SWITCHING NETWORK
DESCRIPTION AND THEORY OF OPERATION
NO. 3 ELECTRONIC SWITCHING SYSTEM

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1. GENERAL

INTRODUCTION

1.01 This section provides a description and the theory of operation of the No. 3 Electronic Switching System (ESS) switching network. The switching network consists of five stages of switching which provide the interconnection capability between all terminals in the office.

1.02 ➧This section is being reissued to correct random slip multiple presentation in Fig. 17, and to clarify pulser operation. Revision arrows are used to emphasize the more significant changes. Equipment test lists are not affected.⬅

PURPOSE

1.03 The switching network provides the facilities for a customer terminal to access any other terminal in the office. These terminals consist of lines, interoffice trunks, and various service circuits.

The switching network, in conjunction with the scanner, provides:

(a) A means for detecting line originations and other supervisory changes

(b) Access for battery and ground required for operating customer line equipment

(c) Access to test circuits for detection of foreign potentials on line, false connections, continuity, line insulation, etc.

RELATIONSHIP

1.04 The relationship of the switching network to the lines, trunks, service circuits, and the controlling elements [3A central control (3A CC), etc.] is shown in Fig. 1. The switching network provides any subscriber access to any other subscriber and to all circuits necessary to complete the call. The 3A CC controls the network via the frame input/output controller (FIOC) and the network controller.

CHARACTERISTICS

1.05 The No. 3 ESS switching network is defined as a 5-stage folded (single-sided) design utilizing sealed contact remanent-reed (remreed) technology (Fig. 2). The basic method for connecting two terminals (A and B) through this type of network is depicted in Fig. 3. To connect terminal A to terminal B, five levels (pairs of contacts) of switches must be closed; ie, 5-stage design. ***Folded*** design refers to the method of folding back through the first two stages to complete the connection. ***Single-sided denotes that all customer lines, trunks, and service circuits are terminated into stage I switches and, therefore, are located on one side of the network.***

1.06 Stage I and II switches are arranged to provide 192 terminals with access to 64 stage III levels. This arrangement is referred to as a concentrator (Fig. 4). Two concentrators are connected in parallel to form a concentrator group (Fig. 5). This provides 384 (192 plus 192) lines, trunks, and service circuits with access to 64 stage III levels, thereby establishing a fixed concentration ratio of 6 to 1 (384 divided by 64).

1.07 The switching network is also referred to as a space-division network in which 2-wire metallic connections are made through the five stages. Two remreed contacts (Fig. 6) are located at each crosspoint to accommodate the required 2-wire switching. "Space division" denotes that the selected path through the network is dedicated to a connection as long as it is in progress and is not shared by any other connection through the network at that time.

1.08 Wired connections between the first- and second-stage switches are the A-links [tip (T) and ring (R) leads]. Access paths between the second and third switching stages are the B-links. There are two types of B-links, wire and circuit (junctor). Half of the B-links are wires directly connecting the second- and third-stage switches. The other half, the circuit-type B-links, are junctor circuits between the second- and third-stage switches.

1.09 The junctor circuit is used between all stage I input connections. The junctor provides the following circuit states to accommodate the various types of terminal-to-terminal connections required to complete a call.

(a) Bypass

(b) Open

(c) Line-to-Line

(d) Line-to-trunk

(e) Trunk-to-line

(f) Audible ring

(g) Overflow tone.

1.10 The junctor circuit provides loop supervision and talk battery in both directions for intraoffice calls and supervision and talk battery toward the line on interoffice calls.

1.11 Remreed crosspoint selection is made by the network controller under direction of the system program operating in the 3A CC.

