pass filters.
Diode-	An electronic component which has the property of conducting current in only one direction. It may be either a 2-element vacuum tube or a crystal.
D-c level setter-	A circuit which restores the level of a d-c signal after it has deteriorated.
Downtime-	Time during which a computer is not performing operational programs.
Excursion-	An outward deviation in amplitude from a mean voltage level. The range through which the voltage is varied while performing a marginal check.
Ferrite-	A magnetic material prepared from compounds of iron, nickel, and cobalt, bound by a ceramic and heat-treated.
Ferrite core-	A ferrite toroid which is made from a type of ferrite having a nearly rectangular hysteresis loop. The toroid is used in the construction of computer memories and is capable of storing one bit. The bit is stored by saturating the core in a direction corresponding to the value of the bit.
Flip-flop-	A bistable electronic circuit ordinarily having three inputs. Two of the inputs correspond to the stable states, and the third is used to complement or to switch from one state to the other regardless of the initial state of the circuit.
Gate-	A circuit having an output and a plurality of inputs so arranged that the output is energized when and only when a definite set of input conditions is met.

Level-	(a) A d-c voltage. (b) The amplitude of an a-c voltage.
Logic diagram-	A diagram which shows logical circuits as blocks labeled with the logical function they perform. Logic diagrams also show the signal flow between these circuits.
Logical operation-	An operation involving the comparison of data and the development of a conclusion based on predetermined conditions.
Module-	A rack of electrical equipment, usually pluggable units.
OR circuit-	A circuit whose output follows the most positive input.
Pluggable unit-	A chassis containing card circuits and which may be removed from the rest of the computer equipment by unplugging it and substituting an identical unit.
Prototype-	(a) The original form from which others are copied. (b) A general term applying to the AN/FSQ-7 (XD-1) and AN/FSQ-7 (XD-2).
Pulse-	A change in voltage or current lasting for a short period of time and then returning to its normal value. The duration of standard pulses in the AN/FSQ-7 is 0.1 microsecond, with a voltage difference of 40 volts.
Pulse amplifier-	A circuit used for power amplification of standard pulses.
Pulse generator-	A circuit which produces standard pulses when a contact is closed or when a specific voltage input is applied.
Register-	A device capable of holding and transferring a word.
Register driver-	A circuit used for the power amplification of standard pulses which have to drive large loads.
Relay driver-	A circuit which uses a vacuum tube or thyratron to actuate a sensitive relay.
Rise time-	(a) The time necessary for a voltage or current to rise from 10 to 90 per cent of its final response. (b) The time necessary for a voltage or current to rise from 0 to 100-(100/E) per cent of its final value.
Sense-	To determine the state of a bistable or multistable device.

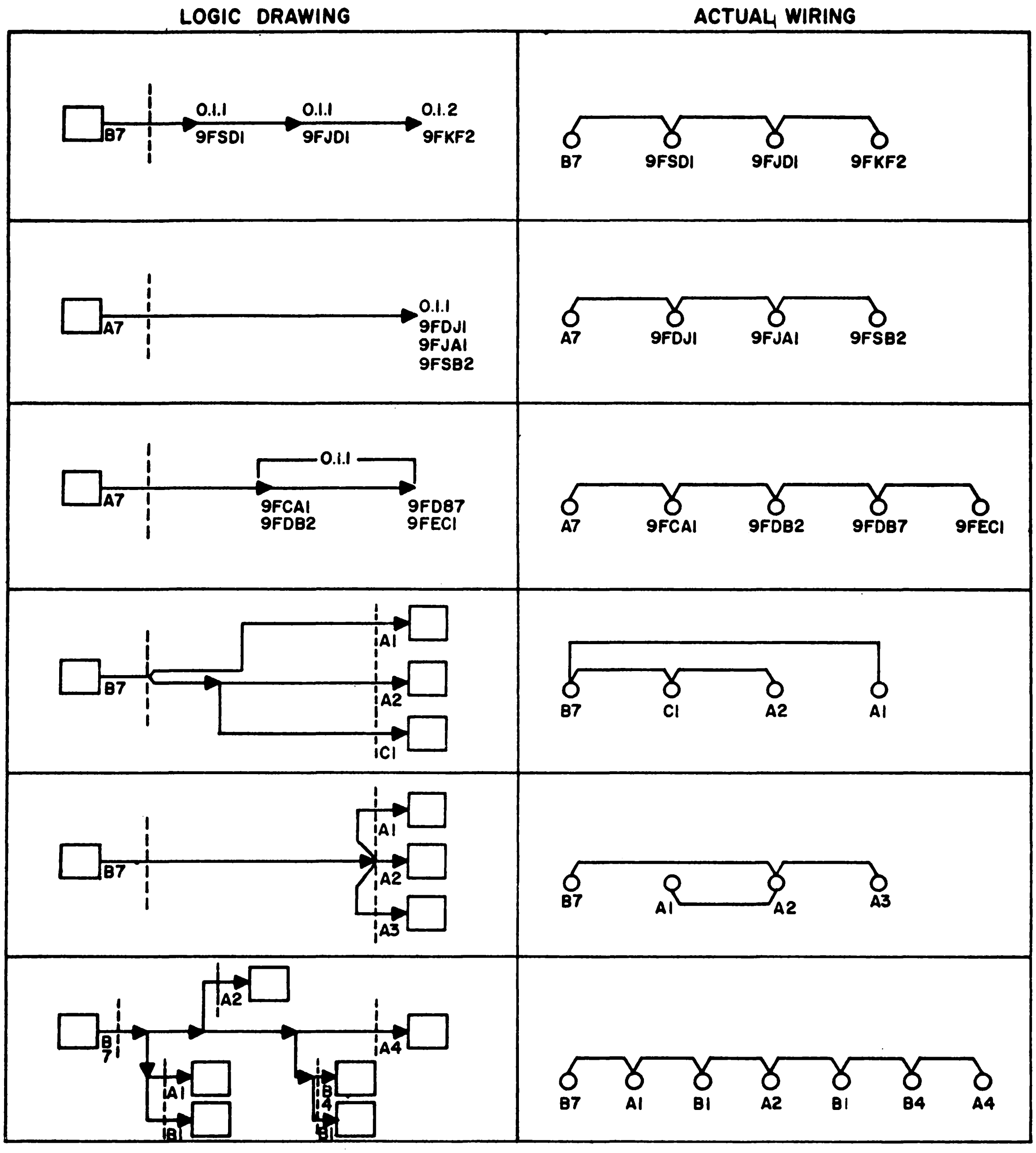

LOGIC DRAWING
ACTUAL WIRING
B7
O.I.I
9FSDI
O.I.I
9FJDI
O.I.2
9FKF2
B7
9FSDI
9FJDI
9FKF2
A7
O.I.I
9FDJI
9FJAI
9FSB2
A7
9FDJI
9FJAI
9FSB2
A7
O.I.I
9FCAI
9FDB2
9FDB7
9FECI
A7
9FCAI
9FDB2
9FDB7
9FECI
B7
AI
A2
CI
B7
CI
A2
AI
B7
AI
A2
A3
B7
AI
A2
A3
B7
A2
A4
AI
BI
B4
BI
B7
AI
BI
A2
BI
B4
A4

Figure 5-2

BASIC TRANSFER, COUNTING AND SHIFTING CIRCUITS

To provide complete exchange of information from one computer register to another, various type transfers and shifts are used throughout the AN/FSQ-7. The basic forms of transfers will be present in this section.

A. Single line Transfer (Figure 5-3)

1. Consists of two operations.

a. Clear - Clear every FF in the register into which the information is to be transferred.

b. Xfer - wherever there is a "1" in the first register, set the corresponding FF in the second register to a "1".

2. At a .5 usec pulse rate, a single line transfer requires a minimum of 1 usec.

3. Requires as many gates and transfer lines as FF positions.

B. Double Line Transfer (Figure 5-4)

1. One operation - Xfer - either a "1" or a "0" is transferred from each FF position in the first register to the corresponding FF in the second register.

2. Requires .5 usecs to complete.

3. Requires twice as many gates and transfer lines as FF positions.

C. Broadside Shift (Correctional Shift Left) - (Figure 5-5)

1. A broadside shift is essentially a double line transfer of the information in a register back into that same register only displaced by one FF position to the right or left.

2. A broadside shift requires .5 usecs. of time to complete.

3. Requires twice as many gates and transfer lines as FF position.

D. Ripple Shift (Figure 5-6)

1. In Figure 5-6 the shift is begun the Xfer pulse strobing GT_5 and GT_6. The information in Bit 14 is shifted to Bit 15 position and a pulse is passed on to the next FF position. In the figure this is to GT_4 and GT_3 where Bit 1 is transferred to GT_1 and GT_2 where the Sign Bit is transferred to Bit 1 position.

2. Due to the delay in each GT the shift process takes place in a rippling manner. In a 16 bit register a ripple shift will transfer the last bit about 1 + usecs. after it

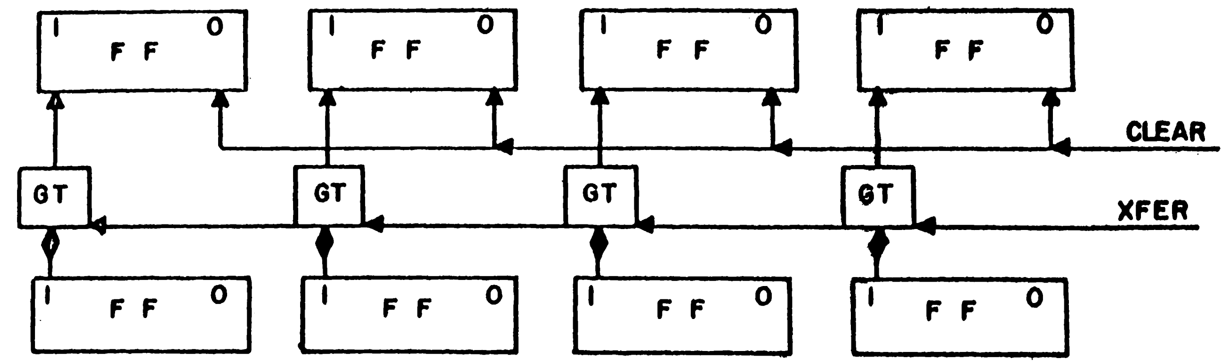


Figure 5-3. Single Line Transfer

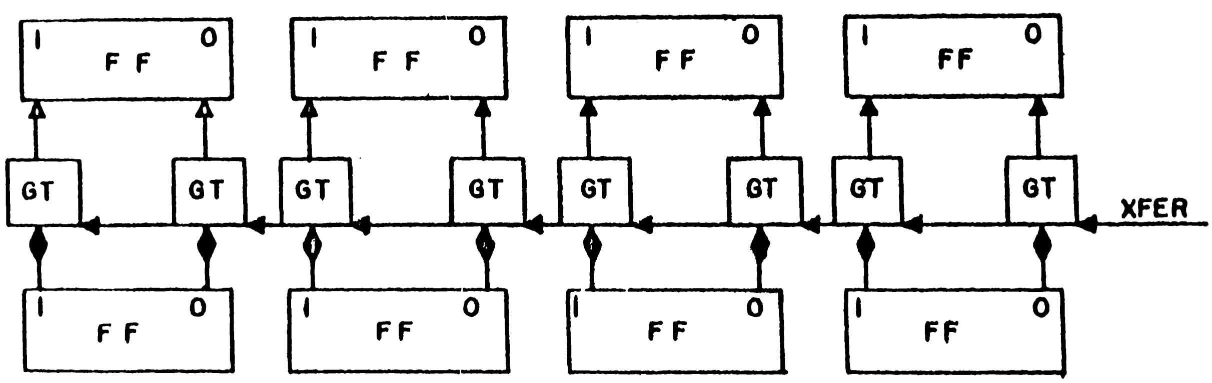


Figure 5-4. Double Line Transfer

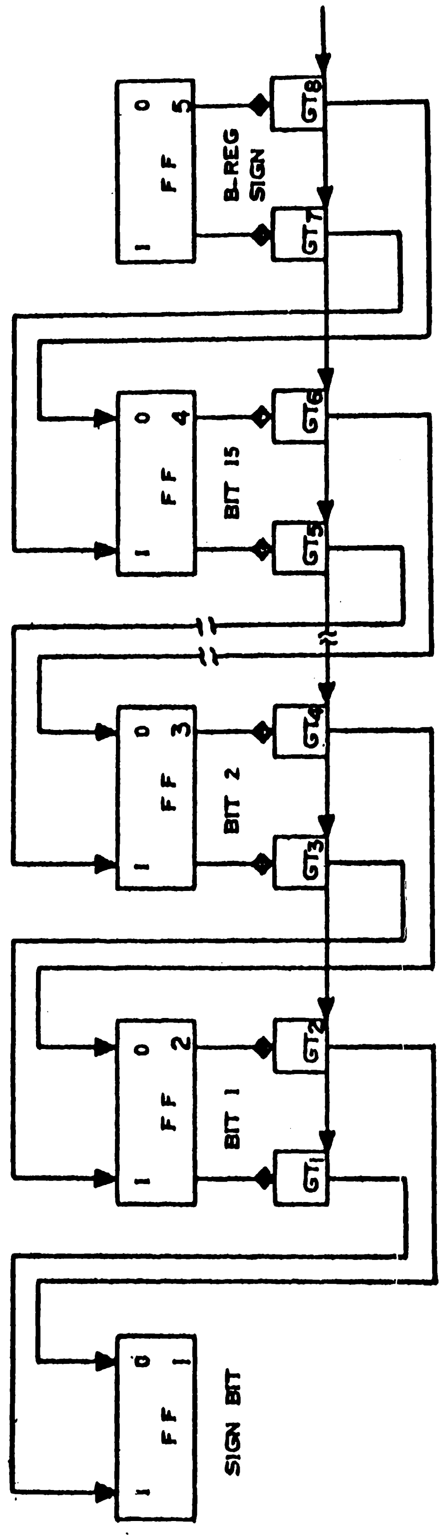


Figure 5-5. Correctional Shift Left

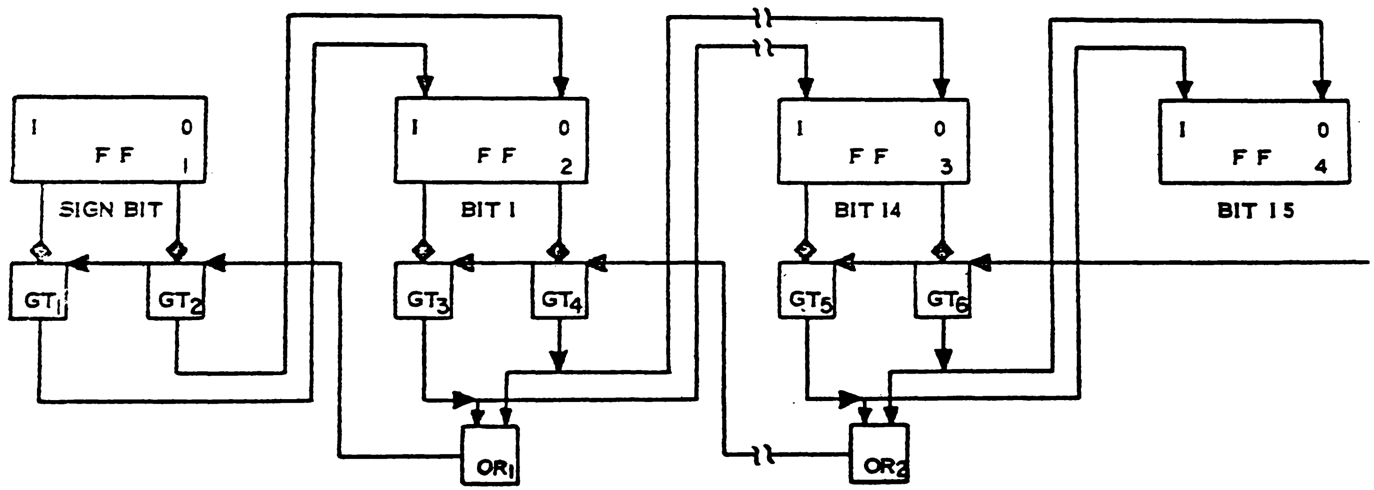


Figure 5-6. Ripple Shift Right

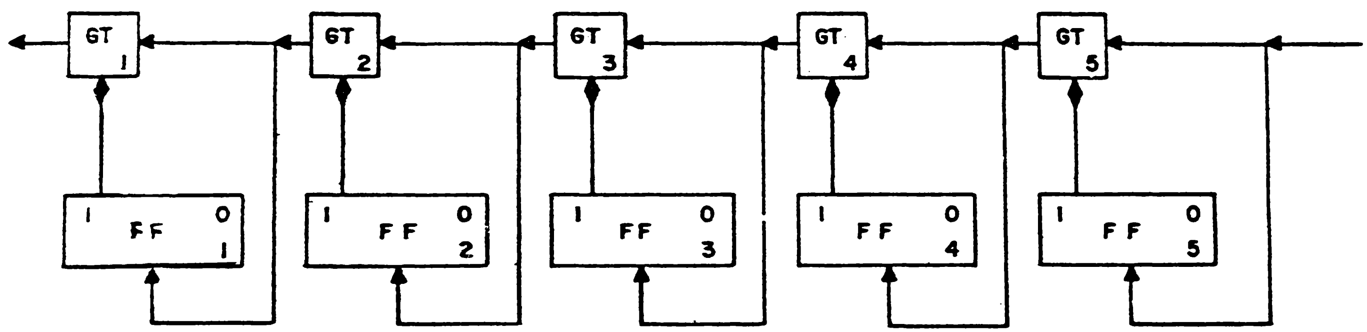


Figure 5-7. 5 Stage Flip Flop Counter

LOGIC

FUNCTION	CIRCUIT	SYMBOL	USE
1. STORAGE	FF	1 FF 0	STORAGE DEVICE PROVIDES STANDARD LEVEL DIVIDER (COUNTING DEVICE).
2. COINCIDENCE	AND (GATE)	GT	DRIVES ONE OUTPUT FROM TWO OR MORE INPUTS.
	AND (DIODE)		
	OR (DIODE)	OR	
3. CONVERSION	INVERTER	1	RESTORES AND INVERTS DETERIORATED SIGNALS (ONLY ONE CIRCUIT) GENERATES STANDARD PULSES AND LEVELS OF PREDETERMINED DURATION
	PULSE GEN.	PG	
4. TIMING	DELAY UNIT	DD	DELAY LINES AND DELAY LINE DRIVERS. GENERATES LEVEL OF PREDETERMINED DURATION.
	SINGLE UNIT	SS	

NON-LOGIC GROUPS

FUNCTION	CIRCUIT	SYMBOL	USE
1. POWER AMP.	CATHODE FOLLOWER	CF	CURRENT AMPLIFIER & MATCHING ISOLATION OF CIRCUITS. REAMPLIFIES ATTENUATED STANDARD PULSE SIGNALS MODEL "A" WORKS AT 50KC (DRIVES LIGHT LOADS) MODEL "B" 2mc OPER. (HEAVY LOADS)
	PULSE AMP.	PA	
2. CONTROL	REGISTER DRIVER	RD	SETS AND CLEARS FF.
	V-TUBE RELAY DRIVER	VRD	OPERATES RELAYS.
	THYRATRON RELAY DRIVER	RYD	A CURRENT SWITCH TO ACTIVATE RELAYS AND PRINT AND PUNCH MAGNETS.
3. RESTORER	DC LEVEL SETTER	LA	RESTORES DETERIORATED LEVELS. MODEL "A" ADJUSTS FOR 0-8 VOLTS. MODEL "B" ADJUSTS FOR 10 to -30 V.

Figure 5-8. Logic and Non-logic Groups

starts transferring the first. When checking the Accumulator circuits at a later date an interesting experiment is to measure this time with a scope.

3. The ripple shift is used because of the method employed by multiplications operations.

E. Binary Counter

Counters are used extensively throughout the computer for step by step control of operations and as devices to indicate time and sequence, etc.

The five stage counter shown in Figure 5-7 will be used to demonstrate the basic operation of counters in general.

1. Operation of A Binary Counter

a) Assume all flip flops clear stepping pulses being applied at a constant frequency. (Counter=00/000)

1st Pulse: Strobes GT 5(deconditioned) and compliments FF 5(Counter=00/001)

2nd Pulse: Strobes GT-5 (Conditioned), compliments FF 5 strobes GT 4 (Deconditioned) and compliments FF-4 (Counter=00/010)

3rd Pulse: Same as 1st Pulse except for a count of (00/011).

4th Pulse: Strobes GT-5 (Conditioned) and compliments FF 5 strobes GT 4 (Conditioned), compliments FF-4 strobes GT 3 (Deconditioned) and compliments FF-3 (Counter=00/100)

2. With each additional pulse the binary count increases by one. The maximum value that will appear in this 5 stage counter is 37_8. The next pulse will clear all counter FF's.

a) Determine no. of pulse required to set FF-1 (all FF's clear to start).

CHAPTER 6 - TEST EQUIPMENT

INTRODUCTION TO THE TUBE TESTER

A. Purpose

1. To provide an accurate indication of tube performance with a minimum of operating skill and judgment required.

2. Through the use of a tube test adapter for each tube type, manual adjustments are eliminated.

B. General Information

1. Types of Tubes Tested

   a. The tube tester is capable of testing eight different tube types.

      1) 0528
      2) 2420
      3) 5749
      4) 5998
      5) 6072
      6) 6136
      7) 6146
      8) 2D21

   b. These tube types are the most commonly used in the AN/FSQ-7 and 8.

2. Types of Tests

   a. Min. and max. plate current.
   b. Max. screen grid current.
   c. Max. control grid current.
   d. Min. grid insulation
   e. Min. heater-cathode leakage

3. General

   a. Tube tester is capable of 11 different tests for each tube type through operation of test push-buttons.

   b. The number of tests actually performed on a tube is dependent on the tube type and the wiring of its test adapter.

   c. Results of a test, except HK Leakage Test, are indicated by the "Accept" and "Reject" indicators on the control panel. A tube must "Accept" on all tests in order for it to be considered good.

Figure 6-1. Electron Tube Test Set, Model TV-11/FSQ, with Test Adapters

C. Physical Description

1. Console

a. Control Panel

1) Main Power switch

2) Fuses

3) Indicators - light when power is applied to respective circuits.

4) Test adapter receptacle - 160 pin receptacle to which test adapter is mounted.

5) Pre-heat sockets - apply, only filament power to tubes to be tested.

6) "Accept-Reject" lights - indicate whether or not test is successful.

7) "No Test" light - indicates when a particular test position is not used.

8) Test pushbuttons - control the movement of a stepping switch which determines the test position.

9) Test lights - indicate at which test position stepping switch has stopped.

10) Heater cathode leakage test light is used as the "Reject" indicator for this position. A tube is defective if the white indicator lights. This position is also used as a safety and rest position since it removes high voltages from the 160 pin connector.

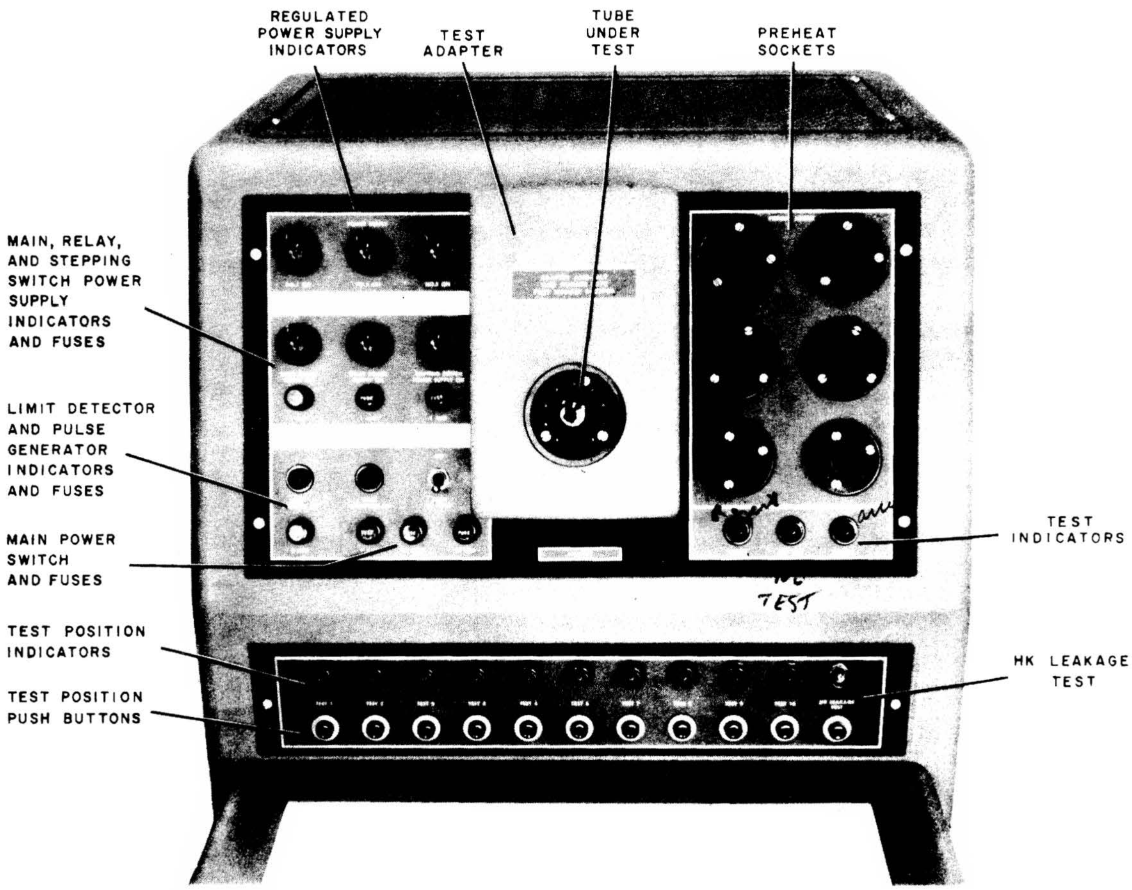


Figure 6-2. Control and Test Panel

b. Location of Chassis

1) Point out the location of chassis on Figure 6-1.

2) Point out the location of the regulated power supply circuit breakers.

D. Summary Questions

1. The tube tester is capable of testing ____________________ different tube types.

2. The five different types of test are:

3. The tube tester should always be left in what position and why?

E. Block Diagram

1. Test Adapter

a. Modifies tester circuitry to test a particular tube type.

b. Contains remote control resistors which adjust the output of the regulated power supplies for each test.

c. Contains voltage-sampling resistors across which a test signal voltage is developed. The signal voltage is sent to the limit detector to be compared with a reference. The signal voltage should always be approx. - .25v for a successful test.

d. Contains jumpers which determine whether a max. or min. test is made at each test position.

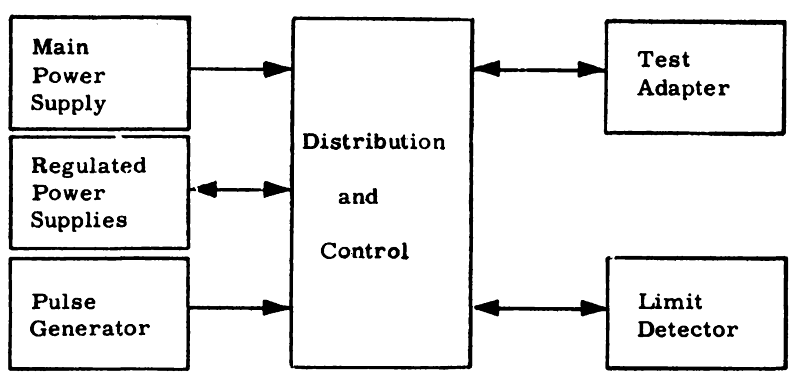


Figure 6-3

e. Completes Wiring from tester circuits to tube under test.

2. Distribution and Control Circuits

a. Contains various power and control indicating lamps, fuses, and circuit breakers.

b. Stepping Switch

1) Used to switch components and jumpers of each test adapter into circuits to perform necessary tests.

2) Switch is stepped by depressing any of the 11 test pushbuttons.

3. Regulated Power Supplies

a. Three identical regulated DC power supplies.

b. Used as voltage sources by tube under test.

c. Typical utilization of power supplies.

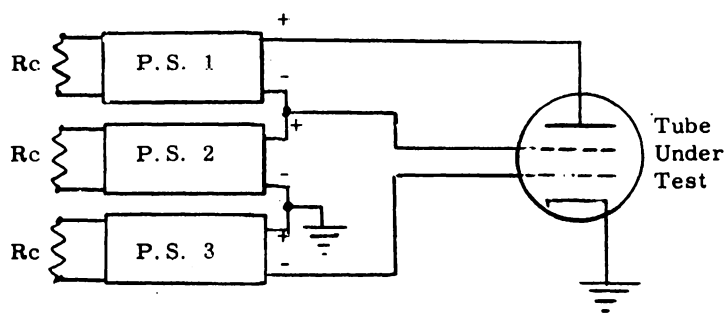


Figure 6-4

d. Regulated supply* outputs can be set to any value between 0V and 200V on each supply by inserting different value control resistors (contained in test adapter). The output follows this formula.

$$\text{Output Voltage} = \frac{\text{R (ohms)}}{1000}$$

4. Limit Detector

a. Compares the signal voltage (approx. - .25v) with a fixed reference of - .25v.

b. In the event the signal voltage is more negative than the reference by 600 microvolts or more, a limit detector relay will pick. If the signal is more positive than the reference (more positive than - .25v). The limit detector relay remains de-energized.

c. The limit detector relay along with the maximum or minimum jumpers in the test adapter determine whether the "Accept" or "Reject" lamp will light.

d. Examples:

1) Minimum jumper in test adapter. (Pin D16 in test adapter)

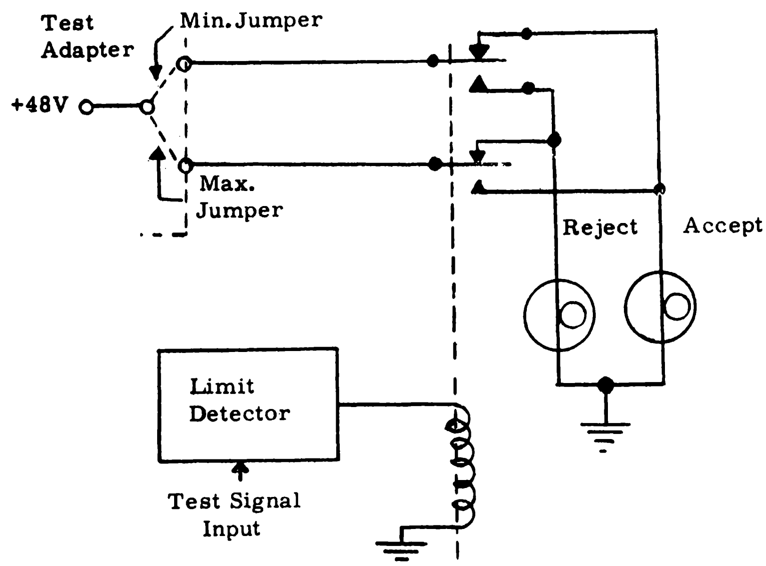


Figure 6-5

a) For a maximum test, the "Accept" lamp will light unless limit detector relay picks (unless signal is more negative than reference).

b) If the limit detector relay picks, this indicates the signal voltage has exceeded the maximum limit and the "Reject" lamp will light.

2) Maximum jumper in test adapter. Pin D17 in test adapter.

a) If signal is more negative than reference, relay picks and "Accept" lamp lights.

b) If relay does not pick, signal has not met minimum specifications and "Reject" lamp is lit.

e. Summary

1) If testing for a maximum condition the min. jumper is inserted and the test signal must not exceed - .25v to be accepted. The test condition should produce a signal of -.25v and no more.

2) If testing for a minimum condition the max. jumper is inserted and the test signal must exceed - .25v to be accepted. The test conditions should produce a signal of -.25v and no less.

f. The limit detector chassis contains its own B+ and B- power supplies. The -.25v reference is developed across a voltage divider within the chassis.

5. Pulse Generator

a. Used when testing type 2420 and 0528 tubes. Permits testing at a duty cycle of from 1 to 5 percent. Checks tube under conditions of heavy conduction without exceeding power dissipation of the tube.

b. Type 2420 tubes are commonly used as gate tubes, pulse amplifiers, and register drivers in computer circuitry.

c. Output waveform frequency is 3.5KC, Pulse width 5 to 10 usec., amplitude, -25v to +10v.

INTRODUCTION TO MANUAL P.U. TESTER

A. Purpose of Equipment - to manually test pluggable units, with the aid of test specifications and logical block diagrams associated with each pluggable unit.

B. Physical Description

1. Comprised of three modules, Figure 6-6, 6-7.

a. Designated as A, B, and C from left to right when facing rear.

b. Module A is a standard nine tube module while B and C are desk type modules.

1) Module A contains:

a) Signal Generation Circuits

b) Calibration Controls

2) Module B contains:

a) Test Station

b) MC Controls

c) DC Power Controls

d) Misc. Jack Connections

e) Power Distribution Box

f) MC Power Supply

g) Test Station Filament Transformer

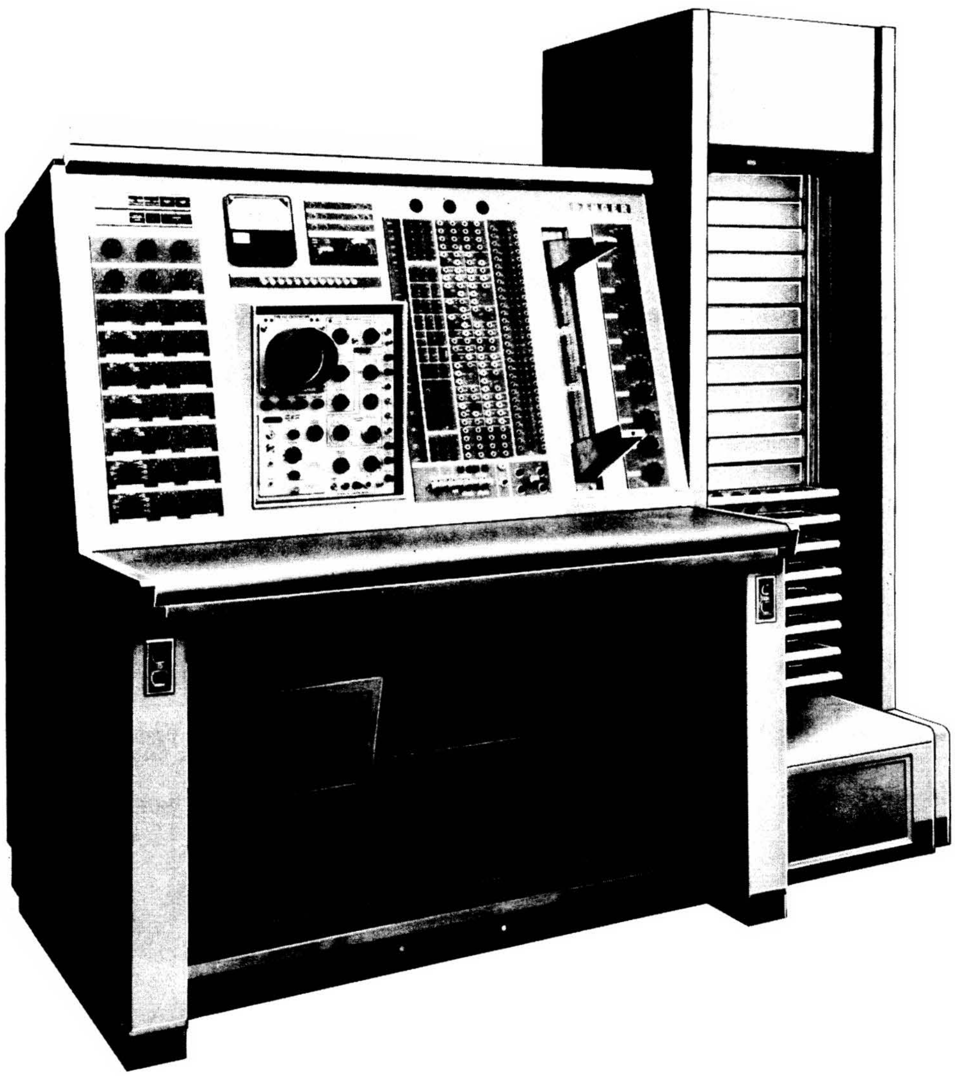


Figure 6-6. Tester, Front Three-Quarter View

3) Module C contains:

a) Signal Generation Circuits

b) Operating Controls

c) Machine Power Controls

d) Oscilloscope

e) Controls associated with MC Power Supply.

2. Component location code.

a. Identifies the module, panel, section, component, and terminal in that order. Example: B2A (53)e

b. Module B and C panels are numbered 1, 2, 3, and 4. From the rear, the left side is one, front is two, right is three, and back is four.

