THEORY OF OPERATION

OF

POWER SUPPLY SYSTEM

FOR

AN/FSQ-7
COMBAT DIRECTION CENTRAL
AND
AN/FSQ-8
COMBAT CONTROL CENTRAL

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LIST OF REVISED PAGES

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PART 1
INTRODUCTION
CHAPTER 1
GENERAL

1.1 PURPOSE

This manual contains information that will enable authorized personnel to become familiar with the theory of operation of the Power Supply System of both the AN/FSQ-7 Combat Direction Central and the AN/FSQ-8 Combat Control Central. The information is also intended to provide maintenance personnel with the theoretical knowledge necessary to perform adequate maintenance.

1.2 SCOPE

This manual describes the theory of operation of the system and the components that supply, distribute, control, and regulate power for the computer of a SAGE site. Power supplied to the air-conditioning and lighting systems is not discussed.

1.3 RELATIONSHIP TO OTHER MANUALS

The *Theory of Operation, Power Supply System AN/FSQ-7 and -8, 3-82-0* is one manual in the set of manuals provided to each SAGE site. The set of manuals provides information on the theory of operation and the maintenance techniques and procedures for all computer equipment.

The following manuals provide the basic information necessary for a complete understanding of SAGE equipment (par. 1.4.4):

Basic Theory of Computers, TO-31P2-2FSQ7-2

Introduction to AN/FSQ-7 and AN/FSQ-8, 3-12-0

Basic Circuits for AN/FSQ-7 and AN/FSQ-8, 3-22-0

Additional manuals which contain information on specific systems may be referenced as necessary. When more detailed information is required on a subject, refer to the manual entitled *Contents.* This manual contains a table of contents for the complete set of manuals and will direct the reader to the proper manual within the set.

Thorough analysis of any given circuit requires reference to the appropriate logic diagrams. The logic diagrams for the Power Supply System are contained in the five volumes of *Schematics, Power Supply and Marginal Checking Systems,* 3-262-0.

Sequence charts contained in *Maintenance Techniques and Procedures of Power Supply and Marginal Checking*, 3-192-0, are helpful in determining relay functions and circuit operations.

Operating procedures are contained in *Operating Procedures for AN/FSQ-7,* TO-31P2-2FSQ7-21; *Operating Procedures for AN/FSQ-8,* TO-31P2-2FSQ8-21; *Operating Procedures for Maintenance of AN/FSQ-7,* 3-122-0; and *Operating Procedures for Maintenance of AN/FSQ-8,* 3-122-0. These manuals provide the procedures required to operate and maintain the equipment but do not include tactical operating instructions.

1.4 USE OF REFERENCES

The method by which text material, tables, and illustrations in this manual are referenced, and the method by which other manuals are referenced, are given below.

1.4.1 Paragraphs

1.4.1.1 Within Same Section or Chapter

References to paragraphs in the same section or chapter are preceded by the abbreviation "par." For example, within Chapter 2, reference to paragraph 3.2.5.1 of Chapter 2 appears as: (par. 3.2.5.1).

1.4.1.2 In Different Chapter or Part

References to paragraphs in chapters or parts other than that in which the reference appears are made as mentioned in paragraph 1.4.11, except that the chapter or part is specified. For example, within Chapter 2, reference is made to paragraph 4.2.8.1 of Chapter 3. This reference appears as: (par. 4.2.8.1, Ch 3). If the reference is in a different part of the manual, the part is also mentioned. For example: (par. 4.2.8.1, Part 1, Ch 3).

1.4.2 Figures

Figure references are similar to paragraph references. The part of the book in which the figure appears is identified by the first number of the reference. For example: (fig. 3–8) refers to the eighth figure in Part 3.

1.4.3 Tables

Tables are referenced in the same manner as figures. For example, reference to the third table in Part 4 appears as: (table 4–3).

1.4.4 Other Manuals

Other manuals are referred to by manual number. The manual referenced may be either a military manual, in which case the manual reference is introduced by the letters "T.O." or an IBM manual, in which case the manual reference is introduced by a number only.

The location of a specific subject may be found by consulting the index or table of contents of the referenced manual.

1.4.5 Logic Diagrams

A logic diagram reference is made by placing the logic number in parentheses. For example, reference to logic diagram 5.4.10.1 is made as: (5.4.10.1). Note that the abbreviation "par." is not used when referring to logic diagrams. The reference may be within a sentence, at the end of a sentence, or within a table.

1.5 NOMENCLATURE

Table 1–1 is a list of the names and numbers of the units mentioned in this manual.

1.6 COMPONENT IDENTIFICATION

Component location and type are designated by a coded combination of numerals and letters. Several coding systems are used since the physical construction of the units used in the equipment differs widely. In all coding systems, the numbers which precede the first upper-case letter designate the unit. The upper-case letter designates the module or section. Succeeding numbers and letters indicate the placement and type of the components. For example, typical location designation 64B7A1f indicates unit 64, module B, panel 7, row A, column 1, and terminal f. Relay designation 63C5 (K31)2a indicates unit 63, module C, panel 5, relay K31, relay-contact set 2, and contact a. Component locations and designations may be found in the component index and component location logic diagrams for the unit in which the component is found.

Note

In this manual, relay contacts are designated by the electrical points on either side of the contacts of a single set of relay contacts. For example, electrical points 63C5(K31)2a and 635C(K31)2c appear in the text as "points 2a-2c of relay 63C5(K31) ...."

TABLE 1–1. LIST OF NOMENCLATURE

UNIT NO.	COMMON UNIT NAME
1	Duplex Maintenance Console
2	Left Arithmetic
19	Computer MCD
23	MI
27	MI and Display MCD
29	Drum MCD
31	Output MCD
32	Crosstell
34*	GFI (Gap-Filler Input)
41*	LRI (Long-Range Input)
45	Duplex Switching Console
46	Aux Drum MCD
47	Simplex Maintenance Console
48	Display CB
55	Simplex Input PD
56	Simplex CB
58	Simplex MC
59	Duplex Input MCD
60	Duplex Power Supply
61	Simplex Power Supply
63	Duplex PCD Unit
64	Simplex PCD Unit
92	Test Pattern Generator
94 and 95	Induction Regulators
169*	Display Console
170*	Display Console
251	Projection Unit
252	Projection Unit
750	SD (Situation Display) Console
787*	SD Console
833	SD Console
935	Auxiliary Display Console

**Units present in AN/FSQ-7 equipment only.*

CHAPTER 2
SITE POWER EQUIPMENT

2.1 GENERAL

The site power equipment includes the equipment located in the powerhouse, the load centers and substations, and the Power Supply System. This equipment generates, regulates, and controls the power required by the site (fig. 1–1).

Each SAGE site has about 3,000 kw of power available. About one-third of this power is required for computer operations. The remaining power is needed for air conditioning and lighting. All SAGE sites are self-sufficient. Both AN/FSQ-7 and AN/FSQ-8 sites receive primary power from diesel generators which are maintained by powerhouse maintenance personnel. The power equipment at each site is almost identical. Therefore, a typical site is discussed. Where differences occur between AN/FSQ-7 and AN/FSQ-8 equipment, such differences will be discussed.

In combined AN/FSQ-7 and AN/FSQ-8 sites, each Central is self-contained, but both receive primary power from the same set of diesel generators. There is no provision for cross-connecting the Power Supply Systems; one Power Supply System cannot supply both the AN/FSQ-7 and the AN/FSQ-8 equipment.

2.2 POWERHOUSE

The primary source of power for a SAGE site is diesel generators located in the powerhouse. The high a-c voltage produced by the diesel generators (480Vac) is fed to bus bars for further distribution to the substations, the load centers, the bus duct sequencing device, the air-conditioning system, and the lighting system. The air-conditioning and lighting systems are not discussed in this manual.

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.

The powerhouse equipment is not under the cognizance of computer maintenance personnel. However, close liaison is required between maintenance personnel at the operations building and those at the powerhouse (refer to 3-192-0).

2.3 LOAD CENTERS AND SUBSTATIONS

The two load centers and three substations receive control signals from, and deliver power to, the Power Supply System. The input to the load centers and substations is 480Vac.

2.3.1 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 480Vac to 120Vac (phase-to-neutral) 208Vac (phase-to-phase). This unregulated ac is fed through CB's to the induction regulators, units 94 and 95.

2.3.2 Substations

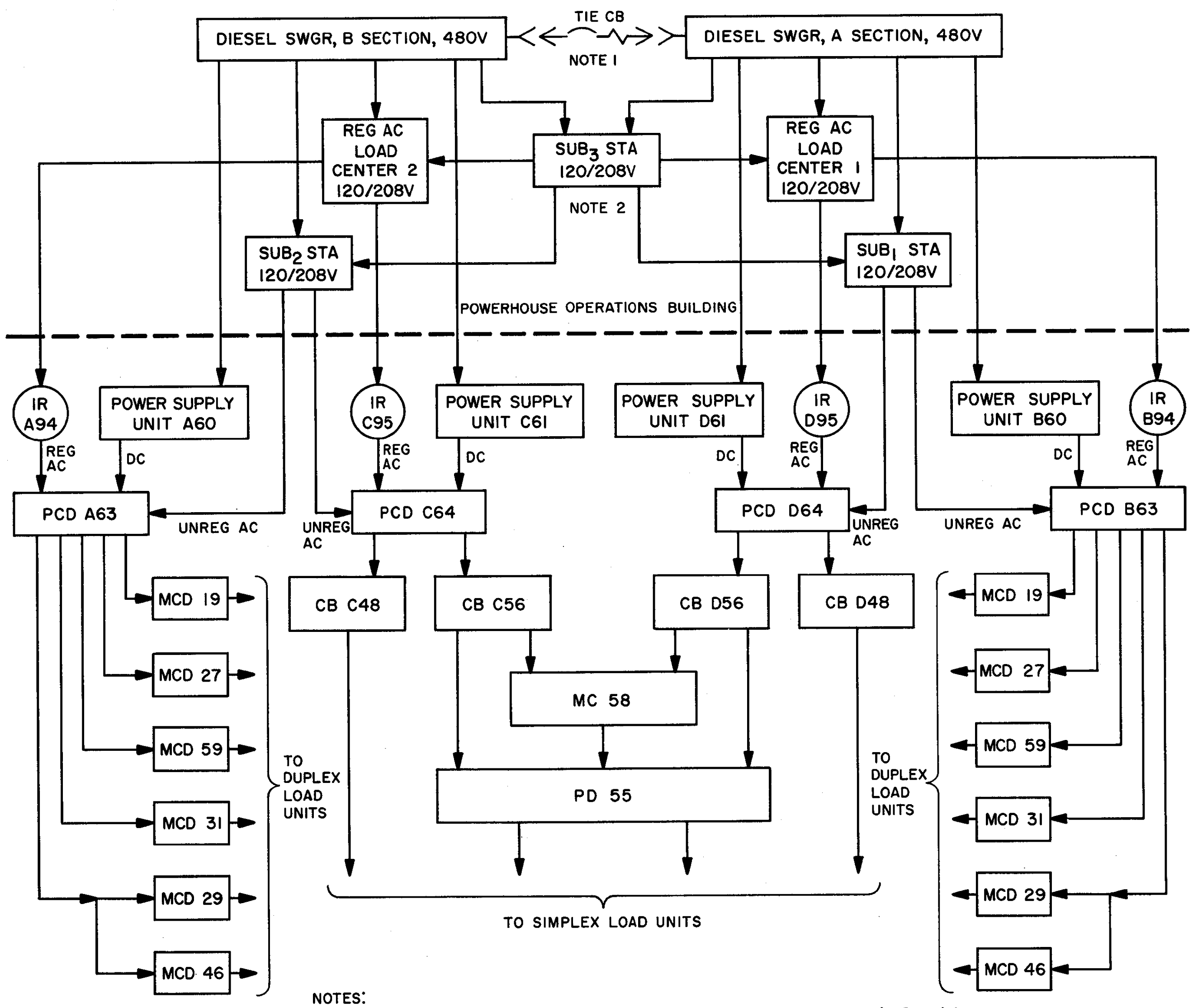
Each of the three substations receive 480Vac from the powerhouse. This voltage is transformed by a 500-kva, delta-wye-connected transformer to 208V unregulated ac and is fed through CB's to the Power Control and distribution (PCD) units. Normally, only two substations are in use. The third is a spare which may replace either another substation or a load center.

2.4 POWER SUPPLY SYSTEM

The power Supply System for the computer load receives 480- and 208Vac. The system regulates ac, produces dc, and controls and distributes all the a-c and d-c power required for the operation of a SAGE computer.

The Power Supply System is composed of the induction regulators, PCD units, marginal checking and distribution (MCD) units, CB units, power distribution (PD) units, and a simplex marginal checking (MC) unit. The units of the Power Supply System are discussed in paragraph 3.3, Chapter 3.

The Power Supply System supplies the power required by the load units of the other systems (fig. 1–1). A load unit may be a single console or a unit composed of several modules. Power is distributed to the load unit through CB's and bus bars and is monitored and controlled by meters, indicators, and switches.



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.

Figure 1–1. Site Power Equipment

CHAPTER 3

POWER SUPPLY SYSTEM

SECTION 1

GENERAL

1.1 INTRODUCTION

The Power Supply System for the SAGE equipment is divided into four independent groups. Power systems A and B supply duplex equipment A and B, respectively. Power Systems C and D supply the simplex equipment (fig. 1–2).

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 induction regulators and d-c power supplies are provided for each system. Switching circuits permit only one duplex and one simplex power system to be in the active status at any given time. The two remaining systems are in the standby status. The status of the simplex and the duplex power systems can be switched independently. Refer to Part 4 for a discussion of the simplex system.

1.2 POWER SOURCES

1.2.1 Unregulated AC

Unregulated high-voltage ac is produced by the diesel generators in the powerhouse (figs. 1–3 and 1–4). Transformers in the substations and load centers reduce this high voltage to 120/208Vac (Sect. 2, Part 3, Ch 2). The output of the transformers is distributed to convenience outlets, test and metering circuits, and the induction regulators.

1.2.2 Regulated AC

The induction regulators regulate the unregulated a-c voltage to 120/208Vac ±1 percent for load-center transformer output-voltage variations of ±10 percent. The output of the induction regulators is distributed to the filament transformers in the load units.

1.2.3 D-C Power

The d-c power supplies convert unregulated 480Vac

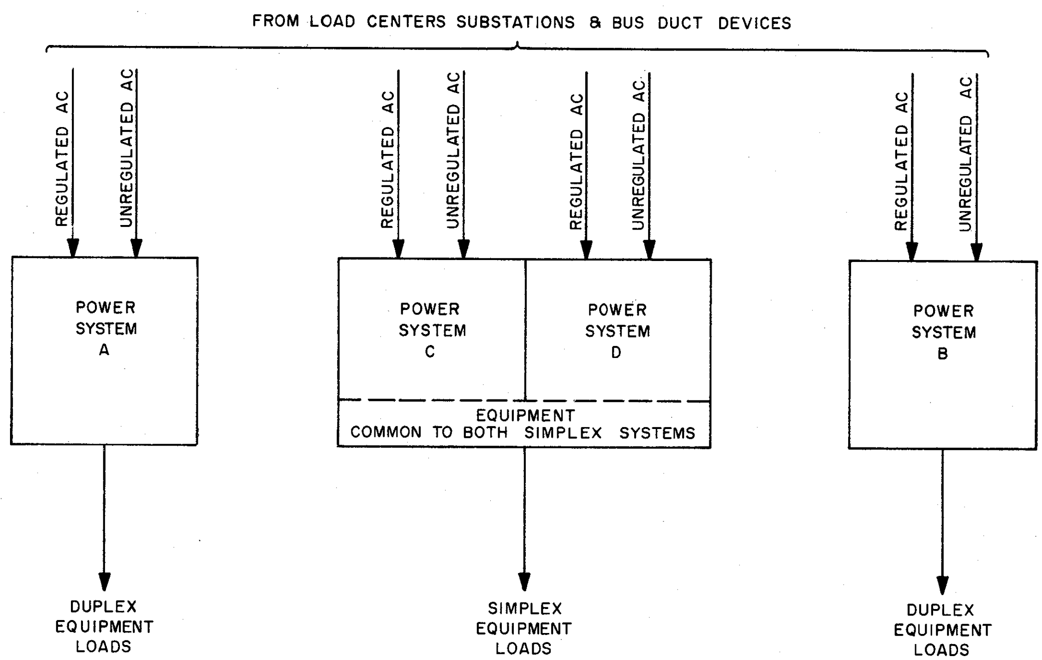


Figure 1–2. Power Supply System, Simplified Block Diagram

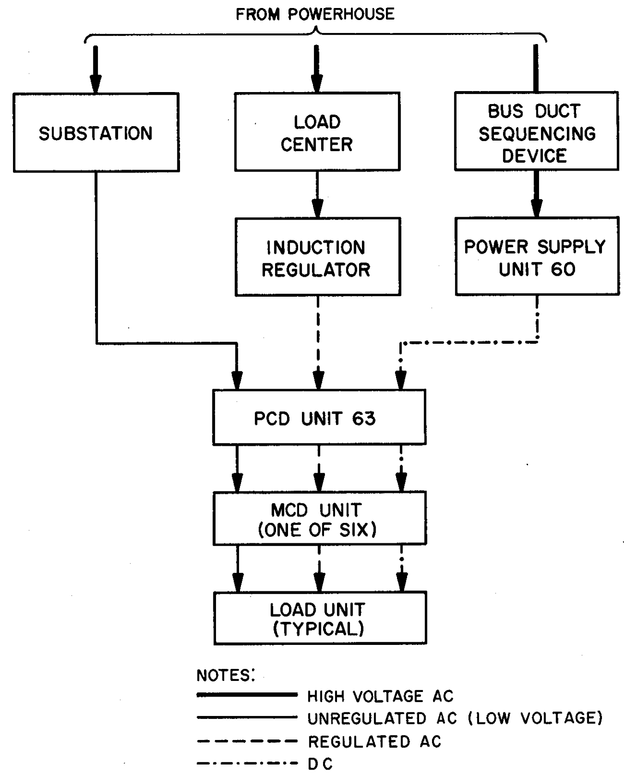


Figure 1—3. Typical Duplex Power and Distribution System, Block Diagram

to 11 d-c voltages. All 11 d-c voltages are used in duplex equipment; only 10 are used in simplex equipment.

1.3 UNITS OF POWER SUPPLY SYSTEM

The Power Supply System includes PCD, power supply, MCD, and CB units, and the PD unit. These units are discussed below and in Section 2.

1.3.1 PCD Units

There are four PCD units in each Central. Two of these (units A63 and B63) are associated with the duplex equipment. The other two (units C64 and D64) are associated with the simplex equipment. The PCD units receive d-c power from the power supply units, regulated ac from the induction regulators, and unregulated ac from the substation transformers. 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).

1.3.2 Power Supply Units

The four power supply units receive unregulated ac from the diesel bus bars and produce the regulated d-c voltages required by the Central. Duplex power supply units A60 and B60 produce 11 d-c voltages; simplex power supply units C61 and D61 produce only 10 d-c voltages since simplex equipment does not require +72Vdc.

1.3.3 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.

1.3.4 CB Units

1.3.4.1 Simplex Input CB Units

The two simplex input CB units (units C56 and D56) contain the CB's necessary to control power to the

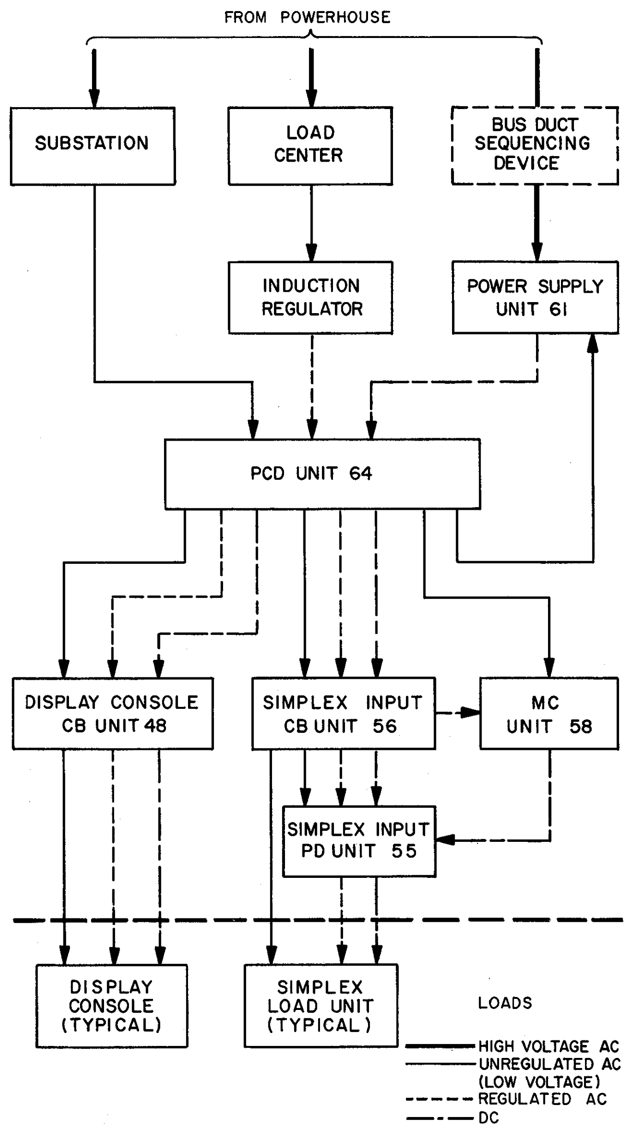


Figure 1—4. Typical Simplex Power and Distribution System, Block Diagram

simplex maintenance console and simplex equipment (fig. 1–4). These units also contain the signal-status relays for inputs.

1.3.4.2 Display Console CB Units

The two display console CB units (units C48 and D48) contain the a-c and d-c CB's required to supply power to the various display consoles of the simplex equipment (fig. 1–4). These units also contain the signal-status relays for displays.

1.3.5 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.

1.4 RELIABILITY

Reliable operation of a SAGE site depends largely on the reliability of the Power Supply System. In the event of total power failure, the site would be inoperative. To prevent total power failure, four independent power sources are incorporated in the equipment. If the active duplex power system fails, the standby power system and standby computer can take over almost immediately. If the active simplex power system fails, the standby simplex power system can be switched to the active status to supply power to the active simplex equipment.

SECTION 2
OPERATING PRINCIPLES

2.1 INTRODUCTION

This section describes the basic functional principles of the Power Supply System. The description covers the four power systems, their divisions into power for duplex and simplex equipment, and various switching operations.

2.2 THEORY OF OPERATION

The power requirements of the Central Computer determine the operational characteristics of the Power Supply System. To ensure long life for the electron tubes in the load units, power is applied in several steps. Filament heater power is applied at a low voltage and gradually increased to rated value. After the filament heater power is at the rated voltage, the d-c voltages are applied in several steps. Power is removed in the reverse order; d-c voltages are removed before the filament heater power.

Other sequencing requirements are determined by the load unit circuitry. All MCD unit relay circuits which apply power to load units require —48Vdc control power to operate. Therefore, the —48Vdc power supply must be at rated voltage before any power (filament or dc) can reach the load units.

2.3 FUNCTIONAL DESCRIPTION

2.3.1 Power for Duplex Equipment

The principal control unit of a power system is the PCD unit. Unregulated and regulated ac and the d-c voltages are supplied to the PCD unit directly from the substation transformers, induction regulators, and d-c power supplies, respectively. The PCD units control and distribute these voltages to the six MCD units. An MCD unit distributes the above power only to its associated load units. During MC operations, an amplidyne introduces a variable voltage in series with one of five standard voltages through the MC voltage contactor in the MCD unit.

2.3.2 Power for Simplex Equipment

Unregulated and regulated a-c and d-c power are supplied to the simplex PCD unit directly from the power sources. The simplex PCD unit distributes 10 d-c voltages (+72V power is not used) through the display console CB unit to the display console and through the simplex input CB unit to the simplex input PD unit. The PD unit takes power from the active simplex power supply and distributes it to all simplex load units in the active status.

2.4 DUPLEX SWITCHING OPERATIONS

Duplex switching operations are accomplished by switching the active or standby status of duplex equipment A and B. Since power supplies A and B are permanently connected to duplex equipment A and B, respectively, power lines are not involved in duplex switching. The duplex switching operation energizes relays which cause the information line from the simplex equipment to be directed to the active duplex equipment. The latter is the duplex equipment which is in direct communication with the active simplex equipment. The active equipment (both simplex and duplex) is that equipment which is performing the air defense function.

If a power failure occurs in the active duplex equipment, duplex switching is required to transfer the air-defense function to the other computer. Maintenance can then be performed on the power system connected to the now standby duplex equipment without interrupting the air defense function.

2.5 SIMPLEX SWITCHING OPERATIONS

Simplex units may be switched from the active to the standby status, or vice versa, by means of the UNIT STATUS switch. If this switch is in the ACTIVE position, unit power is furnished by the active power system (C or D). If it is in the STANDBY position, unit power is furnished by the standby system. The ACTIVE pushbutton on the duplex switching console (unit 45) designates which of the simplex power systems (C or D) is active and connects all active simplex units to this supply. All standby simplex units are connected to the standby power system.

SECTION 3
SYSTEM OPERATING CONDITIONS

3.1 INTRODUCTION

This section contains definitions of the various conditions or statuses in which the Power Supply System may be placed and the method of changing from one condition to another.

3.2 POWER CONDITIONS

There are four distinct power conditions:

a. Bus de-energized

b. Bus energized

c. A-c only

d. Power on

3.2.1 Bus De-energized Condition

In the bus de-energized condition, all power is removed from the load centers, substations, and the d-c power supplies. The diesel generators may be running and connected to the diesel switchgear. In this condition, the —130 Vdc control voltage supplied by the station battery is available if the battery-disconnect switch is closed.

3.2.2 Bus-Energized Condition

In the bus-energized condition, power is supplied to the substations. No power is delivered to the induction regulators or the d-c power supplies. The —130Vdc control voltage may be available (par. 3.2.1). Unregulated 208Vac may also be available.

3.2.3 AC-Only Condition

In the ac-only condition, all regulated and unregulated ac and the d-c voltages are available at the PCD unit and the MCD units. However, only the a-c power and the —48Vdc control voltage is distributed to the load units.

3.2.4 Power-On Condition

In the power-on condition, all unregulated ac and regulated ac and the d-c voltages are distributed through the Power Supply System to the load units.

3.3 OPERATING SEQUENCES

3.3.1 Power-On Sequence

The power-on sequence can be initiated only if the high-voltage bus is energized. When the bus is energized, the power-on sequence is initiated by depressing the POWER ON pushbutton at the maintenance console. This causes relays in the PCD unit to complete circuits that send an *on* signal to the d-c power supply start relays. The input CB to the d-c power supplies closes and the d-c power supplies begin to cycle up. To reduce high initial currents, the d-c power supplies are sequenced on in four groups (par. 2.3, Part 3, Ch 3).

Two seconds after the input CB closes, the ac-start and ac-hold circuits are energized. These circuits apply 50 percent of rated voltage to the tube filaments. Forty-five seconds later, contactors close, and rated voltage is applied to the filaments. About one minute after the ac-start and ac-hold signals are applied, the dc-start and dc-hold signals are applied, and the ac-start signal is removed. Five seconds later, the dc-start signal is removed. The dc-start and dc-hold signals are required to apply the dc voltages to the computer loads.

3.3.2 Power-Off Sequence

Depressing the POWER OFF pushbutton at the maintenance console actuates relays in the PCD unit and the switchgear. The d-c contactors in the MCD units are opened and all d-c power supplies are disconnected from their loads. Since the *on* signal is no longer present, the CB's feeding the d-c power supplies and the filaments open and de-energize all the relays in the PCD and MCD units (par. 3.2, Part 3, Ch 3).

3.4 CONDITION CHANGING

Since d-c voltages are removed from units before maintenance is attempted, provision has been made to place the system in the ac-only status and to return the system to the power-on status.

3.4.1 Power On to AC Only

Depressing the AC ONLY pushbutton interrupts the dc-hold circuits to the load units. D-c power is removed from the units and the units are in the ac-only status (par. 4.3, Part 3, Ch 3).

3.4.2 AC Only to Power On

To re-establish the power-on condition, the POWER ON pushbutton is depressed. The dc-start and dc-hold signals are initiated, and d-c power is supplied to all units (par. 2.4, Part 3, Ch 3).

PART 2
REGULATION, CONVERSION AND METERING EQUIPMENT

CHAPTER 1
INTRODUCTION

1.1 GENERAL

Regulation equipment consists of the induction regulators which regulate the ac required by the Central.

Conversion equipment consists of components which produce, control, and regulate the d-c voltages. This equipment includes magnetic amplifiers, high-frequency alternators, and d-c power supplies.

Metering equipment consists of the various meters used to monitor both the a-c and the d-c voltages. Included in the metering equipment are d-c voltmeters, d-c ammeters, a-c voltmeters, and ripple voltmeters.

1.2 REGULATION EQUIPMENT

The ac produced by the diesel generators in the powerhouse is regulated by the induction regulators in the operations building. The regulated ac is transformed by the filament transformers of the load units and distributed to the filaments of those tubes which require regulated a-c filament voltages.

1.3 CONVERSION EQUIPMENT

1.3.1 Magnetic Amplifiers

A magnetic amplifier is a static device which employs an iron core and windings to control voltage or current. Magnetic amplifiers are used to control the output of the d-c power supplies (Sect. 1, Ch 3).

1.3.2 High-Frequency Alternator

The high-frequency alternator is a motor-driven, self-excited a-c generator which produces the 1,440-cycle ac used by the magnetic amplifiers (Sect. 2, Ch 3).

1.3.3 D-C Power Supplies

The d-c power supplies use rectifiers, magnetic amplifiers, and a high-frequency alternator input to convert 480Vac to the 11 d-c voltages required in the Central (Ch 4).

1.4 METERING EQUIPMENT

Meters are installed on the PCD units and the control chassis of each d-c power supply. The meters on the PCD units are equipped with a selector switch so that one meter may monitor any appropriate voltage or current. The meters on the power-supply control chassis monitor only the output voltage of that particular power supply (Ch 5).

CHAPTER 2
INDUCTION REGULATORS

2.1 INTRODUCTION

Induction regulators (figs. 2–1 and 2–2) are used to regulate the 208Vac output of the load centers because the induction regulators introduce no a-c waveform distortion or d-c ripple, have a high power factor, and are easy to maintain.

An induction regulator is a variable inductor transformer which uses a motor-driven core or rotor as a regulating device. Each induction-regulator cabinet contains six transformers (two for each a-c phase) stacked vertically in two 3-transformer assemblies. The bottom, middle, and top unit of one 3-transformer assembly is electrically in series with, and mechanically interconnected to, the bottom, middle, and top unit, respectively, of the other 3-transformer assembly. The interconnected units are in series and control one phase of ac. Two cores are used for each a-c phase to provide the necessary mechanical strength for the cores to withstand the mechanical stress of a 20,000-amp short-circuit current.

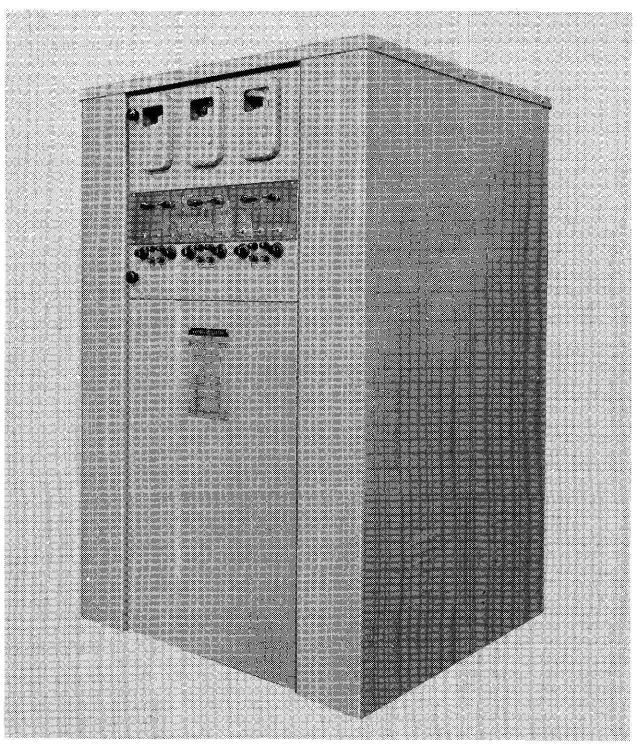


Figure 2–1. Induction Regulator, Right Front View

This discussion of induction regulators is limited to a consideration of a single inductor transformer controlling one a-c phase. Each of the six transformer assemblies in the induction regulator operates in the manner described below. Both of the series-connected transformers controlling one a-c phase operate in electrical and mechanical unison.

2.2 COMPONENTS

The induction regulator consists of a stator and rotor, a reversible electric motor, control switches, a regulating relay, and a motor-control relay.

2.2.1 Stator and Rotor

Each induction regulator unit contains a laminated steel stator (transformer secondary) upon which a regulating winding is wound and a laminated steel rotor (transformer primary) upon which the excitation winding is wound. The rotor (primary) windings are in parallel with the load; the stator (secondary) windings are in series with the load (fig. 2–3).

2.2.2 Motor

The fractional-horsepower motor is a reversible, single-phase capacitor-type motor and is used to change the position of the rotor in relation to the stator.

2.2.3 Control Switches

2.2.3.1 Limit Switch

The limit switch limits the travel of the rotor to 180 degrees. This switch consists of two single-pole, single-throw switches. One switch is in the circuit which causes the motor to turn the rotor and raise the output voltage. The other is in the circuit which causes the motor to turn and lower the output voltage. Tripping devices on the rotor shaft open the switch and stop the motor when the rotor reaches the maximum permissible rotation.

2.2.3.2 Control-Power and Motor-Power Switches

The control-power switch is a single-pole toggle switch which will open the automatic control circuit but not the motor circuit. The motor-control switch controls power to the motor. When this switch and the control-power switch are open, neither the motor nor the control device receive power.

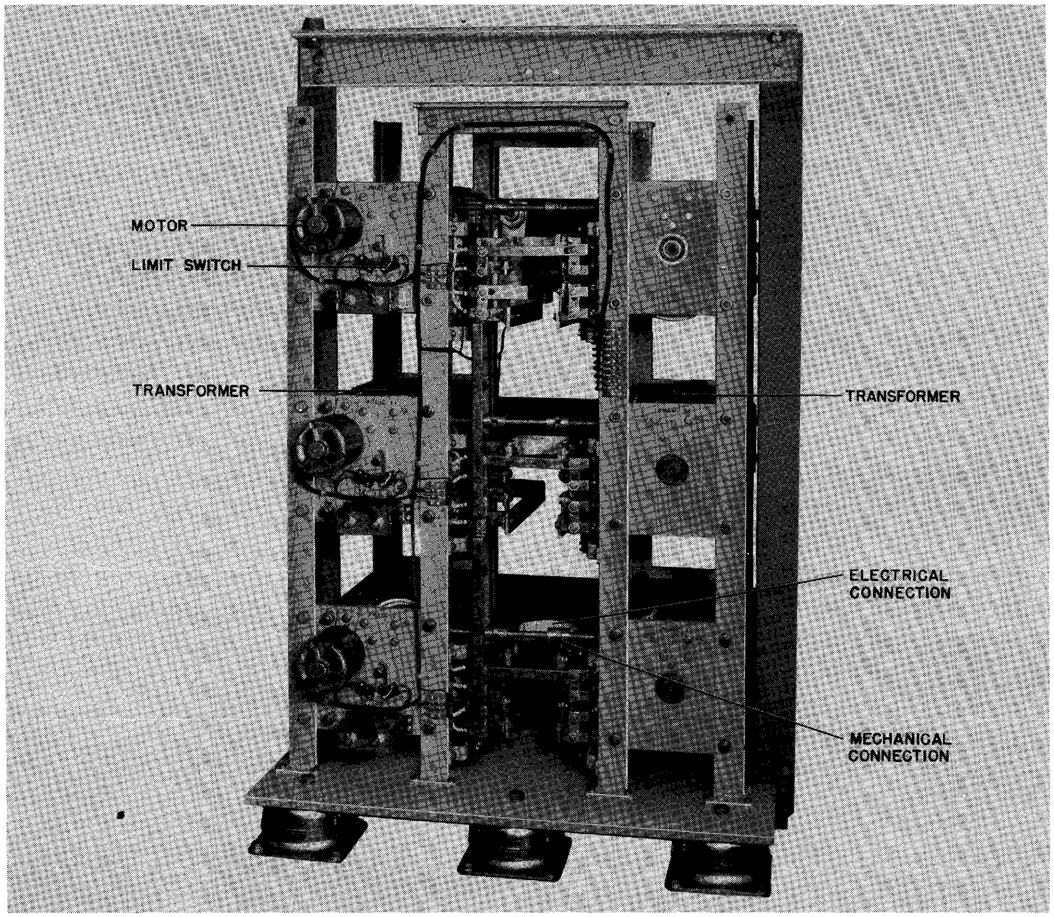


Figure 2–2. Induction Regulator, Front View, Covers Removed

2.2.3.3 AUTOMATIC MANUAL Switch

This switch provides for automatic or manual voltage control. When the switch is in the MANUAL position, the output voltage is controlled by the manual-operation levers of the motor-control relay (par. 2.2.5). When the switch is in the AUTOMATIC position, the output voltage is automatically controlled by the regulating relay. Normally, the switch is in the AUTOMATIC position.

2.2.4 Regulating Relay

This device is both a relay and a sensing instrument. It continually senses the output voltage of the induction regulator. If the voltage begins to vary, it acts as a relay to control the electric motor and return the output voltage to normal (par. 2.3.2).

2.2.5 Motor-Control Relay

The motor-control relay is controlled by the contacts of the regulating relay through two coils. Each coil consists of a winding with a tapped section which energizes the holding coil of the regulating relay (par. 2.3.2.2). The contacts of the motor-control relay complete the circuit to the motor. Two levers on the front panel are used to operate the contacts manually whenever the AUTOMATIC MANUAL switch is in the MANUAL position.

2.3 THEORY OF OPERATION

The principal components of the induction regulator are the variable inductor transformer and the regulating relay. The theory of operation of these components is discussed below.

Note

In this discussion, *raise* and *lower* refer to the effect which these functions have on the output voltage. For example, the lower contacts on the regulating relay, when closed, permit the motor to turn the rotor in such a direction that the output voltage is lowered.

2.3.1 Variable Inductor Transformer

The variable inductor transformer is the voltage-regulating component of the induction regulator. The primary of this transformer is in parallel with the load; the secondary is in series with the load. Output voltage variation is obtained by rotating the rotor inside the

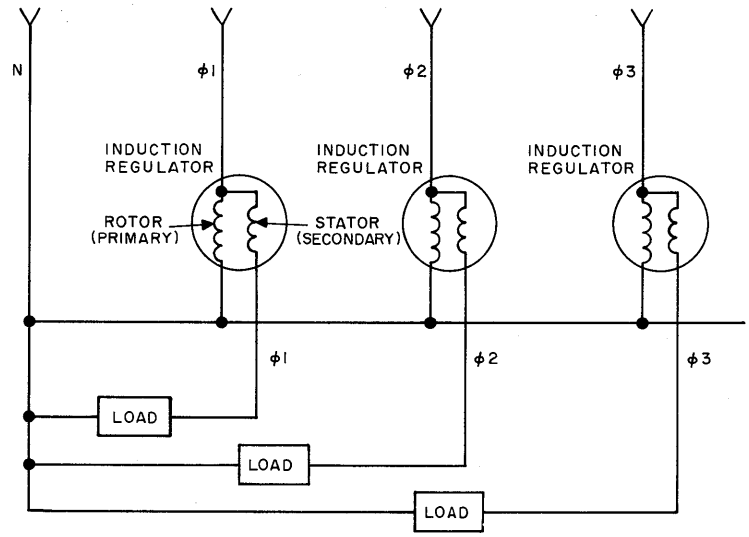


Figure 2–3. Three-Phase Induction Regulator, Simplified Schematic Diagram

stator to change the flux linkage connecting them. Rotation is accomplished by a small electric motor.

The basic operation of the variable inductor transformer may be compared to that of a common autotransformer. In one configuration of the common autotransformer (fig. 2–4), the secondary voltage aids the primary voltage so that the output voltage is higher than the input. Reversing the leads of either the primary or the secondary (but not both), causes the secondary voltage to buck the primary voltage so that the output is lower than the input. In the variable inductor transformer (fig. 2–5), rather than reverse the leads, the

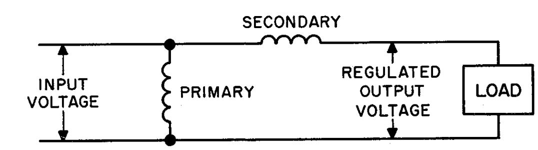


Figure 2–4. Typical Autotransformer, Schematic Diagram

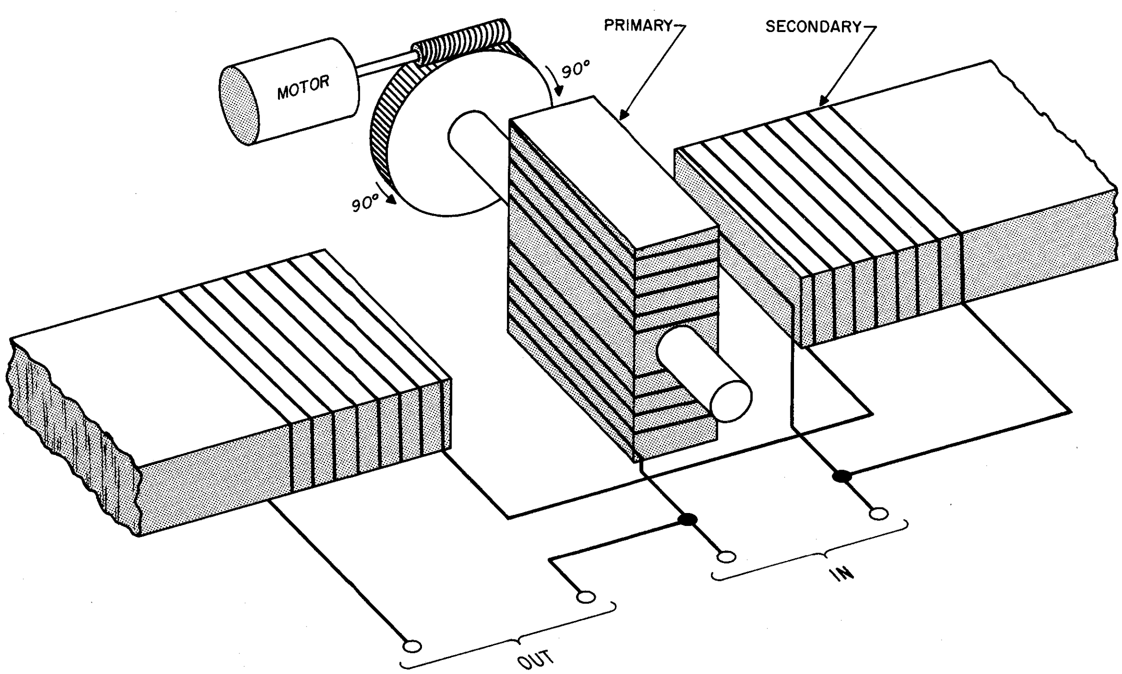


Figure 2–5. Basic Variable Inductor Transformer

output voltage is adjusted by automatically changing the flux linkage between the primary and the secondary windings in both amount and direction. A small motor changes the position of the rotor and stator with respect to each other so that the secondary voltage either aids or bucks the primary voltage.

In the inductor transformer, the output voltage is at a maximum when the secondary voltage is at a maximum and in phase with the primary. When the windings are in the relative position shown in A of figure 2–6, the flux linkage between the stator and the rotor windings is a maximum, and the output voltage is also a maximum (fig. 2–6,B). In this position, the mutual inductance of the two windings is in phase and produces the greatest output from the secondary (stator) windings.

If the windings are positioned as shown in C of figure 2–6, there is still some additive mutual inductance between the windings. The output voltage is now somewhat lower than maximum (fig. 2–6,D).

At the midpoint of rotor movement, the coupling between the primary and the secondary is zero, and the induced secondary voltage is zero. Therefore, when the primary and secondary windings are displaced by 90 degrees, the input and output voltages are essentially the same.

The output voltage of the variable inductor transformer is at a minimum when the secondary voltage is at a maximum but 180 degrees out of phase with the primary voltage. When the windings are in the relative positions shown in E of figure 2–6, the flux linkage is again the greatest, but since the direction of current flow in the primary windings has been reversed from that shown in A of figure 2–6, the flux linkage opposes the flow of output voltage, and the output voltage (fig. 2–6,F) is at a minimum.

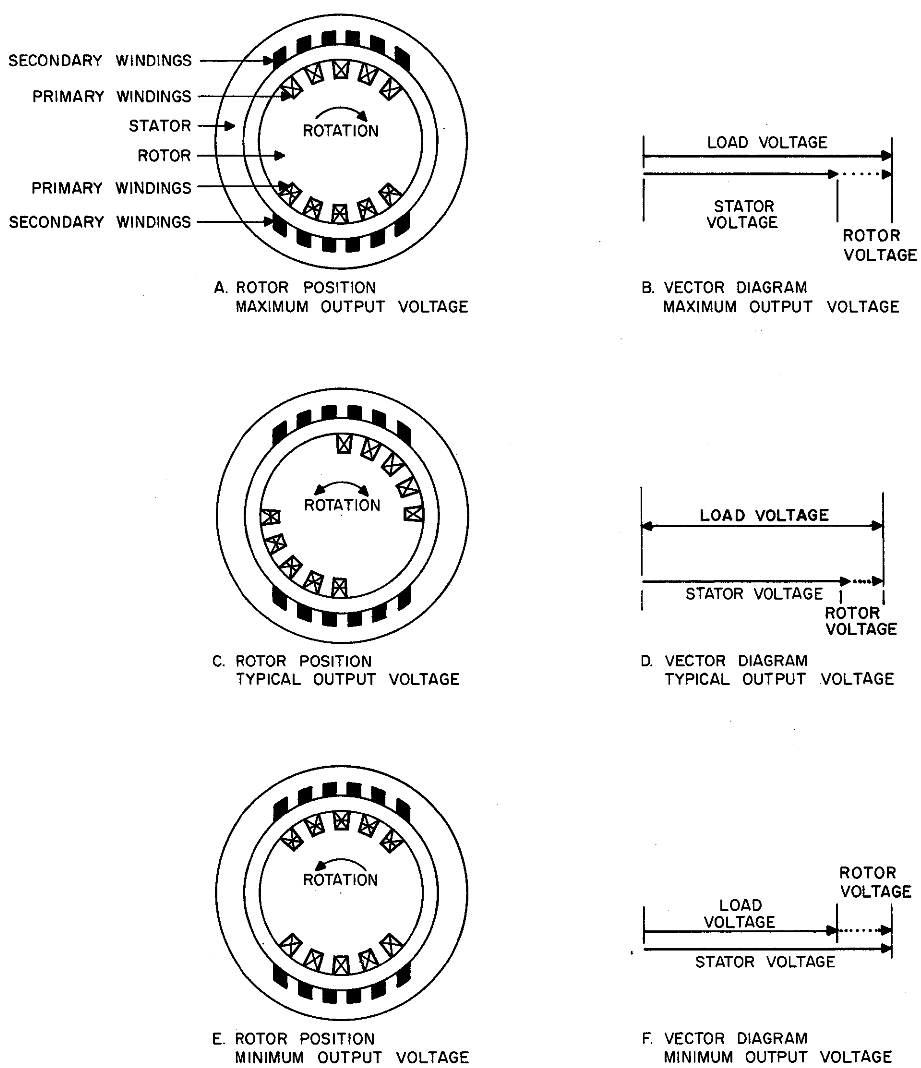


Figure 2–6. Induction Regulator, Rotor Positions and Output Voltage Vectors

2.3.2 Regulating Relay

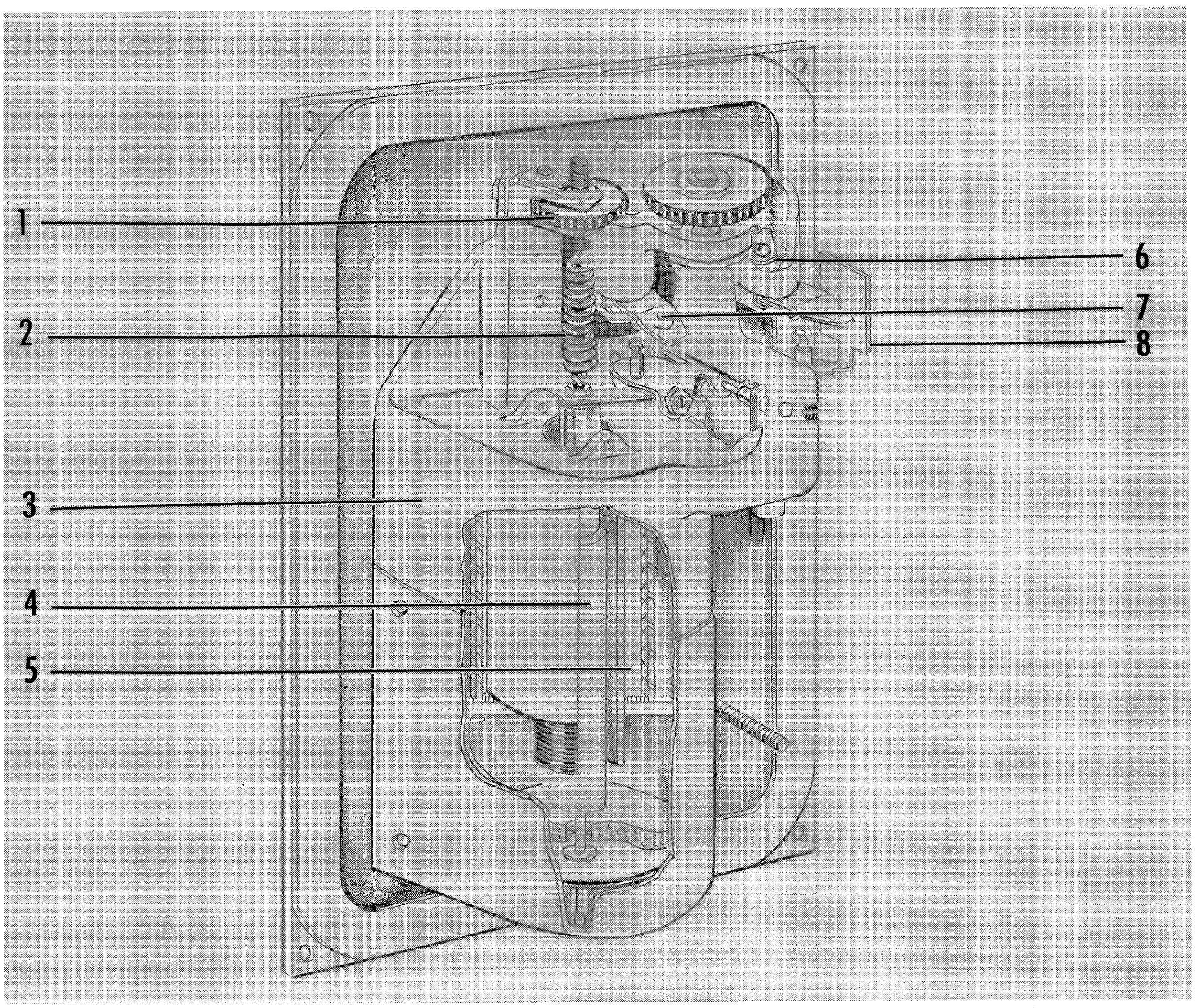
The regulating relay (fig. 2–7) is used to sense the output voltage and to permit the motor to drive the rotor in a voltage-correcting direction.

2.3.2.1 Sensitive Element

The sensitive element of this relay is an iron-core solenoid. The core is suspended on a spring. The solenoid current is made proportional to the voltage by inserting a ballast resistor in series with the solenoid coil. In this manner, the solenoid current remains constant for a given voltage and changes with the voltage to be regulated.

2.3.2.2 Holding Coil

A holding coil is wound over the solenoid coil and in the opposite direction. The holding coil is excited through the tapped section of the motor-control-relay coils. The holding coil modifies the pull of the solenoid and holds the contacts closed until the variable transformer has corrected the output voltage.



1. Adjusting nut for compensating spring
2. Compensating spring
3. Solenoid case assembly
4. Solenoid core
5. Solenoid and holding coil
6. Contact beam with pivots, shunt connector, coupling spring and contacts
7. Stationary contacts with insulated tips
8. Locking plate and connector for stationary contacts

Figure 2–7. Sectional View of Regulating Relay for Induction Regulator

2.3.2.3 Relay Operation

When the relay (fig. 2–7) is in operation, the pull of the solenoid (which varies with relay current) and the pull of the compensating spring are balanced against the weight of the solenoid core. The solenoid operates a set of single-pole, double-throw contacts assembled on a pivoted beam. The left-hand contact closes when the output is too high, and the right-hand contact closes when the output is too low. This action causes the regulator relay to operate the motor and correct the output voltage.

Assume that the output voltage of the variable transformer increases above 208V. The current in the solenoid coil increases, pulling the core up. The compensating spring is relaxed, and the left-hand contact closes. The closed contact completes the circuit to the motor to run it in the lower direction. As the rotor turns, less voltage is induced in the stator windings, and the output decreases. As this occurs, the current in the solenoid coil decreases, and the core is pulled down. At a predetermined voltage (sensed by coil current) the contact opens, and the motor stops.

If the output voltage drops, the current in the coil will drop; the solenoid core will move down and close the raise-relay points; the raise-relay contacts will be closed; the motor will run in the raise direction; and the voltage will be returned to normal.

2.4 TYPICAL OPERATION

2.4.1 General

In operation, two variable transformers are placed in the line of each phase of ac (par. 2.1). The output of these variable transformers is sensed by the regulating relay (par. 2.3.2). The regulating relay causes the motor-control relay (par. 2.2.5) to close the motor circuit. The motor is driven in the direction necessary to compensate for output voltage variation (fig. 2–8).

2.4.2 Regulating Relay

Assume that the output voltage increases. The increased voltage causes an increased current to flow in the solenoid coil of the regulating relay (par. 2.3.2.1). The current pulls the solenoid core into the coil and relaxes the tension on the compensating spring. When the output voltage increases sufficiently, the left-hand contact on the regulating relay closes (par. 2.3.2.3). When this contact closes, the motor-control relay is actuated to drive the motor in the lower direction.

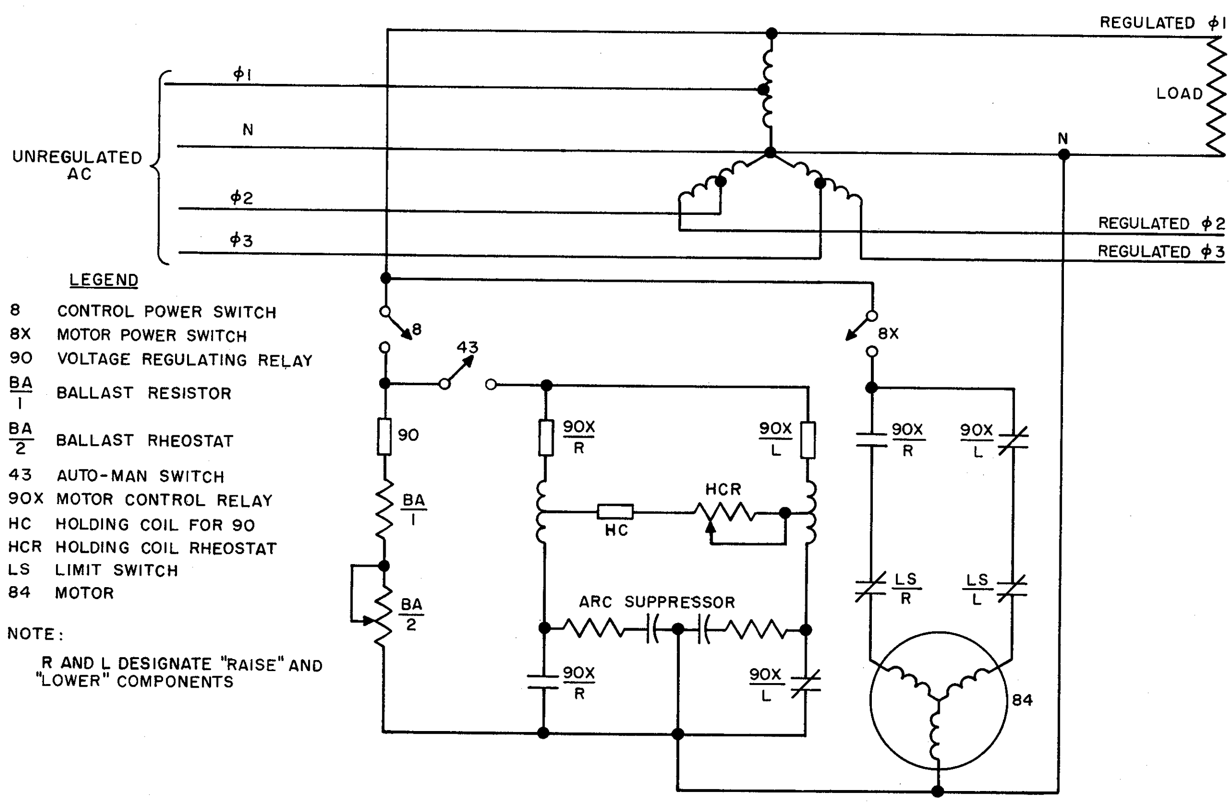


Figure 2–8. Induction Regulator, Phase I, Schematic Diagram

2.4.3 Variable Transformer

When the regulating relay is actuated, the motor begins to turn; in this case, in the lower direction, since the output voltage is assumed to be high. The motor turns the rotor of the variable transformer so that there is less flux linkage between the primary and the secondary. Since the output voltage varies with the flux linkage, reducing the flux linkage reduces the output voltage. The rotor will be turned until the output voltage is no longer excessive. This occurs when the regulating-relay-coil current (proportional to output voltage, par. 2.3.2) and the spring tension balance the weight of the core and open the lower points of the relay. When the lower points are no longer closed, the motor circuit is opened, the motor stops, and the rotor remains stationary until further voltage deviation occurs.