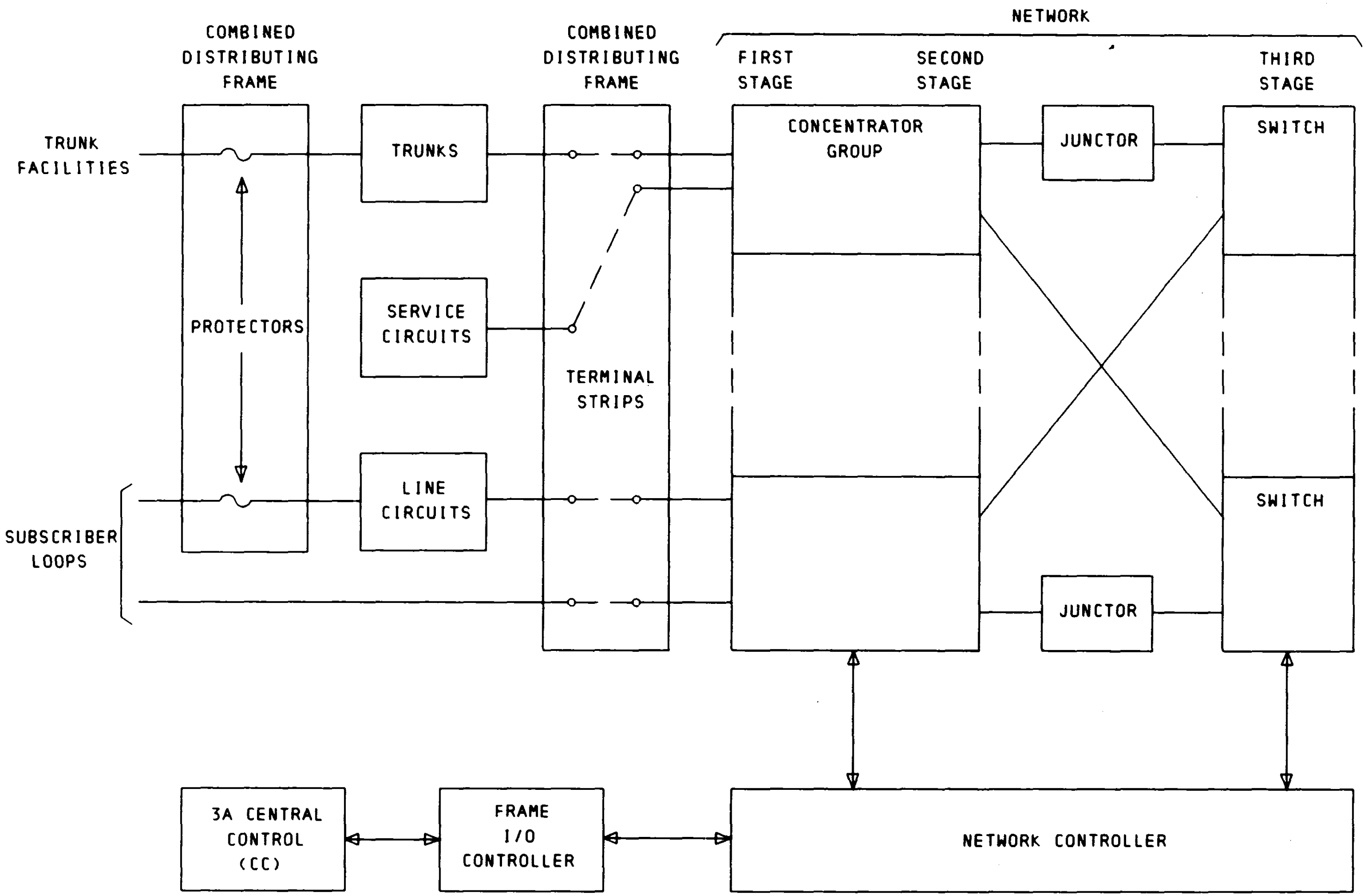


Fig. 1—Switching Network Functional Relationship

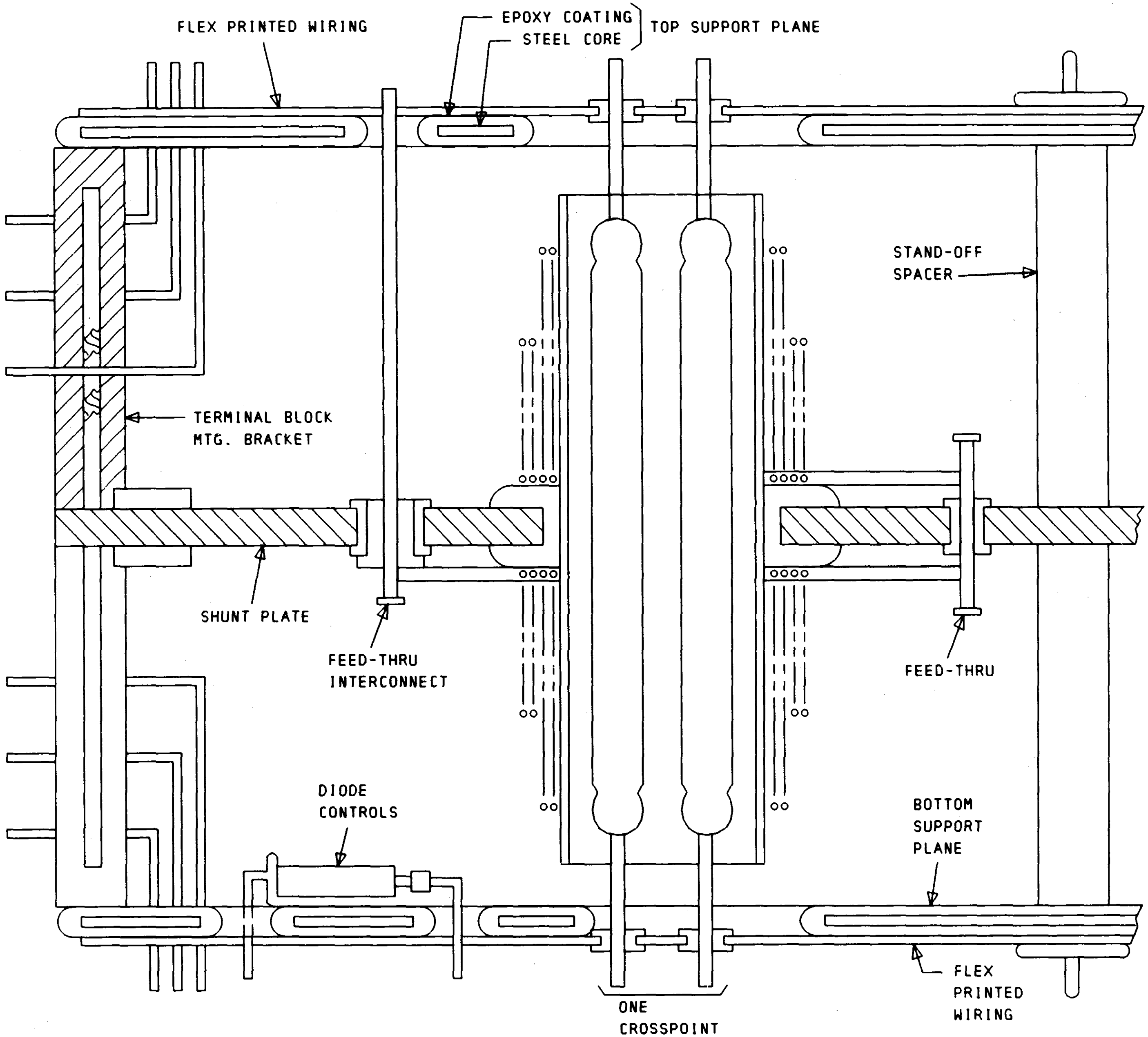


Fig. 2—Remanent Reed Package Construction

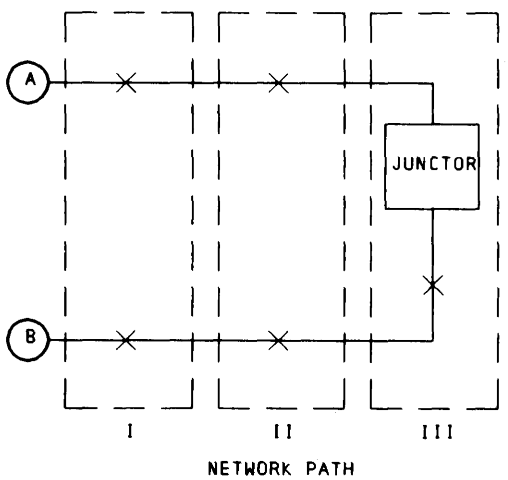


Fig. 3—Network Path

GROWTH

1.12 To accommodate office growth, the switching network of an office can be expanded by adding concentrator groups. A maximum of seven concentrator groups can be controlled by the first network controller, which provides a line capacity of 2688 terminals (lines, trunks, and service circuits). Additional concentrator groups require the installation of a second network controller, which will provide for office expansion to the maximum of 15 concentrator groups with a capacity of 5760 terminals. The growth floor plan (Fig. 7) shows how these facilities would be added as additional capacity is required.

1.13 The network controller is located in the control frame and contains duplicate network controller circuitry to provide redundant control facilities. One of the controllers executes orders, while the other is in standby. Should the operating unit fail, the backup controller (as a part of the SYC) is placed into service. The second control frame (used if office has more than seven network frames) also contains redundant network controllers which are used to control the expanded portion of the network (except for the expanded grids on control frame 0).

2. EQUIPMENT DESCRIPTION

NETWORK FRAME