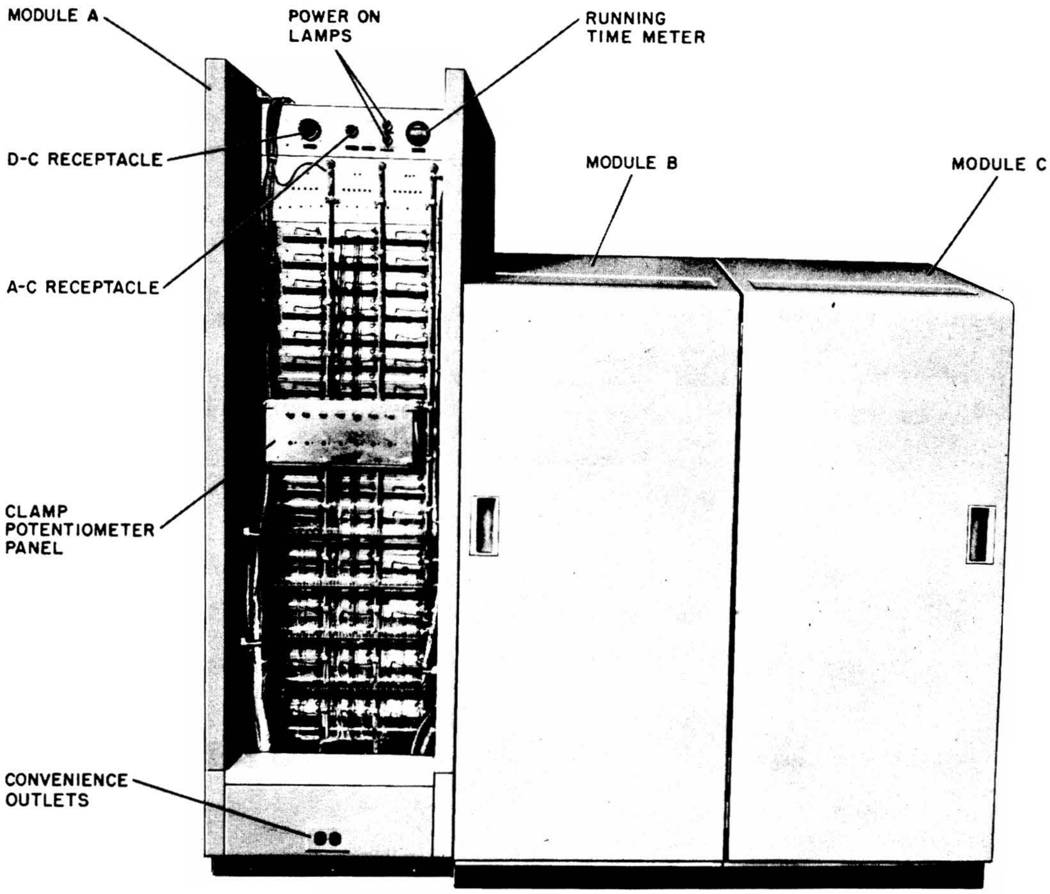


Figure 6-7. Tester, Rear View

1) Additional panels for module B are 5, 6 and 7, which are mounted horizontally with five being the top position.

2) Additional panels for Module C are 5 and 6 which are mounted horizontally with five being the top position.

c. Next letter designates zone in module.

GATE TUBE CIRCUIT, SCHEMATIC

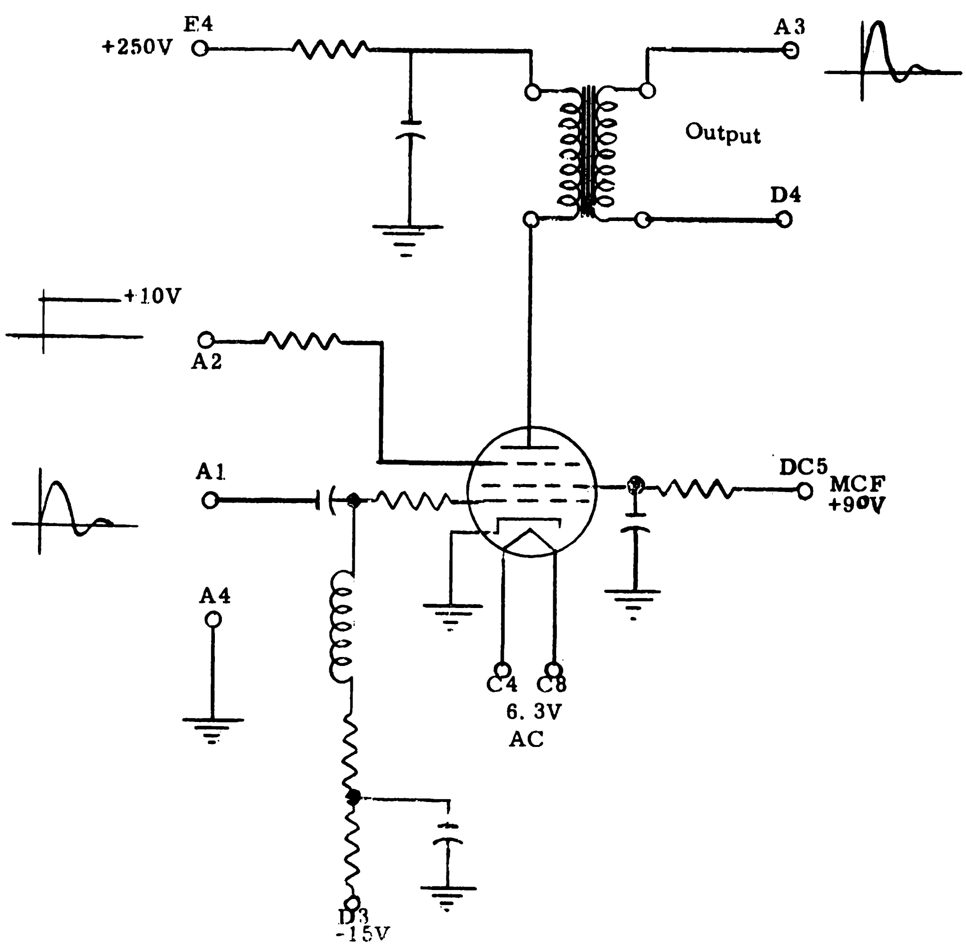


Figure 6-8

C. Basic Principles of Operation

1. Test of a Typical Stage

a. In order to show the basic operations of the tester, the testing of a single typical stage is described. Figure 6-8 shows the schematic diagram of a gate tube stage to be tested. This stage uses 10 terminal pins designated A1, A2, A3, A4, C4, C8, D3, D4, D5, and E4. A standard output pulse is normally obtained from pin A3 when the following conditions exist at the other pins.

1) Standard pulse At A1

2) +10V at A2

3) Ground at A4 and D4

4) 6.3Vac between C4 and C8

5) +250V at E4

6) -15V at D3

7) 100 -ohm load between A3 and ground

8) +90V (MC voltage) at D5

When the plug-in unit containing this stage is plugged into the test station of the tester and power is on, the necessary conditions at A4, C4, C8, E4, D3, and D4 are satisfied; i.e., standard service voltages are automatically applied to the appropriate pins of the plug-in unit. This part of the test setup does not require any manual control because in the standard plug-in units particular pins are always associated with particular service voltages.

For example, if pin E4 is used in a particular plug-in unit, then it is used to make a connection to +250V. In some plug-in units, pin E4 is not used. In that case, it is not connected to any other point on the plug-in unit and the fact that the +250V is connected to it is of no consequence. Thus, +250V can be connected to base pin E4 of the tester test station regardless of the type number of the standard unit which is plugged into the test station. Taking advantage of this standard association of particular pins with particular service voltages, the tester is wired so that standard service voltage connections are made to the base pins of the test station when test station power is turned on. In order to obtain the 100-ohm load, a 100-ohm plug load is plugged into A3 and the adjacent ground jack.

Just a certain set of pins is associated with standard service voltages, another set is associated with MC voltages. Here, however, additional flexibility is required; to gain this flexibility, a programming operation must be performed. The operator of the test set may select any one of three positive voltages for application to pin D5 by means of a selector switch. In this case, he selects +90V. In addition, the operator has tester controls available which allow him to vary this +90V by an arbitrary amount. Thus, for example, he can increase the voltage applied to pin D5 to +100V and then decrease it to +80V. He can then observe the operation of the circuit under these marginal conditions.

As a result of plugging a unit into the tester, turning on test station power, and selecting an MC voltage for pin D5, the gate tube stage of Figure 6-8 has been supplied with the power which is required for operation. It now remains to provide the stage with signal inputs and to observe the output of the stage on the oscilloscope.

The +10V signal for pin A2 is obtained by making a patch connection on the tester front panel between a jack associated with one of the two DC LEVELS switches and another jack which is connected to the A1 pin on the test station. The corresponding DC LEVELS switch is then placed in the +10 position.

Standard pulses of any desired pulse repetition frequency between 80 cps and 4.5 mc can be obtained from output jacks associated with either one of two variable pulse generators which are a part of the tester. The frequency controls of one of these units are set to obtain the desired frequency (as observed on the oscilloscope). An amplitude control can be set to obtain the appropriate amplitude. The output of the pulse generator is then patched to a jack connected to the A1 pin of the test station. The oscilloscope probe is placed in a jack which is connected to the A3 pin of the test station and the output of the gate tube circuit is observed.

Since the +10V applied to pin A2 conditions the gate, an output pulse should be observed. The next step would normally be to remove the +10V from A2 and apply -30V. In this condition, the output pulse should not appear. This change in input is obtained merely by placing the DC LEVELS switch in the -30V position.

2. Test of a Plug-In Unit

a. A plug-in unit normally consists of a number of stages. To check the unit, each stage is checked in turn in a manner similar to that described above.

3. Test Specifications

a. For every plug-in unit which can be tested on the tester, there is a specification which defines the inputs which must be programmed to check each stage of the unit and defines the outputs which should be observed. These specifications do not contain detailed block diagrams of the connections which must be made to produce the specified inputs. Instead, the operator has the responsibility of using the signal-generating facilities of the tester in a way that will obtain such inputs.

D. Block Diagram

1. The manual PU tester may be divided functionally into the following components:

a. Test station

b. Jack panel

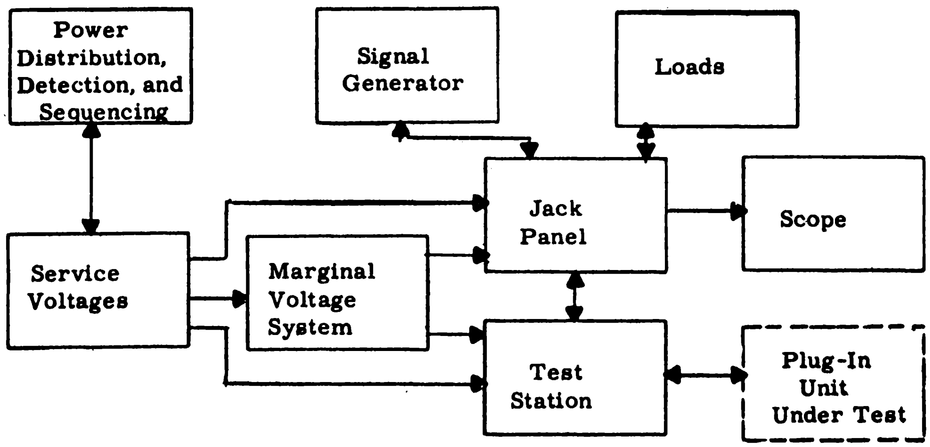
c. Signal generator

d. Load system

e. Service voltage system

f. Marginal checking voltage system

g. Power distribution, detection, and sequencing system



2. Test Station

a. The test station comprises the receptacles into which the plug-in unit to be tested is inserted. All connections between the tester and the unit under test are made through the test station which is designed to accommodate standard 9-tube plug-in units. Standard 6-tube plug-in units and certain nonstandard units can be checked by the tester. However, to check such units, a special adapter is plugged into the test station and then the unit to be checked is plugged into the adapter.

3. Jack Panel

a. The jack panel provides the facility for making interconnections between other components of the tester. By means of the jack panel, components of the signal generator are connected to produce specified test signals. These test signals are connected to jacks of the test station; loads and, in some cases, service voltages are also connected to jacks of the test station.

4. Signal Generator

a. The signal generator is the source of the specified test signals which are used to check the response of the plug in unit under test. In addition to equipment for generating test signals, the generator includes equipment for amplifying the power of these signals to suitable levels. Panel controls are provided for selecting desired values of component circuit parameters such as frequency, amplitude, and time delay which are subject to variation. In general, a specified test signal cannot be obtained merely by connecting the output of one signal generator circuit to a jack of the test station. Rather, it is necessary to make interconnections between several signal generator circuits and to select values of several variable parameters to obtain a signal which is correctly timed, is of the appropriate form, and is at the appropriate power level.

5. Load System

a. In order to check a circuit for normal operation, the circuit should be driving a normal (or equivalent) load. The load for a circuit on one plug-in unit may be located on another plug-in unit. When testing a plug-in unit which is normally loaded by another plug-in unit, the load system of the manual PU tester provides a group of equivalent loads which are connected to the plug-in unit under test as substitutes for the loads which it would normally drive in system operation.

6. Service Voltage Systems

a. The service voltage system provides the service voltages required for the normal operation of the plug-in unit under test. Since certain service voltages are associated with certain pins of all standard plug-in units, there is no need to select these connections for each different plug-in unit to be tested. Instead, the service voltages are automatically connected to the appropriate jacks of the test station when tester power is turned on. On the other hand, service voltages are sometimes required on other pins of the plug-in unit than those normally associated with these voltages. For this reason, all service voltages are brought out to jacks on the jack panel from which they can be connected through other panel jacks to jacks of the test station.

7. Marginal Checking Voltage System

a. One method of checking the operation of a circuit is to vary one of the service voltages supplied to it to a marginal value. The ability of the circuit to operate normally under this marginal condition is a measure of its reliability under normal conditions. In the manual PU tester, the variation of a service voltage is accomplished by series-insertion of the output of an MC supply. The magnitude can be varied and the polarity reversed by means of tester panel controls. Thus, service voltages of positive or negative polarity can be raised or lowered by a selected amount.

There are 10-test station jacks to which MC voltages can be applied; however, MC voltages are supplied to only one point at a time. Prior to a test, the service voltages to be supplied to each of the 10 pins associated with marginal checking are selected by setting 10 switches (and in some cases, also making a jack panel connection). The MC voltages are then applied, one at a time, during the course of the test by depressing pushbuttons associated with each of the MC points.

8. Power Distribution, Detection, and Sequencing System

a. The power distribution, detection, and sequencing system controls the distribution of the unregulated and regulated a-c voltages and the 11d-c voltages supplied to the tester from the site maintenance room power supply. Power is cycled on in sequence which tends to maximize the life of the vacuum tubes in the tester as well as those in the plug-in unit under test. Filament voltage is applied in two steps. Low d-c voltages used to establish clamping and bias levels are applied before high d-c plate voltages. Front panel power, which includes the power applied to the test station, is cycled on after the machine (tester) power has been cycled on. Front panel power is cycled off by the opening of the test station interlock when the plug-in unit under test is removed from the test station. Thus, each time another unit is plugged into the test station, the complete front panel power-on cycle is repeated, affording maximum protection to the tubes of the plug-in units being tested.

In order to protect the site maintenance room power supply, all voltages supplied to the tester are fused at the tester power distribution box. Associated with each fuse is an indicator lamp which remains lighted as long as the circuit is completed through the fuse. For the protection of the tester, the voltage-detection circuit cycles off all d-c power in response to any excessive deviation of one of the 11d-cvoltages or a failure of either of the a-c voltages.

A power isolation switch located on the panel of the power distribution box allows all tester power, with the exception of convenience outlet power, to be isolated to the power distribution box to facilitate maintenance of other parts of the tester. The fused unregulated ac is applied directly to the four convenience outlets and is independent of the distribution control circuitry of the tester.

E. Basic Operation

1. Test Station

a. Standard PU base and pin configuration.

b. Standard filament, service voltage and DC return potential are internally connected to specific pins.

c. Voltage applied when "front panel power" is on.

d. MC voltages are applied by means of switches.

e. Signal inputs and outputs are applied by jacks.

2. Signal Generation

a. Pulse Sources

1) Pulse Generator (PG)

a) Two separate variable frequency, variable amplitude pulse generators designated as PG 1 and PG 2. (C5 (E) and C5 (F))

b) Frequency continuously variable between 20 cycles 4.5 MC.

c) Amplitude variable between 15 volts and 30 volts.

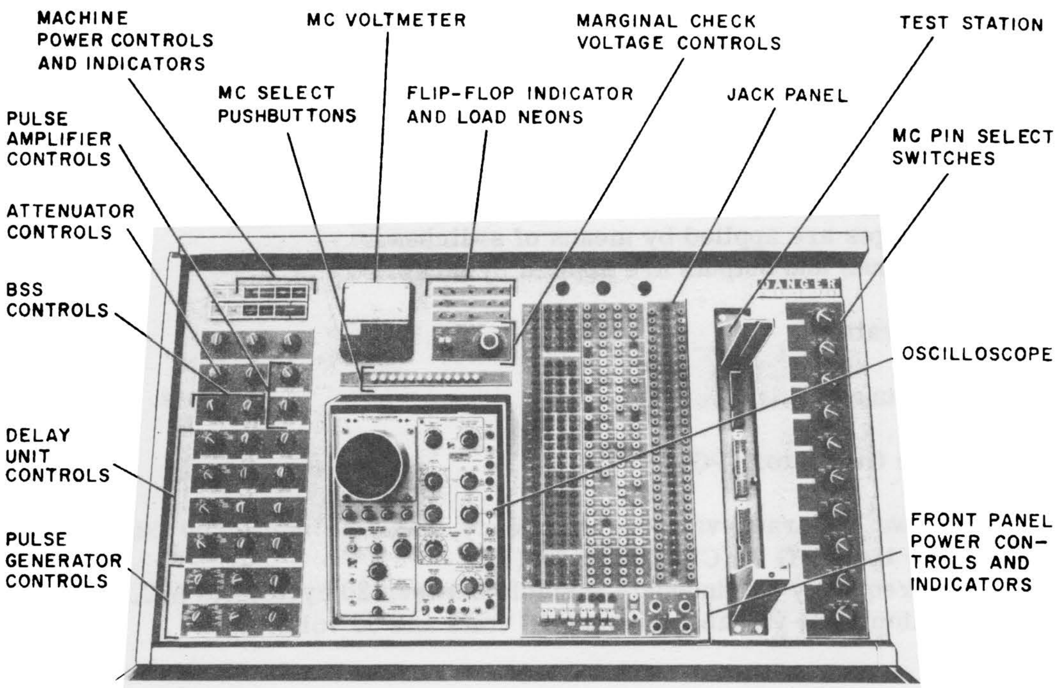
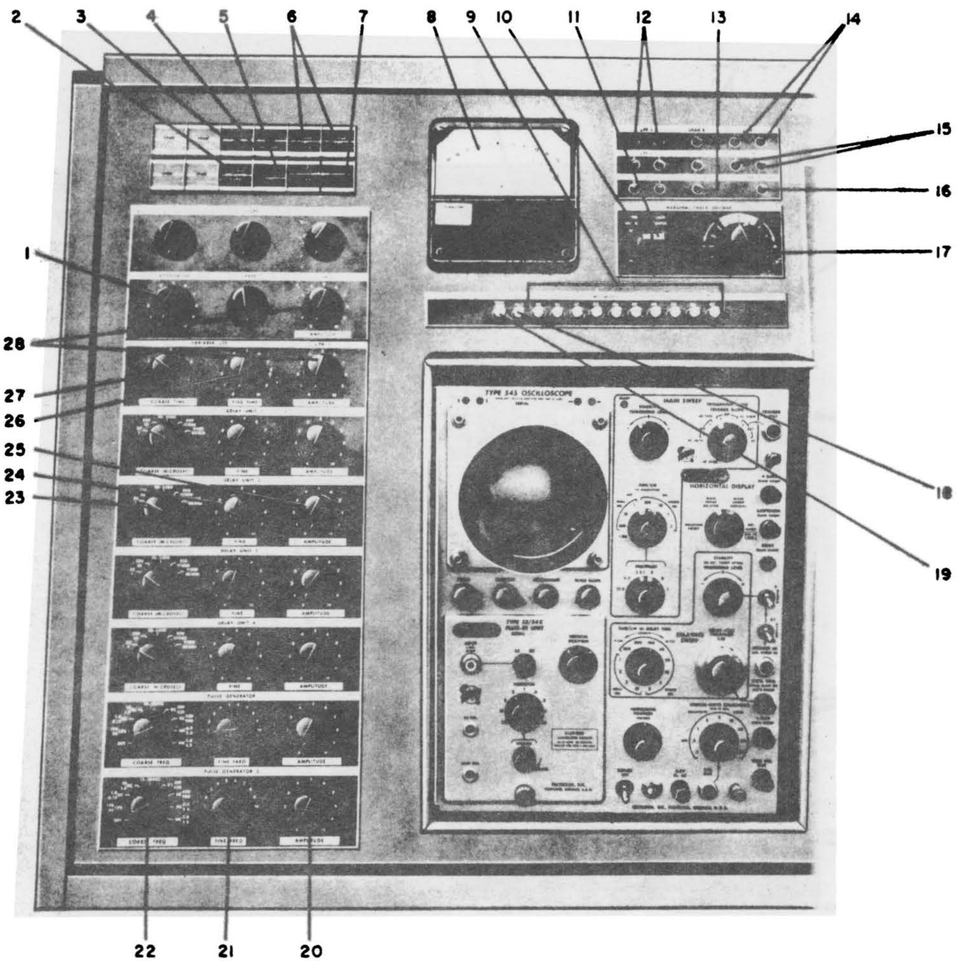
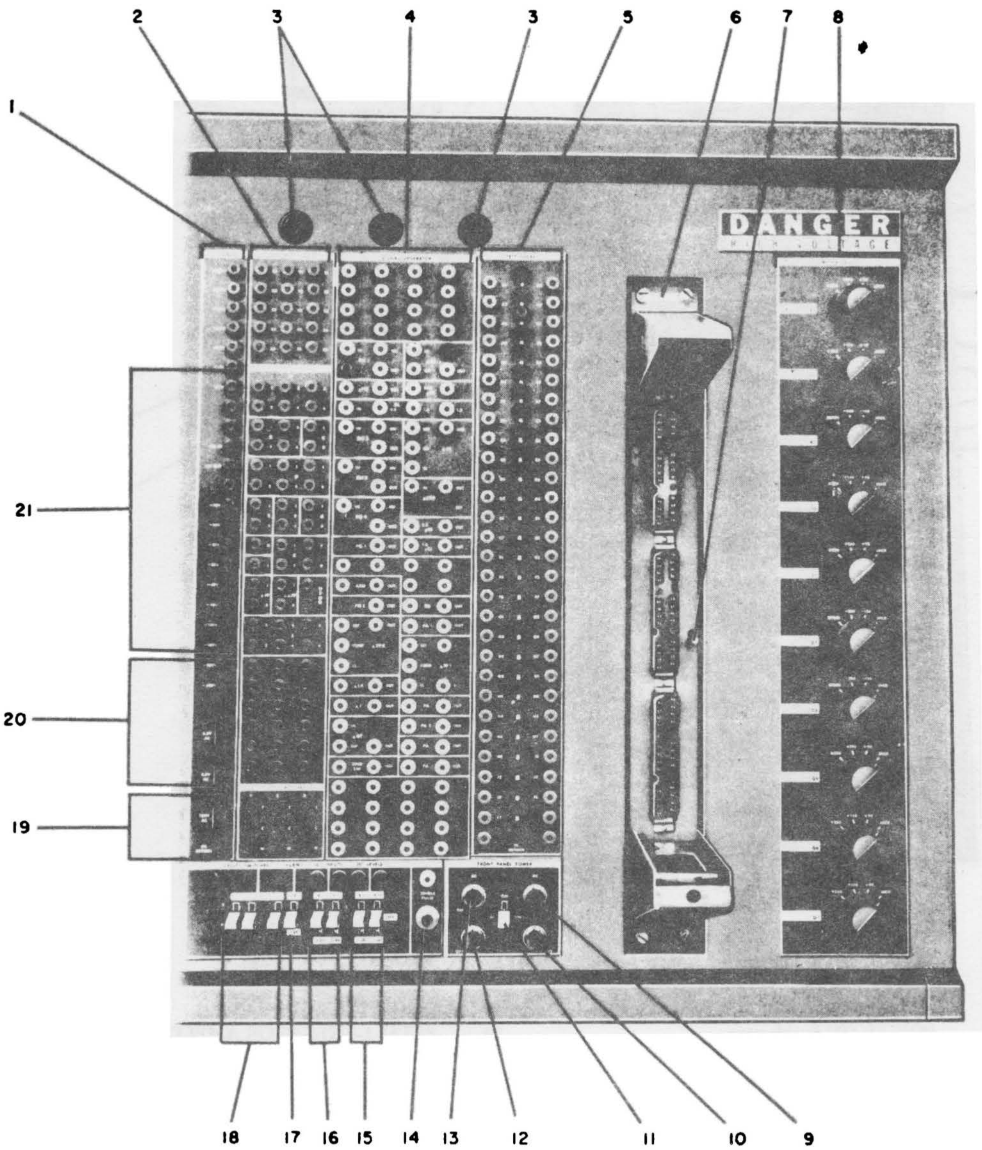


Figure 6-9. Tester, Front Panel



1	Square Wave ATTENUATOR Control
2	VOLTAGE OFF LIMITS ALARM Lamp
3	DC ON Lamp
4	AC ON Lamp
5	POWER ON Pushbutton
6	POWER OFF Lamps
7	UNIT OFF Pushbutton
8	MC Voltmeter
9	MC SELECT Pushbuttons
10	MC METER RANGE Switch
11	JACK INPUT Switch
12	Flip-Flop Neons
13	LOAD E, F, and G Neons
14	bFF 1 and 0 Neons
15	c & aFF 1 and 0 Neons
16	NEON LOAD Lamp
17	EXCURSION Control
18	MC JACK Pushbutton
19	DRUM HEAD Pushbutton
20	PULSE GENERATOR AMPLITUDE Control
21	PULSE GENERATOR FINE FREQ Control
22	PULSE GENERATOR COARSE FREQ Control
23	DELAY UNIT COARSE (MICROSEC) Contro
24	DELAY UNIT FINE Control
25	DELAY UNIT AMPLITUDE Control
26	VARIABLE bSS FINE TIME Control
27	VARIABLE bSS COARSE TIME Switch
28	aPA 1 and aPA 2 AMPLITUDE Switch CONTROLS

Figure 6-10. Tester, Front Panel, C Module Portion



1	VOLTAGE Jacks	12	AC OFF Indicator Lamp
2	SOCKET LOADS Jacks	13	AC ON Indicator Lamp
3	X, Y, Z Can Load Sockets	14	SINGLE PULSE Pushbutton
4	SIGNAL GENERATOR Jacks	15	DC FLIP-FLOP Switches
5	TEST SOCKET Jacks	16	DC UNITS Switches
6	Test Station	17	CLAMP Switch
7	Test Station Interlock Switch	18	UTILITY SWITCHES
8	MC PIN SELECT Switches	19	UTILITY SWITCHES Jacks
9	DC ON Indicator Lamp	20	Spare Jacks
10	DC OFF Indicator Lamp	21	INTERNAL LOADS Jacks
11	ON – AC ONLY Switch		

Figure 6-11. Tester, Front Panel, B Module Portion

CHAPTER 7 - POWER AND MARGINAL CHECKING

DUPLEX POWER DISTRIBUTION AND CONTROL
(Sites 1 thru 16 Only)

Introduction

The total requirements of a DC system is approximately 3000 Kilowatts. This is divided into three approximately equal sections:

1. Air Conditioning

2. Lighting and Miscellaneous

3. AN/FSQ-7 Equipment

The primary source of power for a SAGE site is produced by diesel generators. The high-AC-voltage produced by the diesel generators is fed to bus bars for further distribution to transformers, MG sets, the air conditioning system, and the lighting system.

motor generator

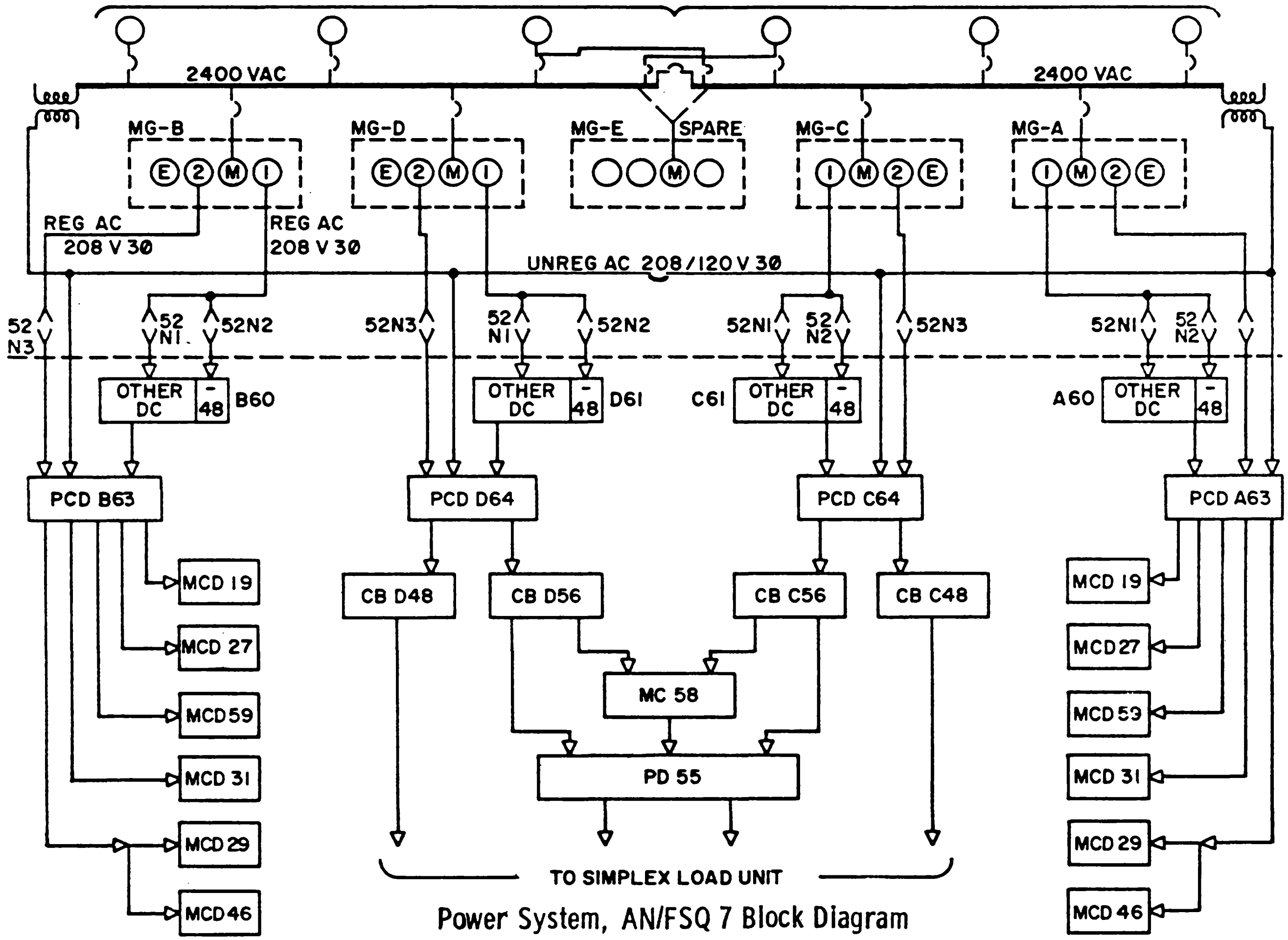
In an AN/FSQ-7 or an AN/FSQ-8 site, one bus bar feeds one duplex and one simplex system; another bus bar feeds the other duplex and simplex system. In combined sites, one bus bar feeds the AN/FSQ-7 equipment and another feeds the AN/FSQ-8 equipment. The bus bars in the combined site may be connected so that any four (or less) diesel generators will supply both the AN/FSQ-7 and the AN/FSQ-8 equipment.

Two transformers in the powerhouse receive the high AC voltage from the bus bars and perform a stepdown function to provide 120/208 VAC for distribution to the computer loads as unregulated AC.

The regulated 60 cycle 120/208 VAC for computer loads is provided by motor generator (MG) sets. MG sets are used instead of transformers because the output is not affected by fast changes in input voltage. One of the five MG sets in the power house is connected as a spare. Each MG set has a motor connected to the high-voltage bus bar. Two of the generators in an MG set provide the output to the switchgear and to a permanent magnet generator used to produce current for the generator fields. The output of the larger generator of the MG set supplies the DC power supplies through circuit breaker devices. The -48V DC relay power supply is connected through one circuit breaker; the other DC power supplies are supplied through another circuit breaker. The output of the smaller generator of the MG set supplies 120/208V regulated AC for distribution to filament transformers in the load units and it also supplies high-voltage power supplies in the display units. Refer to Figure 7-1.

Five sets of switchgear, one for each MG set, control and switch the generator outputs as follows:

1. Power through the DC power supply is applied at half-rated voltage for approximately 10 seconds, after which full voltage is supplied. This reduces the high



Power System, AN/FSQ 7 Block Diagram

Figure 7-1

surge of current that would be present if 100% AC was applied to the DC supplies before the large filter capacitors were partially charged.

2. Regulated AC for filament power is applied at approximately 20 percent of rated voltage and raised to full voltage by a "straightline" increase during a period of one minute. This allows tube filaments to be heated gradually which increases the tube life.

3. The output of the spare MG set is switched to serve in place of any one of the other four MG sets.

4. Protection is provided against overloads, phase-to-phase faults and phase-to-ground faults.

The 52N devices in the output lines from the MG sets control the sequence of applying power to the AN/FSQ-7 equipment.

The power supply system for the SAGE equipment is divided into four separate groups. Power Systems A and B supply duplex equipment A and B, respectively. Power Systems C and D supply the simplex equipment.

Two simplex power supplies are provided to prevent loss of all simplex equipment in the event of a simplex power system failure. The simplex and duplex power systems function independently. Separate MG's and DC power supplies are provided for each system. Switching circuits are provided which permit only one duplex and one simplex power system to be in active status at any given time. The two remaining systems are in a standby status. However, the status of the simplex and duplex systems can be interchanged from active to standby when necessary.

The equipment above the dash line is not the responsibility of Field Engineers so the discussion of this equipment will be brief.

The power supply unit receives regulated AC voltage from the MG set and produces the regulated DC voltages required by the Central. The duplex power supply unit (A60) produces 11 DC voltages and the simplex power supply unit produces 10 DC voltages. The -48V supply is supplied thru a separate 52N device so that -48V can be applied to the following units for control before the other DC voltages are present.

The power control and distribution (PCD) unit receives a DC power from the power supply unit, regulated AC voltage from the MG set, and unregulated AC from the step-down transformer. The function of the PCD unit is to monitor, control, and distribute power to the MCD unit (for duplex equipment) and to the CB unit (for simplex equipment).

The marginal check and distribution (MCD) units serve as secondary power distribution points, and contain relays, contactors, and circuit breakers for distribution and control of power to load units. Each duplex power system contains six of these units.

The display console circuit breaker (CB) units contain the AC and DC circuit breakers required to supply power to the various display consoles of the simplex equipment and the power status relays for displays.

The simplex circuit breaker (CB) units contain the circuit breakers necessary to control power to the simplex maintenance console and simplex equipment.

The simplex input power distribution (PD) unit 55 contains relays and contactors to select power from systems C or D for simplex units as designated by unit status switches and the power supply status.

SUMMARY QUESTIONS

3000 KW

1. The total requirements for a DC system is approximately 3 MEG KW.

2. This is divided into three equal sections: ________, ________, and ________.

3. The primary source of power is diesel generators

4. There are ________ power systems in an AN/FSQ-7.

5. The MG sets change ________ volts AC to ________ AC.

6. One generator in an MG set supplies power to ____________ in the load units and the other supplies AC to the ________________________.

7. ____________ volts DC is provided in unit 60 but not in unit 61.

8. There are ________ PCD units in an AN/FSQ-7.

9. There are ________ MCD units in an AN/FSQ-7.

10. Circuit breakers for displays are located in units ________ and ____________.

11. Only ________ PD unit is contained in an AN/FSQ-7.

DUPLEX POWER DISTRIBUTION

General

Unregulated AC distribution 2400 volts is produced by the diesel generators and supplied to a bus bar. The unregulated AC transformer is connected to the bus. The unregulated AC output from the secondary of the transformer will be connected to the AC outlets in the AN/FSQ-7 units if the unregulated circuit breakers in the PCD and MCD are closed. Since this power is used for maintenance, it is not removed by a normal off sequence.

Regulated AC Distribution

The regulated AC is produced by generator number two in the motor generator sets. It is used to heat the filaments of the vacuum tubes in the load units. Since this voltage is 208 3 ∅ it will be stepped down by filament transformers in the load modules. During the power on sequence this power must be cycled up from 20% to 100%.

DC Distribution

The DC voltages produced by unit 60 are fed thru knife switches in the PCD to circuit breakers in the MCD units. The DC contactors in the MCD will not close until 100% AC has been applied to the filaments.

Description of Units

The units described below are associated with duplex equipment A and B. Therefore, there are two of each unit described. Since A and B are identical, the following descriptions apply to both.

1. PCD Unit Description. Refer to Figures 7-2 and 7-3.

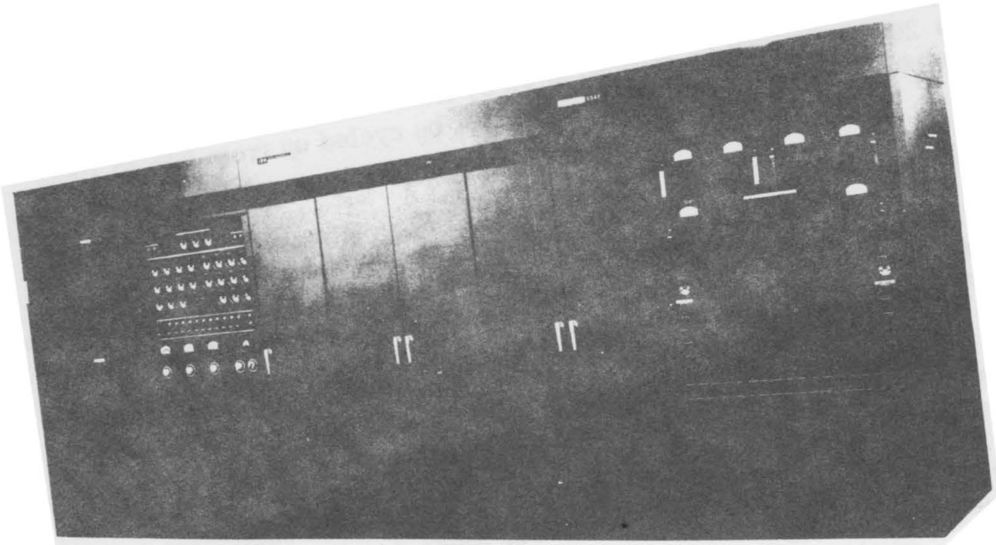
Each PCD unit 63 is divided into modules A, B, C, and D, in that order, from left to right as viewed from the rear. Module A contains the duplex MC equipment. Module B, covered by five doors, contains knife switches, knife-switch interlocks, and power distribution circuitry. Module C contains the indicators and controls associated with power distribution to the duplex equipment. Module D is the CB module. The CB's contained herein are associated with the regulated-AC circuits of the MCD units, the amplidyne (duplex MC generator), and the AC voltmeter; and with the unregulated-AC circuits of the MCD units, the card machines, the drum motors and the convenience outlets, and the tape drive motors.