CHAPTER 3
CONVERSION COMPONENTS

SECTION 1
MAGNETIC AMPLIFIERS

1.1 INTRODUCTION

A magnetic amplifier is an amplifying device in which the gain may be as high as 10^6:1. Magnetic amplifiers are used to regulate the output voltage of the d-c power supplies. These amplifiers are used instead of vacuum tubes because the magnetic amplifiers have no moving parts or any other parts subject to deterioration. Therefore, magnetic amplifiers are highly reliable, virtually maintenance-free devices.

The principal component of a magnetic amplifier is a saturable reactor. This reactor consists of one or more coils of wire, or windings, placed on an iron core which has special magnetic properties.

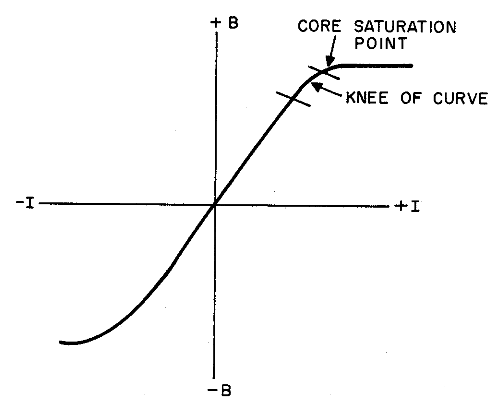
1.2 SATURABLE REACTORS

1.2.1 Basic Concepts

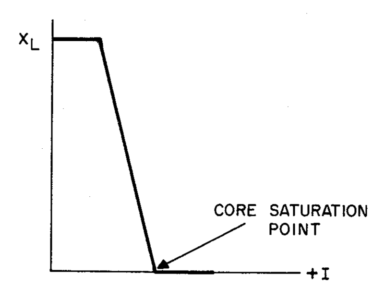
A saturable reactor resembles a transformer in that several windings are wound on an iron core. However, it differs from a transformer in that the reactor operates in the region of core saturation during part of each a-c input cycle.

Since a saturable reactor is composed of coils wound on an iron core, the basic operating principle of the device is that of self-induction. Self-induction is that electromagnetic characteristic whereby an inductive reactance (X_L) is produced in a circuit by varying the flux density of a magnetic field associated with the circuit. Inductive reactance always opposes the a-c input to a circuit and tends to prevent current changes in the circuit. In an iron-core choke, for example, a coil is wound on an iron core. Current in the wire produces a magnetic field around the wire. This field concentrates in the iron core, thereby increasing the flux density in the core. Flux density in the core varies directly with the a-c input to the coil up to the point of core saturation. When the core is saturated, an increase in current in the coil no longer increases the flux density of the core (fig. 2–9,A).

A simple iron-core choke consists of a piece of magnetic material upon which several turns of wire are wound. Assume that in such an arrangement the wire is carrying ac and that the current is zero. When the current begins to rise, the magnetic field surrounding the core starts to expand and cuts the turns of the coil. Since, in effect, a wire is cutting a magnetic field, a current is induced in the wire. This current opposes the rising ac and tends to keep the current in the wire at a low value. The amount of opposition is the inductive reactance (X_L) measured in ohms. The magnitude of X_L is a function of the rate of change of the flux density. Since the flux density varies with the current, and since X_L is a function of the rate of flux density change, then



A. FLUX DENSITY (B) VS CURRENT (I)



B. INDUCTIVE REACTANCE (X_L) VS CURRENT (I)

Figure 2–9. Core Magnetization and Reactance Curves

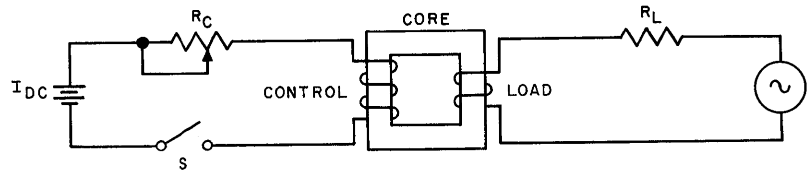


Figure 2–10. Basic Saturable Reactor

X_L is a function of the rate of current change; that is, the a-c frequency. When the core is saturated, X_L is zero, because the rate of change of flux density is zero (fig. 2–9,B).

While the amount of ac through the coil is increasing, the impedance (a-c resistance) of the coil is high and permits little current to flow. When the core saturates, there is no longer a change in flux density; the impedance becomes zero, the coil has only the d-c resistance of the wire, and a large current flows through the coil. Conversely, assume that the ac in the wire is at its maximum value and begins to fall. The falling current will cause the magnetic field to collapse and cut the turns of the coil. Again a current is induced in the coil. This current is opposite in direction to that which was induced in the wire by the rising a-c current and the expanding magnetic field. Consequently, the current induced by the collapsing field tends to keep the current in the wire at a high value even though the ac is decreasing towards zero.

1.2.2 Basic Saturable Reactor

A basic saturable reactor is different from the iron-core choke in that there are two windings associated with the core. One of these windings is the control winding and may be considered to be the input winding. The other winding is the load winding. The load winding may be considered to be the output winding and is connected to some load resistance and an a-c source (fig. 2–10).

1.2.2.1 Ineffective Control Current

Assume that no current is supplied to the control winding of the saturable reactor shown in figure 2–10, and that the a-c voltage impressed on the core through the load winding is not large enough to drive the core to saturation. The total a-c input voltage (fig. 2–11,B) appears across the saturable reactor (fig. 2–11,C). Since the magnetic core never saturates (fig. 2–11, D), the impedance of the reactor remains high and the voltage across the load remains small (fig. 2–11,E).

Assume now that the control current is still zero and that the a-c input voltage (fig. 2–12,A and B) is sufficient to drive the core to saturation during part of the a-c cycle. A portion of the a-c input voltage appears across the saturable reactor (fig. 2–12, C and D), and the core now saturates during the first half-cycle of the a-c input (fig. 2–12,D). However, before the saturation point is reached, a voltage which opposes the flow of a-c to the load is induced in the winding. Since the impedance of this winding is large, very little voltage reaches the load (fig. 2–12,E). When the core satu-

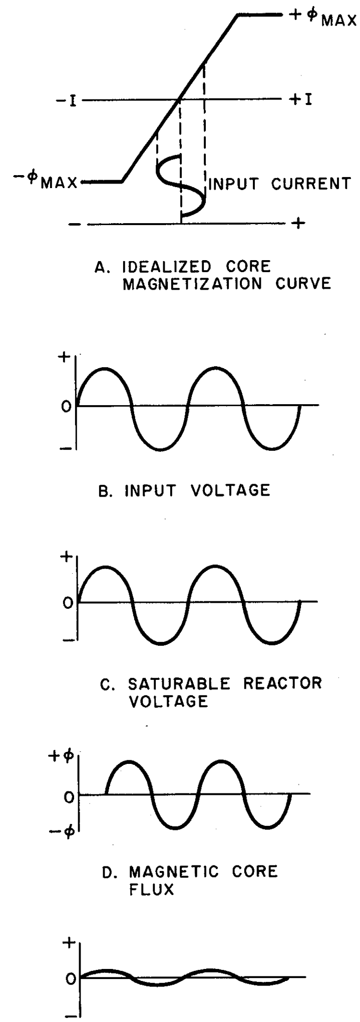


Figure 2–11. Saturable Reactor, Zero Control Current, and Small A-C Input Voltage, Waveshapes

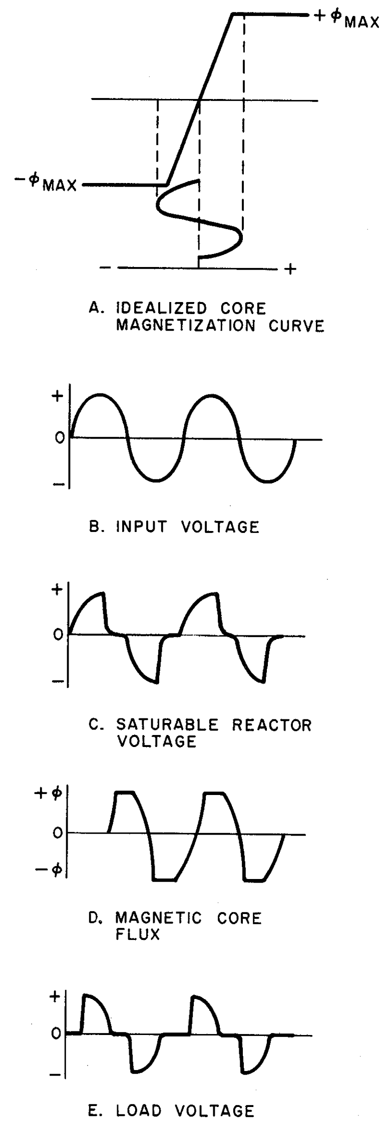


Figure 2–12. Saturable Reactor, Zero Control Current, and Large A-C Input, Waveshapes

rates, the flux density no longer changes and there is no opposing voltage induced in the load winding. The impedance of the output winding drops to the d-c resistance value of the wire, and a large voltage flows through the load winding of the load.

1.2.2.2 Effective Control Current

Assume that a positive control current I_{dc} (fig. 2–10) is applied to the saturable reactor. The magnetic core flux is now displaced towards positive saturation. If a large a-c input is now applied to the control windings, the core will saturate sooner during the positive half-cycle of a-c input voltage and later during the negative half-cycle of a-c input voltage. A smaller portion of the positive half-cycle appears across the saturable reactor and a larger portion appears across the load (fig. 2–13,C and E). During the negative half-cycle, a larger voltage appears across the saturable reactor and a smaller voltage appears across the load. Reversing the polarity of control current I_{dc} displaces the core flux toward negative saturation and reverses the above process so that the small portion of the voltage appears across the load during the positive half-cycle and across the reactor during the negative half-cycle.

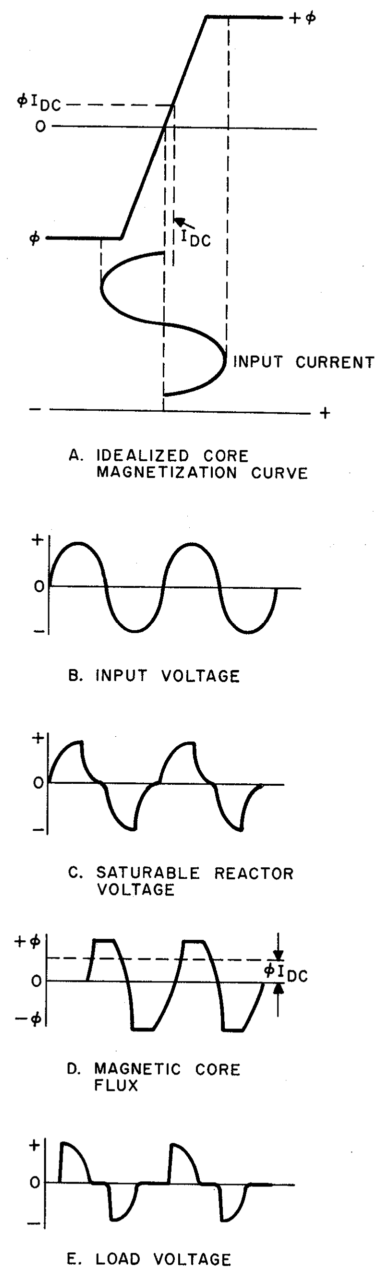


Figure 2–13. Effect of Positive Control Current on Saturable Reactor, Waveshapes

1.2.3 Typical Saturable Reactor

A typical saturable reactor differs from the basic saturable reactor (par. 1.2.2) in that: (a) The core is driven to saturation by applying pulsating dc (full-wave-rectified ac) through the load windings. (b) A bias current is introduced to desaturate the core to an operating point on the knee of the saturation curve (fig. 2–9). (c) The control current varies the core saturation about the operating point established by the bias current.

1.2.3.1 Load-Winding Current

The load wind of a typical saturable reactor does not carry ac but pulsating dc. Dc is used for two reasons:

a. The current must be capable of keeping the core saturated.

b. Dc is required in the load circuit. The load circuit of a saturable reactor in d-c power supply applications is the control circuit of another saturable reactor.

Normally, the dc used in the load winding is the rectified output of an a-c generator. The dc carried by the load winding is sufficient, if not opposed, to drive the core to saturation and thereby permit the total voltage to be applied to the load after being rectified.

1.2.3.2 D-C Bias Current

In order to be useful regulating devices, saturable reactors must operate at the knee of the magnetization curve. To keep the core at the knee of the saturation curve rather than fully saturated, a d-c bias current is introduced into the core. This bias current opposes the current in the load windings and drives the core from saturation to an operating point at the knee of the saturation curve. This operating point is near enough to the saturation point to permit high gain characteristics in the saturable reactor without permitting excessive distortion of the a-c waveform. Also, this point is far enough below the saturation point to permit control of the output without driving the core to saturation.

In operation, the bias current acts as an effective control current (par. 1.2.2.2).

1.2.3.3 Control-Winding Current

In a typical saturable reactor, the control-winding current is dc obtained from a d-c source associated with the device being controlled. The control current varies with the d-c source current and increases or decreases the saturation of the core away from the operating point established by the bias winding. Changing the core saturation changes the flux density of the core and the impedance of the windings on the core (par. 1.2.1). The control winding is wound so that the flux produced by it is aiding the flux produced by the load winding and opposing the flux produced by the bias winding.

1.3 MAGNETIC AMPLIFIER OPERATION

1.3.1 General

A magnetic amplifier is a refined saturable reactor. The magnetic amplifier has control, bias, and load windings which operate in the manner discussed in paragraph 1.2.3. In addition, the magnetic amplifier makes use of a high-frequency a-c input to the load windings to decrease response time. Further refinements include the use of additional windings.

1.3.2 Basic Magnetic Amplifier Circuit

A magnetic amplifier is a saturable reactor whose output has been rectified so that a small d-c input controls a large d-c output. Figure 2–14 is a simplified schematic of a basic magnetic amplifier circuit.

1.3.2.1 Response Time

In a magnetic amplifier, as in any control device, there is a time delay between the application of a change in control-winding current and the response of the output current to this change. The theoretical response time of a magnetic amplifier is the time for one-half cycle of the a-c input to be applied to the load windings. Because the unrectified output current appears as a pulse occurring once each cycle, a change in average output current cannot be observed until the next pulse appears after the control signal is applied to the control windings. Consequently, increasing the frequency of the a-c input to the load windings increases the number of pulses per second and decreases the response time. For example, if a 60-cycle a-c input were rectified, 120 pulses would be impressed on the core each second. If the frequency of the a-c input were increased to 1,440 cycles, 2,880 pulses would be impressed on the core each second, and the response time would decrease from 1/120 second to 1/2880 second.

1.3.2.2 Cascaded Operation

In the d-c power supplies, two magnetic amplifiers are used for control. The control winding of the first-

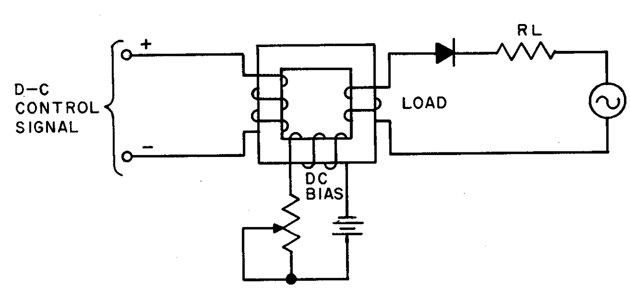


Figure 2–14. Basic Magnetic Amplifier, Simplified Schematic Diagram

stage magnetic amplifier senses changes in power supply output. The load winding of this magnetic amplifier is the control winding of the second-stage magnetic amplifier. The gain of the first magnetic amplifier is therefore multiplied by the gain of the second to produce an overall gain of about 10^6. The load winding of the second-stage magnetic amplifier is the control winding of the power reactors.

1.3.3 Typical Operation

1.3.3.1 General

Assume that the magnetic-amplifier control circuit shown in figure 2—15 maintains regulated 50Vdc through R_L.

This control circuit is a simplified version of the control circuitry used in the d-c power supplies.

1.3.3.2 Circuitry

The Zener diode is used as a constant source of bias current. In the simplified power supply, first-stage magnetic amplifier L1C is held at its operating point by the control winding and the bias winding. This bias current is produced by the output of CR4C which is fed by the auxiliary a-c input. The first-stage bias is controlled by potentiometer R14. Since the auxiliary a-c input current is assumed to be constant, the biasing current and the resultant flux are also constant.

The second-stage amplifier, L2C, receives control current from the load windings of L1C and bias current from a battery. The output of the load windings is rectified and applied, to the load.

1.3.3.3 Voltage Regulation

Assume that the load voltage is exactly 50Vdc. The various windings on both magnetic-amplifier stages permit exactly 50Vdc to flow through RL.

Note

The bias current for L1C and L2C is assumed to be constant.

If the output of the power supply increases to a value above 50V, the voltage difference between the Zener diode and the control winding decreases, and in the control winding the current also decreases. The flux density of the core of L1C decreases and, consequently, the output current decreases. The output current of L1C is rectified and applied to L2C as a control current. The second-stage magnetic amplifier responds in the same manner as L1C.

Since the flux density of L2C is reduced, the voltage in the output winding is also reduced. Since the rectified output of the load winding is the d-c voltage of the power supply, reducing the flux density of L2C reduces the power supply output.

If the output decreases below 50Vdc, the current in the control winding of L1C is increased and the above process is reserved.

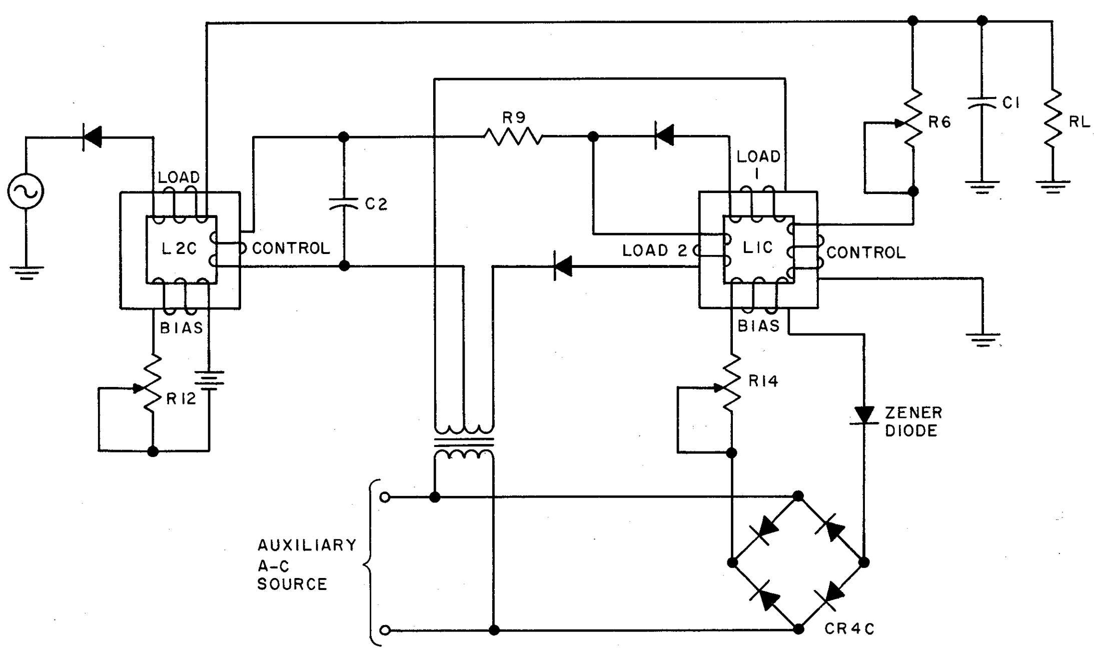


Figure 2—15. Typical Magnetic Amplifier Control Circuit, Simplified Schematic

SECTION 2
HIGH-FREQUENCY ALTERNATOR

2.1 INTRODUCTION

The high-frequency alternator supplies 1,440-cycle, 110Vac to the magnetic amplifiers of the d-c power supplies. The high-frequency input is used because the response time of a magnetic amplifier varies inversely with input frequency. Performance is therefore improved by increasing the input frequency. For example, a magnetic amplifier with a 0.5-cycle response time and a 60-cycle input frequency requires 83 ms to respond to changes in output current. The same magnetic amplifier with a 1,440-cycle input will respond in 347 usec (0.347 ms).

The high-frequency alternator is a motor-driven, d-c excited, a-c generator. The motor and generator are mechanically coupled by a common shaft. The motor receives a 208V, 3-phase, 60-cycle input. The generator delivers 110V, 1,440-cycle, single-phase ac to the transformer which feeds the two magnetic amplifier stages of each d-c power supply.

2.2 THEORY OF OPERATION

2.2.1 Motor

The motor is a standard 3-phase, low-slip induction motor which operates on a 208V, 3-phase a-c input. The motor is directly connected to the rotor of the high-frequency generator through a flexible coupling.

2.2.2 High-Frequency Generator

The high-frequency generator is a dc-excited generator whose armature-winding flux, when cut by the rotor windings, produces a 1,440-cycle output. The output voltage is proportional to magnetic field strength. The output frequency is proportional to the speed of the motor. Since the motor is of a low-slip design, the output frequency varies with frequency variations in the 208Vac input. The output voltage is independent of input voltage variations since the generator is self-excited at operating speeds.

The control circuitry permits either automatic or manual output control.

2.2.3 Typical Manual Operation

In the manual mode of operation (fig. 2–16), transformer T6 supplies power to the winding of MANUAL ADJUST autotransformer T7. The output winding of T7 is the a-c source for bridge rectifier CR1A. This rectifier supplies d-c current to the field. The magnitude of this current, and, consequently, the output voltage, is varied by the MANUAL ADJUST control of T7 during manual operation.

Note

MANUAL ADJUST autotransformer T7 is not disconnected during automatic operation. However, since there is no load on it under this mode of operation, the current it draws from the secondary of T6 is small.

2.2.4 Typical Automatic Operation

The magnetic-amplifier control circuitry operates in the same manner as that discussed in Section 1 except that, in this case, the current in the generator field is being controlled.

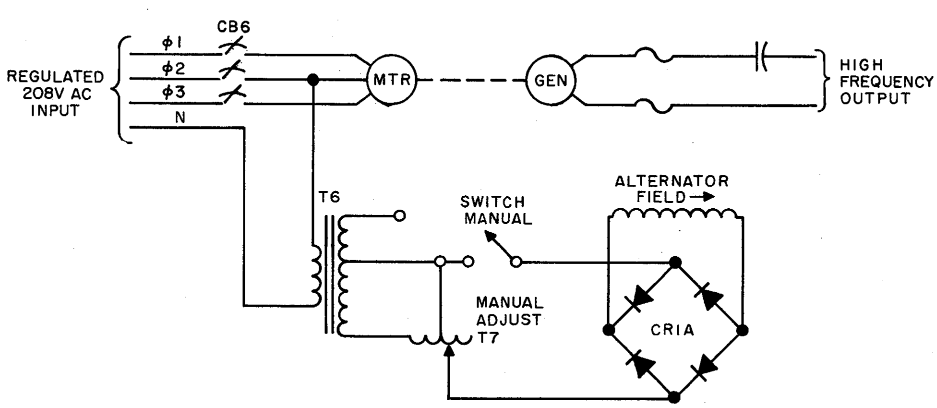


Figure 2–16. High-Frequency Alternator, Manual Control Circuit, Simplified Schematic Diagram

Phase 2 of the a-c input supplies power to transformer T6. The secondary voltage of the center tap (fig. 2–17) is applied to rectifier CR1A which, during the starting period, delivers current to the alternator field. As the alternator speeds up, the output voltage of the regulating section increases. When the output voltage of this section (across CR1A) exceeds the rectified line-to-center-tap secondary voltage of T6, CR1A cuts off. Thus, CR1A supplies current to the alternator field at the start and the regulating circuit supplies current to the field after the alternator is at operating speed.

The a-c feedback winding of the magnetic amplifier establishes the magnetic state of the core. The d-c bias winding is wound so that the flux developed by it opposes the flux developed by the a-c feedback reference winding; thus, an increase in current in the d-c bias winding desaturates the core.

Assume that the alternator output rises above its normal 110V level. As a result, the current through R3 and the voltage across it increase. Because of the increased voltage across R3, which is the a-c output to bridge rectifier CR3A, the d-c output of the rectifier (filtered by inductor L1) increases. Therefore, the current through the d-c bias winding increases. This increase in current desaturates the core slightly and increases the impedance of load windings 2 and 3 of the amplifier. The magnetic-amplifier output, and, hence, the voltage across the alternator field, decreases. The field current decreases, and the alternator output is reduced to the normal level.

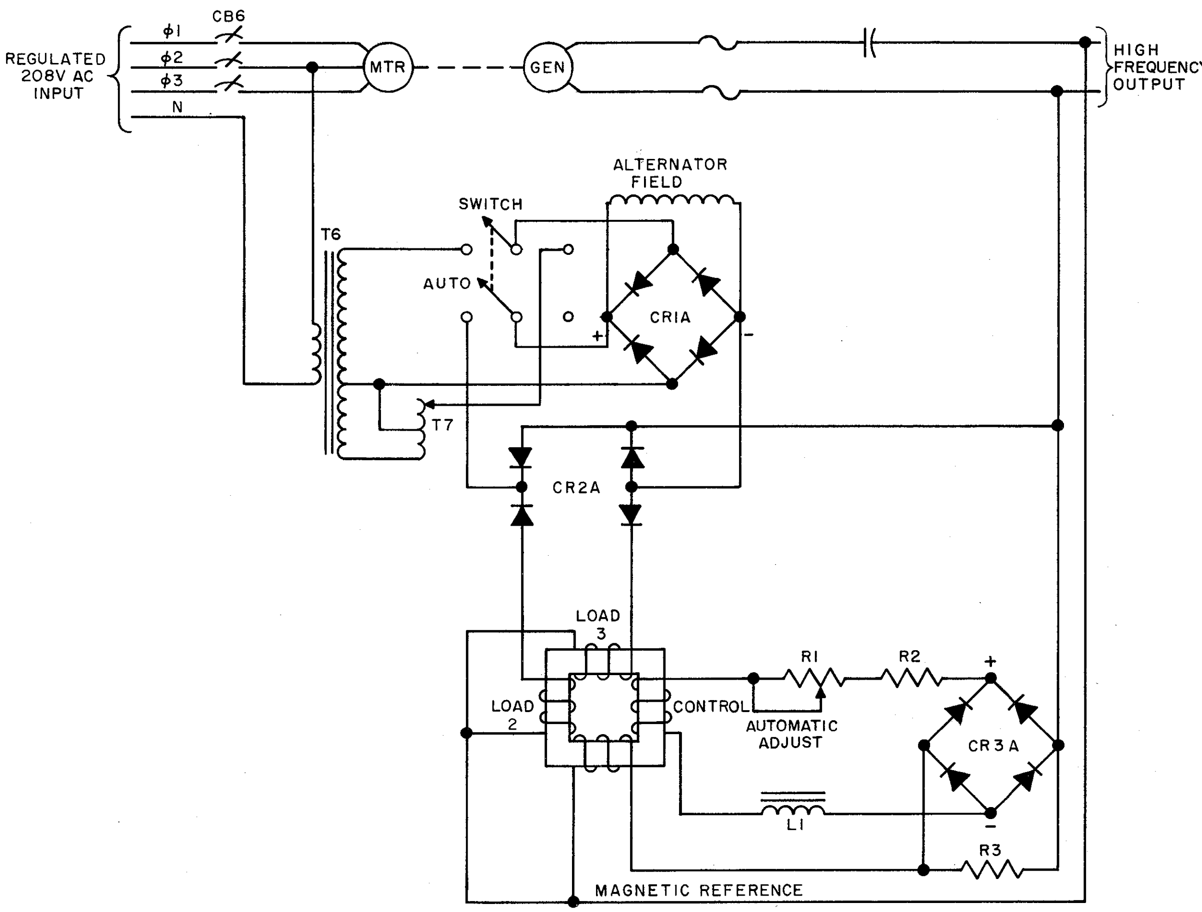


Figure 2–17. High-Frequency Alternator, Automatic Control Circuitry, Simplified Schematic Diagram

CHAPTER 4
D-C POWER SUPPLIES

SECTION 1
GENERAL

1.1 DESCRIPTION OF POWER SUPPLY UNITS

1.1.1 Physical Description

The duplex power supply units (fig. 2–18) are designated units A60 and B60. The simplex power supply units are designated units C61 and D61. Each of the four units is composed of three cubicles: modules A, B, and C. UNIT OFF pushbuttons are located on the front and rear door of each module.

Since each module contains more than one power supply (tables 2–1 and 2–2), components associated with a particular power supply are, wherever possible, placed together in the module. Rectifiers, saturable power reactors, transformers, and filter capacitors are mounted on subassemblies which can be replaced as a unit. The control chassis (regulator section) of each power supply is a drawer-type subassembly mounted on roller slides so that the controls are readily accessible. A high-frequency alternator (Sect. 2, Part 2, Ch 3) is mounted in module B of each unit.

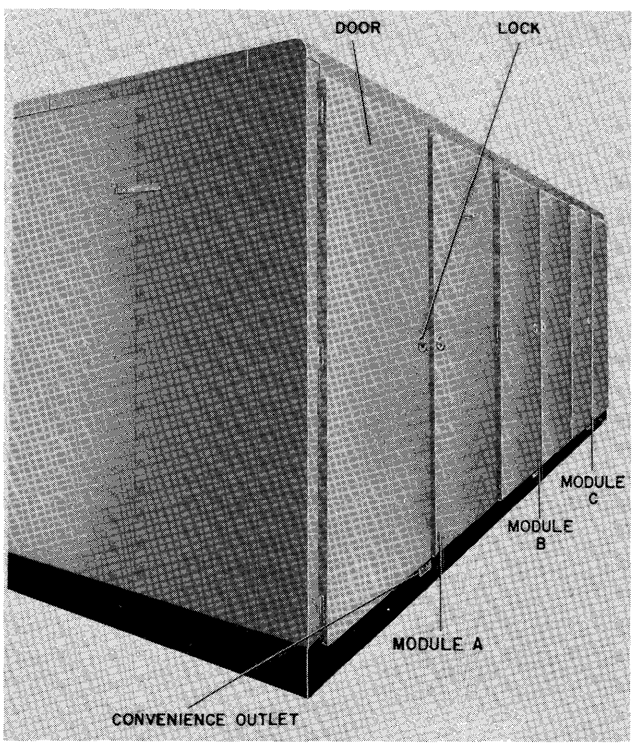


Figure 2–18. Duplex Power Supply, Unit 60

TABLE 2–1. LOCATION OF POWER SUPPLIES, UNITS A60 AND B60

MODULE	POWER SUPPLIES
A	+90V, –150V
B	+600V, +72V, +10V, –15V, –30V
C	+250V, +150V, –48V, –300V

TABLE 2–2. LOCATION OF POWER SUPPLIES, UNITS C61 AND D61

MODULE	POWER SUPPLIES
A	+600V, –300V
B	+90V, +10V, –15V, –30V
C	+250V, +150V, –48V, –150V

1.1.2 Functional Description

Each power supply unit receives unregulated ac from the bus-duct sequencing device and converts it to 11 d-c voltages for duplex equipment. Only 10 voltages are developed in the simplex power supply units since the simplex equipment does not require +72Vdc. The current rating of each supply is given in table 2–3.

In addition to converting 480Vac to the required d-c voltages, the d-c power supplies also regulate the d-c voltages which they produce.

1.2 METHOD OF CONVERSION

The 480Vac generated by the diesel generators is fed to the d-c power supplies through the bus-duct sequencing device. In each individual power supply, this

3-phase, 4-wire ac is fed to the wye-connected primary of an input transformer. The wye-connected, 3-wire, 3-phase a-c output is at approximately the potential of the d-c voltage of the d-c supply. The output of the transformer is rectified by stacks of selenium rectifiers. The d-c output of the rectifiers is controlled by saturable reactors. The latter are controlled by two magnetic-amplifier stages in the control section.

TABLE 2–3. CURRENT RATINGS, D-C POWER SUPPLIES

VOLTAGE	RATED CURRENT (AMP) SIMPLEX	DUPLEX	VOLTAGE	RATED CURRENT (AMP) SIMPLEX	DUPLEX
+600V	85	3	—30V	70	120
+250V	50	65	—150V	80	225
+150V	75	120	—300V	30	55
+90V	60	130	—48V	560	450
+10V	100	45	+72V	—	13
—15V	10	20			

SECTION 2
TYPICAL D-C POWER SUPPLY

2.1 INTRODUCTION

Since all the d-c power supplies produce and control the d-c voltages in a similar manner, only a typical power supply, the duplex +150Vdc supply (5.2.1.2), is discussed in detail. Variations between this supply and other supplies are discussed in Section 3.

2.2 INPUT AND CONVERSION CIRCUITRY

2.2.1 Input Circuitry

Regulated 480 Vac is fed to the primary of wye-connected input transformer T1 (5.2.1.2 and fig. 2–19). The secondary voltage of T1, which is slightly higher than the d-c output voltage, is fed to the load windings of power reactors L1 through L6.

2.2.2 Conversion Circuitry

The output of the load windings of the power reactors is fed to the power rectifiers. These rectifiers and the saturable reactors are arranged so that the load winding of each reactor receives only a half-wave of one phase of current from the output of T1. For example, saturable reactors L1 and L2 are connected only to phase 1 of the transformer secondary. Because of the arrangement of the power rectifiers, the load winding of L2 receives only the positive half-cycle of current from phase 1. While the load winding of L2 is receiving current, the load winding of L1 is prevented from receiving current because of the orientation of its associated power rectifier. During the negative half-cycle of current, the load winding of L1 receives current and the load winding of L2 is isolated from the current source. Similarly, the load windings of saturable reactors L4 and L6 receive only the positive half-cycle of the current of phases 2 and 3, respectively. The load windings of saturable reactors L3 and L5 receive only the negative half-cycles of the current of phases 2 and 3, respectively.

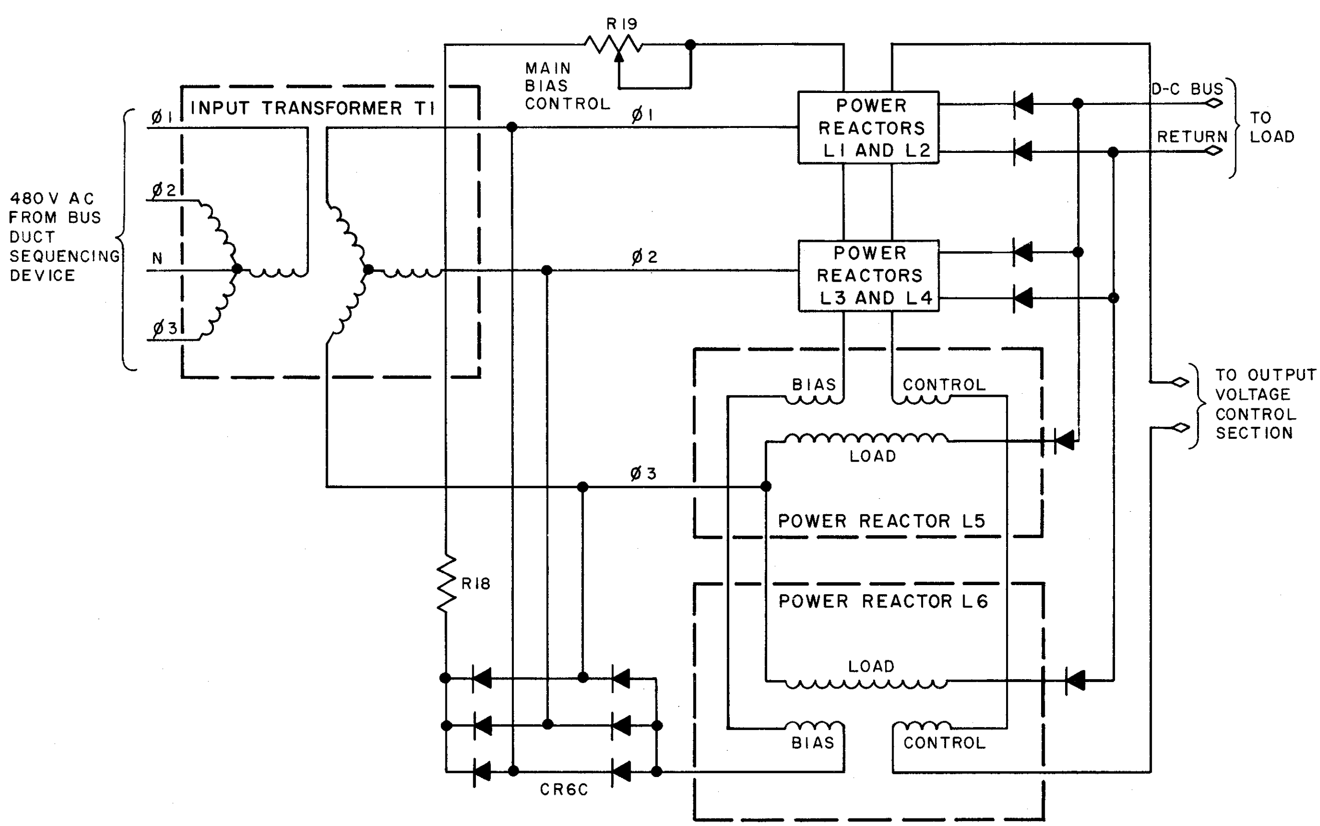


Figure 2–19. Typical Input and Conversion Circuitry, Simplified Schematic Diagram

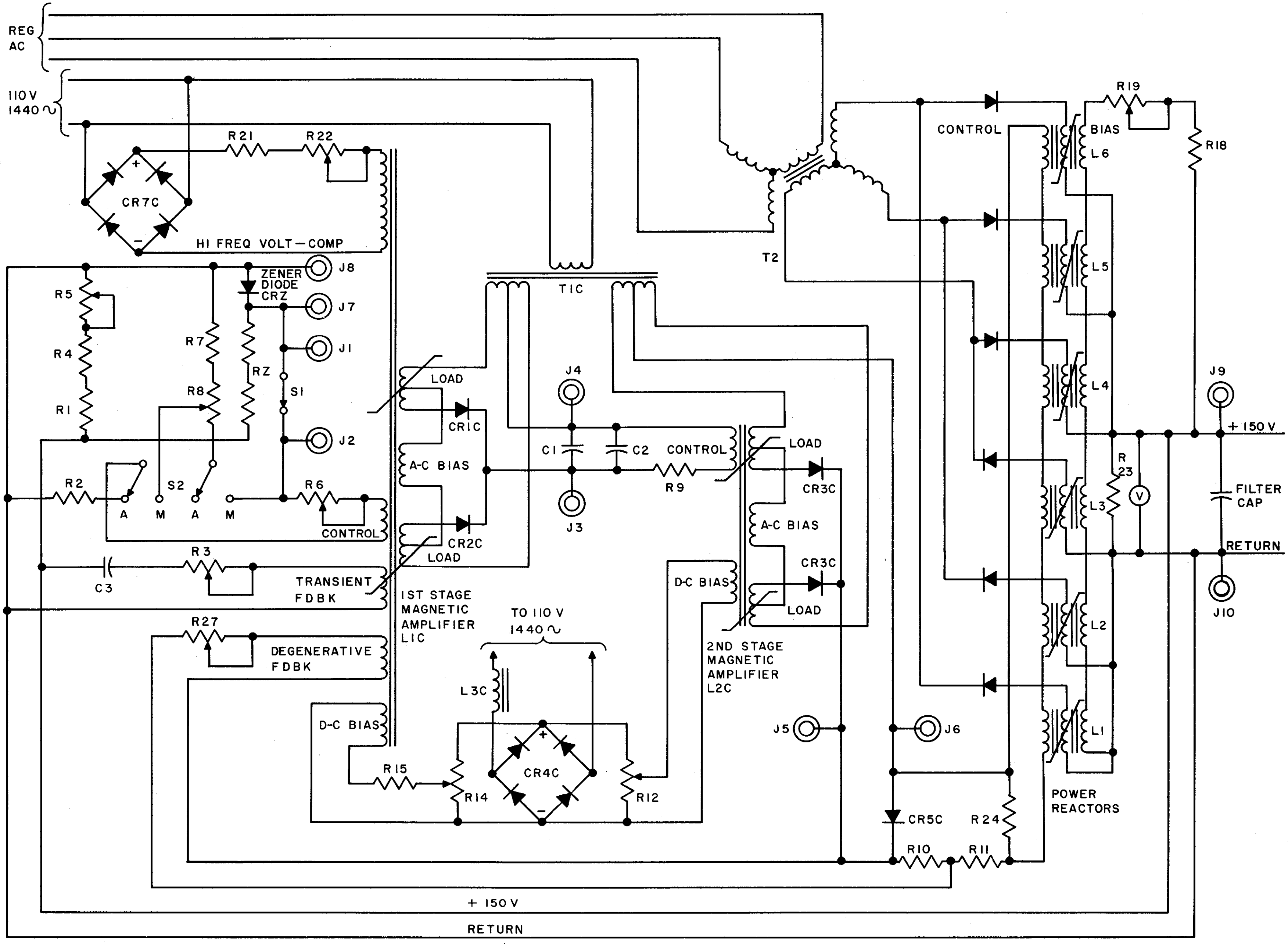


Figure 2—20. Typical D-C Power Supply, Simplified Schematic Diagram

The output of the saturable reactors is the d-c voltage of the supply. This voltage is controlled by the magnetic amplifiers in the control section of the supply. The output of the supply is filtered by filter capacitor C(+150V).

2.3 CONTROL CIRCUITRY

2.3.1 General

The d-c power supplies may be controlled either manually or automatically. The control circuitry for both modes of control consists of a 2-stage magnetic-amplifier control circuit and associated components. The various components, their functions, the controls associated with the circuitry, and typical manual- and automatic-mode circuit operations are discussed below (5.2.1.2 and fig. 2–20).

2.3.2 Manual Control Circuitry

2.3.2.1 General

In manual control, the output of the power supply is monitored by voltmeter VM1. When VM1 indicates that the output voltage is incorrect, MANUAL OUTPUT ADJUST potentiometer R8 is adjusted to return the power supply output to normal (fig. 2–21).

2.3.2.2 Reference Voltage Circuit, Manual Mode

The reference voltage circuit during manual control consists of a Zener diode, resistor Rz, resistor R7, MANUAL OUTPUT ADJUST potentiometer R8, AUTO-MAN switch S2, and reference switch S1.

When the power supply is in operation, the Zener diode provides a constant voltage of about 8.4V. The exact voltage is between 8.2V and 8.6V, depending on the d-c supply. The output voltage of the Zener diode acts as a constant voltage source for potentiometer R8 (5.2.1.2). Changes in power supply output do not change the output of the Zener diode or the voltage available at R8. The amount of voltage tapped off at R8 determines the current which flows through the control winding of first-stage magnetic amplifier L1C. Normally, this current is adjusted by GAIN CONTROL potentiometer R6 to about 1 ma. If the power supply output increases, the movable arm of MANUAL ADJUST potentiometer R8 must be varied so that the voltage fed to the control winding from the diode decreases. This decrease in voltage results in a smaller control current which will return the power supply output to normal.

Conversely, if the power supply output decreases, the movable arm of R8 must be varied to increase the amount of current applied to the control winding.

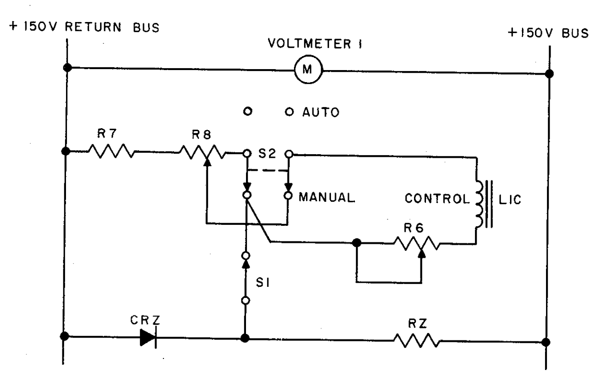


Figure 2–21. D-C Power Supply, Manual Control Circuit, Simplified Schematic

2.3.2.3 First-Stage Magnetic Amplifier

The first-stage magnetic amplifier, LIC (fig. 2–20), is essentially the same as the magnetic amplifier discussed in Part 1, Chapter 3. Additional windings are required on L1C, however, because of its use in a d-c power supply as the first stage of a 2-stage control circuit. These additional windings are the high-frequency-voltage compensation, transient-feedback, degenerative-feedback, and ac-bias windings. These windings plus the control, dc-bias, and load (output) windings are discussed below.

A. Control Winding

The control winding of L1C is designed so that a change in the control current causes a similar change in the flux density of the core.

Note

The cores of the magnetic amplifiers are not normally saturated. The magnetic amplifiers are operated at the knee of the magnetization curve of the core (par. 1.2.3.2, Part 2, Ch 3).

Changes in control-winding current cause proportional flux density changes which, in turn, cause similar changes in the output (load) windings because of the changed impedence of the core of the high-frequency input.

B. Dc-Bias Winding

The core is partially desaturated at all times with the dc induced in it through the dc-bias windings. The biasing current is obtained by rectifying a portion of the high-frequency input with full-wave bridge rectifier CR4C. Changes in bias current result in inverse changes in the magnetic-amplifier output. The dc-bias current is controlled by FIRST STAGE BIAS CONTROL potentiometer R14.

C. High Frequency-Voltage-Compensation Winding

Since the bias windings receive current from the high-frequency alternator, any change in alternator voltage results in a change in bias current. The high-frequency-voltage-compensation winding produces a flux change equal and opposite to that produced in the bias winding by a high-frequency voltage variation. Thus, the effects of high-frequency-voltage variations are nullified by the high-frequency-voltage-compensation winding. Current for this winding is obtained by rectifying a portion of the high-frequency input with full-wave bridge rectifier CR7C. The current flow is controlled by HIGH FREQUENCY VOLTAGE COMPENSATION CONTROL potentiometer R22.

D. Load Windings

The load windings receive voltage from the secondary of HIGH-FREQUENCY INPUT TRANSFORMER T1C. The current in the load windings is determined by the magnetic state of the core which, in turn, is determined by the various currents in the other windings. The current in the load windings varies with the flux density in the core. The output current is rectified by diodes CR1C and CR2C and is applied to the control windings of the second-stage magnetic amplifier.

E. Ac-Bias Winding

Ac-bias windings are added to a saturable reactor to keep the permanent core saturation low and to prevent permanent core magnetization. When the control current is zero, the load current flowing through the load winding magnetically actuates the core unnecessarily. This magnetizes the core and limits the effects of the dc-bias windings. The current in the ac-bias winding reduces the amount of control current required by the magnetic amplifier. The winding is connected between the center taps of the load windings.

F. Transient Feedback Winding

The transient feedback winding senses any transient voltage changes in the output of the d-c power supply and biases the core to compensate for transient voltages which are of too short a duration to be felt by the control windings. The transient feedback winding may be considered as a second control winding which responds to changes which are too rapid to be felt by the control winding. The coil of the transient feedback winding and capacitor C3 form a tuned circuit which responds only to high-frequency transients. Changes in current in this winding cause rapid and compensating changes in the output of the magnetic amplifier.

G. Degenerative Feedback Winding

The degenerative feedback winding provides a means of reducing hunting and oscillation and of increasing the speed and linearity of power supply response. The degenerative feedback current is the rectified output (rectified by CR5C) of the second-stage magnetic amplifier. The feedback current is controlled by DEGENERATIVE FDBK CONTROL potentiometer R20.

2.3.2.4 Second-Stage Magnetic Amplifier

The second-stage magnetic amplifier, L2C, contains control, dc-bias, ac-bias, and load windings. These windings are discussed below.

A. Control Winding

The current in the load windings of L1C is applied to the control winding of L2C through CR1C and CR2C. Capacitors C1C and C2C compensate for the inductive character of the control winding of L2C. Changes in control-winding current cause corresponding changes in the load windings of L2C.

B. Dc-Bias Winding

The dc-bias windings of L2C perform the same function and operate in the same manner as the dc-bias winding of L1C (B of par. 2.3.2.3). The bias current is regulated by SECOND-STAGE BIAS CONTROL potentiometer R12.

C. Ac-Bias Winding

The ac-bias windings of L2C perform the same function and operate in the same manner as the ac-bias winding of L1C (E of par. 2.3.2.3).

D. Load Winding

The load windings receive voltage from HIGH-FREQUENCY INPUT TRANSFORMER T1C. The current in the load winding of L2C is rectified by rectifier CR3C and is applied to the degenerative feedback winding of L1C (G of par. 2.3.2.3) and to the control windings of the saturable power reactors in the conversion section. Changes in the output current of L2C cause corresponding changes in the output of the d-c power supply.

2.3.3 Typical Control Circuitry Operation, Manual Mode

2.3.3.1 General

Assume that the AUTO-MAN switch, S2 (fig. 2–21), is in the MAN position. The reference circuit is now connected as discussed in paragraph 2.3.2.2, and the d-c power supply is operating in the manual mode of voltage control. With the switch in the MAN position, the output voltage can be varied only by changing the setting of potentiometer R8; the output voltage will not correct itself automatically.

2.3.3.2 Output Voltage Variations

Assume that the power supply is in manual control and the output voltage increases. The voltage across the Zener diode will remain constant at about 8.4V. The voltage at potentiometer R8 and the current in the control winding of L1C will therefore remain constant. When the operator observes that the power supply output voltage (read on VM1) has increased, he will vary the setting of R8 so that less current will be applied to the control winding.

A decrease in control current tends to reduce the flux density of the core and increase the impedance of the load windings. Since the output current is inversely proportional to the impedance of the winding, the output current decreases. The rectified output is applied to the control winding of the second-stage magnetic amplifier.

When the current in the control winding of L2C decreases, the flux density of the core is reduced, the impedance of the load winding is increased, and the output is decreased. The output current of L2C is rectified and fed to the control winding of each of the power reactors in the conversion section.

The power reactors respond to the decreased control current in the same manner as the first- and second-stage magnetic amplifiers. Since the output of the saturable power reactors is the d-c voltage of the supply, reducing the control current on the reactors reduces the output of the supply. When the output of the power supply decreases, R8 is varied to increase the control current of the first stage with a consequent increase in stage output. The second-stage output increases, and the power supply output increases to normal voltage.

2.3.3.3 High-Frequency Voltage Variations

The high-frequency-voltage-compensation winding (C of par. 2.3.2.3) compensates for variations in the 110Vac output of the high-frequency alternator. The rectified output of the alternator is applied to the compensation winding so that a change in current (proportional to an a-c voltage change) offsets the effects of the change in the d-c bias current. The net result is that there is no change in the output of the magnetic amplifier.

2.3.3.4 Output Voltage Surges

The transient feedback windings compensate for sudden changes in output voltage. If the d-c output increases, the current in this winding increases and tends to reduce the output of the magnetic amplifier stage.

2.3.4 Automatic Control Circuitry

2.3.4.1 General

Automatic voltage control differs from manual control in that the control current for L1C is not obtained from the Zener diode but by sensing changes in the power supply output.

During automatic operations, the AUTO-MAN switch is in the AUTO position. Normally, the d-c power supplies are automatically controlled.

2.3.4.2 Reference Voltage Circuit, Automatic Mode

In automatic operations, the reference input circuit consists of the Zener diode, resistor Rz, a voltage-divider network composed of resistors R1 and R2, AUTOMATIC VOLTAGE ADJUST potentiometer R5, AUTO-MAN switch S2, and reference switch S1 (fig. 2–22).

The output voltage of the Zener diode is opposed by the portion of the d-c supply voltage tapped across the voltage divider network composed of R1 and R2 (fig. 2–22). The voltage across the Zener diode is higher than that across the voltage divider network. Under automatic voltage control, any change in the power supply output voltage results in a similar change across the voltage divider. The difference between the voltage across the divider and the output voltage of the Zener diode determines the current which flows through the control winding of the first-stage magnetic amplifier. Since the Zener diode voltage is higher, an increase in voltage across the voltage divider network (i.e., an increase in d-c output voltage) decreases the difference in voltage between the Zener diode output and the voltage output of the voltage divider network. This decrease in voltage results in a smaller control current. Conversely, a decrease in d-c output voltage results in a greater control current.

2.3.4.3 First-Stage Magnetic Amplifier

The operation of the first-stage magnetic amplifier is the same in automatic control as it is in manual con-

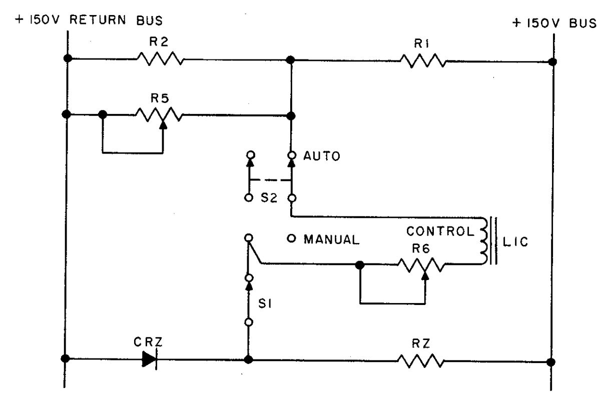


Figure 2–22. D-C Power Supply, Automatic Control Circuit, Simplified Schematic

trol (par. 2.3.2.3). The only difference is in the method used to obtain control current for this stage.

2.3.4.4 Second-Stage Magnetic Amplifier

The operation of the second-stage magnetic amplifier is the same under either mode of control. Refer to paragraph 2.3.2.4.

2.3.5 Typical Control Circuit Operation, Automatic Mode

2.3.5.1 General

In the automatic mode of operation, the power supply will automatically produce a closely regulated d-c voltage. The automatic mode is the normal operating mode for the power supplies.

2.3.5.2 Output Voltage Variations

Assume that the output of the typical d-c power supply increases above the nominal output voltage. When the output rises, the voltage at the midpoint of voltage divider R1 and R2 (5.2.1.2 and fig. 2–20) also rises. The difference between this voltage and the output of the Zener diode determines the current in the control winding of L1C. An increase in d-c output voltage increases the voltage at the midpoint of the divider and decreases the voltage difference between the diode and the divider. Since the load on the circuit remains constant, the normal 1-ma current in the control winding of L1C decreases. The first- and second-stage magnetic amplifiers react to this decreased control current in the manner discussed in paragraph 2.3.3.2 to bring the power supply output down to normal.

2.3.5.3 High-Frequency Voltage Variations

The control circuitry responds to variations in high-frequency voltage in the same manner in either mode of control. Refer to paragraph 2.3.3.3.

2.3.5.4 Output Voltage Surges

The control circuitry responds to output voltage surges in the same manner in either mode of control. Refer to paragraph 2.3.3.4.

SECTION 3

D-C POWER SUPPLY VARIATIONS

3.1 GENERAL

Although the d-c power supplies are similar in operation, there are variations in the filtering circuits. These variations are discussed below.

3.2 FILTERING CIRCUITS

All of the d-c power supply outputs are filtered by banks of filter capacitors. In addition to the capacitors, the duplex +10V and both −30V power supplies (5.2.1.4, 5.2.1.6, and C/D 5.2.1.6) have a choke-coil filter installed in series with the output. This filter is required on these low-voltage, high-current power supplies to prevent the power supply output from oscillating when the load is comparatively small.

The induction filter also partially isolates the power reactors from the line transients. Assume a heavy load is placed on the output. The output current drops and the filter capacitors discharge. The inductance of the coil changes the time constant of the circuit so that the effect of the current change is felt by the control circuits before it is felt by the power reactors. As a result, the control circuits have time to correct the output voltage before the transient is felt by the power reactor circuits.

CHAPTER 5

METERING EQUIPMENT

SECTION 1

GENERAL

1.1 INTRODUCTION

The d-c and a-c voltages are monitored by ammeters and voltmeters installed on the PCD units. A voltmeter is also installed on the front panel of the control chassis of each d-c power supply.

The four meters on the PCD units are the DC AMMETER which indicates output current of the selected d-c power supply; the AC VOLTMETER which indicates the a-c voltage of the selected a-c power; the RIPPLE VOLTMETER which indicates the peak-to-peak ripple voltage (a-c component) in the d-c output; and the DC VOLTMETER which indicates d-c output voltage. These meters are discussed in this section. The ripple voltmeter, as a typical meter, is discussed in Section 2. The voltage monitor relays are discussed in Section 1, Part 3, Chapter 3.

1.2 D-C AMMETER

Each power supply has an ammeter shunt in its d-c return lead. When the selector switch is operated to any of its positions (except position 1), the meter is placed in parallel with the shunt of the power supply selected. For example (fig. 2—23), if the selector switch is operated to position 10, current flows from the d-c return through a shunt to the +150V supply. Meter current flows from the d-c return through contacts 10-1a of the middle deck, through the meter terminals, and through contacts 10-1a of the rear deck to the +150V supply. The ammeter circuits for the other power supplies are similar.

1.3 A-C VOLTMETER

The contacts of the selector switch associated with the a-c voltmeter are divided into four groups. One

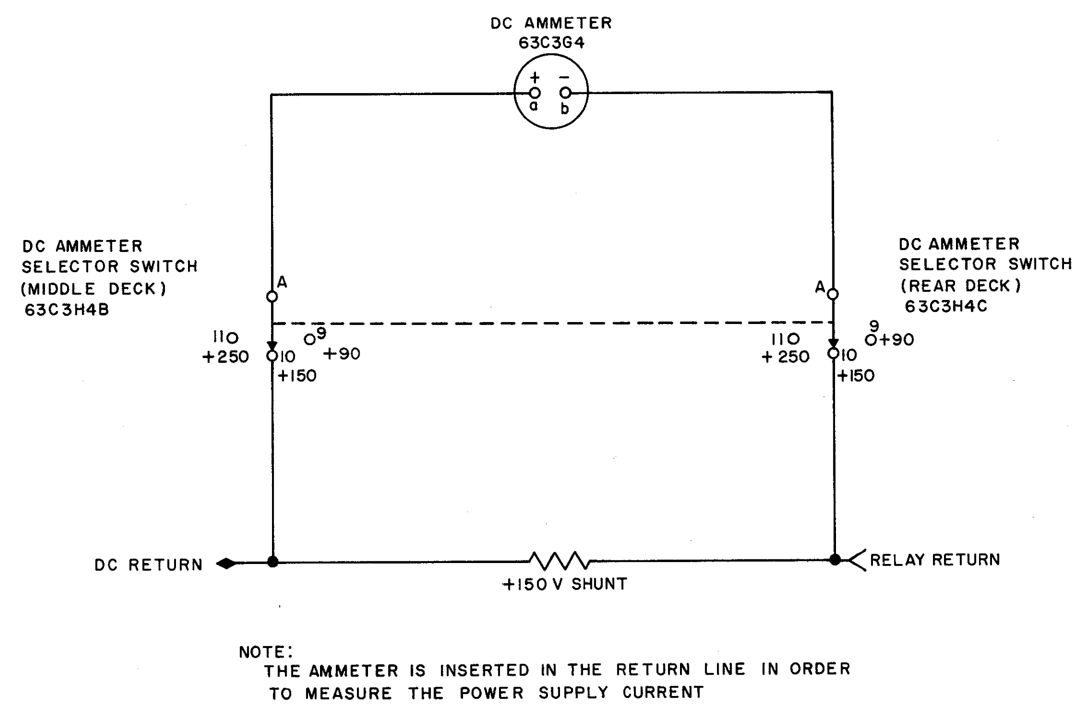


Figure 2—23. PCD Unit, Typical Ammeter Circuit, Simplified Schematic Diagram

group, consisting of contacts 2, 3, and 4, connects the meter to measure phase-to-phase voltages. For example, if the selector switch is placed in position 2, the voltage between phase 3 and phase 1 of the unregulated d-c line is indicated. Terminal b of the voltmeter is connected to phase 3 as follows: From terminal b of the voltmeter, the circuit to the phase-1 line is completed through contacts a-2 of the middle deck, contacts a-2 of the front deck, and contacts 7 and 4 of the rear deck. The phase-3 line is connected through contacts a-2 of the rear deck to terminal a of the meter. At position 3 of the selector switch, the voltmeter is connected across the phase-2 and -3 lines. At position 4, the meter is connected across the phase-1 and -2 lines.

A second group of contacts of the selector switch connects the meter across any one of three unregulated a-c voltage lines and neutral. Contacts 5, 6, and 7 of the middle deck connect to the unregulated a-c neutral line. These same contacts on the rear deck tie into contacts 2, 3, and 4 of the rear deck and make connections to the unregulated a-c voltages.

The third group, contacts 8, 9, and 10, places the voltmeter for phase-to-phase readings of the a-c input to the d-c power supplies. The interconnections of contacts 10, 9, and 8 of the middle deck insert a resistance in the circuit so that the meter can be used to read the high-phase-to-phase voltage. The same contacts on the rear deck connect the meter to phases 1, 2, and 3, respectively.

Contacts 1, 11, and 12 compose the fourth group. These contacts place the voltmeter across regulated a-c neutral and one of the three regulated a-c phases. At position 1, for example, the voltmeter indicates regulated a-c voltage between regulated a-c neutral and regulated a-c phase 1.

1.4 RIPPLE VOLTMETER

The ripple voltmeter (Sect. 2) is connected across the outputs of the d-c supplies. One side of the meter is connected to the d-c return. The other side is connected to the particular voltage supply selected through the voltage divider circuit. The meter has its own small power supply.

The front deck of the selector switch connects the meter to the d-c return at all 12 positions. The middle deck selects the desired power supply. The rear deck provides voltage-divider selection. Varying the moving contact on the rear deck either adds or removes resistance in the voltage-divider circuit. However, each switch position always includes the 10K and 240K resistors and the capacitor.

To measure the amount of ripple present in the +600V supply, the selector switch is placed in position 12. A d-c return is immediately available from the front deck at position 12. Contact 12 on the middle deck of the selector switch, connects the meter to the +600V power supply. Contact 12 on the rear deck connects the entire voltage divider network (except the 1K resistor) to the meter circuit.

1.5 D-C VOLTMETER

The selector switch associated with the d-c voltmeter connects the meter across the power supply to be measured and selects the appropriate multiplier resistor for that power supply. For the positive power supplies, the middle deck of the switch connects terminal a of the meter to the power supply through the selected multiplier resistor; the rear deck connects terminal b of the meter to d-c return. For the negative supplies, terminal a is connected to d-c return by the middle deck; terminal b is connected to the supply through the multiplier resistor. For example, consider the metering circuit for the +600V supply. When the selector switch is rotated to position 1, electron flow is from the d-c return through contact 2 of the middle deck to contact 1 of the rear deck. From this point, the current flows through contact 13, the meter terminals, contacts 13-1 of the middle deck, and the 750K multiplier resistor to the positive side of the +600V supply. The metering circuits for the remaining power supplies and for the 130V battery supply are similar to the circuit described above.

SECTION 2
RIPPLE VOLTMETER

2.1 INTRODUCTION

The ripple voltmeter (fig. 2–24) is an a-c, vacuum-tube voltmeter (VTVM) consisting of a peak-to-peak reading voltmeter (the voltmeter is actually an rms-reading meter calibrated in volts, peak to peak), a 2-tube negative feedback amplifier, and a power supply.

The purpose of this voltmeter is to measure directly the ripple component associated with any of the 11 d-c voltages supplied by the d-c power supply unit. A selector switch permits the selection of any of these 11 voltages for ripple component measurement. Multipliers associated with the particular range selected are automatically inserted in the input circuit by the selector switch.

2.2 VOLTMETER CHARACTERISTICS

The characteristics of the ripple voltmeter are listed in table 2–4.

2.3 THEORY OF OPERATION

Excessive ripple (pulsations in d-c voltage caused by unfiltered a-c harmonic components) causes noise, signal distortion, and other undesirable effects which usually prevent electronic equipment from functioning properly. For this reason, it is often found necessary to measure the amount of ripple present in a d-c supply output voltage and to determine whether or not the ripple is excessive.

When a d-c voltage is to be examined to determine the magnitude of ripple voltage, the selector switch is set to the range required to measure the selected voltage (fig. 2–23). Voltage is then applied through the selected multiplier and the 0.047-uf capacitor to the control grid of the 5702 tube, the first voltage amplifier. The 0.047-uf capacitor blocks all d-c voltages, permitting only the ripple component to be applied between the grid and the cathode of the first voltage amplifier. The 1-megohm input resistor has the dual function of setting the input impedance at approximately 1 megohm and bypassing the input dc to ground.

The ripple voltage is amplified by the first voltage amplifier and applied through a 0.047-uf capacitor to the control grid of the 5719 power amplifier tube. The output voltage of this final amplifier stage is then developed across the 47K plate load resistor. The output

TABLE 2–4. CHARACTERISTICS OF RIPPLE VOLTMETER

CHARACTERISTIC	SPECIFICATION
Frequency range	20-50,000 cps
Scale indication	Scale reads peak-to-peak volts based on a sine-wave input
Scales (or multiples thereof)	1V and 0-2.5V
Scale divisions for both scales	0.5V
Sensitivity	10-mv rms for full-scale deflection
Accuracy	3% of full-scale reading
Power requirements	6.3Vac, 60 cycles at 0.45 amp for tube filaments. 125-200Vdc at 1.5 ma ±20% for the tube plate supply
Input impedance	1 megohm
Tubes used:	
First voltage amplifier stage	5702 tube
Output stage	5719 tube
Bridge rectifier	Four 1N51 crystal rectifiers

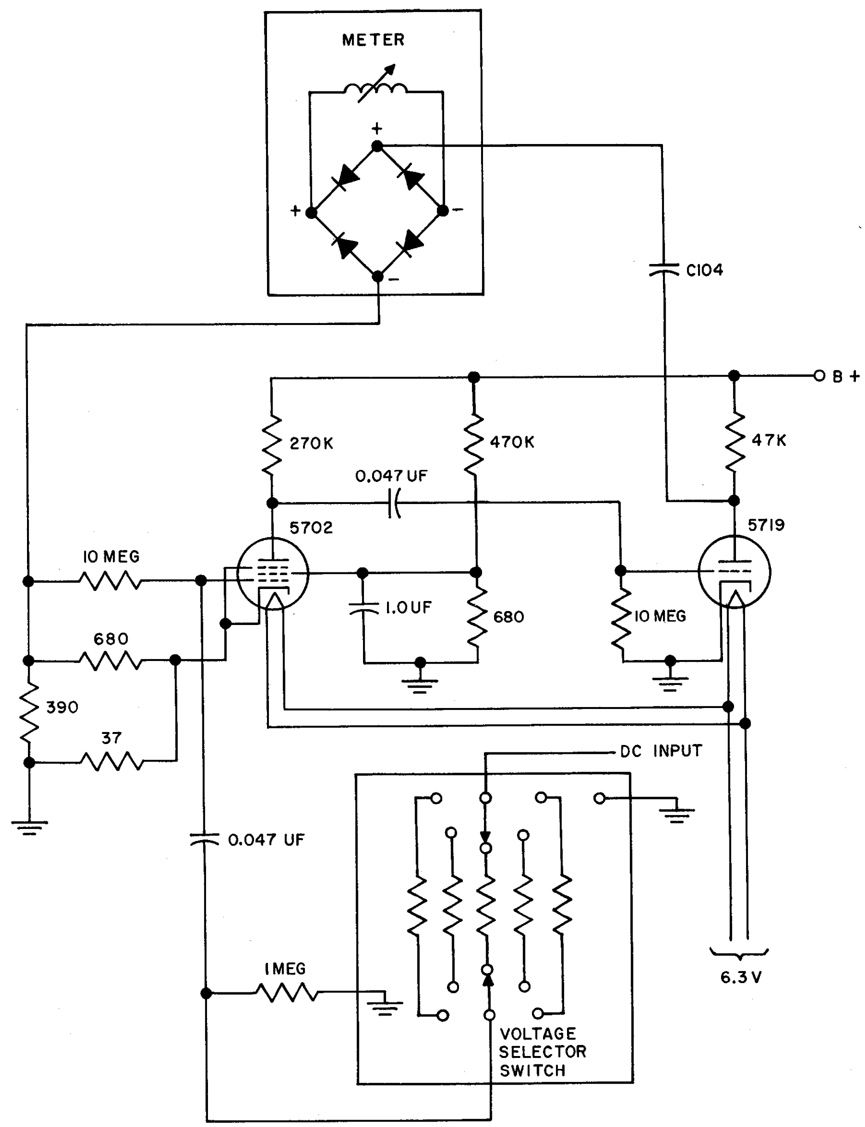


Figure 2–24. Ripple Voltmeter, Simplified Schematic Diagram

voltage of this 2-stage amplifier (amplified ripple voltage) is then applied, through series-blocking capacitor C104, across the series combination of a bridge rectifier and a network of resistors in the cathode circuit of the first voltage amplifier.

2.3.1 Metering and Feedback Circuitry

The bridge rectifier is a full-wave rectifier. An rms-reading voltmeter with the scale calibrated in volts, peak to peak, is connected across the bridge rectifier output terminals. The rectified amplifier-output voltage therefore actuates the voltmeter, and the meter reading is proportional to the amount of ripple voltage present.

A portion of the return path for the output ripple voltage consists of the network of 680-, 390-, and 37-ohm resistors in the cathode circuit of the first voltage amplifier tube. The amplified output is therefore fed back to the cathode of the input stage approximately 360 degrees out of phase with the input voltage (degenerative feedback). Because of the even number of stages involved, feedback is most conveniently introduced into the cathode circuit of the first voltage amplifier.

The use of a degenerative amplifier allows the ripple voltmeter amplifier to be independent of gain variations caused by tube aging, supply voltage variations, and circuit component value changes. Noise or hum voltage components introduced by the amplifier itself are also greatly reduced. Therefore, a highly stable, reliable, and accurate ripple voltmeter is obtained with the aid of negative feedback.

2.3.2 Ripple Voltmeter Power Supply

The B+ and filament power is supplied to the ripple voltmeter's amplifier by a small power supply especially built for this purpose. Except for six output and input soldering terminals, the supply is a completely sealed unit. Input voltage supplied to the two line terminals is 120Vac, 60 cycles. Output voltages and currents are 125 to 160Vdc, at 15 ma for B+ power and 5.5 to 7.0Vac, 60 cycles, at 0.5 amp for filament power.

PART 3
DUPLEX DISTRIBUTION AND CONTROL

CHAPTER 1
GENERAL

SECTION 1
INTRODUCTION

1.1 SCOPE

The same units are used for both distribution and control within the Power Supply System. Distribution and control are discussed in Chapters 2 and 3 of this part. The discussion explains the flow of power from the powerhouse to the load units. Each type of power (regulated ac, unregulated ac and dc) is discussed separately, and the distribution and control circuitry for each is traced from its source to the load units (figs. 3–1 and 3–2).

Only the duplex distribution and control circuitry and the duplex PCD, MCD, and load units are discussed in this part. For a discussion of simplex control and distribution circuitry, refer to Part 4.

1.2 DESCRIPTION OF UNITS

1.2.1 General

The units described below are associated with duplex equipment A and B. Therefore, there are two of each unit described, one associated with each computer. Since units A and B are identical, the following descriptions apply to both. The duplex power supply units are described in Section 1 of Part 2, Chapter 4.

1.2.2 PCD Unit 63

1.2.2.1 Physical Description

Each PCD unit 63 (fig. 3–3) 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 a-c voltmeter; and with the unregulated-ac circuits of the MCD units, the card machines, the drum motors, the convenience outlets, and the tape drive motors.

1.2.2.2 Functional Description

Unit 63 receives 11 d-c voltages from unit 60 (par. 1.1.2, Part 2, Ch 4), unregulated 208Vac from the substations, regulated 208Vac from the induction regulators, 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 (figs. 3–1 and 3–2).

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.

1.2.3 MCD Units

1.2.3.1 General

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 in table 3–1.

TABLE 3–1. 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

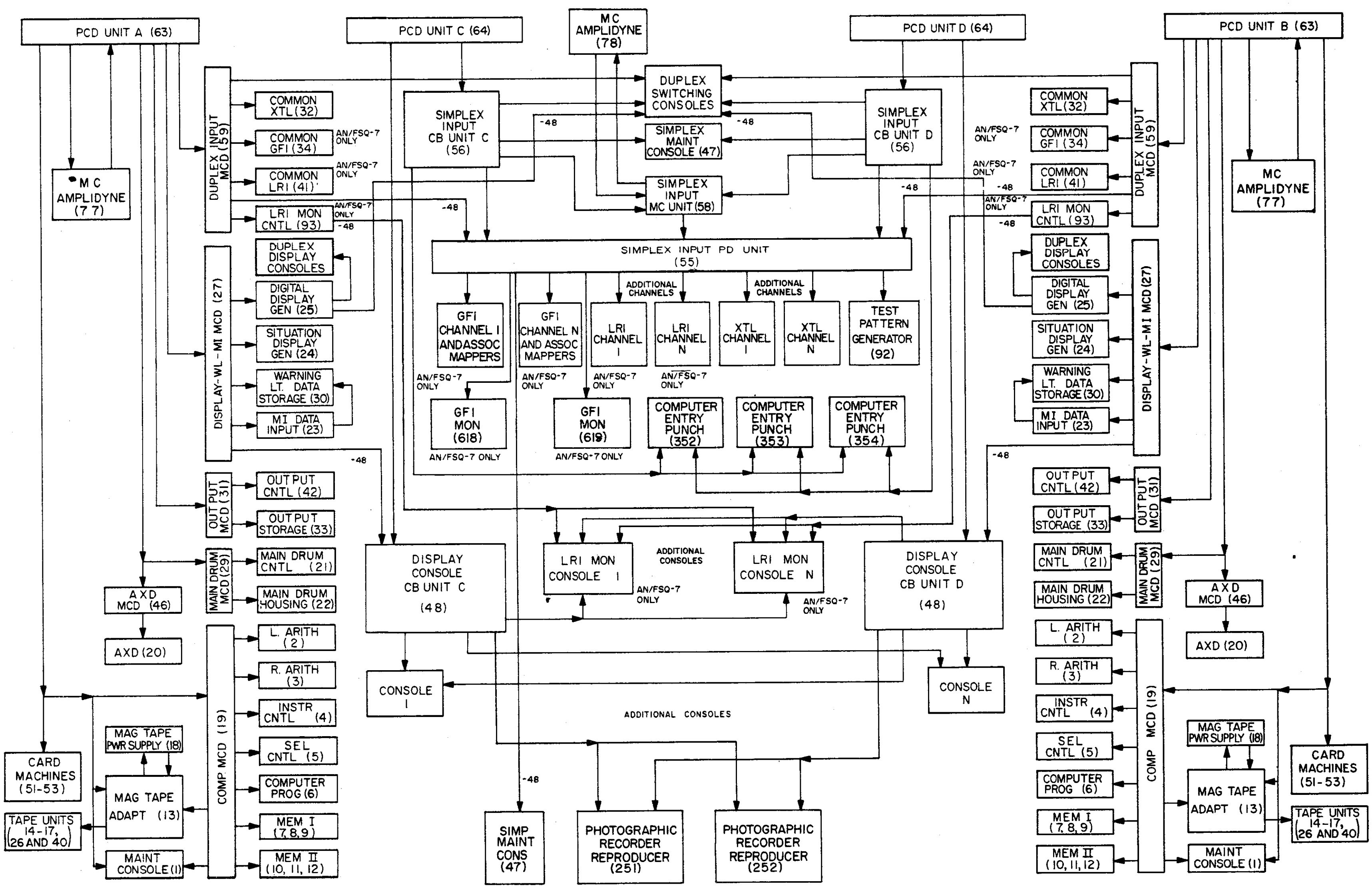


Figure 3–1. Power Distribution, AN/FSQ-7, Block Diagram

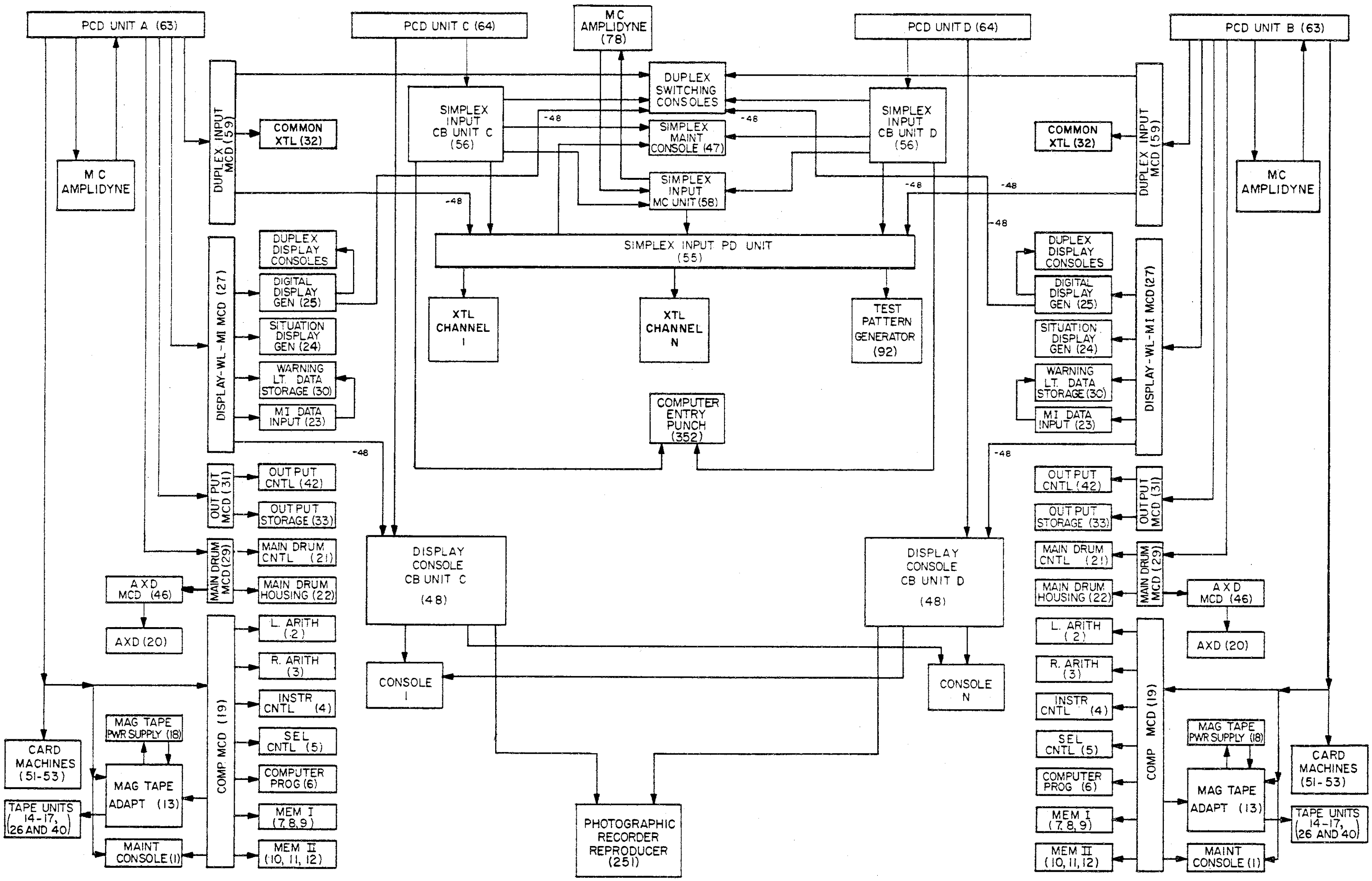


Figure 3—2. Power Distribution, AN/FSQ-8, Block Diagram

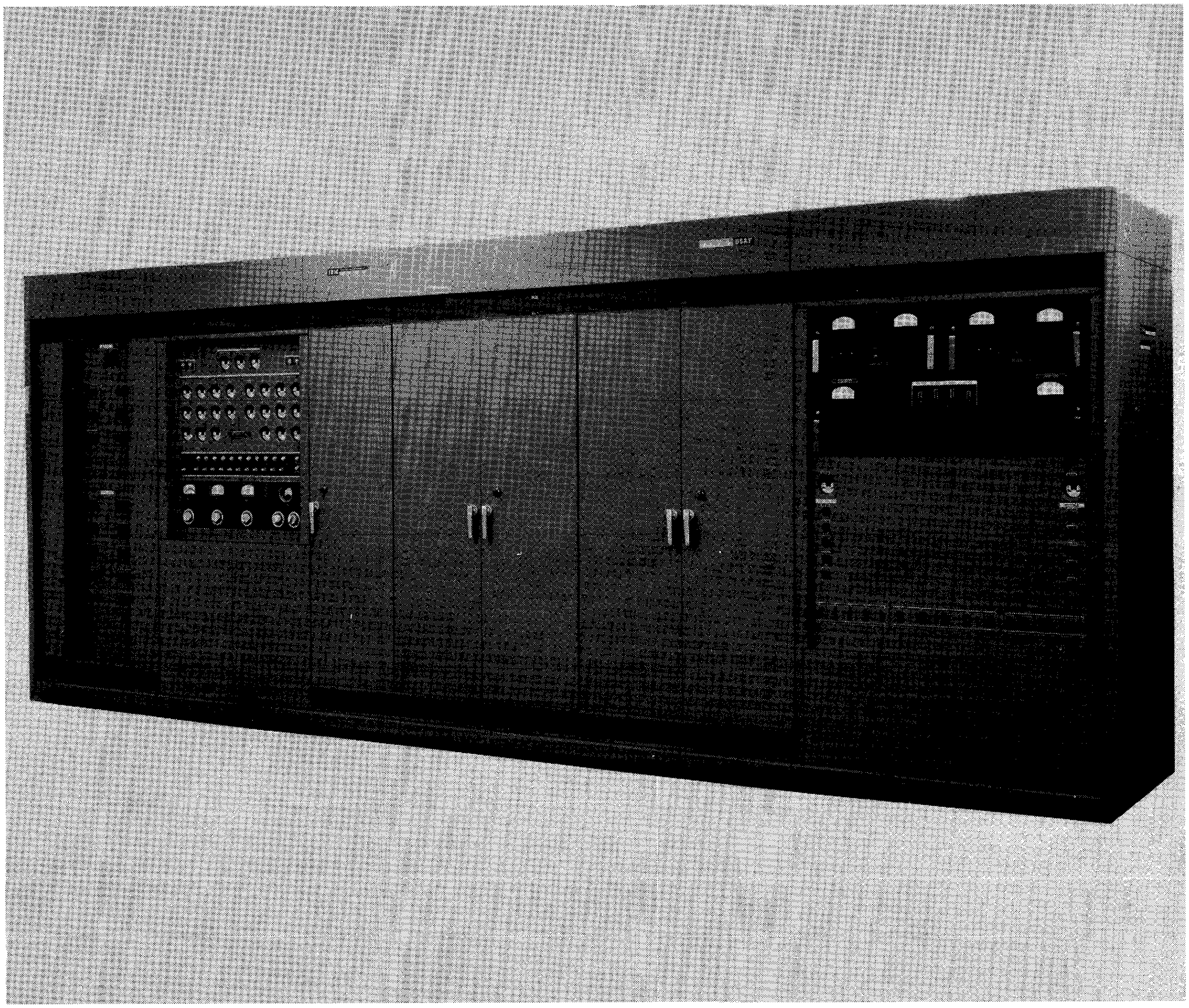


Figure 3–3. PCD Unit 63

1.2.3.2 Physical Description

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 3–4. All MCD units contain contactors, distribution and MC relays, line CB's, MC CB's, and control components and indicators.

1.2.3.3 Functional Description

The MCD units control and distribute power to the load units (table 3–2) and introduce a variable voltage during MC operations. Besides the functions listed in table 3–2, units 27, 31, and 59 serve an additional function in signal status switching. Unit 27 provides a signal which initiates the power 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.

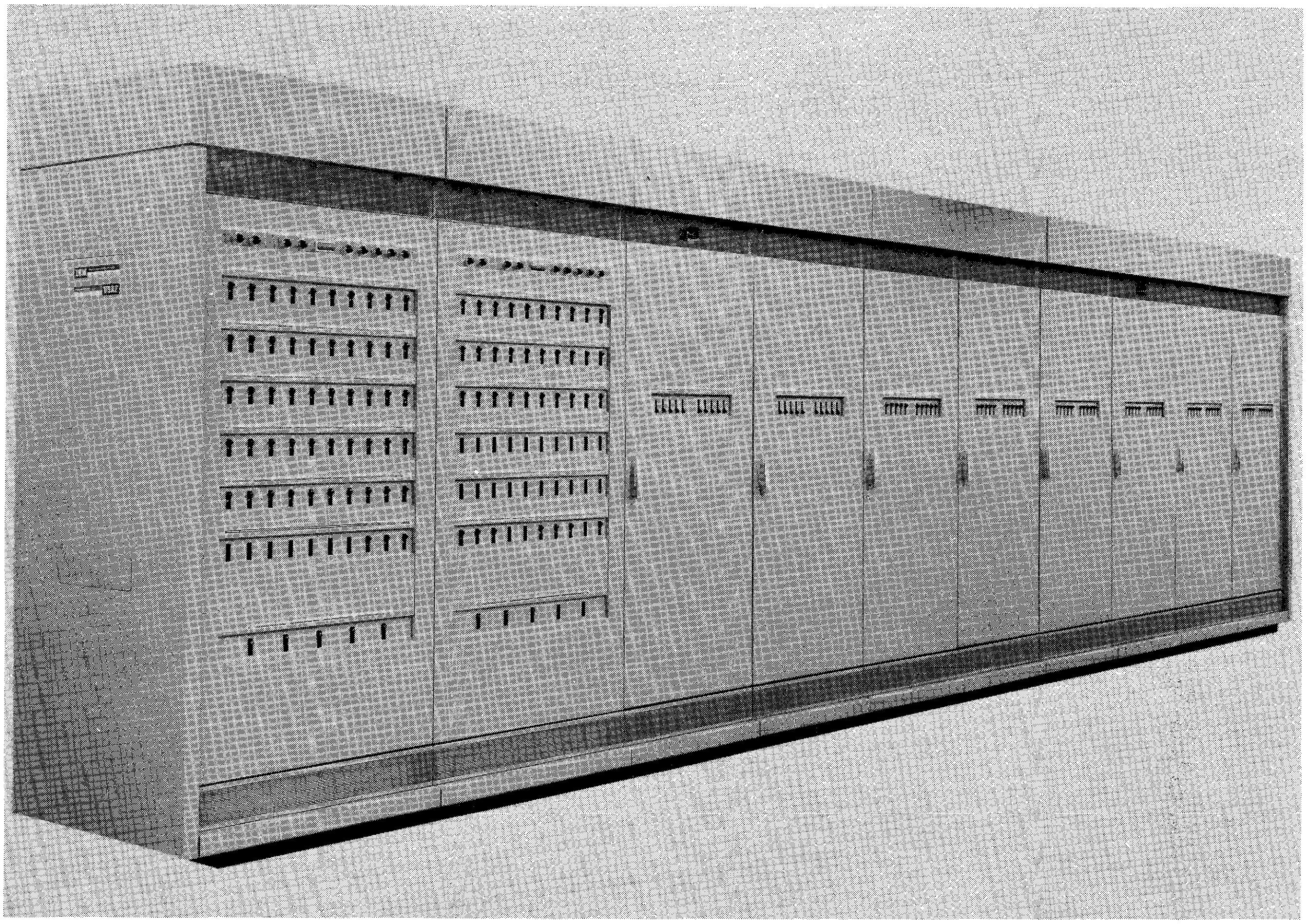


Figure 3–4. Computer MCD Unit 19

TABLE 3–2. Z MODULES FOR LOAD UNITS

MCD UNIT	UNIT CONTAINING Z MODULE	ASSOCIATED LOAD UNITS
19	2	
	3	
	4	
	5	
	6	
	9	7 and 8
	12	10 and 11
	13	18, 14, 15, 16, and 17
27	23	30
	24	
	25	
29	21	
	22	
	None	Drum motors
31	33	
	42	
46	20	
59	93	
59 module E		32 (common equipment only)
		34 (common equipment only)
		41 (common equipment only)

Note: Units 34 and 41 are found only in AN/FSQ-7 equipment.

Note

In AN/FSQ-8 equipment, there is no unit 34 or 41. These units appear only in AN/FSQ-7 equipment.

1.2.4 Load Units

1.2.4.1 Physical Description

There are many types of load units all of which are divided into modules. The left arithmetic element, unit 2, is a typical load unit (fig. 3–5). 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 the top of most modules. The filament transformers receive regulated, single-phase 120Vac from the induction regulator and produce two regulated 6.3Vac outputs at 35 amperes each. The 6.3Vac outputs may be used in series, in parallel, or separately.

1.2.4.2 Functional Description

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

The Z module receives power from the MCD unit and distributes it through CB's to the other modules in the unit. Consequently, the status of the load unit may be controlled from the Z module.

The three transformers in each module transform the regulated ac to the filament voltages required by the electron tubes in that module.

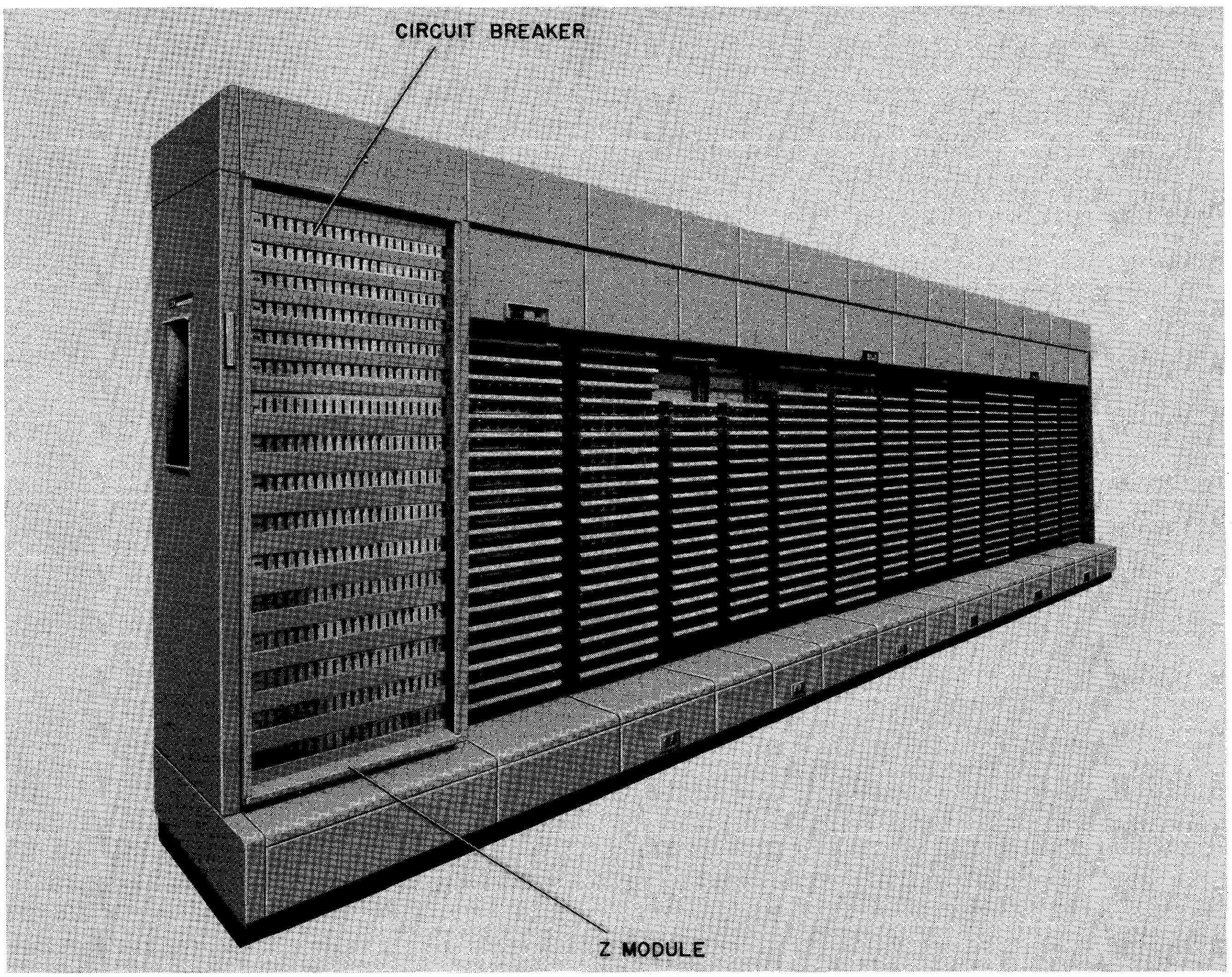


Figure 3–5. Left Arithmetic Element, Unit 2

SECTION 2
OVERALL ANALYSIS

2.1 INTRODUCTION

The distribution and control circuitry is identical in both portions of the duplex equipment. Power system A is used as a typical example. The power distributed includes unregulated ac, regulated ac, and 11 d-c voltages.

2.2 POWER DISTRIBUTION

2.2.1 Unregulated A-C Distribution

Unregulated 480Vac is produced by the diesel generators. This high a-c voltage is fed to the d-c power supplies, the substations, and the load centers. The d-c power supplies convert the unregulated ac to 11 d-c voltages. The substations and load centers transform the 480Vac to unregulated 208Vac. The output of the load center is regulated by the induction regulators; the output of the substation is distributed to the PCD unit, the MCD units, and the convenience outlets at the base of the load units. Since this voltage is used during maintenance activities, it is not removed by a normal power-off sequence. Unregulated ac is also used to operate the drum motors, magnetic tape drive motors, amplidyne motor, and for other applications.

2.2.2 Regulated A-C Distribution

Regulated 208Vac is the output of the induction regulators. This voltage is distributed to PCD unit 63 and the load units. The regulated ac fed to the PCD unit is distributed to the MCD units and the tube circuits in the load units. The regulated ac, fed directly to the load units from the induction regulators, is distributed to the filament transformers in the load modules. The filament transformers step the regulated ac down to 6.3V and 12.6V regulated ac for use by the tube filaments.

2.2.3 D-C Distribution

The d-c voltages produced by unit 60 are fed to PCD unit 63. The PCD unit distributes the 11 d-c voltages to the six MCD units and the load units for application to the electronic circuitry.

2.3 POWER CONTROL

2.3.1 Unregulated A-C Control

Unregulated ac is controlled by a CB in unit 63 and by CB's in the MCD units. Separate unregulated-ac CB's are used to control this voltage to each drum motor and tape drive motor. Since the load units do not have unregulated-ac CB's, this voltage is removed from the load unit by the CB in the associated MCD unit.

2.3.2 Regulated A-C Control

During a normal power-on sequence, regulated ac is applied to the load units before any dc is applied This procedure permits the tubes to warm up before being subjected to operating voltages. An ac-on signal may be initiated at unit 63 for all the associated duplex equipment, at an MCD unit for the associated load units, or at the Z module of a load unit for that load unit. The regulated ac may be removed by opening the regulated-ac CB's in the PCD unit, the MCD units, or the Z module of the load units.

2.3.3 D-C Control

The voltages are applied to the tubes in at least two steps after the tubes have been warmed up by regulated ac. The application of the d-c voltages is initiated by a dc-on signal during a normal power-on sequence. The d-c voltages may be removed by opening the knife switches in the PCD unit, the CB's in the MCD units, or the CB's or the DC ON – DC OFF switch at the Z module of the load units.

CHAPTER 2
ANALYSIS OF DUPLEX DISTRIBUTION CIRCUITRY

SECTION 1
INTRODUCTION

1.1 SCOPE

This chapter describes the circuitry which distributes the unregulated and regulated ac and the d-c voltages throughout the duplex portion of the Power Supply System. A block diagram analysis of the distribution facilities provides an overall description of power distribution for the duplex load equipment. The detailed analysis of duplex distribution circuitry describes the distribution of the a-c voltages and a typical d-c voltage through typical power supply units.

1.2 GENERAL

The same units are used to distribute and control power. These units are described in Chapter 1, Section 1. Power distribution begins in the powerhouse. In the powerhouse the unregulated 480Vac output of the diesel generators is applied to bus bars for distribution to the Operations (Computer) Building.

In the Operations Building, a portion of the unregulated high-voltage ac is transformed to a lower voltage. A portion of the lower-voltage ac is regulated; the remainder is distributed to the load units as unregulated ac. The remaining unregulated high voltage is fed to the d-c power supplies, unit 60, where it is rectified to 11 d-c voltages. The dc voltages are then distributed to the load units. The following discussion of distribution circuitry includes only that equipment under the cognizance of IBM personnel. The distribution circuitry within the powerhouse is not discussed.

SECTION 2
UNREGULATED A-C DISTRIBUTION

2.1 GENERAL

Unregulated high-voltage ac is used as the input to the d-c power supplies, the load centers, and the substations. The load centers and substations reduce the 480Vac to 120/208Vac. The unregulated low voltage produced by the substation is distributed to convenience outlets and to various motors. The voltage produced by the load centers is regulated by the induction regulators.

The following discussion traces the distribution of 480Vac to the d-c power supplies and the distribution of 208Vac from the load centers and the substations to PCD unit 63, typical MCD unit 19, and a typical load unit, left arithmetic element, unit 2.

2.2 HIGH-VOLTAGE DISTRIBUTION

2.2.1 General

The 480Vac produced by the diesel generators is distributed to the d-c power supplies, the load centers, and the substations (fig. 3–6). Only the d-c power supplies are under IBM cognizance. The distribution circuitry between the high-voltage bus bar and this unit is discussed below.

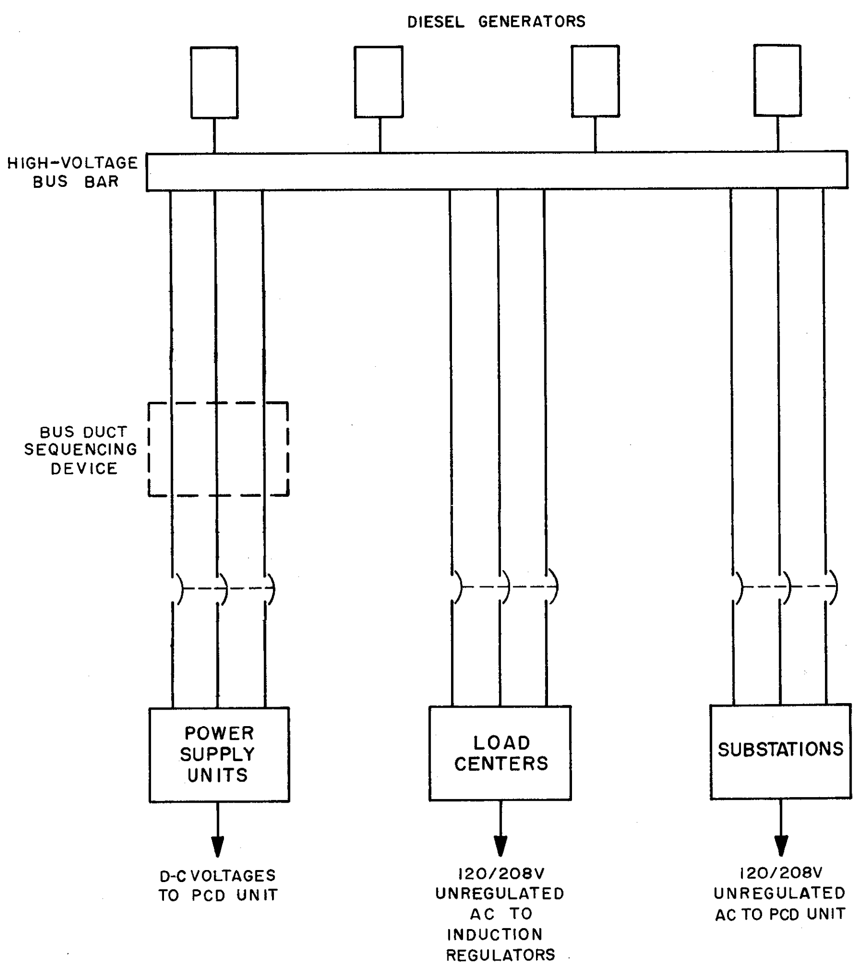


Figure 3—6. High-Voltage A-C Distribution, Block Diagram

2.2.2 Power Supply Unit 60

From the high-voltage bus bar (5.2.1.13), the 480Vac is distributed to the individual d-c power supplies in unit 60 through 3-phase CB's (table 3–3).

Note

Although logics 5.2.1.13 and 5.2.1.14 indicate that the 480Vac is regulated, it is considered unregulated in this manual. Only the 208Vac output of the induction regulators is considered to be regulated ac.

TABLE 3–3. 480VAC DISTRIBUTION CIRCUIT BREAKERS

CB's	POWER SUPPLIES FED
A (CB 1)	+90V, –150V
B (CB 2)	+600V, +10V, –15V, –30V, +72V, high-frequency alternator
C (CB 3)	+250V, +150V, –48V
C (CB 5)	–48V

2.3 LOW-VOLTAGE DISTRIBUTION

2.3.1 General

The output of the load centers and substations (fig. 3–7) is unregulated 208Vac. The output of the load centers is fed to the induction regulators for regulation. The output of the substation is fed to the PCD unit for distribution through the system.

2.3.2 Substation

The output of the substation is applied to a 208Vac bus bar through a 3-phase CB. From the bus bar, the 208Vac is distributed through a 3-phase CB to bus bars 63D3L(L1), 63D3L(L2), and 63D3L(L3) in PCD unit 63. One bus bar is used for each a-c phase. From these bus bars, the unregulated ac passes through a set of six 3-phase CB's. One CB controls all three phases of the unregulated ac distributed to each of the MCD units (table 3–4). Since MCD unit 19 is typical, the distribution to this unit is discussed. The CB which controls unregulated ac to MCD unit 19 is 63D3G3 (5.3.2.2, sheet 1, and table 3–4). From this CB, unregulated ac is fed to the bus bars in unit 19.

2.3.3 MCD Unit 19

From 3-phase CB 63D3G3 in unit 63, each phase of unregulated ac is fed to a separate bus bar in unit 19. Phase 1 is fed to bus bar 19B1R1; phase 2, to 19B1R2; and phase 3, to 19B1R3 (5.3.3.1, sheet 1).

Phase 1 of 120V (phase-to-neutral) ac is applied through CB's to convenience outlets in units 1, 2, 5, 10, 11, and 12 (par. 2.3.4). Phase 2 is distributed through CB's to convenience outlets in units 3, 6, and 13. Phase 3 is distributed through CB's 19B1L1 and 19B1L2 to convenience outlets in locations 4A1 and 8B1 of sections C through K of MCD unit 19 (5.3.3.1, sheet 1). Phase 3 is also distributed to units 4, 7, 8, and 9.

2.3.4 Load Unit

Two lines of phase 1 of 120V unregulated ac from MCD unit 19 are connected through CB's 19B1C1 and 19B1C2 to junction boxes at the top and bottom of the Z module of unit 2 (5.3.2.2, sheet 2). The line from 19B1C1 is connected to convenience outlets N2 and 2L on the tube side of the unit. Additional outlets may be connected at 2J, 2G, 2E, and 2C. The line from 19B1C2 is connected to outlets 2P, 2M, 2D, and 2B on the wiring side of unit 2. Additional outlets may be installed at 2K, 2H, and 2F. The neutral lines from both branches join at a junction box and return to the MCD unit as a common unregulated a-c neutral.

TABLE 3–4. UNREGULATED A-C DISTRIBUTION FROM BUS BARS 63D3L(L1), 63D3L(L2), AND 63D3L(L3)

3-PHASE CB NO.	LOCATION	DESTINATION
CB 12	63D3G3	MCD unit 19
CB 13	63D3G2	MCD unit 27
CB 14	63D3H3	MCD unit 46 and 29
CB 15	63D3H2	MCD unit 31
CB 16	63D3J3	MCD unit 59
CB 17	63D3J2	Printer unit 52
CB 18	63D3K3	MCD unit 46 for drum motors
CB 19	63D3K2	Amplidyne unit 77
CB 20	63D3L3	Internal and miscellaneous
CB 21	63D3L2	Adapter unit 13

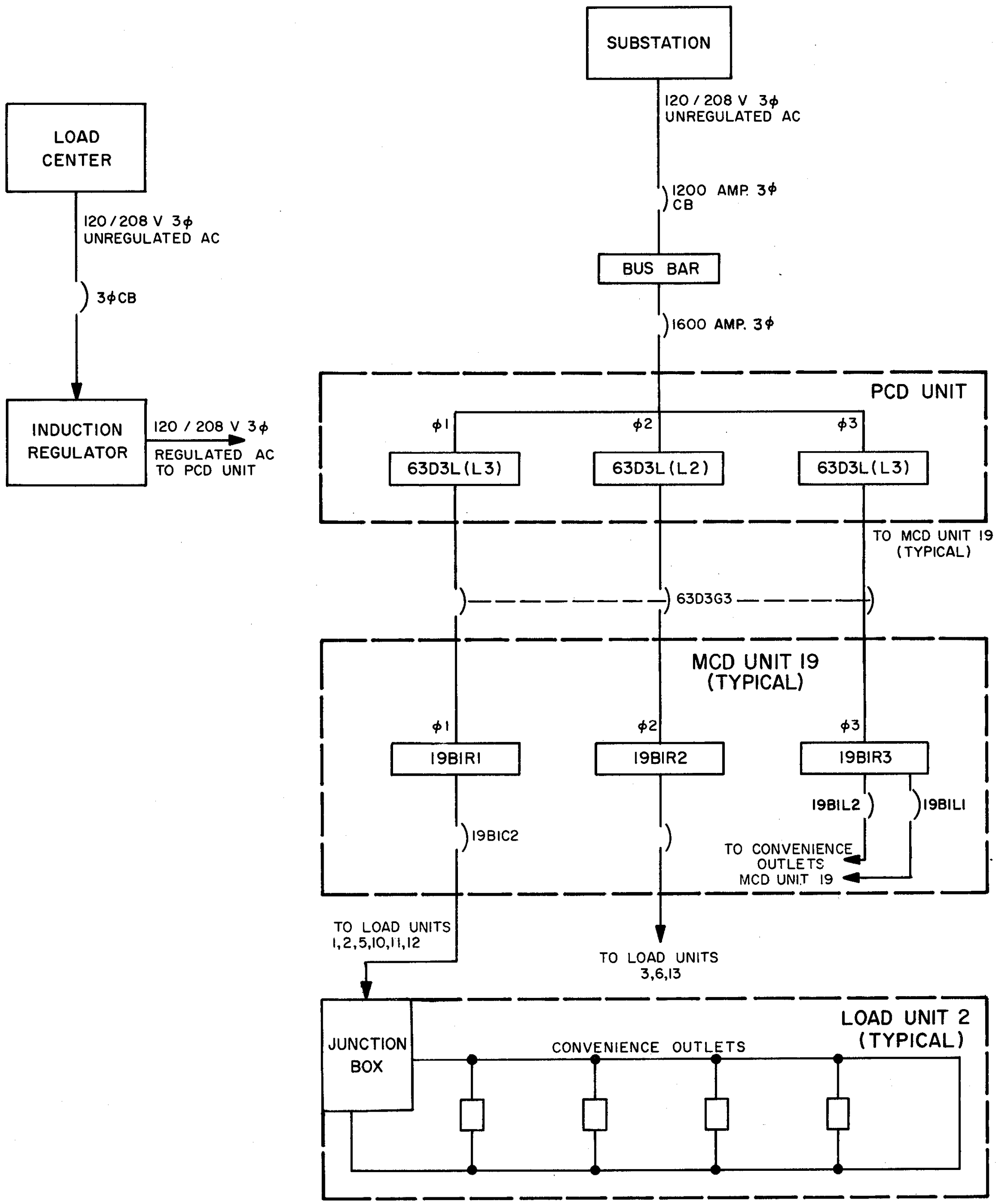


Figure 3–7. Low-Voltage Unregulated A-C Distribution, Block Diagram

SECTION 3
REGULATED A-C DISTRIBUTION

3.1 GENERAL

Regulated ac from the induction regulator is fed to PCD unit 63 (fig. 3–8) for internal distribution within that unit and for distribution through the MCD units and the Z modules to the filament transformers of the load units. The flow of regulated ac among these units and the protective devices used are similar to those employed in the distribution of unregulated ac.

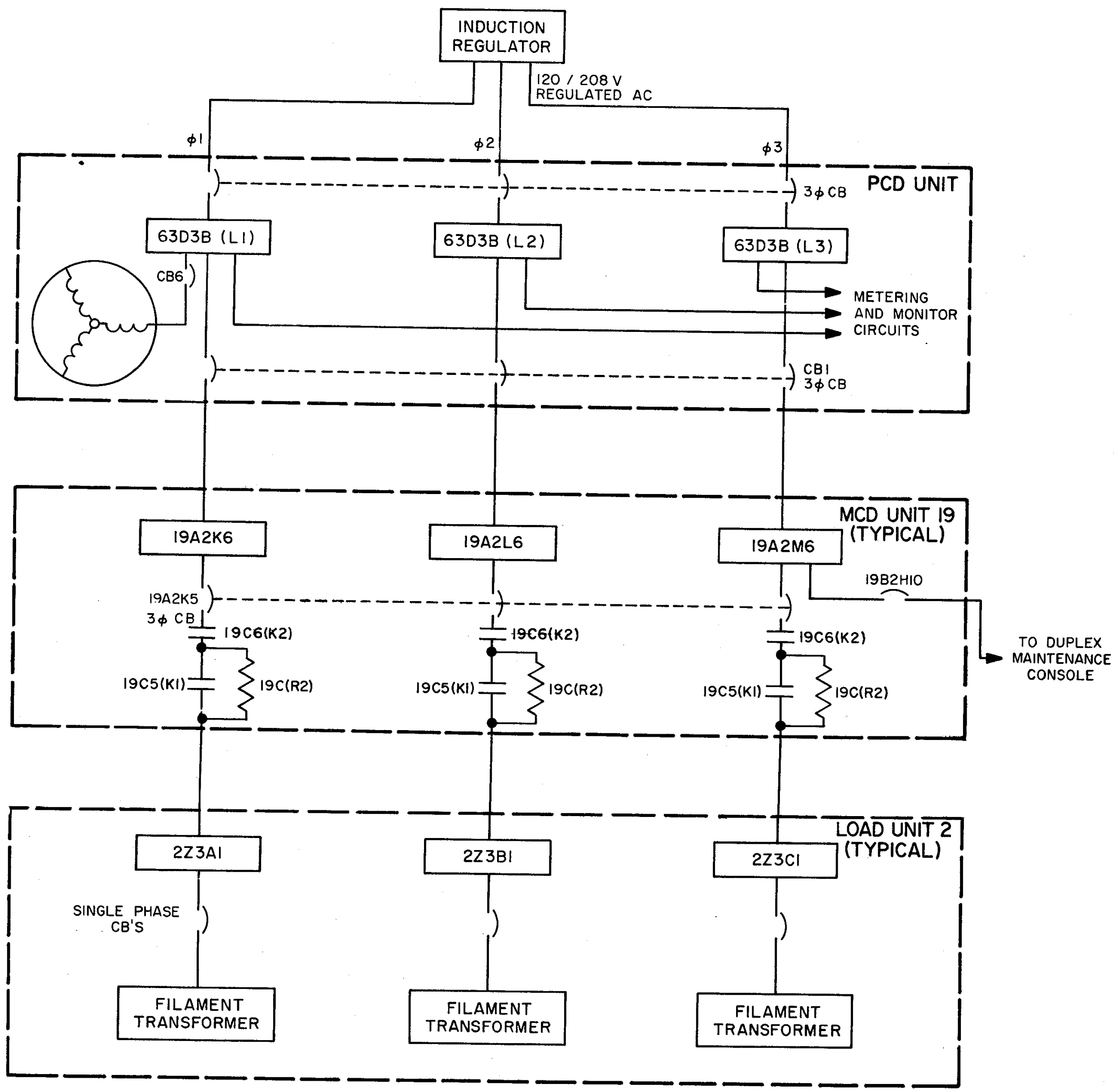


Figure 3–8. Regulated A-C Distribution, Block Diagram

3.2 PCD UNIT

The 3-phase regulated a-c output of the induction regulator is fed to bus bars 63D3B(L1), 63D3B(L2), and 63D3B(L3) in PCD unit 63 (5.3.2.2).

Phase 1 is fed to 63D3B(L1); phase 2, to 63D3B(L2); and phase 3, to 63D3B(L3). From the bus bars, the regulated ac is distributed to the internal circuits of the PCD unit and to the MCD units through 3-phase CB's (table 3—5).

Within PCD unit 63, phase 1 is fed to module A through CB 6. This phase drives the motors in the MC cam timing units. All three phases are fed to module C through CB 7. Phase 1 of this voltage is metered by the a-c voltmeter. Phases 2 and 3 are fed to the coil of the warning level relay of the input voltage monitor relay.

3.3 MCD UNIT

Regulated ac is fed to typical MCD unit 19 through CB 1. All three a-c phases are distributed to the MCD unit. Phase 1 is connected to bus bar 19A2K6; phase 2, to 19A2L6; and phase 3, to 19A2M6. From these bus bars, each phase is distributed to filament transformers in the various load units. The three phases are distributed to typical load unit 2 through 19A2K5 (5.3.3.2).

Phase 3 is also distributed from bus bar 19B2M6 through CB 19B2H10 to the duplex maintenance console (5.3.3.10).

3.4 LOAD UNIT

The load units receive all three phases of ac from the MCD unit. The left arithmetic element, unit 2, receives ac through CB 19A2K5 at bus bars 2Z3A1, 2Z3B1, and 2Z3C1 (5.3.3.2, sheet 2). From these bus bars, regulated ac is distributed to the filament transformers through single-phase CB's. One CB is associated with each filament transformer.

TABLE 3—5. REGULATED A-C DISTRIBUTION TO MCD UNITS

3-PHASE CB NO.	LOCATION	DESTINATION
CB 1	63D3A2	MCD unit 19
CB 2	63D3B3	MCD unit 27
CB 3	63D3B2	MCD units 46 and 29
CB 4	63D3C3	MCD unit 31
CB 5	63D3C2	MCD unit 59
CB 6	63D3D3	Module A PCD unit 63 for marginal checking
CB 7	63D3D2	PCD unit 63 and miscellaneous

SECTION 4
D-C DISTRIBUTION

4.1 GENERAL

The 11 d-c voltages produced by the power supply units are applied to bus bars in unit 63. Most of these voltages are distributed to the MCD units as non-MC dc. Five of the voltages are fed through relays to the output of an amplidyne which varies the voltages applied to the load units during MC operations (refer to 3-92-0).

The distribution of non-MC d-c voltages is discussed in this section. The +150Vdc circuit is discussed as a typical circuit. The distribution of MC voltages is discussed in *Theory of Operation of Marginal Checking System for AN/FSQ-7 and -8,* 3-92-0.

4.2 POWER SUPPLY UNIT

The output of each d-c power supply is fed to a bus bar (fig. 3–9) in the power supply unit. From this bus bar, the voltage is fed to the 9-pole knife switches in the PCD unit.

4.3 PCD UNIT

In the PCD unit, one knife switch provides the power to each MCD unit (5.3.2.1). The MCD units do not all receive the same voltages, since no unit requires both +600V and +72Vdc (table 3–6). A separate bus bar and knife switch applies the –48Vdc control voltage to the MCD units.

The +150Vdc is distributed to MCD unit 19 through knife-switch contacts 63B3D1 and 63B3D2 (5.3.2.1). Table 3–6 lists the knife-switch contacts which apply the various voltages to the MCD units.

4.4 MCD UNIT

From the PCD unit knife switches, the +150Vdc is distributed to CB 19A2C9 in the MCD unit (5.3.3.2). From the CB, the +150V line passes through points of relay 19C6(K3). During normal operation, these points are closed and the corresponding points of relay 19C6(K4) are open. During MC operation, the condition of these relays is reversed. The voltage is now fed to a bus bar in the load unit.