Unit 63 receives 11 DC voltages from unit 60, unregulated 208 from the unregulated AC transformer, regulated 208V from the MG sets and controls and distributes this power to the duplex equipment. Although some power is distributed directly to the load units, most of the power is sent to the MCD units for further distribution to the load units.

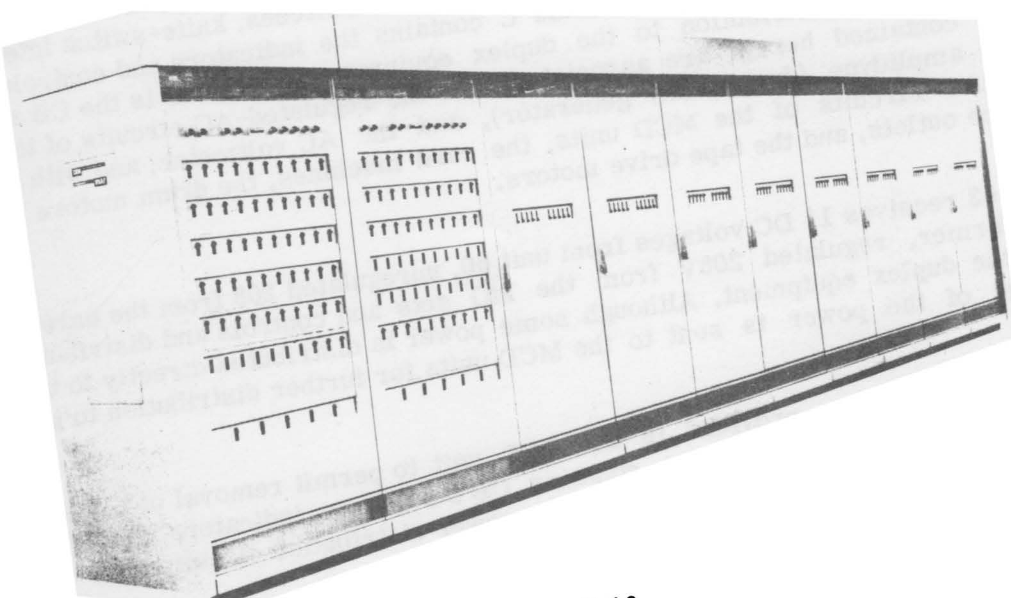
Knife switches are provided in the PCD unit to permit removal of power close to the source. The PCD unit also contains CB's switches, indicators, and metering circuits to permit observation and control of the power distribution circuitry.

2. MCD Units

There are six pairs of MCD units associated with the duplex equipment. Each MCD unit distributes and controls the power distributed to its associated load units. The MCD units and their associated equipment groups are listed following:



PCD Unit 63



MCD Unit 19

Figure 7-2

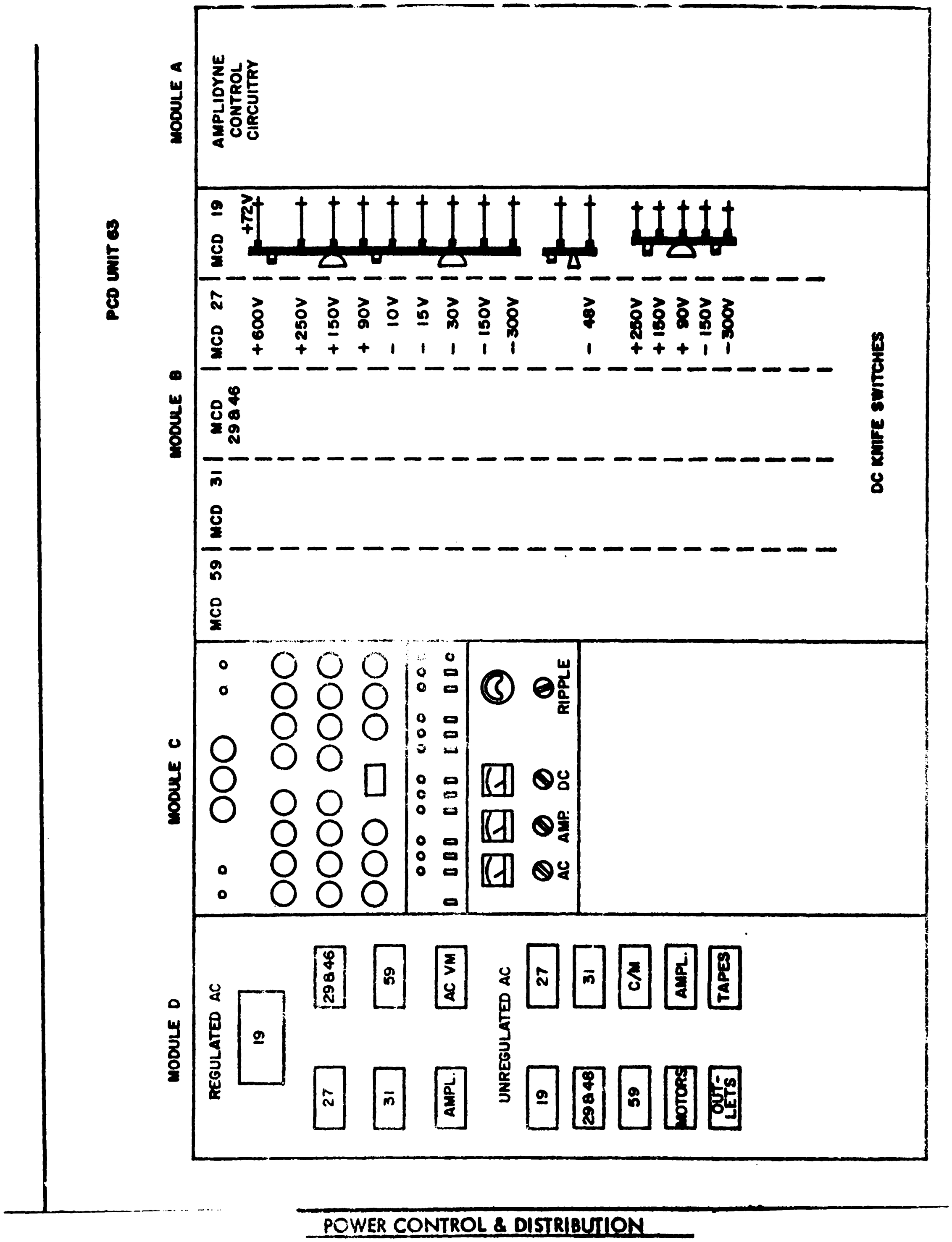

PCD UNIT 63
MODULE A
AMPLIDYNE CONTROL CIRCUITRY
MODULE B
MCD 19
+72V
MCD 27
+600V
+250V
+150V
+90V
-10V
-15V
-30V
-150V
-300V
-48V
+250V
+150V
+90V
-150V
-300V
MCD 29846
MCD 31
MCD 59
DC KNIFE SWITCHES
MODULE C
AC
AMP.
DC
RIPPLE
MODULE D
REGULATED AC
19
29846
27
59
31
AC VM
AMPL.
UNREGULATED AC
27
19
31
29848
C/M
59
AMPL.
MOTORS
TAPES
OUT-LETS
POWER CONTROL & DISTRIBUTION

Figure 7-3

SYSTEMS SUPPLIED BY MCD UNITS

MCD Unit	System or Portion
19	Central Computer
27	Display, Manual Input, and Warning Light
29	Main Drum
46	Auxiliary Drum
31	Output
59	Common Equipment Input

Each MCD unit is unique in external dimensions and internal divisions. Some are divided into modules and others are divided into sections. Component location logic shows the placement of components within the MCD units. A typical MCD unit (unit 19) is shown in Figure 7-2. All MCD units contain contactors, distribution and MC relays, line CB's, MC CB's, and control components and indicators.

1.2.3.3 Function Description - The MCD units control and distribute power to the load units and introduce a variable voltage during MC operations. Besides the functions listed, units 27, 31, and 59 serve an additional function in signal status switching. Unit 27 provides a signal which initiates the signal switching operation for display consoles when the ACTIVE pushbutton is depressed in the alternate control panel of the duplex switching console. Unit 31 serves a similar function for outputs. Unit 59 performs a similar function for input common equipment in units 32, 34, and 41 under similar conditions. Module E of unit 59 functions as the power module for these input load units.

3. Load Units

There are many types of load units which are divided into modules. At one end is the Z module which contains CB's, bus bars, switches, and indicators for distribution and control of power to the entire unit. Three filament transformers (one for each phase of regulated AC) are mounted in rows A and B of most modules.

The load units perform the functions of the computer. The function of the load unit is discussed in the manual pertaining to the system in which the unit is included.

Some load units do not contain Z modules. The power to these units will be supplied directly from the MCD or from the Z module of another unit. The following is a list of these units:

Unit Not Containing Z Module	Unit Supplying Power
7 and 8	9
10 and 11	12
18, 14, 15, 16, 17	13
30	23
65 and 66	67
41, 34, 32	MCD 59
Main Drum Motors	MCD 29
AXD Drum Motors	MCD 46

Unregulated AC (Figure 7-4)

The following discussion is for load unit 2. This is a typical load unit, and the other load units will be similar.

1. PCD Unit 63

The output of the unregulated transformer in the switchgear is applied to a 3Ø Bus. CB's are connected to the bus for protection of the circuits to the separate MCD's. The CB used for MCD 19 is 63D3G3. This is a three-phase CB.

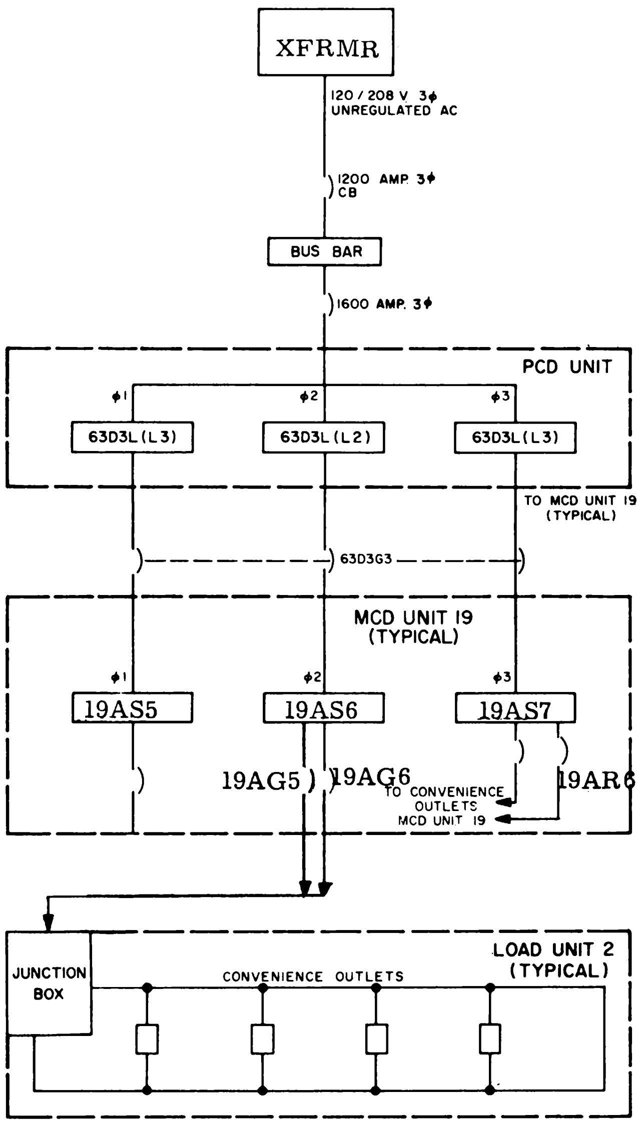
2. MCD Unit 19 & Load Units

The output from the 3Ø circuit breaker in the PCD supplies bus bars 19 A S 5-6-7 in MCD 19. The output of 19AS5 is connected to eight single phase circuit breakers. 19AR6 (sheet 2 5.3.3.1) supplies the unregulated AC to the AC outlets in the MCD. 19AS6 supplies 6 single phase CB's. 19AG6 (sheet 2 5.3.3.2) supplies the unregulated AC to the AC outlets in Unit 2. 19AS7 supplies 6 single phase CB's. These supply unregulated AC to AC outlets in other load units supplied by unit 19.

Regulated AC (Figure 7-5)

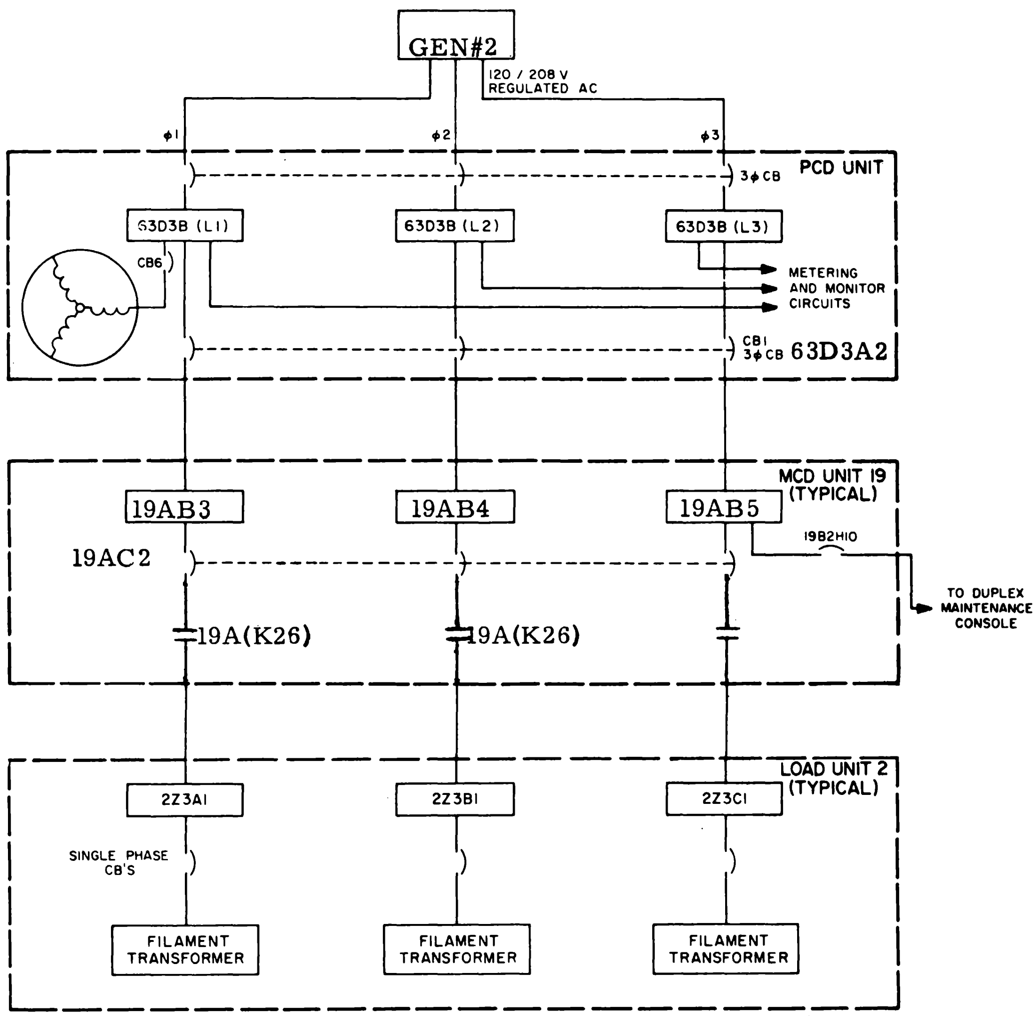
1. PCD Unit 63

The output from generator 2 in the MG set is connected thru a 52N device to bus bars 63D 3B (L1), (L2), and (L3) in the PCD. The outputs from these bus bars go thru 3Ø CB 63D3A2 to MCD 19. Other 3Ø breakers in the PCD will supply regulated AC to the other MCD's, to the marginal check motor in the PCD, and AC to the sensitrols and AC voltmeter.



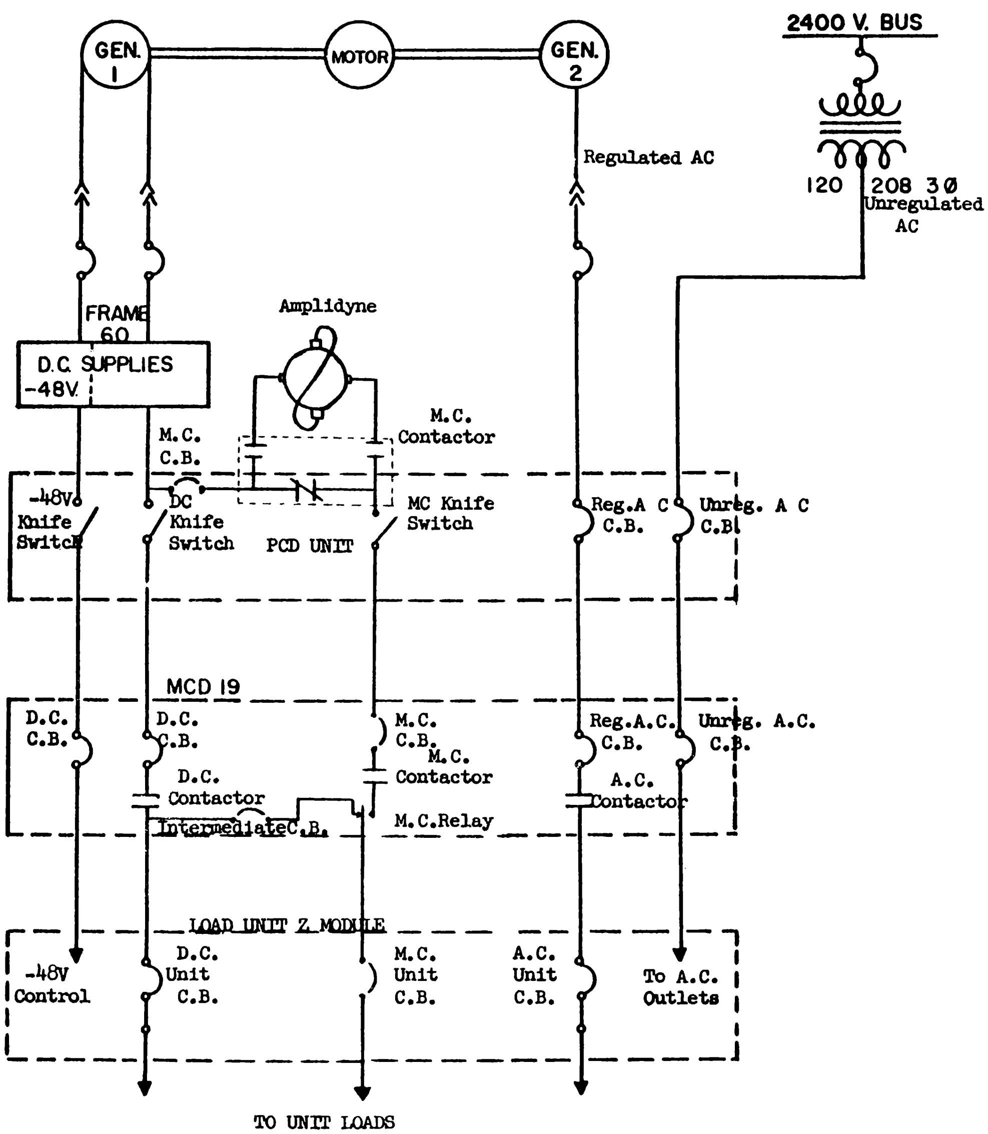
Unregulated A-C Distribution, Block Diagram

Figure 7-4



Regulated A-C Distribution, Block Diagram

Figure 7-5



DUPLEX POWER FLOW, COMPUTER A

Figure 7-6

2. MCD Unit 19

Regulated AC is fed from the 3Ø CB's in PCD 63 to 3Ø bus bars 19AB3, 19AB4, and 19AB5 in the MCD 19. The 3Ø CB connected to these bus bars for distribution to Unit 2 is 19AC2. The AC contactor 19A (K26) will be closed before AC is cycled up to the filaments. It will be opened to allow filament power to be removed from Unit 2 without disturbing the power distribution to other load units. The output from this relay will be connected to bus bars in the Z module of Unit 2.

3. Load Unit 2

The load units receive all three phases of AC from the MCD unit. The input lines will be connected to bus bars Z3A1, Z3B1, and Z3C1. From these bus bars the regulated AC is distributed thru single phase CB's to the filament transformers in the load modules.

DC Distribution (Refer to Figure 7-6)

1. Power Supply Unit

The power supplies are used to rectify, filter, and regulate the 11 DC voltages used in the AN/FSQ-7. The input is 208V 3Ø AC from Gen. 1 in the MG set. The power supply output is supplied to bus bars in the PCD.

2. PCD Unit 63

The 11 DC voltages from the power supply unit connect to bus bars in the PCD. This voltage is fed thru knife switches before it is distributed to the MCD units. There are 5 groups of knife switches in the PCD. Each group of switches contains 3 separate switches. One switch is used for standard DC voltage, one for -48V, and the other for marginal check voltages. The DC voltage knife switch comprises 9 separate knives on one handle so that all 9 will be opened or closed at the same time. Only 9 are used for the 10 service voltages because +72V and +600V will never be provided to the same MCD. The marginal check knife switch is comprised of 5 separate knives on one handle. The voltages used for marginal checking are +250, +150, +90, -150, and -300. The -48 volt knife switch is two separate knives on one handle. Two knives are needed to carry the large currents from this supply. This knife is separate from the service voltage knife so that the -48 volts can be supplied to control relays and indicators without applying service voltages to the loads.

There are no CB's in the PCD for service voltages or -48 volts. There is one marginal check circuit breaker in each of the 5 MC lines. The output of the MC CB's goes thru the normally closed points of an MC contactor and then to the MC knife switch. The amplidyne will be connected in series with the line by closing the MC contactors to apply margins to an MC load.

3. MCD Units

The service voltages from the PCD connect to bus bars in the MCD. From the bus bars the voltages will go thru CB's in section B of the MCD. The marginal check voltages go thru CB's in section H and the intermediate CB's are located in section D.

Using +250 volts Non MC as an example to load unit 2, it can be seen on the chart on 5.3.3.1 that this voltage came from 63B3C1 in the PCD; to bus bar 19BA10. The output from this bus connects to 8 CB's. 19BB10 is the CB used for +250V distribution to unit 2. The MC +250 volts came from 63B 3R1 to bus bar 19HA5. The output from this bus connects to 8 CB's. 19HA5 is the CB used for distribution of MC +250 volts to unit 2. On logic 5.3.3.2 these two CB's can be found in the lower left corner of the logic. The N MC voltage goes to Hi DC contactor 19C (K29). The output from this contactor goes to a bus bar in the Z module of unit 2 and to an intermediate CB. The MC relay will only be picked when it is desired to apply margins to loads in unit 2. There are many different MC loads in unit 2 that receive voltage from the +250 volt line. It is necessary to apply margins to only a few of these loads at one time. Therefore, more than one MC relay will be necessary for the +250 volts.

4. Load Unit 2

The DC voltages from the DC contactor or the MC relay in the MCD unit is connected to a bus bar in the Z module to be distributed thru CB's to the load modules.

Return Lines and Ground

In place of a ground for electrical returns, the AN/FSQ-7 and -8 uses four special electrical systems. There are two for AC neutral, one for DC return, and one equipment bond.

AC Neutral Lines

The unregulated neutral line for the duplex equipment is connected from the neutral side of each of the secondary windings of the 3∅ unregulated transformer in switchgear to the unregulated AC neutral bus in the PCD. The bus bar is connected to the line printer, the MCD units and to unit 63 for internal grounding. From the MCD units, the neutral lines are fed to junction boxes in the Z module of the load units associated with the MCD. The unregulated AC neutral line is the return line for the convenience outlets in the units.

Regulated AC neutral line is connected from the neutral output of generator two thru the PCD and MCD's to bus bars in the Z module of the load units. From this bus a return loop is connected to the neutral end of the primary windings of the filament transformers.

DC Return Lines

Many DC return lines connect from the load modules of a load unit to the Z module. From this module a single line for each voltage is returned from that unit to the MCD where it is connected to the same voltage lines from other load units supplied by the MCD. The lines from the MCD's are returned to the PCD where they are connected together and returned to the corresponding DC supply.

Equipment Bond

This grounds the frame of each unit in the equipment. The equipment bonds of the load units in each power system are connected to a bus bar in the MCD.

The MCD bus is connected to the grounded frame of the associated PCD. All four power system bonds are connected together in the simplex load units.

SUMMARY QUESTIONS

1. Unregulated AC is supplied from the 2400V bus to a power system thru a_____ .
2. Regulated AC is supplied to the duplex system from a __________ set.
3. The input to the power supplies is __________ volts 3Ø AC.
4. All power used in the AN/FSQ-7 goes thru a __________ unit.
5. There are ________ MCD's in an AN/FSQ-7.
6. The power off button does not remove ________ from the load units.
7. AC is applied to the DC supplies in ________ steps.
8. AC is cycled up from _______ % to 100%.
9. The _______________ in the MCD must be closed before AC is cycled up.
10. DC is applied to the loads after the ______________ are hot.

DUPLEX POWER CONTROL

Introduction

When cycling up power, the AC must be completely cycled up before DC is applied to the loads.

-48 volts is brought up before any other DC voltage for use in control and indication.

The DC supplies are brought up in two steps and allowed time to settle to the desired voltage before the outputs are applied to the loads.

The -48V supply must be up to the correct voltage to close the AC contactor in the MCD before the AC generator is cycled up.

DC is applied to the loads by closing the DC contactors.

The initial control voltage for picking relays to bring up power is +130V from batteries in the power house.

Controls

1. Power Supply Unit

Since the DC power supplies are remotely controlled, unit 60 has no external controls except unit off pushbutton.

2. PCD Unit

The CB's for regulated and unregulated AC and the CB for the battery disconnect switch in module C must be closed in order to supply power to the MCD DC 130V.

The Unit off pushbutton in module C drops all power for the associated system.

Interlocks on the doors initiate a normal power off when a door is open.

The knife switches open a micro switch, when the switches are closed. The micro switches are used for alarm indications.

The voltage monitors in module C is a D'Arsonval microammeter movement with series resistor multipliers. These monitors will cause relays to pick when they move off center by a pre-determined amount. They are used to warn the operators of the input voltages or shut down the equipment in the event of large variations. Two insulated contacts hold the indicator in the center position when power is being brought up.

Each voltage monitor has an associated Test-Normal-Reset switch in Test which allows the relay contacts to be shorted to allow a power supply to be adjusted without shutting down power.

The reset position causes the insulated arms of the associated monitor to move the indicator to the center position. The contacts that close a relay circuit when touched by the indicator are magnetized, so that indicator does not oscillate. The reset switch separates the indicator from the contacts.

Power on Sequence

1. Restart Conditions

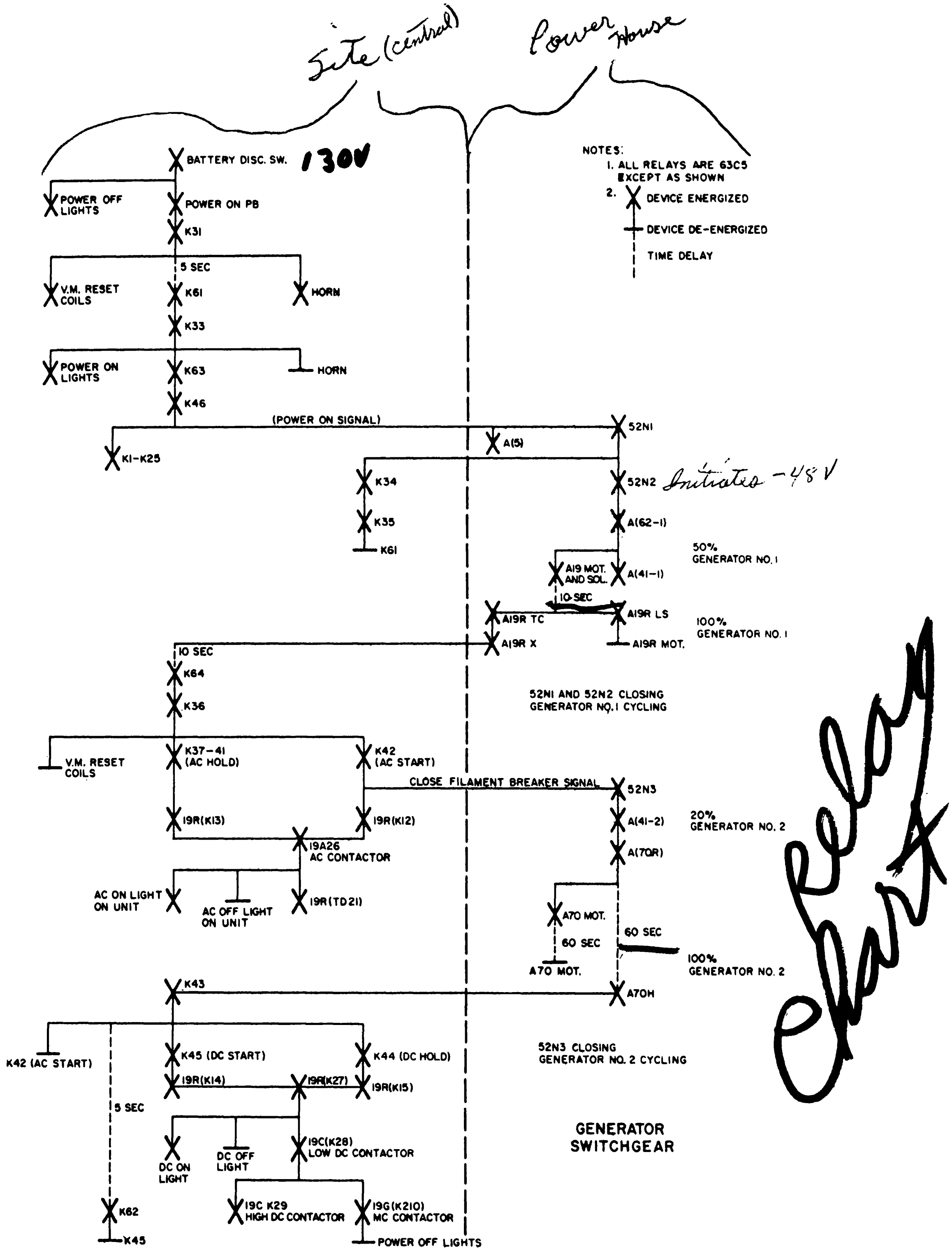
Before power sequences can be initiated, the following manual operations must be accomplished:

a. The diesel generators must be running and the high-voltage bus in the power house must be energized.

b. The BATTERY DISCONNECT switch and the BATTERY DISCONNECT CB must be closed.

c. The MG set circuit breaker must be closed.

d. "B" Module door on the PCD must be closed.



Duplex Power-On Sequence Chart

Figure 7-7

When the preceding conditions have been fulfilled, the system is ready to initiate a normal power-on sequence.

2. Power Off to Power On

When the prestart conditions have been fulfilled, a power-on sequence may be initiated. This sequence is automatic after the POWER ON pushbutton is depressed. Refer to Figure 7-7.

When the POWER ON pushbutton (5.4.2.1) is depressed, relay K31 is picked, closing the power-on sequence circuit. Points 1a and 1c of this relay close and hold the relay energized when the POWER ON pushbutton is released. Points 3a-3c close to complete the circuit, which energizes the reset coils of the voltage monitor relays. Energizing these coils prevents the voltage monitor relays from functioning until the d-c power supplies have reached operating voltage.

Points 4a-4c of K31 (5.4.2.3) close, permitting the battery voltage to sound the alarm horn.

Points 5a-5c of K31 (5.4.2.3) close in the circuit to the POWER ON lamp, but this lamp is not illuminated because points of K33 are open. Points 6a-6b open in the circuit supplying the AC ONLY lamp. Points 2a-2c (5.4.2.1) close to complete the circuit to time delay relay K61. After a 5-second delay, K61 picks and points 1-2 close, picking K33. When K33 picks, its points 6a-6b (5.4.2.3) open and the alarm horn is silenced. Also, points 8a-8c close, applying power to the POWER ON lamps. Points 10a-10c of K33 (5.4.2.1) close to complete the circuit to relay K63.

When K63 picks, its points 1-2 close to complete the circuit to K46. Relay K46 sends a power-on signal to the switchgear. This signal closes the 52N1 and 52N2 devices which connect the output of generator 1 to the DC supplies and picks relay K34 thru the "Down Signal Switchgear" points. Auxiliary points on 52N1-52N2 will also close a relay current to the generator and starts a 10 second delay. 50% AC is now applied to the DC supplies. At the end of the 10 sec. delay in switch-gear, 100% current is applied to the generator field. This also closes point in series with K64, which will pick this relay and start another 10 sec. delay to allow the filter capacitors to settle. -48V is now available to indicators in the MCD.

After the 10 sec. delay, K64 picks and points of K64 close, causing K36 to pick. Points 2a-2b of K36 close the circuit to drop the voltage monitor reset coils. Points 1a-1c close the circuit which energizes K37 through K41 respectively, sending the a-c hold signals to MCD 19. Points 1a-1c of K36 also complete a circuit that picks K42 and sends the close filament-breaker signal to the switch gear. Points of K42 (5.4.3.1) also prepare circuits that energize AC start relay 19R (K12). The AC hold and AC start signals initiate the normal-on sequence for unit 19. With the circuit breakers closed, when power is applied to unit 19, the -48V from CB19DA1 (5.4.3.1) passes through contacts 3a-3c of PCD AC CB interlock K37 to pick AC start relay 19R (K13). Contacts 2a-2c of AC start relay K42 energize AC start relay 19R (K12) for 60 seconds.

With the UNIT OFF switch closed and the AC ON-AC OFF Switch in the center position, the -48V from CB 19BB1 (5.4.3.2) can be applied through now closed contacts of relay 19R (K13) and through contacts 1-2 of relay 19R (K12) to AC contactor relay 19A (K26). After relay 19A (K26) picks, it will hold through its own 1-2 contacts. Contacts 3-4 complete the circuit to time delay relay 19R (TD21). Contacts 5-6 apply -48V to the green AC ON lamp which lights and contacts 7-8 open, extinguishing the AC OFF lamp.

When AC start relay 19R (K12) is energized by closed contacts 2a-2c of K42, the AC filament load contactors are picked. The close filament breaker signal furnished when contacts 1a-1c of K42 close picks the 52N3 CB device. Contacts 7-7c of 52N3 pick relay A41-2 (5.4.1.1, sheet 2). Contacts of A41-2 close, furnishing 20% excitation to generator 2 and picking relay A70-R. Relay Z70-R in turn energizes the A70 motor. The A70 motor is energized for 60 seconds, in which time generator 2 cycles up linearly from 20% excitation to 100% excitation, thereby supplying maximum AC to the load.

When the generator reaches maximum voltage K43 (5.4.2.1) is picked through closed contacts of relay A70H. Relay K42 is dropped and AC start relay 19R (K12) is dropped. When K43 picks, the voltage monitor reset switches for the filament generator UNDER VOLTAGE sensitrol are dropped. Contacts of K43 also pick K44, closing the circuit for the DC hold signal and opening the circuit that extinguishes the POWER OFF lamps. Other contacts of K43 pick relay K45, closing the circuit for the DC start signal and closing the circuit to pick time delay relay K62. The time delay relay keeps K45 energized for 5 seconds, initiating the DC start relays. At the end of the 5-second delay, K45 is dropped.

Contacts 1-2 of DC hold relay 19R (K15) are closed when DC hold relay K44 (5.4.3.1) is energized. DC start relay 19R (K14) is energized for 5 seconds through contacts 1a-1c of DC start relay K45.

First 9 lines indicate that the slow operating contacts 3 & 4 of 19R (TD 21) close to operate 19R (TD 22). This statement is incorrect. The lesson plan at this point does not explain the operation of 19R (TD 22) which serves an important function in applying DC to a load unit.

19R (TD 22) will be picked through normally closed contacts 19R (K27) and 19R (TD 21) by -48V from 19BB1 (-48V CONTROL) as soon as 48V is available and so it will actually be picked before the DC start and hold relays are energized.

There are three pick paths for 19R (TD 22). One is through normally closed contacts of TD 21, another is through normally closed contacts of K27 and the third is through normally open contacts of K28, K29, and K210.

DC can be applied to a load unit 45 or 60 seconds after AC applied depending on whether we initiate a "power on" or "unit on" sequence. In the case of a "power on" sequence TD 21 has already been picked (15 sec) before K27 picks, opening one of the pick paths to TD 22. When K27 picks K28, K29 and K210 must pick within 1 sec. to provide a hold path for TD 22. If one of these relays fails to pick, K27 will drop 1 sec after it was picked due to the N/C contacts 3 and 4 of TD 22 opening. As soon as K27 drops TD 22 will pick and if the operator desires to attempt reapplication of power he must manually operate the DC on switch of the associated load unit.

3. AC Only to Power On

A Power Supply System in the AC-only status is identical to that which is present when a power-off to power-on sequence is initiated except that K32 is picked. This prevents K31, K44, and K45 from picking, thereby preventing a DC-hold and DC-start sequence from being initiated in the MCD's. At the completion of the AC-only sequence, the Power Supply System will have regulated AC applied to the load unit and DC applied only up to the MCD unit.

Changing the Power Supply System from an AC-only status to a power-on status is accomplished by depressing the POWER ON pushbutton on the duplex maintenance console.

When the POWER ON pushbutton is depressed, K31 (5.4.2.1) is energized through the same path as for the power-off to power-on sequence. At the same time, the energizing path to K32 is opened. Contacts 4a-4c of K32 open to prevent the relay from being re-energized when the POWER ON pushbutton is released. Contacts 5a-5b of K32 close in the energizing paths of DC start relay K45, DC hold relay K44 and relay K62. Contacts 2a-2c of both K31 and K32 are in parallel in the energizing path to K61. Consequently, K61 is not de-energized during this change in power status.

When relay K44 is energized, its points 4a-4c complete the energizing circuit to relay 19R (K15). Contacts 12-1c of K45 complete the energizing circuit to 19R (K14). Since 19R (K14) and 19R (K15) are the DC start and DC hold relays, respectively, for MCD unit 19 and its associated load units, energizing these relays completes the circuits which permit the DC voltages to be distributed to the load units. The relay sequence in typical load unit 2 is the same as that discussed in power off to power on.

When this sequence is completed, DC power is being distributed on the load units and the Power Supply System is in a power-on status.

Power Off Sequence

1. Normal-Off Sequences

The normal power-off sequence is initiated at unit 63 by depressing the POWER OFF switch located on the duplex maintenance console. A systematic removal of all operating power leaves only the motor-generator (MG) sets running in the powerhouse.

Depressing the POWER OFF pushbutton immediately drops relays K31 and K33 since contacts 1a-1c of both relays open, removing 130V DC from the coils. The AC ONLY lamp lights at this time because power is applied through normally closed contacts 8a-8b of relay K32, normally closed contacts 6a-6b of K31, and the closed contacts of K34.

Contacts 2a-2c of K31 open and immediately drop relay K61. Contacts 3a-3c of K31 drop K44 and K62. Relay K63 drops when contacts 10a-10c of K33 open. Relay K63 has a delay drop feature which allows it to hold for 1 second before it de-energizes. The 1-second delay allows the relays in the MCD units to sequence off the voltages to the load units. This is done as described below.

When relay K44 is dropped, its contacts 4a-4c open and drop DC hold relay 19R (K15) (5.4.3.1). Contacts 1-2 of 19R (K15) drop DC control relay 19R (K27). When 19R (K27) drops, its contacts 21-22 open, extinguishing the DC ON lamp in the power module of unit 2. Contacts 9-10 close, applying power to and lighting the DC OFF lamp in the power module of unit 2. Contacts 25-26 open, extinguishing the ALL UNITS ON lamp in unit 19. Contacts 11-12 open, dropping high-voltage DC Contactor relay 19C (K29) and MC DC contactor relay 19G (K210), and contacts 7-8 open, reducing the number of hold circuits for low-voltage DC contactor relay 19C (K28).

When 19G (K210) drops, its contacts 1-2 open further, reducing the number of hold circuits for low-voltage DC contactor relay 19C (K28). Contacts 7-8 of 19G (K210) close, applying -48V to the UNIT OFF lamps in units 19 and 2 and to the POWER ALARM lamp and the buzzer relay 1F2 (K17) in the duplex maintenance console. Marginal checking DC contacts L1-T1 through L5-T5 of contactor 19G (K210) (5.3.3.2) open, removing all possibilities of marginal checking unit 2.

When relay 19C (K29) drops, its contacts 1-2 open, and with 19R (K27) and 19G (K210) dropped low-voltage DC contactor relay 19C (K28) will drop. Power distribution contacts L1-T1 through L5-T5 of contactor 19C (K29) (5.3.3.2) open, removing high-voltage DC from unit 2. When 19C (K28) drops, power distribution contacts L1-T1, L2-T2, and L3-T3 of contactor 19C (K28) (5.3.3.2) open, and the low-voltage DC is removed from the load unit.

At the end of the 1-second delay, contacts of relay K63 open, dropping relay K46, and the power-on signal to the switchgear is cut off. Contacts 1a-1c of K46 open, de-energizing voltage monitor relays K1 through K25. The now opening monitor relays cause relay K35 to drop. The removal of the power on signal causes 52N1 to open which removes AC from all DC supplies except -48V. This causes generator 2 to start cycling down from 100% output which opens the points that picked K43. After 60 secs., generator 2 output will be down to 20%. This will cause the 52N3 device to open and remove the 20% field current to the generator. This in turn drops 52N2 which opens the "Down Signal Switchgear" points and drops K34. The points in series with K64 are also opened at this time.

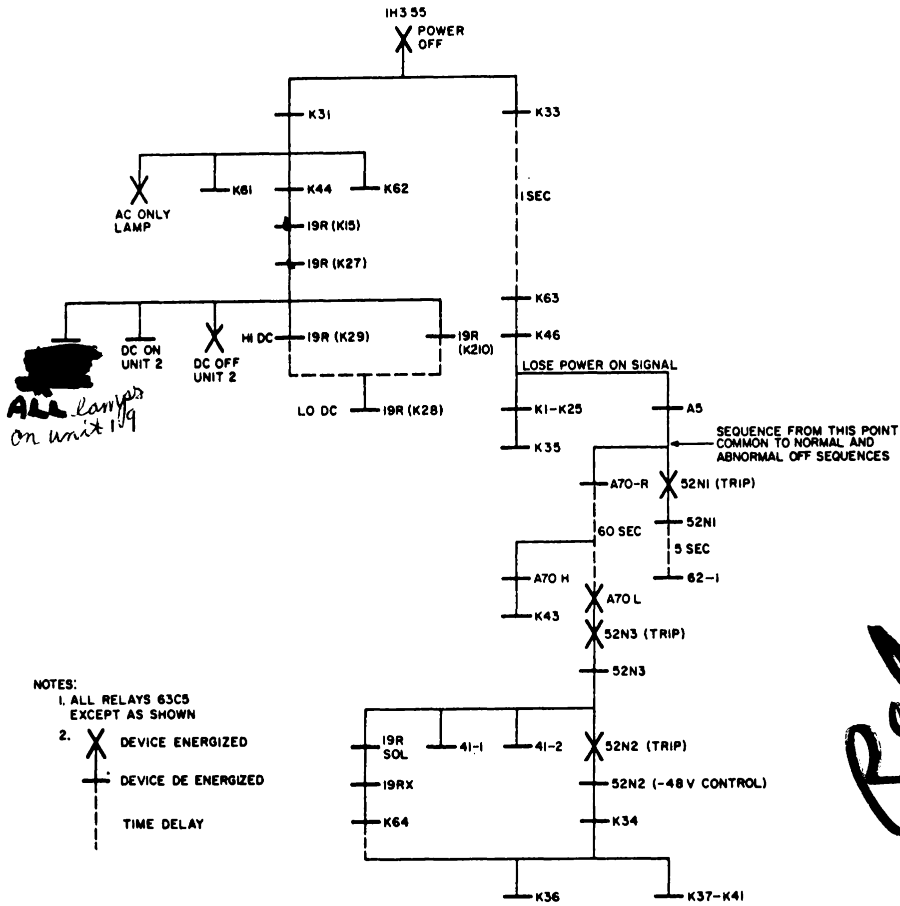
Abnormal-Off Sequence

1. General

The abnormal off (or emergency off) sequences remove all power from a power system without regard to sequencing in the load unit. The removal of power is initiated either manually by depressing a UNIT OFF or EMERGENCY OFF pushbutton or automatically by the shutdown level of the voltage monitor relays. Refer to Figure 7-8.

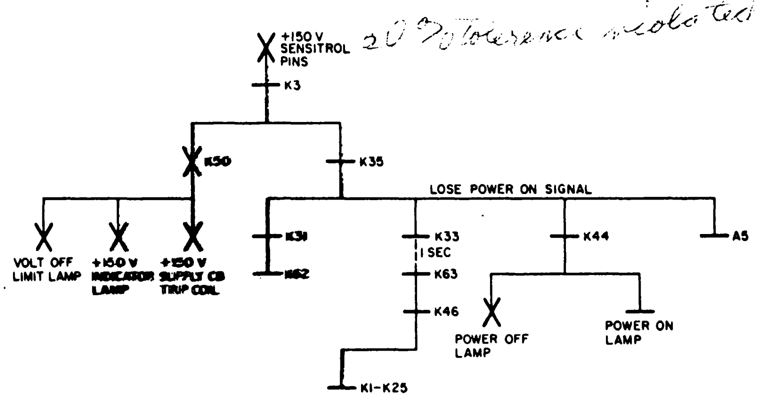
The UNIT OFF pushbuttons are located directly on each power supply unit, PCD unit, or MCD unit of the Power Supply System. The EMERGENCY OFF pushbuttons are located on various pillars throughout the Operations Building.

Depressing a UNIT OFF pushbutton will remove power only from the system associated with that particular pushbutton; i.e., A, B, C, or D. Depressing an EMERGENCY OFF pushbutton removes the power from all power systems. The emergency-



Relay Chart

Duplex Normal-Off Sequence Chart



Abnormal-Off Sequence Chart

Loose Power Immediately

Figure 7-8

off sequence should be executed only when extensive and severe damage to a site is to be avoided or when power must be removed to avoid serious injury or death to personnel.

2. PCD, MCD Maintenance Console, or Power Supply Unit-Off Sequence

When any of the UNIT OFF pushbuttons in the units mentioned above are depressed, the switchgear relay (A5) for the associated power system is de-energized. Points of the switchgear relay de-energize the under-voltage device in the circuit supplying unregulated AC to the PCD unit. As a result, the unregulated AC is removed from the associated power system. Simultaneously, points of the undervoltage device open, removing 130V DC from the switchgear, resulting in both the regulated AC and DC power also being removed from that particular power system.

3. EMERGENCY-OFF Sequence

When an EMERGENCY-OFF pushbutton is depressed, all switchgear relays (A5) are de-energized. Each relay causes the same action in its own power system as described above. As a result, all power is removed from all simplex and duplex power systems. NOW

4. Automatic Abnormal-Off Sequence

The voltage monitor relay circuits automatically shut down the Power Supply System when the DC power supplies deviate $\pm 20\%$ from the normal, or when the regulated AC deviates $\pm\%$. In the following discussion, the $\pm$ 150V DC circuit is discussed as a typical circuit.

Operation of the 150V monitor relay (5.4.2.2) at the shutdown level causes its associated relay (K3) to drop. When K3 drops, its contacts 13-6 energize relay K50. When K50 is energized, its contacts 4a-4c close, energizing the +150V CB shunt trip coil. Also, contacts 3a-3c and 6a-6c of K50 close, causing the +150V INDICATOR and the VOLTAGE OFF LIMITS lamps to light, respectively. When the CB shunt trip coil is energized, the CB contacts open, and the +150V DC power is removed from the equipment.

Contacts 5-12 of relay K3 open when the relay drops, causing relay K35 to drop. When K35 drops (5.4.2.1), the overall shutdown sequence is initiated as follows: Contacts 2a-2c of K35 open, dropping DC hold relay K44. When K44 drops, its contacts 2a-2c open, removing power from and extinguishing the POWER ON lamp (5.4.2.3). Contacts 3a-3b of K44 close, applying power to and lighting the POWER OFF lamp. Contacts 5a-5c of K35 (5.4.2.1) open and drop relays K31 and K33. When K31 drops, its contacts 3a-3c open and drop relay K62. Contacts 10a-10c of K33 open and drop 1-second SR relay K63, which drops relay K46. When K46 drops, its contacts 1a-1c open and drop voltage monitor relays K1 through K25.

NOTE: Relay K3 was dropped previously due to operation of the +150V monitor relay at the shutdown level.

Contacts 5a-5c of relay K35 open when the relay drops. The power-off sequence from this point is identical with the normal-off sequence from the same point.

LOAD UNIT CONTROL

General

After a duplex power system is operating, the individual load units can be turned on or off as necessary. The different conditions of power-off, power-on, or AC only can be obtained by the proper manipulation of controls on the rear of the power (Z) module of the load unit. The operation of circuit components in achieving the desired power condition is automatic. Unregulated AC and -48V DC and +130V DC cannot be controlled from the Z module of the load unit and may be on in the unit when all indicators show that the unit is off. The lamps on the rear of the Z module indicate whether any power is on and which group of circuit breakers has a fault.

If the AC-ON and DC-ON switches on the load unit Z module were in the off position when the duplex power system was cycled up, the load unit will have no service voltages or AC applied. Power may be cycled up on the load unit from the control switches on the Z module door.

A unit power-on sequence initiated from the load unit must be accomplished in two separate steps. The AC-ON sequences must first be initiated by placing the AC-ON switch in the up position. Filament power will be applied to the load with the proper sequencing and warmup delays. After AC is applied, the DC-ON sequence may be initiated by placing the DC-ON switch in the up position. DC service and MC voltages will be applied to the load unit in the proper sequence.

NOTE: Both the AC-ON and DC-ON switches are spring loaded to return to the center position when they are released from the on position.

After power has been applied to the load unit, the Z module controls may be used to place the unit in an AC only status or a power off status.

To place the unit in an AC only status, the DC-on switch may be pushed downward to the off position. DC service and MC voltages will be sequenced off.

NOTE: The AC-ON and DC-ON switches are not spring loaded to return from the off position.

To place the unit in a power-off status, any of three sequences may be employed. DC may be removed as above and then AC removed by placing the AC-ON switch in the down position. Power may also be removed by simply placing the AC-ON switch downward into the off position without touching the DC-ON switch. In this case DC will automatically be removed before AC. Finally all power (except -48V and +130V) may be removed by depressing the red 'Unit Off' pushbutton on the Z module door.

Prestart Conditions for 'Unit Power On'

All the circuit breakers on the front of the power module must be closed if a normal-on sequence of power is desired. If either the DC NON-MARGINAL CHECK CB TRIP lamp or DC MARGINAL CHECK CB TRIP lamp is lighted, only the AC power can be applied. If the AC FILAMENT CB TRIP lamp is lighted, one of the AC filament circuit breakers is open; therefore, no DC power can be applied, and regulated AC is lost to the load which is fed by that particular CB. Unregulated AC and -48V DC and +130V DC have been applied during control at the PCD and MCD units.

MCD unit 19 must be on and operating properly for power to be applied to unit 2. During the usual normal-on sequence, the AC ON-AC OFF and DC ON-DC OFF switches on unit 2 would have been in the central position, and power would have been applied to unit 2 when it was applied to other units associated with unit 19 through the start and hold signals and power received from the switchgear components. However, when the AC ON-AC OFF switch is left in the AC OFF position, power is not applied to load unit 2 when power is applied to the MCD unit and the associated load units.

SUMMARY QUESTIONS

1. The initial control voltage for turning on power is __________ volts DC.

2. -48V and +72V has a warning voltage monitor that sounds a warning when the supply is off by ________ %.

3. Regulated AC is cycled up from 20% to 100% to protect the __________________.

4. The last contactor to close in the MCD during the normal power-on sequence is the ________________ contactor.

5. All regulated AC and DC can be removed to one load unit by opening the ____________________ CB in the MCD for that load unit.

6. If a DC CB is opened on module B of the MCD, ________ power will be removed from one load unit.

7. __________ volts DC is present in a load unit in the AC only condition.

8. If a knife switch is closed but not far enough to close the micro switch, the MCD will have __________ power present.

9. If K44 (DC Hold) has an open pick coil, only _________ , ________, and _________. volts will be present in the load unit after 5 seconds.

10. -48 volts is applied first for _______ , and _____________.

SIMPLEX POWER DISTRIBUTION AND CONTROL
(Sites 1 thru 16 only)

NOTE: This section will cover the distribution and control of power into units 56, 58, and 48 only.

Introduction

The prime source of power to the site equipment is diesel generators which supply 2400V to a split bus bar.

This power is used for three approximately equal loads:

1. Air conditioning
2. Lighting and Miscellaneous
3. AN/FSQ-7

The AN/FSQ-7 equipment is made up of four separate power systems:

1. System A
2. System B
3. System C
4. System D

Each of these systems will use three principal types of power:

1. Unregulated AC
2. Regulated AC
3. Regulated DC

The Unregulated AC will be stepped down from 2400 volts to 208V 3ϕ by a transformer.

The Regulated AC will be produced by a generator which is driven by a motor that is connected to the 2400V bus bar.

The Regulated DC is produced by rectifying the output of another AC generator that is connected to the same motor as the Regulated AC generator.

One motor and two generators make up one motor generator (MG) set. One of these sets will be used in each of the four power systems.

Units 60 and 61 contain the DC power supplies that rectify the AC and regulate and filter the DC output voltages. Unit 60 produces 11 DC voltages and Unit 61 produces 10. The power requirements for +72 volts in the simplex equipment are not great enough to warrant the addition of a separate supply for this voltage. It will be developed in the MC Unit 58 across a voltage divider network from the +90 volt supply. The DC voltages produced by Unit 60 are as follows:

1. +600
2. +250
3. +150
4. +90
5. +72
6. +10
7. -15
8. -30
9. -48
10. -150
11. -300

The output from the DC supplies will go to Unit 64 which is a Power Control and Distribution (PCD) unit. This unit will separate the DC voltages on different lines to be distributed to Circuit Breaker (CB) units in a simplex system or to Marginal Check and Distribution (MCD) units in a duplex system.

The CB units will distribute the voltage to individual display consoles and Power Distribution (PD) modules for inputs. They will also provide CB's for protection of each of these units.

The MCD units provide the distribution of the voltages to separate load units and contain CB's for protection and control relays for the control of power to the different load units.

Simplex Power Distribution

1. General

The two simplex power systems are referred to as C and D. These two systems are identical in content. Therefore, the units in the systems will be discussed as one power system. The different unit numbers will be preceded by a C or D to indicate the system that this unit is used with. Two units are used for both power systems but are not common to either. These are MC58 and PD 55. Only one of each of these units is contained in an AN/FSQ-7.

2. PCD Unit 64, Figures 7-9, 7-12.

Each PCD unit 64 is divided into three modules, A, B, and C, in that order from right to left as viewed from the front. Module A is covered by two doors and one combination-type lock at the front and also at the rear. Module A contains knife switches and bus bars for the distribution of power. Module B contains the indicators and controls to monitor the power that is available for distribution. Module C contains the main CB's that are used to interrupt the AC power as follows: regulated AC to CB unit 48, CB unit 56, and the AC voltage monitors; unregulated AC to CB unit 48, CB unit 56, internal convenience outlets and ripple voltmeter power supply, and projector units 251 and 252.

Power control and distribution unit 64, which receives unregulated AC from the transformer, regulated AC from generator 2 and DC from power supply unit 61, distributes and controls this power for the simplex equipment. The power is applied to CB units 48 and 56 for distribution to the simplex load units.

Knife switches are provided in unit 64 to permit removal of power close to the source. Bus bars have numerous terminals for distribution of power, and CB's protect the circuits against overloads. Switches, indicators, and metering circuits permit observation and control of the distribution circuitry.

3. Display Console CB Unit 48, Figure 7-9, 7-13.

Each display console CB unit 48 comprises 10 modules, A through K (the letter I is not used), from left to right as viewed from the front. Module A contains the UNIT OFF pushbutton, the AC CB TRIP and DC CB TRIP lamps, and CB's and a CB TRIP lamp for each display console.

Display console unit 48 provides for distribution of power to the display consoles and protects the distribution circuitry with CB's. The AC CB TRIP lamp or the DC CB TRIP lamp lights whenever a CB opens. The CB TRIP lamps in the last eight modules of unit 48 indicate which display consoles are inoperative because of open CB's.

Circuit breakers in Module A can remove power received from PCD unit 64 as follows:

Unregulated AC for projector units 251 and 252.

All regulated AC for distribution modules of unit 48.

Plus 600V DC for distribution modules of unit 48.

Circuit breakers in module B can remove the DC from the distribution modules. The CB's in the other eight modules control the power to the display consoles.

4. Simplex Input CB Unit 56, Figures 7-11, 7-14.

Each simplex input CB unit 56 comprises six modules, A through F, from left to right as viewed from the front. Module A contains the UNIT OFF pushbutton, the AC CB TRIP, DC CB TRIP, and MC CB TRIP lamps, and CB's.

Module B contains CB's. The remaining four modules contain numerous CB's and a CB TRIP lamp for each channel.

Simplex input CB unit 56 provides for distribution of power to the input channels and protects the distribution circuitry with CB's. The AC CB TRIP, DC CB TRIP, or MC CB TRIP lamp lights whenever a CB opens. The CB TRIP lamps in the last four modules of unit 56 indicate which channels are inoperative because of open CB's.

Circuit breakers in module A can remove the following power received from PCD unit 64: unregulated AC for the convenience outlets, the computer entry punches, and the amplidyne motor; regulated AC for the distribution modules of unit 56.

Module B contains the DC backup CB's for the distribution modules and simplex maintenance console unit 47 and DC distribution CB's for MC unit 58. Module C contains the unregulated AC distribution CB's in addition to the regulated AC and DC distribution CB's located in the remaining three modules.

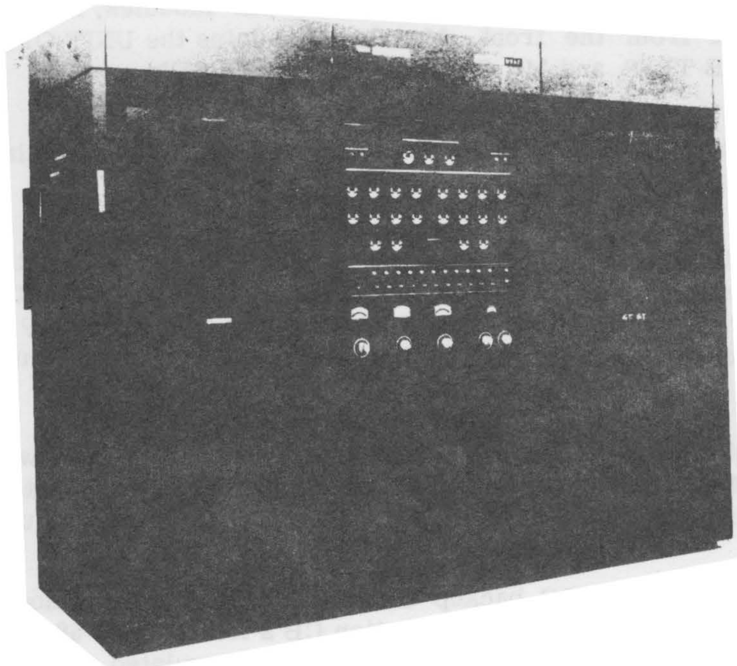
5. Simplex Input PD Unit 55, Figure 7-10.

Simplex input PD unit 55 comprises 12 modules, A through M (the letter I is not used), from left to right as viewed from the front. Module A contains three sliding units. Each of the remaining modules contains six sliding units. The front of each module is closed by a combination-type locking door. Above the doors and above each sliding unit are two POWER ON lamps and an AC ELAPSED TIME indicator.

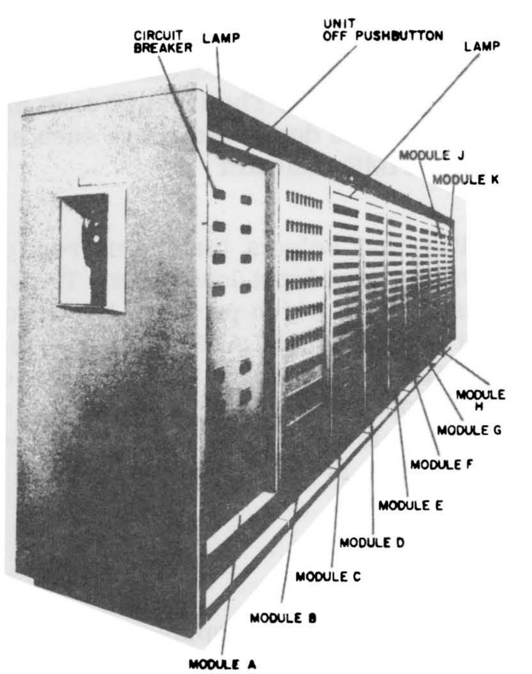
Power distribution unit 55 contains circuitry that selects the power from power system C or D and distributes that power to the simplex input load units. The relays that transfer the power are in the sliding units, each of which provides the power for one channel as marked on the front of PD unit 55. The AC ELAPSED TIME indicator records the time during which the regulated AC (filament power) is applied to the channel equipment. When DC is applied to that channel, one of the POWER ON lamps, above the AC ELAPSED TIME indicator, lights. The upper lamp is lighted when power system C is providing the power; the power lamp, when system D is providing the power.

6. Display Console

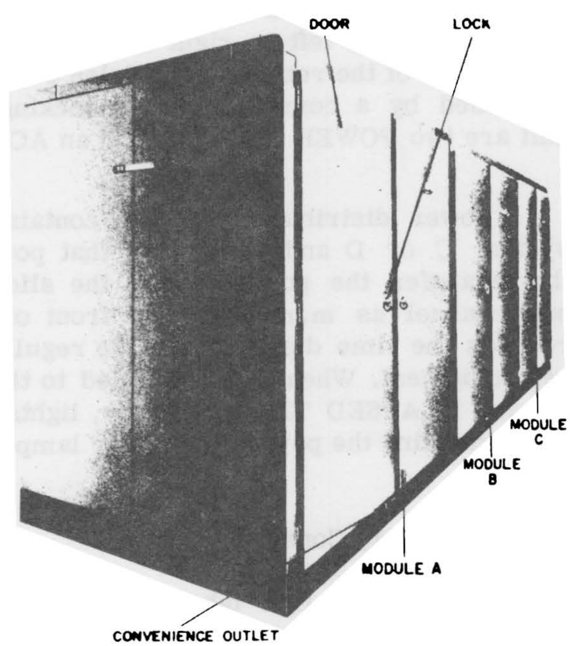
All units that take power from CB unit 48 are called display consoles in this text regardless of the actual function of each unit. For descriptions of display consoles, refer to Display System JPC's.



PCD Unit 64, Left Front View



Display Console CB Unit 48, Left Front View



Power Supply

Figure 7-9

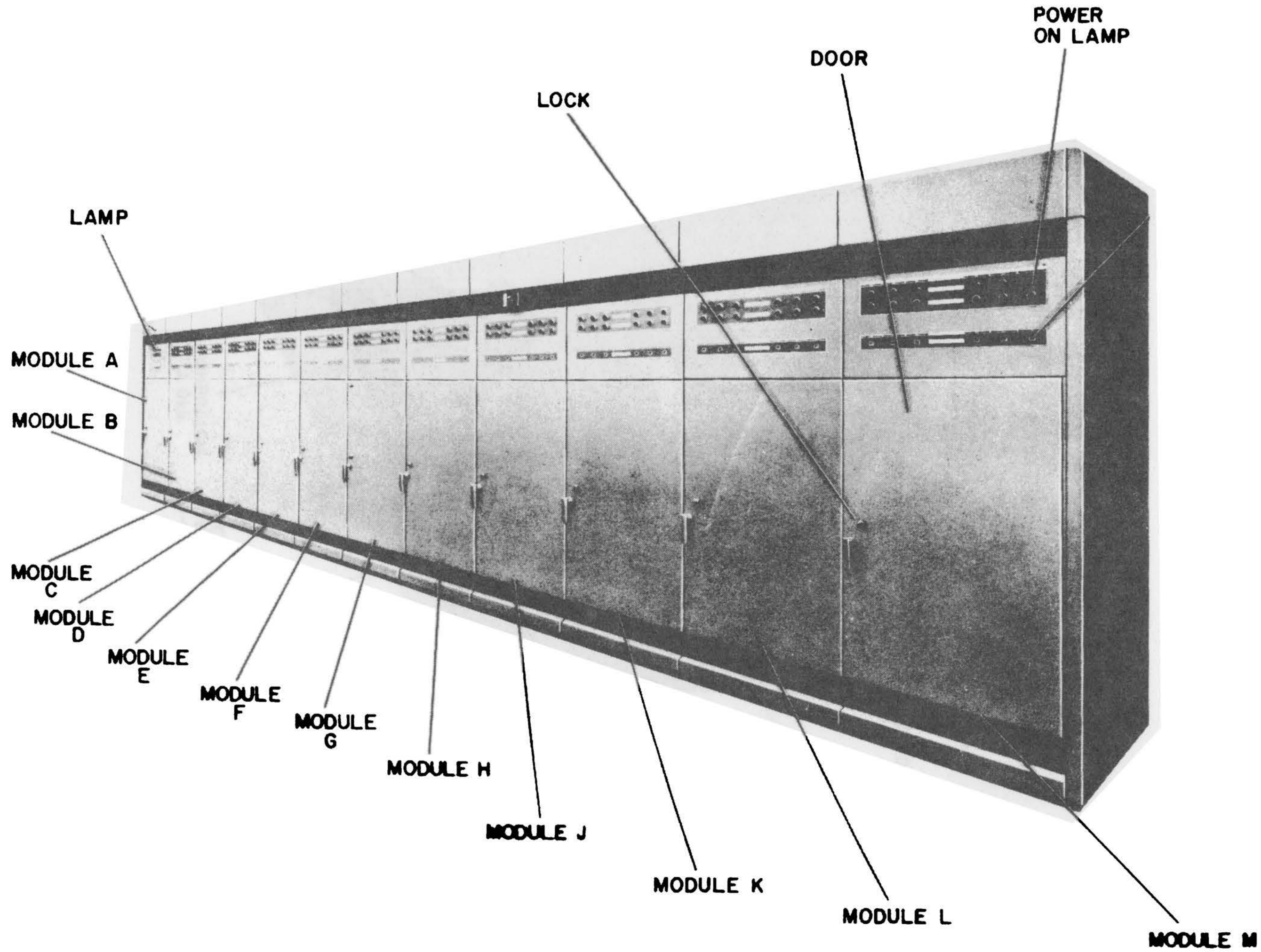
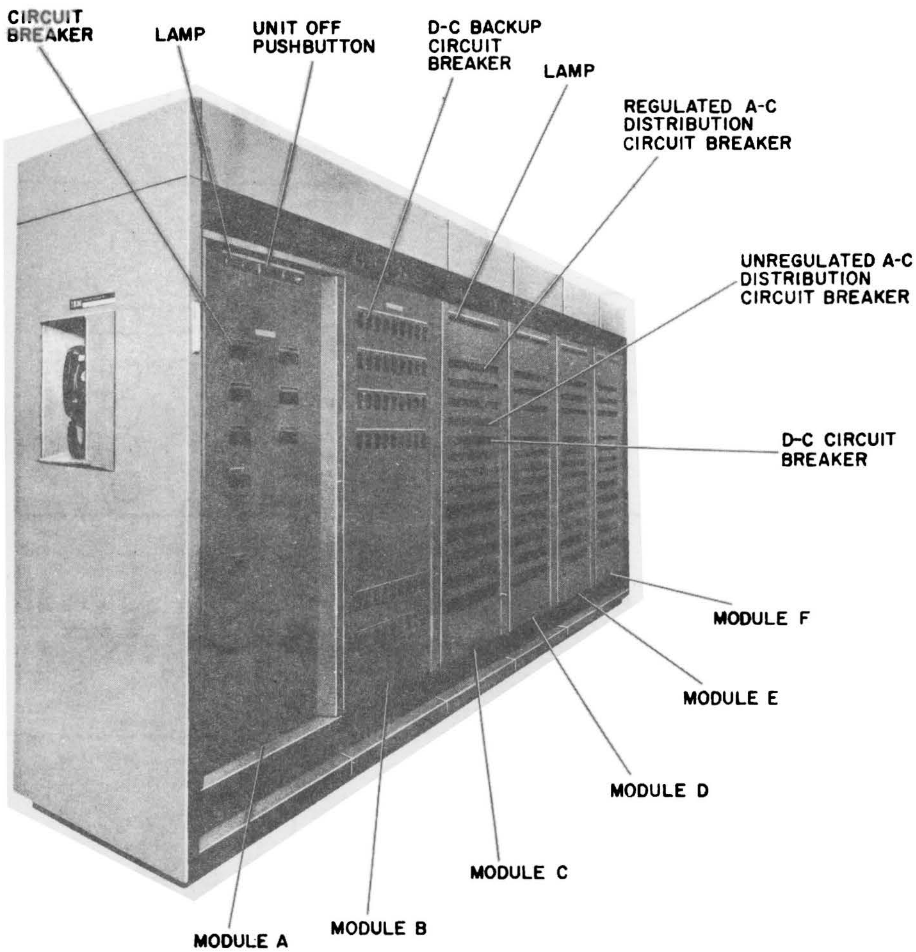


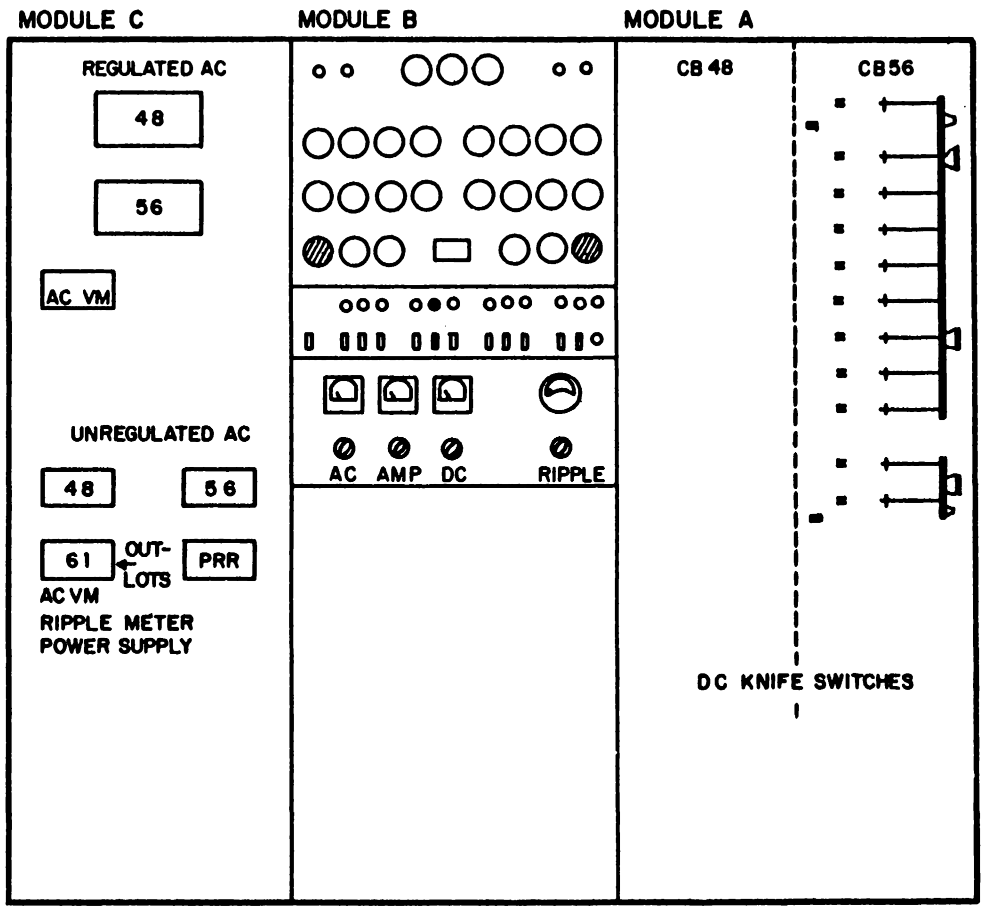
Figure 7-10

Simplex Input PD Unit 55, Right Front View



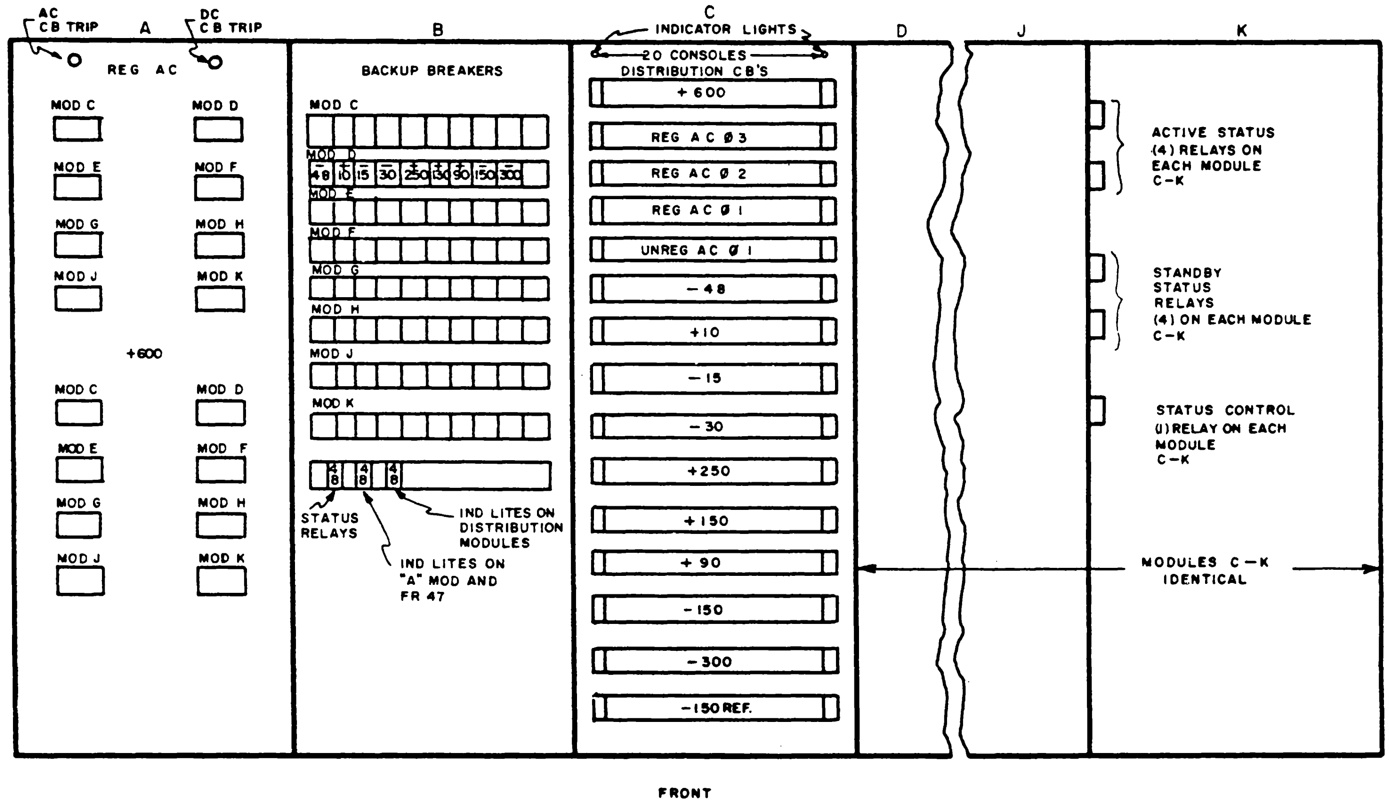
Simplex Input CB Unit 56, Left Front View