4.5 LOAD UNIT

After passing through the CB and the MC relay in the MCD unit, +150Vdc is distributed to bus bar 2Z3J21 in the Z module of the typical load unit. From this bus bar, the d-c voltage is distributed to CB's 2Z3J8 through 2Z3J20 and from the CB's to modules B, C, D, E, F, G, H, J, K, L, M, N, and P, respectively, of unit 2. The +150V, +10V, and –30Vdc are distributed to the duplex maintenance console from their respective bus bars in unit 2.

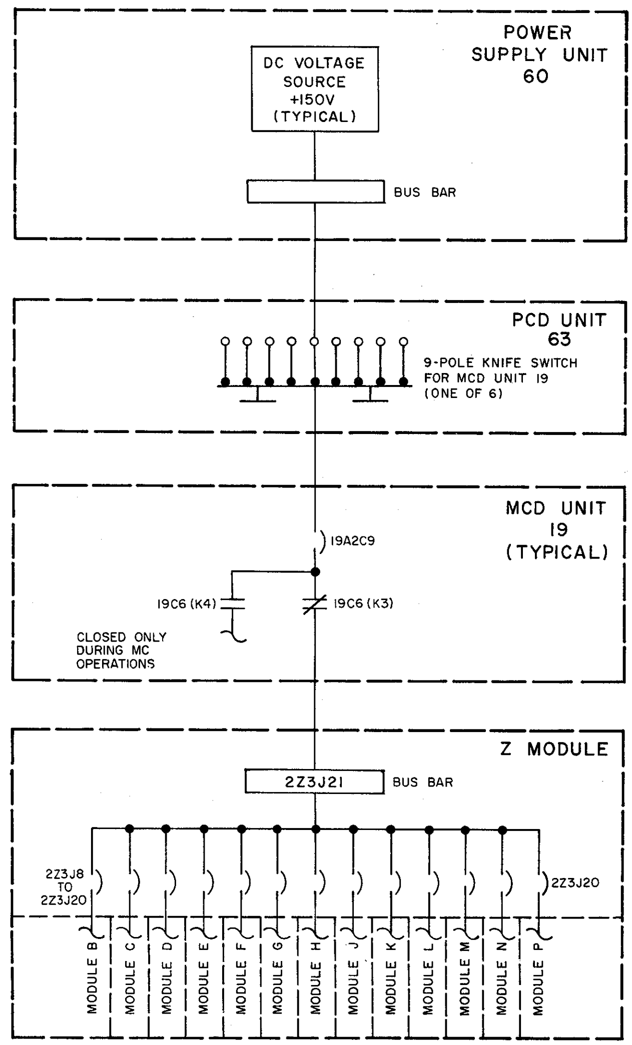


Figure 3–9. Typical D-C Distribution (+150Vdc), Block Diagram

TABLE 3–6. KNIFE-SWITCH CONTACTS APPLYING D-C VOLTAGES TO MCD UNITS

VOLTAGE	UNIT 19	UNIT 27	UNIT 29 AND 46	UNIT 31	UNIT 59
+600	–	63B3A4-3	–	63B3A8-7	–
+250	63B3C2-1	63B3C4-3	63B3C6-5	63B3C8-7	63B3C10-9
+150	63B3D2-1	63B3D4-3	63B3D6-5	63B3D8-7	63B3D10-9
+90	63B3E2-1	63B3E4-3	63B3E6-5	63B3E8-7	63B3E10-9
+10	63B3G2-1	63B3G4-3	63B3G6-5	63B3G8-7	63B3G10-9
–15	63B3H2-1	63B3H4-3	63B3H6-5	63B3H8-7	63B3H10-9
–30	63B3J2-1	63B3J4-3	63B3J6-5	63B3J8-7	63B3J10-9
–150	63B3K2-1	63B3K4-3	63B3K6-5	63B3K8-7	63B3K10-9
–300	63B3L2-1	63B3L4-3	63B3L6-5	63B3L8-7	63B3L10-9
+72	63B3A2-1	–	–	–	–
–48	63B3N2-1	63B3N4-3	63B3N6-5	63B3N8-7	63B3N10-9

Note: Contacts A through L for each unit are nine poles of separate knife switches.

SECTION 5
METERING CIRCUIT DISTRIBUTION

5.1 GENERAL

The circuitry for the various metering circuits is discussed below. In the instances where several voltages are monitored by several meters (e.g., voltage monitor relays), a typical circuit is discussed.

5.2 VOLTAGE MONITOR RELAY

The warning-level and shutdown-level voltage monitor relay circuits for each of the d-c power supplies and for the regulated a-c and power supply input voltages are essentially the same. The +150Vdc monitor circuit is typical.

The +150Vdc is distributed to the voltage monitor relays from the bus bar in PCD unit 63 (5.4.2.2). From this bus bar, the voltage is fed to the moving coils of the warning-level and the shutdown-level relays. If the +150Vdc deviates to the warning level, the pointer on the relay meter makes contact (par. 1.3.2.2, Part 3, Ch 3) and the +130Vdc from the station battery picks relay K14. Points of K14 complete the circuit to the VOLTAGE OFF LIMITS light at the PCD unit and the maintenance console. If the shutdown level is reached, relay K50 is dropped; the +150Vdc power supply is shut off immediately; the other d-c power supplies are cycled down; and the system is placed in the ac-only status.

5.3 A-C VOLTMETER

The a-c voltmeter can be connected to all phases of regulated 208Vac, unregulated 208Vac, and the 480V power supply input. The voltmeter receives the input voltages from the bus bars in unit 63 and the bus-duct sequencing device. A selector switch permits selection of any phase-to-phase or phase-to-neutral voltage for metering (5.4.2.4). For point-to-point distribution, refer to par. 5.2.2, Part 4, Chapter 2.

5.4 D-C AMMETER

The d-c ammeter is connected in the ammeter shunt circuit. The +150Vdc circuit is typical. This circuit originates at bus bar 63B7B7 in module B of unit 63 (5.3.2.1). The shunt line is connected to the ammeter selector switch at 63C7C3C (5.4.2.4). This point is in the middle deck of the ammeter selector switch. The ammeter is connected between this point and 63C7A3u in the rear deck of the switch when the +150V current is being measured (Part 4, Ch 2). The shunt return line is connected between the rear deck and junction box 63B7A7b in module B (5.3.2.1).

5.5 RIPPLE VOLTMETER

The ripple voltmeter circuit consists of a voltmeter power supply, a voltage selector switch, an RC filtering network, and a ripple voltage range selector switch.

The voltmeter power supply (5.4.2.4) is connected between phase 1 and neutral of the unregulated a-c circuit fed from bus bar 63D3(L1). The RC filter circuit filters out the d-c power supply voltage to permit measurement of the a-c component. The ripple voltmeter circuit is connected to the knife switches in unit 63. This circuit also supplies the voltage monitor relays, but the ripple voltmeter is connected into the circuit prior to distribution to the voltage monitor relays.

The typical +150Vdc line is connected to the knife switches at 63B3D10a (5.3.2.1). From the knife switches, the +150V line is connected where the d-c voltage is filtered out to the RC network. Between the RC network and the ripple voltmeter, the a-c component passes through a 3-position range selector switch. This switch regulates the full-scale voltmeter deflection to 0.25V, 1V, or 2.5V.

5.6 D-C VOLTMETER

The +150Vdc is fed through a 300K resistor in the d-c voltage multiplier circuit to point 11 in the middle deck of the d-c voltmeter selector switch. From this point, the voltage passes through the voltmeter mechanism to point 11 of the rear deck. From the rear deck, the voltage is returned to the front deck of the selector switch.

SECTION 6
NEUTRAL LINES, RETURNS, AND GROUND

6.1 GENERAL

In place of a ground for electrical returns, the AN/FSQ-7 and -8 equipment uses four special electrical systems. Two systems provide neutral lines for regulated and unregulated ac; one system provides a return for all d-c voltages except the —48V relay voltage; the fourth system provides the —48Vdc return. Ground is an equipment bond which eliminates the danger of high voltages collecting on a unit.

6.2 A-C NEUTRAL LINES

6.2.1 Unregulated AC

The unregulated a-c neutral line for the duplex equipment is connected to the unregulated a-c feeder CB neutral in the substation. From this point, the neutral line is connected to the unregulated a-c neutral bus bar in the PCD unit. From this bus bar, neutral lines are connected to the line printer, five of the MCD units (the neutral line for unit 46 is connected through unit 29), and to unit 63 for internal grounding.

From the MCD units, the neutral line is fed to junction boxes in the Z module of the load units associated with the MCD unit. The unregulated a-c neutral is the return line for the convenience outlets in the units.

6.2.2 Regulated AC

Regulated a-c neutral is connected to the neutral side of the induction regulator. In PCD unit 63, this neutral line is connected to the regulated a-c neutral bus bar. From the bus bar, neutral lines are distributed to the MCD units in the same manner as the unregulated a-c neutral lines. In a typical load unit, unit 2, the regulated a-c neutral is connected to bus bar 2Z1(TB2)a in the Z module. A filament return loop is connected to the bus bar. This loop is connected to the neutral point of each filament transformer in the load unit.

6.3 D-C RETURN LINES

6.3.1 D-C Return

The d-c return lines are distributed throughout the load units and the Power Supply System. Returning from the load units, the d-c return lines for each voltage are connected together and returned to the MCD units. At the MCD units, the return line for a typical voltage is connected to the return lines of that voltage which are coming from other load units. This line is returned to the d-c power supply through the PCD unit.

6.3.2 Relay Return

Relay return lines are connected to the relay return line in the MCD unit. From the MCD unit, the return lines are connected to the relay return bus bar in unit 63. From this bus bar, the return line is returned to the d-c supply.

6.4 EQUIPMENT BOND

The equipment bond grounds the frame of each unit in the equipment. The equipment bond terminates at terminal 47J3(E31)h in simplex maintenance console unit 47. The equipment bonds of the units in each power system are connected to a bus bar in the MCD unit. The MCD unit bus bars are connected to the grounded frames of their associated PCD units.

The equipment bonds of power systems A and B are connected together at the simplex load units where they are connected to a common equipment bond for systems C and D.

CHAPTER 3

ANALYSIS OF DUPLEX CONTROL CIRCUITING

SECTION 1

INTRODUCTION

1.1 SCOPE

This chapter contains a detailed analysis of the circuitry required to operate the duplex power supply equipment. The controls and indicators on the units are discussed. The various power statuses for each unit and the normal power-on, power-off, and abnormal power-off sequences are described. The various power sequences are discussed in the sections devoted to the status of the equipment after the sequence is completed. For example, the power-on to ac-only sequence is discussed in the section dealing with ac-only sequences.

1.2 GENERAL

Control of power condition and unit status is possible from various units. The status of the entire duplex power supply may be controlled by pushbuttons at the PCD unit or at the duplex maintenance console. Pushbuttons and switches at the MCD units permit control of the associated load units. Controls at the Z module of a load unit determine the status of the entire load unit.

Note

In the following discussion, when the control circuitry involves several MCD and load units, MCD unit 19 and left arithmetic element, unit 2, are discussed as a typical MCD unit and a typical load unit, respectively.

1.3 CONTROLS

1.3.1 Power Supply Unit

Since the d-c power supplies are remotely controlled, power supply unit 60 has no external controls except UNIT OFF pushbuttons (par. 1.1.1, Part 2, Ch 4). The operating controls required for maintenance are installed on the internally mounted control chassis of each d-c supply. These controls are discussed in *Maintenance Techniques and Procedures, Power Supply and Marginal Checking System, AN/FSQ-7 and -8*, 3-192-0.

1.3.2 PCD Unit

1.3.2.1 General

The CB's in module D and the BATTERY DISCONNECT switch in module C must be closed before the power system is energized. The CB's, when opened, de-energize the regulated and unregulated a-c circuits to the MCD units and the load units. The BATTERY DISCONNECT switch controls the output of the +130Vdc station battery. This 130Vdc is a control voltage which operates relays before the —48Vdc power supply is energized.

The UNIT OFF pushbutton for PCD unit 63 is in module C. Depressing this pushbutton shuts down, without sequencing, all d-c and regulated a-c voltages distributed from this unit. Unregulated ac is distributed to the convenience outlets regardless of the power status of the PCD unit. The CB's and knife switches in the PCD unit are enclosed by the doors on the unit. Interlocks on the doors initiate a normal power-off sequence when a door is opened. The CB's and knife switches must be closed and the door secured before the power system is energized.

1.3.2.2 Voltage Monitors

Each voltage monitor (5.4.2.2) in module C is a suppressed-zero, D'Arsonval movement microammeter with series resistor multipliers; monitors are used to indicate variations in all d-c voltages. The relays warn of small voltage changes and shut down equipment in the event of large variations. The a-c voltage monitor relays are equipped with a bridge-type rectifier in addition to the multiplier resistors. The pointer on the instrument indicates the voltage level on a scale calibrated in percent-rated volts. In addition, the pointer acts as a moving contact by closing at either end of the travel. Attraction between the magnetic moving contact and the magnetized stationary contact makes this possible.

A. Switches

Each voltage monitor has an associated TEST-NORMAL switch. A single reset switch, located on module C, transfers the reset coils of all voltage monitors from their normal position to the 130Vdc line through contacts 3a-3c of either relay 63C5(K31) or 63C5(K33). Each TEST-NORMAL switch shorts out the voltage monitor relay contacts feeding 63C5(K35) and permits adjustments to be made in the power system under test without causing the voltage monitor relays to shut down the system. In the TEST position, a circuit is completed to ac-only relay 63C5(K32) through closed contacts 7a-7c of 63C5(K33). With the switch in this position, it is not possible to reach a power-on status.

B. Normal Operation

In the power-on sequence, closing contacts 3a-3c of either ac-only relay energizes the reset coils which open the voltage monitor relay reset switch contacts. Before the power-on signal is initiated, the warning level and shutdown level relays are clamped in the midposition of the scale. After all d-c power supplies are energized, the relays are unclamped and begin to monitor the d-c power supply voltages.

C. Warning Level

The operation of a voltage monitor relay at the warning level occurs when a voltage deviation reaches ±5 percent for all d-c power supplies except the —48 and +72V power supplies. The warning level of —48 and +72V power supplies and the regulated ac for the power supplies is ±10 percent of the rated voltage. The warning level of the filament-regulated ac is ±5 percent of the recommended voltage.

When the warning level is reached, an appropriate lamp lights on duplex PCD unit 63 and on duplex maintenance console unit 1, thus providing a visual indication of the trouble location. For example, if the +600Vdc reaches the warning level, the +600V warning level voltage monitor relay contacts close (5.4.2.2) and associated relay 63C5(K12) de-energizes. Power is applied to the +600 OFF LIMIT lamp on unit 63 through now closed contacts 6 and 13 of this relay. At the same time, power is applied to the VOLTAGE OFF LIMITS lamp at unit 1 (5.4.2.3) through now closed contacts 4 and 12 of 63C5(K12) and at unit 45 (7.2.1) through contacts 1a-1c of 1F2(K7). No other action occurs.

D. Shutdown Level

Operation of the +600V voltage monitor relay (5.4.2.2) at the shutdown level causes its associated relay 63C5(K1) to drop. This action initiates a power-off sequence which first removes the +600V supply from the circuit and then removes all operation power from the equipment. When power is removed, the POWER ON lamp is extinguished and the POWER OFF lamp is lit. (Refer to par. 5.4.)

1.3.3 MCD Units

The CB's in each MCD unit control the power distributed by that MCD unit. By means of the CB's, individual d-c service voltages and MC voltages may be disconnected from any load unit associated with the MCD unit. However, opening any d-c CB will cause the d-c contactors to open. This will cause the removal of all d-c power from the associated load units. The UNIT OFF pushbutton removes, without sequencing, all power (except unregulated ac) distributed by an MCD unit to its associated load units.

1.3.4 Load Units

Most of the load units have similar control circuitry. Left arithmetic element (unit 2) is described herein as a typical load unit. The load unit is controlled from the Z module. Circuit breakers in the Z module permit removal of any voltage from any other module of the load unit. However, opening any d-c CB opens the associated d-c contactor and causes all d-c power to be removed from the load unit.

A control and indication panel is located on the rear of the Z module. The AC ON-AC OFF and DC ON-DC OFF switches permit the load unit to be placed in the off, a-c only, or power-on status. The UNIT POWER OFF pushbutton, when depressed, or the AC ON-AC OFF switch, when placed in the AC OFF position, shuts off all power on the load unit except the unregulated ac at convenience outlets.

1.3.5 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 (fig. 3—10). The indicator lamps on this module are discussed in 1.4.5.

Module H contains the following POWER GROUP pushbuttons:

a. UNIT OFF pushbutton—initiates power-off sequence units 60 and 63 and, consequently, all of the associated portion of duplex equipment.

b. POWER OFF pushbutton—initiates a power-off sequence for the associated power system.

c. AC ONLY pushbutton — initiates a dc-off sequence in the power system and leaves ac on the filaments of the tubes, at convenience outlets, and on motors.

d. POWER ON pushbutton—initiates a power-on sequence for the associated power system.

1.4 INDICATORS

1.4.1 Power Supply Unit

There are no visible indicators on the duplex power supply unit. A d-c voltmeter is installed in the control chassis of each d-c power supply to indicate the output of the supply. During normal operation, the voltmeters are behind the closed doors of the unit.

1.4.2 PCD Unit

Module C of PCD unit 63 contains all of the power supply indicators except those required for marginal

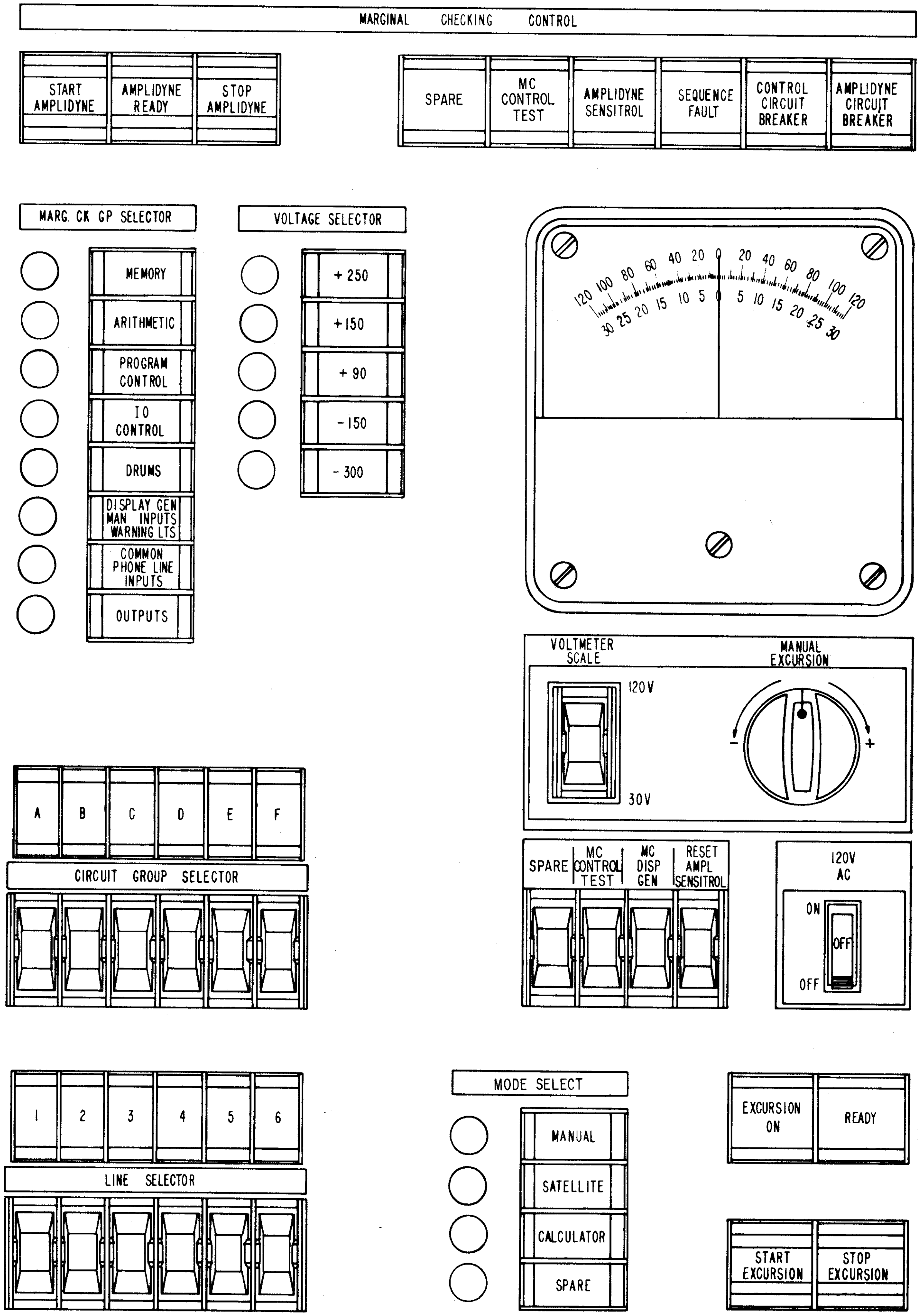


Figure 3–10. Module H, Duplex Maintenance Console

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 a-c filament voltage shutdown level, the a-c 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 d-c power supplies (par. 1.3.2.2).

The off-limit lamps include the FILAMENT VOLTAGE lamp, the INPUT TO SUPPLIES lamp, and one lamp for each of the 11 d-c power supplies.

Four meters permit accurate reading of all voltages. The AC VOLTMETER provides a visual indication of a-c voltages. The multiple-position controls 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 d-c supplies.

1.4.3 MCD Units

Every MCD unit has one of each of the following:

a. Green RESET lamp

b. Red AC CB TRIP lamp

c. Red DC CB TRIP lamp

d. Green ALL UNITS ON lamp

In addition, each MCD unit contains one amber UNIT OFF lamp for each unit associated with the MCD unit. Each MCD unit also contains one single-stroke CB alarm bell.

1.4.4 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. The a-c time on (elapsed time) indicator is located beside the UNIT POWER OFF switch.

1.4.5 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:

a. MCD AC BREAKER

b. NEON ALARM

c. VOLTAGE OFF LIMITS ALARM

d. MAINT CONSOLE AC BREAKER

e. COMPUTER MCD

f. PCD UNIT

g. AC SWITCH GEAR

h. TAPE ADAPTER

i. DISPLAY MI MCD

j. OUTPUT MCD

k. DRUM MCD

l. TAPE POWER SUPPLY

m. AUXILIARY DRUM MCD

n. 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.

1.5 INTERLOCK CIRCUITS

1.5.1 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 microswitches operated by CB's or knife switches. These microswitches control contactors which permit the flow of power to various portions of the equipment. Separate interlock circuits are provided for a-c and d-c circuits. In the d-c circuits, there are separate interlocks for the MC and the non-MC lines.

1.5.2 Knife-Switch Interlocks

The 9-pole and 5-pole knife switches in the PCD unit are interlocked with the dc-hold circuit (5.4.6.1). 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 d-c power for the associated system to cycle down and causes an interlock to close to complete a circuit to the PCD TROUBLE lamp at the duplex maintenance console.

1.5.3 Circuit Breaker Interlocks

Figure 3—11 is a simplified schematic of the CB interlocks at a typical MCD unit. As shown in this figure, an ac-on sequence cannot be initiated, even if the AC ON switch is closed, unless relay K6 is picked. This relay cannot be picked unless the filament a-c CB interlock is closed. Similarly, the MC and non-MC CB interlocks, as well as the a-c CB interlocks, must be closed before a d-c power-on sequence can be initiated. Also, the interlocks are so arranged that a-c filament power must be present before any of the d-c voltages can be applied.

1.5.4 Door Interlocks

These 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 d-c power fcr the associated system to cycle down.

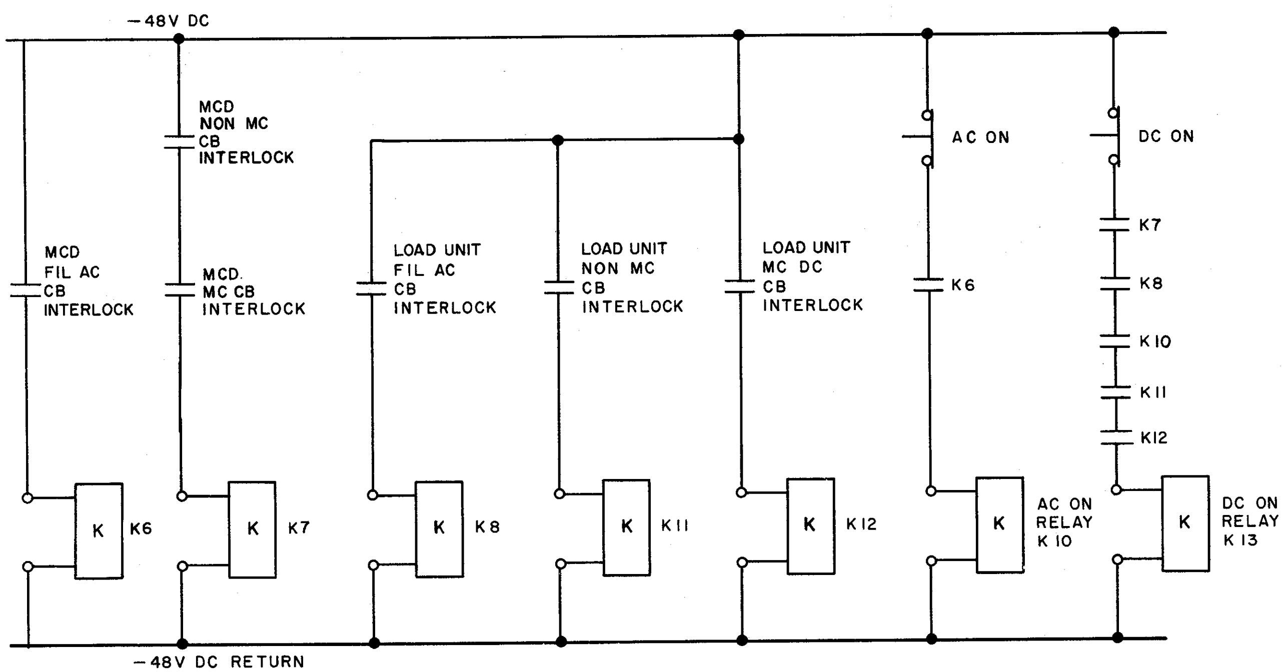


Figure 3–11. Simplified Schematic, CB Interlock Circuit

SECTION 2
NORMAL POWER-ON SEQUENCES

2.1 GENERAL

PCD units A63 and B63 control all the power distributed to the duplex portions of the SAGE equipment. The PCD units monitor all regulated and unregulated a-c and d-c voltages and also supply the switchgear and the MCD units with power-sequencing signals.

Control power is supplied to each PCD unit by the 130Vdc battery in the powerhouse. This voltage is supplied through the BATTERY DISCONNECT CB and the BATTERY DISCONNECT switch.

This section discusses the prestart conditions, the power-off to power-on sequence, and the ac-only to power-on sequence for one of the duplex systems.

2.2 PRESTART 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 powerhouse must be energized.

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

c. The AC FEED CB's to the substations must be closed.

d. The load center control switch must be closed.

e. The knife switches and the CB's in the PCD unit and the CB's in the MCD units and the load units must be closed.

f. All interlocked doors must be closed.

When the conditions listed in a, b, c, and d, above, are accomplished, the system is in a power-available status. The battery voltage is fed to the CLOSE CB in the load center through the manually closed load center control switch and through auxiliary contacts of the AC FEED CB of the substation. These conditions close the normally open point in the POWER AVAILABLE phantom (5.4.2.1).

2.3 POWER OFF TO POWER ON

When the prestart conditions have been fulfilled, and the power available signal is present at the PCD unit (par. 2.2), a power-on sequence may be initiated. This sequence is automatic after the POWER ON pushbutton on the maintenance console is depressed.

Note

So that all duplex load units may receive power automatically, both the AC ON-AC OFF and the DC ON-DC OFF switches on all load units must be in the center position.

The +130Vdc essential control voltage is applied to one side of POWER ON pushbutton 1H3(S3) through the now closed POWER-AVAILABLE points (phantom, 5.4.2.1), door interlocks B3AA1 through B3AA10 of unit 63, and POWER OFF pushbutton 1H3(S5). Depressing the POWER ON pushbutton causes simultaneous actions to occur in the switchgear and the PCD unit.

In the switchgear, depressing the POWER ON pushbutton completes the 130Vdc circuit to relay 1A (fig. 3–12) through relays K33, K63, and K46. Points of 1A and auxiliary contacts of the load center CB (closed when the load center control switch was operated) complete the circuit to CLOSE CB 52A. Points of 52A complete the circuit to the d-c supply input CB. The CB closes and energizes the 480Vac bus duct (5.2.1.13).

Note

Switchgear components are designated by a number and the letter designating the system with which the component is associated. For example, relay 1A is associated with duplex system A; relay 1B performs the same function as 1A but is associated with system B. System A is used as a typical duplex system.

Completion of this action closes the opened points in the phantom labeled DC SUPPLY INPUT BREAKER CLOSED (5.4.2.1) and supplies 480Vac to the high-frequency alternator and the —48Vdc power supply. When the CLOSE CB 52A in the load center closes, ac is fed to the induction regulator for regulation and distribution to the PCD unit. At this time, the FILAMENT INPUT DE-ENERGIZED light on unit 63 is extinguished, and the POWER OFF lights at unit 63 and the duplex maintenance console are lighted (5.4.2.3).

In the PCD unit, depressing the POWER ON pushbutton completes the +130Vdc circuit between IH3(E22)c and IH3(E22)e to pick power-on relay 63C5K31 (fig. 3–13).

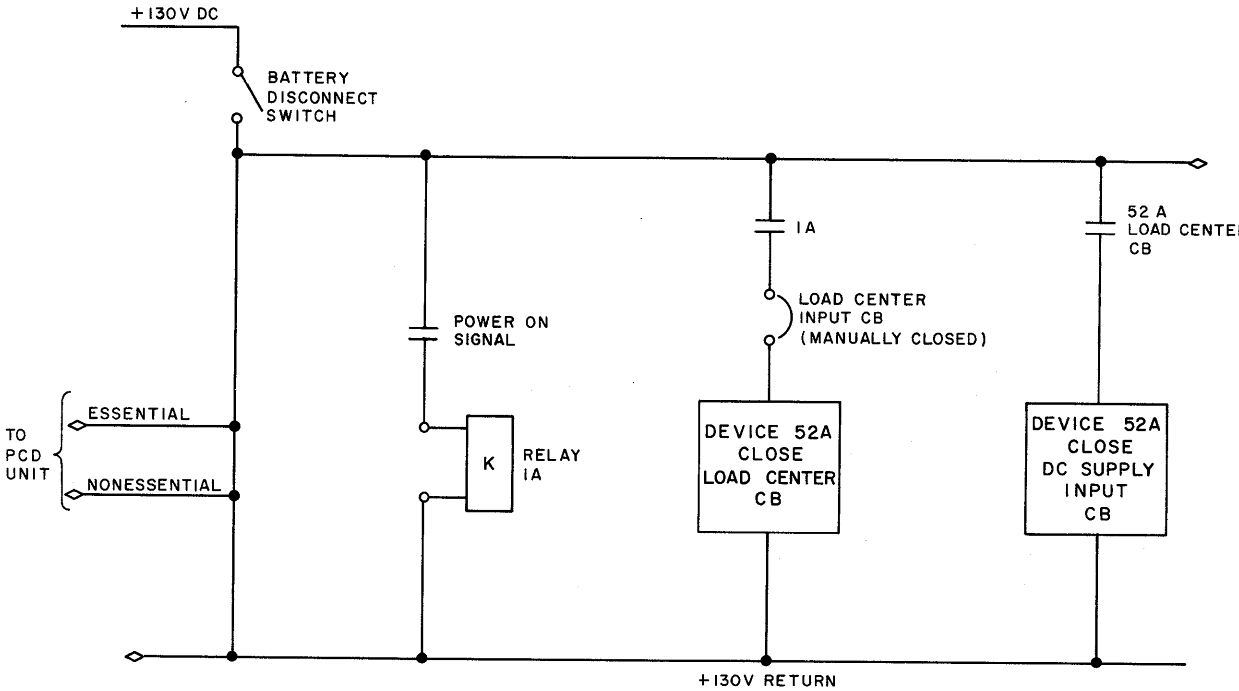


Figure 3—12. Power-On Sequence, Switchgear Circuitry, Simplified Schematic

Note

In the following discussion, precede all relay designations with 63C5 and all other designations with 63 unless complete designations are given.

When relay K31 picks, its points 1a-1c close. These points 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 audible alarm.

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 relay 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. Points of K61 operate 5 seconds after the coil is energized. Points 1-2 of K61 close to complete the circuit to K33. When K33 picks, its points 6a-6b (5.4.2.3) open, and the audible alarm is silenced. 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. Points 2a-2c of K46 close and complete the circuit which transmits the power-on signal to bus duct time delay relay 60A(K4) (5.2.1.14).

Points 1a-1c and 4a-4c of K46 complete circuits to voltage monitor relays K1 through K25. These relays are actuated but do not shut down the power supply because the moving contacts of the voltage monitors are clamped by the now energized voltage monitor reset coils (5.4.2.1). Points 5-12 of K1 through K11 and points 7-13 of K25 close to complete the circuit to K35. Points 2a-2c of K35 complete the circuit to K44, but this relay does not actuate because points 1a-1c of K43 are not yet closed.

During the preceding sequence in the PCD unit, the switchgear-unit circuit has been completed by points of K46 to close the d-c supply input CB. When this CB is closed, relay K64 is energized. When K64 picks, its points 1-2 close to complete the energizing path to K36 and K65. Relays K37, K39, K38, K40, and K41 are picked through now closed points 1a-1c of K36, points 8-14 of K25, and auxiliary points of regulated a-c CB's in units 19, 27, 29, and 46 (interlocked), 31, and 59, respectively. Relay K42 is picked through now closed points 2a-2c of K33 and normally closed points 3a-3b of K43.

After 1 minute, K65 picks and its points 1-2 close in the energizing circuit of K43. When K43 picks, its points 1a-1c close and complete the pick path to K44,

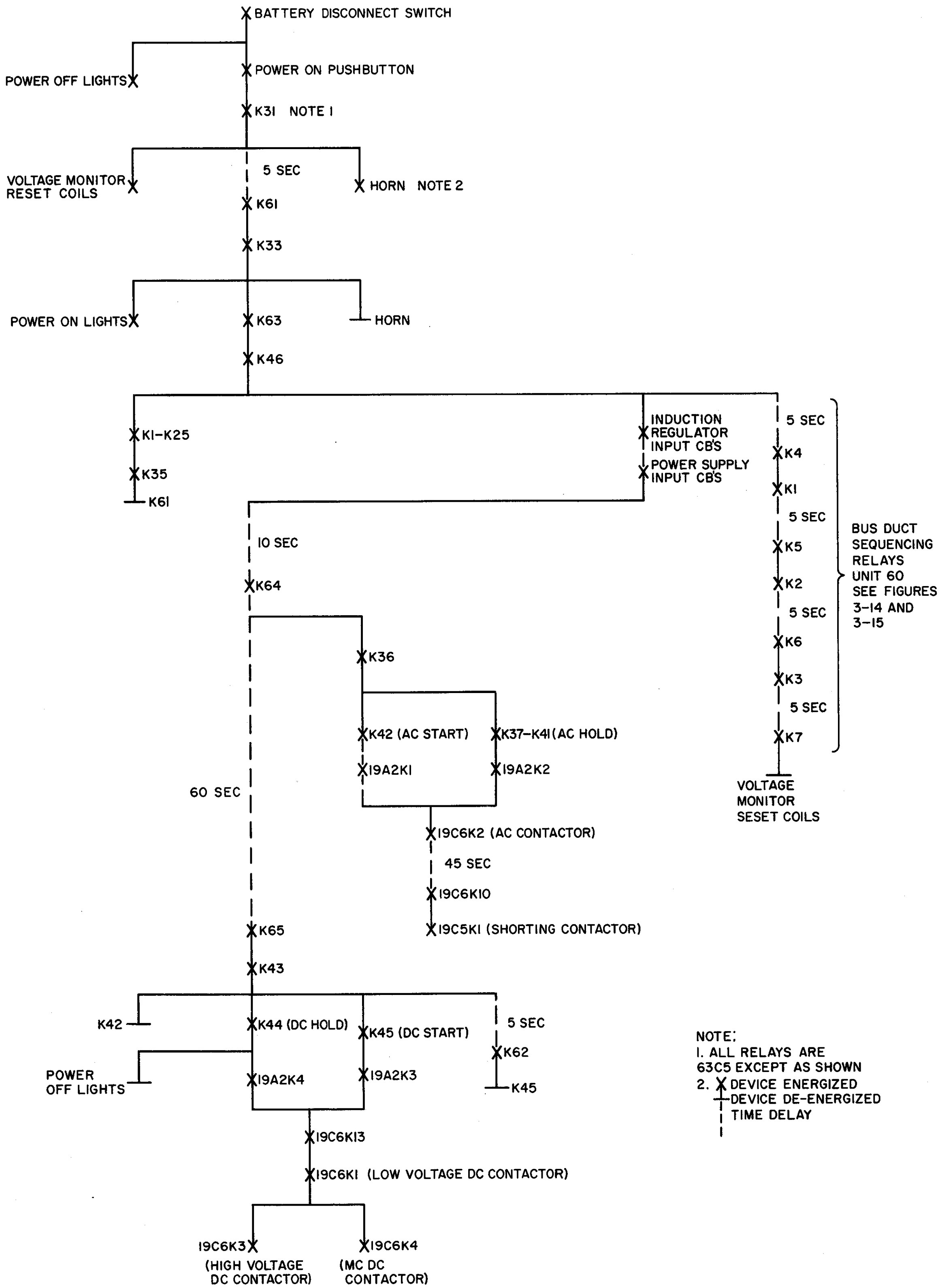


Figure 3–13. Normal Duplex Power-On Sequence, PCD Unit 63, MCD Unit 19, and Unit 2, Simplified Sequence Chart

K62, and K45. Relays 44, and 45 pick immediately; K62 delays 5 seconds before picking.

Points of relays K42, K37, K45, and K44 complete the pick circuits to the ac-start, ac-hold, dc-start, and dc-hold relays, respectively, in unit 19. The latter relays are energized by the —48Vdc control voltage.

Before d-c power is distributed to the MCD units, the d-c power supplies must be energized. The power supplies are sequenced on by the sequencing device in unit 60 (5.2.1.14). When relay 60A(K4) is picked (fig. 3—14) by a circuit completed through points 2a-2c of K46 and points 4a-4c of K35, its points 9-10 close after 5 seconds (table 3—7). When these points close, the —48Vdc control voltage energizes relay 60A(K1). Points 5-6 of 60A(K1) complete the cricuit to 5-second time-delay relay 60B(K5). Points K1-L1, K2-L2, and K3-L3 of 60A(K1) (5.2.1.13) complete the 480Vac circuit to the +90V and —150Vdc power supplies (fig. 3—15). When points 9-10 of 60B(K5) close (5.2.1.14), relay 60B(K2) is picked. Points 5-6 of 60B(K2) complete the circuit to 60B(K6). Points T1-L1, T2-L2, and T3-L3 of 60B(K2) close to complete the 480Vac circuit to the +600V, +10V, —15V, —30V, and +72Vdc power supplies. When 60B(K6) picks, its points 15-16 close to complete the circuit to relay 60C(K3). Points 5-6 of 60C(K3) close in the pick path of 5-second time-delay relay 60C(K7). Points K1-L1, K2-L2, and K3-L3 of 60C(K3) close to complete the 480Vac circuit to the +250V, +150V, and —300Vdc power supplies.

When relay 60C(K7) picks, its normally closed points 9-10 (5.4.2.1) open and interrupt the circuit to the reset coils of the voltage monitor relays. De-energizing the coils releases the pointers, and the voltage monitors begin to monitor the outputs of their respective supplies.

When relay K42 picked, its points 2a-2c closed to complete the —48V path to ac-start relay 19A2(K1) and relay 19B2(K1) in MCD unit 19 (5.4.3.1). In a similar manner, points 3a-3c, 1a-1c, and 4a-4c of relays K37, K45, and K44, respectively, close to complete circuits to ac-hold relay 19A2(K2) and auxiliary relay 19B2(K2), to dc-start relay 19A2(K3) and auxiliary relay 19B2(K2), and to dc-hold relay 19A2(K4), and auxiliary relay 19B2(K4). In the typical load unit, left

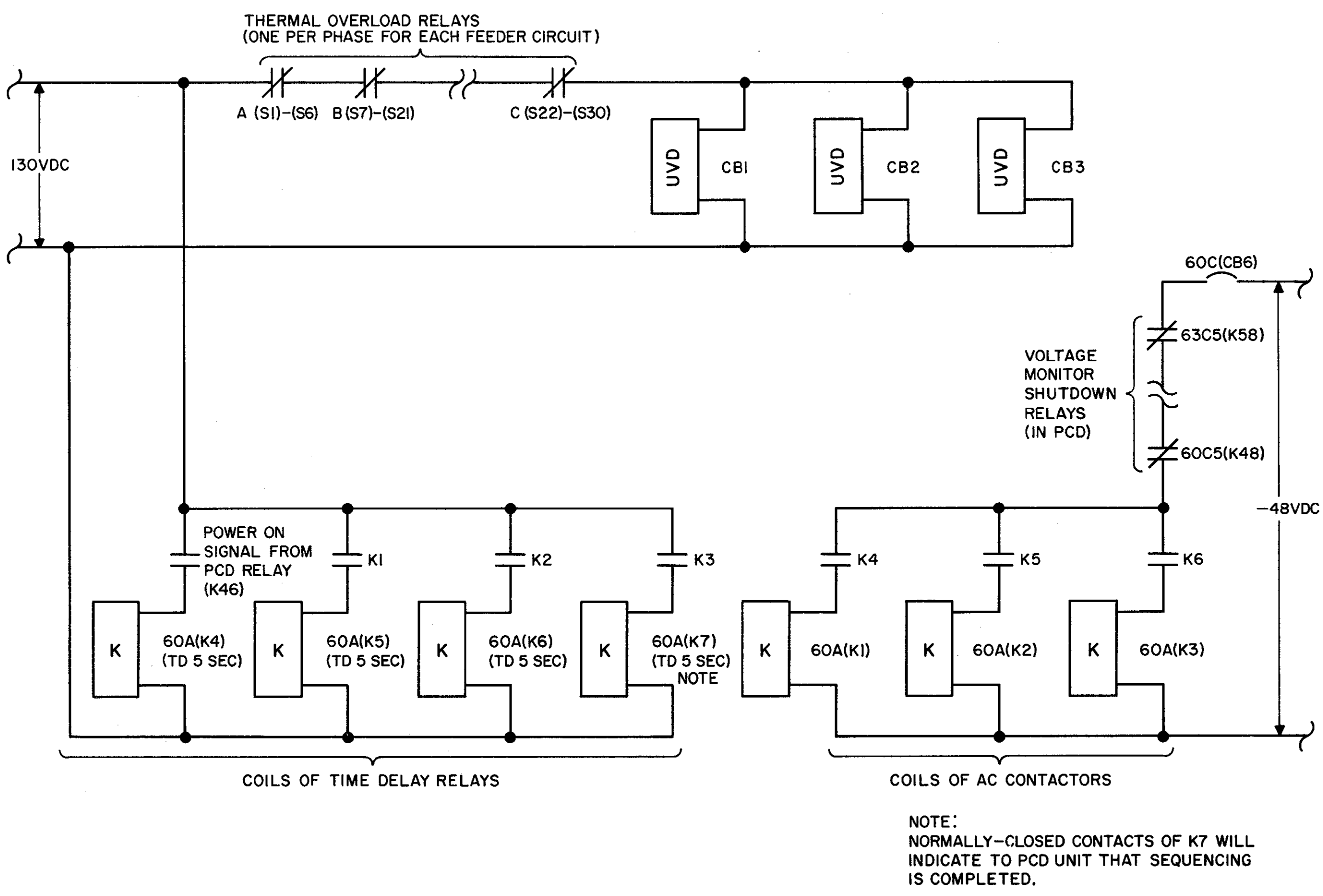


Figure 3—14. Bus Duct Sequencing Device, Control Section

TABLE 3–7. D-C POWER SUPPLY SEQUENCING

GROUP	VOLTAGE UNIT 60	VOLTAGE UNIT 61	WHEN ENERGIZED
Group 1	—48V and high-frequency alternator	—48V and high-frequency alternator	When dc input CB closes, (par. 2.3.1)
Group 2	+90	+600	5 seconds after Group 1
	—150	—300	
Group 3	+250	+250	5 seconds after Group 2
	+150	+150	
	—300	—150	
Group 4	+600	+90	5 seconds after Group 3
	+72	+10	
	+10	—15	
	—15	—30	
	—30		

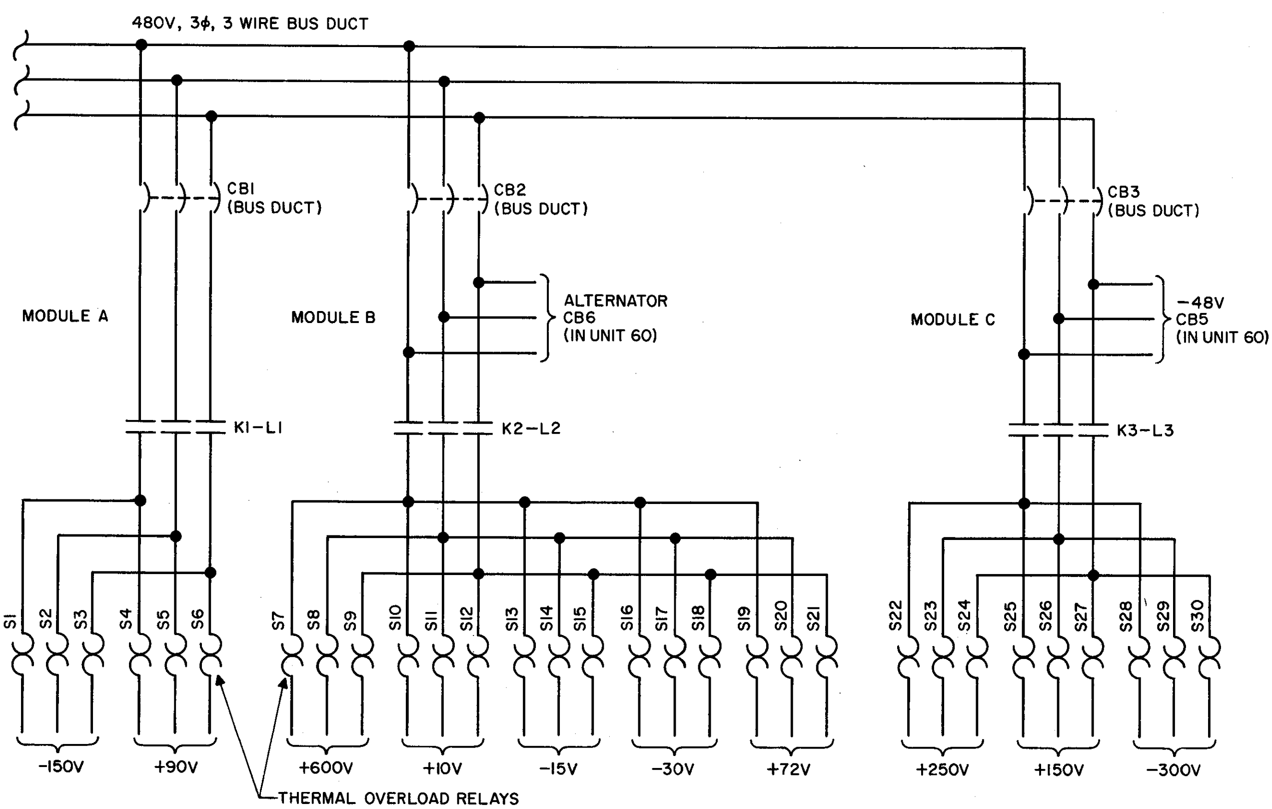


Figure 3–15. Bus Duct Sequencing Device, Power Section

arithmetic element unit 2, the —48Vdc control voltage is applied through CB 19A2C1 (5.4.3.2) and now closed points 1a-1c of ac-hold relay 19A2(K2), the OFF position of the AC ON-AC OFF switch 2Z1C11, now closed points 1a-1c of ac-start relay 19A2(K1), and now closed points 1a-1c of filament a-c CB interlock relay 19C6(K6) to relay 19C6(K2). Points 1-2 of 19C6(K2) close to hold the relay energized when the ac-start signal is released. Points 5-6 close to illuminate the AC ON (green) lamp, while points 7-8 open to extinguish the AC OFF (red) lamp. Points 3-4 of 19C6(K2) close to complete the energizing circuit to 19C6(K10). Points 3-4 of 19C6(K10) close to energize 19C6(K9).

The —48Vdc control voltage also energizes 19C6 (K13) through the following points:

a. 1a-1c of dc-hold relay 19A2(K4)
b. 1a-1c of CB interlock relays 19C6(K7), 19C6 (K8), 19C6(K11), and 19C6(K12)
c. 3-4 of relay 19C6(K9)
d. 7-8 of relay 19C6(K10)
e. OFF position of the DC ON-DC OFF switch 2Z1C3
f. 1a-1c of dc-start relay 19A2(K3)

Points 1-2 of relay 19C6(K10) complete the energizing circuit to 19C5(K1). Points 1-2 of low-voltage d-c contactor 19C5(K1) and now closed points 2a-2c of 19C6(K13) complete the circuit to 19C6(K1). Now closed points 1-2 of 19C6(K1) and 4a-4c of 19C6(K13) complete the circuit to high-voltage d-c contactor 19C6 (K3) and MC d-c contactor 19C6(K4).

Points 3-4 of 19C6(K1), 19C6(K3), and 19C6(K4) hold 19C6(K9) energized when slow-release points 3-4 of 19C6(K10) open, and 19C6(K13) picks to open points 3a-3c of that relay. Points 1-2 of relays 19C6(K3) and 19C6(K4) hold 19C6(K1) energized when 19C5 (K1) is de-energized by points 1-2 of 19C6(K10).

2.4 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 duplex maintenance console. Refer to paragraph 4.2 for action of switches, relays and indicators utilized in reaching ac-only status.

When the POWER ON pushbutton is depressed, relay K31 (5.4..1) is energized through the same path as it is for a power-off to power-on sequence (par. 2.3). At the same time, the energizing path to relay K32 is opened. Points 4a-4c of K32 open to prevent the relay from being re-energized when the POWER ON pushbutton is released. Points 5a-5b of K32 close in the energizing paths of dc-start relay K45, dc-hold relay K44, and relay K62. Points 2a-2c of both K31 and K32 are in parallel in the energizing path to K61. Consequently, this relay is not de-energized during this change in power status.

When relay K44 is energized, its points 4a-4c complete the energizing circuit to relays 19A2(K4) and 19B2(K4). Points 1a-1c of K45 complete the energizing circuit to 19A2(K3) and 19B2(K3). Since 19A2(K3) and 19A2(K4) 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 d-c voltages to be distributed to the load units. The relay sequence in typical load unit 2 is the same as that discussed in paragraph 2.3.

When this sequence is completed, d-c power is being distributed to the load units and the power supply system is in a power-on status.

SECTION 3
NORMAL POWER-OFF SEQUENCES

3.1 GENERAL

All voltages are removed in the reverse order of their application. The d-c voltages are removed from the tubes; then the a-c filament voltages are removed. The +130Vdc control voltage and the unregulated 208Vac are not removed by a normal power-off sequence.

This section discusses the normal sequence for removing the above voltages from power system A or B when it is in either the power-on or the ac-only status. The discussions are limited to the typical units previously discussed; viz., PCD unit 63, MCD unit 19, and left arithmetic element, unit 2.

3.2 POWER ON TO POWER OFF

Power is normally removed by depressing the POWER OFF pushbutton at the duplex maintenance console. When this pushbutton (5.4.2.1) is depressed, relays 63C5(K31) and 63C5(K33) are de-energized (fig. 3–16).

Note

In the following discussion, precede all PCD unit relay designations by 63C5 and all other component designations (except switchgear components) by 63 unless a complete designation is given. Switchgear components are designated in full.

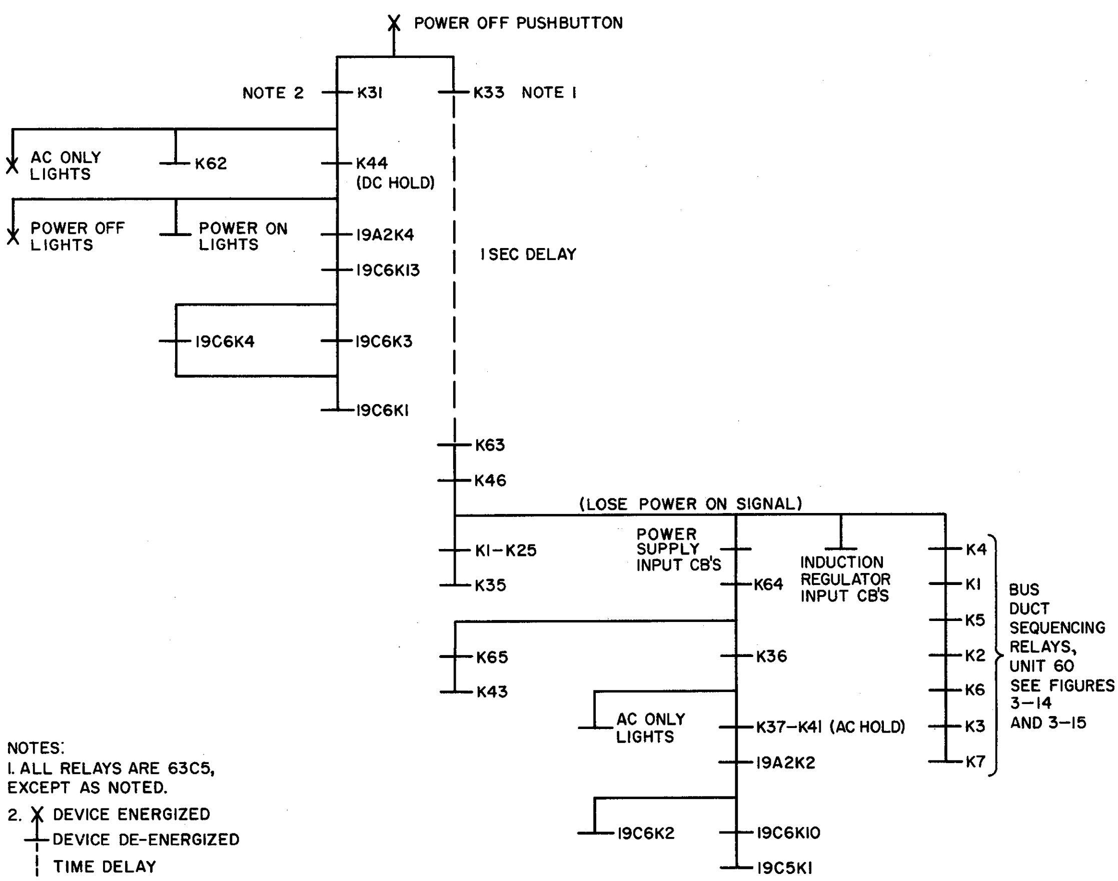


Figure 3–16. Normal Duplex Power-Off Sequence, PCD Unit 63, MCD Unit 19, and Unit 2, Simplified Sequence Chart

De-energizing relay K31 opens points 3a-3c in the circuit to dc-hold relay K44. Points of K44 open and de-energize dc-hold relay 19A2(K4) and auxiliary relay 19B2(K4). Points of these two relays open the dc-power circuits to remove all the d-c voltages from the MCD and load units. Points 2a-2c of K31 open to de-energize K61. Points 10a-10c of K33 open to de-energize K63. Relay K63 delays 1 second before opening points 1-2 to de-energize K46.

In the switchgear, de-energizing K46 causes switchgear relay 1A to be de-energized. When 1A drops, it energizes the trip coils of load center CB 52A (output CB) and power supply input CB 52A (input CB). This action opens the point in the DC SUPPLY INPUT BREAKER CLOSED phantom (5.4.2.1) and removes the input to the induction regulators, thereby removing regulated ac from the system.

Note

There are two switchgear components designated 52A. They are distinguished by the parenthetical reference to their respective functions.

When the d-c supply input CB opens, all the d-c supplies are de-energized because the 480Vac input is removed, and relay K64 (5.4.2.1) is de-energized. Points 1-2 of K64 open to de-energize relays K36 and K65. Points 1a-1c of K36 open and de-energize the ac-hold relays for the MCD units.

The system is in the power-off status as soon as the load center output CB trips. The relay actions occurring after this action prepare the system for the next power-on sequence.

3.3 AC ONLY TO POWER OFF

When the system is in the ac-only status, d-c power has been removed from the load units, but the d-c power supplies are still energized.

Depressing the POWER OFF pushbutton de-energizes relay K32 which de-energizes relay K61 by opening points 2a-2c. Points 1-2 of K61 open and permit K33 to drop. Simultaneously, the previously discussed switchgear sequence (par. 3.2) takes place, a-c power is removed; the d-c power supplies are de-energized; and the system is in the power-off status.

SECTION 4
AC-ONLY SEQUENCES

4.1 GENERAL

The power-off to ac-only sequence is similar to the power-on sequence. However, no d-c power is distributed to the load units because the dc-start and dc-hold relays in the MCD units are not energized.

Before the power-off to ac-only sequence can be initiated, the prestart conditions which are required for a power-on sequence must be accomplished (par. 2.2, Sect. 2). The sequence is initiated by the AC ONLY pushbutton at the duplex maintenance console.

The ac-only to power-off sequence is similar to the power-off sequence. In the power-on to power-off sequence, both a-c and d-c power are present before the sequence is initiated. In the ac-only to power-off sequence, the d-c voltages have been removed before the sequence is initiated. The POWER OFF pushbutton initiates this sequence.