Figure 7-11



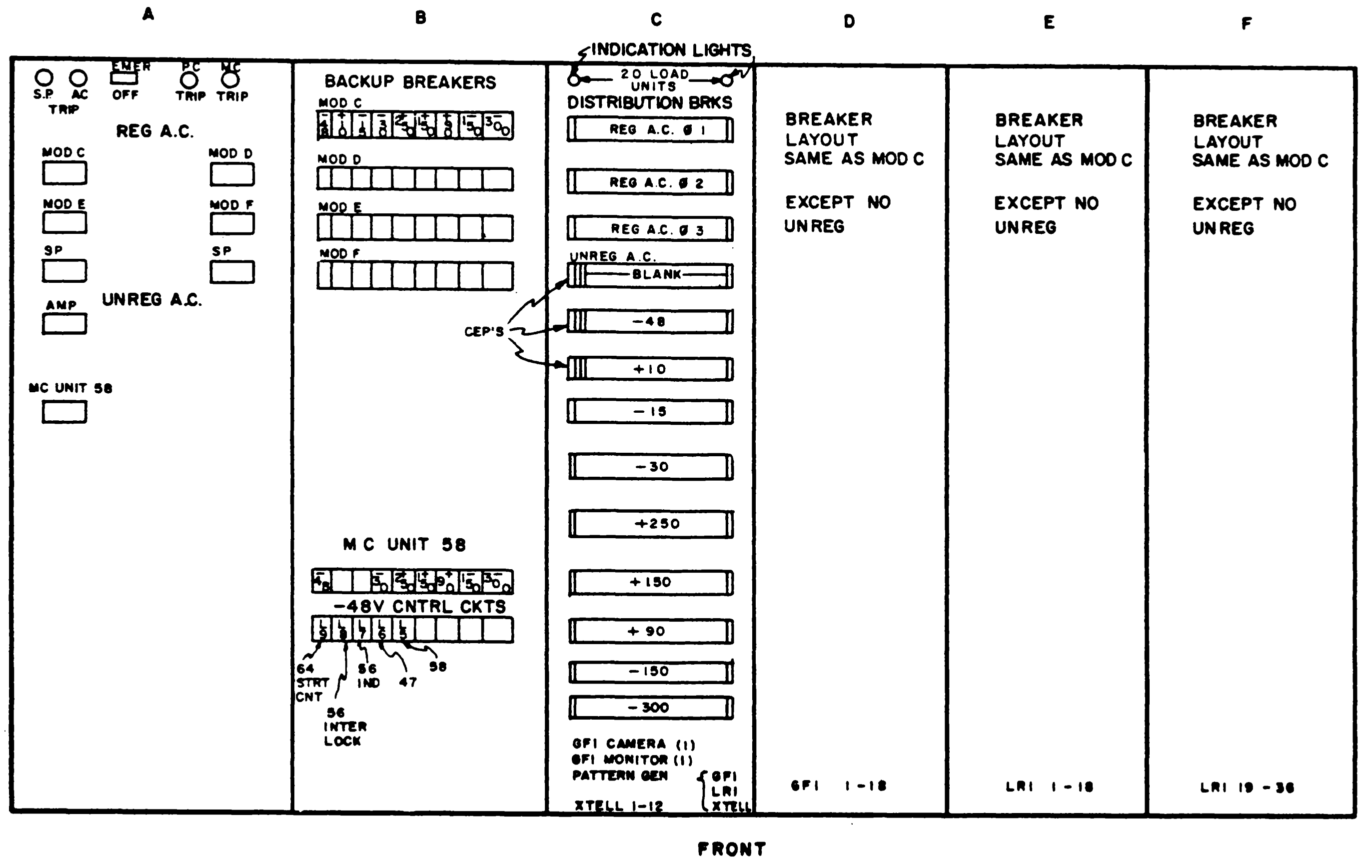
PCD 64

Figure 7-12



CB UNIT 48

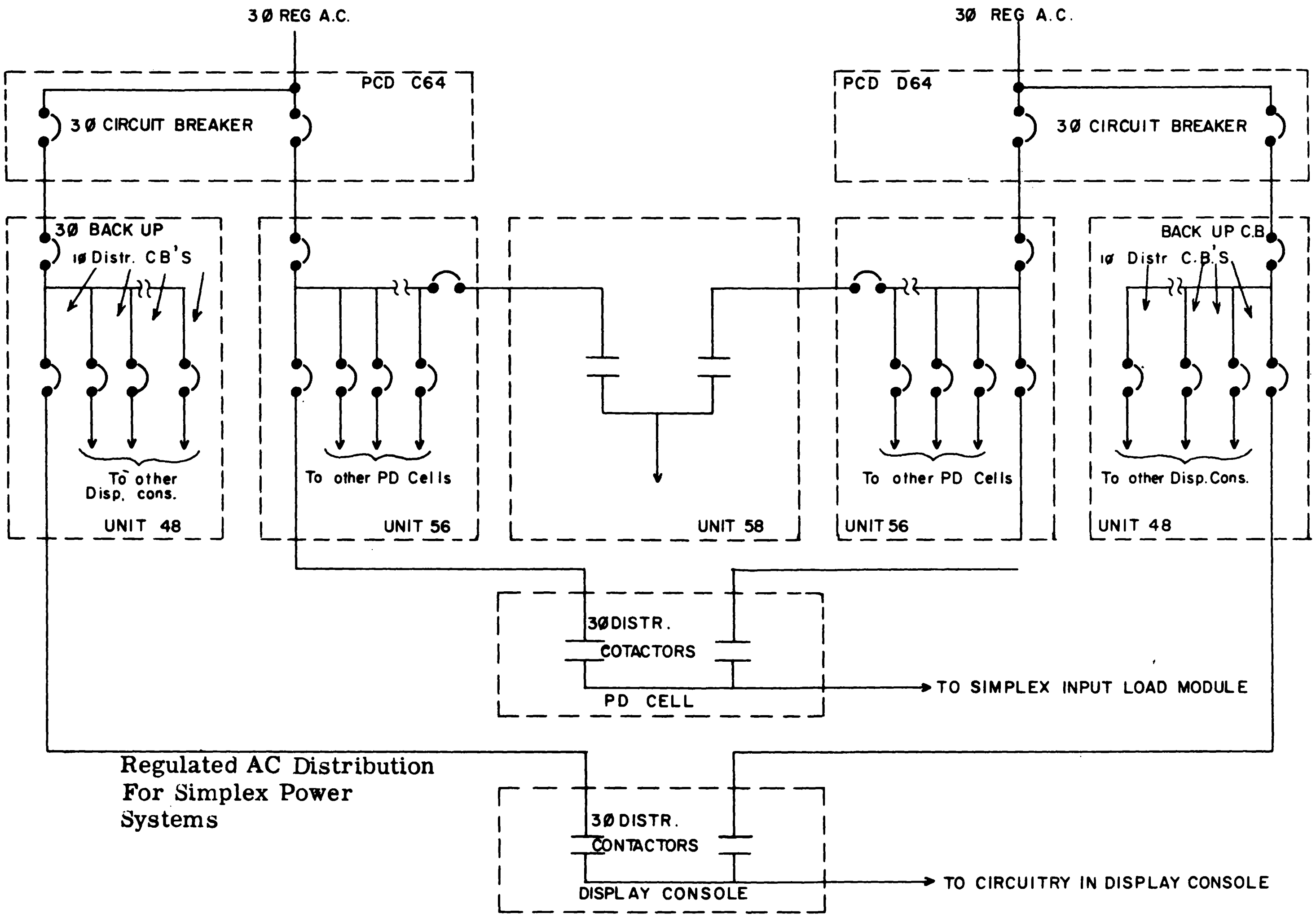
Figure 7-13



CB UNIT 56

Figure 7-14

4/1460 4/366 9 273



Regulated AC Distribution
For Simplex Power
Systems

Figure 7-15

7. Simplex Input Load Unit

Some of the input load units and portions of several others are simplex equipment. These units receive their power from simplex input PD unit 55, which receives the power from system C or D through the respective CB unit 56. The duplex portions of these divided load units receive the power from System A or B through the respective MCD unit 59.

Unregulated AC

The voltage is used at the convenience outlets of all units in the simplex power system. It is also used to run the amplidyne motor for simplex marginal check. if power ~~sumby standby~~ power) is standby

Unit 78

also outlets in units 56, 58, 55, 47

SIMPLEX POWER CONTROL

Controls

1. When power system C or D is turned on to provide power for the simplex displays, the power is also brought up for the simplex inputs on the same system, unless the appropriate knife switches and CB's are opened to prevent power from being distributed to the inputs.

Controls on simplex maintenance console unit 47 provide for most of the control of the power for the simplex displays. Power system C or D is brought individually to power-on or AC only status by depressing the correct pushbutton on the simplex maintenance console. Each power system is normally shut down from the simplex maintenance console. Pushbuttons on several units in each power system permit quick shutdown of that power system. Emergency switches located on columns throughout the operations building shut down all power systems simultaneously.

The operator at duplex switching console unit 45 selects the active power system by depressing the correct ACTIVE pushbutton. The power status of each display console can be selected by means of the unit status switch on each console.

2. Power Supply Unit 61

Power supply unit 61 has a UNIT OFF pushbutton on each module. Depressing this pushbutton shuts down all power distributed from the associated power system without sequencing. The DC power supplies are remotely controlled and require no individual operating controls.

3. PCD Unit 64

The UNIT OFF pushbutton for PCD unit 64 is in Module B. The CB's in Module C are normally closed before the power system is energized, unless some units are faulty. These CB's, when opened, keep regulated or unregulated AC from the CB unit or other equipment, as is designated above the control.

Voltage monitors (Sensitrols) indicate deviations from the rated voltage. When a deviation occurs which causes the indicating needle to touch the magnetized pin at the other end, the indicating needle remains on the pin and shorts out a relay coil. If the de-energized relay is a warning circuit, a lamp is lighted. If the de-energized relay is in a shutdown circuit, the source of power for the power supply unit is disconnected. One RESET switch is provided to center the indicating needles of all voltage monitors. A TEST-NORMAL switch is provided for each voltage monitor. This switch bypasses the voltage monitor to permit adjustment of that particular DC power supply.

The DC knife switches in the PCD unit are protected by doors on the unit. Since interlocks on the doors shut off the power when a door is opened, these knife switches must be positioned as desired and the door secured before the power system is energized.

4. Display Console CB Unit 48

Display Console CB unit 48 and unit 56 have a UNIT OFF pushbutton, located on module A, in addition to the CB's. The remaining modules have rows of CB's.

5. Display Console

Power on a display console can be controlled at each display console by means of the UNIT STATUS switch.

6. Simplex Input PD Unit 55

Simplex Input PD Unit 55 has no external controls to operate the simplex equipment. All sliding units are covered by doors that are locked with combination-type locks.

7. Simplex Maintenance Console Unit 47

Power controls on the simplex maintenance console are located on module H. In the power control group are three pushbuttons: POWER ON, POWER OFF, and AC ONLY. These are used to initiate sequences to place the associated power system in the desired power status. In the status group is the RESET AUDIBLE ALARM pushbutton, which silences the audible alarm that was set off by any circuit on the power panel. The audible alarms circuit is automatically restored to active status when the trouble is cleared. At the bottom of the power supply control panel is the SERVICE OPPOSITE SIMPLEX SWITCH. When maintenance on the inactive power system is contemplated, the SERVICE OPPOSITE SIMPLEX SWITCH on the active power system is shifted downward to remove the -48V control power from the circuitry in the system requiring maintenance.

8. Duplex Switching Console Unit 45

The ACTIVE pushbuttons on the simplex switching panels of the duplex switching console are used to select the power system that will be active. This pushbutton is described with the other controls on the duplex switching console.

Indicators

1. Power Supply Unit 61

There are no visible indicators on the power supply unit for the simplex equipment. A DC voltmeter is installed in the control chassis of each DC power supply to indicate the output of the supply. In normal operation, the voltmeters are behind the closed doors of unit 61.

2. PCD Unit 64

Module B in PCD unit 64 contains all the indicators. In the upper left corner are two power status lamps: FIL INPUT DE-ENERGIZED and POWER OFF. In the upper right hand corner are the AC ONLY and the POWER ON lamps. Between the pairs of power status lamps are the AC voltage monitors. These include the shutdown level filament AC, the power supply input, and the warning level filament AC. The other voltage monitors include 10 shutdown level and 10 warning level voltage monitors for the DC power supplies.

The off-limit lamps include the FILAMENT VOLTAGE lamp, the INPUT TO SUPPLIES lamp, and one lamp for each of the 10 DC power supplies. The four meters permit accurate reading of all voltages. The multiple-position control on the AC VOLTMETER provides a visual indication of any AC voltage. The multiple-position controls on the DC AMMETER, the RIPPLE VOLTMETER, and the DC VOLTMETER provide individual readings of the 10 DC voltages.

3. Display Console CB Unit 48

Numerous indicators on the front side of CB unit 48 show which display console has power applied. Near the UNIT OFF pushbutton on Module A are the AC CB TRIP lamp and the DC CB TRIP lamp. Numerous other CB TRIP lamps are located at the top of modules C through K. One CB TRIP lamp is located above each column of circuit breakers.

4. Display Consoles

A column of panel lamps illuminates the column of controls for the display console. These lights can be dimmed by a series potentiometer. A row of lamps illuminates the desk at the front of the display console. These lights can also be dimmed by a series potentiometer.

5. Simplex Input CB Unit 56

CB Unit 56 has indicators on the fronts of modules A, C, D, E, and F to show which channels have power applied. Near the UNIT OFF switch in module A are the AC CB TRIP lamp, the DC CB TRIP lamp, the MC CB TRIP lamp, and the spare lamp.

6. Simplex Input PD Unit 55

POWER ON lamps on PD Unit 55 indicate whether the sliding units receive power from system C or D. The upper lamp, when lighted, indicates that power for the sliding unit is received from system C; the lower lamp indicates that power is received from system D. Every module contains one pair of lamps for every sliding unit in that module. Below each pair of lamps is an AC TIME ON (elapsed time) indicator for every sliding unit.

7. Simplex Maintenance Console Unit 47

Numerous lamps on the simplex maintenance console indicate the status of power in power systems C and D and in the channels of the simplex input load units. The power supply control panels for power systems C and D are located in module H. The lamps on these two panels are grouped according to the functions under alarm, power control, and status.

The seven alarm lamps are described below:

a. PCD UNIT ALARM - Indicates a failure in the PCD unit and, when lighted, is accompanied by an audible alarm.

b. SWITCH GEAR UNIT ALARM - Indicates a failure in the AC switch-gear and is accompanied by an audible alarm when lighted.

c. AC BACKUP CB UNIT 56 - Indicates an open backup CB that normally provides AC to the LRI, GFI, or XTL unit. There are two AC backup CB's for LRI, each supplying half of the channels, one for XTL and one for GFI.

d. DC BACKUP OR -48V CB UNIT 56 - Indicates that one of the backup CB's that supply DC to LRI, XTL, or GFI is open. There are two sets of DC backup CB's for LRI, one for XTL, and one for GFI. This lamp also indicates an open CB in the -48V line supplying the interlock relays and the status relays.

e. AC BACKUP CB UNIT 48 - Indicates an open AC backup CB for displays. There is an AC backup CB for every 20 display consoles.

f. DC BACKUP OR -48V CB UNIT 48 - Indicates that one of the backup CB's that supply DC to the displays is open. There is a group of CB's for every 20 display units. This lamp also indicates an open CB in the -48V line supplying the interlock relays and the status relays.

g. VOLTAGE OFF LIMITS ALARM - Lights whenever the VOLTAGE OFF LIMITS lamp in the PCD unit lights.

The five status lamps are described below:

a. ACTIVE - Lights at the same time as the ACTIVE lamp on the duplex switching console and indicates when that power system is active.

b. STANDBY - Lights whenever the STANDBY lamp on the simplex panel of the duplex switching console lights.

c. -48V UNIT 48 - Lights whenever the -48V control power is applied to CB unit 48, and shows that the CB which provides -48V to the indication circuits in unit 48 is closed. An audible alarm is sounded whenever this light is extinguished by opening of the indication CB.

d. -48V UNIT 56 - Lights whenever the -48V control power is applied to CB unit 56, and shows that the CB which provides -48V to the indication circuits in unit 56 is closed. An audible alarm is sounded whenever this light is extinguished by opening of the indication CB.

e. MASTER READY - Indicates that all power has been supplied to the simplex load units connected to this power system and that a time delay has been allowed to stabilize the components.

Introduction

1. When cycling up power the AC must be applied to the filaments before the DC is applied to the loads.

2. -48 volts is brought up before any other DC voltage for use in control and indication.

3. The DC supplies are brought up in two steps and allowed to settle down before the outputs are applied to the loads.

4. -48 volts must be applied to the display consoles and the PD unit to close AC contactors so that when the AC is cycled up the tube filaments are connected to the output of generator Nr. 2.

5. AC is first applied by causing 20% control current to be applied to the field winding of generator 2. This current is increased at a linear rate over a 60 second period to 100%. This will heat the filaments slowly to increase the tube life.

6. After AC is cycled up DC contactors are closed in the display consoles and the PD unit to apply DC to the loads.

7. The initial control voltage for picking relays to bring up power is 130 volts from batteries in the power house.

Power On Sequence

1. Prestart Conditions

a. The diesel generators must be running and the high-voltage bus in the power house must be energized.

b. The Battery Disconnect switch and the Battery Disconnect CB must be closed.

c. The MG set circuit breaker must be closed and the motor up to speed.

2. Power Off to Power On

When the prestart conditions have been fulfilled, a power on sequence may be initiated by pressing the power on pushbutton.

AC ONLY TO POWER ON - A Power Supply System in the AC-only status is placed in the power-on status by depressing the POWER ON pushbutton on the simplex maintenance console.

Power Off Sequence

This sequence is similar to the power-on to power-off sequence for duplex equipment, and is automatic after the POWER OFF pushbutton on the simplex maintenance console is depressed.

SUMMARY QUESTIONS

1. The prime source of power to the site equipment is ______________________.

2. The four power systems are________, ________, __________ and______________.

3. Power contactors for a Display console are located in the__________________.

4. Power contactors for an input load are located in Unit ___________.

5. Back up breakers are located in Units__________ and ________.

6. ___________ power is applied to the simplex loads before low DC.

7. All unregulated AC to Unit 55 can be removed with CB's on Units _____________

and_______________.

8. A backup CB in Unit 48 supplies power to __________consoles.

9. A distribution CB in Unit 48 supplies power to ____________ console.

10. Signal status relays are picked when ________volt is available if all CB's are closed.

11. All DC power will be applied to a PD cell before __________ AC.

12. If a console is active, power is applied to that console from the _______________ power system.

13. No ________ voltages are supplied to a display console.

14. Unit 58 is used for ________________.

15. There are _______ CBs in a +10V line between the PCD and a console.

DUPLEX POWER DISTRIBUTION AND CONTROL
(Sites 17 through 26 only)

Introduction

The total requirements of a DC system is approximately 3,000 kilowatts. This is divided into three approximately equal sections:

1. Air Conditioning

2. Lighting and Miscellaneous

3. AN/FSQ-7 Equipment

The primary source of power for a SAGE site is diesel generators located in the powerhouse. The high AC voltage produced by the diesel generators (480V AC) is fed to bus bars for further distribution to the sub-stations, the load centers, the bus duct sequencing device, the air-conditioning system, and the lighting system.

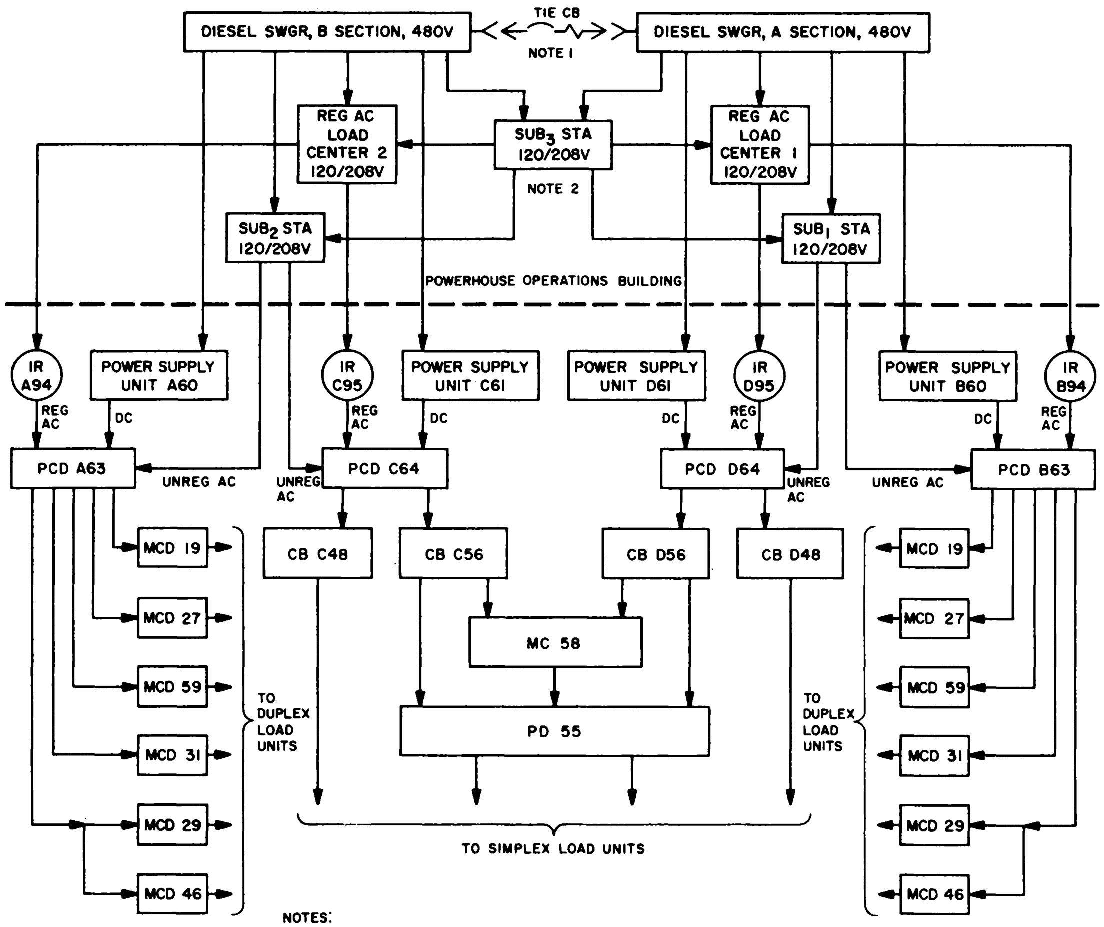
In an AN/FSQ-7 or an AN/FSQ-8 site, one bus bar feeds one duplex and one simplex power system; another bus bar feeds the other duplex and simplex power system. These bus bars can be connected together when necessary. In combined sites, one bus bar feeds the AN/FSQ-7 equipment and another feeds the AN/FSQ-8 equipment. The bus bars in the combined site may be connected so that any four (or less) diesel generators will supply both the AN/FSQ-7 and the AN/FSQ-8 equipment.

Since the split-bus voltage is affected by many transients and fluctuations, transformer and regulator equipment is utilized before power is supplied to the Air Conditioning, Lighting, and Miscellaneous equipment.

Load Centers - The two load centers are located on the second floor of the operations building. Each load center contains a 300-KVA, delta-wye-connected transformer and input and output circuit breakers (CB's). The transformer reduces the 3-phase 480 VAC to 120 VAC (phase-to-neutral) 208 VAC (phase-to-phase). This unregulated AC is fed through CB's to the induction regulators, Units 94 to 95.

Substations - Each of the three substations receives 480 VAC from the powerhouse. This voltage is transformed by a 500-KVA, delta-wye-connected transformer to 208V unregulated AC and is fed through CB's to the Power Control and distribution (PCD) units. Normally, only two substations are in use, the third is a spare which may replace either another substation or a load center.

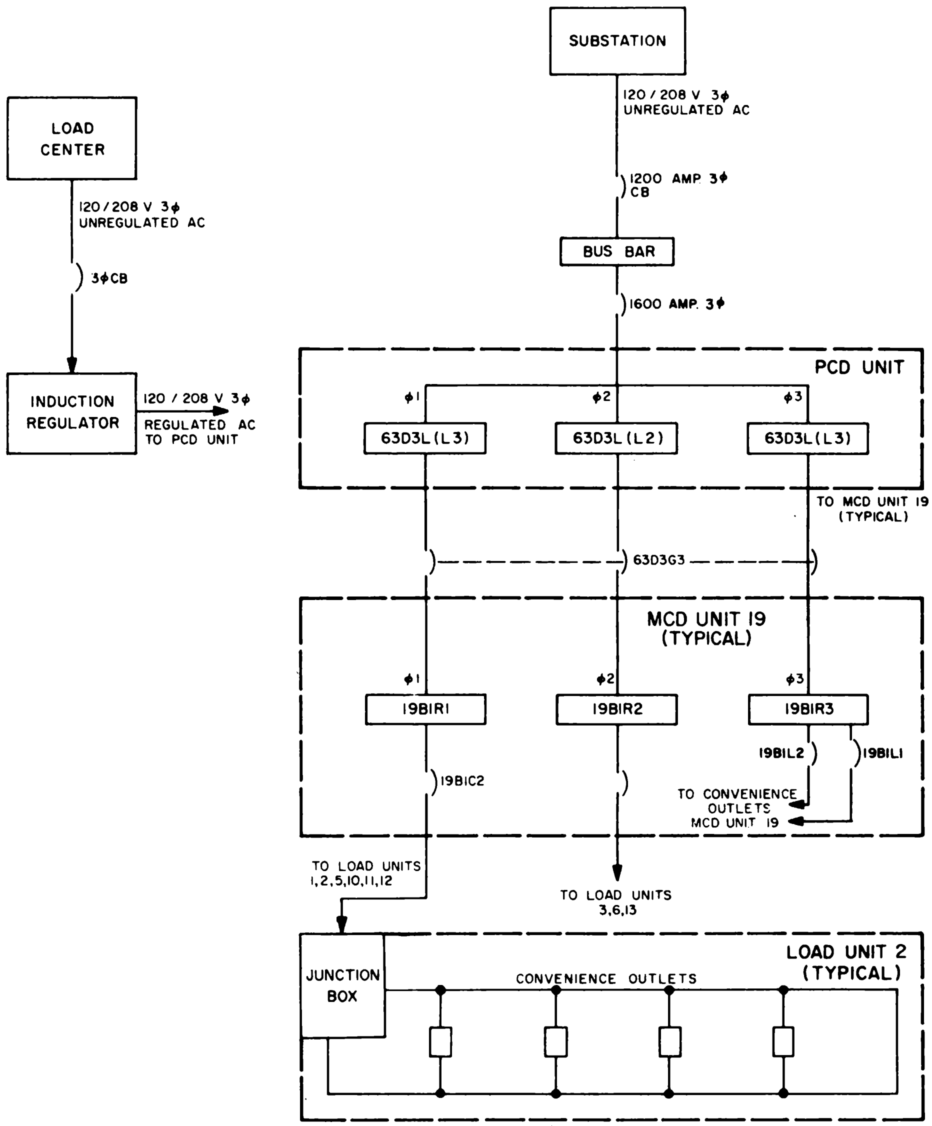
Induction Regulators - The induction regulators regulate the unregulated AC voltage to 120/208 VAC +1% for load center transformer output-voltage variations of



NOTES:
1. EITHER A OR B DIESEL SWITCHGEAR (SWGR), BUT NOT BOTH, MAY FEED SUBSTATION (SUB STA) 3.
2. SUBSTATION 3 WILL FEED NO MORE THEN ONE LOAD CENTER OR ONE SUBSTATION AT A TIME.

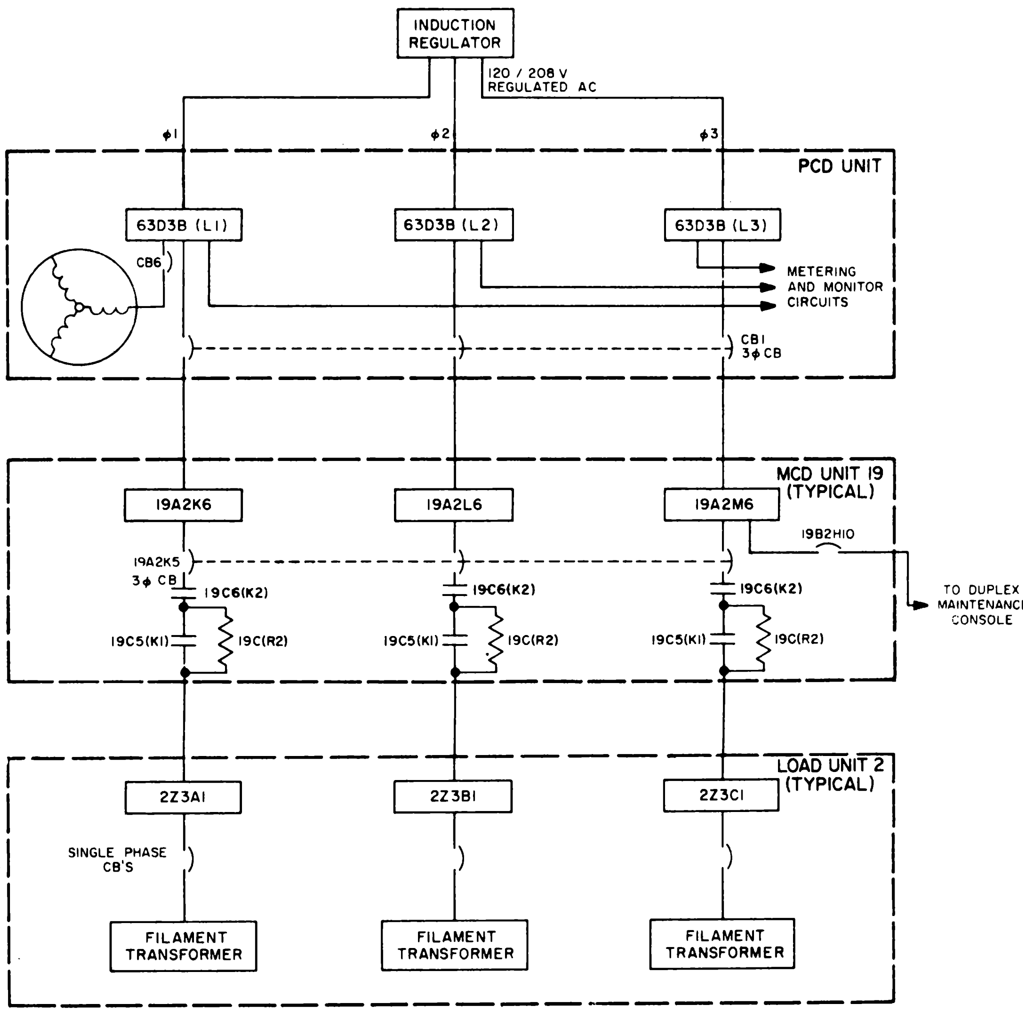
Site Power Equipment

Figure 7-16



Unregulated A-C Distribution, Block Diagram

Figure 7-17



Regulated A-C Distribution, Block Diagram

Figure 7-18

+10%. The output of the induction regulators is distributed to the filament transformers in the load units.

Power Supply Units - The four power supply units receive unregulated AC from the diesel bus bars and produce the regulated DC voltages required by the Central. Duplex power supply units A60 and B60 produce 11 DC voltages; simplex power supply units C61 and D61 produce only 10 DC voltages since simplex equipment does not require +72 VDC.

PCD Units - There are four PCD units in each Central. Two of these (units A63 and B63) are associated with duplex equipment. The other two (units C64 and D64) are associated with the simplex equipment. The PCD units receives DC power from the power supply units, regulated AC from the induction regulators, and unregulated AC from the substation transformer. Each of the PCD units monitors, controls, and distributes power to the MCD units (for duplex equipment) and to the CB units (for simplex equipment).

MCD Units - Power systems A and B each contain six MCD units: Units 19, 29 46, 31, 27 and 59. These units serve as secondary power distribution points and contain relays, contactors, and CB's for distribution and control of power to load units.

Display Console CB Units - The two display console CB units (units C48 and D48) contain the AC and DC CB's required to supply power to the various display consoles of the simplex equipment. These units also contain the signal-status relays for displays.

Simplex Input CB Units - The two simplex input CB units (units C56 and D56) contain the CB's necessary to distribute power to the simplex maintenance console and simplex equipment. These units also contain the signal-status relays for inputs.

Simplex Input PD Unit - Simplex input PD Unit 55 contains relays and contactors to select power from power systems C or D for simplex input units as designated by the UNIT STATUS switches and the power supply status.

MC Unit 58 - The Marginal Check Unit contains the indicators, circuit breakers, and control circuitry for applying margins to input channel equipment.

Control and Indication

1. Duplex Maintenance Console

a. Duplex Maintenance Console - One maintenance console is provided for duplex equipment A and one for duplex equipment B. The power controls are located on module H of the duplex maintenance console.

Module H contains the following POWER GROUP pushbuttons:

UNIT OFF pushbutton - removes without sequencing all power for the associated system.

POWER OFF pushbutton - initiates a power-off sequence for the associated power system.

AC ONLY pushbutton - initiates a DC-OFF sequence on the power system and leaves AC on the filaments of the tubes, at convenience outlets, and on motors.

POWER ON pushbuttons - initiates a power-on sequence for the associated power system.

2. Indicators

a. Power Supply Unit - There are Power On indicators on the duplex power supply unit. A DC voltmeter is installed in the control chassis of each DC power supply to indicate the output of the supply. During normal operation, the voltmeters are behind the closed doors of the unit.

b. PCD Unit - Module C of PCD Unit 63 contains all of the power supply indicators except those required for marginal checking. In the upper left corner are two power status lamps: FIL INPUT DE-ENERGIZED and POWER OFF. In the upper right corner are the AC ONLY and the POWER ON power status lamps. Between the pairs of power status lamps are voltage monitor relays associated with the AC filament voltage shutdown level, the AC filament voltage warning level, and the power supply input. The remaining voltage monitor relays include 11 shutdown level monitor relays and 11 warning level monitor relays for the DC power supplies.

The off-limit lamps include the FILAMENT VOLTAGE lamp, the INPUT TO SUPPLIES lamp, and one lamp for each of the 11 DC power supplies.