4.2 POWER OFF TO AC ONLY

The +130Vdc control power is fed through the BATTERY DISCONNECT switch, the door interlock, and the normal positions of both the POWER OFF and the POWER ON pushbuttons to the AC ONLY pushbutton (5.4.2.1). Depressing the pushbutton completes the circuit to relay K32.

Note

In the following discussion, precede all relay designations by 63C5 and all component designations by 63C unless a complete designation is given.

When K32 is energized, its normally closed points 1a-1b open. Since these points are in the energizing path of power-on relay K31, that relay cannot be energized. Points 3a-3c of K32 close to complete the circuit to the voltage monitor reset coils, causing the coils to prevent action of the voltage monitor relays. Points 4a-4c of K32 close to hold the relay energized when the AC ONLY pushbutton is released. Normally closed points 5a-5b of K32 open when the relay is energized. Since points 5a-5b are in the energizing path of dc-hold relay K44 and dc-start relay K45, neither of these relays can be energized. Consequently, no d-c power is distributed to the load units. Points 2a-2c of K32 complete the energizing path to K61.

Relay K61 delays 5 seconds before actuating. When K61 picks, its points 1-2 close to complete the circuit to relay K33. Points 1a-1c of K33 close and the relay is now held by these contacts. When K33 is energized, points 10a-10c close and complete the circuit to K63. Points 1-2 of K63 complete the circuit to relay K46. When K46 is energized, its points 2a-2c close to complete the circuit for the power-on signal to the powerhouse. The d-c supply input CB closes (par. 2.3, Sect. 2) and, as a result, relay K64 is picked. When K64 picks, its points 1-2 close in the energizing path of relays K36 and K65. Points 1a-1c of K36 close and complete the energizing circuit to ac-start relay K42 and to ac-hold relays K37, K38, K39, K40, and K41. Points of the latter relays close in MCD units 19, 27, 29 and 46, 31, and 59, respectively, and permit regulated ac to be distributed to the filament transformers and to the filaments of the tubes in the load units associated with the MCD units.

When K65 is energized, its points 1-2 close in the energizing path of K43. When K43 is energized, its points 1a-1c close and prepare the circuit for the application of d-c power.

The ac-only sequence is now complete as regards the circuitry in the PCD unit. Relays K37 and K42, when actuated, close points 3a-3c and 2a-2c, respectively, in typical MCD unit 19. When these points closed, the −48Vdc circuits were completed to ac-hold relay 19A2(K2) and ac-start relay 19A2(K1), respectively, and auxiliary relays 19B2(K2) and 19B2(K1).

In the typical load unit, left arithmetic element unit 2, points of relays 19A2(K1), 19A2(K2), 19B2(K1), 19B2(K2), and 19C6(K6) and the OFF position of the AC ON-AC OFF switch complete the circuit to relay 19C6(K2). Points 3-4 of 19C6(K2) complete the energizing path to relay 19C6(K10).

Points 1-2 of 19C6(K10) complete the circuit to 19C5(K1). The ac-only sequence is now complete. The AC ON lamp (green) on unit 2 is illuminated through now closed points 5-6 of 19C6(K2), and the AC OFF lamp (red) is extinguished when points 7-8 of this relay open.

4.3 POWER ON TO AC ONLY

The power-on to ac-only sequence is initiated by depressing the AC ONLY pushbutton at the duplex maintenance console. When the sequence is initiated, the Power Supply System is in the power-on status. This sequence removes all d-c power but leaves regulated ac on the filaments of the tubes and unregulated ac on the convenience outlets. The ac-only status is the normal power status for maintenance.

Note

In the following discussion, precede all relay designations with 63C5 and all other component designations with 63 unless a complete designation is given.

The power-on to ac-only sequence is initiated by depressing the AC ONLY pushbutton at the maintenance console (5.4.2.1). When the pushbutton is depressed, relay K32 is energized by the +130Vdc battery current through the door interlocks and the normal positions of both the POWER OFF and POWER ON pushbuttons. When K32 is energized, its normally closed points 1a-1b open in the energizing path of K31 and de-energize that relay. Points 5a-5b of K32 open in the energizing circuit of relays K44 and K62. These relays are de-energized. Points 4a-4c of K44 open (5.4.3.1) and de-energize dc-hold relay 19A2(K4) and auxiliary relay 19B2(K4). Points 1-2 of K62 close in the energizing path of dc-start relay K45(5.4.2.1). This relay is not energized because the points of K62 are in series with now opened points 5a-5b of K32.

Points 1a-1c of 19A2(K4) open in the path of relay 19C6(K13) and this relay is de-energized. Points 7a-7b of 19C6(K13) close to illuminate the red DC OFF light for unit 2; points 6a-6c open to extinguish the green DC ON light for the unit. Points 4a-4c open and cause 19C6(K3) and 19C6(K4) to de-energize. The equipment is now in the ac-only status. The —48Vdc control voltage is present and the d-c power supplies are operating. No d-c power is distributed to the MCD or the load units.

SECTION 5
ABNORMAL-OFF SEQUENCES

5.1 GENERAL

The abnormal-off (or emergency-off) sequences remove all power from a power system without regard to sequencing in the load units. These sequences are initiated automatically by the shutdown-level voltage monitor relays or manually by maintenance personnel. The emergency-off sequence is initiated by depressing an EMERGENCY-OFF pushbutton or a UNIT OFF pushbutton on any of the following units:

a. Power supply units

b. PCD units

c. MCD units

The EMERGENCY-OFF pushbuttons are located on various pillars throughout the operations building. This sequence should be used 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.

5.2 PCD, MCD, OR POWER SUPPLY UNIT-OFF SEQUENCE

Note

Depressing the UNIT OFF pushbutton on either the PCD or the MCD unit removes power only from the associated power system. Depressing an EMERGENCY-OFF pushbutton removes power from all power systems.

When any of the UNIT OFF pushbuttons mentioned above are depressed (par. 5.1), switchgear relay 5 for the associated power system is de-energized. Points of relay 5 energize lockout device 86 and de-energize the undervoltage device in the circuit supplying unregulated ac to the PCD unit. The unregulated ac is removed from the associated power system. Simultaneously, points of device 86 open and de-energize switchgear relay 1. When relay 1 drops, both switchgear devices 52 (par. 3.2) drop and remove regulated a-c and d-c power at the induction regulator and bus-duct sequencing device, respectively. The actions caused by switchgear relay 1 in this sequence are the same as those caused by relay 1 during a normal power-off sequence. The principal difference is in the method by which relay 1 is de-energized.

5.3 EMERGENCY-OFF SEQUENCE

When an EMERGENCY-OFF pushbutton is depressed, all switchgear relays 5 are de-energized. Each relay 5 causes the same action in its own power system as described in paragraph 5.2. As a result, all power is removed from all simplex and duplex power systems.

5.4 AUTOMATIC ABNORMAL-OFF SEQUENCE

The voltage monitor relays automatically shut down the Power Supply System when the d-c power supplies deviate ±20 percent from normal or when the regulated ac deviates ±10 percent. In the following discussion, the +150Vdc circuit is discussed as a typical circuit (fig. 3–17).

Operation of the +150V voltage monitor relay (5.4.2.2) at the shutdown level causes its associated relay 63C5(K3) to drop. This action initiates a power-off sequence which first removes the +150V supply from the circuit and then removes all operating power from the equipment.

When 63C5(K3) drops (5.4.2.1), its contacts 5-12 open, thus dropping relay 63C5(K35). This action energizes 63C5(K35) (5.4.2.2) through closed contacts 3a-3b of 63C5(K35), contacts 3a-3b of 63C5(K36), contacts 4a-4c of 63C5(K46), contacts 6-13 of 63C5(K3), and contacts 2a-2b of shutdown relays 63C5(K49) through 63C5(K59). The +150V CB shunt trip coil is energized through closed contacts 1a-1c of 63C5(K50); the CB contacts open, and the +150Vdc power is removed from the equipment.

When relay 63C5(K35) drops (5.4.2.1), the overall shutdown sequence is initiated as follows: contacts 2a-2c of 63C5(K35) open, dropping dc-hold relay 63C5(K44). When contacts 2a-2c of 63C5(K44) open, power is removed from the POWER ON lamp (5.4.2.3) which extinguishes. Contacts 3a-3b of the same relay close, applying power to the POWER OFF lamp which lights. Contacts 5a-5c of 63C5(K35) (5.4.2.1) open, dropping 63C5(K31). This action initiates a normal-off sequence (par. 3.2, Sect. 3) which removes all operating power from the equipment.

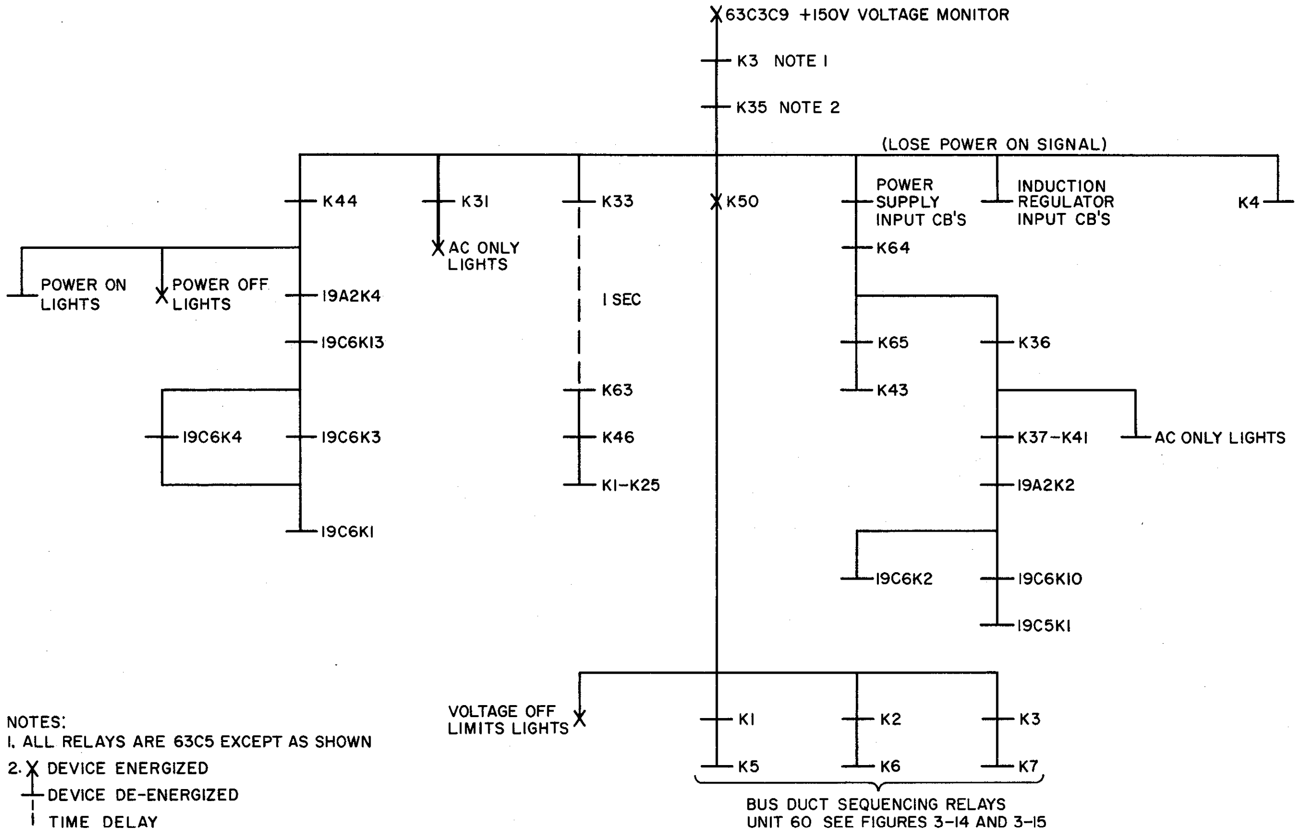


Figure 3—17. Abnormal Duplex Power-Off Sequence, PCD Unit 63 (Voltage Monitors), MCD Unit 19, and Unit 2, Simplified Sequence Chart

SECTION 6
LOAD UNIT CONTROL

6.1 GENERAL

After a duplex power system is operating, the individual load units can be turned off as necessary. The power-off, power-on, or ac-only status can be obtained by actuating the proper controls on the rear of the Z module of the load unit. The operation of circuit components in achieving the desired power condition is automatic. Unregulated ac and —48 and +130Vdc cannot be controlled from the Z module of the load unit and may be present in the unit when all indicators show that the unit is off. The lamps on the rear of the Z module indicate the power status of any tripped CD's.

In the following discussion, it is assumed that power has been removed from a typical unit, left arithmetic element, unit 2, and that the PCD unit and MCD unit 19 are in a power-on status.

Note

The power-on sequences initiated at the load units require two steps: ac on and dc on. Each step must be initiated by the proper switch. An a-c power-on sequence must be initiated before d-c power can be obtained at the load unit.

Power may be removed by reversing the above procedure, by depressing the UNIT OFF pushbutton, or by removing a-c power.

6.2 PRESTART CONDITIONS

All the CB's on the front of the Z module must be closed if a normal-on sequence of power is desired. If either the DC NONMARGINAL CHECK CB TRIP lamp or DC MARGINAL CHECK CB TRIP lamp is lighted, only the a-c power can be applied. If the AC FILAMENT CB TRIP lamp is lighted, one of the a-c filament CB's is open and neither a-c nor d-c power can be applied. Unregulated ac and —48 and +130Vdc have been applied during control at the PCD and MCD units.

MCD unit 19 must be on and operating properly to enable 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 MCD unit 19 and all other associated load units. However, when the power to the load unit is removed or the AC ON-AC OFF switch is left in the AC OFF position, power is not applied to that load unit when power is applied to the MCD unit and the associated load units.

6.3 NORMAL POWER SEQUENCES

6.3.1 Power Off to AC Only

The circuitry which applies regulated ac to a load unit during load unit control does not involve an ac-start signal from the PCD unit nor does the voltage cycle up gradually.

Placing the AC ON-AC OFF switch (5.4.3.2) momentarily in the AC ON position energizes relay 19C6 (K2) through points 1a-1c of ac-hold relay 19A2(K2), points 1a-1c of filament a-c CB interlock relay 19A2(K6), and points 1a-1b and 3a-3c of AC ON-AC OFF switch 2Z1C11.

When 19C6(K2) picks, the following sequences occur:

a. Points L1-T1, L2-T2, and L3-T3 (5.3.3.2) apply phases 1, 2, and 3, respectively, of regulated ac at full voltage for distribution through unit 2.

b. Points 1-2 close (5.4.3.2), providing a hold circuit for 19C6(K2) when the AC ON-AC OFF switch is released.

c. Points 3-4 close, energizing 19C6(K10). This relay picks and completes the same circuits now as it does in a power-off to power-on sequence.

d. Points 5-6 close, applying power to light the green AC ON lamp, 2Z1B11, and to operate the AC TIME ON (elapsed time) indicator, 2Z1C9.

e. Points 7-8 open, removing power from the red AC OFF lamp, 2Z1D11. Unit 2 is now in the ac-only status.

6.3.2 AC Only to Power On

The circuitry which applies the d-c voltages is the same as that used in a normal power-on sequence except that the dc-start signal is not involved.

Momentarily placing the DC ON-DC OFF switch (5.4.3.2) in the DC ON position energizes d-c control relay 19C6(K13) through the following, now closed points:

a. Points 1a-1c of interlock relays 19C6(K7) and 19C6(K12)

b. Points 1a-1c of dc-hold relay 19A2(K4)

c. Points 3-4 of 19C6(K9)

d. Points 7-8 of 19C6(K10)

e. Points 1a-1b and 3a-3c of DC ON-DC OFF switch 2Z1C3.

Relay 19C6(K13) picks and completes the same circuits now as it does in a normal power-off to power-on sequence.

6.3.3 Power On to AC Only

Placing the DC ON-DC OFF switch in the DC OFF position opens the circuit to 19C6(K13). When this relay drops, the d-c voltages are immediately removed from unit 2. The lamps indicate that the unit is in the ac-only status.

6.3.4 AC Only to Power Off

Moving the AC ON-AC OFF switch (5.4.3.2) into the AC OFF position opens points 1a-1b of the switch and drops relays 19C6(K2) and 19C6(K10). The regulated ac is removed immediately from unit 2 in the same manner as that described in the ac-only to power-off sequence (par. 2.3, Sect. 2). If the AC ON-AC OFF switch is operated before the DC ON-DC OFF switch, the d-c power will also be removed from unit 2 without operating the DC ON-DC OFF switch.

Note

Depressing the UNIT OFF pushbutton causes the same sequence because this pushbutton and the AC ON-AC OFF switch are in series in the energizing circuit to relay 19C6(K2).

6.4 ABNORMAL POWER SEQUENCES

6.4.1 General

An abnormal power-off sequence is initiated whenever a CB interlock is opened. The CB interlocks which cause an abnormal power-off sequence are discussed below.

6.4.2 Filament A-C CB Interlock Open

The filament a-c CB's in the load units have interlock contacts which close when the CB is closed. When any one of filament a-c CB's 2Z3A8 through 2Z3A20, 2Z3B8 through 2Z3B20, or 2Z3C8 through 2Z3C20 open, its interlock contacts open (5.4.3.2) and de-energize filament a-c CB interlock relay 19C6(K8). When this relay drops, the following occurs:

a. Points 3a-3b close to illuminate the red FIL AC CB TRIP lamp 2Z1A11.

b. Points 1a-1c open and permit 19C6(K13) to de-energize. This removes all d-c power from the unit. The red DC OFF lamp, 2Z1D3, is also illuminated through points 7a-7b.

6.4.3 Nonmarginal Checking D-C CB Interlock Open

In the non-MC d-c CB interlock circuit, contacts b-d of CB's 2Z3D20 through 2Z3M20 must be closed to keep relay 19C6(K11) energized. If this relay is de-energized, points 1a-1c open and d-c control relay 19C6(K13) is de-energized, thereby removing d-c power and illuminating the DC OFF lamp. The red NMC DC CB TRIP lamp is illuminated through now closed points 3a-3b of 19C6(K11).

6.4.4 Marginal Checking D-C CB Interlock Open

In the MC d-c CB interlock circuit, CB's 2Z3N16 through 2Z3S16 must be closed to keep MC d-c CB trip relay 19C6(K12) energized. If this relay is de-energized, its points 1a-1c open in the energizing circuit of 19C6-(K13). De-energizing relay 19C6(K12) lights the red MC DC TRIP lamp, 2Z1A9, through now closed points 3a-3b. De-energizing 19C6(K13) removes all d-c power and illuminates the red DC OFF lamp.

SECTION 7
POWER CONTROL VARIATIONS

7.1 GENERAL

Variations of the standard 2-step power control sequence exist in the equipment. These variations divide the standard 2-step control sequence into a 3-step control sequence which applies high-voltage dc in two parts.

7.2 TYPICAL 3-STEP SEQUENCE

The manner in which MCD unit 31 (5.4.6.1) controls the application of d-c power to output storage unit 33 (5.4.6.3) is typical of the standard 3-step sequence.

Note

In the following discussion, the portion of a relay designation in parentheses indicates equivalence to the similarly designated relay in unit 59. Relay 31C6(K3) (5.4.6.3) performs the same function in unit 31 as relay 59G6(K3) (5.4.7.5) does in unit 59.

The control of ac and low-voltage dc in unit 31 is similar to that described for unit 19. However, an additional relay, 31C6(K5) (5.4.6.3), is included in unit 31. This relay, which is picked by 31C6(K1), applies the following non-MC d-c voltages to unit 33: +90V, −150V, and −300V. This is the second step in the 3-step sequence. The third step is the application of the remaining non-MC dc and all of the MC dc. This step is accomplished when 31C6(K5) picks 31C6(K3) and 31C6(K4). These relays apply the non-MC and MC dc, respectively, to the load unit.

7.3 LOAD UNIT INTERLOCK

Another variation in power control consists of interlocking load units so that one will receive power before the other. For example, units 33 and 42 are interlocked so that unit 42 receives power from output MCD unit 31 before unit 33 is energized. This interlocking is accomplished by placing points 5a-5c of relay 31B6(K13) (5.4.6.2), the d-c control relay for unit 42, in the d-c control circuit for unit 33 (5.4.6.3). Therefore, power cannot be applied to unit 33 until the d-c control relay for unit 42 is picked.

7.4 SUMMARY OF POWER CONTROL VARIATIONS

Table 3–8 summarizes the variations in power control sequencing that exist in the equipment. The table indicates, in general, the type of variations for the different units. Full details can be obtained by examination of the referenced logic diagrams.

TABLE 3–8. POWER CONTROL SEQUENCE VARIATIONS

UNIT MCD	LOAD UNIT	LOGIC	REMARKS
19	2,3,4,5,6	5.4.3.1 through 5.4.3.6	Standard control circuit, 2-step sequence
19	7,8,9	5.4.3.7	Standard control circuit, 3-step sequence
—	10,11,12	5.4.3.8	Standard control circuit, 3-step sequence
—	13	5.4.3.9	The control for tape adapter unit 13 includes the standard control circuitry. However, additional control circuitry is required for the nonstandard voltages from the tape power supplies. These voltages cannot be supplied until the sequence for the standard voltages has been completed. Control circuitry is provided for all of the tape drives.
27	167,168,169, 171,174	5.4.4.6	One set of control relays and contactors is provided in unit 27 for these consoles. Although this control is basically standard, each console also has individual controls similar to those of the display consoles in the duplex area.

TABLE 3–8. POWER CONTROL SEQUENCE VARIATIONS (Cont'd)

UNIT MCD	LOAD UNIT	LOGIC	REMARKS
29	21,22	5.4.5.2, 5.4.5.3	Both of these units require a modified 3-step sequence control circuit. Basically, the circuit is the same as the standard 3-step sequence. It differs from the standard in that the two load units are interlocked so that the sequence must be complete for unit 21 before it can start for unit 22. After the completion of the third step for unit 22, —150V is applied to the model A flip-flops in both units.
46	20	5.4.8.2	Modified 3-step sequence control similar to the one described for units 21 and 22. Consists of a standard 3-step sequence circuit with an additional step for the —150V to the model A flip-flops.
31	33,42	5.4.6.1 through 5.4.6.3	Standard control circuit, 3-step sequence. However, the two load units are interlocked so that the sequence for unit 42 is complete before it can start for unit 33.
59	32,34,41*	5.4.7.1 and 5.4.7.3	Standard control circuit, 2-step sequence. However, module E of unit 59 acts as the Z module for these units.

**Units 34 and 41 are present only in AN/FSQ-7 equipment.*

PART 4
SIMPLEX POWER DISTRIBUTION AND CONTROL
CHAPTER 1
GENERAL
SECTION 1
INTRODUCTION

1.1 SCOPE

This part describes the power systems used to provide power for the simplex equipment of SAGE. Physical and functional descriptions are given for all units used in distribution and control of power for the simplex equipment. The overall analysis is divided into power distribution and control for displays and power distribution and control for inputs. Detailed analysis appear in the other four chapters:

Chapter 2 – Power Distribution for Displays
Chapter 3 – Power Control for Displays
Chapter 4 – Power Distribution for Inputs
Chapter 5 – Power Control for Inputs

1.2 DESCRIPTION OF UNITS

1.2.1 General

Some units in the Power Supply System provide power for the simplex equipment only. Since two systems are used to provide power for the simplex equipment, two of each of power supply unit 61, PCD unit 64, display console CB unit 48, and simplex input CB unit 56 are required and designated C or D, depending on whether the units are in power system C or D. One other unit, simplex input PD unit 55, performs the input functions for both systems C and D and, consequently, is not duplicated. The power supply units are described in Part 2, Chapter 4, Section 1.

1.2.2 PCD Unit 64

1.2.2.1 Physical Description

Each PCD unit 64 (fig. 4–1) 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 a-c power as follows: regulated ac to CB unit 48, CB unit 56, and the a-c 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.

1.2.2.2 Functional Description

Power control and distribution unit 64, which receives unregulated ac from the substation, regulated ac from the line regulator, 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.

1.2.3 Display Console CB Unit 48

1.2.3.1 Physical Description

Each display console CB unit 48 (fig. 4–2) 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. Module B contains CB's. The remaining eight modules contain numerous CB's and a CB TRIP lamp for each display console.

1.2.3.2 Functional Description

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

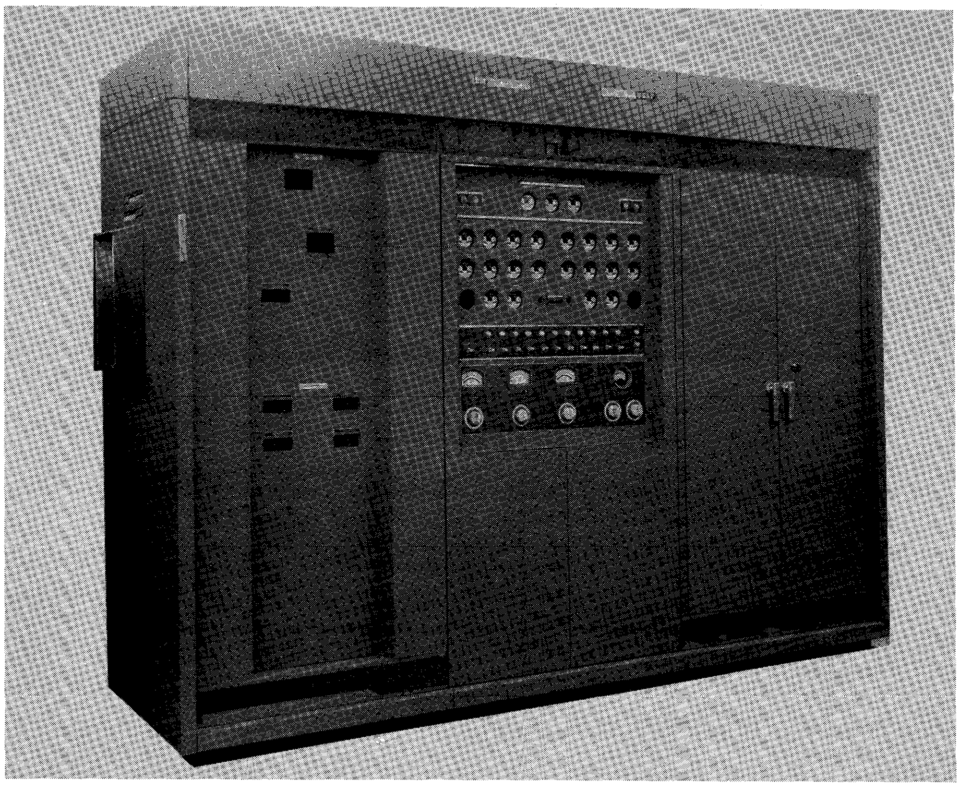


Figure 4–1. PCD Unit 64, Left Front View

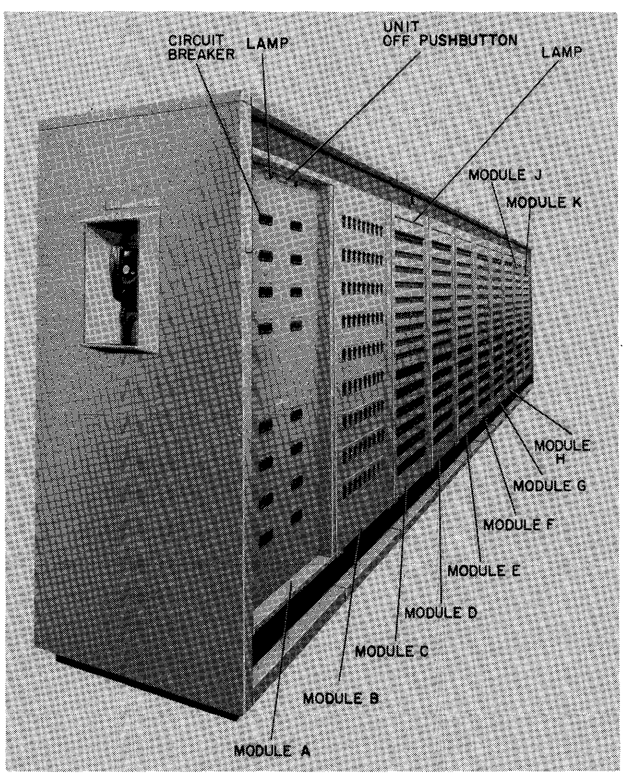


Figure 4–2. Display Console CB Unit 48, Left Front View

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:

a. Unregulated ac for projector units 251 and 252
b. All regulated ac for distribution modules of unit 48
c. Plus 600Vdc 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.

1.2.4 Simplex Input CB Unit 56

1.2.4.1 Physical Description

Each simplex input CB unit 56 (fig. 4–3) 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.

1.2.4.2 Functional Description

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

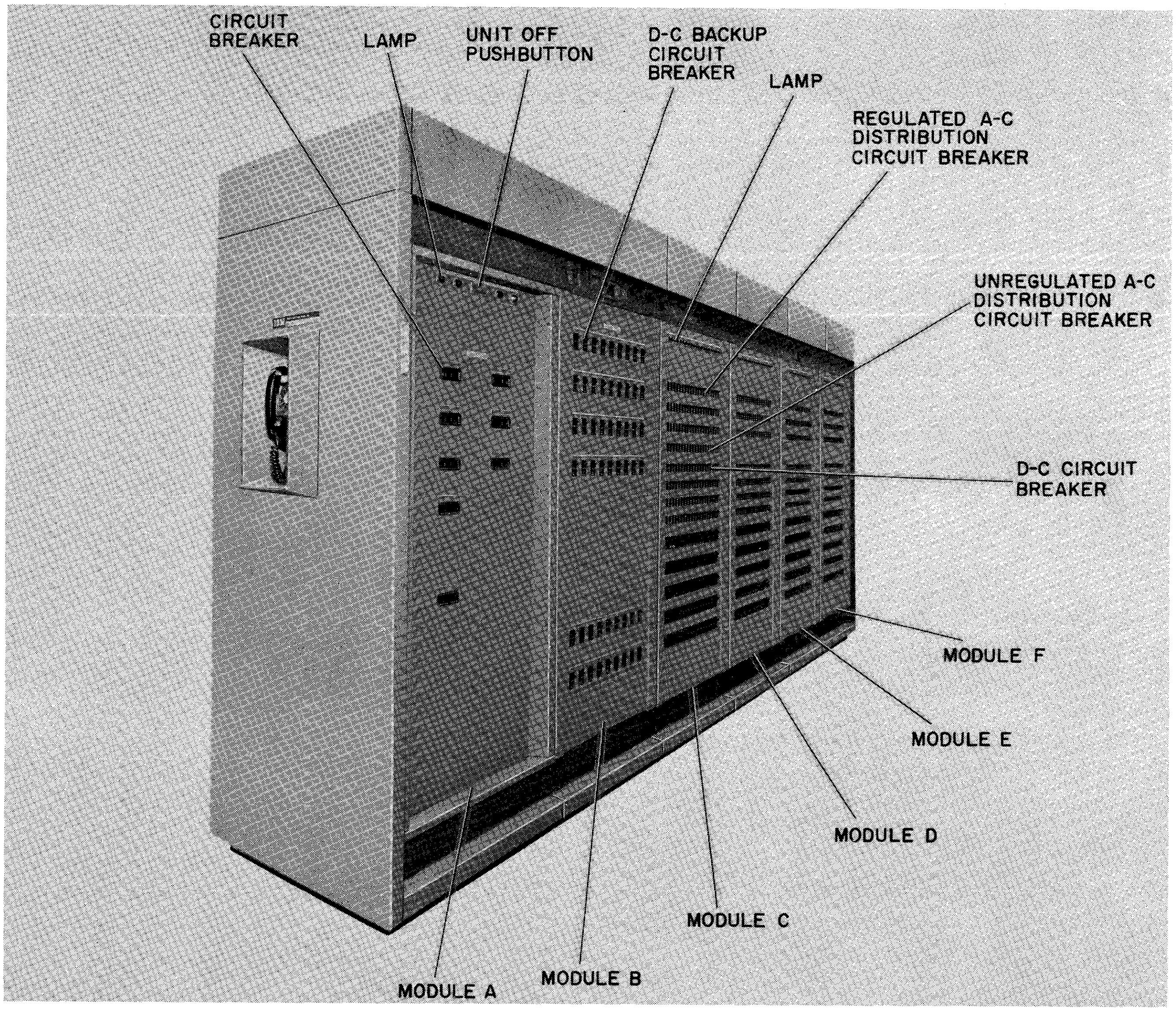


Figure 4–3. Simplex Input CB Unit 56, Left Front View

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

1.2.5 Simplex Input PD Unit 55

1.2.5.1 Physical Description

Simplex input PD unit 55 (fig. 4–4) 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.

1.2.5.2 Functional Description

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,

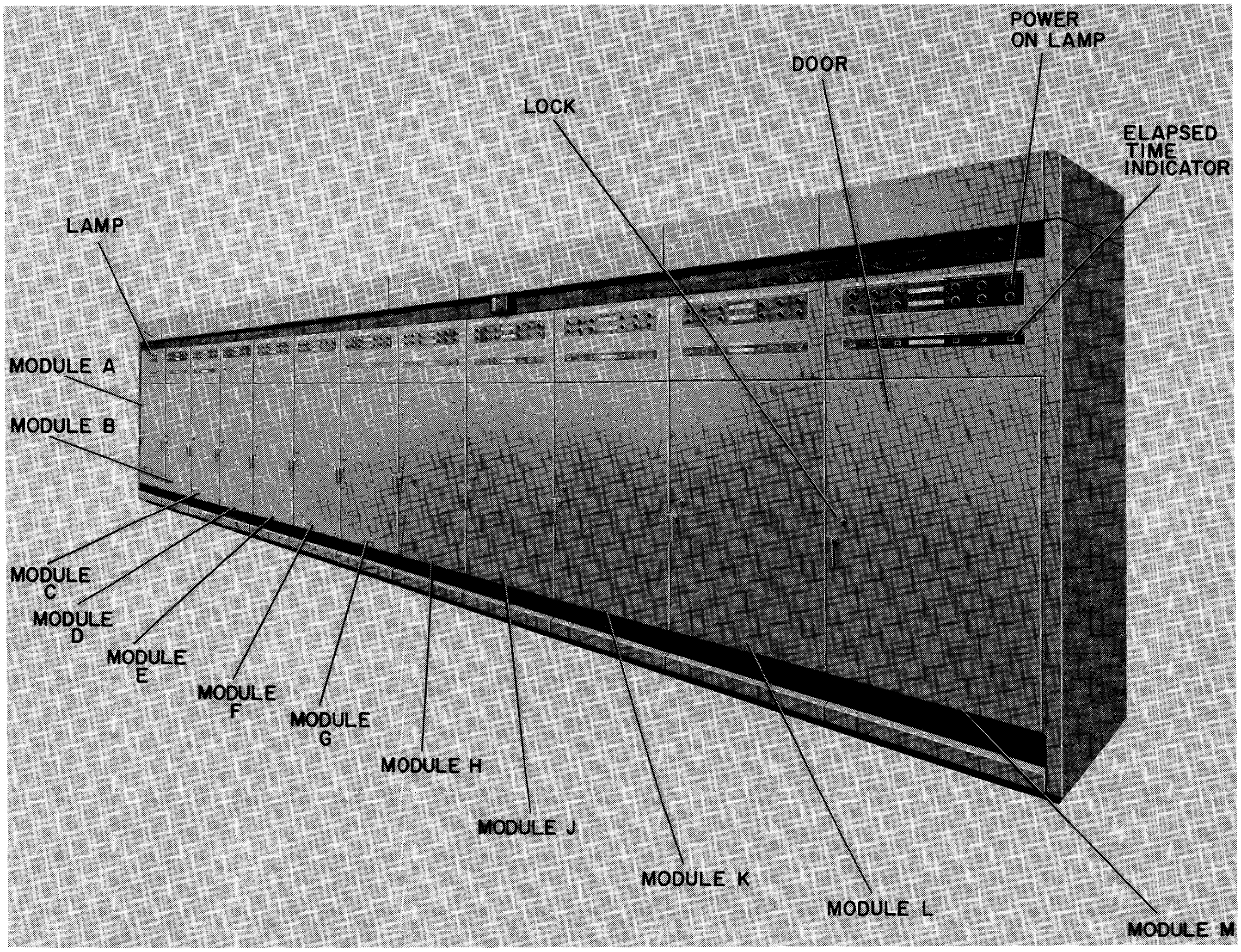


Figure 4—4. Simplex Input PD Unit 55, Right Front View

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 lower lamp, when system D is providing the power.

1.2.6 Simplex Load Unit

1.2.6.1 Display Console

All units that take power from CB unit 48 are called display consoles in this manual regardless of the actual function of each unit. When specific load units are mentioned, the titles are the same as those on the list of nomenclature (table 1—1). For descriptions of display consoles, refer to *Theory of Operation, Display System, AN/FSQ-7* and *-8,* 3-62-0.

1.2.6.2 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 received 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 (Part 3). Titles of specific simplex input load units appear on the list of nomenclature (table 1—1). For descriptions of the input load units, refer to *Theory of Operation, Input System, AN/ FSQ-7 and -8,* 3-52-0.

SECTION 2
OVERALL ANALYSIS

2.1 INTRODUCTION

This overall analysis is a general description of the Power Supply System to show the distribution and control features. System C is listed as a typical power system, eliminating the need for labeling the units C or D. The power that is distributed includes unregulated ac, regulated ac, and 10 d-c voltages.

The sources of power for simplex equipment are similar to the power for duplex equipment. Power is received from the powerhouse (fig. 3–6) and supplied to substations, load centers, and sequencing devices for the power supply unit.

The substation transforms high-voltage ac into 3-phase unregulated 120/208Vac, which is supplied to the PCD unit (fig. 1–4) for distribution to units that contain convenience outlets, electric motors, heating elements, and arc lights.

The load center transforms high-voltage ac into 3-phase unregulated 120/208Vac, which is regulated by the induction regulator and supplied to the PCD unit. The PCD and subsequent units distribute this regulated 120/208Vac to the projector units and to the transformers in the load units for further reduction in voltage and application to the filaments of the electron tubes.

The power supply unit receives 3-phase unregulated 480Vac from the bus duct sequencing device and rectifies the ac into 10 d-c voltages. One of these d-c voltages is used as a control voltage throughout the equipment. The other voltages are distributed to the load units for use in the electronic circuits.

The distribution and control of simplex power is arranged in two patterns, one for displays and one for inputs.

2.2 POWER DISTRIBUTION AND CONTROL FOR DISPLAYS

Most of the display consoles receive their power from either simplex power system, as determined by the power system (C or D) that is active and the position of the unit status switch on the display console.

The power delivered to the power system is applied to PCD unit 64, except for some unregulated ac, which is applied to power supply unit 61 and rectified into d-c voltages before it is applied to PCD unit 64. From unit 64, the unregulated ac, regulated ac, and 10 d-c voltages for displays are applied to CB unit 48 and then to the simplex display consoles. Unit 48 has CB's that protect the distribution circuits to the display consoles.

Power supply unit 61 receives unregulated ac, for convenience outlets only, from PCD unit 64.

Power for the duplex display consoles is applied from MCD unit 27 (fig. 3–1) to CB unit 48 and then distributed to those display consoles.

The voltage monitors in PCD unit 64 automatically sense and indicate the power supply input voltage, the regulated a-c voltages for filament power, and the 10 d-c voltages. When excessive deviations are sensed, actions are initiated for warnings or an abnormal shutdown sequence. Through the meters provided, the above voltages and the current of any of the 10 d-c power supplies can be observed. The power for displays can be controlled from PCD unit 64, display console CB unit 48, or the display console involved.

No facilities are provided for marginal checking the display consoles.

2.3 POWER DISTRIBUTION AND CONTROL FOR INPUTS

Some input units have duplex loads and simplex loads in the same unit. These units receive power from several power systems. Refer to *Theory of Operation, Input System, AN/FSQ-7 and -8,* 3-52-0. A voltmeter must be used to determine whether all power is off particular units when maintenance activities are necessary.

Power distribution and control for the duplex equipment is provided through MCD unit 59 (table 3–1). The description in Part 4 is limited to simplex equipment.

The power flow to PCD unit 64 is the same for inputs as for displays (par. 2.2). However, from unit 64, the power is applied to CB unit 56. The unregulated ac is applied directly to the simplex load units (GFI, XTL, LRI, etc.). During normal operation, the regulated ac and the nine d-c voltages are applied through simplex input PD unit 55 to the load units. Switching to the active power system is performed by relays in the sliding units within PD unit 55. Only eight of the d-c voltages are used in the electronic circuitry of the load units. The —48Vdc is used to control the relays.

For marginal checking purposes, five of the d-c voltages are distributed from CB unit 56, through MC unit 58, where the variation is introduced to the one voltage at a time, and then through PD unit 55 to the simplex load unit. Overall control of the power applied to the simplex input load units is effected at PCD unit 64. The monitoring equipment is explained in the description for displays (par. 2.2) since the same voltages are used for inputs.

Circuit breakers in CB unit 56 protect the distribution circuitry and can also be opened or closed manually to control power to the input load units. The status of each channel of the load units is determined at the appropriate control panel on the simplex maintenance console.

CHAPTER 2

POWER DISTRIBUTION FOR DISPLAYS

SECTION 1

INTRODUCTION

1.1 SCOPE

Chapter 2 presents a detailed analysis of the circuitry used in distributing power to the display consoles. This analysis is divided into separate sections for unregulated a-c distribution, regulated a-c distribution, d-c distribution, metering circuit distribution, and neutral lines, returns, and grounds. The last section explains only the overall arrangements of the neutral lines, returns, and grounds, individual neutral lines and returns being listed in conjunction with the specific distribution circuits.

1.2 GENERAL

The distribution of power for displays begins at PCD unit 64. Unregulated 120/208Vac is distributed at unit 64 to convenience outlets in PCD unit 64, power supply unit 61, and display console CB unit 48, and from CB unit 48 to the load units (display consoles).

Regulated 120/208Vac is distributed from PCD unit 64, through CB unit 48, where additional CB's protect the circuits, and then to the projection units and display consoles for application to filament transformers.

The 10 d-c voltages from power supply unit 61 are received at unit 64 and distributed through CB unit 48 to the display consoles.

SECTION 2
UNREGULATED A-C DISTRIBUTION

2.1 GENERAL

Unregulated 120/208Vac is provided at convenience outlets on most units for drop lights and power tools and at projector units 251 and 252 for the arc lights, motors, and an electric heater. This power is also distributed to meters for visual indications when readings are desired (Sect. 5). Primary distribution involves the distribution through the 3-phase CB's in PCD unit 64. Distribution to convenience outlets involves typical circuits in power supply unit 61, display console CB unit 48, and typical display consoles. The 120V (phase to neutral) is used for unregulated ac, but normal distribution voltage drop reduces the usable voltage to approximately 115V.

2.2 PRIMARY DISTRIBUTION

Three-phase unregulated ac is applied from the substation feeder breaker to bus bars 64C9L1, L2, and L3 (CD 5.3.2.2) in PCD unit 64. Unregulated ac is distributed through 3-phase CB's to other locations. Table 4–1 lists these CB's and the destinations.

TABLE 4—1. UNREGULATED A-C DISTRIBUTION THROUGH PCD UNIT 64

3-PHASE CB CB NO.	LOCATION	DESTINATION
CB 9	64C7F2	CB unit 48
CB 12	64C7G1	CB unit 48 for projector units 251 and 252
CB 11	64C7G2	PCD unit 64, meters, and unit 61

Note: See logic diagram CD 5.3.2.2 for the circuits listed above.

The unregulated a-c neutral lines are returned to terminals 64C5A12-15 on the unregulated a-c neutral bus bar.

2.3 CONVENIENCE OUTLETS

2.3.1 Power Supply Unit 61

Twelve convenience outlets in unit 61 receive unregulated ac. Three-phase CB 64C7G2 (CB 11) protects the unregulated a-c lines to the metering circuits in unit 64 and the convenience outlets in unit 61. Phase 3 is applied to terminal 64B7C5u (CD 5.4.2.4), then to terminal 61C(TB35)9 (CD 5.2.1.1) and to four convenience outlets, and then to additional outlets (CD 5.2.1.9 and CD 5.2.1.7). The a-c neutral lines return to terminal 64(TB35)10 (CD 5.2.1.1) and connect to terminal 64B7C51 (CD 5.4.2.4).

2.3.2 Display Console CB Unit 48

Unregulated ac from CB 64C7F2 (CB9) (CD 5.3.2.2) is applied to bus bars 48C3E1, 48D3E1, and 48E3E1 (CD 5.3.9.1). Individual phases are then distributed to convenience outlets in display console CB unit 48 (table 4–2) and to the display consoles (table 4–3).

2.3.3 Load Units

2.3.3.1 Typical Display Console

Unregulated a-c distribution through the display consoles can be traced on Display System logic diagrams that show power distribution (*Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0).

For example, unregulated 120Vac (phase 1 to neutral) (table 4–3) is applied to situation display console unit 169 (S 4.2.6) at pins 30 and 31 of jack connector J5 from power system C. This unregulated ac is applied to convenience outlets J13. The unregulated ac received from power system D at pins 30 and 31 of jack connector J12 is applied to convenience outlets J14. Either of these two sources of unregulated ac can be switched by the number 4 contacts of relay K1C or K1D to apply power to panel light and cigarette lighter transformer T1. The unregulated a-c neutral from T1 is connected to the neutral side of J14. This neutral is connected to pin 22 of J12 and returned to neutral bus bar terminal 48E1B2-1 (CD 5.3.9.1).

2.3.3.2 Projection Unit

The unregulated 120Vac is applied to projection unit 251 (4.8.6) at pins 30 and 31 of J5 from power system C. This unregulated ac is applied to convenience outlets X11, X12, X15, and X16. The unregulated ac received from power system D at pins 30 and 31 of J12 is applied to convenience outlets X13, X14, X17, and X18. The unregulated a-c neutral lines are connected to pins 22 and 23 of J5 and J12 and returned to terminal 8 on neutral bus bar 48E1B2 (CD 5.3.9.1).

TABLE 4—2. UNREGULATED A-C DISTRIBUTION IN UNIT 48

PHASE	INPUT BUS BAR	DISTRIBUTION BUS BAR	CB	CONVENIENCE OUTLET
1	48E3E1	48A1A1	48A1B1	48C1F2
			48A1E1	48F1F2
			48A1E2	48K1F2
			48A1B2	48G1F2
2	48D3E1	48A1A2	48A1C1	48D1F2
			48A1C2	48H1F2
3	48C3E1	48A1A3	48A1D1	48E1F2
			48A1D2	48J1F2
Neutral	48A1K	—	—	—

Note: See logic diagram CD 5.3.9.1 for the circuits listed above.

TABLE 4—3. TYPICAL A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN DISPLAY CONSOLES

UNIT 48 INPUT BUS BAR	INTERMEDIATE DISTRIBUTION BUS BAR	FINAL DISTRIBUTION BUS BAR	COLUMN (CONNECTION POINT)	CB	CONSOLE UNIT NO.	LOGIC DIAGRAM NO.
48E3E1 for Phase 1	—	48E2F	21	48E2F21	169	4.2.6
			20	48E2F20	750	4.2.6
			etc.	etc.		
			14	48E2F14	251	4.8.6
			13	48E2F13	252	4.8.6
			etc.	etc.		
			2	48E2F2	833	4.2.6
	48H3E1	48H2F	21	48H2F21	787	4.2.6
			etc.	etc.		
			2	48H2F2	935	4.4.2

Note: Additional distribution points can be found on logic diagrams CD 5.3.9.1, sheet 2, and S 5.0.9.10.

The unregulated a-c circuits in the other load units can be traced by the same procedure.

2.4 PROJECTION LIGHTS, MOTORS, AND HEATER

Unregulated ac from CB 64C7G1 (CB 12) (CD 5.3.2.2) is applied to bus bars 48A2A2, 48A2A3, and 48A2A4 (CD 5.3.9.1). The 3-phase CB 48A2B3 protects the unregulated a-c circuits for the arc light, motors, and an electric heater in projection unit 251. Plug connector P1 in power system C connects to a cable that conducts the power to J1 (4.8.5 in *Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0).

SECTION 3
REGULATED A-C DISTRIBUTION

3.1 GENERAL

The 3-phase regulated 120/208Vac is provided to filament transformers in the load units, where the voltage is stepped down and applied to the filaments of the tubes. A typical circuit is used to trace regulated ac through PCD unit 64 and CB unit 48 into a display console. Regulated ac in the PCD unit is also distributed to the AC VOLTMETER for visual indications and to voltage monitor relays for automatic monitoring of changes in voltage (par. 5.3.3).

3.2 PCD UNIT 64

Three-phase regulated ac is applied from induction regulator unit 95 to bus bars 64C9L1, L2, and L3 (CD 5.3.2.2) in PCD unit 64. Regulated ac is distributed through 3-phase CB 64C7A1 (CB1) to display console CB unit 48 for further distribution and through CB 64C7C2 (CB3) for distribution to the metering circuits in PCD unit 64 (Sect. 5).

3.3 CB UNIT 48

Regulated ac from CB 64C7A1 (CB1) (CD 5.3.2.2) is applied to bus bars 48A6B1, B2, and B3 (CD 5.3.9.1) for phases 3, 2, and 1, respectively. Distribution proceeds from these bus bars, through 3-phase CB's, to other bus bars, through single-phase CB's and to plug connectors that apply the power to interunit cables for distribution to the display consoles (table 4–4).

The regulated a-c neutral lines return from the display consoles on pins 28, 32, and 35, tie to bus bars in CB unit 48 (CD 5.3.9.1), return to regulated a-c neutral bus bar 48A6B4, and connect to bus bar terminal 64C5B9 (CD 5.3.2.2).

3.4 LOAD UNITS

3.4.1 Typical Display Console

The regulated a-c distribution through the display consoles can be traced on Display System logic diagrams that show power distribution (*Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0).

For example, regulated 120Vac (phase 1 to neutral in table 4–4) is applied to situation display console unit 753 (S 4.2.6) at pins 20, 24, and 26 of J5 from power system C.

Note

Some incorrect logic may show phase 3 on these pins.

The number 3 contacts of K1C apply 120Vac to J37-S9. When power system D provides the power, K1D is energized and K1C is de-energized.

3.4.2 Projection Unit

Projection units receive regulated ac in a manner similar to the display consoles. Phase 1 (table 4–4) is applied to pins 20, 24, and 26 of J5 from power system C. In projection unit 251, this power is applied across the number 3 contacts of K1C (4.8.6) to J37-S9.

TABLE 4—4. TYPICAL REGULATED A-C DISTRIBUTION POINTS TO DISPLAYS

BUS BAR	3-PHASE CB	TERMINAL	BUS BAR	BUS BAR	DISTRIBUTION TERMINALS	SINGLE-PHASE CB	PLUG CONNECTOR PIN NO.	CONSOLE UNIT NO.	LOGIC NO.
48A6B3	48A6C2	e	48C3D1	48C2E1	48C2E21	48C2E21	20, 24, or 26	753	S 4.2.6
(Phase 1 applied from terminal 64C7A1d)	48A6C2	e	48C3D1	48C2E1	48C2E20	48C2E20	20, 24, or 26	754	S 4.2.6
	48A6C2	e	48C3D1	48C2E1	48C2E19	48C2E19	20, 24, or 26	755	S 4.2.6
					etc.	etc.	Same	etc.	
	48A6D2	e	48E3D1	48E2E1	48E2E14	48E2E14	20, 24, or 26	251	4.8.6
	48A6D2	e	48E3D1	48E2E1	48E2E13	48E2E13	20, 24, or 26	252	4.8.6
					etc.	etc.	Same	etc.	
	(See Column 5 on CD 5.3.9.1, sheet 2)	(See note on CD 5.3.9.1, sheet 2)	(See Column 8 on CD 5.3.9.1, sheet 2)	(See Column 11 on CD 5.3.9.1, sheet 2)	(See Column 18 on CD 5.3.9.1, sheet 2)	(See Column 19 on CD 5.3.9.1, sheet 2)		(See 5.0.9.10 for correct site application)	(See *Schematics for Display System)*

SECTION 4
D-C DISTRIBUTION

4.1 GENERAL

The d-c power is used during the operation of SAGE equipment. Nine d-c voltages (+600, +250, +150, +90, +10, —15, —30, —150, and —300V) are distributed to the display consoles for use in the electronic circuits. The 10th voltage (—48V) is used as a control voltage to energize relay coils. A battery source of 130Vdc is also used as control power; however, this voltage is mentioned only with control functions and is not discussed in these distribution circuits. Display consoles are not marginally checked; therefore, only non-MC voltages are distributed to the display consoles.

4.2 POWER SUPPLY UNIT 61

The d-c power is rectified from a-c power (Part 2, Ch 4) by the d-c power supplies in unit 61. The 10 d-c power supplies apply their d-c voltage to bus bars in unit 61 (table 4–5), from which the voltages are applied to PCD unit 64.

TABLE 4–5. BUS BARS IN UNIT 61 FOR D-C VOLTAGES

VOLTAGE	BUS BAR	MODULE
+600	TB100-6	A
+250	TB100-4	C
+150	TB100-8	C
+90	TB100-15	B
+10	TB100-9	B
—15	TB100-14	B
—30	TB100-12	B
—150	TB100-5	C
—300	TB100-7	A
—48	TB100-1	C

4.3 PCD UNIT 64

Nine of the 10 simplex d-c voltages developed in unit 61 (CD 5.3.2.1) are applied to nine bus bars in PCD unit 64 (table 4–5). The +600V line is connected, not to a bus bar, but directly to a contact of the 9-pole knife switch that supplies d-c power to display console CB unit 48. Eight of the nine bus bars (excluding the —48V bus bar) are connected to the other eight contacts of the 9-pole knife switch. The —48 bus bar is connected to a double-pole knife switch to provide control power for CB unit 48 and its load units.

Table 4–6 shows the knife switch contacts that apply the d-c voltages to display console CB unit 48. (Distribution of d-c voltages to the metering circuits is described in Sect. 5.)

TABLE 4–6. D-C VOLTAGES IN UNIT 64 FOR DISPLAY CONSOLE CB UNIT 48

VOLTAGE	CONTACTS OF KNIFE SWITCH 64A6
+600	B7-B8
+250	D7-D8
+150	E7-E8
+90	F7-F8
+10	G7-G8
—15	H7-H8
—30	J7-J8
—150	K7-K8
—300	L7-L8
—48	M7-M9
	N7-N9

Note: See logic diagram CD 5.3.2.1 for the circuitry that shows the points listed above.

4.4 CB UNIT 48

Nine d-c service voltages and the —48V control voltage are applied from the knife switch (table 4–6) in unit 64 to the main bus bars in display console CB unit 48 (CD 5.3.9.2., sheet 1). Each voltage is then applied from its main bus bar through CB's to bus bars in other modules of unit 48 for distribution to the display consoles.

For example, +250Vdc is taken from contact D8 of knife switch 64A6 (CD 5.3.2.1) and applied to terminal 1 on main bus bar 48B2B5 (table 4–7 and CD 5.3.9.2, sheet 1). One line then proceeds from the main bus bar through CB 48B2C5 to terminal 1 on bus bar 48C2L. The line from terminal 48C2L21a applies +250V to CB 48C2L21 (CD 5.3.9.3). Pin 4 of every plug connector P5 for power system C or plug connector P12 for power system D is used to apply the +250V to each display console. The d-c returns connect at pins 11, 12, and 13 of P5 and P12 (CD 5.3.9.3) and return to bus bar 48C1D2-1.

4.5 LOAD UNITS

4.5.1 Typical Display Console

The d-c distribution through the display consoles can be traced on Display System logic diagrams *Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0).

For example, +250V (table 4–7) is applied to situation display console unit 753 (S 4.2.6) at pin 4 of J5 from power system C. When unit 753 is receiving power, the +250V is applied through contacts 2 of K4C and is available for the electronic circuits discussed in *Theory of Operation, Display System of AN/FSQ-7 and -8,* 3-62-0. When power system D supplies the power, contacts 2 of K4C are open and contacts 2 of K4D are closed.

The chassis ground of the display console provides the d-c return and connects to pins 11, 12, and 13 of J5 and J12. Pins 16 and 17 are also grounded to the chassis and provide the equipment bond.

4.5.2 Projection Unit

The d-c distribution through the projection units can be traced in the same way as any display console (par. 4.5.1).

The +250Vdc (table 4–7) applied on pin 4 of J5 or J12 (4.8.6) passes through contacts 2 of K4C when K4C is energized and appears at J37-U6 and other connected terminals.

TABLE 4–7. TYPICAL D-C DISTRIBUTION POINTS IN UNIT 48

VOLTAGE	MAIN BUS BAR	CB	DESIRED CONSOLE	DISTRIBUTION BUS BAR	TERMINAL	CB	PLUG CONNECTOR PIN NO.
+250	48B2B5	48B2C5	753	48C2L	21	48C2L21	4
	48B2B5	48B2C5	754	48C2L	20	48C2L20	4
	48B2B5	48B2C5	755	48C2L	19	48C2L19	4
	(See logic diagram CD 5.3.9.2 for these and comparative distribution points)					(See Column 19 on CD 5.3.9.3, sheet 1)	(See CD 5.3.9.3, sheet 3)
				(See Column 5 on CD 5.3.9.3, sheet 1)			
	48B2B5	48B2E5	251	48E2G	14	48E2L14	4
	48B2B5	48B2E5	252	48E2G	13	48E2L13	4

SECTION 5
METERING CIRCUIT DISTRIBUTION

5.1 GENERAL

Equipment for manual and automatic monitoring of simplex power is provided in PCD unit 64. The four meters for readings can be switched manually. Voltage monitors operate automatically to sense and indicate the voltages applied to them.

5.2 METERS

5.2.1 Introduction

Four meters on PCD unit 64, which are equipped with circuit selection switches, enable the operators to observe the precision of the power supplied. These meters are the AC VOLTMETER, DC VOLTMETER, RIPPLE VOLTMETER, and DC AMMETER. In the paragraphs that follow, voltage applications will be traced to each meter. (Refer to Part 2, Ch 5, for the theory of the meters.)

5.2.2 AC Voltmeter

The a-c voltages are applied to terminals on the three decks of the ac voltmeter selector switch.

5.2.2.1 Unregulated AC

Three-phase unregulated ac from CB 64C7G2 (CD 5.3.2.2) is applied to terminals 64B7C5d, s, and u (CD 5.4.2.4). (Refer to table 4–8 for the application of each phase to the terminals of the a-c voltmeter selector switch.) The unregulated a-c neutral lines connect to terminal 64B7C5l and return to terminal 64C5A14 (CD 5.3.2.2) on the neutral bus bar.

5.2.2.2 Power Supply Input

Bus ducts (CD 5.2.1.13) provide 480V 3-phase ac for the d-c power supplies in unit 61. Some of this power is also applied through three switches and fuses to terminals 64B7C5j, h, and g (CD 5.4.2.4). (Refer to table 4–8 for the application of each phase to the terminals of the a-c voltmeter selector switch.)

5.2.2.3 Regulated AC

Three-phase regulated ac from CB 64C7C2 (CD 5.3.2.2) is applied to terminals 64B7C5c, b, and a (CD 5.4.2.4). (Refer to table 4–8 for the application

TABLE 4–8. VOLTAGE APPLICATIONS TO A-C VOLTMETER

TYPE OF VOLTAGE	PHASE	DISTRIBUTION TERMINAL	TERMINAL OF REAR DECK 64B3H5C	TERMINAL OF FRONT DECK 64B3H5A
Unregulated ac	1	64B7C5d	4,7	2
	2	s	3,6	4
	3	u	2,5	3
	Neutral	l	–	5,6,7
Power supply input	1	64B7C5j	10	8
	2	h	9	10
	3	g	8	9
Regulated ac	1	64B7C5c	1	–
	2	b	12	–
	3	a	11	–
	Neutral	m	–	1,12,11

Note: See logic diagram CD 5.4.2.4 for the circuits of the points listed above.

TABLE 4—9. VOLTAGE DISTRIBUTION TO D-C VOLTMETER

VOLTAGE	TERMINAL ON KNIFE SWITCH 64A6	FUSE	DISTRIBUTION TERMINAL	RIPPLE METER SELECTION SW MIDDLE DECK TERMINAL	D-C VOLTMETER MULTIPLIER (RESISTOR)	CONTACTS OF D-C VOLTMETER SELECTOR SWITCH MIDDLE DECK 64B3H3B	CONTACTS OF D-C VOLTMETER SELECTOR SWITCH REAR DECK 64B3H3C
+250	D5	64B2C1	64B2D4a	11	300K	12	—
+150	E5	64B2F1	64B2D4d	10	300K	11	—
+90	F5	64B2G1	64B2H4a	9	150K	9	—
+10	G5	64B2L1	64B2M4a	7	15K	7	—
—15	H5	64B2P1	64B2M4d	6	30K	—	6
—30	J5	64B2R1	64B2S4a	5	75K	—	5
—150	K5	64B2U1	64B2S4d	3	300K	—	3
—300	L5	64B2V1	64B2W4a	2	750K	—	2
—48	N5	64B2Y1	64B2W4d	4	75K	—	4
+600	B7	64B2A1	64B2B4a	12	750K	1	—
D-c returns	Ammeter circuit	—	64B7A3j	—	—	2,3,5,6	7,9,11,12,1
—48V returns	Ammeter circuit	—	64B7A3h	—	—	4	—
	(See CD 5.3.2.1)	*(See CD 5.4.2.2)*			*(See logic diagram CD 5.4.2.4 for these points)*		

of each phase to the terminals of the a-c voltmeter selector switch.) The regulated a-c neutral from terminal 64B7C5m returns to terminal 64C5B10 on the neutral bus.

5.2.3 D-C Voltmeter

Eleven d-c voltages are applied to the contacts of the d-c voltmeter selector switch. Any of 10 d-c voltages (+250, +150, +90, +10, —15, —30, —150, —300, —48, and +600V (table 4—9) from unit 61 or the +130V from a battery source can be observed on the DC VOLTMETER (par. 1.5, Part 2, Ch 5).

A nonessential line of 130V control power from terminal d of battery disconnect switch 64B5B11 (CD 5.4.2.1) is applied to distribution terminal 64B6H2s (CD 5.4.2.3) and then to contact 10 of middle deck 64B3H3B of the d-c voltmeter selector switch (CD 5.4.2.4). The return for the 130V battery power is contact 10 of the rear deck, through the 150K-ohm resistor, to terminal 64B6H3r (CD 5.4.2.3), and back to the power source. The selector switch has 12 contacts, but contact 8 is not used.

5.2.4 Ripple Voltmeter

Ten d-c voltages are applied to the contacts of the ripple meter selector switch. Any of these voltages (+250, +150, +90, +10, —15, —30, —150, —300, —48, and +600V) can be observed on the RIPPLE VOLTMETER (par. 1.4, Part 2, Ch. 5) when connected to the meter circuit by the selector switch. The distribution points of these circuits are listed in table 4—9. Any voltage selected at the middle deck of the ripple meter selector switch (CD 5.4.2.4) is applied to ripple meter divider circuit 64B3H1D and RANGE SELECTOR switch 64B3H2A before it is applied to the movement of RIPPLE VOLTMETER 63B3G1.

The d-c return lines from the meter movement and the divider circuit connect to the front deck of the ripple meter selector switch to terminals on the d-c voltmeter selector switch and to d-c return or relay return lines. Positions 1 and 8 have no connections, and either position can be used for the off position.

5.2.5 D-C Ammeter

The d-c ammeter can be switched into the circuit of any of the 10 d-c power supplies in unit 61. An appropriate ammeter shunt (CD 5.3.2.1) is located in the d-c return line of each d-c power supply (par. 1.2, Part 2, Ch 5). The shunts connect to a common d-c return bus bar, which connects to the d-c return (cold) lines from CB units 48 in power systems C and D. Refer to table 4—10 for distribution points to the d-c ammeter.

5.3 VOLTAGE MONITORS

5.3.1 Introduction

PCD unit 64 contains 23 voltage monitors (par. 1.3.2.2, Part 3, Ch 3). The a-c and d-c voltages that are distributed throughout the simplex equipment are applied to these voltage monitors (CD 5.4.2.2) for automatic monitoring of the voltages.

TABLE 4—10. DISTRIBUTION POINTS TO D-C AMMETER

VOLTAGE	POWER SUPPLY RETURN TERMINAL	TERMINAL ON POWER SUPPLY SIDE OF AMMETER SHUNT	D-C AMMETER SELECTOR SWITCH TERMINALS	TERMINAL ON D-C RETURN BUS
+ 250	61C(TB100)3	64A5B3	11	64A5C3
+ 150	61C(TB100)7	64A5B4	10	64A5C4
+ 90	61B(TB100)16	64A5B5	9	64A5C5
+ 10	61B(TB100)10	64A5B6	7	64A5C6
— 15	61B(TB100)13	64A5B7	6	64A5C7
— 30	61B(TB100)11	64A5B8	5	64A5C8
— 150	61C(TB100)6	64A5B9	3	64A5C9
— 300	61A(TB100)8	64A5B10	2	64A5C10
— 48	61C(TB100)2	64A5C13	4	64A5D13
+ 600	61A(TB100)5	64A5B2	12	64A5C2
	(See CD 5.3.2.1)	(See CD 5.4.2.4)	(See CD 5.3.2.1)	

5.3.2 Power Supply Input Voltage

Phases 2 and 3 of the power supply input voltage are applied to voltage monitor 64B3A5.

Phase 2 from terminal 9 of the a-c voltmeter selector switch (table 4–8) is applied to terminal e of voltage monitor 64B3A5 (CD 5.4.2.2), and phase 3 from terminal 8 of the a-c voltmeter selector switch is applied to terminal c.

5.3.3 Regulated A-C Voltage

The regulated ac (filament heater power) is applied to warning level voltage monitor 64B3A4 and shutdown level voltage monitor 64B3A6.

Phase 2 is applied from terminal 64B7C5b (CD 5.4.2.4) to the e terminals of voltage monitors 64B3A4 (CD 5.4.2.2) and 64B3A6. Phase 3 is applied from 64B7C5a (CD 5.4.2.4) to the terminals on the two voltage monitors (CD 5.4.2.2)

5.3.4 D-C Voltages

The 10 d-c voltages for simplex equipment are monitored by 20 voltage monitors. Each voltage (table 4–11) is applied across resistors to a warning level voltage monitor and across other resistors to a shutdown level voltage monitor.

TABLE 4–11. D-C VOLTAGE APPLICATIONS TO VOLTAGE MONITORS

		WARNING LEVEL		SHUTDOWN LEVEL	
VOLTAGE	FUSE	RESISTORS (Prefixed by 64)	VOLTAGE MONITORS	RESISTORS (Prefixed by 64)	VOLTAGE MONITORS
+ 250	64B2C1	B2D5, B2D6	64B3B2	B2D1, B2D2	64B3B8
+ 150	64B2F1	B2E6, B2E5	64B3C1	B2E2, B2E1	64B3C9
+ 90	64B2G1	B2H5, B2H6	64B3C2	B2H1, B2H2	64B3C8
+ 10	64B2L1	B2M5, B2M6	64B3D2	B2M1, B2M2	64B3D8
— 15	64B2P1	B2N5 —	64B3D3	B2N1 —	64B3D7
— 30	64B2R1	B2S5, B2S6	64B3C3	B2S1, B2S2	64B3C7
— 150	64B2U1	B2T6, B2T5	64B3B3	B2T2, B2T1	64B3B7
— 300	64B2V1	B2W5, B2W6	64B3B4	B2W1, B2W2	64B3B6
— 48	64B2Y1	B2X6, B2X5	64B3C4	B2X2, B2X1	64B3C6
+ 600	64B2A1	B2B5, B2B6	64B3B1	B2B1, B2B2	64B3B9

SECTION 6
NEUTRAL LINES, RETURNS, AND GROUNDS

6.1 GENERAL

Instead of using a ground for electrical returns, four special electrical systems are installed. Two systems provide neutral lines for the ac, one for unregulated and one for regulated. Two systems provide d-c returns: one system for all d-c voltages, except the relay voltage, and one system for the relay return. Ground is an equipment bond that eliminates the danger of a high voltage collecting on any unit.

6.2 NEUTRAL LINES

6.2.1 Unregulated A-C Neutral

The unregulated a-c neutral line of each simplex power system connects PCD unit 64 to a feeder breaker at the substation (CD 5.3.2.2.). From the bus bar in unit 64, two neutral lines connect to neutral bus bars in display console CB unit 48 (CD 5.3.9.1), one for convenience outlets and one for the projection units. One line connects to terminal 64B7C51 (CD 5.4.2.4). From these locations, the unregulated a-c neutral lines are distributed throughout the simplex equipment as described in conjunction with unregulated a-c distribution for displays.

6.2.2 Regulated A-C Neutral

The regulated a-c neutral line of each simplex power system connects a bus bar in PCD unit 64 (CD 5.3.2.2) to the particular induction regulator neutral (power system C to induction regulator C95, and power system D to induction regulator D95). From the bus bar in unit 64, one neutral line connects to a regulated a-c neutral bus bar in CB unit 48 (CD 5.3.9.1, sheet 2), and one line connects to terminal 64B7C5m (CD 5.4.2.4). From these locations, the regulated a-c neutral lines are distributed throughout the simplex equipment as described in conjunction with regulated a-c distribution.

6.3 D-C RETURN LINES

6.3.1 D-C Return

Returns for dc are distributed throughout the units of the power system and the display area. Throughout the units, d-c return lines are common for all d-c voltages except the —48V (relay power).

Returning from the display consoles, the d-c return lines are connected together, returned to CB unit 48, and returned to d-c return bus bar 64A5 (CD 5.3.2.1). From this bus bar, the returning dc is conducted to its respective d-c power supply after passing through the appropriate ammeter shunt in PCD unit 64.

6.3.2 Relay Return

Relay return lines are provided throughout the units of the power systems, display consoles, and the other control units to return the —48Vdc. From the display consoles, the relay return lines connect to bus bar 48B3A2 (CD. 5.3.9.2, sheet 4). Relay return lines from the CB unit and the PCD unit control equipment connect to relay return bus bar 64A5 (CD 5.3.2.1). The —48Vdc then passes through the ammeter shunt in PCD unit 64 and returns to the —48V power supply in unit 61.

6.4 EQUIPMENT BOND

The equipment bond grounds the frame of each display console. One or more conductors in the power cable to each display console connect to chassis ground of the console. These conductors connect to equipment bond bus bars in the different modules of CB unit 48 (CD 5.3.9.2, sheet 5). The bus bars in the different modules of CB unit 48 connect to bus bar 48B1A1. One equipment bond line connects to equipment bond bus bar 64C5, which is grounded (par. 5.4, Ch 4).

CHAPTER 3
POWER CONTROL FOR DISPLAYS

SECTION 1
INTRODUCTION

1.1 SCOPE

In this chapter the control circuitry is described in detail, and the operation of controls, indicators, and components is explained. The controls and indicators are described first; then the various conditions of each unit and the normal-on, normal-off, and abnormal-off sequences are explained.

1.2 GENERAL

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.

1.3 CONTROLS

1.3.1 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 d-c power supplies are remotely controlled and require no individual operating controls.

1.3.2 PCD Unit 64

The UNIT OFF pushbutton for PCD unit 64 is in module B. The CB's in module C (fig. 4–1) 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 either end, the indicating needle remains on the pin and shorts out a relay coil. If the de-energized relay is in 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 d-c power supply.

The d-c 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.

1.3.3 Display Console CB Unit 48

Display console CB unit 48 (fig. 4–2) has a UNIT OFF pushbutton, located on module A, in addition to the CB's. The remaining modules have rows of CB's.

1.3.4 Display Console

Power on a display console can be controlled at each display console by means of the UNIT STATUS switch (Sect. 6).

1.3.5 Simplex Maintenance Console Unit 47

Power controls on the simplex maintenance console are located on module H (fig. 4–5). 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

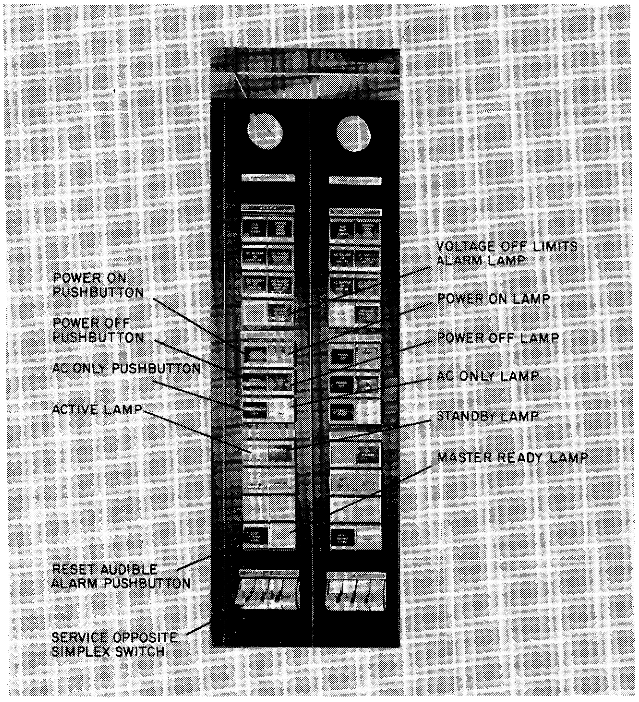


Figure 4—5. Power Supply Control Panels on Unit 47

RESET AUDIBLE ALARM pushbutton, which silences the audible alarm that was set off by any circuit on the power control 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.

1.3.6 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 (par. 3.2.1, Part 5).

1.4 INDICATORS

1.4.1 Power Supply Unit 61

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

1.4.2 PCD Unit 64

Module B in PCD unit 64 (fig. 4—1) 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 a-c 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 d-c power supplies.

The off-limit lamps include the FILAMENT VOLTAGE lamp, the INPUT TO SUPPLIES lamp, and one lamp for each of the 10 d-c 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 a-c voltage. The multiple-position controls on the DC AMMETER, the RIPPLE VOLTMETER, and the DC VOLTMETER provide individual readings of the 10 d-c voltages.

1.4.3 Display Console CB Unit 48

Numerous indicators on the front side of CB unit 48 (fig. 4—2) show which display console has power applied. Near the UNIT OFF pushbutton in 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.

1.4.4 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.

1.4.5 Simplex Maintenance Console Unit 47

1.4.5.1 General

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 (fig. 4—5) 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.

Other descriptions of these indicators are contained in *Theory of Operation, Input System for AN/FSQ-7 and -8,* 3-52-0.

1.4.5.2 Alarm Lamps

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 a-c switchgear 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 a-c 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 d-c 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 a-c backup CB for displays. There is an a-c backup CB for every 20 display consoles.

f. DC BACKUP OR —48 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.

1.4.5.3 Power Control Lamps

These three lamps, POWER ON, POWER OFF, and AC ONLY, indicate the same conditions as in the PCD unit.

1.4.5.4 Status Lamps

The five status lamps are described below:

a. ACTIVE – Lights at the same time as the ACTIVE lamp on the duplex switching console (par. 2.3.2., part 5,) 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 applied to the simplex load units connected to this power system and that a time delay has been allowed to stabilize the components.

1.4.5.5 Computer Entry Punch Lamps

The power indicators on this panel are described in the description of these units in *Theory of Operation, Input System for AN/FSQ-7 and -8,* 3-52-0.

1.4.5.6 Simplex Input Load Units

The power indicators on the simplex load units (XTL, LRI, GFI, etc.) are described along with the other indicators of the appropriate channels in *Theory of Operation, Input System for AN/FSQ-7 and -8,* 3-52-0.

1.4.6 Duplex Switching Console Unit 45

The power indicators on the simplex panels of the duplex switching console are described along with the other indicators on unit 45 in paragraph 3.3, part 5.

SECTION 2
NORMAL POWER-ON SEQUENCES

2.1 GENERAL

This section is divided into prestart conditions, the power-off to power-on sequence, and the ac-only to power-on sequence. If detailed information on the operations of the following sequences are desired, refer to the appropriate sequence charts in *Maintenance Techniques and Procedures, Power Supply and Marginal Checking, AN/FSQ-7 and -8,* 3-192-0.

The power-on sequence is initiated by the operator of simplex maintenance console unit 47 after the prestart conditions have been fulfilled. The PCD unit monitors all unregulated and regulated a-c and d-c voltages, and also supplies the switchgear with power-sequencing signals. Control power is supplied to the PCD unit by the 130Vdc battery in the powerhouse. This voltage is supplied through the BATTERY DISCONNECT CB and the BATTERY DISCONNECT switch.

Since most of the components involved in the control of power for the simplex equipment are located in PCD unit 64, the relay designations in this section should be prefixed by 64B5 and all other designations by 64 unless complete designations are given.

2.2 PRESTART CONDITIONS

Before any power sequences are initiated, the following manual operations should be accomplished:

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

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

c. The AC FEED CB's to the substations must be closed.

d. The load center control switch must be closed.

e. The knife switches and the CB's in the PCD unit, and the CB's in the CB units and the load units, must be positioned as desired.

f. All interlocked doors must be closed.

Note

To prevent power from being applied to the inputs when the power-on sequence is begun, change the procedure in step e. Open the 9-pole knife switch, contacts D2-D3 to L2-L3 (table 4—22), to keep the d-c voltages from CB unit 56; open CB 64C7B1 (par. 3.2, Ch 4) to keep regulated ac from unit 56. Do not open the 2-pole knife switch, contacts M1-M3 and N1-N3, as the —48V control power is required for some power-on sequences.

When the operations listed in a, b, c, and d are accomplished, the system is in a power-available status. The battery voltage is fed to the CLOSE CB in the load center through the manually closed load center control switch and auxiliary contacts of the AC FEED CB of the substation. These conditions close the normally open points in the power available phantom block (CD 5.4.2.1).

The +130Vdc nonessential control power from BATTERY DISCONNECT switch B5B11 is applied through resistor R16 (CD 5.4.2.3) and a normally closed point in the load center to FILAMENT INPUT DE-ENERGIZED lamp B3A9, which lights. When the filament input at the load center is applied, the normally closed contacts (in the phantom block on CD 5.4.2.3) open and the normally open contacts close. The FILAMENT INPUT DE-ENERGIZED lamp is extinguished, and POWER OFF lamp B3A8 is lighted.

2.3 POWER OFF TO POWER ON

After the prestart operations have been completed, a power-on sequence (fig. 4—6) may be initiated. This sequence is automatic after the POWER ON pushbutton on simplex maintenance console unit 47 has been depressed.

When the power-available points are closed, the +130Vdc essential control voltage is applied through POWER OFF switch 47H3(J6 or J5)S2 (CD 5.4.2.1) to terminal a of POWER ON pushbutton 47H3S1. Depressing the POWER ON pushbutton applies the +130Vdc to terminal c, which energizes signal relay K31. Points 1a-1c of K31 provide a hold circuit when the POWER ON pushbutton is released. Points 3a-3c provide the +130Vdc through normally closed contacts 9-10 of the bus duct sequencing relay K7 (CD 5.2.1.14) to the voltage monitor reset coils (CD 5.4.2.1). The voltage monitors are clamped. Points 4a-4c of K31 (CD 5.4.2.3) complete the circuit of +130Vdc nonessential control power through normally closed contacts 6a-6b

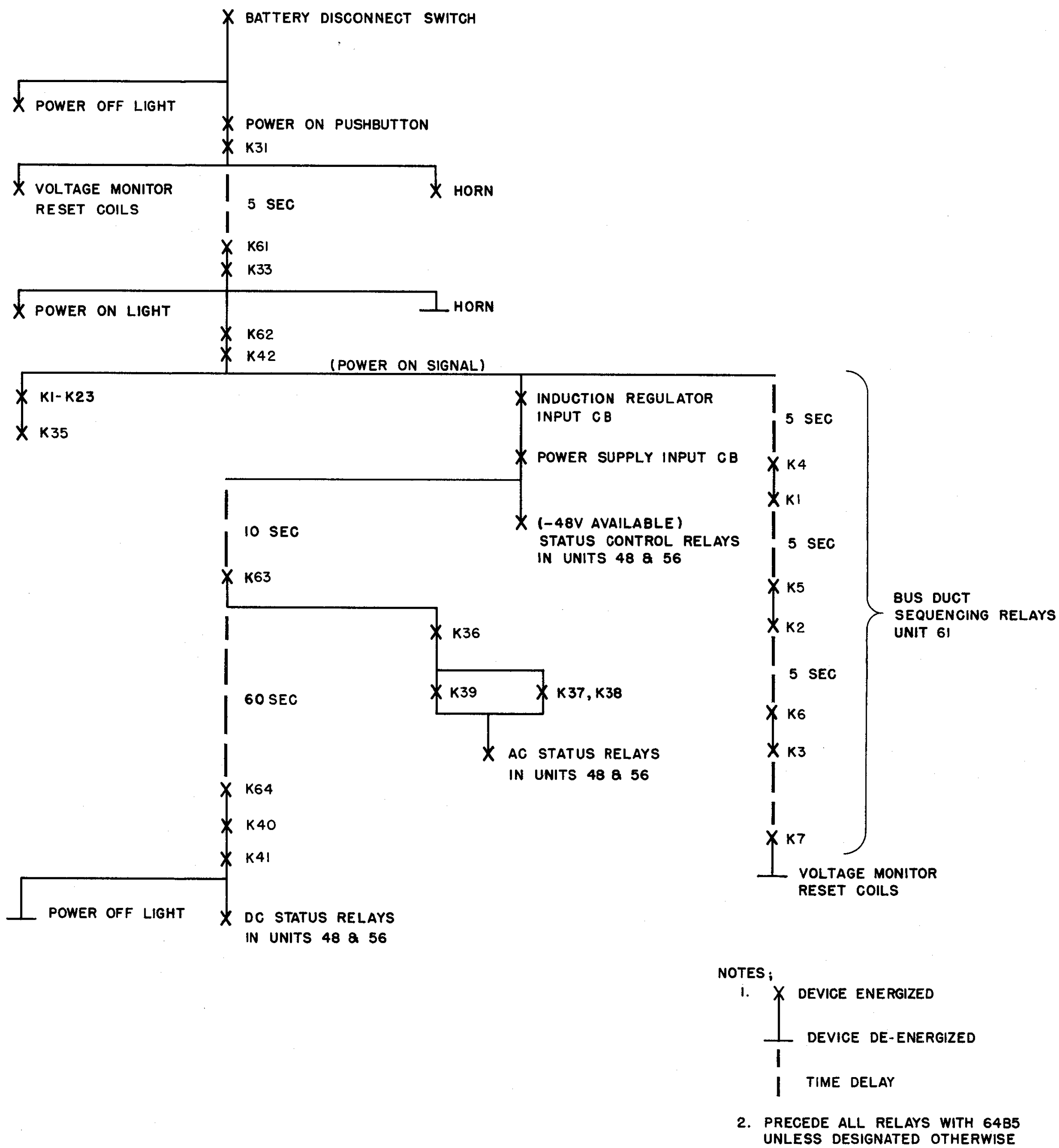


Figure 4—6. Simplex Normal Power-On Sequence Chart

of K33, sounding the 5-second AUDIBLE HORN. Points 2a-2c of K31 (CD 5.4.2.1) energize time-delay relay K61.

After a 5-second delay, points B5J1v-w of K61 close, completing the circuit that energizes signal relay K33. Points 1a-1c of K33 provide a hold circuit when K61 is de-energized later. Points 6a-6b (CD 5.4.2.3) open and interrupt the circuit to the 5-second AUDIBLE HORN, which silences. Points 8a-8c complete the circuit through resistor R37, points 5a-5c of K31 which were closed five seconds earlier, and normally closed points 7a-7b of K32 to light POWER ON lamps B3A1 in unit 64 and 47H3(X9) in the simplex maintenance console. Points 10a-10c of K33 (CD 5.4.2.1) complete the circuit to energize K62.

Points B5J1n-m of K62 complete the circuit that energizes K42. Points 1a-1c of K42 (CD 5.4.2.2) close, completing the circuits to voltage monitor relays K1 through K23. The actions of points on these relays are explained later.

Points 2a-2c of K42 (CD 5.4.2.1) close, sending power-on signals through normally closed points 5a-5b of K36 to load center C or D and to bus duct time delay relay K4 (CD 5.2.1.14). The power-on signal causes the CB in the input to the induction regulator to close, which then closes the CB in the input to the d-c power supplies.

Note

Some logic diagrams incorrectly refer to CD 5.2.1.13 for relay K4.

Points 5-12 of voltage monitor relays K1 through K10 and K23 (shutdown level) close (CD 5.4.2.1), energizing signal relay K35.

Relay K35 has points 4a-4c in the circuits of the power-on signals to the load centers and the power supply input bus duct. These points close and maintain the power-on signal when K36 is energized. Points 5a-5c of K35 close and maintain the power-available signal from the load center when K36 is energized. Normally closed points 1a-1b of K35 open, de-energizing K61, which drops immediately but has no effect on any other circuit.

The power to the d-c power supplies in unit 61 is applied in the same manner as in unit 60 (par. 2.3, Part 3, Ch 3), with the power supplies arranged in groups (Table 3—10) for sequencing.

When the d-c power supply input CB is closed (CD 5.4.2.1) time delay relay K63 is energized. After 10 seconds, points B5J1e-f close, completing the circuits to energize time delay relay K64, which requires 1 minute to close its points, and signal relay K36.

Points 4a-4c of K36 (CD 5.4.2.3) provide a source of relay power through points 5a-5c of K33, previously closed, for the individual voltage-off-limit lamps in PCD unit 64. If any of warning level voltage monitor relays K11 through K22 are de-energized by the pinning of the moving contacts after being unclamped by bus duct sequencing relay K7 (phantom block on CD 5.4.2.1), their points 6-13 (CD 5.4.2.3) will close and provide power to light their respective VOLTAGE OFF LIMITS lamp.

Relay K36 closes its points 1a-1c (CD 5.4.2.1), completing the circuit to energize K39 and K37 if regulated a-c CB 64C7A1 (CB1) (CD 5.3.2.2) is closed and K38 if CB 64C7B1 (CB2) is closed. Points of K39 and K37 (CD 5.4.9.1) provide control power to energize relays in the application of power to simplex display load units. Points of K39 and K38 (CD 5.4.10.1) provide control signals to apply power to the simplex input load units.

The following description applies to simplex display power only. Since most of the components in the following description are located in CB unit 48, the component designations should be prefixed by 48 except when complete designations are provided. (Refer to par. 2.3, Ch 5, for a comparable description of simplex input power.)

When the CB's are closed (step e in par. 2.2) in display console CB unit 48, auxiliary (interlock) points b-d are closed and points c-d are opened. The —48Vdc from the —48Vdc power supply is distributed (Ch 2, Sect. 4) to bus bar 48B2L10 (CD 5.4.9.1, sheet 1). From CB 48B2L8, the —48V is applied to terminal B2M3n and to the interlock circuits to energize status control relays C3K2, D3K2, E3K2, F3K2, G3K2, H3K2, J3K2, and K3K2. Relay C3K2, for example, is energized by the application of —48V control power from terminal B2M3n, to terminal A6C1d, and through points b-d of CB's A6C2, A6H2, B2C9, B2C8, B2C7, B2C6, B2C5, B2C4, B2C3, B2C2, and B2C1. When the above relays are energized, their points 1a-1c (CD 5.4.9.1, sheet 2), 2a-2c, 3a-3c, and 4a-4c close, preparing other relay circuits for signals from the simplex maintenance console.

The —48V control power is applied to bus bar 56B2L10 (CD 5.4.10.1) in simplex input CB unit 56 at the same time as simplex display CB unit 48. From CB 56B2L6, the —48V is applied to terminal e on barrier strip E1, point 3a of SERVICE OPPOSITE SIMPLEX SWITCH 47H3 (S6), point 2a of relay 47H3 (K3) (S5.4.11.1), points 1c of relays 47H3(K2), K3, K4, and K5, point 1b of relay 47H3(K6), pin A27 of the cable connector on the simplex maintenance console, pin B of a cable connector on the duplex switching console, and point 1c of 45K1, through points 3c-3a of 45K1 (when K1 was not tripped) to energize K2. Whenever —48V is applied to point 1c of 45K1, the ON lamp (X4) on that simplex switching panel of the duplex switching console is lighted.

The above procedure is used if the power-on sequence follows the shutdown of power during active status. For other conditions, the ACTIVE pushbutton must be depressed to trip K1 of the active power system and to pick K1 of the standby power system. The SERVICE OPPOSITE SIMPLEX switches (S6) are considered in the normal position.

If power system C is active, switching relay 45C-(K1) is latched (all transfer points are up). The —48V is applied across points 1a-1c of 45C(K1) to light the ACTIVE lamp (X3) on the switching panel of power system C of the duplex switching console and ACTIVE lamp 47H3(X13) on the C power supply control panel on the simplex maintenance console. This latter circuit can be traced from point 1a of 45C(K1) to pin C of J1 on the duplex switching console, to pin A26 of P1 on the simplex maintenance console, across normally closed points 1a—1b of 47H3(K7), across 150-ohm R1, to energize 47H3(K10). Points 7-5 of 47H3 (K10) close, completing the circuit to light ACTIVE lamp 47H3 (X13). Points 7-5 of 47H3 (K10), when closed, also complete the circuit to energize 47H3(K7). Transfer point 1a of K7 then provides a hold circuit through point 1c to keep K7 energized and the ACTIVE lamp lighted. Points 1a-1b open, dropping 47H3 (K10). However, the circuits that were completed through points 7-5 of L10 are now completed through points 1a-1c of K7.

When 45C(K2) is energized, the following action occurs. Points 1a-1b open to de-energize the pick coil of 45D (K1) (in the other power system). Points 2a-2c of 45C(K2) close, applying —48V to energize the a-c control relays in CB unit 56 (par. 2.2, Ch 5). Points 3a-3c close, applying —48V to energize the a-c control relays in CB unit 48 (circuit traced from point to point in the following text). Points 4a-4c and 5a-5b close, completing circuits that apply —48V from power system D (the alternate system) to the standby control relays in CB units 56 and 48, respectively, of system D when power is on in power system D. The SERVICE OPPOSITE SIMPLEX SWITCH, when shifted to off, interrupts the —48V circuits to the standby control relays.

Regulated ac is applied to the display console CB unit when K37 and K39 (CD 5.4.2.1) are energized. From bus bar 48B2L10 (CD 5.4.9.1, sheet 1), —48V is applied across CB 48B2L9, across now closed points 1a-1c of CB interlock relay K37 and points 2a-2c of ac-on signal relay K39, to pin B9 of the plug connector on the simplex maintenance console, to point 2a of SERVICE OPPOSITE SIMPLEX switch 47H3 (S6), to pin B17 of the cable connector on the simplex maintenance console, to pin F of the cable connector on the duplex switching console, across now closed points 3c-3a of 45K2, to pin G of the cable connector on the duplex switching console, to pin B36 of the cable connector on the simplex maintenance console, to terminal b of barrier strip E1, to pin A7 of the plug connector on the simplex maintenance console, across now closed points 2a-2c of 48C3K2 (CD 5.4.9.1, sheet 2), D3K2, E3K2, F3K2, H3K2, J3K2, and K3K2, to energize a-c active status relays C3E2, C3C2, D3D2, etc. (CD 5.4.9.1, sheet 2).

If all the regulated a-c CB's are closed in a display console, auxiliary (interlock) points d-b (lines 4—7 on CD 5.4.9.2) are closed, and —48V is applied from the appropriate CB (CD 5.3.9.2) across points of relays C3E2, C3C2, D3E2, etc. (above) to pin 44 of the cable connector for the desired display console.

Refer to *Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0, for the appropriate power logic diagram. For example, —48V is received on pin 44 of connector J5 (S 4.2.6) and applied through UNIT STATUS switch S29 (must be in the active position) to energize relay K1C. Contactors of K1C apply regulated ac to the electronic circuitry of the display console. The regulated ac for the filaments is now on the display consoles.

One minute after time delay relay K64 is energized, its contacts B5J1c-d close (CD 5.4.2.1), energizing relay K40. Points 1a-1c of K40 close, providing a circuit through now closed points 3a-3c of K31, normally closed points 5a-5b of K32, and now closed points 2a-2c of K35, to energize K41.

Relay K41 has points 4a-4c (CD 5.4.9.1) in the dc-on (active) signal circuit to the simplex maintenance console (type 78004 panel, schematic diagram) and the duplex switching console from display console CB unit 48. Points 5a-5c are in the dc-on (standby) signal circuit. These circuits are used in switching the power status of power systems C and D at the duplex switching console.

When K41 is picked, its points 3a-3b open (CD 5.4.2.3), and POWER OFF lamps B3A8 and 47H3 (X10) are extinguished.

Points 4a-4c of K41 close (CD 5.4.9.1), completing the circuit from terminal b of barrier strip E1 in the simplex maintenance console (CD 5.4.11.1) (—48V was applied to terminal b of barrier strip E1 during the ac-on procedure) through pin A52 of the plug connector on the simplex maintenance console, through K41 and points 4a-4c of relays 48C3K2 (CD 5.4.9.1, sheet 2), D3K2, E3K2, F3K2, G3K2, H3K2, J3K2, and K3K2, to energize signal relays C3J2, C3G2, D3J2, etc. (CD 5.4.9.1, sheet 2).

If all the d-c CB's are closed in a display console, auxiliary points b-d (lines 15-24 on CD 5.4.9.2) are closed, and —48V is applied from the appropriate CB (CD 5.3.9.2) across points of relays C3J2, C3G2, D3J2, etc. (above) to pin 46 of the cable connector for the desired console.

Refer to *Schematics for Display System of AN/FSQ-7 and -8,* 3-252-0, for the appropriate power logic diagrams. For example, —48V is received on pin 46 of connector J5 (S 4.2.6) and applied through UNIT STATUS switch S29 (must be in the active position), across now closed contacts of K1C, to energize K2C. Points of K2C apply —48V to K3C, which applied the low d-c voltages first. Relay K4C is then energized through points of K2C and K3C and applies the high d-c voltages to that display console.

The display consoles that have their UNIT STATUS switches in the active position will now be in the power-on status.

2.4 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. Refer to paragraph 4.2 to determine the condition of switches, relays, and indicators for the ac-only status.

When POWER ON pushbutton 47H3(S1) (CD 5.4.2.1) is depressed, relay 64B5K32 is de-energized and K31 is energized. Points 1a-1c of K31 provide a hold circuit when the POWER ON pushbutton is released. Relays K61, K33, K62, K42, K1 through K23, K35, K63, K36, K64, K37, K38, K39, and K40 are energized. Points 5a-5b of K32 close, completing the path to energize K41. The points of K41 (CD 5.4.9.1 and S 5.4.11.1) then enable the d-c-on signals to reach the display consoles and energize the signal relays that apply the d-c voltages (par. 2.3).

SECTION 3
NORMAL POWER-OFF SEQUENCE

3.1 GENERAL

In the normal power-off sequences, the power is removed in steps. First the d-c voltages and then the a-c filament power are removed. The +130Vdc battery voltage for control circuits and the unregulated 120/208Vac are not removed during the normal power-off sequences. However, the methods of removing these voltages are described in the same paragraphs, following the automatic procedures, so that all power can be removed.

This section describes the normal sequence for removing the power from power system C or D when it is in either the power-on or the power-off status.

3.2 POWER ON TO POWER OFF

This sequence is similar to the power-on to power-off sequence for duplex equipment (par. 3.2, Part 3, Ch 3) and is automatic after the POWER OFF pushbutton on the simplex maintenance console is depressed.

Relays K31 and K33 (CD 5.4.2.1) are de-energized when POWER OFF pushbutton 47H3(S2) is depressed. Points of K31 interrupt circuits to de-energize K61 and K41 and extinguish the POWER ON lamps (CD 5.4.2.3). Normally closed points of K41 complete the circuits to the POWER OFF lamps, which light, and other points interrupt the circuits (CD 5.4.9.1 and CD 5.4.11.1), which remove the d-c voltages from the display consoles and the simplex input load units. Points of K33 open (CD 5.4.2.1), de-energizing K62. One second later, the points of K62 de-energize K42. Points of K42 interrupt the power-on signals, shutting off the inputs to the d-c power supplies and the induction regulator. The d-c voltages and the regulated a-c power are removed from PCD unit 64 and the distribution circuitry.

The unregulated ac can be removed from particular display consoles by opening the proper CB at both CB units 48. Unregulated ac is removed from one CB unit 48 by opening CB 9 (table 4–1) and from PCD unit 64 by opening the substation unregulated a-c feeder breaker (CD 5.3.2.2).

3.3 AC ONLY TO POWER OFF

Power system C or D was placed in ac-only status by sequencing from power off to ac only (par. 4.2) or from power on to ac only (par. 4.3). In either case, the relays, switches, and indicators will be in the same condition.

The power-off sequence from ac-only status is initiated by depressing the POWER OFF pushbutton. Relays K32 and K33 (CD 5.4.2.1) are de-energized when POWER OFF pushbutton 47H3 (S2) is depressed. Points of K32 interrupt circuits to de-energize K61 and to extinguish the AC ONLY lamps (CD 5.4.2.3). Points of K33 open (CD 5.4.2.1), de-energizing K62. One second later, the points of K62 de-energize K42. The points of K42 interrupt the power-on signals, shutting off the inputs to the d-c power supplies and the induction regulator. The d-c voltages are removed from PCD unit 64, and the regulated ac is removed from all power system C or D and from all display consoles connected to the power system being shut down.

The unregulated ac can be removed as described in the power-on to power-off sequence (par. 3.2).

SECTION 4
AC-ONLY SEQUENCES

4.1 GENERAL

In this section, a simplex power system is placed in the ac-only status from either the power-off or the power-on status. These sequences are initiated by the AC ONLY pushbutton on the simplex maintenance console and proceed automatically to the ac-only status.

4.2 POWER OFF TO AC ONLY

When the *power available* points in the load center are closed, the +130Vdc essential control voltage is applied through POWER OFF switch 47H3(S2) (CD 5.4.2.1), through points a-b of POWER ON switch 47H3(S1), to point a of AC ONLY switch 47H3(S3). Depressing the AC ONLY switch applies the +130Vdc to point c and energizes signal relay K32. Points 4a-4c of K32 provide a hold circuit when the AC ONLY pushbutton is released.

The following procedure is similar to a portion of the power-off to power-on sequence (par. 2.3) as is summarized below.

Relay K32 completes the circuits to energize the voltage monitor reset coils, which clamp the voltage monitor relays, to energize time delay relay K61, to light AC ONLY lamp B3A2 (CD 5.4.2.3), and to sound the 5-second AUDIBLE HORN. After a 5-second delay, the points of K61 (CD 5.4.2.1) close, energizing K33. Points of K33 silence the 5-second AUDIBLE HORN (CD 5.4.2.3) and energize K62 (CD 5.4.2.1), which energizes K42. Relay K42 energizes voltage monitor relays K1 through K23 (CD 5.4.2.2) and sends the power-on signal (CD 5.4.2.1) to the load center and to bus duct time delay relay K4 (CD 5.2.1.14). Points of K1 through K10 and K23 (CD 5.4.2.1) energize K35.

Since —48V is used for control power in applying regulated ac to the display consoles, the d-c power supplies must be sequenced on (par. 2.3, Part 3, Ch 3) and the d-c input breaker closed before time delay relay K63 can be energized. Ten seconds after K63 is energized, the points close and apply 130Vdc to the coils of signal relay K36 and time delay relay K64. Relay K36 energizes K37, K38, and K39. The regulated ac is then applied to the display consoles in the same manner as described in the power-off to power-on sequence (par. 2.3).

One minute after K64 is energized, its points close and energize K40. However, points 5a-5b of K32 are now open and prevent K41 from being energized. The relay sequence stops with PCD unit 64, display console CB unit 48, simplex input CB unit 56, the display consoles, and the simplex input load units in ac-only status.

4.3 POWER ON TO AC ONLY

If power system C or D is in the power-on status, the power system can be placed in ac-only status by depressing the AC ONLY pushbutton on the simplex maintenance console. To determine the condition of the relays involved in this procedure, refer to the power-off to power-on sequence (par. 2.3).

Relay K32 (CD 5.4.2.1) is energized when AC ONLY pushbutton 47H3(S3) is depressed or the voltage-monitor test switch is operated. Points of K32 de-energize K31, while the other points of K32 are substituted for points of K31. Relay K41 is also de-energized, which interrupts the circuits to the d-c control circuits in the display consoles. The d-c voltages are removed from the display consoles. Points 8a-8c of K32 (CD 5.4.2.3) complete the circuit to illuminate the AC ONLY lamps, while points 7a-7b interrupt the circuit to the POWER ON lamps. PCD unit 64, CB units 48 and 56, simplex input unit 55, and the simplex loads are now in ac-only status.

SECTION 5
ABNORMAL-OFF SEQUENCES

5.1 GENERAL

The abnormal-off sequences remove all power (except +130Vdc battery control power) from a power system without regard to sequencing. Some sequencing of relays occurs after the power is off. These sequences should be used only when extensive and severe damage to equipment is to be avoided, or when power must be removed to avoid serious injury or death to personnel.

The abnormal-off sequence that is initiated by a UNIT OFF switch on PCD unit 64, power supply unit 61 or a CB unit removes the power from that particular power system. When an EMERGENCY OFF switch located on columns throughout the site is activated, the abnormal-off sequence occurs simultaneously in all power systems. The shutdown level voltage monitors automatically initiate an abnormal sequence only in the particular power systems which they monitor.

5.2 UNIT OFF PUSHBUTTONS

When a UNIT OFF pushbutton (CD 5.4.2.2) is depressed on PCD unit 64, CB unit 48, CB unit 56, or power supply unit 61, the circuit of essential +130Vdc to the switchgear is interrupted. The resulting action (par. 5.2, Part 3, Ch 3) removes all power from the power system involved.

5.3 EMERGENCY OFF SWITCH

A number of EMERGENCY OFF switches are located on columns throughout the operations building to remove power from all systems in extreme emergencies. The break-glass-type switches effect a total power shutdown of the entire Power Supply System by removing battery power from all switchgear systems (par. 5.3, Part 3, Ch 3).

5.4 VOLTAGE MONITOR

The shutdown level voltage monitor circuits automatically shut down a power system when the d-c power supplies deviate ±20 percent from recommended voltage or when the regulated ac for the filaments deviates ±10 percent (par. 5.4, Part 3, Ch 3).

SECTION 6
CONTROL AT DISPLAY CONSOLE

6.1 GENERAL

The individual display consoles can be switched at any time from active to off or any other condition by rotating the UNIT STATUS switch. Some display consoles are duplex and are connected permanently to one of the two Central Computers. (Refer to *Theory of Operation, Display System, AN/FSQ-7 and -8,* 3-62-0). These duplex display consoles also have unit status switches but have SIG in place of the standby position. Three types of unit status switches are described below.

6.2 SIMPLEX UNITS OF DISPLAY EQUIPMENT

The UNIT STATUS switch designated as type A in figure 4–7 is used on display units which are simplex. This type of switch is used because each display console which is simplex must operate with either of the computers; therefore, status selection is necessary at the individual console. Power and signal lines of a unit using this type of switch are switched for the five switch positions as indicated below:

a. ACTIVE – A-c and d-c power lines are connected from the active simplex power supply system. Signal lines are connected between the active Central Computer and the unit containing the switch.

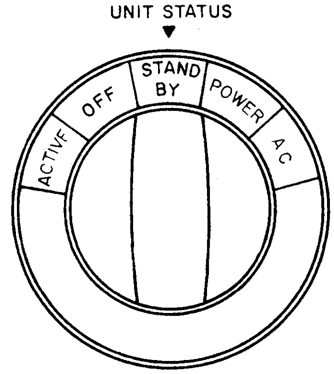
b. OFF – All power and signal lines are disconnected from the unit containing the switch.

c. STANDBY – A-c and d-c power lines are connected from the standby simplex power supply system. Signal lines are connected between the standby Central Computer and the unit containing the switch.

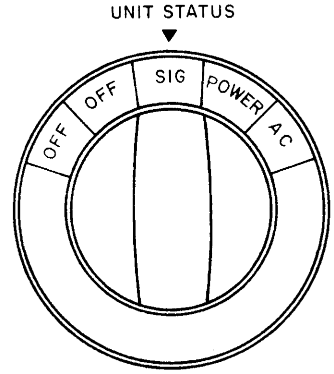
d. POWER – A-c and d-c power lines are connected from the standby simplex power supply system. All signal lines are disconnected from the unit containing the switch.

e. AC – A-c power lines are connected from the standby simplex power supply system. All signal lines and d-c power lines are disconnected from the unit containing the switch.

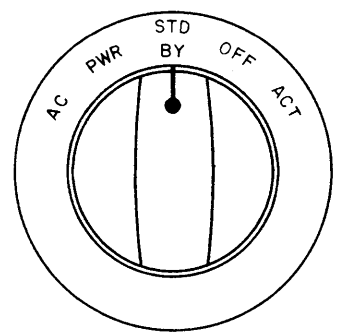
This type of switch is used on the Command Post console desk section, and on all situation display (SD) consoles and auxiliary (aux) display consoles having unit numbers higher than 175.



A. SIMPLEX DISPLAY CONSOLE



B. PHOTOGRAPHIC RECORDER REPRODUCER UNIT



C. DUPLEX DISPLAY CONSOLE

Figure 4–7. Types of Unit Status Switches Used in Display Equipment

6.3 PHOTOGRAPHIC RECORDER-REPRODUCER UNIT

The UNIT STATUS switch indicated as type B in figure 4–7 is used on photographic recorder-reproducer (PRR) units 251 and 252. The PRR unit is a simplex unit of display equipment, and, therefore, provision is made to connect this unit to either the active or the standby Central Computer. The power and signal lines of the PRR unit are switched for the five positions of the switch as indicated below:

a. AC – A-c power lines are connected to the PRR unit from the standby simplex power supply system. All d-c power lines and signal lines are disconnected from the PRR unit.

b. PWR – A-c and d-c power lines are connected to the PRR unit from the standby simplex power supply system. All signal lines are disconnected from the PRR unit.

c. STDBY – A-c and d-c power lines are connected to the PRR unit from the standby simplex power supply system. Signal lines are connected between the PRR unit and the standby Central Computer.

d. OFF – All power lines are disconnected from the PRR unit. All signal lines are disconnected from the PRR unit.

e. ACT – A-c and d-c power lines are connected to the PRR unit from the active simplex power supply system. Signal lines are connected between the PRR unit and the active Central Computer.

6.4 DUPLEX UNIT OF DISPLAY EQUIPMENT

The UNIT STATUS switch designated as type C in figure 4–7 is used on display consoles which are duplex. This type of switch is used because each display console which is duplex is permanently connected to one Central Computer, and status selection is not necessary at the individual console. Power and signal lines of a unit using this type of switch are switched for the four different switch positions as indicated below:

a. AC – A-c power lines are connected from the duplex power supply system of the computer to which the console is connected. All signal and d-c power lines are disconnected.

b. POWER – A-c and d-c power lines are connected from the duplex power supply system of the computer to which the console is connected. All signal lines are disconnected.

c. SIG – A-c and d-c power lines are connected from the duplex power supply system of the computer to which the console is connected. Signal lines are connected between the console and the Central Computer having the same designation as the console. For example, signal lines are connected between unit A168 and the A computer when the UNIT STATUS switch on unit 168 is placed in the SIG position.

d. OFF – All power and signal lines are disconnected at the console.

This type of unit status switch is used on the following units of display equipment:

A45	A171
B45	B171
A167	A174
B167	B174
A168	A175
B168	B175

The UNIT STATUS switch on duplex switching console unit 45 controls the distribution of signal and power lines to the display portion of unit 45 only.

CHAPTER 4

POWER DISTRIBUTION FOR INPUTS

SECTION 1

INTRODUCTION

1.1 SCOPE

Chapter 4 presents a detailed analysis of the circuitry used in distributing power to the simplex input load units. This presentation is divided into separate sections for unregulated a-c distribution, regulated a-c distribution, d-c distribution, and neutral lines, returns, and grounds. The last section explains only the overall arrangements of the neutral lines, returns, and grounds, individual neutral lines and returns being listed in conjunction with the specific distribution circuits.

1.2 GENERAL

The distribution of power for inputs begins at PCD unit 64 (fig. 3–1). Unregulated 120/208Vac is distributed from unit 64 to convenience outlets in CB unit 56, PD unit 55, MC unit 58, the simplex input load units, and simplex maintenance console unit 47. The unregulated ac is applied to each load unit directly from CB unit 56 without passing through PD unit 55. Power systems C and D each supply unregulated ac to one-half of the convenience outlets in PD unit 55 and in every simplex input load unit. Both power systems also supply unregulated ac to the motor of the amplidyne and to the computer entry punches.

Regulated 120/208Vac is distributed from PCD unit 64, through CB unit 56, through PD unit 55, to the simplex load units.

Ten d-c voltages are received at PCD unit 64, only nine of which are used in the simplex input equipment. The voltages are distributed from unit 64, through CB unit 56 and PD unit 55, to the simplex input load units. The control voltage (—48V) is also distributed to MC unit 58 and to simplex maintenance console unit 47. Some of the simplex input load units have facilities for marginal checking. During marginal checking, any of five of the d-c voltages is applied through CB unit 56, to MC unit 58, where voltage variations are introduced, through PD unit 55, and then to the simplex input load.

Simplex input CB unit 56 contains the necessary CB's to supply power to the following units:

a. Load units

   XTL unit 32

   GFI unit 34

   LRI unit 41

   Test pattern generator unit 92

   Computer entry punch units 352, 353, and 354

Note

Units 34 and 41 are not used in AN/FSQ-8. Refer to Part 7.

b. Control units

   Simplex maintenance console unit 47

   Simplex marginal checking unit 58

   Simplex input PD unit 55

SECTION 2
UNREGULATED A-C DISTRIBUTION

2.1 GENERAL

Unregulated 120/208Vac is provided at numerous units for distribution to convenience outlets, for use by card entry punch units 352, 353, and 354, and to supply power for the prime mover of the simplex marginal checking generator (amplidyne). Primary distribution involves the distribution through the 3-phase CB's in PCD unit 64. Distribution to convenience outlets is shown in the tables for simplex input CB unit 56, simplex input PD unit 55, one typical load unit, MC unit 58, and simplex maintenance console unit 47. One phase of unregulated ac is distributed to card entry punch units 352, 353, and 354. Three-phase unregulated ac is supplied to the motor of the amplidyne.

Distribution to metering circuits is described in Chapter 2, Section 5.

2.2 PRIMARY DISTRIBUTION

Three-phase unregulated ac is applied from the substation feeder breaker to bus bars 64C9L1, L2, and L3 (CD 5.3.2.2) in PCD unit 64. The unregulated ac is distributed through 3-phase CB 64C7F1 (CB 10) to bus bars (table 4–12).

TABLE 4–12. UNREGULATED A-C BUS BARS IN UNIT 56

PHASE	INPUT BUS BAR	MAIN BUS BAR
1	56A6H3	56A1A4
2	56A6H2	56A1A3
3	56A6H1	56A1A2
Neutral	—	56A1K1

Note: See logic diagram S 5.3.10.2 for these components.

2.3 CONVENIENCE OUTLETS

2.3.1 Power Supply Unit 61

Refer to paragraph 2.3.1, Chapter 2, for this information.

2.3.2 Simplex Input CB Unit 56

Phase 3 to neutral provides 120V unregulated ac for the convenience outlets in simplex input CB unit 56 (table 4–13). The neutral side is connected to terminal 10 on unregulated a-c neutral bus bar 56A1K1 (S 5.3.10.2).

TABLE 4–13. UNREGULATED A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN CB UNIT 56

BUS BAR	CB	CONVENIENCE OUTLETS
56A1A2	56H1	56C1
56A1A2	56H1	56D1
56A1A2	56H5	56E1
56A1A2	56H5	56F1

Note: See logic diagram S.3.10.2 for these components.

2.3.3 Simplex Input PD Unit 55

Simplex input PD unit 55 receives unregulated ac from both simplex input CB units (C and D). Phase 3 from the main bus bar 56A1A2 (S 5.3.10.2) of power system C and of power system D provides unregulated ac for the convenience outlets in unit 55 (table 4–14).

TABLE 4–14. UNREGULATED A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN PD UNIT 55

POWER SYSTEM	CB	CONVENIENCE OUTLETS
C	56A1B1	55A1, 55B1, 55C1
	56A1B5	55D1, 55E1, 55F1
D	56A1B1	55G1, 55H1, 55J1
	56A1B5	55K1, 55L1, 55M1

Note: See logic diagram S5.3.10.2 for these components.

2.3.4 Load Units

Unregulated ac to the convenience outlets on the load units is applied directly from both simplex input CB units 56 without passing through PD unit 55. The distribution to XTL unit 32 (S 5.3.10.2) is listed in table 4–15 as a typical load unit.

TABLE 4–15. UNREGULATED A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN A TYPICAL LOAD UNIT

POWER SYSTEM	CB	CONVENIENCE OUTLETS
C	56A1E5	32A, 32C, 32E
	56A1E1	32L, 32N, 32R
D	56A1E5	32B, 32D, 32F
	56A1E1	32M, 32P, 32S

Note: See logic diagram S5.3.10.2 for these components.

2.3.5 MC Unit 58

Unregulated ac to the convenience outlets on MC unit 58 (S 5.3.10.2) is applied from both simplex input CB units 56 (table 4–16).

TABLE 4–16. UNREGULATED A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN MC UNIT 58

POWER SYSTEM	CB	CONVENIENCE OUTLETS
C	56A1C1	58B8A
	56A1C5	58D8A
D	56A1C1	58B4A
	56A1C5	58D4A

Note: See logic diagram S5.3.10.2 for these components.

2.3.6 Simplex Maintenance Console Unit 47

Unregulated ac to the convenience outlets on simplex maintenance console unit 47 (S 5.3.10.2) is applied from both simplex input CB units 56 (table 4–17).

TABLE 4–17. UNREGULATED A-C DISTRIBUTION TO CONVENIENCE OUTLETS IN UNIT 47

POWER SYSTEM	CB	CONVENIENCE OUTLETS
C	56A1D1	47B1E1, 47C1E1, 47D1E1
	56A1D5	47E1E1, 47F1E1, 47J5F1
D	56A1D1	47G1H1, 47H1E1
	56A1D5	47K1E1, 47J1E1, 47K5E1

2.4 CARD ENTRY PUNCH UNITS 352, 353, AND 354

Phase 1 to neutral of 120V unregulated ac is supplied to card entry punch units 352, 353, and 354 (logic diagram 2.2.1.2 and table 4–18). Each card entry punch is supplied through a power connector (PC) with the same terminal number.

2.5 AMPLIDYNE MOTOR

All three phases of 208V (phase-to-phase) unregulated ac are supplied to the amplidyne to power the motor (table 4–19).

TABLE 4–18. UNREGULATED A-C DISTRIBUTION TO UNITS 352, 353, AND 354

POWER SYSTEM	TERMINAL ON BUS BAR 56C2F1	CB	NEUTRAL BUS BAR 56A1K1 TERMINAL	PC TERMINAL	UNIT NO.
C	21	56C2F21	—	PC3	352
	—	—	1	PC4	352
	20	56C2F20	—	PC3	353
	—	—	2	PC4	353
	19	56C2F19	—	PC3	354
	—	—	3	PC4	354
D	21	56C2F21	—	PC1	352
	—	—	1	PC2	352
	20	56C2F20	—	PC1	353
	—	—	2	PC2	353
	19	56C2F19	—	PC1	354
	—	—	3	PC2	354

Note: See logic diagram S5.3.10.2 for these points.

TABLE 4–19. UNREGULATED A-C DISTRIBUTION TO AMPLIDYNE MOTOR

PHASE	POWER SYSTEM	BUS BAR	CB TERMINAL	CONTACTORS	MOTOR CONNECTION
1	C	56A6H3	e	58B6A2(L3-T3)	T3
2		56A6H2	f	58B6A2(L3-T3)	T3
3		56A6H1	g	58B6A2(L1-T1)	T1
1	D	56A6H3	e	58B2A4(L3-T3)	T3
2		56A6H2	f	58B2A4(L2-T2)	T2
3		56A6H1	g	58B2A4(L1-T1)	T1
					(See S5.3.10.4)

Note: See logic diagram S5.3.10.2 for these points.