Four meters permit accurate reading of all voltages. The AC VOLTMETER provides a visual indication of the AC voltages. The multiple position controls on the on the DC AMMETER, the RIPPLE VOLTMETER, and the DC VOLTMETER provide a means of determining the voltage, amperage, and the ripple voltage of each of the 11 DC supplies.

c. MCD Units - Every MCD unit has one of each of the following:

Green RESET lamp

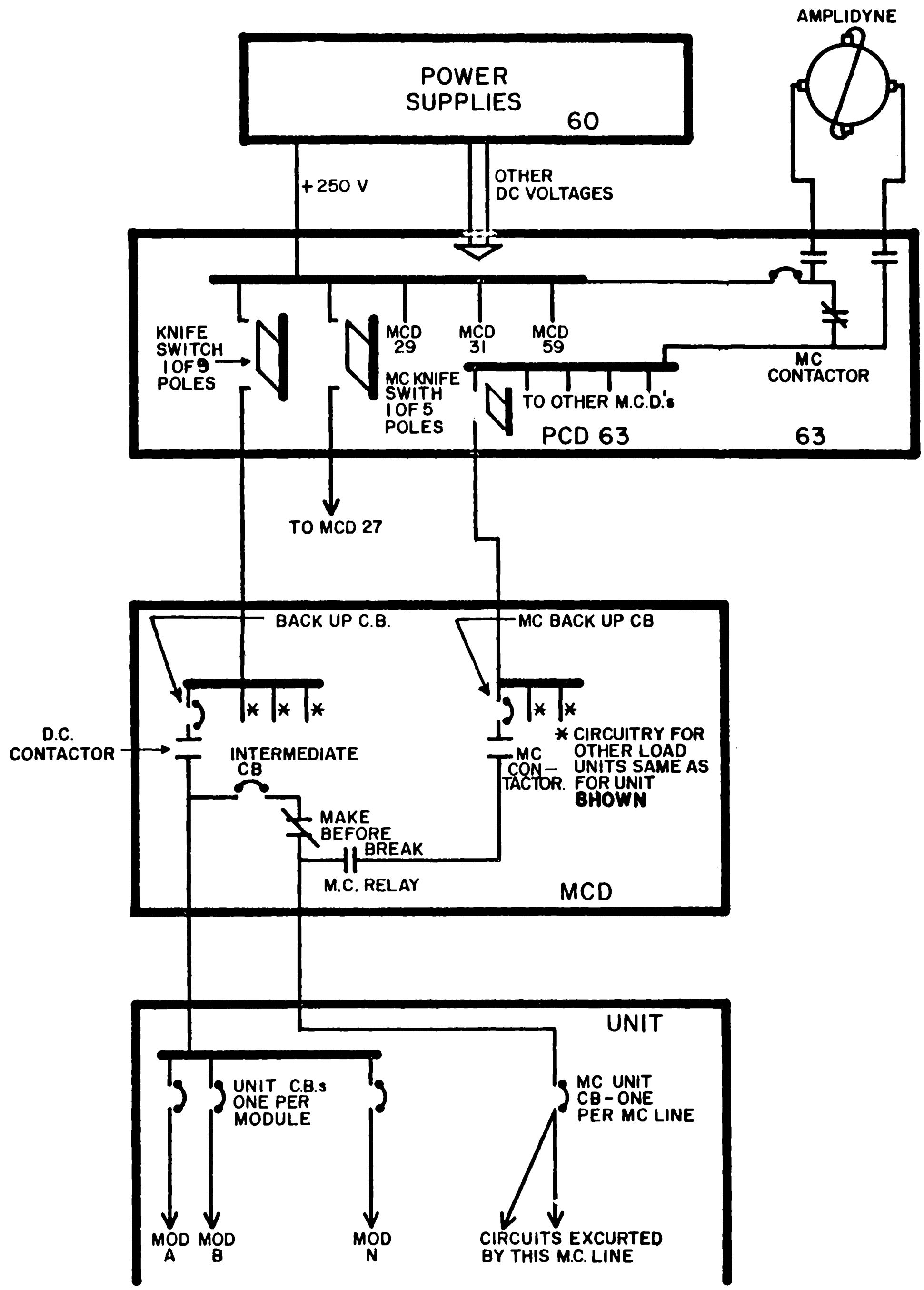
Red AC CB TRIP lamp

Red DC CB TRIP lamp

Green ALL UNITS ON lamp

In addition, each MCD unit contains one amber UNIT OFF lamp for each unit associated with the MCD unit.

d. Load Units - The indicators for a load unit are on the control and indication panel located on the rear of the Z module of that load unit. Four lamps indicate the following conditions: AC FILAMENT CB TRIP, DC-NON-MARGINAL CHECK CB TRIP, DC MARGINAL CHECK CB TRIP, and UNIT OFF. Lamps are also located above and below the AC ON-OFF and DC ON-OFF switches to indicate the following conditions: AC ON, AC OFF, DC ON, and DC OFF.



DUPLEX POWER DISTRIBUTION

Figure 7-19

e. Duplex Maintenance Console - Indicators on the duplex maintenance console which apply to the Power Supply System are the alarm lamps located on module G. These lamps are listed below:

MCD AC BREAKER

NEON ALARM

VOLTAGE OFF LIMITS ALARM

MAINTENANCE CONSOLE AC BREAKER

COMPUTER MCD

PCD UNIT

AC SWITCH GEAR

TAPE ADAPTER

DISPLAY MI MCD

OUTPUT MCD

DRUM MCD

TAPE POWER SUPPLY

AUXILIARY DRUM MCD

DUPLEX INPUT MCD

Module G also contains the computer status lamp.

Module H contains POWER GROUP indicator lamps associated with the POWER OFF, POWER ON, and AC ONLY pushbuttons. A single lamp is associated with the operation of each pushbutton.

3. Interlock Circuits

a. General

The interlock circuits ensure that power is applied to the various portions of the equipment only when there is no danger of injury to personnel or of damage to the equipment. The interlocks consist of micro-switches operated by CB's or knife switches. These micro-switches control contactors which permit the flow of power to various portions of the equipment. Separate interlock circuits are provided for AC and DC circuits. In the DC circuits, there are separate interlocks for the MC and the non-MC lines.

b. Knife-Switch Interlocks - The 9-pole and 5-pole knife switches in the PCD unit are interlocked with the DC-hold circuit. All knife switches must be closed before the DC-hold relay in each MCD unit can be picked. In addition, since the microswitch contacts are normally open when the knife switches are closed, opening a knife switch causes all DC power for the associated MCD to cycle down and causes an interlock to close to complete a circuit to the PCD TROUBLE lamp at the duplex maintenance console.

c. Door interlocks prevent operation of the equipment with the console doors open. Since dangerous high voltages exist inside the equipment when it is in operation, microswitches mounted on the doors energize contactors when the doors are opened. The door interlock contactors operate in the same manner as the knife switch interlock to open normally closed points in the power circuitry and prevent power from being applied or to cause all DC power for the associated system to cycle down.

SUMMARY QUESTIONS

1. The total requirements for a DC system is approximately__________ kw.

2. This is divided into three equal sections:_______ ,_______ , and________ .

3. The primary source of power is_______________ .

4. There are__________ power systems in the AN/FSQ-7.

5. A load center changes_______volts AC to________volts AC.

6. Substations supply 120 VAC unregulated to the_____________ .

7. The regulated AC from the Induction Regulators goes to __________in bad units.

8. ___________ volts DC is produced in Unit 60 but not in Unit 61.

9. There are_______ PCD units in an AN/FSQ-7.

10. There are________ MCD's in an AN/FSQ-7.

11. Signal-status relays for displays are located in units ________ and _________ .

12. Only_______ PD unit is contained in an AN/FSQ-7.

13. The induction regulators supply regulated AC to the _________________________ .

14. The sub-station supplies 208V 30 AC for the _________________ .

15. The supply input is_________volts 30 AC.

16. All power used in the AN/FSQ-7 goes through a____________ unit.

17. There are_________MCD units in an AN/FSQ-7.

18. The power off button does not remove ________________ power from the load units.

19. The relay points that short out the 50% regulated AC resistor is located in the

____________ unit.

20. There is one contactor in the __________ voltage line from the PCD to the load.

21. MC loads are supplied power through the __________ knife switches.

Induction Regulators

1. Purpose

Induction regulators are used to regulate the 208V AC output of the load centers because the induction regulators introduce no AC waveform distortion or DC ripple, have a high power factor, and are easy to maintain.

Status Switching

1. Introduction

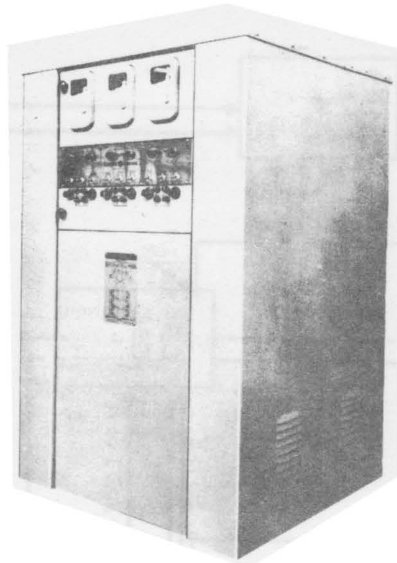
a. The status of the four systems is controlled by the Duplex switching console unit 45.

b. The power systems A or B will in no way be affected by Duplex switching. Signal status relays in MCD 27, MCD 59, and the output storage unit will cause signals to be switched but power will not be changed.

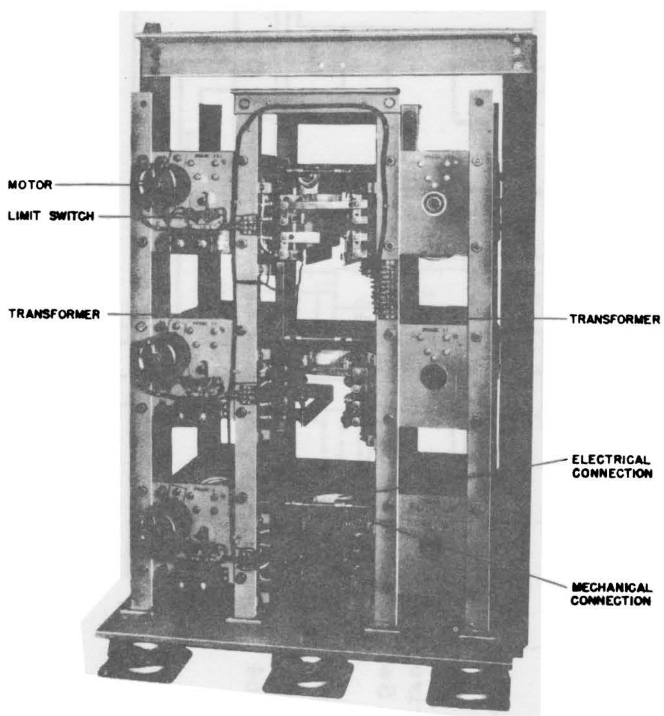
c. The power to simplex units will be switched by a simplex status change.

d. The Active simplex power system will supply power to the Active simplex loads. The Standby simplex power system will supply power to the standby simplex loads. Each of the simplex loads can be changed to a different status with the unit status switch associated with that load.

e. A Simplex Display Console will receive signals from the Active computer when the console is Active, and from the Standby computer when the console is standby. There must be eight status control lines entering each display console, two from each system. Only four of these lines will have power applied at any one time. If the A and C systems are Active and B and D are Standby, the Active Status control lines from MCD A 27 and CB C 48 will have -48V applied. The standby status control lines from MCD B27 and CB D48 to the console will have -48 volts applied. This will cause power contactors in the console to apply power from the C power system if the console is Active, or from the D power system if the console is Standby. The signal relays in the console will be closed to connect the output of DDGE and SDGE of the A computer to the console circuits, if the console is Active. If the console is Standby, signal relays to the B computer will be closed.



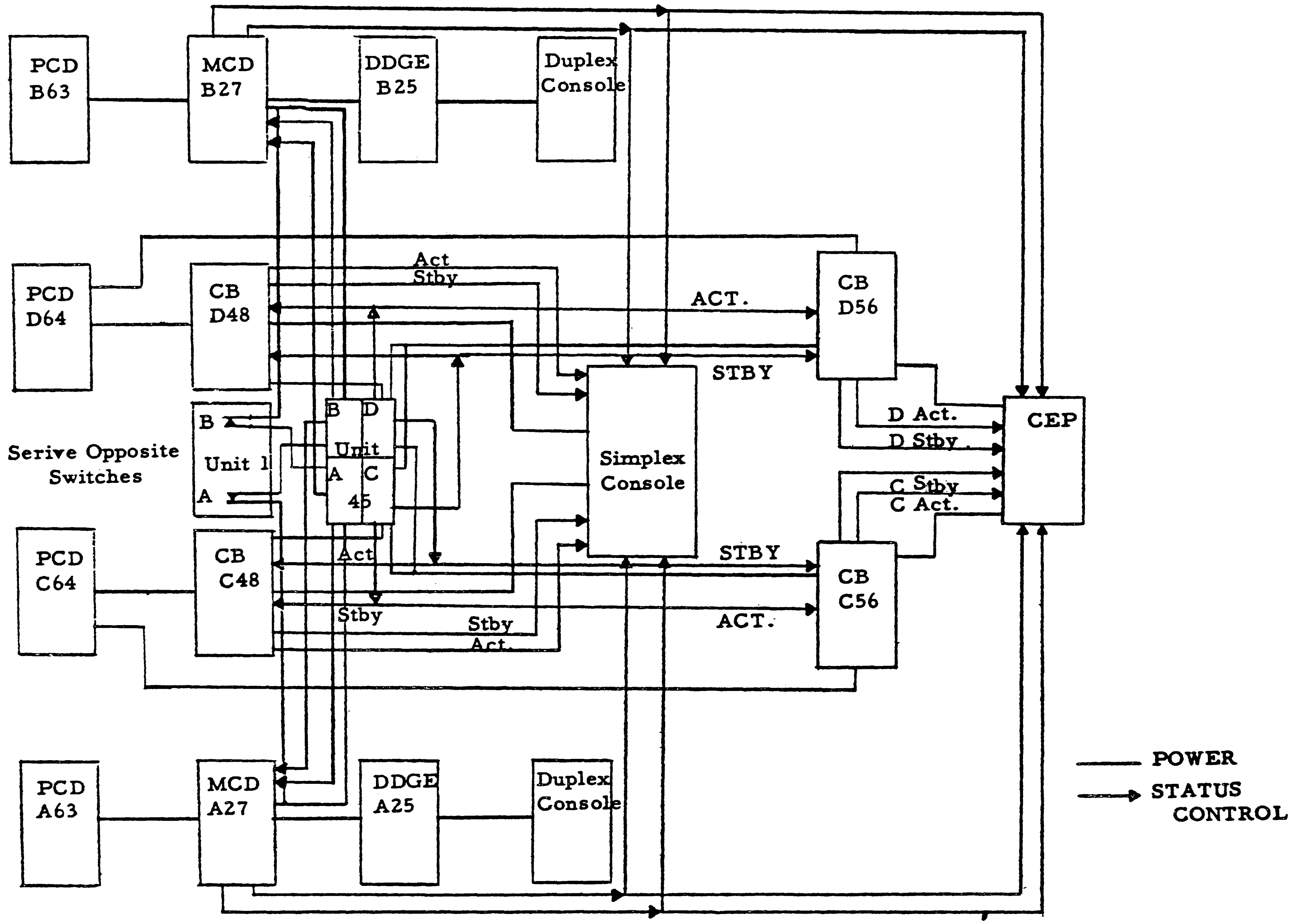
Induction Regulator, Right Front View



Induction Regulator, Front View, Covers Removed

Figure 7-20

Figure 7-21



SIMPLIFIED STATUS SWITCHING

f. A CEP or any of the input PD units receive 8 status control signals. Only four of these will be hot at any one time. If the A and C systems are active and B and D are Standby, the Active status control lines from the A and C systems will be hot and the standby status control lines from the B and D systems will be hot. If the CEP is Active, contactors will be closed in the CEP that will cause power to be applied to the loads from the C power system and the CEP will send signals to the A computer. If the CEP is Standby, power will be applied from system D and signals will be sent to the B computer.

g. The Switching Console Unit 45 has 4 sections labelled A, B, C, and D. Each section will control the status of the corresponding system. Each section contains a relay that will be picked when the corresponding system is Active. All relays will be dropped in a section when the corresponding system is standby. Standby relays will be picked in the A system from the B panel when the B system is active. This will also hold true with the other systems. This allows relays in any system to be picked by power from that system.

Duplex Switching

1 General

Duplex switching controls which of the two duplex equipments, A or B, is in the active status. The alternate duplex equipment is in the standby status.

If a failure occurs in the power system supplying the active equipment, duplex switching is necessary to transfer the alternate duplex equipment to the active status. Maintenance can then be performed on the power system connected to the standby duplex equipment without interruption of the air defense function.

Power systems A and B are turned on at the duplex maintenance console. However, they are permanently connected to their respective computers. The operator at the duplex switching console decides which computer will be active. Status and alarm lamps indicate the condition of each power system.

2 Duplex Switches on Duplex Switching Console

a. Active Pushbutton

The Active pushbutton on either duplex signal switching panel, when depressed, initiates the switching action which makes the associated equipment active by performing the following functions:

Sends a signal to place the other computer in standby status.

Places MCD units 27 and 59 in active or standby status, depending on whether equipment A or B is active. These MCD signals, in turn, operate relays which supply -48V DC to the display consoles, to determine which computer information will be displayed, and to the XTL input channel.

Switches output storage unit 33 by means of an output active signal that determines whether the output information is to be sent over telephone lines or used for testing purposes when unit 33 is in the standby status.

b. Interlock Override Bypass Pushbutton

The Interlock Override Bypass pushbutton allows the operator of the duplex switching console to bypass any open power interlock which would prevent duplex switching. In the event that an emergency condition occurs, this switch enables the operator to apply -48V DC to the Active pushbutton. This pushbutton is located in a recessed position and cannot be depressed accidentally during normal operating procedure.

c. Operate-Test Overrride Bypass Switch

The switch allows an active computer and its associated power system to be placed in the test mode. Usually, the computer is placed in the test mode only when the computer is in standby status. This signal is applied to the master TEST-OPERATE COMPUTER switch located on the duplex maintenance console.

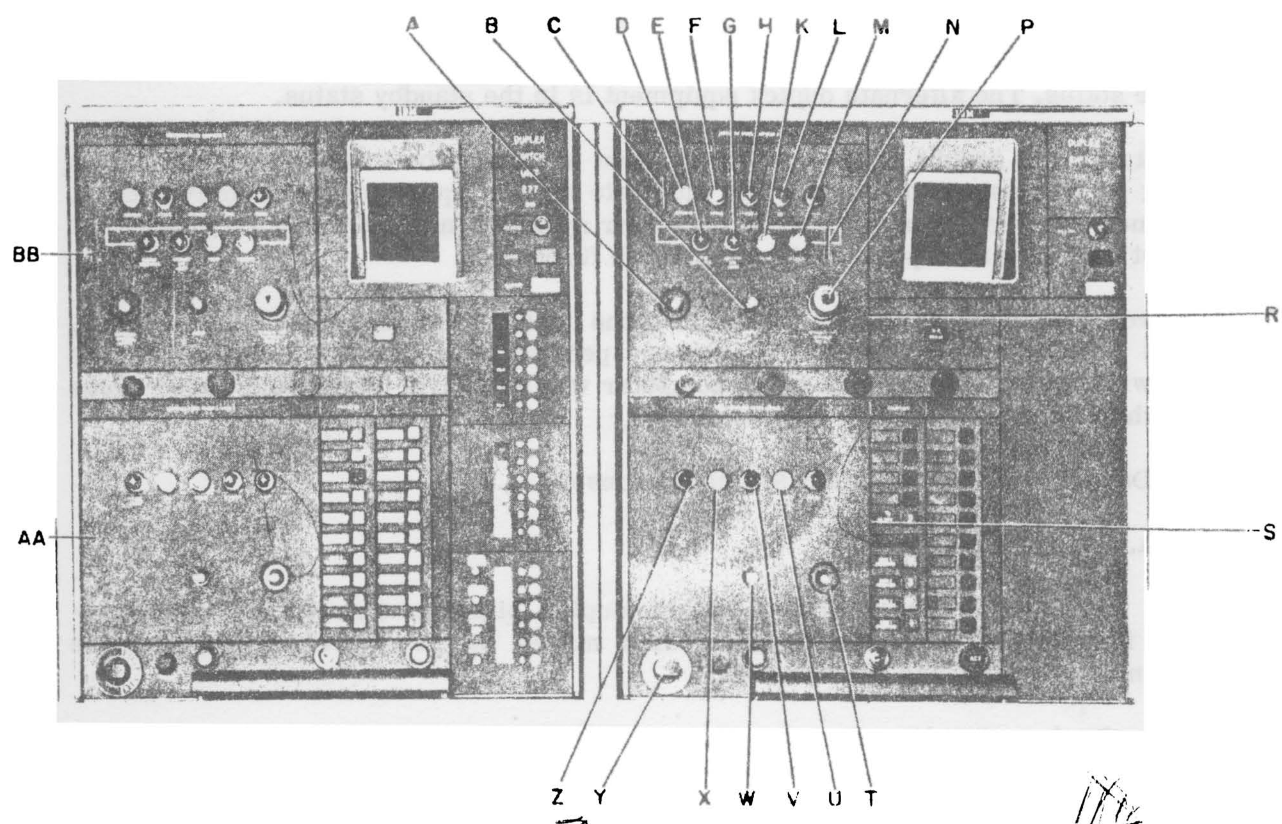


Figure 7-22

USS

ACT. PWR.

ACTive

Standby

The OPERATE-TEST OVERRIDE BYPASS switch is operated with a key which remains in the custody of the maintenance supervisor.

d. Unit Status Switch — Point Y

The unit status switch controls the distribution of the control and signal lines only for the display portion of the duplex switching console.

3. Status Lamps on Duplex Switching Panel

a. Operate Lamp — Point D

This lamp is lighted when the associated computer is not in the test mode or is not disabled.

b. Active Lamp — Point F

This lamp is lighted when the associated computer has received a switching-complete signal.

c. Standby Lamp — Point H

This lamp is lighted when the associated computer is in the standby status, and can be tested, marginally checked, or utilized for regular computer functions not involved in the air defense program.

d. Test Lamp — Point L

This lamp is lighted when the particular computer is in the test mode. Normally, this lamp is lighted when the standby lamp is also lit; but if the computer is in the Active status with the Active lamp lighted, the Test lamp is lighted by means of the Operate-Test Override Bypass pushbutton and air defense functions are not being performed.

4. Alarm Lamps on Duplex Switching Panel — Point D

a. Output Switching Lamp

When the Output Switching Lamp is lighted, one of the relays in output storage unit 33 has not transferred, and computer information is not being sent out on telephone lines. This malfunction will occur only during switching from the standby to the active status.

b. Voltage Off Limits Lamp — Point G

Whenever one of the power supplies deviates more than +5% from (+10% for -48V or +72V) the regulated output, the associated voltage monitor relay in the PCD unit completes a circuit that lights the Voltage OFF Limits on the duplex switching console. This lamp is only an alarm and indicates that a search would be initiated to determine the deviating power supply and the cause of the malfunction. When the deviation reaches $\pm$ 20%, ($\pm$10% for AC shutdown) there will be an automatic shutdown of power from the power supply unit and PCD unit involved.

c. Neon Alarm Lamp   Point K

The Neon alarm lamp on the duplex switching console is lighted when the Neon Alarm Lamp on the duplex maintenance console is lighted, indicating some alarm condition in one or more of the duplex load units.

d. Disabled Lamp   Point L

An open power contactor in the MCD unit associated with its respective Central Computer, Drum, Display, Input, or Output System lights the Disabled lamp. This signal is routed through PCD unit 63 and is sent to the duplex maintenance console as an interlocked signal that prevents duplex switching and lights the Disabled lamp on the duplex switching console.

5. Detailed Duplex Switching Action

a. General

Duplex switching is the changing of the standby computer (and associated power supply and other duplex equipment) to the active status.

Depressing the Active pushbutton on the appropriate duplex switching panel of the duplex switching console initiates a relay sequence that performs the switching operation. Assume that Computer A is active and Computer B is in standby status.

b. Duplex Switching Interlocks

When all the interlocks are closed, points 1a-1b of relays 1E2(K8) and 1E2 (K14) (7.1.14) points 2a-2b of relays 1G4(K14) and 1G4(K15) and interlock contacts in in the duplex power equipment are open, leaving interlock relay 1F3(K7) de-energized.

c. Duplex Switching Permitted

A -48V duplex-switching-permitted signal (7.1.14) is then applied across points 4-5 of relay 1F3(K7) (7.1.14), Pin S of cable connector J2 on the duplex switching console (7.2.1) across contacts AC of the depressed Active pushbutton 45B(S2), to pin F of P1 on panel B of the duplex switching console, to pin A of P1 on panel A of the duplex switching console, to energize the trip coil of latching-type switching relay 45A(K1), placing computer A in standby status.

d. Computer B Active

Points 1a-1c of 45A(K1) (7.2.1) open, interrupting the circuits to the Active lamps for system A. Points 2a-2c open, interrupting the circuit to the standby lamps for system B. The above lamps are extinguished. Points 3a-3c of 45A(K1) open, de-energizing 45A(K2).

Normally closed points 1a-1b of 45A(K2) now close, providing -48V to pin E of P1 on panel A of the duplex switching console, to pin D of P1 on panel B, to energize pick coil of switching relay 45B(K1).

Points 1c-1a of 45B(K1) close, completing the circuits to light the active lamps for system B. Points 2c-2a close, completing the circuits to light the Standby lamps for system A. Points 3a-3c of 45B(K1) close, energizing 45B(K2).

The action of the other points on 45B(K2) and 45A(K2) activates relays that perform other duplex switching functions.

e. MCD Unit 27 Signal Status Relays

Points 2a-2c of 45B(K2) close, energizing status relays in MCD unit 27 (5.4.4.7). This circuit is traced from CB 27J2G9, to terminal 27K2A2n, to terminal 1G3(E34)a(7.2.1), to pin D of J2 on the computer B switching panel on unit 45, across now closed contacts 2c-2a of 45B(K2) to pin E of J2, to terminal 1G3(E34)b, to terminal 27N1J1a(5.4.4.7) in MCD unit 27 for System B, to the coils of active status relays 27N1A2 through 27N1H2 and 27N3A2 through 27N3H2 for system B duplex display consoles.

The standby status relays for system A duplex display console are energized through points 5c-5a of 45B(K2). This circuit can be traced from terminal 1G3(E34)a (7.2.1) in the duplex maintenance console for system A, across normally closed contacts 1a-1b of the Service Opposite Duplex Switch 1G3(S21), to terminal 1G3(E34)e, to pin C of J3 in the computer B switching panel of unit 45, across now closed points 5c-5a of 45B(K2), to pin D of J3, to terminal 1G3(E34)f in the duplex maintenance console for system A, to the coils of standby status relays 27N1A3 through 27N1H3 and 27N3A3 through 27N3H3 for system A duplex display consoles. When the Service Opposite Duplex Switch is switched off, contacts 1a-1b are opened and the standby status relays cannot be energized.

f. MCD Unit 59 Signal Status Relays

Points 3c-3a of 45B(K2) complete the circuits to energize the active status relays for the simplex input load units.

This circuit can be traced from CB 59A2H3(5.4.7.6) in MCD unit 59 of power system B to terminal 1G3(E34)c (7.2.1) in the duplex maintenance console for system B, to pin F of J3 on the computer B switching panel of unit 45, across now closed contacts 3c-3a of 45B(K2), to pin G of J3, to terminal 1G3(E34)d in the duplex maintenance console for system B, to terminal 59B6A4d(5.4.7.6) in MCD unit 59 of power system B, to the coil of relay 59F3E2 for the test pattern generators of computer entry punch units 352, 353, and 354, across now closed points 5-6 of high-voltage DC contactor relays K3 in locations 59B6, 59C6, 59D6, and 59G6 (applied the high-voltage DC to the load units from MCD unit 59 when these relays were energized during duplex power-on sequence) to the coils of the other active status relays. Standby status relays 59F1A3, 59F1B3, 59F3A3, 59F3B3 in MCD unit 59 of power system A, can be energized through points 6c-6a of relay 45B(K2) (7.2.1) and a circuit similar to the standby status relays in MCD unit 27, if the MC contactor relays K4 (5.4.7.6) are energized.

g. Outputs Switching

Points 4c-4a of 45B(K2) (7.2.1) initiate the outputs switching by completing the circuits that energize the outputs active relays. Whenever one of the active relays fails to pick, the OUTPUTS SWITCHING alarm lamps are lighted.

h. Switching Time Delay and Audible Alarm

At the same time that the ACTIVE lamps (7.1.15) on the duplex maintenance console are lighted (points 1c-1a of 45BK1 close), relay 1F4(K10) is energized through normally closed points 1a-1b of 1F4(K11). Points 1c-1a of 1F4(K10) close, applying 120V AC to the Hayden Timer 1F4(K10) (7.2.1). Points 2a-2c of 1F4(K10) (7.1.15) close, applying a -48V surge to the 5-uf capacitor (7.1.14) between terminals 27 and 28 on terminal board 1F3(E2). The surge is transmitted across the diode between terminals 32 and 31, to energize relay 1F3(K8) momentarily. Points 5-7 of 1F3(K8) then hold the relay energized, providing an audible alarm to indicate that the computer is active. This alarm is stopped by depressing the RESET AUDIBLE ALARM pushbutton 1G3(S32), opening contacts 2a-2c. The other circuits activate this alarm in a similar manner.

Points 3a-3c of 1F4(K10) (7.1.15) provide a ground circuit for the grid of the thyratron pulse generator in the Central Computer. The output of this generator sets up the controls to indicate that duplex switching is initiated.

At the end of the time delay set by the Hayden Timer 1F3(E35), points a-c of the timer close, applying -48V to 1F4(K11). Points 1a-1b of 1F4(K11), open, dropping 1F4 (K10). Points 2a-2c of 1F4(K11) provide a hold circuit when the Hayden Timer is de-energized by points 1a-1c of relay 1F4(K10) opening. Points 4a-4c send a duplex switching-completed signal to Selection Control unit 5 of the Central Computer. Points 2a-2c of 1F4(K12) provide a ground circuit for the grid of the thyratron pulse generator in Instruction Control unit 4 of the Central Computer. The output of this generator sets up the controls to indicate that duplex switching is completed. Points 3a-3c of 1F4(K10) were opened, breaking the circuits to the grid of the thyratron pulse generator that sets up the controls to indicate that duplex switching was initiated. The floating grid stops the thyratron pulse generator.

The comparable relays in the duplex maintenance console for computer A, 1F4(K11) and 1F4(K12), are de-energized when the ACTIVE lamps are extinguished by points 1a-1c of 45A(K1) in the computer A switching panel of unit 45.

i. System Disabled

The DISABLED lamp, X9, on a duplex switching panel of unit 45 is lighted whenever an interlock is open and relay 1F3(K7) (7.1.14) is energized. The -48V is then applied along the duplex switching interlocked line from point 2a of 1G4(K15), across now closed points 5-7 of 1F3(K7), to terminal 1H3(E15)c, to pin R of J2 on the duplex switching console, to the DISABLED lamp.

j. Emergency Switching

An INTERLOCK OVERRIDE pushbutton is provided in the event that duplex switching is required when an interlock is open and the DISABLED lamp is lighted.

If interlock relay 1F3(K7) (7.1.14) is energized (an interlock is open), contacts 4-5 will be open and the duplex-switching-permitted signal will be interrupted. Contacts of the ACTIVE switch S2 on the duplex switching console will have no voltage applied. When INTERLOCK OVERRIDE pushbutton S3 and ACTIVE pushbutton S2 are depressed, -48V is applied through the following circuit (Table 7-1). Trip coil UL of 45A(K1) will initiate the switching sequence to make computer B active.

k. Test-Operate Override Bypass Switch

When the STANDBY lamps on the duplex maintenance console for system B are extinguished (above), 1F2(K16) (7.1.15) is de-energized.

Points a-c of 1F2(K16) (7.2.1) are then open, which prevents any testing operations on the active computer unless the TEST-OPERATE OVERRIDE BYPASS switch 45B(S1) is closed with the key. If this switch is closed, -48V can be applied to computer test relays 1G4(K17) and 1G2(K5) by shifting the OPERATE COMPUTER-TEST switch to the TEST position. The circuit can be traced from point 3c of duplex switching relay 45B(K1), across points a-c of the bypass switch, to pin T of J2 on the computer B switching panel of unit 45, to terminal 1F3(E18)a in the duplex maintenance console for system B, to point c of 1F2(K16), across contacts 4b-4a of OPERATE COMPUTER-TEST switch 1G3(S9), and across now closed contacts 2a-2b to the coils of 1G4(K17) and 16G(K5).

TEST lamps 1G3(X179) and X2 in duplex switching console unit 45 are lighted when points 2a-2c of 1G3(K5) close. OPERATE lamps 1G3(X180) and X5 in unit 45 are lighted when 1G4(K17) is de-energized, normally closed points 3a-3b are closed, and -48V is provided by the closing of points 1a-1c of duplex switching relay 45B(K1) in Computer B switching panel of unit 45.

6. Service Opposite Duplex Switch

When one computer and associated equipment are shut down for maintenance, the associated duplex switching panel of unit 45 still receives -48V through several circuits from the active duplex maintenance console. This -48V power can be removed by switching off the SERVICE OPPOSITE DUPLEX SWITCH on the active duplex maintenance console. The contacts listed below are then opened, interrupting the circuits that would be provided in the normal position.

Contacts 1a-1b of the SERVICE OPPOSITE DUPLEX SWITCH are closed in the normal position. The circuit can then be completed to energize the standby status relays in standby MCD unit 27 with -48V from the active MCD unit 27. Contacts 2a-2b, when closed (in the normal position) during standby status, provide -48V to light the standby lamps. Contacts 3a-3b provide -48V from active MCD unit 59 to energize the standby status relays in standby MCD unit 59.

INTERLOCK OVERRIDE CIRCUIT

POINT OR TERMINAL	COMPONENT	LOGIC DIAGRAM
e	CB 19B2H1	5.3.3.10
f	1G3(E33)	7.1.4
1c	1F2(K7)	7.2.1
1c	1F4(K12)	
c	1F2(K16)	
1c	1G2(K9)	7.2.1
7	1F3(K5)	7.1.14
7	1F3(K4)	
7	1F3(K3)	
7	1F3(K1)	7.1.14
3b	1G4(K17)	7.1.7
2a	1G2(K5)	7.1.7
2a	1G3(S21)	7.2.1
d	1H3(E25)	
B	P2-J2	
1c	45B(K1)	
3c	45B(K1)	
c-a	45B(S3)	
a-c	45B(S2)	
F	J1-P1 (Computer B)	
A	P1-J1 (Computer A)	
y'	45A(K1) UL	7.2.1

Table 7-1

7. Alarms

a. Neon Alarm

The NEON ALARM lamp, 1G3(X6), on the duplex maintenance console (7.2.1) and the associated NEON lamp in the alarm group on the duplex switching console light whenever an alarm condition occurs. The -48V is provided to these lamps when 1G2(K9) is energized. This circuit proceeds from CB 19B2H1 (5.3.3.10), to terminal 1G3(E33)f (7.1.4), to point 1c of 1F4(K12), to point c of 1F2(K16), and across now closed points 1c-1a of 1G2(K9) to the lamps.

Relay 1G2(K9) is energized whenever any alarm relays 1F3(K1), (K3), (K4), or (K5) is energized as the result of a condition that causes a drum alarm, computer alarm, outputs alarm, or an angular position counter (APC) alarm in the drums.

b. Voltage Off Limits

The VOLTAGE OFF LIMITS lamp, 1G3(X7), on the duplex maintenance console (7.2.1) is lighted, and 1F2(K7) is energized when any of the voltage monitor relays in PCD unit 63 detects an excessive voltage deviation. Points 1c-1a of 1F2(K7) close, applying -48V from CB 19B2H1 (5.3.3.10), across now closed points 1c-1a of 1F2(K7) (7.2.1), to terminal 1G3(E8)f, to pin N of J2 on computer B switching panel of unit 45, to VOLTAGE OFF LIMITS lamp X11.

SUMMARY QUESTIONS

1. Unit________ controls the status of all four systems.

2. ________________________ relays in Unit 27 and 59 will be changed by the duplex switching console.

3. There are______________K2 relays in the A and B panels of unit 45, but only one of these will be picked at any one time.

4. When computer A is active, status control relays in both systems will be picked by relay K2 in panel____________.

5. An active computer may be put into test by closing the ______________________ ________________switch.

6. The unit status switch on unit 45 changes the status of the __________________ .

7. An open DC contactor in the MCD will light the __________ lamp on the switching console.

8. There are________standby signal status relays in unit 27.

9. Each of these relays contain__________ sets of contacts.

Simplex Switching

1. General

Simplex switching, performed at the duplex switching console, controls which of the two simplex power systems C or D, is connected to the active simplex equipment and which is connected to the simplex units in the standby status. If a failure occurs in the system supplying power to the active simplex units, simplex switching is necessary to interchange the active and the standby power systems. After switching, maintenance is performed on the system connected to the standby simplex equipment, without interrupting the air defense function.

These power systems are turned on at the simplex maintenance console. The operator at the duplex switching console decodes which system will be active and which standby. Status and alarm lamps indicate the conditions of each power system.

2. Simplex Controls on Duplex Switching Console

a. Active Pushbutton

The ACTIVE pushbutton on either simplex power switching panel, when depressed, places the associated simplex power system in the active status and automatically places the other simplex power system in the standby status.

b. Interlock Override Bypass Pushbutton

When any power supply in the simplex power supply unit deviates more than a fixed amount, an off-limits alarm is activated and provides an interlock that prevents switching the standby power system for simplex equipment to the active status. The INTERLOCK OVERRIDE BYPASS pushbutton allows the operator at the duplex switching console to bypass the power interlock and switch the standby power system to the active status.

3. Indicators on Simplex Switching Panel

a. ON Lamp

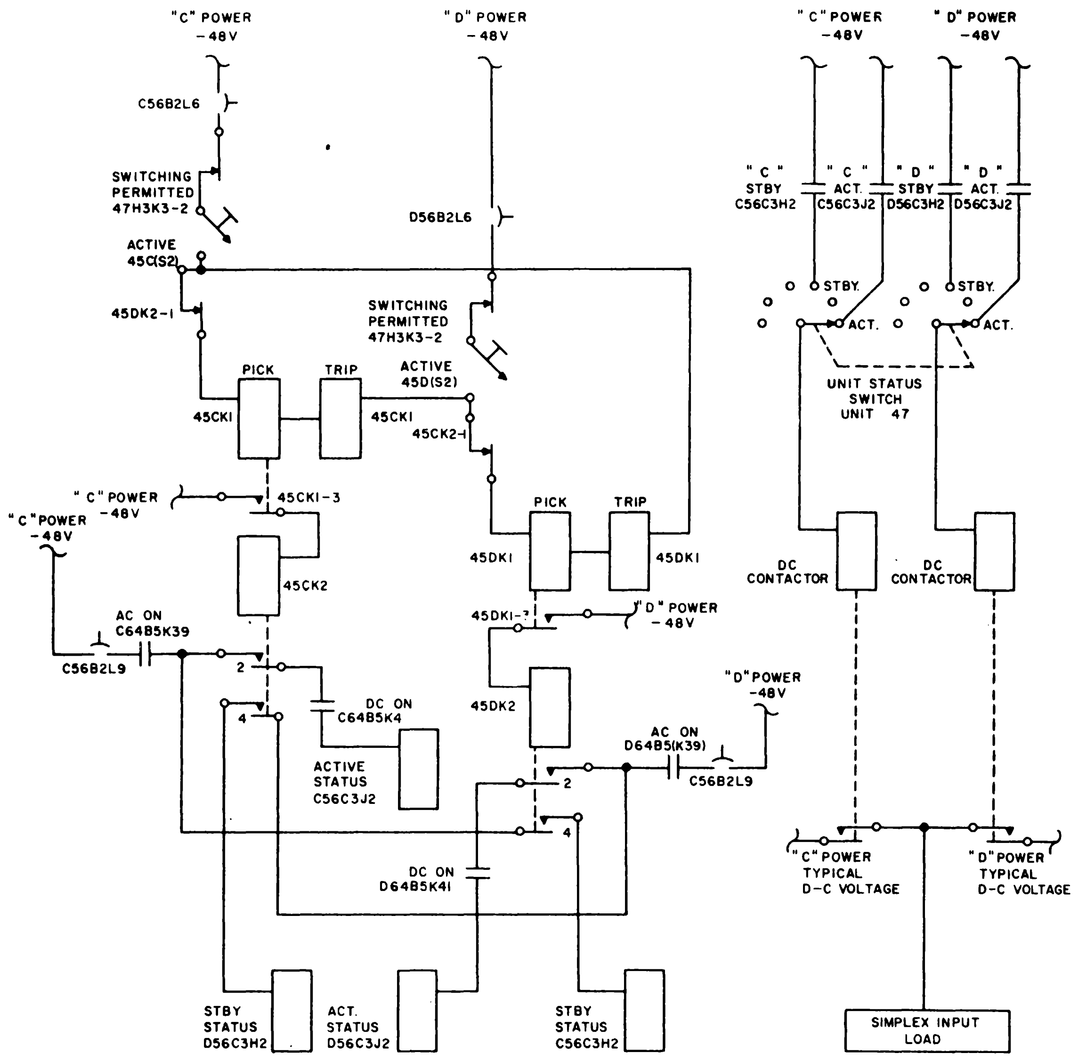
The ON lamp is lighted when the associated power system is on. The on-off status of the power system is controlled by the operator at the simplex maintenance console.

b. ACTIVE Lamp

If the ACTIVE pushbutton is depressed when the ON lamp is lighted the power system will become active and the ACTIVE lamp will light.

c. STANDBY Lamp

The STANDBY lamp indicates a standby status and lights when the particular power system is on and the ACTIVE pushbutton on the alternate power system is depressed.



Typical Load Unit, Simplified Simplex Switching

Figure 7-23

d. POWER ALARM Lamp

The POWER ALARM lamp lights when a regulated voltage from the simplex power supply unit deviates more than $\pm 5\%$ from its normal output. The POWER ALARM lamp also lights when the power is shut down.

4. Detailed Simplex Switching Action

Simplex switching operations involve power transfer and are accomplished as follows: power system C is assumed to be the active system, and power system D the standby system. To place the simplex power equipment in this status, ACTIVE pushbutton 45C(S2) is depressed to pick 45C(K1) and 45C(K2). Power is transmitted through points of AC-on control relay 64B5K39 and DC-on control relay 64B5K41 to pick active status relay 56C3J2 from system C. Points of the active status relay apply -48V power through the unit status switch (in the ACTIVE position) on unit 47 to the DC contactor. A typical DC voltage from power system C is then applied to the simplex load. The -48V power from system D is transmitted through points 4 of 45C(K2) of system C to standby status relay 56C3H2 of system D.

When ACTIVE pushbutton 45D(S2) on the power system D switching panel of unit 45 is depressed 45C(L1) is energized through points 1b-1a of 45C(K2). Points 1c-1a of 45D(K1) (S 5.4.11.1) close to light the ACTIVE lamps associated with power system D. Points 2c-2a close to light the STANDBY lamps associated with power system C. Points 3c-3a close to energize 45D(K).

Relay 45D(K2) completes circuits that activate status relays for displays and simplex inputs. Points 2c-2a complete the circuits that energize the active status relay associated with power system D. A typical DC voltage is applied through points of 56C3J2 and the ACTIVE position of the unit status switch on the associated panel of the simplex maintenance console to DC contactor is then applied through this contactor to a simplex input load. Points 3c-3a complete the circuits that energize the active status relays in CB unit 48. The -48V that energizes the standby status relay in CB unit 56 for power system C is controlled by points 4c-4a of 45D(K2) after crossing contacts 1a-1b of the SERVICE OPPOSITE SIMPLEX SWITCH on power system D control panel on the simplex maintenance console. Points 5c-5a control the standby status relays in CB unit 48 for power system C after the -48V is provided across contacts 2a-2b of the SERVICE OPPOSITE SIMPLEX SWITCH. This switch must be in the normal position to energize the standby status relays of power system C.

When power system C is shut down and maintenance is desired on the power system C switching panel of unit 45, the -48V is removed from the plug connectors by switching off the SERVICE OPPOSITE SIMPLEX SWITCH on the power system D control panel of the simplex maintenance console. In addition to interrupting the two circuits listed above, the switch also opens contacts 3a-3b and removes the -48V that appears as far as the open circuit ending at point 2c of 45C(K1).

SUMMARY QUESTIONS

1. The active simplex power supplies power to the ____________ display consoles.

2. The power to a console may be switched with the ________________ switch on the console or by changing the ____________ of simplex power.

3. The __________ of a console will not be changed during simplex switching.

4. Each CEP has__________ status control signal lines.

5. The C power system is made standby by pressing the__________ pushbutton on panel_______________of unit 45.

6. The C power system service opposite switch removes -48V to the _______ panel of unit 45 from system ____________ .

Display Consoles Status Switching

1. Introduction

a. Before an attempt is made to learn the status control for simplex display consoles, it would be to the students' advantage to thoroughly understand the distribution of power to a display console.

b. This power is applied to bus bars in modules A and B of unit 48. Eight backup CB's are connected to each bus bar. The backup CB's will supply power to 20 consoles through distribution CB's. One distribution CB will supply one DC voltage on 10 of AC to a display console.

c. Each backup breaker has interlock points that are used to pick control relays for 20 consoles.

d. Each distribution CB has interlock points that control the status control lines to the console fed by the associated CB.

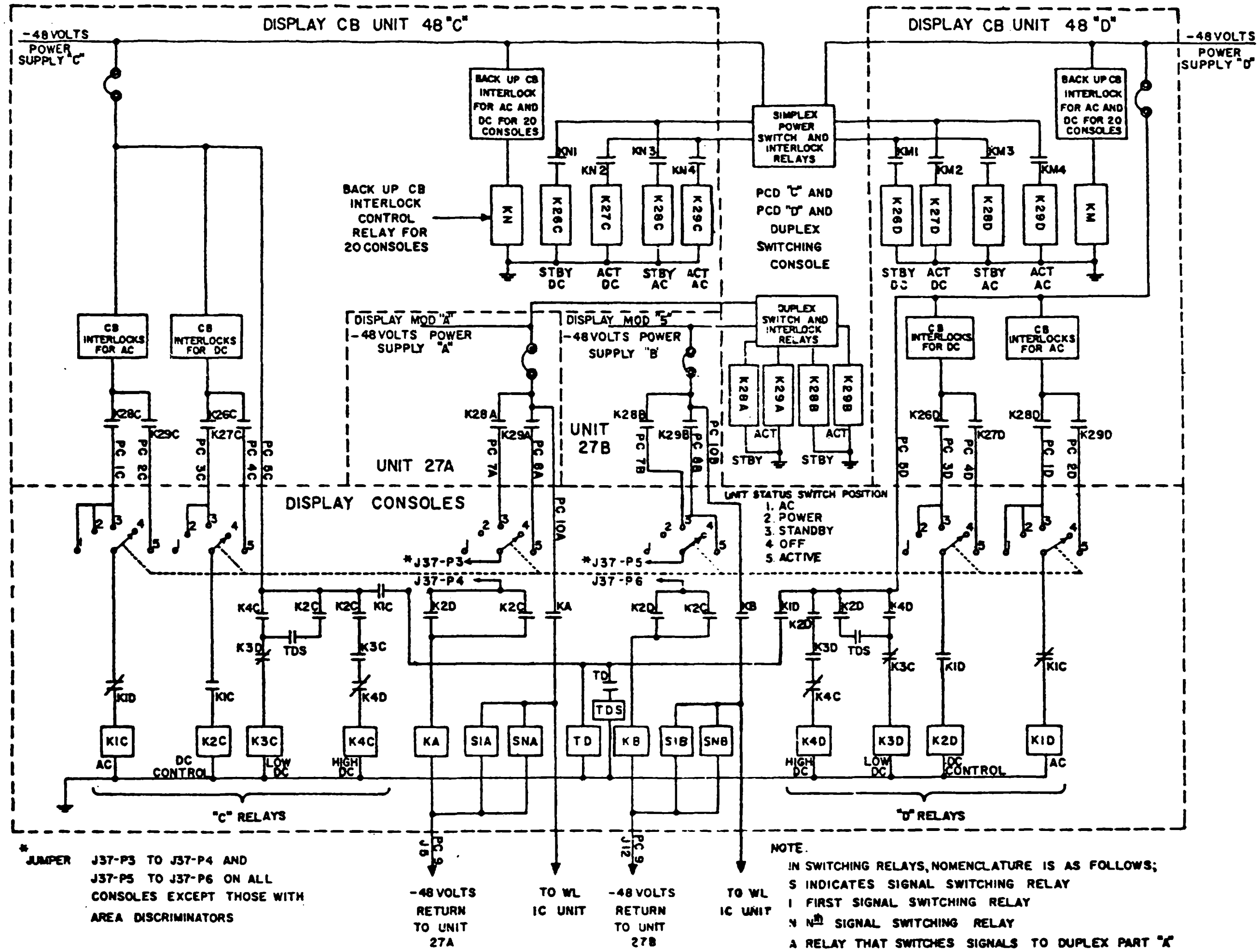
e. All backup and distribution CB's supplying power to a console must be closed before all power can be applied to that console.

2. Unit Status Switch

a. This switch has 5 positions that will be used to control the signal and power status of the console.

b. The AC position of the switch allows the AC contactor in the standby AC power line to apply power to the filaments. No DC power or signals will be connected to the circuits in the console.

c. The POWER position causes power (both AC and DC) to be applied to the loads in the console from the standby simplex power system.



* JUMPER J37-P3 TO J37-P4 AND J37-P5 TO J37-P6 ON ALL CONSOLES EXCEPT THOSE WITH AREA DISCRIMINATORS

NOTE.
IN SWITCHING RELAYS, NOMENCLATURE IS AS FOLLOWS;
S INDICATES SIGNAL SWITCHING RELAY
I FIRST SIGNAL SWITCHING RELAY
N N^{th} SIGNAL SWITCHING RELAY
A RELAY THAT SWITCHES SIGNALS TO DUPLEX PART "A"
B RELAY THAT SWITCHES SIGNALS TO DUPLEX' PART "B"

SIMPLEX POWER AND SIGNAL CONSOLE SWITCHING

Figure 7-24

d. The STANDBY position causes power to be applied to the console from the standby simplex power system, and signals to be applied from the standby computer.

e. The OFF position disconnects all power and signals from the loads in the console.

The ACTIVE position of the switch causes power to be applied to the loads in the console from the active simplex power system and signals to be applied from the active computer.

3. Status Control

a. The relays in the console contain the relay number and the system that this relay is used with. K1C, for instance, is used with the C power system. S1A is a signal contactor that connects the signals from the A computer to the loads. Two sets of power contactors are contained in each console so that power may be applied from either of the simplex power systems. Two sets of signal relays are contained in the console to apply signals from either the A or B computers.

b. The K1C relay is an AC contactor. It will be picked if the following conditions are present:

(1) K1D is dropped.

(2) The C supply is active and the unit status switch is in the active position or if the C supply is standby and the unit status switch is in the positions 1, 2, or 3.

(3) The K28C points are closed and if the unit status switch is in positions 1, 2, or 3. The K28C points are closed if all backup CB's are closed for this console and the C power system is standby.

(4) The interlocks are all closed on the AC distribution CB's for this one console.

(5) The -48V distribution CB for this console is closed.

(6) -48V is present in C48.

c. Relay K1C must be closed 45 seconds before the DC voltages are applied to allow the filaments to get hot. The TD relay is a 45 sec. delay pick relay that will delay the closing of the DC contactors. When K1C picks, the K1C points in series with the TD relays will apply -48V to the pick coil through the -48V distribution CB in CB48. The TD relay has very small contacts. They will not carry the large current necessary to pick the large DC contactor relays, but they will not be damaged by the current to pick the TDS relay. This relay has the large contacts required for picking DC contactors. K1C also closes points to pick K2C, which is a DC control relay. The sequence of applying DC after AC is applied is as follows:

(1) K2C picks and the TD relay starts to close.

(2) After 45 sec., the TD points close to pick the TDS relay.

(3) The TDS points are in series with K2C points to pick the low DC contactor.

(4) The low DC contactor has large current carrying points in the +10, -30, and -150 volt lines. This low DC is applied first to provide bias for the tubes before the plate voltages are applied.

(5) The K4C points in parallel with the K2C and TDS points are used when bringing power down on the console to make sure that high DC drops before low DC.

(6) The K3C points closing in series with the K4C relay will apply high DC voltages.

d. When power is applied to the console from the C power system, signals may still be applied from either the A or B computer. Signals will only be applied to the console when the unit status switch is in the active or standby position. The relays that connect the signals from the A computer are labelled S1A to S18A and from the B computer are labelled S1B to S18B. The sequence for applying signals is as follows:

(1) When the DC control relay has picked, the points in series with the KA and KB relays will close.

(2) With the unit status switch in the standby position, the KA relay will pick if the A computer is standby or the DB relay will pick if the B computer is standby.

(3) With the unit status switch in the active position, the KA relay will pick if the A computer is active or the KB relay if the B computer is active.

(4) Before the KA Relay can be picked, the A computer must have power applied to MCD 27 and the -48 V CB in unit 27 for this console must be closed. The active or standby relays in unit 27 must also be closed for this console. These relays will be picked through the K2 relay in the A section of unit 45 when the A computer is active or through the B section of unit 45 when the A computer is standby. The duplex switch and interlock relays will allow the K2 relay in section A or B of unit 45 to be picked if all interlocks are closed. These interlock points are shown in logic 7.1.15.

(5) A jumper between J37 - P3 and J37 - P4 in the console must also be present to pick the KA relay.

e. The different combinations of power and signals to a display console are controlled by the status of the console and the status of the four systems. The following chart lists all of the possible combinations.

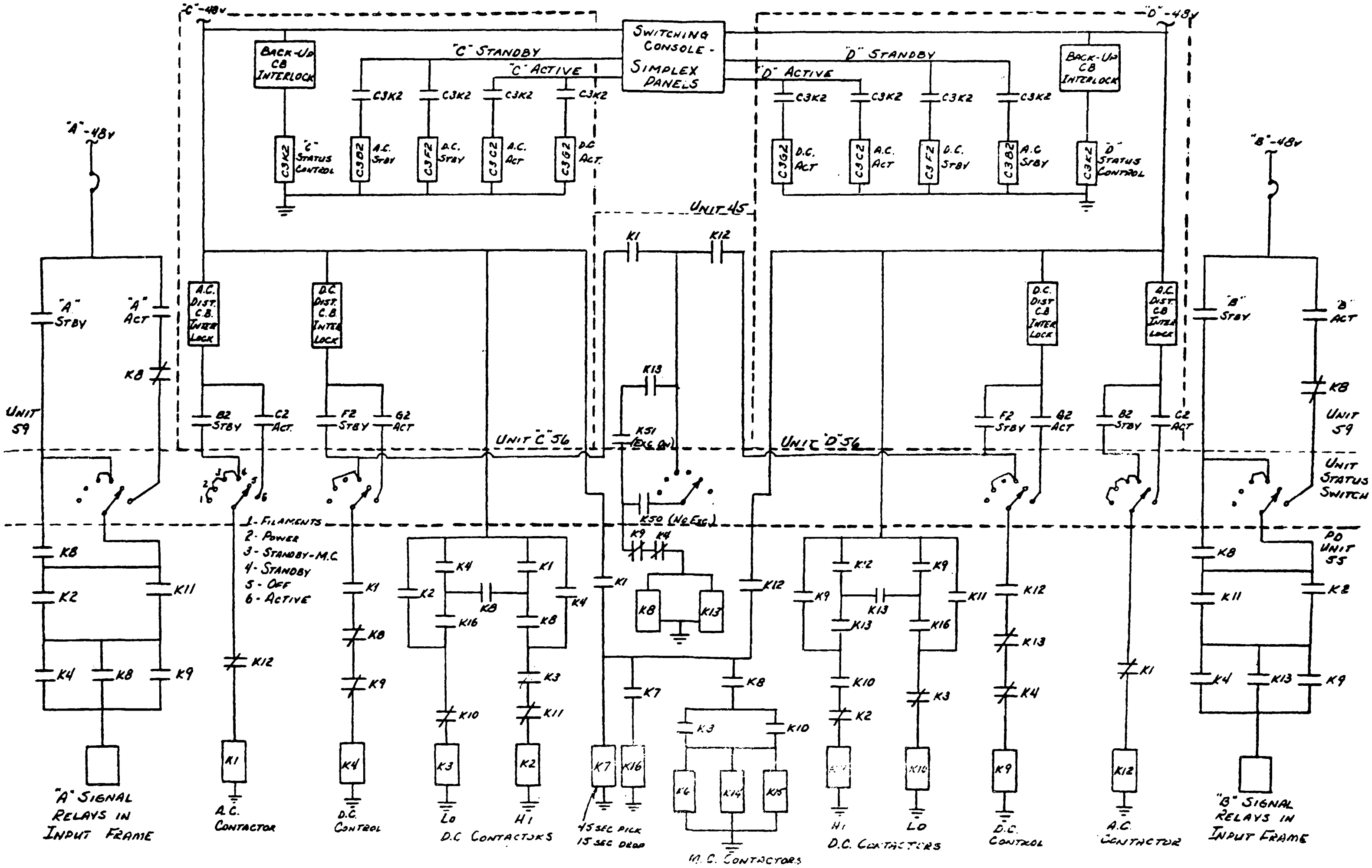
Status of Computers	Status of Simplex Power	unit status switch Status of Console	Signal Source to Console	Simplex Power Source to Console
A Active B Standby	C Active D Standby	Active	A	C
A Active B Standby	C Standby D Active	Active	A	D
A Standby B Active	C Standby D Active	Active	B	D
A Standby B Active	C Active D Standby	Active	B	C
A Active B Standby	C Active D Standby	Standby	B	D
A Active B Standby	C Standby D Active	Standby	B	C
A Standby B Active	C Standby D Active	Standby	A	C
A Standby B Active	C Active D Standby	Standby	A	D
Either Active	C Active D Standby	Power	None	D
Either Active	C Standby D Active	Power	None	C
Either Active	C Active D Standby	AC	None	D (AC only)
Either Active	C Standby D Active	AC	None	C (AC only)

SUMMARY QUESTIONS

1. When computer A is active, a standby console can have power applied to its loads from ____________ simplex power system.

2. One backup CB in unit 48 controls power to ________________ consoles.

3. One DC distribution CB can control all ____________ voltages to a console.



SIMPLEX INPUT SIGNAL AND POWER STATUS

Figure 7-25

4. The backup CB's have interlocks that are in series to control the pick voltage to a ________________________ relay.

5. The DC distribution CB's for one console have interlock points in series to pick the _________ relay in the console.

6. The sequence of applying power to a console is _______ , ________ , and then _______________ in that order.

7. The down sequence of power when a console is turned off is __________ first, then _______ , and then __________ .

8. Signals are applied__________ low DC power.

9. The TD relay points close _________ seconds after power is applied to the pick coil.

10. The ___________ power system supplies the power to pick the A signal relays in a console.

Input Channel Status Switching

1. Introduction

a. Before an attempt is made to learn the status control of input channels, it would be to the students advantage to thoroughly understand the distribution of power to an input channel.

b. This power is applied to bus bars in modules A and B of unit 56. Four backup CB's are connected to each bus bar plus one MC CB to each of the MC voltage buses. The backup CB's supply power to 20 input channels through distribution CB's. One distribution CB will supply one DC voltage or 10 of AC to a channel.

c. Each backup CB has interlock points that are used to pick control relays for 20 input channels.

d. Each distribution CB has interlock points that control the status control lines to the input channel fed by the associated CB.

e. All backup and distribution CB's supplying power to a channel must be closed before all power can be applied to that channel.

f. The power source of an input channel can be either the C or D power system. The switching of this power takes place in the PD unit 55 sliding units.

This sliding unit will be controlled by the unit status switch for the associated channel and the status of duplex equipment. Each input channel has a control panel on unit 47, the simplex maintenance console.

2. Unit Status Switch

Each pluggable panel on the simplex maintenance console associated with a simplex input channel contains a unit status switch for control of power distribution to that channel.

The non-MC voltage lines, MC lines, and signal lines are switched, as listed below, for the six positions of the unit status switch:

a. ACTIVE - The non-MC power lines are connected to the non-MC power bus bars from the active power supply. The MC lines are connected to the non-MC power bus bars from the active power system. The AC power lines are connected to the AC bus bars from the active power system. The signal lines are connected to the active computer.

b. STANDBY - The non-MC power lines are connected to the non-MC power bus bars from the standby power system. The MC power lines are connected to the non-MC power bus bars from the standby power system. The AC power lines are connected to the AC bus bars from the standby power system. The signal lines are connected to the standby computer.

c. STANDBY - MC - The non-MC power lines are connected to the non-MC power bus bars from the standby power system. The MC power lines are connected to the MC bus bars from the standby power system by the MC relays in the simplex MC unit. The AC power lines are connected to the AC bus bars from the standby power system. The signal lines are connected to the standby computer.

d. POWER ON - The non-MC power lines are connected to the non-MC power bus bars from the standby power system. The MC lines are connected to the non-MC bus bars from the standby power system. The AC power lines are connected to the AC bus bars from the standby power system. The signal lines are disconnected.

e. AC ONLY - All DC lines are disconnected. The AC power lines are connected to the AC power bus bars from the standby power system. The signal lines are disconnected.

f. OFF - All power lines and signal lines are disconnected for the associated unit of simplex equipment.

3. Status Control

a. The relays in the PD cell contain the relay number and the purpose of this relay. Two sets of power contactors are contained in each PD cell so that power may be applied from either of the simplex power systems. Two sets of signal relays are contained in the PD cell to apply signals from either the A or B computers.

b. The K1 relay is an AC contactor. It will be picked if the following conditions are present:

(1) K12 is dropped.

(2) The C supply is active and the unit status switch is in the active position or if the C supply is standby and the unit status switch is in position 1, 2, 3, or 4.

(3) If the unit status switch is in the first 4 positions, the AC standby status relay must be picked.

(4) The AC distribution CB's must be closed to close the interlocks to supply the power to pick the relay.

(5) The AC standby status relay will be picked by K2 in the D section of unit 45 through status control relay points.

(6) The status control relay will be picked by closing all of the backup CB's for this PD cell.

c. Relay K1 must close 45 secs. before the DC contactors to allow time for the filaments to get hot before plate voltages are applied. This delay is provided by relay K7. K7 has small relay contacts. The necessary current to pick the large DC contactors would burn out these contacts, so K7 picks K16, which has larger contacts. The sequence for picking the DC contactors is as follows:

(1) When the AC contactor closes, points are closed in the pick path for K7 and K4. K4 will be picked if the status relay points are closed, the DC distribution CB's are closed, and the unit status switch is in position 2, 4, or 6. The K4 relay closes points in the signal relay pick path and in the high and low DC contactors pick paths.

(2) When the 45 sec. delay is over, the K7 relay will pick K16 which will close contacts in the K3 pick path which will cause this relay to pick.

(3) When K3 picks the low DC voltages will be applied to the input channel loads. It will also close point to pick K2.

(4) When K2 picks, the high DC voltages will be applied to the loads in the input channel. K2 also closes points in the signal relay line to close signal contactors from either the A or B computers. Signals can only be applied when the unit status switch is in the standby MC, standby, or active positions.

d. Before margins can be applied to the input channel, the MC contactors must be closed to connect the MC voltages to the MC loads. These contactors will be closed in the following sequence when the unit status for a channel is in the standby MC position.

(1) The DC control relays cannot be picked when applying margins so the DC contactors will be picked by MC control relays K8 and K13.

(2) The K1 relay will pick the TD relay K7 which in turn picks K16. It will also pick the MC control relays through the unit status switch, the K50 points, and normally closed points of K9 and K4. The K50 points will be closed if there is a zero output from the amplidyne, the MC CB's are closed on the standby unit 56, and the MC distribution CB's are closed on unit 58.

(3) K8 will close points to pick K3. It will also close points in the pick lines to K6, K14, K15, K2, K4, and the signal relays.

(4) K3 will apply the low DC and pick K2, K6, K14 and K15.

(5) K2 will apply the high DC and pick the signal relays. It also closes point to K3. This ensures that the high DC drops before low DC.

(6) K13 will close points in series with the K51 points.

(7) K51 will pick when an excursion is applied with the amplidyne. This prevents the MC contactors from opening while margins are applied to these contactors. If the unit status switch is moved from standby MC to standby while margins are applied, the MC control relays will remain picked through the K51 points until the margin is removed.

e. The different combinations of power and signals to an input channel are controlled by the status of the console and the status of the four systems. The following chart lists all of the possible combinations.

Status of Computers	Status of Simplex Power	Status of Channel	Signal Source to Channel	Power Source to Channel
A Active B Standby	C Active D Standby	Active	A	C
A Active B Standby	C Standby D Active	Active	A	D
A Standby B Active	C Standby D Active	Active	B	D
A Standby B Active	C Active D Standby	Active	B	C
A Active B Standby	C Active D Standby	Standby MC or Standby	B	D
A Active B Standby	C Standby D Active	Standby MC or Standby	B	C
A Standby B Active	C Standby D Active	Standby MC or Standby	A	C

Status of Computers	Status of Simplex Power	Status of Channel	Signal Source to Channel	Power Source to Channel
A Standby B Active	C Active D Standby	Standby MC or Standby	A	D
Either Active	C Active D Standby	Power	None	D
Either Active	C Standby D Active	Power	None	C
Either Active	C Active D Standby	AC	None	D (AC only)
Either Active	C Standby D Active	AC	None	C (AC only)

SUMMARY QUESTIONS

1. When computer A is active, a channel can have power applied to its loads from ________________ simplex power system.

2. One backup CB in unit 56 controls power to__________channels.

3. One DC distribution CB can control all __________voltages to a channel.

4. The backup CB's have interlock points that are in series to control the pick voltages to a__________________ relay.

5. The DC distribution CB's for one console have interlock points in series to pick the ____________ relay in the console.

6. The sequence of applying power to a console is________ , _______ , and then ______________ in that order.

7. Signals are applied __________ high DC power.

8. The time delay relay points close ___________ seconds after power is applied to the pick coil.

9. The ______________ power system supplies the power to pick the A signal relays in a PD cell.

MARGINAL CHECKING

Introduction - Part I

1. Need for a Marginal Checking System

a. MIT demonstrated the value of such a system in the following tests:

(1) Statistically a 5,000 tube and a 10,000 diode computer will break down every half hour.

(2) A computer of 50,000 or more tubes can never operate.

(3) MIT constructed test units of 400 tubes.

Performed repetitive operation 24 hrs. a day

Installation of M.C. System increased reliability by 50 to 1.

Machine was checked for 1/2 hr. in every 24 hrs. to remove aging components.

With this treatment, the machine operated without error for three weeks on the average and several times up to 45 days.

2. Definition of Marginal Checking

A means of artificially aging circuits by varying voltages used to detect aging components. Needed to

a. Any variation of the voltage from the normal is called an excursion.

(1) A plus excursion on a grid simulates a tendency towards sensitivity of a circuit.

(2) A minus excursion on the grid of a circuit simulates low conductivity due to age.

(3) Excursions in Flip-Flop circuits simulate an unbalanced condition as would an aging component.

b. The point of voltage variation at which a circuit fails or at which the variation has reached a safe limit is called the margin.

3. Method of Operation

a. Test routines are run through the element to be checked and voltage variations are induced in circuitry in one of three ways.

(1) Manual Mode

Circuit and voltage selections and variations are made from the Maintenance Console.

(2) Calculator Mode (computer operation)

Circuit and voltage selections are coded in an M.C. word and are operated on by the computer.

(3) Satellite mode; selections are made the same way as manual mode except voltage variations are produced by the maint. man via Satellite Control Box (Not Used Extensively)

b. The test routines that are most used in conjunction with the Marginal Checking System are:

(1) Reliability Programs

To determine the overall operation and condition of the equipment.

Mainly used with the Calculator Mode.

Since the computer operates correctly under excursions, it can be relied upon to calculate correctly for a predetermined period in the future.

(2) Diagnostic Programs

Generally used after a reliability program has discovered a low margin or failure.

Are more capable in narrowing down the area of malfunction or in actually locating the trouble.

4. Procurement of Marginal Checking Data

a. Life Expectancy curves on all selections are continuously being improved and revised by information derived from the Prototype Machines and the sites in operation. Results from these tests are used for the establishment of Prescribed Margins.

(1) A Prescribed Margin is the point at which, if the circuit does not fail, it is considered good. Note that a Prescribed Margin is not fixed. It depends on the type of test being run.

5. Marginal Checking Systems

a. These are three separate M.C. Systems

Duplex "A"

Duplex "B"

Simplex

b. Duplex "A" and "B"

(1) Both of these two systems are identical and as a result what is said of one is applicable to the other.

(2) Duplex Systems feed their corresponding computers.

c. Simplex System

(1) The theory of this section of the system is the same as that for the other portions, except for its operation in the Calculator Mode.

(2) In the Calculator Mode of operation, the Simplex System must be set into motion through the standby computer's Marginal Checking System.

6. Power Distribution

a. Normal power flow to Non-M.C. Loads

b. Normal power flow to M.C. Loads

c. Power flow to M.C. Loads during M.C. Operation

(1) Discuss the Marginal Check Relay

Make before break points to prevent arching and to accomplish a smooth change-over in origin of operating voltage.

Points are able to carry the current load but not able to break it.

Circuitry is designed to allow the operation of the Marginal Checking Relay only when there is less than one volt difference between the N/O points and the N/C points.

d. Power Flow Diagram (Duplex Power Distribution) (See Figure 7-26)

7. Description of the Marginal Checking Control Panel on the Duplex Maintenance Console

a. Selection Pushbuttons and Switches

(1) Equipment Group Pushbuttons

Eight in number, one for each logical physical breakdown of the system.

MC-1	Core Memory
MC-2	Arithmetic Units
MC-3	Program Element
MC-4	Selection Control Element
MC-5	Drums

DUPLEX POWER DISTRIBUTION

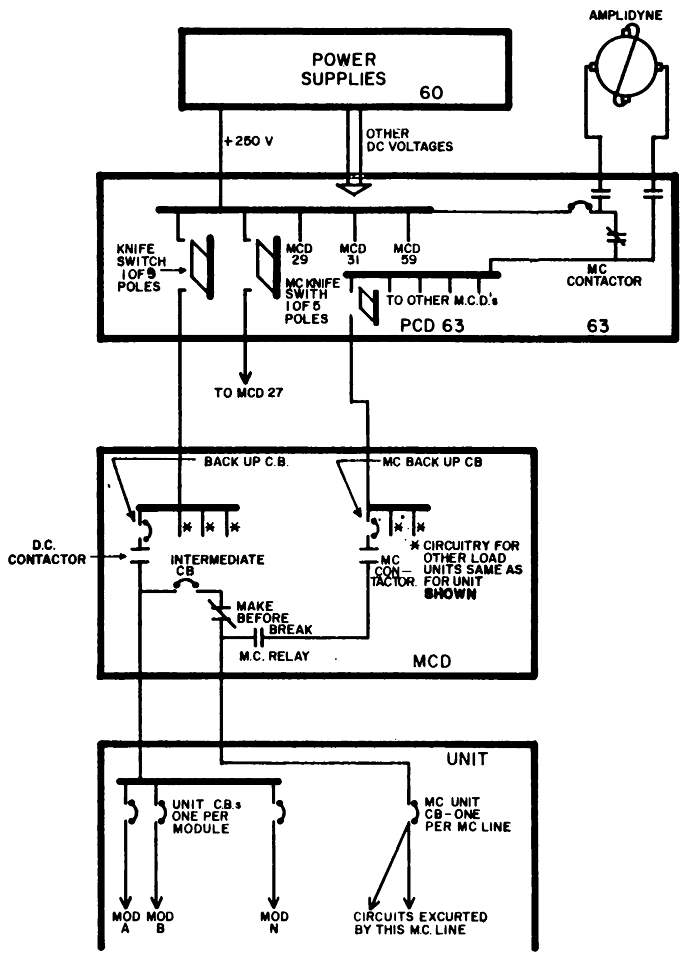
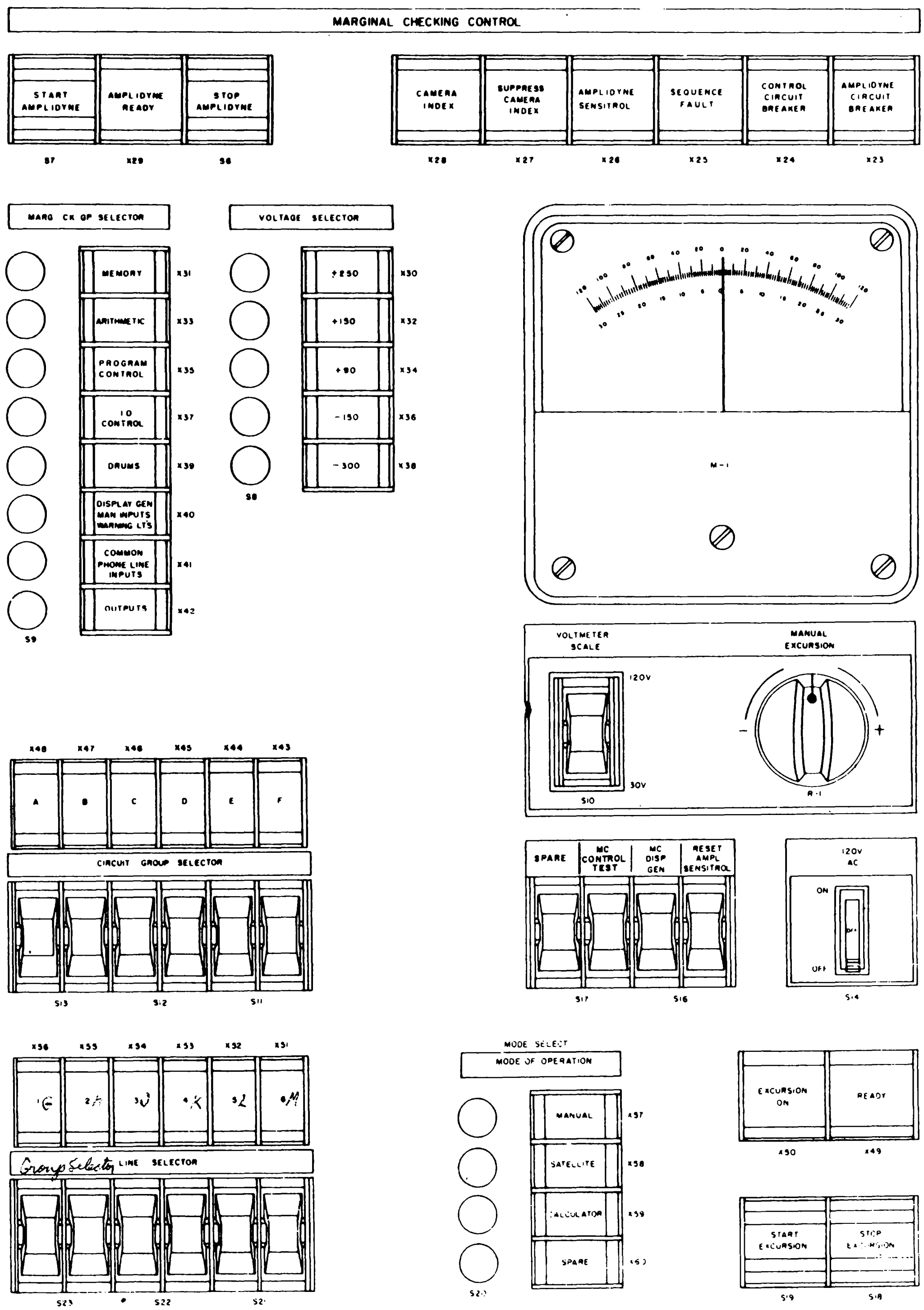


Figure 7-26



Simplex in red

Figure 7-27. Module "H" Duplex Maintenance Console

Mod "J" Simplex " "

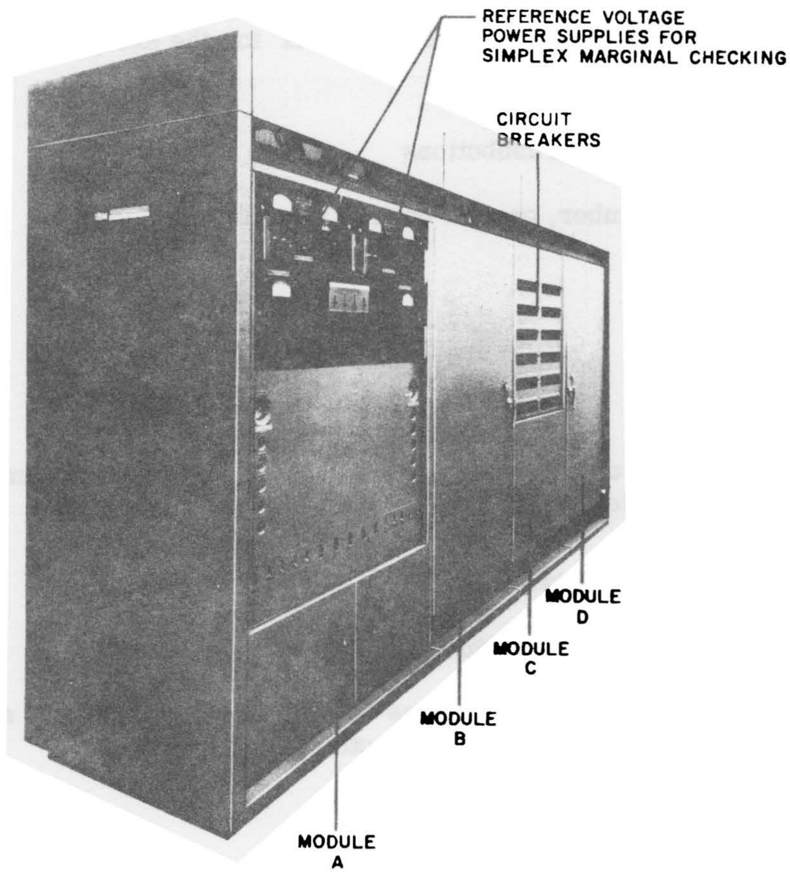


Figure 7-28. Simplex MC Unit 58

MC-6 Display element, manual inputs, etc.
MC-7 Input Common Equipment
MC-8 Output Equipment

Only one of the above can be selected at any one time because of mechanical and electrical interlocks.