SECTION 3
REGULATED A-C DISTRIBUTION

3.1 GENERAL

Three-phase regulated 120/208Vac is applied to filament transformers in the load units, where the voltage is stepped down and applied to the filaments of the electron tubes. A typical circuit is used to trace regulated ac through PCD unit 64, CB unit 56, and PD unit 55, and into a simplex load unit.

3.2 PCD UNIT 64

Three-phase regulated ac is applied from induction regulator unit 95 to bus bars 64C9L1, L2, and L3 (CD 5.3.2.2) in PCD unit 64. The regulated ac is distributed through 3-phase CB64C7B1 (CB2) to simplex input CB unit 56 for further distribution. The distribution of regulated ac to the metering circuits is presented in paragraph 5.2.2.3, Chapter 2.

3.3 CB UNIT 56

Regulated ac from CB 64C7B1 (CB2) (CD 5.3.2.2) is applied to bus bars, 56A6B1, B2, and B3 (S5.3.1.0.1), for phases 3, 2, and 1, respectively. Distribution proceeds from these bus bars (table 4–20) through 3-phase CB to other bus bars, through single-phase CB's to the leads that conduct the power to simplex input PD unit 55.

3.4 PD UNIT 55

Regulated ac from simplex input CB unit 56 (table 4–20) is applied to simplex input PD unit 55. Contactors in sliding units (S 5.3.10.1) within unit 55 connect power system C or D to provide the regulated ac for the load units that are operating. The regulated ac provided by power system C or D is applied to leads in cables and conducted to simplex load units.

3.5 SIMPLEX LOAD UNIT

The load units (XTL unit 32, GFI unit 34, LRI unit 41, and test pattern generator unit 92) receive 3-phase regulated 120Vac (S 5.3.10.1) through power cables from simplex input PD unit 55. This unregulated ac is applied to terminals of the filament transformers (table 4–21) in the numerous modules of the load units.

Terminals of the secondary windings on the filament transformers provide the low-voltage ac for the filaments of the electron tubes.

TABLE 4–20. TYPICAL REGULATED A-C DISTRIBUTION POINTS TO SIMPLEX INPUT LOAD UNITS

BUS BAR	3-PHASE CB	3-PHASE CB TERMINAL	BUS BAR	BUS BAR	SINGLE-PHASE CB	PIN ON PU CONNECTOR P3	P2A	CHANNEL
C 56A6B3 (Phase 1 applied from terminal 64C7B1f)	56A6C2 (See Column 6 on S 5.3.10.1)	g	56C3B1 (See Column 7 on S 5.3.10.1)	56C2C1 (See Column 8 on S 5.3.10.1)	56C2C16 15 14 56C2C13 etc. (See Column 10)	14 14	7&50 7&50	XTL GFI LRI XTL 1 etc. (See Column 1)
C 56A6B2 (Phase 2 applied from terminal 64C7B1e)	56A6C2 (See Column 6 on S 5.3.10.1)	f	56C3C1 (See Column 12 on S 5.3.10.1)	56C2D1 (See Column 13 on S 5.3.10.1)	56C2D16 15 14 56C2D13 etc. (See Column 15)	13 13	14&43 14&43	XTL GFI LRI XTL 1 etc. (See Column 1)

TABLE 4–20. TYPICAL REGULATED A-C DISTRIBUTION POINTS TO SIMPLEX INPUT LOAD UNITS (cont'd)

BUS BAR	3-PHASE CB	3-PHASE CB TERMINAL	BUS BAR	BUS BAR	SINGLE-PHASE CB	PIN ON PU CONNECTOR P3	PIN ON PU CONNECTOR P2A	CHANNEL
C 56A6B1	56A6C2	e	56C3D1	56C2E1	56C2E16	11	41&42	XTL
(Phase 3 applied from terminal 64C7B1d)	(See Column 6 on S 5.3.10.1)		(See Column 17 on S 5.3.10.1)	(See Column 18 on S 5.3.10.1)	15			GFI
					14			LRI
					56C2E13	11	41&42	XTL 1
					etc.			etc.
					(See Column 20)			(See Column 1)

TABLE 4–21. TYPICAL A-C APPLICATION TO FILAMENT TRANSFORMERS

CHANNEL IN UNIT 32	PHASE 1	PHASE 2	PHASE 3	NEUTRAL
1	32A(T3)6	32A(T2)6	32A(T1)6	32A(T1)1
2	32B(T2)6	32B(T1)6	32B(T3)6	32B(T1)1
3	32C(T1)6	32C(T3)6	32C(T2)6	32C(T1)1
etc.	etc.	etc.	etc.	etc.

Note: See logic diagram S 5.3.10.1 for these locations.

SECTION 4
D-C DISTRIBUTION

4.1 GENERAL

The Power Supply System provides d-c power for the electronic circuits. Eight d-c voltages (+250, +150, +90, +10, —15, —30, —150, and —300V) are distributed to the input equipment. The ninth voltage, —48V, is used as a control voltage to energize relay coils. A battery source of 130Vdc is also used as control power; however, this voltage is mentioned only with control functions and is not discussed in these distribution circuits. Five of these voltages (+250, +150, +90, —150, and —300V) are also routed through special circuits for use in marginal checking certain simplex load units. A typical marginal checking application is covered in paragraph 4.4.2. For more details regarding marginal checking, refer to the *Theory of Operation, Marginal Checking System, AN/FSQ-7 and -8,* 3-92-0.

4.2 POWER SUPPLY UNIT 61

The d-c power is rectified from a-c power (Part 2, Ch 4) by d-c power supplies in unit 61. Only 9 of the 10 d-c voltages (table 4—5) are used in the input equipment. The +600V power is not required.

4.3 PCD UNIT 64

Eight contacts of a 9-pole knife switch connect the distribution lines of simplex input CB unit 56 to the d-c voltage bus bars in PCD unit 64 (table 4—22). A double-pole knife switch provides the —48V for control power.

Distribution of d-c voltages to the metering circuits is described in Chapter 2, Section 5.

4.4 CB UNIT 56 AND PD UNIT 55

4.4.1 Nonmarginal Checking Voltages

Eight d-c service voltages and the —48V control voltage are applied from the knife switch (table 4—22) in unit 64 to the main bus bars in simplex input CB unit 56 (CD 5.3.10.3). Each voltage is then applied from its main bus bar through CB's to bus bars in other modules of unit 56 for distribution to the input load units.

For example, the +250V is taken from contact D2 of knife switch 64A6 (CD 5.3.2.1) and applied to terminal 1 on main bus bar 56B2B5 (table 4—23 and CD 5.3.10.3). One line then proceeds from terminal 2 on the main bus bar through CB 56B2C5 to terminal 1 on bus bar 56C2L1. The line from terminal 13 then applies the +250V to CB56C2L13 (S 5.3.10.5, sheet 1), to connection 55B6C4h in PD unit 55, to pin 4 in plug connector P3 of type 78019 sliding unit 55B-4, to pin 49 in jack connector J2A, to connection 55B6A1h to terminal 32AZ4b. Contacts 1a-1c of K2 in the pluggable unit apply the +250V when power system C is active. Contacts 1a-1c of K11 apply the +250V when power system D is active.

Other distribution lines can be traced in the same manner. The one d-c return line for each channel (S 5.3.10.7) provides the return for all d-c voltages.

In card entry punch units 352, 353, and 354, only +10 and —48Vdc are distributed. The —48 is distributed for control voltage (S 5.4.10.4). For unit 352, the +10V is applied across CB 56C2H21 (S 5.3.10.6)

TABLE 4—22. D-C VOLTAGES IN UNIT 64 FOR SIMPLEX INPUT CB UNIT 56

VOLTAGE	CONTACTS OF KNIFE SWITCH 64A6
+250	D2-D3
+150	E2-E3
+ 90	F2-F3
+ 10	G2-G3
— 15	H2-H3
— 30	J2-J3
—150	K2-K3
—300	L2-L3
— 48	M1-M3
	N1-N3

Note: See logic diagram CD 5.3.2.1 for these points.

TABLE 4—23. TYPICAL D-C DISTRIBUTION POINTS THROUGH UNITS 56 AND 55

TYPICAL CHANNEL	XTL 1	GFI 1, 2	GFI 1, 2
Voltage	+250 V	+250V	+150V
Main Bus Bar (CD 5.3.10.3)	56B2B5	56B2B5	56B2B4
Backup CB (CD 5.3.10.3)	56B2C5	56B2D5	56B2C4
Distribution Bus Bar (CD 5.3.10.3)	56C2L1	56D2L1	56D2M2
Distribution Terminal (CD 5.3.10.3)	56C2L13	56D2L20	56D2M20
Distribution CB (S 5.3.10.5)	56C2L13 (Sheet 1, line 23)	56D2L20 (Sheet 2, line 23)	56D2M20 (Sheet 2, line 53)
Unit 55 Connection (S 5.3.10.5)	55B6C4h (Sheet 1, line 24)	55D6C4h (Sheet 2, line 24)	55D6C4j (Sheet 2, line 54)
Sliding Unit (S 5.3.10.5)	55B-4 (Sheet 1, line 2)	55D-4 (Sheet 2, line 2)	55D-4 (Sheet 2, line 2)
Input Connector S 5.3.10.5, sheet 8)	J3	J3	J3
Input Connector Pin	4	4	2
System C Contractor Relay	K2	K2	K2
System C Relay Contacts	1a-1c	1a-1c	2a-2c
Output Connector	J2A	J2A	J2A
Output Connector Pin	49	49	31
Cable Connection (S 5.3.10.5)	55B6A1h (Sheet 1, line 26)	55D6A1h (Sheet 1, line 26)	55D6A1j (Sheet 2, line 56)
Load Unit Connection (S 5.3.10.5)	32AZ4b (Sheet 1, line 27)	34AZ4b (Sheet 2, line 27)	34AZ4c (Sheet 2, line 27)

to pin 27 of a power connector (PC) cable, and then to relay contacts 12BL (2.2.1.2, Sect. 10B). Relay contacts in unit 352 apply the +10Vdc to unit 23, which in turn connects to other load units. The d-c return line, consequently, is provided through the d-c returns for duplex equipment.

4.4.2 Marginal Checking Voltages

The voltages used for marginal checking the simplex equipment are taken from the main bus bars in CB unit 56 (par. 4.4.1). Each voltage is protected by a CB in unit 56 before it is applied to MC unit 58. For marginal checking, the output of the amplidyne is switched in series with the selected voltage and applied to the selected circuits.

4.5 SIMPLEX INPUT LOAD UNIT

4.5.1 Nonmarginal Checking Voltages

The distribution of d-c voltages through the simplex input load units (XTL unit 32, GFI unit 34, LRI unit 41, and test pattern generator unit 92) can be traced on the standard wiring charts (fig. 4–8). (Refer to *Military Reference Data Standards*, subsection 1-2-4-2 par. 7, on the interpretation of standard wiring charts). For example, in XTL 1, the +250V is applied to unit 32 at terminal 32AZ4b (table 4–23) and then distributed to terminal E4 (fig. 4–8) in other locations of that load unit.

4.5.2 Marginal Checking Voltages

The distribution of MC voltages through the simplex input load units can be traced on unit supplement charts in *Schematics for Input System of AN/FSQ-7 and Q-8*, 3-232-0. Refer to *MRD Standards,* subsection 1-2-4-2, paragraph 7 for useful instructions.

SHEET 16 OF 21

FRAME NO. 25 MODULE E

TITLE SERVICE WIRE SPECIAL

REFERENCE DRAWING

FROM: PLUGGABLE UNIT OR ROW	FROM: TERMINAL	TO: PLUGGABLE UNIT OR ROW	TO: TERMINAL	VOLTAGE	WIRE COLOR	CHECK	JUMPER PART NO.
Y	D2	Y	F1	-30	BLUE		3002514
Z	1h	Y	A4	-48 RET	BLACK		3002502
Z	2c	Z	3j	-150	GREEN		3002515
Z	5c	Z	4d	+90	GRAY		3002510
Y	G1	V	2g	-48	WH/ORN/GRN		3003998
Y	H5	Y	2e	-48	WH/ORN/GRN		3003998
V	A8	Y	E5	-30	BLUE		3002514
V	E2	V	G7	+90	WH/GRY		3002511
X	E2	X	B6				
G	E2	G	B5				
	B5		B6				
	B6		D5				
	D5		D6				
	D6		G5				
	G5		G6				
G	G6	G	G7				
H	E2	H	B5				
	B5		B6				
	B6		D5				
	D5		D6				
	D6		G5				
	G5		G6				
H	G6	H	G7				
J	E2	J	B5				
	B5		B6				
	B6		D5				
	D5		D6				
	D6		G5				
	G5		G6				
J	G6	J	G7				
K	E2	K	B5				
	B5		B6				
	B6		D5				
	D5		D6				
	D6		G5				
	G5		G6				
K	G6	K	G7	+90	WH/GRY		3002511

WIRE: CODE	COLOR	VOLTAGE	PART NO.	Q'T'Y
6	BLUE	-30	3002514	
935	WH/ORN/GRN	-48 RET	3003998	
5	GREEN	-150	3002515	
8	GRAY	+90	3002510	

Figure 4–8. Typical Assembly Wiring Chart

SECTION 5
NEUTRAL LINES, RETURNS, AND GROUNDS

5.1 GENERAL

Like the duplex and display equipment, the input and output equipment has a-c neutral lines, d-c returns, and equipment bonds.

5.2 NEUTRAL LINES

5.2.1 Unregulated A-C Neutral

An unregulated a-c neutral line from each PCD unit 64 (CD 5.3.2.2) connects to bus bar 56A1K1 (S 5.3.10.2) in simplex input CB unit 56. From this bus bar, the neutral lines are distributed throughout the simplex input equipment as described in conjunction with unregulated a-c distribution (Sect. 2).

5.2.2 Regulated A-C Neutral

A regulated a-c neutral line from each PCD unit 64 (CD 5.3.2.2.) connects to bus bar 56A2A1 (S 5.3.10.1) in simplex input CB unit 56. From this bus bar, the neutral lines are distributed throughout the simplex input equipment as described in conjunction with regulated a-c distribution (Sect. 3).

5.3 D-C RETURN LINES

5.3.1 D-C Return

Returns for dc are distributed throughout the units of the power system and the loads. One d-c return arrangement is common for all d-c voltages except the —48V (relay power).

Returning from the load units, the d-c return lines are connected together, returned to CB unit 56, and returned to d-c return bus bar 64A5 (CD 5.3.2.1.). From this bus bar, the returning d-c is conducted to its respective d-c power supply after passing through the appropriate ammeter shunt in PCD unit 64.

5.3.2 Relay Return

Relay return lines are provided throughout the units of the power systems, load units, and the other control units to return the —48Vdc. From the input load units, the relay return lines connect to bus bar 56B3A2 (S 5.3.10.7). The —48V return lines from this bus bar return to bus bar 64A5 (CD 5.3.2.1.). The —48Vdc then passes through the ammeter shunt in PCD unit 64 and returns to the —48V power supply in unit 61.

5.4 EQUIPMENT BOND

The equipment bond grounds the frame of each unit in the equipment, except for the maintenance console. The equipment bond in simplex maintenance console unit 47 ends at terminal 47J3(E31)h (S 5.3.10.7). The equipment bonds of the units in each power system are connected through their respective CB unit to equipment bond bus bar 64C5 (CD 5.3.2.1.). The equipment bonds of power systems A, B, C, and D are connected together at simplex input load units. Equipment bonds from ground bus bars of the load units connect to equipment bond bus bars in PD unit 55, and other bonds from ground plates in the load units (5.3.7.2, 5.3.7.3, and 5.3.7.4) connect to MCD unit 59. One line connects d-c return bus bar 64A5 to equipment bond bus bar 64C5. The frames of sections A, B, and C of PCD unit 64 are also connected to this equipment bond bus bar. This bus bar then connects to the equipment bond terminal of line regulator C95 or D95.

CHAPTER 5
POWER CONTROL FOR INPUTS

SECTION 1
INTRODUCTION

1.1 SCOPE

In this chapter the control circuitry is described in detail, and the operation of controls, indicators, and components is explained. Only descriptions of controls and indicators on units 56 and 55 are provided in this chapter. The controls and indicators on the other units involved in power control for inputs are described under controls (par. 1.3, Ch 3) and indicators (par. 1.4, Ch 3) for displays. The conditions of various circuits during the normal-on, normal-off, and abnormal-off sequences are explained in detail.

1.2 GENERAL

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

The operator at simplex maintenance console unit 47 initiates the normal sequences in the control of the power for the simplex inputs. 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 immediate 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 power system that is to be active by depressing the correct ACTIVE pushbutton. The power status of each input channel can be selected by means of the unit status switch of that channel on pluggable panels in the simplex maintenance console.

1.3 CONTROLS

1.3.1 Simplex Input CB Unit 56

Simplex input CB unit 56 (fig. 4–3) has a UNIT OFF pushbutton, located on module A, in addition to the CB's.

1.3.2 Simplex Input PD Unit 55

Simplex input PD unit 55 (fig. 4–4) has no external controls to operate the simplex equipment. All sliding units are covered by doors that are locked with combination-type locks.

1.3.3 Other Units

Several units are used in controlling power for displays as well as for inputs. The controls on those units are described in paragraph 1.3, Chapter 3. The controls on the duplex switching console are described in paragraph 2.2.1, Part 5.

1.4 INDICATORS

1.4.1 Simplex Input CB Unit 56

CB unit 56 (fig. 4–3) has indicators on the front 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.

1.4.2 Simplex Input PD Unit 55

POWER ON lamps on PD unit 55 (fig. 4–4) 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 (par. 1.2.5, Ch 1). Below each pair of lamps is an AC TIME ON (elapsed time) indicator for every sliding unit.

1.4.3 Other Units

The indicators on other units involved in controlling power for displays are described in paragraph 1.4, Chapter 3. The indicators on the duplex switching console are described in paragraphs 2, 3, and 2.4, Part 5.

SECTION 2

NORMAL POWER-ON SEQUENCE

2.1 GENERAL

The normal power-on sequences for inputs occur simultaneously with the power-on sequences for displays when the POWER ON push-button on the simplex maintenance console is depressed. Therefore, the same prestart conditions (par. 2.2, Ch 3) must exist. To prevent the application of power to displays, the following steps can be performed in conjunction with the prestart conditions:

1. Open contacts of knife switch 64A6(table 4–6) to keep d-c voltages from CB unit 48.
2. Open CB 64C7A1 (par. 3.2, Ch 2) to keep regulated ac from unit 48.

2.2 POWER OFF TO POWER ON

This sequence is automatic after the POWER ON pushbutton on simplex maintenance console unit 47 has been depressed. The operation of the relays in PCD unit 64 and the indications on units 64 and 47 are the same as the power-on sequence for displays (par. 2.3, Ch 3).

Since most of the components in the following description are located in CB unit 56, the component designations should be prefixed by 56 except when complete designations are provided.

The —48V control power is applied to bus bar B2L10 when the —48Vdc power supply produces the power. When the CB's in simplex input CB unit 56 are closed (step e in par. 2.2, Ch 3), auxiliary (interlock) points b-d (CD 5.4.10.1) are closed and points c-d are opened. The control relay in each interlock circuit can then energize (table 4–24) when —48V control power is applied. For example, —48Vdc from CB B2L8 is applied across auxiliary points b-d of CB's A6C2 and B2C1 through B2C9 to energize status control relay C3K2.

The —48V control power from CB B2L6 is applied through pin B30 of the plug connector of the simplex maintenance console (S 5.4.11.1), to terminal e on barrier strip 47H3E1, to point 3a of SERVICE OPPOSITE SIMPLEX SWITCH 47H3(S6), to point 2a of relay 47H3K3, to points 1c of relays 47H3K2, K3, K4, and K5, and point 1b of relay 47H3K6, to pin A27 of the plug connector on the simplex maintenance console, to pin B of a cable connector on the duplex switching console, to point 1c of relay 45K1, across now closed points 3a-3c of 45K1 (when relay K1 was not tripped) to energize 45K2.

The above procedure is used if the power-on sequence follows the shutdown of power during active status. For other conditions, the ACTIVE pushbutton

TABLE 4–24. POWER CONTROL INTERLOCK CIRCUITS FOR INPUTS

			BACKUP CB's IN UNIT 56								
CHANNEL IN GROUP	INTER-LOCK RELAY	REGU-LATED AC	—48V	+10V	—15V	—30V	+250V	+150V	+90V	—150V	—300V
CE 352, 353, 354 GFI Monitor, Test Pattern Generator, XTL	C3K2	A6C2	B2C9	B2C8	B2C7	B2C6	B2C5	B2C4	B2C3	B2C2	B2C1
GFI	D3K2	A6C3	B2D9	B2D8	B2D7	B2D6	B2D5	B2D4	B2D3	B2D2	B2D1
LRI 1 through 18	E3K2	A6D2	B2E9	B2E8	B2E7	B2E6	B2E5	B2E4	B2E3	B2E2	B2E1
LRI 19 and up	F3K2	A6D3	B2F9	B2F8	B2F7	B2F6	B2F5	B2F4	B2F3	B2F2	B2F1
	(CD 5.4.10.1)	(S 5.3.10.1)	(Circuits containing these CB's are found on logic diagram CD 5.3.10.3.)								

must be depressed to trip K1 of the active power system and to pick K1 of the standby power system. The service opposite simplex switches are assumed to be in the normal position.

If CB 64C7B1 (par. 3.2, Ch 4) is closed, auxiliary points 3a-3c are closed (CD 5.4.2.1) and enable points 1a-1c of relay 64B5K36 to complete the circuit to energize relay 64B5K38. Points of 64B5K39 and 64B5K38 (CD 5.4.10.1) complete the circuit to apply power to the simplex input load units.

The —48Vac-on signal from CB 56B2L9 energizes the a-c control relays (CD 5.4.10.1). This circuit can be traced as follows: across now closed points 1a-1c of relay 64B5K38, across now closed points 3a-3c of relay 64B5K39, to pin B11 of the plug connector on the simplex maintenance console (S 5.4.11.1), to point 1a of the SERVICE OPPOSITE SIMPLEX SWITCH, to pin B13 of the plug connector on the simplex maintenance console, to pin D of a cable connector on the duplex switching console, across now closed points 2a-2c of relay 45CK2, to pin E of a cable connector on the duplex switching console, to pin B38 of the plug connector on the simplex maintenance console, to terminal a on barrier strip 47H3E1, to pin A5 of the plug connector on the simplex maintenance console, across now closed points of the interlock relays (table 4—24), to the coil of the a-c active status relays (CD 5.4.10.1).

Points of the a-c active status relays (S 5.4.10.3, blocks 9 and 10) complete the circuit for the ac-control voltage to energize a-c contactor relays K1 in sliding units which are part of PD unit 55. This circuit can be traced as follows. The —48V that is distributed from bus bars in CB unit 56 (CD 5.3.10.3) is applied (S 5.4.10.3, block 88) across a CB (block 33), across now closed auxiliary points b-d of a-c distribution CB's for all three phases, following the dotted line (for marginal checked units, Note XI), across now closed points of relay C3C2 or C3E2, to pin A8 of a cable connector to contact 1 on wafer A of the unit status switch on the simplex maintenance console. When the unit status switch of a channel is in the ACT position, —48V is applied to pin A7 of the cable connector, to pin 14 of the plug connector on the sliding unit (S 5.4.10.3, sheet 9) which is part of PD unit 55, through normally closed points 7a-7b of relay K12 (when power system C is active) to energize a-c contactor relay 55K1. Power contactors 1a-1c, 2a-2c, and 3a-3c of 55K1 (S 5.3.10.1) apply regulated ac to the filament transformers in the simplex input load units.

Approximately 1 minute after the regulated ac is applied to the simplex input equipment, the d-c voltages are applied in two steps: first the low voltages (+10, —15, —30V), and then the high voltages (+250, +150, +90, —150, —300V).

One minute after time delay relay 64B5K64 is energized (par. 2.3, Ch 3), its contacts close (CD 5.4.2.1), energizing 64B5K40. Points 1a-1c of relay K40 complete the circuit that energizes 64B5K41.

The interlock relays (table 4—25) are energized if the interlock circuits are complete. Also —48V control voltage had been applied previously to terminal a of barrier strip 47H3E1 (S 5.4.11.1). This control voltage, a dc-on signal, is now applied from terminal a of barrier strip 47H3E1, across now closed points 6a-6c of 64B5K41, across now closed points of the interlock relays (table 4—24) to energize the d-c active status relays (CD 5.4.10.1).

Points of the d-c active status relays (S 5.4.10.3, blocks 14 and 15) complete the circuit to provide dc-control voltage to energize dc-control relays K4 in the sliding units which are part of PD unit 55. This circuit can be traced as follows. The —48V from the CB (S 5.4.10.3, block 33) is applied across now closed auxiliary points b-d of the d-c distribution CB's (blocks 22-29), across points of the d-c status relays (blocks 14 and 15), to pin A3 of a cable connector, to contact 1 on wafer B of the unit status switch, to pin A4 of a cable connector, to pin 15 of the plug connector on the sliding unit which is part of PD unit 55, across now closed points 8a-8c of K1, across normally closed points 2a-2b of K8, and across normally closed points 1a-1b of K9 to energize dc-control relay K4 in the sliding unit.

When the points of K1 closed, time delay relay K7 was energized. Relay K7 functions to delay the application of d-c power 45 seconds after the a-c power was applied if the power control is exercised at the unit status switch (par. 6.3). Points 2-3 of K7 complete the circuit to energize K16.

Points 5a-5c of K16 are now closed, and the circuit to energize K3 is completed through now closed points 2a-2c of K4 and closed points 7a-7b of K10. The low-voltage d-c contactor relay (S 5.3.10.5) completes the distribution circuits to apply the +10, —15, and —30V to the associated channel of simplex input loads.

Auxiliary points 8a-8c of low-voltage d-c contactor relay K3 (S 5.4.10.3) complete the circuit through now closed points 3a-3c of K4 and closed points 8a-8b of K11 to energize high-voltage d-c contactor relay K2. Relay K2 (S 5.3.10.5) completes the distribution circuits to apply the high d-c voltage to the associated load channel. All power is now applied to the simplex input channel. Points 9a-9c of K2 (S 5.4.10.3) close, completing the circuit to light the lamp (block 58) that shows that system C is furnishing the power to that channel.

When system D furnishes the power for the channel, relays K12, K9, K10, K11, etc., are substituted for the relays mentioned above.

2.3 AC ONLY TO POWER ON

This sequence is the same as the ac-only to power-on sequence for displays (par. 2.4. Ch 3).

The points of relay 64B5K41 (CD 5.4.10.1 and S 5.4.11.1) enable the dc-on signals to reach d-c contactor relays K3 and K2 in the sliding units of PD unit 55. (Refer to the last portion of par. 2.2.) Low-voltage d-c contractor relay K3 (CD 5.4.10.1) is energized first, applying the +10, —15, and —30V to the simplex input load channel. After the normally open points of K3 are closed, high-voltage d-c contactor relay K2 is energized, applying the other d-c voltages to that channel. Points 9a-9c of K2 complete the circuit to light the lamp that shows that system C is furnishing the power to that channel.

SECTION 3
NORMAL POWER-OFF SEQUENCES

3.1 GENERAL

The normal power-off sequence for inputs is the same as for displays (Ch 3). First the d-c voltages and then the a-c filament power are removed. The +130Vdc battery voltage for control circuits and the unregulated 120/208Vac are not removed during the normal power-off sequences. Additional CB's and switches must be opened to remove the remaining power.

3.2 POWER ON TO POWER OFF

This sequence is similar to the power-on to power-off sequence for duplex equipment (par. 3.2, Part 3, Ch 3) and is automatic after the POWER OFF push-button on the simplex maintenance console is depressed.

Relays K31 and K33 (CD 5.4.2.1) are de-energized when POWER OFF pushbutton 47H3(S2) is depressed. Points of K31 interrupt circuits to de-energize K61 and K41 and extinguish the POWER ON lamps (CD 5.4.2.3). Normally closed points of K41 complete the circuits to the POWER OFF lamps, which light, and other points interrupt the circuits (CD 5.4.10.1) which remove the d-c voltages from the displays and the simplex input load units.

Points of K33 open (CD 5.4.2.1), de-energizing K62. One second later, the points of K62 de-energize K42. Points of K42 interrupt the power-on signals, shutting off the inputs to the d-c power supplies and the induction regulator. This removes the d-c voltages and the regulated a-c power from PCD unit 64 and the distribution circuitry.

The unregulated ac can be removed from particular simplex input channels by opening the proper CB at the C and D CB unit 48. The unregulated ac is removed from one CB unit 48 by opening CB 10 in PCD unit 64 (par. 2.2, Ch 4) and from PCD unit 64 by opening the substation unregulated a-c feeder breaker (CD 5.3.2.2).

3.3 AC ONLY TO POWER OFF

Power system C or D was placed in ac-only status by sequencing from power off to ac only (par. 4.2) or from power on to ac only (par. 4.3). In either case, the relays, switches, and indicators will be in the same condition.

The power-off sequence from ac-only status is initiated by depressing the POWER OFF pushbutton. Relays K32 and K33 (CD 5.4.2.1) are de-energized when POWER OFF pushbutton 47H3(S2) is depressed. Points of K32 interrupt circuits to de-energize K61 and to extinguish the AC ONLY lamps (CD 5.4.2.3).

Points of K33 open (CD 5.4.2.1), de-energizing K62. One second later, the points of K62 de-energize K42. The points of K42 interrupt the power-on signals, shutting off the inputs to the d-c power supplies and the induction regulator. The d-c voltages are removed from PCD unit 64, and the regulated ac is removed from all power system C or D and from all simplex input channels connected to the power system being shut down.

The unregulated ac can be removed as described in the power-on to power-off sequence (par. 3.2).

SECTION 4
AC-ONLY SEQUENCES

4.1 GENERAL

Power system C or D is placed in the ac-only status from either the power-off or the power-on status. These sequences are initiated by the AC ONLY pushbuttons on the simplex maintenance console and proceed automatically to the ac-only status.

4.2 POWER OFF TO AC ONLY

This sequence for inputs is the same as the power-off to ac-only sequence for displays (par. 4.2, Ch 3), except different points on relay 64B5K39 are used in other circuits to apply regulated ac to the simplex input load units.

The —48V from CB 56B2L9 (CD 5.4.10.1) is applied across now closed points 1a-1c of relay 64B5K38 and points 3a-3c of relay 64B5K39 to provide the control power at terminal a of barrier strip E1 in the simplex maintenance console and to provide the ac-on signal across now closed points of the status control relays to energize a-c active status relays 56C3C2, C3E2, D3C2, D3E2, etc. (CD 5.4.10.1). These a-c status relays complete the circuits through the interlock points of the CB's (S 5.4.10.3, sheet 9) to energize a-c contactor relays K1 in the sliding units of PD unit 55. Relays K1 apply the regulated ac to the simplex input channels.

4.3 POWER ON TO AC ONLY

This sequence for inputs is the same as the power-on to ac-only sequence for displays (par. 4.3, Ch 3), except different points on 64B5K41 interrupt the d-c control circuits to the simplex input channels.

SECTION 5
ABNORMAL-OFF SEQUENCES

The abnormal-off sequences for inputs are the same as the sequences described for displays (Sect. 5, Ch 3).

SECTION 6
CONTROL AT SIMPLEX MAINTENANCE CONSOLE

6.1 GENERAL

Power system C or D is placed in the power-on, power-off, or ac-only status from the simplex maintenance console by depressing the correct pushbutton to initiate the desired sequence (Sects. 2 through 4).

When a power system is in power-on status and is not active, the associated ACTIVE pushbutton on the duplex switching console must be depressed to place that power system in active status.

All other controlling operations for a particular simplex input channel are performed at its particular panel on the simplex maintenance console. The status of the particular channel is selected by means of the UNIT STATUS switch. Power conditions of the associated channel can be observed on indicators in the power group of six lamps, three for power system C and three for power system D. The UNIT STATUS switch and these three pairs of lamps are described below. The other controls and indicators on these panels are described in the *Theory of Operation, Input System, AN/FSQ-7 and -8,* 3-52-0.

6.2 DESCRIPTION OF CONTROL PANEL

6.2.1 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 upper portion of an XTL pluggable panel (fig. 4–9) is shown as a typical panel.

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 a-c power lines are connected to the a-c 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 a-c power lines are connected to the a-c 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 a-c power lines are connected to the a-c 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 a-c power lines are connected to the a-c bus bars from the standby power system. The signal lines are disconnected.

e. AC ONLY – All d-c lines are disconnected. The a-c power lines are connected to the a-c 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.

6.2.2 Power Indicators

6.2.2.1 SIGNAL CONTACTORS CLOSED Lamp

Lamp A is lighted when computer A is receiving information from that particular input channel; lamp B, when computer B receives the information.

6.2.2.2 POWER CONTACTORS CLOSED Lamp

Lamp C is lighted when power system C is supplying the power for this channel; lamp D, when power system D is supplying the power.

6.2.2.3 CIRCUIT BREAKER ALARM Lamp

Lamp C or D is lighted when one or more of the associated CB's in CB unit 56 are tripped.

6.3 INDICATION CIRCUITRY

6.3.1 Information Signal Lamps

The circuitry that explains the operation of the SIGNAL CONTACTORS CLOSED lamps (X8) and (X12) (par. 6.2.2.1) on the power indication panel of the simplex maintenance console are described in

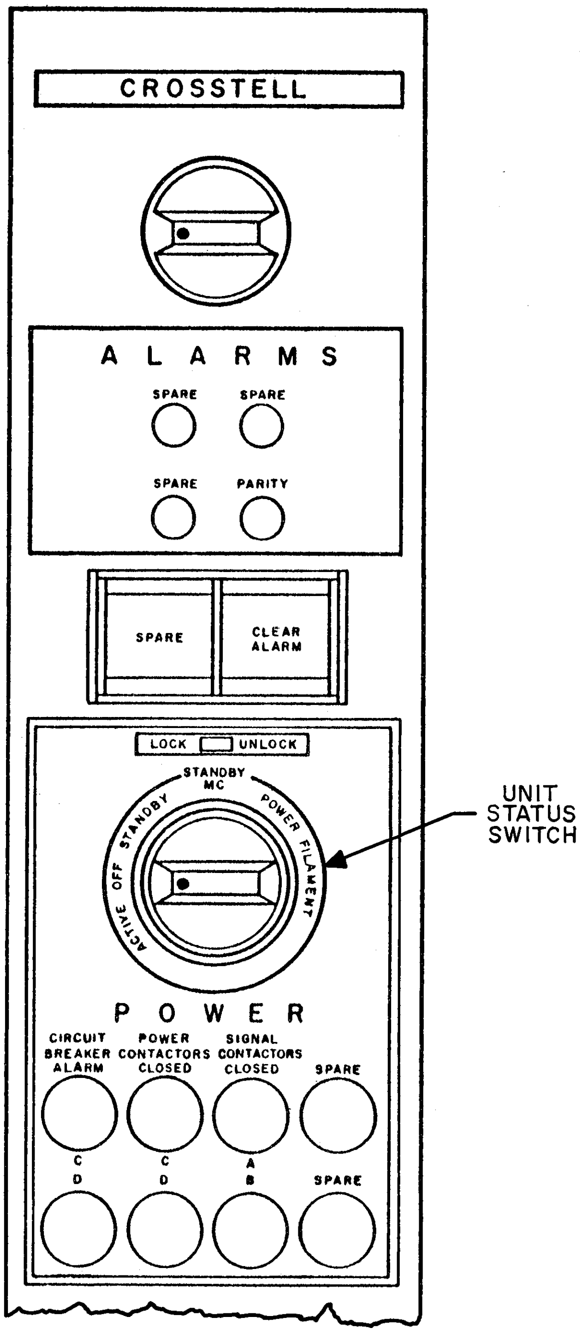


Figure 4–9. Unit Status Switch on Crosstell Panel of Unit 47

Theory of Operation, Input System, AN/FSQ-7 and -8, 3-52-0.

6.3.2 Power Lamps

The POWER CONTACTORS CLOSED lamp C (X9) on the simplex maintenance console (S 5.4.10.3) and the C POWER ON lamp on PD unit 55 (par. 1.4.2) are lighted when points 9a-9c of high-voltage d-c contactor relay close (par. 2.2 or 6.3). The POWER CONTACTORS CLOSED lamp D (X13) is controlled by K11.

6.3.3 CB Trip Lamps

The CIRCUIT BREAKER ALARM lamp C (X10) on the simplex maintenance console and the associated CB TRIP lamp on CB unit 56 are lighted by points c-d (S 5.4.10.3, block 21), which close when the CB (block 33) is opened.

6.4 ACTIVE STATUS

A simplex input channel can be switched from off to active status by turning the appropriate UNIT STATUS switch on the simplex maintenance console (fig. 4–9) to the active position when power is applied to the simplex input load units from power system C or D.

Regulated ac is applied through CB's (S 5.3.10.1) to sliding units in PD unit 55. The d-c voltages are applied across CB's (S 5.3.10.5) to the units. When a unit status switch for a particular channel is in the OFF position, the relays in the associated sliding unit are de-energized and the power contactors are open. Consequently, the channel is not operative.

During the power-on sequence for inputs (par. 2.2), regulated ac (S 5.3.10.1) was applied first and blocked by open contactors of K1 (system C) and K12 (system D). Then the d-c voltages (S 5.3.10.5) are applied to one side of the open contacts of K2 and K3 (system C) and K10 and K11 (system D). The a-c and d-c control relays were also energized during the power-on sequence (par. 2.2).

The —48V (a-c active) control voltage is applied across the now closed points (S 5.4.10.3, blocks 9 and 10) of the a-c control relays to pin A8 of the plug connector on the simplex maintenance console, and to contact 1 on wafer A of the UNIT STATUS switch.

When the UNIT STATUS switch (S 5.4.10.3) is placed in the ACT position, the —48V is picked by movable contactor a, applied to pin A7 of the plug connector on the simplex maintenance console and to pin 14 of plug connector P2B on the sliding unit in PD unit 55 to energize a-c contactor relay K1. Regulated ac is applied to the filament transformers at reduced voltage because of resistors R10, R11, and R12 (S 5.3.10.1).

Points 6a-6c of K1 close to energize time delay relay K7, and points 8a-8c close to energize dc-control relay K4 through wafer B of the UNIT STATUS switch. Points 2a-2c of K4 now set up the circuit to energize low-voltage d-c contactor relay K3 as soon as K7 functions. After a 45-second delay, points 2-3 of K7 close to energize K16. Points 1c-1a, 2c-2a, and 3c-3a of K16 (S 5.3.10.1) now short out R10, R11, and R12, providing rated a-c voltage to the filament transformers.

Points 5a-5c of relay now close, completing the circuit to energize K3. The contactors of K3 (S 5.3.10.5) apply +10V, —15V, and —30V to the associated channel of the simplex input loads. Auxiliary points 8a-8c of low-voltage d-c contactor relay K3 (S 5.4.10.3) then complete the circuit to energize high-voltage d-c contactor relay K2.

When power system D provides the power, wafers F and E are substituted for the control, above, offered by wafers A and B, respectively. Wafers G and H utilize signals from duplex power system A or B. Wafer D is not used for active status.

6.5 STANDBY MC STATUS

Marginal checking is performed when the unit status switch is in the STANDBY MC position. While marginal checking is in progress, the power status of the channel involved cannot be changed until the excursion-on relays are de-energized.

To reach the standby MC status (S 5.4.10.3, sheet 9), the d-c contactor relays (K3 and K2 for power system C or K10 and K11 for power system D) are not energized, as wafer B of the unit status switch has no connection for position 4. Regulated ac is applied in the same manner as in active status (par. 6.4). After K1 (for power system C) or K12 (for power system D) is energized, K8 and K13 are energized. The circuit for power system C is traced in table 4—25.

After K8 and K13 are energized through the circuit completed by position 4 on wafer D of the unit status switch, points 5c-5a of K13 provide a hold circuit through points 1a-1c of an excursion-on (MC) relay (S 5.4.10.3, blocks 82 and 81). As long as the associated excursion-on relay is energized during marginal checking, K8 and K13 will remain energized.

Points 1c-1a of K8 provide a hold circuit for a-c contactor relay K1. Points 2b-2a prevent d-c control relay K4 from being energized. Points 3c-3a provide a circuit to energize low-voltage d-c contactor relay K3 through points 9c-9a of K1 after points 5c-5a of K16 are closed following the action of time delay relay K7. Points 4c-4a of K8 provide a circuit for points 8c-8a of K3 to energize high-voltage d-c contactor relay K2. These circuits all remain complete, regardless of the movement at the unit status switch, until K8 and K13 are de-energized.

TABLE 4—25. CIRCUIT TO ENERGIZE RELAYS K8 AND K13

POINT OR TERMINAL	COMPONENT	BLOCK NO. ON S 5.4.10.3
e	CB	33
d-b	D-C CB	29, 28, 27, 26, 25, 24, 23, 22
Terminal		18
Points	Control relay	17-16
Terminal		13
Terminal		20
Terminal		65
16	J3-P3	
10c-10a	K1	
10a	K12	
5c	K13	
48	P2B-J2B	
Terminal		64
A17	Connector	118
4	Unit Status	
a	Wafer D	
A16	Connector	119
Terminal		83
Points	Control relay	79-80
Terminal		77
40	J2B-P2B	
4b-4a	K9	
4b-4a	K4	
Y	K8 and K13	

PART 5

SYSTEM SWITCHING

CHAPTER 1

INTRODUCTION

1.1 SCOPE

This part describes the substitute facilities that enable the SAGE equipment to remain operative when some major components fail. The various switching functions are explained.

1.2 GENERAL

The Power Supply System is designed with sufficient switching flexibility so that the total loss (failure) of any major component does not permanently affect the operation of the SAGE Site. The switching facilities are:

a. Primary split bus bars in the powerhouse which can be connected together

b. Spare diesel generators which can be connected to either bus

c. A spare substation which can replace either a load center or another substation

d. Duplex switching which transfers information flow to either computer

e. Simplex switching which transfers the simplex equipment to either of two power sources

The facilities listed in a through c allow for the loss of one-half of the primary bus system while still being able to maintain both computer power systems and one simplex power system.

1.3 SPLIT-BUS ARRANGEMENT

The high-voltage bus bars are divided into two sections, bus A and bus B, with a CB in the center. The system is normally operated with this CB open so that a fault on one side of the bus bars does not directly affect the other. If a fault occurs in the left half of the bus bars, power systems A and C are disabled. Power systems B and D are still operating, and these two power systems can energize duplex equipment B and the simplex equipment, thereby enabling the site to perform its function. However, the spare diesel generator can be tied to either half of the high-voltage bus bars and provide power for either of the formerly disabled power systems.

1.4 SPARE SUBSTATION

In addition to the two substations that normally supply the four power systems, a spare substation can be switched to assume the load of either of the other substations or of either of the load centers.

CHAPTER 2
DUPLEX SWITCHING

2.1 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 (fig. 5—1) decides which computer will be active. Status and alarm lamps indicate the condition of each power system.

2.2 DUPLEX SWITCHES ON DUPLEX SWITCHING CONSOLE

2.2.1 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:

a. Sends a signal to that particular computer to indicate it has been placed in active status.

b. Sends a signal to place the other computer in standby status.

c. 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 —48Vdc to the display con-

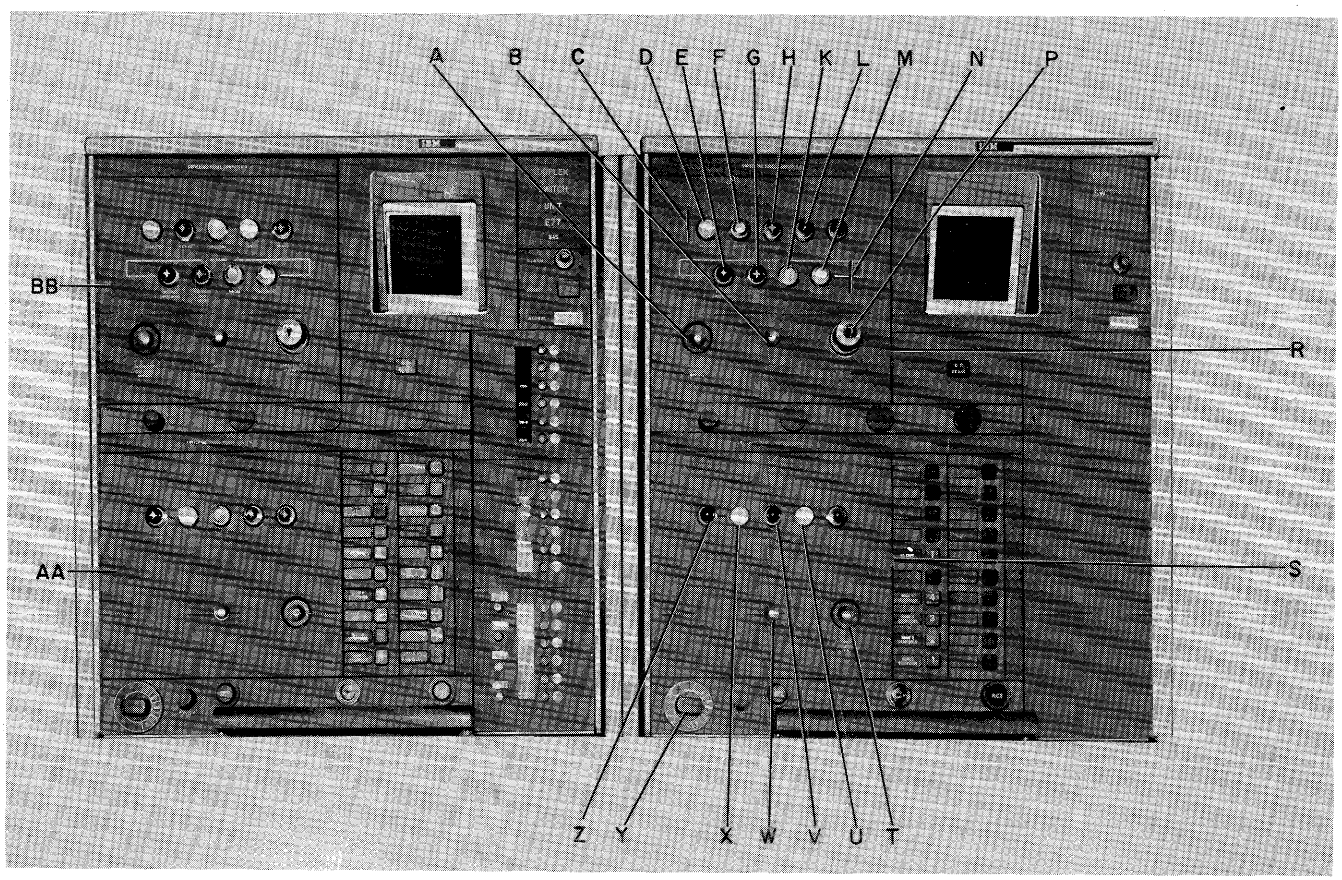


Figure 5—1. Duplex Switching Console Unit 45, Front Panels

soles, to determine which computer information will be displayed, and to the XTL input channel.

d. 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.

2.2.2 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 —48Vdc to the ACTIVE pushbutton. This pushbutton is located in a recessed position and cannot be depressed accidentally during normal operating procedure.

2.2.3 OPERATE-TEST OVERRIDE 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 the standby status. This signal is applied to the master TEST-OPERATE COMPUTER switch located on the duplex maintenance console.

The OPERATE-TEST OVERRIDE BYPASS switch is operated with a key which remains in the custody of the maintenance supervisor.

2.2.4 Unit Status Switch

The unit status switch controls the distribution of the control and signal lines only for the display portion of the duplex switching console. Refer to Part 4, Chapter 3, for a description of this switch.

2.3 STATUS LAMPS ON DUPLEX SWITCHING PANEL

2.3.1 OPERATE Lamp

This lamp is lighted when the associated computer is not in the test mode or is not disabled.

2.3.2 ACTIVE Lamp

This lamp is lighted when the associated computer has received a switching-complete signal.

2.3.3 STANDBY Lamp

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.

2.3.4 TEST Lamp

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.

2.4 ALARM LAMPS ON DUPLEX SWITCHING PANEL

2.4.1 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.

2.4.2 VOLTAGE OFF LIMITS Lamp

Whenever one of the power supplies deviates more than ± 5 percent from the regulated output, the associated voltage monitor relay in the PCD unit completes a circuit that lights the VOLTAGE OFF LIMITS lamp 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 ± 20 percent, there will be an automatic shutdown of power from the power supply unit and PCD unit involved.

2.4.3 NEON Alarm Lamp

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.

2.4.4 DISABLED Lamp

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.

2.5 DETAILED DUPLEX SWITCHING ACTION

2.5.1 General

Duplex switching is the changing of the standby computer (and associated power supply and other duplex equipment) to the active status. Refer to *Theory of Operation, Central Computer, AN/FSQ-7 and -8*, 3-32-0, for more details.

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.

2.5.2 Duplex Switching Interlocks

When all the interlocks are closed, points 1a-1b of relays 1E2(K8) and 1E2(K14) (7.1.14 in *Schematics for Central Computer of AN/FSQ-7 and -8,* 3-212-0), points 2a-2b of relays 1G4(K14) and 1G4(K15) and interlock contacts in the duplex power equipment are open, leaving interlock relay 1F3(K7) de-energized.

2.5.3 Duplex Switching Permitted

A —48V duplex-switching-permitted signal (7.1.4) is then applied across points 4-7 of relay 1F3(K7) (7.1.14), pin S of cable connector J2 on the duplex switching console (7.2.1), across contacts a-c 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) (fig. 5—2), placing computer A in standby status.

2.5.4 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.

2.5.5 MCD Unit 27 Signal Status Relays

Points 2a-2c of 45B(K2) close, energizing active 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 of 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) 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.

2.5.6 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, and across now closed points 5-6 of high-voltage d-c contactor relays K3 in locations 59B6, 59C6, 59D6, and 59G6 (applied the high-voltage d-c 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 (table 5—1).

TABLE 5—1. ACTIVE STATUS RELAYS FOR SIMPLEX INPUT CHANNELS

D-C CONTACTOR RELAY	ACTIVE STATUS RELAYS	LOAD UNIT CHANNEL
None	59F3E2	CEP Units 352, 353, 354
59B6(K3)	59F1A2 59F1B2 59F3A2 59F3B2	LRI
59C6(K3)	59F1C2 59F3C2	XTL
59D6(K3)	59F1D2 59F3D2	GFI

Note: See logic diagram 5.4.7.6 for these locations.

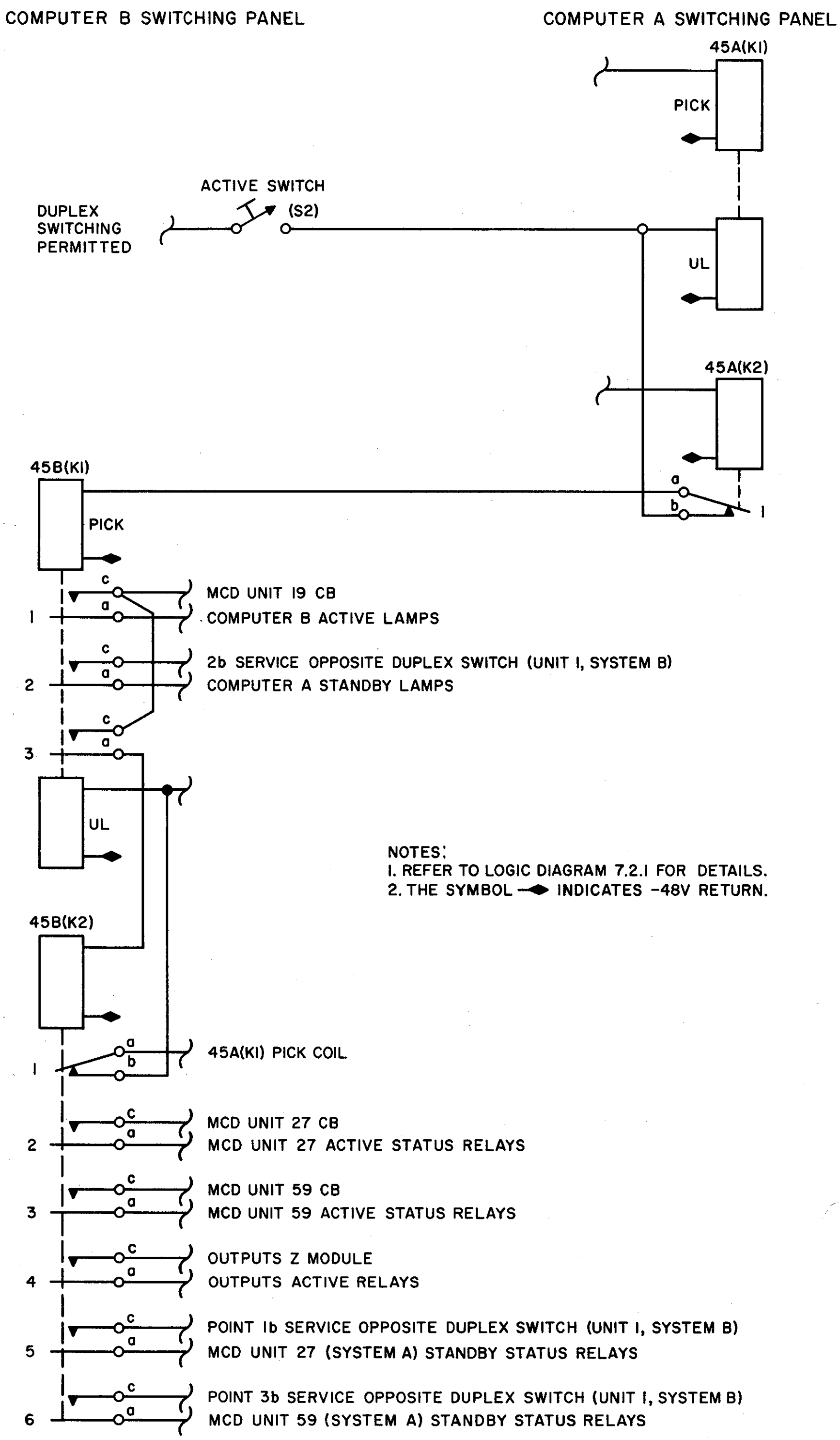


Figure 5–2. Duplex Switching Circuits

Standby status relays 59F1A3, 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.

2.5.7 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.

2.5.8 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 120Vac to the Haydon Timer* 1F3(E35) (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 1a-1b and shorting out the relay coil with 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 Haydon 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 Haydon 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 circuit to the grid on the thyratron pulse generator that sets up the controls to indicate that duplex switching was initiated. The floating grid stops the thyratron pulse generator.

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The comparable relays in the duplex maintenance console for computer A (1F4K11 and 1F4K12) 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.

2.5.9 System Disabled

2.5.9.1 Indication

The DISABLED lamp, X9, on a duplex switching panel of unit 45 is lighted whenever an interlock is open (par. 2.5.2) 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(E25)c, to pin R of J2 on the duplex switching console, to the DISABLED lamp.

2.5.9.2 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, par. 2.5.2), contacts 4-5 will be open and the duplex-switching-permitted signal will be interrupted. Contact 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 5—2). Trip coil UL of 45A(K1) will initiate the switching sequence to make computer B active.

2.5.10 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 1G2(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

TABLE 5–2. 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

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.

2.6 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 (par. 2.5.5) 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 (par. 2.5.4). Contacts 3a-3b provide —48V from active MCD unit 59 to energize the standby status relays in standby MCD unit 59 (par. 2.5.6).

2.7 ALARMS

2.7.1 General

Alarm conditions are indicated by lamps on the duplex maintenance console and the duplex switching console. Alarm buzzers in the duplex maintenance console provide audible alarms.

2.7.2 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.

2.7.3 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 (par. 1.3.2.2, Part 3, Ch 3). 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.

CHAPTER 3
SIMPLEX SWITCHING

3.1 GENERAL

Simplex switching, performed at the duplex switching console (fig. 5–1), 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 decides which system will be active and which standby. Status and alarm lamps indicate the conditions of each power system.

3.2 SIMPLEX CONTROLS ON DUPLEX SWITCHING CONSOLE

3.2.1 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.

3.2.2 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.

3.3 INDICATORS ON SIMPLEX SWITCHING PANEL

3.3.1 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.

3.3.2 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.

3.3.3 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.

3.3.4 POWER ALARM Lamp

The POWER ALARM lamp lights when a regulated voltage from the simplex power supply unit deviates more than ± 5 percent from its normal output. The POWER ALARM lamp also lights when the power is shut down.

3.4 DETAILED SIMPLEX SWITCHING ACTION

Simplex switching operations involve power transfer and are accomplished as follows (fig. 5–3): 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 d-c contactor. A typical d-c 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(K1) is tripped and 45C(K2) is unlatched. Relay 45D(K1) 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 re-associated with power system D. A typical d-c voltage lays (56C2J2, etc) in CB unit 56. Power from system D 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 the d-c 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.

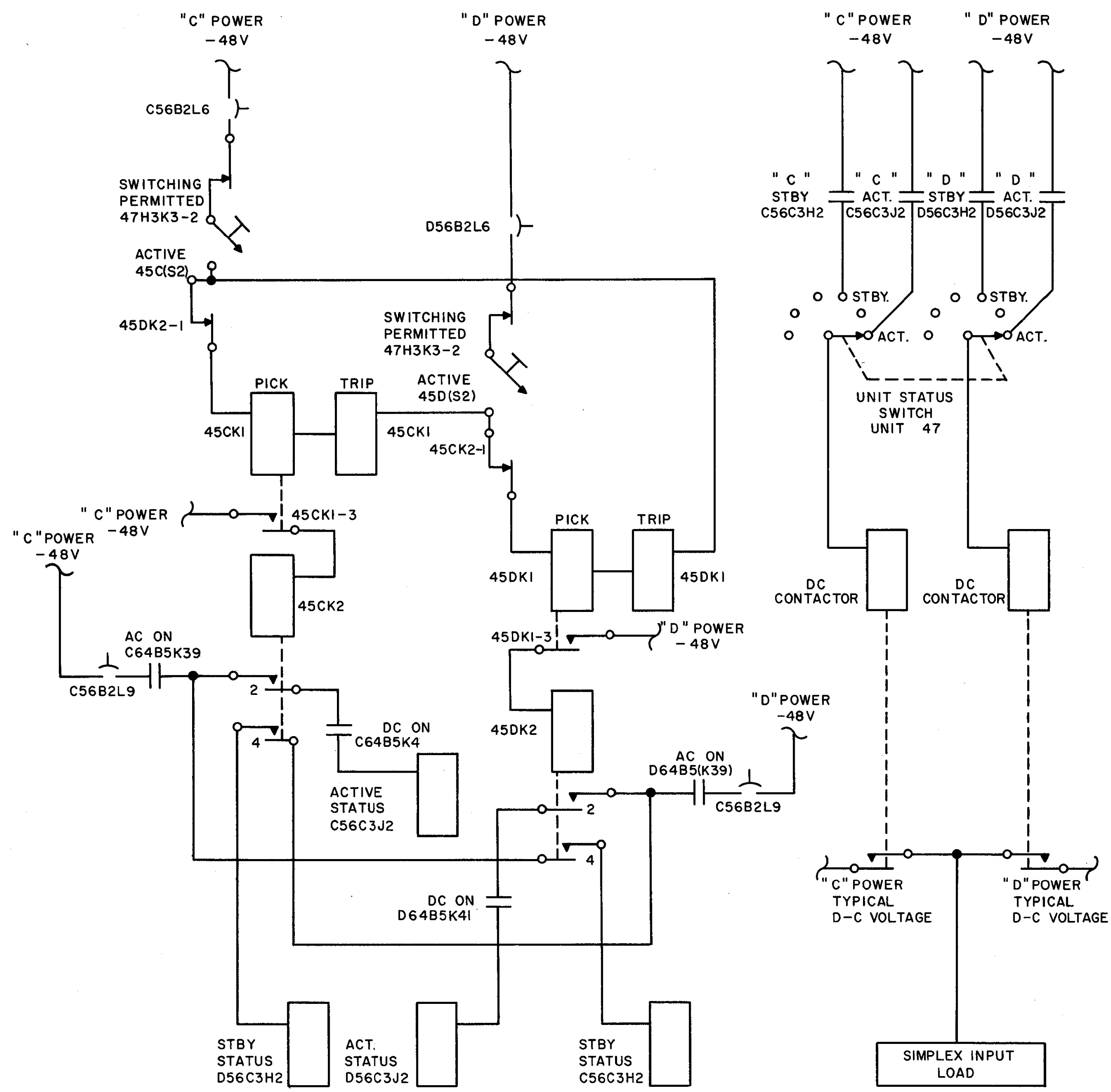

Figure 5—3. Typical Load Unit, Simplified Simplex Switching

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).

PART 6

NONSTANDARD VOLTAGE POWER SUPPLIES

CHAPTER 1

INTRODUCTION

1.1 SCOPE

Part 6 deals exclusively with nonstandard voltage power supply unit 18 and the associated control and distribution circuitry. The MC portion of this unit and the excursions applied to these nonstandard voltages are described in *Theory of Operation, Marginal Checking System AN/FSQ-7 and -8,* 3-92-0.

1.2 DESCRIPTION OF UNIT 18

1.2.1 Physical Description

Unit 18 is 32 inches wide, 44 inches deep, and 68 inches high, and weighs approximately 1,500 pounds. The unit is provided with casters to permit easy movement. Indicators, CB's and CB-trip lights, MC controls, a voltmeter, and a line selection switch are mounted on the control panel (fig. 6–1) of unit 18.

TABLE 6–1. SECTIONS OF UNIT 18 (5.0.3.15)

SECTION	FUNCTION
A	Power control panel
B	MC control
C	Terminal board
D	—270V dc control
E	—270V dc supply
F	MC supply
G	—130V dc control
H	—130V dc supply
J	+270V dc control
K	+270V dc supply
L	—60V dc control
M	—60V dc supply
N	3-5-kva autotransformer
P	+140V dc control
R	+140V dc rectifier
S	+140V dc supply
T	Capacitor drawer

This unit is divided into shelf-like sections to provide maintenance personnel ready access to specific portions of the unit. Logic diagram 5.0.3.15 indicates the location of the various sections; table 6–1 lists the functions of each section within unit 18. All connections to this unit are made through one multiple-pin-type plug connector and cable from unit 13.

1.2.2 Functional Description

Magnetic tape power supply unit 18 provides the tape drive units and the tape adapter unit with five nonstandard d-c voltages and an a-c filament voltage. There are three tape power supply units, one associated with each computer and one spare. Each tape power supply unit contains five d-c power supplies, a marginal checking d-c power supply, an a-c supply, and a portion of the tape power distribution and control circuits. The five d-c power supplies are of the saturable-reactor selenium rectifier type, with electronic voltage control. The MC supply is of the selenium rectifier type. The tape drive a-c filament voltage is developed across the autotransformer.

The tape power supply output voltages are listed in table 6–2. Voltages are applied to the four IBM 728 tape drive units (units 14, 15, 16, 17, 26, and 40) and tape adapter unit 13.

TABLE 6–2. MAGNETIC TAPE POWER SUPPLY OUTPUTS

REGULATED VOLTAGE (VOLTS)	CURRENT (AMP)
+270 dc	0.75
+140 dc	6.5
— 60 dc	2
—130 dc	3
—270 dc	0.2
236 ac	15
—30 to +30 dc	15

Note

Units 26 and 40 are spare units and are not installed in AN/FSQ-8 equipment.

Each of the d-c output voltages can be monitored by a VOLTMETER located on the tape power supply control panel. A RANGE SELECTOR switch is provided to switch the voltmeter across any of the d-c output voltages. This VOLTMETER is also used during marginal checking to measure the excursion.

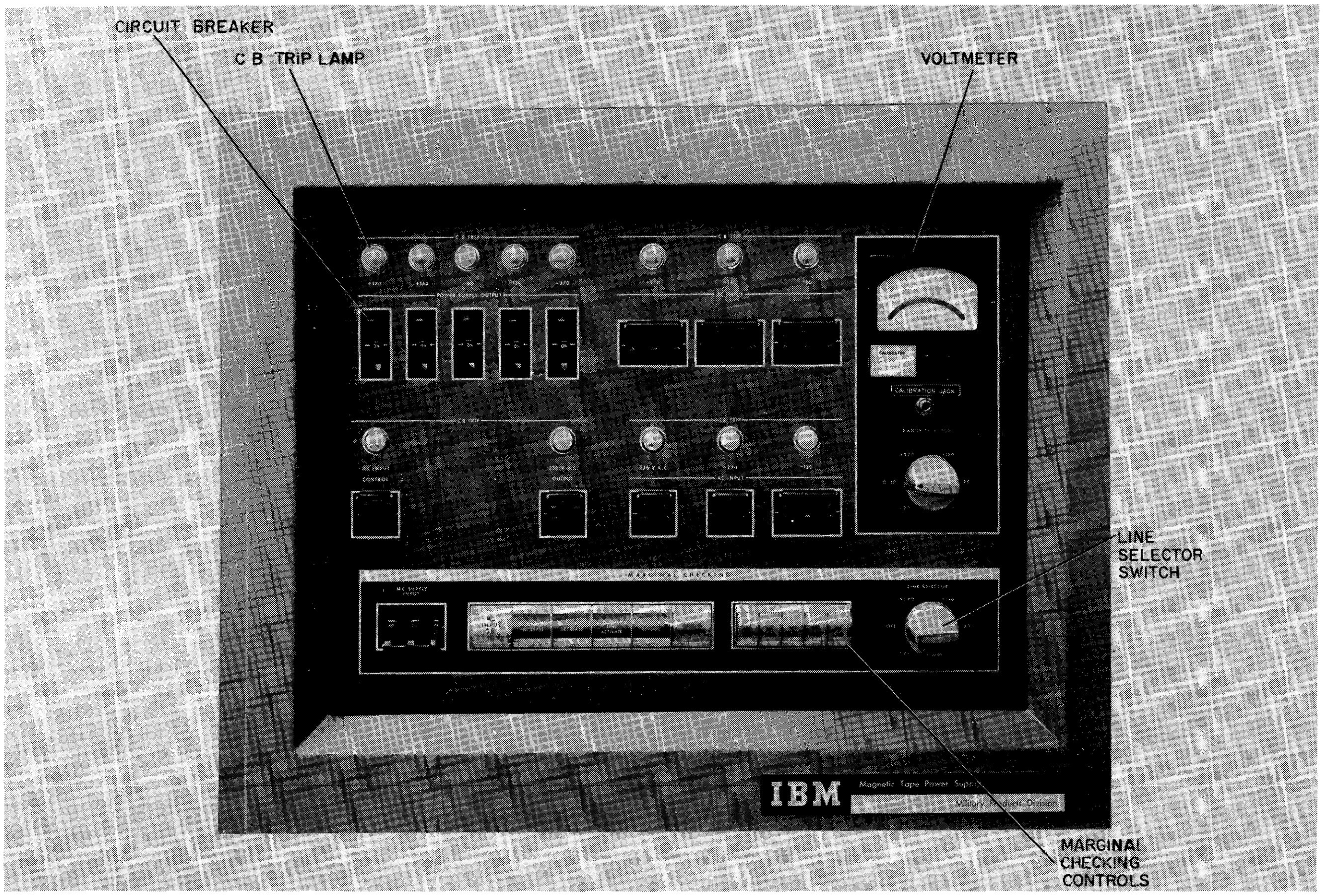

Figure 6—1. Magnetic Tape Power Supply Unit 18, Control Panel

CHAPTER 2
BLOCK DIAGRAM DESCRIPTION

2.1 GENERAL

The three magnetic tape power supply units are identical and function in a similar manner. Figure 6–2 is an overall block diagram of a single unit and its related components.

2.2 TAPE POWER SUPPLY INPUTS

Three-phase, 60-cycle regulated 208Vac is applied to the tape power supply through unit 13 from MCD 19. This 3-phase power supplies the basic power requirements of the tape power supply. Various voltages are tapped from this main supply to feed specific circuits within the tape power supplies.

The input to the zero-sense MC circuit is 120V single-phase, 60-cycle ac. This voltage is also applied to the reversible drive motor used to drive the MC autotransformer.

The tape-power-supply control tube filaments are supplied with 108V, single-phase, 60-cycle ac. This power is also applied to the 236Vac autotransformer, which supplies filament voltage to the tape drive units.

2.3 POWER SUPPLIES

The five d-c power supplies in unit 18 are similar and provide the following nonstandard d-c voltages:

a. +270V
b. +140V
c. —60V
d. —130V
e. —270V

As shown in figure 6–2, the input voltages to these power supplies are 208Vac single-phase and 208Vac 3-phase with the exception of the —270Vdc supply, which does not utilize the 3-phase input. The +140Vac power supply is described below as a typical example of power supply operation.

Three-phase, 208Vac is applied to the 3-phase transformer; the output is applied to the 3-phase series saturable reactors. The saturable reactors develop the required output voltage of the power supply. (For a detailed discussion of magnetic amplifiers, refer to Part 3, Ch 3.) This voltage is rectified by the 3-phase selenium rectifiers providing +140Vac. The bias windings and control windings of the reactors are supplied current from the d-c control section to regulate the d-c output voltage. This d-c control section is an electron tube chassis which utilizes the 208Vac single-phase input to furnish operating voltages.

The time-delay and control circuits in the Z module of unit 13 apply the input voltages to the nonstandard d-c power supplied.

2.4 TAPE POWER SUPPLY OUTPUTS

The five d-c output voltages from the power supply in unit 18 are applied through the normally closed contacts of MC relays contained within the MC portion of the unit to the Z module of unit 13. (Refer to *Theory of Operation, Marginal Checking System,* AN/*FSQ-7 and -8,* 3-92-0, for a description of the MC circuits.) In addition, the 236Vac single-phase output from the autotransformer is also applied to this module. These voltages are then distributed to the tape drive units and load modules.

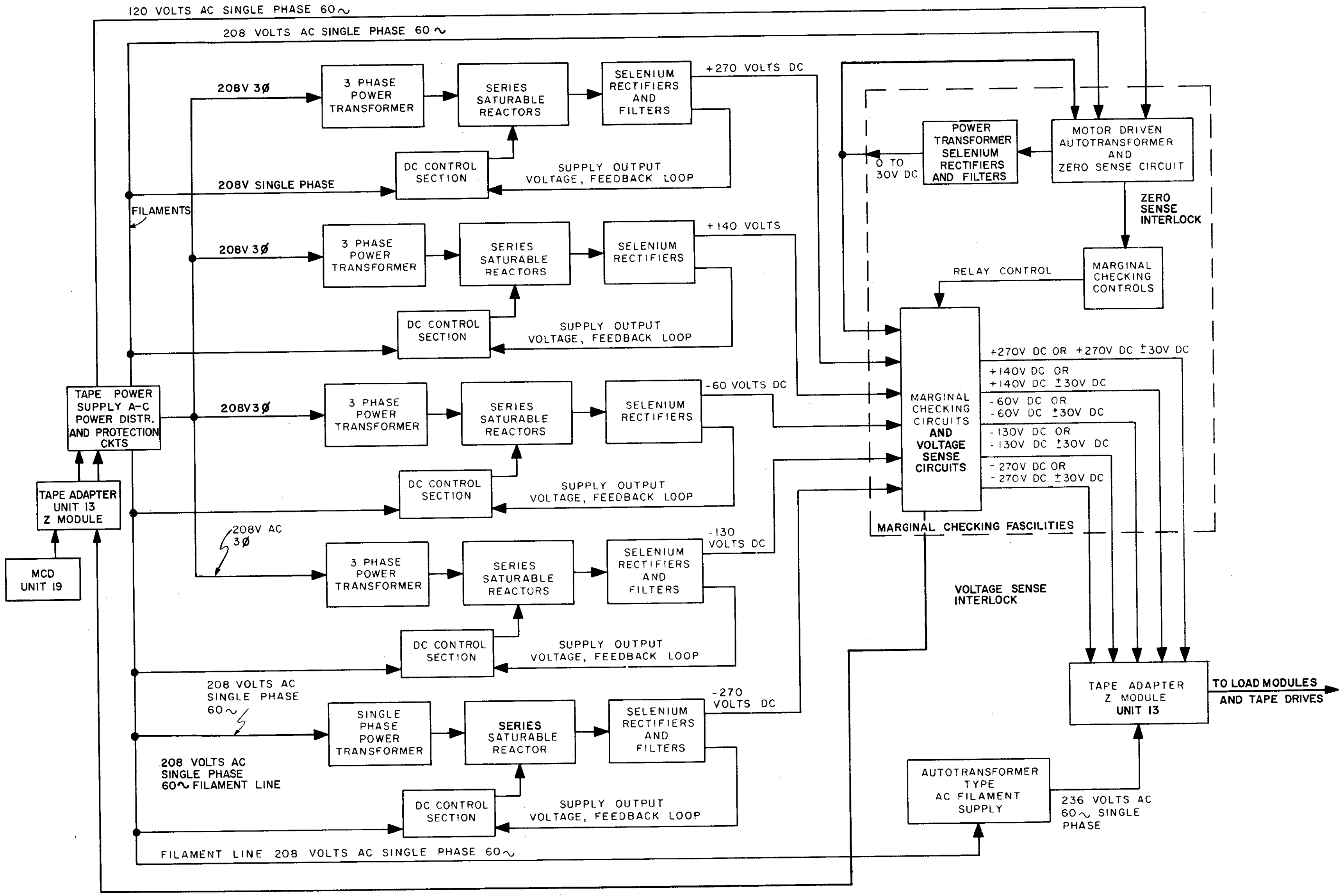

Figure 6–2. Magnetic Tape Power Supplies, Block Diagram

CHAPTER 3

DETAILED CIRCUIT ANALYSIS

3.1 INTRODUCTION

This chapter provides a detailed circuit analysis of the tape power supply control and distribution circuits. A detailed analysis of a typical d-c power supply and its d-c control chassis is also included.

3.2 DISTRIBUTION AND CONTROL CIRCUITRY

Three-phase 208Vac power is applied to the magnetic tape power supply in two steps. The first step applies power to the d-c control sections of the d-c power supplies in unit 18, and the autotransformer is then applied to the tape drive units. After a 1-minute warm-up period, 3-phase, 208Vac is applied in the second step to the power transformer of the d-c power supplies in unit 18 and the d-c outputs are distributed to the tape drive units. This power-on sequence is initiated by the a-c and d-c power-on signals at MCD 19 and by the time delay and protection circuits of unit 13.

3.2.1 AC On

Applying ac-start and hold signals from unit 63 (5.4.3.9, sheet 1) energizes relays 19R(K12) and 19R (K13), respectively, in MCD unit 19. A —48V circuit is now completed through CB 19BJ1, contacts 19 and 20 of 19R(K13), contacts 3 and 4 of 19R(K131), the UNIT OFF and AC ON-OFF switches on unit 13, and contacts 19 and 20 of 19R(K12), to the coil of relay 19A(K136). This relay picks and energizes relay 19R (TD131) through contacts 3 and 4. Contacts 1 and 2 of K136 complete a hold circuit for both of these relays when a-c start relay 19R(K12) drops.

Relay 19A(K136), when energized, applies 3-phase 208Vac to unit 13 (5.3.3.9, sheet 3), which distributes this power to the autotransformer and d-c control sections in unit 18 (5.3.3.11, sheet 1). In addition, 120Vac is supplied to the MC power supply.

3.2.2 DC On

Relay 19R (TD131) (5.4.3.9, sheet 1) and d-c start and hold relays 19R(K14) and 19R(K15), respectively, complete the circuit to 19R(K137). This pick circuit is completed through CB19BJ1, contacts 19 and 20 of 19R(K15), contacts 3 and 4 of 19R(K132) through (K135), contacts 3 and 4 of 19R(TD132), contacts 7 and 8 of 19 (TD131), the DC ON OFF switch on unit 13, and contacts 19 and 20 of 19R(K14), to the coil of 19R(K137). This relay, in conjunction with 19R-(TD131), picks 19R(K138) after a 45-second time delay. Relays K138 and K137 now pick 19R(K139). Energizing relays K137 and K139 completes a —48V circuit to 13Z2(K19) in unit 13 which controls the application of 208Vac to the d-c power supplies of unit 18 (5.4.3.9, sheet 2). Figure 6—3 is a simplified schematic diagram of this circuit.

Minus 48Vdc is applied through contacts of K137 and K139, the now closed contacts of 18B(K15), and the AC ON-OFF switch to the coil of 13Z2(K19). In addition, —48Vdc is applied through this same circuit and the contacts of 13Z2(K11) to the coil of 13Z2(K2) and 13Z2(K3). When 13Z2(K19) picks, —48Vdc is applied through CB's to 13Z5(K20), 13Z2(K12), 13Z2-(K4), 13Z2(K5), and 13Z2(K13). Minus 48Vdc is applied to these relays along three separate paths, as shown in figure 6—3. Relay K12 is a time-delay relay and remains de-energized for one minute.

When 13Z5(K20) picks, 3-phase, 208Vac is applied through contacts of 19A(K136) and 13Z5(K20) to the power transformers of the d-c power supplies in unit 18 (5.3.3.9, sheet 3).

When 13Z2(K4) picks, power is applied through contacts of 13Z2(K19), 13Z2(K4), 13Z2(K12), and 13Z5(K20) to 13Z2(K19), 13Z2 (K4), 13Z2(K12), and applied through contacts of 13Z2(K19), 13Z2(K4), and 13Z5(K21) to 13Z5(K22). Relays K22 and K21 are interlocked and hold as long as they are energized. When K22 picks, the NONSTANDARD D-C OFF lamp is extinguished and the ON lamp is lit on unit 13 (5.4.3.9, sheet 1). When K5 and K13 pick, —48Vdc is applied through the contacts of 13Z2(K19), 13Z2(K13). 13Z2(K5), and 13Z2(K2) to the coil of 13Z5(K23). When K23 picks, —48Vdc is applied through the contacts of 13Z2 (K19), 13Z2(K13), 13Z2(K5), and 13Z5-(K23) to 13Z5(K24). Relays K24 and K23 are interlocked and hold as long as both relays are energized. Relays K24 and K23 (5.3.3.9, sheet 2) connect the d-c output of the power supplies in unit 18 to tape drive unit 14 (fig. 6—4). In addition, the NONSTANDARD DC OFF lamp for unit 14 is extinguished and the ON lamp is lit. (The other tape drive units are supplied dc in a similar manner, as shown in 5.4.3.9 and 5.3.3.9.)

Each d-c power supply in unit 18 has a relay energized in its output (5.3.3.11, sheet 8). The contacts of these relays are in parallel and form a series circuit

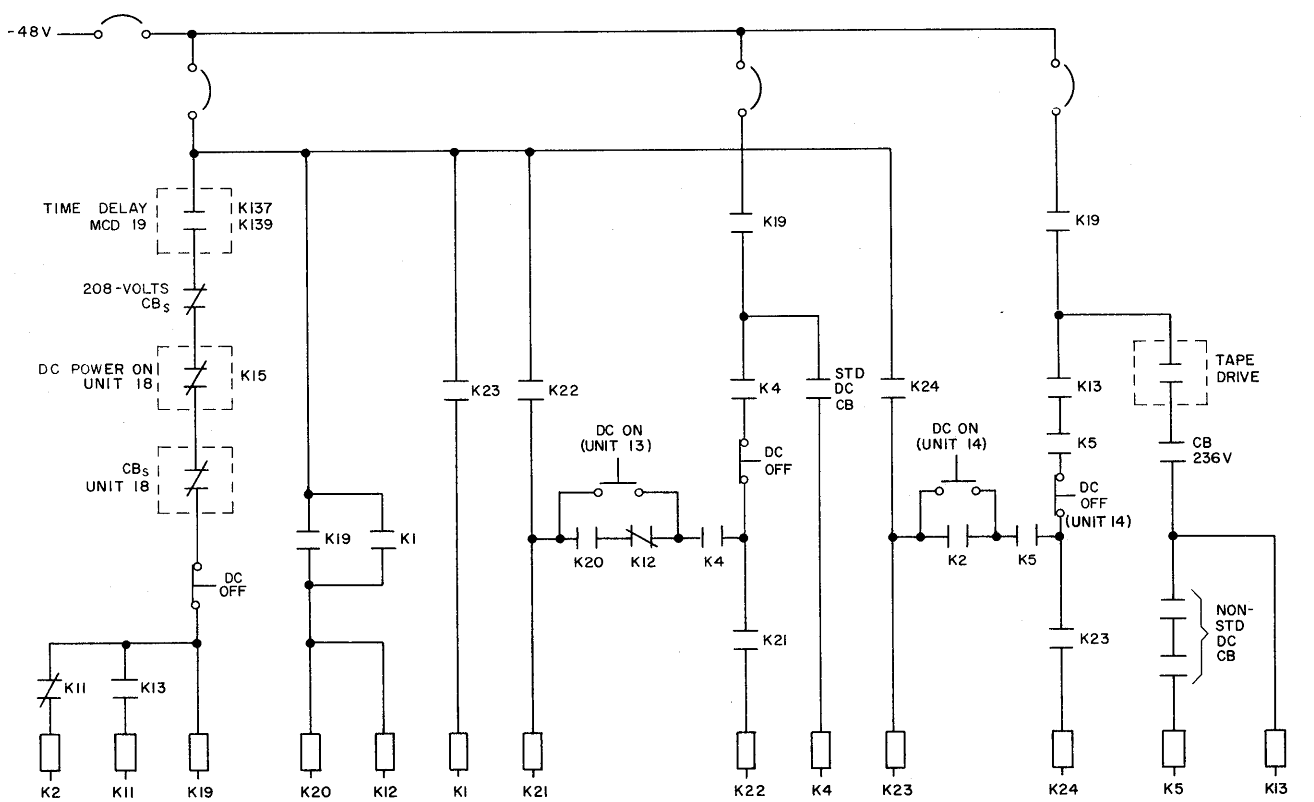

Figure 6—3. Magnetic Tape Drive Unit 14, Simplified Relay Circuit

with the coil of 18B(K15). Should any d-c output fail, its associated relay drops and picks K15 (5.3.3.11, sheet 9). The contacts of this relay are normally closed, allowing 13Z2(K19) to energize in order to sequence d-c power on, as described above. Energizing K15 breaks the circuit to K19, causing all relays to drop. This removes the d-c inputs to the tape drive units and the 3-phase, 208Vac input to the d-c power supplies.

3.3 TYPICAL NONSTANDARD D-C VOLTAGE POWER SUPPLY

Since the five power supplies of the magnetic tape power supply unit are similar, the +140V power supply is described below as a typical example of their operation (fig. 6—4). This power supply is shown on logic 5.3.3.11, sheet 3. (Note that the —270V power supply uses a single-phase power input and, in this respect, differs from the other power supplies.)

3.4 POWER CIRCUIT

The 208Vac input to the +140V power supply is applied to the primary windings of transformer 18S (T1). The a-c output from the 3-phase secondary of this transformer is applied through the gate windings of saturable reactors 18S(L1), 18S(L2), and 18S(L3) to a 3-phase full-wave rectifier circuit consisting of rectifier stacks 18R(CR1) and 18R(CR2).

The impedance of the saturable reactor gate windings, in conjunction with 18S(T1), determines the a-c output voltage that is to be rectified by the full-wave rectifier. The rectified output is 140V at terminals 18R (TB1) and 18R(TB1)d. This d-c output voltage is then filtered by a bank of 24, 900-uf capacitors.

As the impedance of the reactor gate windings is increased or decreased by means of the control and bias windings, the resultant d-c output voltage is increased or decreased. The control section of the power supply furnishes the control currents to these windings in response to control signals which maintain the output voltage at 140V regardless of line or load fluctuations.

3.5 CONTROL SECTION

A typical control unit is designed to derive its excitation from a 208V single-phase, 60-cycle, a-c voltage source. The input voltage is connected to terminals 18E(TB1)e and 18E(TB1)f (5.3.3.11, sheet 3). This typical control unit is designed to provide approximately 5 ma of d-c excitation at approximately 462V for the bias windings of the saturable reactors, which are in series with a resistor of approximately 50 kil-

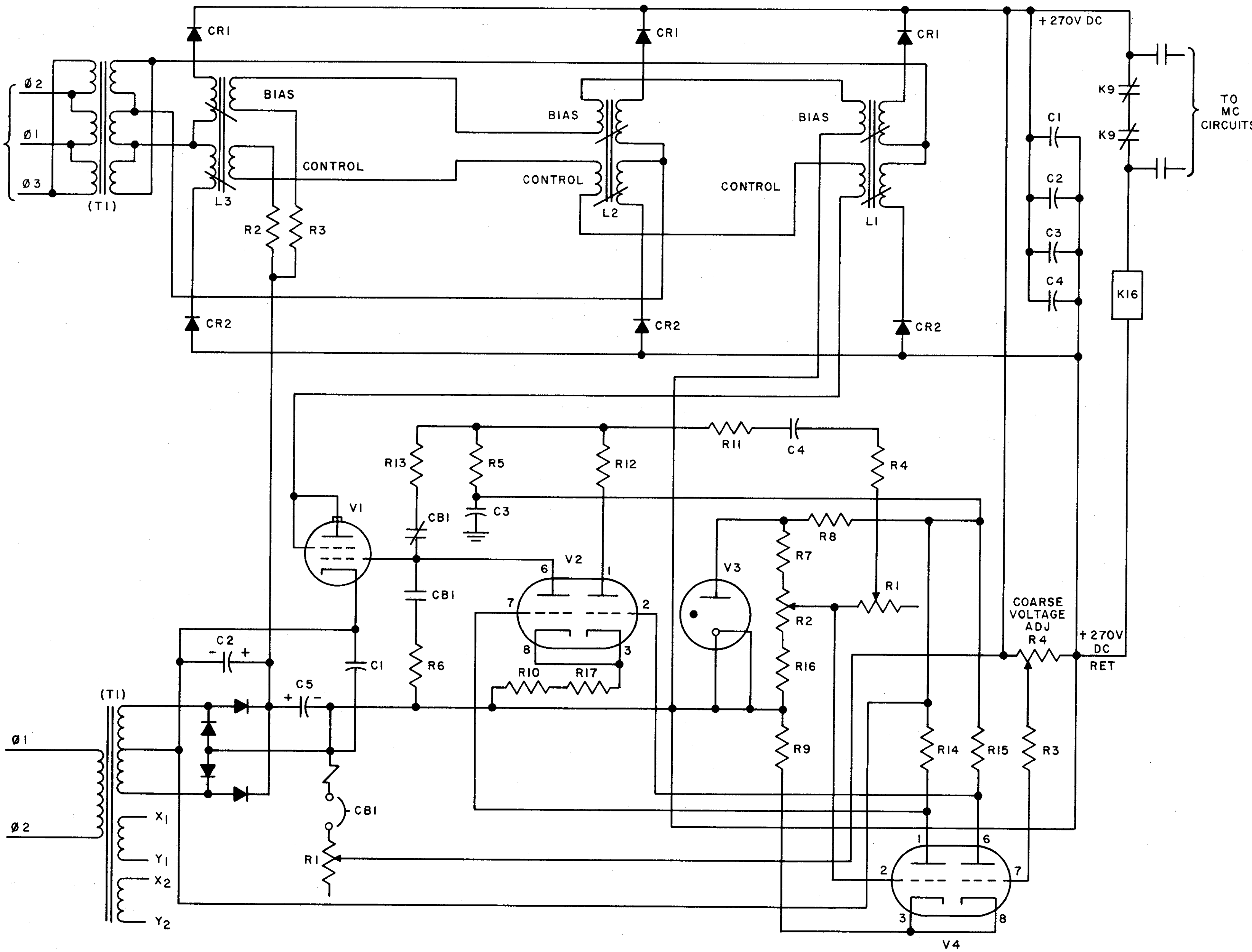

Figure 6–4. Typical Magnetic Tape Power Supply, Simplified Schematic Diagram

ohms (K). This bias circuit is connected between terminals 18P(TB1)b (positive) and 18P(TB1)c (negative).

The control unit also furnishes variable excitation of 0 to 70 ma for the control windings of the saturable reactors. The circuit is supplied between terminals 18P (TB1)b (positive) and 18P(TB1)a (negative). This control circuit is controlled by vacuum tube 18P(V1), a type 6146 beam-power tube.

The input signal by which the current through the control winding is adjusted is connected to terminals 18P(TB1)c (positive) and 18P(TB1)d (negative). Through the medium of the first amplifier tube, 18P (V4), a type 6072 dual triode, this signal voltage is compared with a reselected portion of a reference voltage across a regulator tube, 18P (V3), a type 5783W3 tube.

3.5.1 Control Chassis Power Supply

The d-c operating voltages for the control chassis are obtained from an auxiliary rectifier circuit. This rectifier circuit derives its a-c input from the center-tapped secondary winding of input power transformer 18P(T1) (5.3.3.11, sheet 3). The voltage rating of this winding is approximately 219V, terminal to terminal. This winding supplies two selenium rectifier stacks, 18P(CR1) and 18P(CR2). These are center-tapped rectifiers of the voltage-doubler type. The two stacks are connected to form a bridge-type rectifier circuit. The output is connected directly to a 16-uf, 600V electrolytic capacitor, 18P(C5). The positive terminal of this capacitor is referred to as the positive bus; the negative terminal is referred to as the negative bus. These are positive and negative voltages with reference to the center tap of the transformer winding, which is referred to as the neutral bus. Between the positive bus and the neutral bus is another electrolytic capacitor, 18P(C2), rated at 15-uf, 450Vdc. Between the neutral bus and the negative bus is a similar electrolytic capacitor, 18P(C1), with the same rating. The various vacuum tubes operate between these three d-c lines.

The neutral bus is not grounded because it is connected to one of the output terminals of the power supply being controlled, and the power supply terminal may or may not be grounded. Hence, capacitor 18P-(C1) is connected between the neutral bus and ground to prevent changing currents, voltages, etc, from affecting the control circuits.

Two filament windings on power transformer 18P(T1) supply the filaments of amplifier tubes 18P-(V2) and 18P(V4) and power tube 18P(V1). Neither of these filament windings is grounded.

3.5.2 Power Amplifier Stage

The 6146 beam-power tube is operated as a triode by connecting the screen grid (terminal 3) to the plate cap.

The plate voltage source for this tube is taken from the positive bus to the neutral bus. This is approximately 231V under load conditions. The cathode (terminal 1) is directly connected to the neutral bus. The neutral bus then becomes the cathode reference level. The plate of this tube is connected through the control windings of the saturable reactors in series with an external resistor to the positive bus. The control grid of this tube (terminal 5) has its potential referenced to the neutral bus. Since the grid potential is not driven positive, the range of grid voltage control is from 0 to approximately —60V. This voltage is sufficient to cut off the plate current through the tube. Then this tube is supplying the control windings of the saturable reactors, and voltages are induced in the control windings by the action of the gate windings. These induced voltages may affect the plate voltage applied to the tube. For this reason, the control grid voltage required to cut off the plate current may be greater than that which would be required to cut off the tube with d-c supply voltage only.

The control of this tube is such that, when the grid is made more negative with respect to the cathode, the plate current through the tube will decrease and thereby decrease the control current to the saturable reactor. The impedance of the gate windings increases, and the output voltage from the power supply being controlled also decreases. Conversely, a positive grid signal increases the plate current, causing the gate winding impedance to decrease and, hence, the output voltage to increase.

3.5.3 Amplifier Stages

3.5.3.1 General

The type of amplifier circuit used in the control section is a cathode-coupled type amplifier. The type 6072 dual triode amplifier tubes have a common cathode resistor which has an appreciable voltage drop across its length. This voltage drop is produced by the sum of the two cathode currents of the twin triode elements. These cathode currents are the plate currents of the respective triode sections. In series with each plate lead is a plate resistor. For symmetry, both plate circuit resistors are alike in value. The supply voltage for an amplifier stage is applied between the common ends of the plate resistor and the common cathode resistor.

The behavior of this circuit is predicated on the assumption that the current through the common cathode resistor is constant; that is, the sum of the two cathode currents is a constant quantity. Thus, if the one grid-to-cathode voltage tends to reduce the plate current in that half-tube, the current in the other half-tube will increase to keep the sum of two currents constant. However, the plate current through the input section may change more than the current through the output section because the voltage drop across the common cathode resistor cannot be constant if the cathode potential drops slightly to influence the grid-to-cathode potential of the output triode, whose grid potential is fixed.

Note

To explain the operation of the various amplifier stages, voltage will be assumed for necessary points. The actual voltages may not be in agreement with these assumed values. This system will be used to explain all amplifier stages.

3.5.3.2 Intermediate Amplifier Stage

This amplifier stage supplies the grid circuit of the 6146 beam-power tube in response to an amplified signal of input voltage received from the input voltage amplifier. This stage receives a double input and delivers a single output.

The intermediate amplifier derives its supply voltage from a positive point on a resistance voltage divider, 18P(R5) and 18P(R11), connected between the positive bus and the neutral bus. This allows the positive end of the triode supply voltage to be about 50V more positive than the neutral bus, so that, when neither triode is cut off, its plate potential has a tendency to rise above the potential of the neutral bus. The common cathode resistor of this amplifier stage is connected to the negative bus. Thus, the supply voltage for this stage is of greater magnitude than the voltage between the neutral bus and the negative bus.

For a given supply voltage, the choice of values for the plate resistors in combination with the input voltage-input current (e_b - i_b) characteristics of the triode elements determines the resistance required in the common cathode resistor circuit. These values are selected so that, when the grid-to-cathode voltage on the input triode becomes more negative than the quiescent value, the grid-to-cathode voltage of the output triode becomes less negative than the quiescent value. Both grid voltages should change by equal amounts. The plate current of the input triode then decreases by a given amount, and the plate current of the output triode increases by a like amount, so that the grid-to-cathode voltage of the 6146 tube tends to become negative by an amount sufficient to cut off the plate current through the tube. In other words, the plate of the output triode of this intermediate amplifier tube must be capable of being reduced in potential by about 60V to 100V negative with respect to the neutral bus. When the grid potential is reversed, so that the plate current of the input triode increases and the plate current of the output triode decreases, the plate potential of the output triode tends to seek a level of voltage above that of the neutral bus. The grid-to-cathode potential of the 6146 tube will not be driven in a positive direction to the full 50V level above the neutral bus because the grid current through the 6146 and the plate resistor, 18P(R13), of the output triode section causes a voltage drop which tends to maintain the grid-to-cathode potential of the 6146 tube at the approximate level of the neutral bus. Until the grid current of the 6146 tube becomes appreciable, the cathode-coupled amplifier circuit remains reasonably well balanced. When the grid current becomes appreciable, this balance is no longer maintained. The normal operation of this circuit is such that the intermediate amplifier stage operates in a balanced fashion.

The voltage drop across the common cathode resistor, 18P(R10), and across 18P(R17) determines the quiescent operating level of the two input signals to the two control grids (terminal 2 of the input triode section and terminal 7 of the output triode section). Any increase in the quiescent amount of current through this common cathode resistor increases the voltage drop across the two plate resistors, and vice versa. Since the voltage drop across the plate resistor of the output triode should change between 50V (corresponding to zero-grid voltage on the 6146 beam power tube) and 110V (corresponding to —60V grid voltage on the 6146 tube), the quiescent level of voltage across this plate resistor should be approximately 80V. For example, assume the quiescent voltage to be 75V, which, across a 150K resistor, requires a plate current of 0.5 ma through that triode element. The plate current of the other triode element will likewise be 0.5 ma. Hence, the common cathode current will be 1 ma. This current through the 111K common cathode resistor will develop a voltage drop of 111V, measured from the negative bus. If the negative bus voltage is —231V, the quiescent level of the cathodes is —120V with respect to the neutral bus. Since the cathodes are 111V positive from the negative bus, and the plates are 25V negative from the neutral bus, it leaves a plate-to-cathode voltage of approximately 95V for each triode. One of a family of grid voltage curves of the e_b - i_b characteristics for that triode element will pass through the operating point of 95V at 0.5 ma and will determine the grid-to-cathode voltage value for this operating point. Suppose this value is 10V; the input signal level to the two control grids (terminals 2 and 7) will be 111V minus 10V, or 101V, above the negative bus. This will be the output level of the preceding amplifier stage, measured in terms of voltage above the negative bus.

The control sense of this intermediate amplifier stage, tube 18P(V2), (5.3.3.11, sheet 3) is such that a decrease in the one input voltage, measured between the grid (terminal 2) and the negative bus, and a corresponding increase in the other input voltage, measured between the grid (terminal 7) and the negative bus, has the effect of making the grid-to-cathode voltage (terminals 2 and 3) of the input triode more negative; this tends to decrease its plate current while making the grid-to-cathode voltage (terminals 7 and 8) of the output triode less negative, which tends to increase its plate current. Thus, the plate voltage (terminals 1 and 3) of the input triode is increased while the plate voltage (terminals 6 and 8) of the output triode is decreased. That is, the decrease of plate current through the input triode decreases the voltage drop across its plate resistor 18P(R12) and raises the potential of the resistor-and-plate-terminal toward 50V above the neutral bus; the increase of plate current through the output triode increases the voltage drop across its plate resistor 18P(R13) and lowers the potential of the resistor-and-plate terminal away from its reference point of 50V above the neutral bus. This change of potential across 18P(R13) has the effect of making the grid-to-cathode potential of the 1646 beam power tube more negative, which decreases its plate current, reducing the control current excitation to the saturable reactors and decreasing the output voltage of the power supply.

3.5.3.3 Input Amplifier Stage

This is a cathode-coupled amplifier with a different supply voltage than that of the intermediate stage to which it supplies signal voltages. The stage operates as a single input with double output. Since the quiescent plate voltage of 111V above the negative bus has been determined by the voltage drop across the common-cathode resistor of the intermediate stage, it follows that the range of plate voltage change need be only a few volts above or below this quiescent value. The quiescent value is already approximately 120V below the level of the neutral bus, so the plate voltage excursion need never rise above this neutral-bus voltage; hence, the neutral-bus-to-negative-bus voltage may be used to supply this input stage.

The selection of resistor values for this input amplifier stage is based on the minimum value of input voltage signal which will be used with these control units, namely that of the —60V power supply. Hence, the input voltage will never be less than —60V nominal value; and, since the specifications usually call for a range of adjustment of ±10 percent, the —10 percent value sets the minimum input voltage at 54V. The grids of the input stage will operate at a potential which is negative relative to their cathodes; hence, the voltage drop across the common cathode resistor, 18P(R9), would be a few volts greater than the input signal voltage. However, design consideration dictates a voltage value in the order of 54.5V, at which value the quiescent current through the 33K common cathode resistor is approximately 1.65 ma. If this current is equally divided between the two plate circuits, the plate current of each triode section is 0.825 ma. This current produces a voltage drop of 123.75V across each plate resistor, 18P(R14) and 18P(R15), of 150K measured down from the neutral bus which corresponds to 107.25V up from the —231V negative bus. This is a value close enough to the 111V value selected for the cathode drop of the intermediate stage (it allows about —37.5V quiescent value of grid-to-cathode potential on the intermediate triode sections) to show how the circuit established an equilibrium operating point in the vicinity of these values.

The signal voltage is applied to the grid (terminal 7) of this dual triode tube, 18P(V4), thus making this element the input triode. This signal voltage is the voltage measured between the grid (terminal 7) and the negative bus. The potential of the grid (terminal 2) of the other triode is determined by a reference voltage which is the standard of comparison for the input voltage signal. This reference voltage is the preselected amount of voltage between the slider of the voltage-adjusting potentiometer, 18P(R2), which connects to grid terminal 2 and the negative bus. The order of magnitude of this reference voltage is the voltage at which the signal on the input grid (terminal 7 to negative bus) is to operate. (This amplifier stage might be considered to be in its quiescent state when the input grid (terminal 7) is connected to, or is at the same potential as, the other grid (terminal 2) of the trailing element.)

When the input signal voltage changes, by an increase in the voltage between the input grid (terminal 7) and the negative bus, it has the effect of making the grid-to-cathode voltage (terminals 7 and 8) less negative so that the cathode current of that triode section increases. This increase in cathode current tends to increase the total current through common cathode resistor 18P(R9) and raises the potential of the cathodes. Assume that this cathode potential is raised by half the amount of voltage change applied to the grid-to-neutral-bus circuit. Then, if voltage in the grid-to-neutral-bus circuit of the output triode (terminal 2 to neutral bus) is unchanged, the grid-to-cathode voltage (terminals 2 to 3) will have changed by the same half-amount as the signal change applied to the input grid circuit, except that the direction of change will have been such that the grid (terminal 2) is more negative with respect to its cathode (terminal 3). This decreases the cathode current through this output triode section. The sum of the two cathode currents (the lesser than quiescent amount from cathode 3 and the greater than quiescent amount from cathode 7) is now slightly greater than the quiescent sum because the cathode potential has increased slightly to effect the operation of the output triode section. Generally, the increased amount of current through the input triode is greater than the decreased amount of current through the output triode. Thus, the two output potentials measured across the plate resistors have not changed by equal amounts; but the error is not great, and the larger the voltage drop across the common cathode resistor, the smaller the error.

The control sense of this input amplifier stage tube, 18P(V4), is such that an increase in the magnitude of the input voltage (an increase in the value of output voltage of the power being controlled), measured between the grid (terminal 7) and the negative bus, has the effect of making the grid-to-cathode voltage less negative. This causes an increase in plate current through this input triode section and plate resistor 18P(R15), thereby decreasing the plate potential. Similarly, and simultaneously, there is a decrease in the plate current of the output triode section, which causes a decrease in the voltage drop across plate resistor R14 and an increase in the output plate potential. Since these two plates are connected to the input triode grid and the output triode grid, respectively, of the intermediate amplifier stage, the decrease in potential of the one plate and the increase in potential of the other serve to unbalance the intermediate amplifier and produce an amplified decrease in the voltage applied to the grid-to-cathode circuit of the beam-power stage so as to decrease its plate current. This, in turn, decreases the control current to the saturable reactors, increasing the gate winding impedances and thereby reducing the output voltage of the power supply. Thus, an increase in signal voltage tends to decrease the source of this very signal voltage, which is a stable operating condition leading to a new equilibrium condition at a slightly increased value of signal voltage.

3.5.4 Reference Voltage

The terminal voltage of a cold-cathode, glow-discharge type voltage regulator tube changes little when its plate current is changed appreciably. It is desirable that this voltage remain constant over the expected life of the tube and that any changes which take place do so very gradually over the life of the tube. Because of their constant voltage characteristics, these tubes must be supplied from constant potential sources through current-limiting resistors. Otherwise, minor increases of voltage about the normal operating value would increase the current through the tube and permanently damage it. Resistor 18P(R8) is this series-connected ballast resistor. The series combination of tube and resistor is supplied with current from the neutral-to-negative bus voltage. If the voltage source is 231V and the tube's voltage drops 87V, the difference voltage, 144V, would be applied across 68K of R8 and would indicate 2.1 ma of current flowing through the tube. However, as low a value as 54V might be required for the reference voltage applied to the grid circuit (terminal 7 to negative bus) of the input amplifier, tube 18O(V4), and as high a voltage as 66V. Hence, some means must be provided to reduce the 87V potential of this tube to between 54V and 66V. This is accomplished by a voltage divider connected across the terminals of the tube. The voltage divider comprises the series connection of a fixed resistor, 18P(R7), of 33K, a 100K potentiometer, 18P(R2), with adjustable slider, and a 47K resistor, 18P(R16). With 87V across this tube, the voltage divider draws 0.48 ma of current, which is subtracted from the 2.1 ma which would flow through the tube in the absence of the circuit across its terminals, leaving approximately 1.62 ma through the tube.

Since the voltage across the regulator tube is constant, the voltage across the voltage divider is constant, and, if no current is drawn from the slider tap of the voltage divider, the output voltage of this divider (slider to negative bus voltage) is also constant. Moving the slider towards the R7 end increases the reference voltage and causes the signal voltage to operate at a correspondingly higher level. Moving the slider towards the R16 end decreases the reference voltage and causes the signal voltage to operate at a lower level.

3.5.5 Adaptation to Other Values and Polarity of Supply Voltage

When the input signal voltage is in excess of the nominal 60V, as in this case 140V, a voltage divider is used across the power supply output to provide a 60V input which will be proportional to the 140V source. Adjustable resistor 18P(R8) between terminals 18R(TB1)c and 18R(TB1)d provides this 60V signal input.

The positive terminal of the input signal voltage is connected to input terminal d of the control unit; the negative terminal of the signal voltage is connected to input terminals 18P(TB1)c and 18P(TB1)d for the +140V supply.

3.5.6 Stabilizing or Anti-Hunting Circuit

The single and hunting circuit comprises circuit elements 18P(R1), 18P(R4), and 18P(C4), connected in series between the positive bus and the reference voltage grid (terminal 2) of input amplifier tube 18P(V4). Of these elements, 18P(R1) is an adjustable potentiometer connected as a rheostat. The function of this series resistance-capacitance (RC) circuit is to introduce into the grid circuit (terminal 2 to negative bus) of the output section of tube 18P(V4) an adjustable amount of the 120-cycle ripple voltage which appears on the auxiliary direct potential between the positive and negative buses. This has the effect of nullifying, or actually producing a phase reversal of, a somewhat similar 120-cycle voltage which appears at this grid point, as the result of a portion of a 120-cycle component of the input signal voltage appearing at this point. This 120-cycle ripple voltage, introduced by the RC circuit, is amplified by the intermediate amplifier stage and appears greatly magnified at the grid of the output stage. This varies the ratio of the average value of grid voltage on the 6146 tube to the average value of the input signal which is fed back from the output of the power supply. Thus it affects the pattern of behavior of the plate current of the 6146 tube on the control winding of the saturable reactor.

This RC anti-hunting circuit has a pronounced effect on the pattern of response of the output voltage to changes in a-c supply voltage and in load current; it is for this reason, more so than for stabilizing the output voltage during steady-state operation, that the circuit is important.

3.5.7 Overvoltage Protection

With no protection, the plate current of the beam-power tube would increase, causing an uncontrollable increase of the output voltage of the power supply when one of the following conditions occurs:

a. Certain tubes, triode elements, or circuit points fail by short-circuiting anode-to-cathode, grid-to-plate, or grid-to-cathode, as in the case of input section 1-2-3 of intermediate amplifier tube 18P(V2) or output element 1-2-3 of input amplifier tube 18P(V4).
b. Input terminals 18P(TB1)c and 18P(TB1)d short-circuit.
c. Voltage-regulating divider resistor 18P(R7) short-circuits.
d. Fail by open-circuiting or loss of emission as in the case of output element 6-7-8 of intermediate amplifier tube 18P(V2), input element 6-7-8 of input amplifier tube 18P(V4), or voltage regulator tube 18P(V3).
e. The reference voltage divider along 18P(R16) and open-circuits.

In the event of overvoltage on the output terminals of the power supply, the trip-coil circuit of CB 18P (CB 1) (whose coil circuit is connected to control unit terminals 18P(TB1)g and 18P(TB1)c in series with external calibrating resistor 18P(R3) across the output voltage of the power supply) will be sufficiently energized to trip its mechanism. Its main contacts, in series with the trip coil, will open to de-energize the trip circuit so that the mechanism must be reset manually. Its auxiliary normally closed contacts 5 and 3 will open, and auxiliary normally open contacts 5 and 4 will close to transfer the grid of the beam-power tube via resistor (R6) to the potential of the negative bus. This is more than an adequate value of negative grid voltage to shut off the plate current and reduce the output voltage of the power supply to a low value.

3.5.8 Common Circuit Failures

The effects produced by open- and short-circuit conditions were discussed in 3.5.7. A normal pattern of change would lie in between these extremes. The change to be expected as a result of tube aging is a decrease in either peak cathode-emission values or average cathode-emission values.

3.5.8.1 Voltage Regulator Tube V3

This is the key tube in this control circuit since the voltage which is being maintained is dependent on the stability of the tube's constant voltage characteristic. Most probably, as the tube ages, the cathode emitting surface area will decrease and the terminal voltage will increase. This effect should take place gradually over the expected life of the tube rather than suddenly at some unexpected moment. The end of useful life is when the terminal voltage of the tube exceeds the limits or range set by the manufacturer. Actually, the tube could be operated until the range of voltage adjustment on potentiometer R2 had been used up, provided the terminal voltage is stable at these higher values.

3.5.8.2 Input Amplifier Tube V4

This stage is complicated by the fact that it is really two triode elements which may not, and probably will not, age equally. Again, it will be assumed that emission losses increase with tube aging. Should either triode element, alone, lose emission, it will require different grid-to-cathode potentials to achieve balanced output voltages. This would shift the level of the input signal voltage on the one grid relative to the reference voltage on the other grid, the grid of the tube having the lower emission value nearer to its cathode in potential. In any event, the effect will be to raise the level of the output voltage with respect to the negative bus; this may have the effect of dropping the operating level of the output of the intermediate amplifier, which means that it might not be possible to turn on the 6146 tube as much as might be required to achieve full output from the power supply, particularly under low line voltage conditions.

3.5.8.3 Intermediate Amplifier Tube V2

This is analyzed much like the input stage except that a loss of emission will tend to raise the output voltage level with respect to the negative bus; this may make it difficult to turn off the 6146 tube as much as might be required to keep the output voltage down to the desired level under low load and/or high line voltage conditions. Simultaneously, the tendency for the output voltage level of this amplifier to be higher would mean that the input voltage level would be required to be raised to compensate; this would require a slightly higher value of voltage to be regulated at the input terminals of the input stage.

3.5.8.4 Power Tube V1

Low emission on this tube limits the amount of plate current, peak value, and/or average value, which this tube could furnish to saturate the saturable reactor. Hence, the rated full load output from the power supply could not be achieved.

3.5.8.5 Selenium Rectifiers

These rectifiers age by a gradual increase in internal resistance in the current-conducting (forward) direction. The end-of-useful life of selenium rectifiers is said to be reached when the forward resistance doubles in value. However, the voltage loss due to this resistance increase is but a few percent of the output voltage, so that doubling this increase only changes the output voltage by a minor amount. Lowering the positive and negative bus voltages will affect the operating levels of the output voltages of the input and intermediate amplifiers, which may require readjustment of the reference voltage potentiometer to maintain a particular value of output voltage from the power supply. An appreciable lowering of the positive bus voltage will decrease the amount of saturating current which is available from the 6146 power tube; this may lower the rated full-load output of the power supply. A decrease in the negative bus voltage may raise the output voltage level of the intermediate and input amplifier stages so much that it affects the minimum value of plate current from the 6146 tube and allows the power supply voltage to rise above the preset level under light load conditions.

3.5.8.6 Electrolytic Capacitors

These devices age by drying out and thus by suffering a decrease in capacitance. The primary effect of the latter will be to cause an increase in ripple voltage and a lowering of the average voltage level of the positive and negative bus voltage.

An increase in the ripple content of the auxiliary positive and negative bus voltages will cause this ripple to be amplified by the amplifier stages which will drive these stages out of balanced operation, with a consequent change in the rates of average output voltage to average input voltage and with an ultimate effect of shifting the level of the power supply output voltage. The equipment will no longer operate desirably under transient conditions of line and/or load change.

3.6 PROTECTIVE UNITS

Unit 18 has two protective circuits, one in case of overvoltage and the other in case of nonstandard power supply output failure. Each will be discussed separately below.

3.6.1 Power Supply Output Failure

If anyone of the power supplies fails (no output voltage developed, a short circuit across the output), the relay connected across its output (K16 through K20) drops and its contacts close. When the contacts close, —48V is applied through the now closed contacts of the output relay (K16-K20) to the coil of relay K15 (unit 18). After a delay, this relay picks and its contacts open. This action removes power from the coil of relay K19 (fig. 6—3), and the relay drops. When relay K19 drops, its contacts open, causing the input power to be removed from the saturable reactors and causing the d-c outputs of all the power supplies to be disconnected from the load. High a-c voltages for filament transformers and for marginal checking are still connected.

3.6.2 Overvoltage Circuit Breaker Trip

In the control section of each power supply, CB 1 is placed and adjusted to trip at no more than 15 percent over the rated d-c output voltage of the supply. In the event that 15 percent overvoltage exceeds the rated voltage of the capacitors, CB 1 is adjusted to trip at less than rated capacitor voltage. Whenever an overvoltage causes CB 1 to trip, the supply shuts down as described in 3.5.7. This, in turn, causes all the power supplies to be shut down as described in 3.6.1.

PART 7
AN/FSQ-8 DIFFERENCES FROM AN/FSQ-7

7.1 SCOPE

This part summarizes the differences between the AN/FSQ-7 equipment, which is described in the preceding parts, and the AN/FSQ-8 equipment.

7.2 GENERAL

Most of the AN/FSQ-8 equipment is the same as the AN/FSQ-7 equipment. Certain units, however, are not provided in the AN/FSQ-8 equipment. These absences also affect some of the existing units because numerous components within these units are not used. The sizes of the cabinets are not changed, but several modules (or sections) have no external wiring.

If the correct logic diagrams are used to trace the desired circuits, the typical examples provided in the previous parts can be used as helpful guides.

7.3 UNITS AFFECTED IN POWER SUPPLY SYSTEM

7.3.1 Introduction

All the units of the Power Supply System are provided for the AN/FSQ-8 equipment. However, several units contain fewer components. The units affected include display MCD unit 27, duplex injut MCD unit 59, display console CB unit 48, simplex input CB unit 56, and simplex input PD unit 55.

7.3.2 Units in Power Systems A and B

7.3.2.1 Display MCD Unit 27

In AN/FSQ-8 equipment, display console units 169, 170, and 787 are not employed. In unit 27, there are no changes in wiring. The changes necessitated by the removal of these units are effected in display console CB unit 48.

7.3.2.2 Duplex Input MCD Unit 59

Module E of unit 59 contains the CB's which distribute power to units 32, 34, and 41 in AN/FSQ-7 equipment. Since units 34 and 41 are not present in AN/FSQ-8 equipment, there are only those CB's associated with unit 32. The lines normally associated with units 34 and 41 are taken only to the bars in module A of unit 59.

7.3.3 Units in Power Systems C and D

7.3.3.1 Display Console CB Unit 48

Modules F through K of CB unit 48 are not used since fewer CB's and bus bars are required to supply power to the limited number of display consoles. The unused CB's and bus bars are wired within unit 48, but wiring leading from the unused modules is not provided.

7.3.3.2 Simplex Input CB Unit 56

Modules D, E, and F of CB unit 56 are not used. The components are provided, and the internal wiring is complete, but the external wiring from modules D, E, and F is missing.

7.3.3.3 Simplex Input PD Unit 55

Modules D through M of PD unit 55 are not used. The sliding units and other components are provided, and the internal wiring is complete, but external wiring from modules D through M to CB unit 56 and the load units is missing.

7.4 UNITS MISSING IN AN/FSQ-8

7.4.1 Introduction

Many units in the Display System and the Input System are not provided for AN/FSQ-8. Several units in the Output System are provided but not utilized.

7.4.2 Display System

The following units mentioned in the preceding parts of this manual are not provided for AN/FSQ-8 sites: SD console units 169 and 170, and SD console unit 787.

Refer to *Theory of Operation, Display System, AN/FSQ-7 and -8* for complete explanations on the differences of the display equipment in AN/FSQ-7 and AN/FSQ-8.

7.4.3 Input System

The following units mentioned in the preceding parts of this manual are not provided for AN/FSQ-8 sites: GFI unit 34 and LRI unit 41.

Refer to *Theory of Operation, Input System AN/FSQ-7 and -8* for complete explanations on the differences of the input equipment in AN/FSQ-7 and AN/FSQ-8.

7.4.4 Output System

Refer to *Theory of Operation, Output System, AN/FSQ-7 and -8* for information on the difference of the output equipment in AN/FSQ-7 and AN/FSQ-8.

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