It should be noted that the first four of these selections are concerned with the computer per section and will be controlled by MCD 19. The other selections will be controlled by their individual MCD but for the exception of auxiliary drums. This will be explained later.

(2) Voltage Group Pushbuttons

Five in number, one for each of the following:

+250 volts
+150 volts
+ 90 volts
-150 volts
-300 volts

Only one of the above can be selected at any one time because of mechanical and electrical interlocks.

(3) Circuit Group Switches

Total of 6 switches which are lettered A through F.

Any combination of these switches can be made at any time. If no switches are depressed, all selections will automatically be made.

(4) Line Group Switches

Total of 6 switches numbered 1 through 6.

Any combination of these switches can be made at any time. If no switches are depressed, all selections will automatically be made.

(5) Combination of Switches

The maximum number of selections that can be made at any one time is 36. This is because there can only be:

One Equipment Group Selection
One voltage group selection
Six Circuit group selections (12 circuit groups in simplex)
Six line group selections No Line Groups

(6) Circuit Capabilities

There is a total possible operation of 1440 selections. In use at the present time there are approximately 1000.

Introduction - Part 2

1. Marginal Checking Definitions

The following terms are pertinent to the Marginal Checking System:

a. Amplidyne - An electromechanical amplifier whose output is a variable voltage that is inserted in series with an MC service voltage to produce an MC test voltage.

b. Circuit Group - All those circuits which have approximately the same safe limit for one specific MC voltage.

c. Equipment Group - The largest amount of equipment which is combined for MC purposes; also called MC group. The 9 equipment groups are:

(1) MC1 - Memory

(2) MC2 - Arithmetic

(3) MC3 - Program and Instruction Control

(4) MC4 - IO Selection control

(5) MC5 - Drums

(6) MC6 - Displays, manual inputs and warning lights

(7) MC7 - Common phone-line input, duplex portion

(8) MC8 - Outputs

(9) MC9 - Simplex equipment

d. Excursion - the range through which the service voltage is varied during an MC operation; the voltage variation itself.

e. Line Group - A group of circuits which usually have the same logical functions.

f. Margin - The amount of voltage variation introduced into a circuit before circuit failure occurs.

g. MC Service Voltage - One of the five DC service voltages used for MC purposes.

h. MC Test Voltage - The algebraic sum of the MC service voltage and the excursion.

i. Prescribed Margin - The margin at which, if a circuit does not fail, it is assumed to be capable of reliable operation until the next test period.

j. Safe Limit - An excursion which, if exceeded, could result in damage to circuits and components.

k. Voltage Group - All of those circuits which are serviced by a particular MC service voltage.

2. Philosophy

Marginal checking is a preventive maintenance procedure used to increase the reliability of AN/FSQ-7 and -8 equipment. A computer containing 5,000 tubes and 10,000 diodes can be expected to fail every 1/2 hour after the circuit elements are initially aged. Since the number of diodes and tubes in AN/FSQ-7 and -8 equipment exceeds these quantities, computer failure can be expected more frequently than every 1/2 hour. The Marginal Checking System is incorporated to increase the useful operating time of the equipment by determining the components which are likely to fail between scheduled maintenance periods. In addition to determining the reliability of the equipment, the Marginal Checking System also aids maintenance personnel in diagnosing and locating troubles.

Marginal checking is usually controlled by a program. The program directs the computer to perform the normal computer operations of addition, subtraction, etc., while the program varies certain circuit parameters about their normal values. In this way, the computer is made to perform normal functions under adverse operating conditions.

3. Methods of Marginal Checking

Marginal checking is a method of preventive maintenance in which certain operating conditions are varied about their normal values in order to detect components which are deteriorating. These deteriorating components can then be replaced before they fail and cause computer errors. Since components values normally change with age, the variations that can be introduced before component (or circuit) failure occurs becomes less as the components age. The amount of variation from the nominal value that can be introduced before circuit failure occurs is called the margin of reliability of that circuit.

There are three variations which could be introduced into a circuit:

a. Variation of vacuum-tube filament voltages.

b. Variation of circuit component values.

c. Variation of circuit DC service voltages.

Each of these methods is discussed below.

4. Variation of Filament Voltages

If the filament voltage of a tube were periodically varied, it would be possible to simulate a condition in which a low cathode emission would cause failure. Anticipation of this condition would make it possible to replace the tube before failure occurs.

Low cathode emission could be simulated by periodically decreasing the voltage on the filament from its nominal operating value to a value at which useful emission failed. Each time the filament voltage was decreased, the difference between the nominal operating voltage and the failure point would be noted. Over a period of time, this difference, or margin, would become smaller.

Eventually, a point would be reached where this difference was so small that emission failure could reasonably be expected before the next periodic check. The tube would be replaced at that time in order to prevent tube failure from occurring during computer operating time. This failure-anticipation and prevention would improve computer reliability and minimize the computer down-time.

However, this method of marginal checking is not used, except in some display-console tubes, because it is limited to the anticipation and prevention of those computer failures caused only by tube failures. A more comprehensive method is necessary to detect imminent failures caused by failures of components other than vacuum tubes.

5. Variation of Component Values

Failure of components other than vacuum tubes could be anticipated by a periodic artificial aging of the components. Artificial aging could be accomplished by introducing components with different values into the circuit to determine the effects of such a change. By periodically noting the amount of change necessary to cause circuit failure, and by determining how much normal component aging would produce such a change, a time could be established at which the component must be replaced to prevent circuit failure before the next scheduled test.

To introduce changes to component values, it would be necessary to connect variable components to the normal circuit for testing purposes. Because of the large quantity of circuit components used in AN/FSQ-7 and -8 equipment, this method of marginal checking would be impractical. Therefore, it is not used.

6. Variation of DC Service Voltage

Another method of marginal checking (that used in AN/FSQ-7 and -8 equipment) is to vary the service voltage on the circuit. Since the circuit components change in value with age, the amount that a circuit's service voltage may be varied before circuit failure occurs will also change. The amount of voltage variations that can be introduced before the circuit fails is called the margin of the voltage on the circuit. As the components age, the margin decreases. When the circuit fails at normal operating voltage, the margin is zero. However, if the margin is regularly checked and its gradual decrease is noted, the time of circuit failure can be anticipated. The components which would cause the anticipated failure can then be replaced to prevent the circuit from failing during normal equipment operation.

This method of marginal checking provides a practical test method applicable to all equipment components. For this reason, it is the method of marginal checking used in AN/FSQ-7 and -8 equipment.

7. Marginal Checking Techniques

The actual circuit to be marginally checked is selected on the basis of an equipment breakdown. The MC procedure must simulate a normal circuit operation so that the MC test may be performed under dynamic circuit conditions.

The figure represents a typical circuit selected for marginal checking. The operation of this circuit is such that successive pulses place a "1" in FF 2, transfer it to FF 4, and then clear both flipflops.

During the MC operation, an excursion is applied to the MC voltage lines of FF2. Assume that at some excursion value, the computer senses that a "1" was not transferred to FF4.

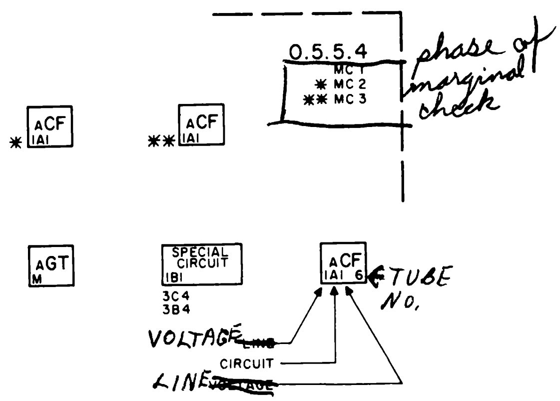
The excursion is stopped and the margin is noted. A first analysis might indicate that FF2 has deteriorated enough to cause circuit failure when the excursion was applied. A further analysis would indicate that the defect may not be in FF2. It is possible that gate tube (GT) 1 is delivering a pulse with an amplitude which is so small that a slight change in the voltage applied to FF2 causes the circuit to fail. It is also possible that GT 3 has aged to the point where the output of FF2 must be normal in order for GT 3 to pass the pulse.

By using this type of analysis, maintenance personnel can determine the overall operating condition of the various elements of the equipment. By using marginal checking, maintenance personnel can determine whether failures may be expected within a given time, or whether a particular portion of the equipment has deteriorated to the extent that components must be replaced to prevent system failure.

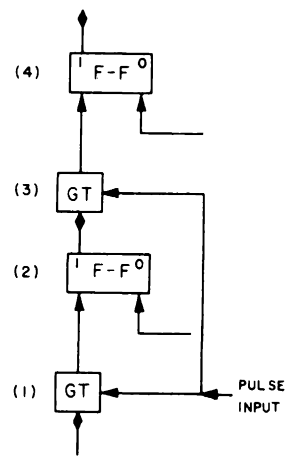
8. Determining Circuit Reliability

When a circuit is designed, an initial prescribed margin, based on line voltage and safe limits, is assigned. During MC tests, the prescribed margin is applied to the circuit. If the circuit functions properly with the prescribed margin applied, the circuit is assumed to be capable of reliable operation until the next scheduled test.

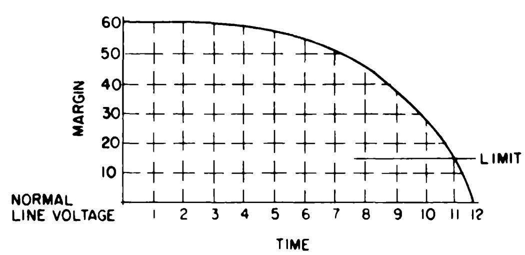
To determine the voltage at which the circuit will fail, increasing excursions are applied until the circuits fail. The results of this test are plotted to establish a life curve (margin at failure versus circuit operating time). A new prescribed margin is now established on the premise that the circuit will fail before the next test period if the present margin is equal to or less than a certain value. The circuit being tested must be replaced before the margin reaches its prescribed limit. For example, if a reliability test shows that the margin is 25V, it is apparent from the life curve that



MC Selection on Logic Diagrams



MC Selected Circuit



Typical Life Curve

Figure 7-29

the margin will drop below the allowable limit before the next reliability test is performed. At this point, the circuit is replaced to prevent circuit failure during the computer operation.

A useful curve is one that allows the margin limit to be approached gradually during each successive testing period. Certain circuits do not have useful curves because they deteriorate gradually but fail suddenly. Other circuits operate for long periods with practically no change in margin, and then the margin drops sharply in a short period of time. Since, in these latter circuits, no appreciable decrease takes place, it is difficult to determine when the circuit should be replaced. The circuits for which life curves cannot be established represent only a small percentage of the circuits in the AN/FSQ-7 and -8 equipment. Most circuits in the equipment have life curves which allow relatively accurate determination of the time at which the circuit must be replaced to prevent failure during computer operating time.

9. MC Equipment Groups

The MC equipment groups are based on the physical location and function of the equipment.

Only one of the first eight groups is marginally checked by the duplex MC equipment. The ninth group is marginally checked by the simplex MC equipment. This group may be selected and tested simultaneously with one of the eight duplex MC groups.

10. Voltage Groups

The +250, +150, +90, -150, and -300 volt potentials in both duplex and simplex equipment may be varied for marginal checking. Only one of these voltages may be varied at one time because only one amplidyne (variable voltage source) is available in each MC system.

The combination of an equipment group and a single voltage represents the largest amount of equipment that can be tested at one time, and this combination is further broken down into circuit groups and line groups.

11. Circuit Groups

A voltage group is divided into circuit groups on the basis of circuit type and application. Each voltage group is divided into six circuit groups in simplex equipment. Any number of circuit groups may be selected simultaneously.

When a circuit group is selected, only the circuits serviced by the selected MV voltage within the selected MC equipment group will be marginally checked. This selection isolates equipment faults to a relatively small area.

12. Duplex Line Groups

In duplex equipment, circuit groups are further divided into line groups. This breakdown is made to distinguish various parts of a circuit group. Each circuit group is divided into six line groups, any of which may be selected at one time.

The amount of simplex equipment does not warrant a line-group breakdown. In place of a line-group breakdown, simplex equipment is provided with UNIT STATUS switches.

13. Simplex Unit Status Switches

The circuit groups of the simplex equipment may be subdivided by the UNIT STATUS switches on the simplex maintenance console. Only those channels whose UNIT STATUS switches are in the STANDBY-MC position are connected to the simplex MC system. Any number of UNIT STATUS switches may be placed in the STANDBY-MC position simultaneously.

14. Calculator Mode

During calculator-mode operations, the MC system is controlled automatically by programmed instructions from the computer. The speed of the calculator mode makes it the most advantageous type of control for routine testing. The slower-speed manual and satellite modes are used to investigate specific circuits found to be faulty during calculator-controlled tests.

When MC operations are controlled by the computer, only the following maintenance console controls remain effective on the MC control panel.

a. STOP EXCURSION

b. STOP AMPLIDYNE

c. MODE SELECTOR

d. MC CONTROL TEST

For calculator control of the simplex MC system, a duplicate set of calculator control lines connects the duplex PCD unit to the simplex MC system. A relay interlock controlled by the duplex switch on the duplex switching console permits only the lines from the PCD unit of the standby computer to be connected to the simplex MC system.

It is possible to have calculator-controlled excursions on both the duplex and the simplex MC systems simultaneously. However, the simplex excursions must be applied first. If the duplex excursion is applied first, initiating a simplex excursion will stop the duplex excursion.

15. Manual Mode

In the manual mode of control, the equipment to be tested is selected by means of pushbuttons and toggle switches on the MC control panel of the maintenance console. The voltage excursion is controlled by a potentiometer on the MC control panel of the maintenance console, and observed on a voltmeter at the same location. During this mode, all controls and pushbuttons on the MC control panel are operative.

16. Logic Diagrams

Marginal checking information is included on the logic diagrams of the equipment that is marginally checked. Some of this information is included in the block representation of the circuit being checked. The OR circuits, AND circuits, and other occasional circuits which are not marginally checked are the only circuit blocks which do not contain MC information.

The MC information appearing on the logic diagram indicates the MC selection for that particular circuit with respect to the parameters of a complete MC selection. The four parameters of a complete duplex MC selection are: equipment group, voltage group, circuit group, and the line group. The three parameters of a complete simplex MC selection are: equipment group, voltage group, and circuit group.

The equipment group is indicated beneath the logic number in the upper right-hand corner of the block diagram. The equipment group is designated by the letters MC followed by a number. Asterisks are used to designate more than one equipment group for a logic diagram.

The voltage group is indicated by the left-hand numbers inside the circuit block. The voltage and the identifying voltage-group numbers are as follows: (1) +250V, (2) +150V, (3) +90V, (4) -150V, and (5) -300V.

The circuit group is indicated by the letter in the circuit block. The circuit groups for duplex equipment are designated by the letters A through F. The circuit groups for simplex equipment are designated by the letters A through M, excluding I.

The line group is indicated by the right-hand number in the circuit block. No line group selection is indicated for simplex equipment. The letter S between the voltage-group number and the circuit-group letter indicates simplex equipment.

Circuits which may be tested by more than one selection are represented as shown by the special circuit block. The selection having the most positive voltage appears inside the block; the most negative voltage appears in the lowest position outside the block. An indirectly checked circuit is represented by the letter M, as shown in the AGT circuit block.

SUMMARY QUESTIONS

1. The device used to vary the voltage to an MC load is an __________ .

2. All of the circuits which have about the same safe limits for one MC voltage make up a __________ group.

3. Drums make up one __________ group.

4. A circuit is assumed to be good if it does not fail at ________________ .

5. Filaments voltages are varied for marginal checking in ____________________.

Amplidyne

1. Introduction

a. Physical Description

Amplidyne is a DC Generator with the normal output brushes shorted.

This short circuit causes a large current to flow through the shorted winding and thus a secondary field is built up 90 degrees out of phase with the primary field.

Adding a second set of brushes 90 degrees from the original set will now allow us to pick up output due to the shorted winding.

Polarity of the input to the primary field will determine the polarity of the output at the secondary brushes.

The output of the amplidyne is controlled by a very small amount of input voltage on the field winding due to the amplification effect in the amplidyne.

b. Advantage of the Amplidyne

When inserted in a voltage line, it has a very low resistance, less than one ohm.

Response to a reference voltage is extremely fast. The rise time plus the settling down time allowable in the AN/FSQ-7 system is 150 ms.

The Amplidyne can be controlled with a minimum of circuitry and power.

When inserted in the circuitry it will compensate for any loss within itself.

Marginal Checking Programming

1. Introduction

The Marginal Checking System is controlled automatically by the Central Computer during calculator-mode operations. The Central Computer is controlled by a program which instructs the computer to perform certain functions. Pertinent operating and sensing instructions and a typical control word and MC program are discussed in the following paragraphs.

2. Basic MC Program

01	CAD	Marginal check word
02	FST	377760 (Live Test register)
03	PER21	00000 operate mc word
04	HLT	00000

a. Instruction 01 will take the MC word and place it in the accumulator.

b. Instruction 02 will place the MC word in the live test register where it will be transferred to relays in the MC system via Thyratrons located in the Left and Right Arithmetic Units.

c. Instruction 03 will cause the Thyratrons that are conditioned to fire and in combination with the Left Sign bit will cause either a Start or Change Excursion to occur.

d. Instruction 04 is necessary to allow time for the cams to rotate and then let the coded restarts indicate the next operation to take place with the computer.

3. MC Program Instructions

Six program instructions are especially applicable to the calculator mode of marginal checking. Three of these instructions are in the operate class, two are in the sense class, and one is the Halt (HLT) instruction. The operate instructions start and stop the MC process. The Sense instructions interrogate the MC FF in the Central Computer to determine the status of the MC system.

Before a control word in the test register can be recognized and interpreted by the MC control system, the appropriate Operate instruction must be given by the program.

a. Per 21 Start Excursion Instruction

(1) Per 21 and Left sign a "1" will cause a Start New Excursion in either the Duplex or Simplex equipment depending on the Group selection.

(2) Per 21 and Left sign an "0" will cause a Change Excursion in either the Duplex or Simplex equipment depending on the Group selection.

(3) This instruction must be programmed after the test register is loaded with an MC control word. In the MC system, the PER 21 instruction removes the selections of the previous excursions and provides for restoring the computer program in the mode designated by bits L1-L2 of the control word after an excursion has been applied. In the Central Computer, the PER 21 instruction causes the information held in the test register FF's to be gated into the thyratron register. In this way, the control word is stored in the calculator-MC-control relays. The instruction also resets all control flip-flops (FF's) in the Central Computer, resets all FF's in the manual data input element, and fires a thyratron which energizes a start-excursion relay.

b. Per 22 Stop Duplex MC Excursion Instruction.

Per 22 is used to stop a Duplex MC Excursion.

The PER 22 instruction provides a control-clear pulse to reset the control FF's in the Central Computer and to reset all FF's in the manual data input element. In the MC system, the instruction provides for restarting the computer in the mode indicated by bits L3-L4 after the excursion is removed.

c. Per 23 Stop Simplex MC Excursion Instruction.

Per 23 is used to stop a Simplex MC Excursion only and usually is followed by a HLT instruction.

This instruction (PER 23) operates in the simplex system in the same manner as a PER 22 instruction functions in the duplex system.

d. BSN 20 Sense Duplex MC Excursion On Instruction

This instruction interrogates the duplex MC FF to determine whether an excursion has been applied to the duplex MC system. The test branch of the program will be executed if the FF is set (excursion on) at the time of interrogation. The sensing process will not affect the condition of the FF.

e. BSN 27 Sense Simplex MC Excursion On Instruction

This instruction interrogates the simplex MC FF and operates in the same manner as the BSN 20 instruction.

The MC FF in either system is used in calculator mode. Manual-mode operations do not affect the normally-cleared FF.

f. Halt (HLT) Instruction

This instruction causes the Central Computer to stop executing instructions. Any operation in progress, at the time the HLT instruction is given is decoded and completed, then the computer will halt. When the computer is halted by this instruction, the program counter contains the address of the instruction immediately following so that restarting the computer by depressing the CONTINUE pushbutton will cause the instruction immediately following the HLT to be executed.

A marginal check control word MC-restart operation will not return control to the instruction following the HLT, but rather to test memory, core memory, load from card reader, or load from AM drums.

g. Change Excursion LS-O

(1) A normal Start Excursion must have first preceded this operation since Per 21 with L sign an "0" will only affect bits L1, L2, L7, L9, L10, L11, L12. Thus it has no effect on the selection only on the restart, polarity, and voltage magnitude and Bits L3-L4-L5 and L6 under certain conditions.

(2) Change Excursions cause the rotation of cam unit 2 only.

(3) The Change Excursion must be given before the existing selection is stopped either by a Per 22, Per 23, or the time duration set up in the start excursion word.

h. Stop Excursion

(1) Two programming methods of stopping an excursion exist. The first is the already discussed Per 22 or Per 23. The second method is the time duration coding.

(2) Either method will cause both cam units to rotate and give the restarts specified by the left 3 and 4 bits.

i. Restarts

(1) There are two restart locations specified in the MC word.

(a) Restart after start excursion

(b) Restart after stop excursion

(2) The Restart after Start Excursion will be the place or location where the computer will begin from after a Per 21 and a New or Change Excursion word. The coding for this restart is located in the Left 1 and 2 bits of the Marginal Check word.

(3) The Restart after Stop Excursion will be the place or location where the computer will begin from after a Per 22, Per 23 or when the time duration specified in the MC word has expired. The coding for this restart is located in the Left 3 and 4 bits of the Marginal Check Word.

(4) Types of Restarts

(a) Continue from 3.77760

This restart will cause the computer to react the same as if the Start from Test Memory pushbutton on the Maintenance Console were depressed.

(b) Load from Card Reader

This restart will cause the computer to react the same as if the Load from Card Reader pushbutton on the Maintenance Console were depressed.

The program initiated by this restart is as follows:

```
LDC      00000
SEL 01   00000
RDS      00030
BPX      00000
```

(c) Load from AMA-1 Drum

This restart will cause the computer to react the same as if the Load from AM Drums pushbutton on the Maintenance Console were depressed. The program initiated by this restart is as follows:

LDC	0.00000
SDR 02	0.00000
RDS	0.00030
BPX	0.00000

(d) Continue from Core Memory Location 0.00000

This restart will cause the computer to react the same as if the Continue pushbutton on the Maintenance Console were depressed since just prior to the receipt of the continue pulse, a Reset Flip-Flops pulse will be generated by the MC system.

j. Reset Flip-Flops Pulse

(1) This pulse is identical to the pulse generated by the Reset Flip-Flops pushbutton on the Maintenance Console.

(2) The timing between any of the Restarts and the Reset Flip-Flops pulse is very critical and is further complicated by a pulse that will set an indicating Flip-Flop.

4. MC Control Word

The MC control word is a 32-bit word with specific control functions assigned to groups of bits within the word. The functions assigned to the groups of bits are given. Each bit of the MC word is associated with an FF in the test register. Each FF, in turn, conditions a thyratron relay driver (RYD) which is operated by a Stop-Excursion or Start-Excursion instruction. Each group of bits within the MC word controls a different MC selection or operation. The MC control relays actuated by the MC word are the same relays actuated by controls on the maintenance console during manual control.

An MC word may start an excursion sequence (start-excursion word) or make changes in an already applied excursion (change-excursion word). The left sign (LS) bit of the word determines whether the word is a start-or-change excursion word.

a. Start-Excursion Word

If the left-sign bit of the MC word contains a one (LS-1), the MC word is a start-excursion word. A start-excursion word removes any existing selections in the MC system and selects new equipment and excursions. In a start-excursion word all information pertinent to equipment and excursion selections must be specified.

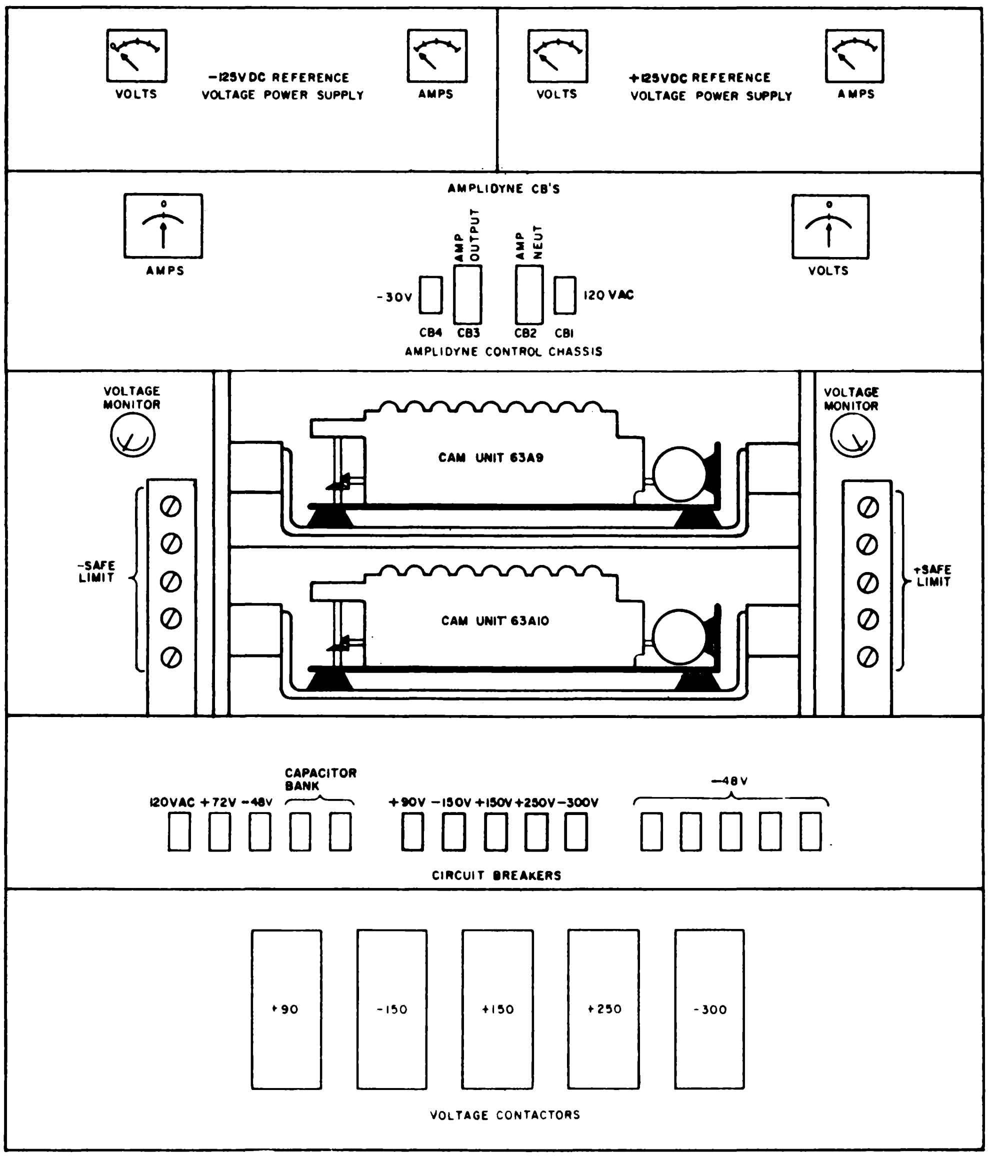


Figure 7-30. Controls and Indications, Module A, PCD Unit 63

b. Change-Excursion Word

If the left-sign bit of the MC word contains a zero (LS-0), the word is a change-excursion word. A change-excursion word alters the magnitude and polarity selections of the existing excursion. The excursion duration is not normally changed, but the excursion-duration timers are reset to zero. A change-excursion word does not provide for equipment selection nor remove previous equipment selections.

In a change-excursion word, the excursion magnitude, polarity, and first restart information must be specified, even if these values are to remain unchanged. Second restart and time duration can be altered due to a logical addition of these bits.

5. Typical MC Program

A typical MC program may be divided into two interwoven routines: the executive routine, and the test routine. The executive routine loads the test routine: sets up the initial test conditions of equipment to be tested, excursion magnitude, and excursion duration; and checks the results of the test routine. The test routine causes the selected circuits to perform normal operations with the excursions voltages applied.

In the typical program, the test routine is loaded into memory from the card reader. The executive routine then reads the MC control word, stores it in the live test register, gives a PER 21 instruction, and halts. The MC system initiates a restart which branches to the BSN 20 instruction stored in memory location 0.00000. Providing an excursion is on (BSN 20 instruction), the test routine is begun and the required tests are made on the selected circuits. If an excursion is not on, the program branches back to the executive routine to obtain an MC word and begin an excursion.

At the end of the tests, the result is fed to the executive routine which determines the success or failure of the test. If the test failed, the excursion is lowered, the error is printed out, and the test is rerun. If the test was successful, it is repeated and the program is continued.

BIT	FUNCTION	BINARY CODE	OPERATION
LS	Start Excursion	1	New Start
LS	Change Excursion	0	Change magnitude, polar and first restart
1 and 2	Restart the computer program after the excursion has been applied Restart #1	01	Continue from 00000
		11	Load from Card Reader
		00	Load from drums
		10	Continue from 3.77760
3 and 4	Restart the computer after the excursion has been removed Restart #2	10	Continue from 3.77760
		11	Load from card reader
		00	Load from drums
		01	Continue from 00000

BIT	FUNCTION	BINARY CODE	OPERATION
5 and 6	Excursion duration	00	Infinite
		01	3 seconds
		10	7 seconds
		11	30 seconds
7	Excursion polarity	0	Positive
		1	Negative
8	Spare		
9 to 12	Excursion Magnitude	0000	0 V
		0001	10 V
		0010	12 V
		0011	14 V
		0100	16 V
		0101	18 V
		0110	20 V
		0111	25 V
		1000	30 V
		1001	35 V
		1010	40 V
		1011	50 V
		1100	60 V
		1101	70 V
		1110	85 V
		1111	100 V
13 to 15	Voltage Group	001	+250 V
		010	+150 V
		011	+ 90 V
		100	-150 V
		101	-300 V
RS to 3	MC Equipment Group	0000	Spare
		0001	MC-1 Memory
		0010	MC-2 Arithmetic
		0011	MC-3 Prog. & Cont.
		0100	MC-4 I/O Control
		0101	MC-5 Drums
		0110	MC-6 Displays
		0111	MC-7 Inputs
		1000	MC-8 Outputs
		1001	MC-9 Simplex

BIT	FUNCTION	BINARY CODE	OPERATION
		1010-1111	Spares
4 to 9	Circuit-group selection	000 000	No selection
		100 000	Circuit A
		010 000	Circuit B
		001 000	Circuit C
		000 100	Circuit D
		000 010	Circuit E
		000 001	Circuit F
10 to 15	Duplex Line-group selection	000 000	No selection
		100 000	Line 1
		010 000	Line 2
		001 000	Line 3
		000 100	Line 4
		000 010	Line 5
		000 001	Line 6
	Simplex circuit group selection (MC-equipment-group 9)	000 000	No selection
		100 000	Circuit G
		010 000	Circuit J
		000 100	Circuit K
		000 010	Circuit L
		000 001	Circuit M

SUMMARY QUESTIONS

1. Margins can be applied with a program when in the__________ mode.
2. An excursion can be started with the______________ instruction.
3. If LS of an MC word is a 1, this is a______________word.
4. A change-excursion word must contain__________ , __________ , and ______ bits.
5. The two routines of an MC program are __________ and ____________.

APPENDIX

AN/FSQ-7 PUBLICATIONS

1. THEORY MANUALS	3-32-0	CENTRAL COMPUTER SYSTEM
	3-42-0	DRUM SYSTEM
	3-52-0	INPUT SYSTEM
	3-62-0	DISPLAY SYSTEM
	3-72-0	OUTPUT SYSTEM
	3-82-0	POWER SUPPLY SYSTEM
	3-92-0	MARGINAL CHECKING SYSTEM
	3-112-0	THEORY OF PROGRAMMING
2. REFERENCE MANUALS	3-3-0	SPECIAL CIRCUITS
	3-4-0	ILLUSTRATED PARTS BREAKDOWN
	3-12-0	INTRODUCTION
	3-13-0	LOGIC INDEX HANDBOOK
	3-22-0	BASIC CIRCUITS
3. SCHEMATICS BOOKS	3-212-0	CENTRAL COMPUTER SYSTEM
	3-222-0	DRUM SYSTEM
	3-232-0	INPUT SYSTEM
	3-242-0	OUTPUT SYSTEM
	3-252-0	DISPLAY SYSTEM
	3-262-0	POWER AND MARGINAL CHECKING
	3-272-0	WARNING LIGHTS SYSTEM
4. PLUGGABLE UNITS BOOK	3-282-0	CONTAINS SCHEMATICS OF ALL PUs
5. MAINTENANCE MANUALS	MI-01	AIR CONDITIONING SYSTEM
	MI-02	CALIBRATION
	MI-03	CARD READER IBM TYPE 713
	MI-04	CARD RECORDER, IBM TYPE 723
	MI-05	CENTRAL COMPUTER AND MAINTENANCE CONSOLE
	MI-06	COMPUTER ENTRY PUNCH
	MI-07	DISPLAY CONSOLES
	MI-08	DISPLAY GENERATOR, MI AND WARNING LIGHTS
	MI-09	DRUM SYSTEM
	MI-10	GAP FILLER INPUTS (OBSOLETE)
	MI-11	LRI AND CROSSTELL SYSTEMS
	MI-12	MC SYSTEM
	MI-13	64 MEMORY
	MI-14	OUTPUT SYSTEM
	MI-15	PRRE
	MI-16	POWER SYSTEM
	MI-17	PRINTER, IBM TYPE 718
	MI-18	CONSOLE COORDINATOR
	MI-19	TAPE POWER SUPPLY SYSTEM

MI-20	TAPE SYSTEM IBM TYPE 728
MI-21	TEST PATTERN GENERATOR
MI-22	256 MEMORY

DIVIDED INTO SECTIONS (ABOVE RED BOOKS)

1. INTRODUCTION
2. PREVENTIVE MAINTENANCE TASKS
3. DIAGNOSTIC TECHNIQUES
4. CHECK PROCEDURES
5. CORRECTIVE PROCEDURES
6. FIELD TECH. INSTRUCTIONS
7. MISCELLANEOUS

ATC Keesler 6-1633

SAVE A LIFE

If you observe an accident involving electrical shock,
DON'T JUST STAND THERE - DO SOMETHING!

RESCUE OF SHOCK VICTIM

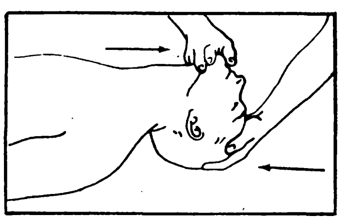
The victim of electrical shock is dependent upon you to give him prompt first aid. Observe these precautions:

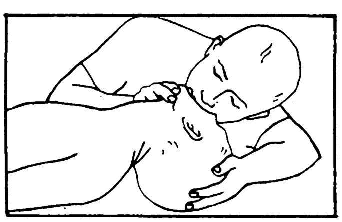
1. Shut off the high voltage.
2. If the high voltage cannot be turned off without delay, free the victim from the live conductor. REMEMBER:
   a. Protect yourself with dry insulating material.
   b. Use a dry board, your belt, dry clothing, or other non-conducting material to free the victim. When possible PUSH - DO NOT PULL the victim free of the high voltage source.
   c. DO NOT touch the victim with your bare hands until the high voltage circuit is broken.

FIRST AID

The two most likely results of electrical shock are: bodily injury from falling, and cessation of breathing. While doctors and pulmotors are being sent for, DO THESE THINGS:

1. Control bleeding by use of pressure or a tourniquet.
2. Begin IMMEDIATELY to use artificial respiration if the victim is not breathing or is breathing poorly:
   a. Turn the victim on his back.
   b. Clean the mouth, nose, and throat. (If they appear clean, start artificial respiration immediately. If foreign matter is present, wipe it away quickly with a cloth or your fingers).





   c. Place the victim's head in the "sword-swallowing" position. (Place the head as far back as possible so that the front of the neck is stretched).
   d. Hold the lower jaw up. (Insert your thumb between the victim's teeth at the midline - pull the lower jaw forcefully outward so that the lower teeth are further forward than the upper teeth. Hold the jaw in this position as long as the victim is unconscious).
   e. Close the victim's nose. (Compress the nose between your thumb and forefinger).
   f. Blow air into the victim's lungs. (Take a deep breath and cover the victim's open mouth with your open mouth, making the contact air-tight. Blow until the chest rises. If the chest does not rise when you blow, improve the position of the victim's air passageway, and blow more forcefully. Blow forcefully into adults, and gently into children.
   g. Let air out of the victim's lungs. (After the chest rises, quickly separate lip contact with the victim allowing him to exhale).
   h. Repeat steps f. and g. at the rate of 12 to 20 times per minute. Continue rhythmically without interruption until the victim starts breathing or is pronounced dead. (A smooth rhythm is desirable, but split-second timing is not essential).

DON'T JUST STAND THERE - DO SOMETHING!