2.01 Most of the switching network components are located on the network frame (Fig. 8). All first- and second-stage remreed switches and associated junctors are located in the network frame. The first- and second-stage switches are connectorized to facilitate repair and minimize interruption of service during repair.

A. First-Stage Switch

2.02 The first stage of the remreed network is physically constructed of forty-eight 8-by-8 switches, representing one concentrator group. The 8-by-8 arrangement provides for eight vertical terminal assignments and eight horizontal terminal assignments. Since there are two concentrators in a concentrator group, half of these switches (24) are used in each concentrator. To correspond to the physical packaging of the switches into units, both sets of 24 are broken down into three equal-sized groups designated A, B, and C, each containing eight 8-by-8 switches (Fig. 9).

B. Cutoff Contacts

2.03 The cutoff contacts (on the first stage remreed switch assembly) for the line-attending element (ferrod) (Fig. 9) are associated with the verticals on the first-stage switch. The contacts remove the line-attending element when service has been requested and also allow maintenance testing.

C. Second-Stage Switch

2.04 The second stage of the remreed network consists of sixteen 8-by-8 switches per concentrator group (Fig. 9). Eight of the switches are used in each concentrator. This arrangement provides 64 inputs and 64 outputs for the second stage associated with a concentrator. The two (64) second-stage outputs (per concentrator) are connected in parallel to provide the 6-to-1 concentration ratio per concentrator group. The outputs of each first stage (of a concentrator group) are slip multiple connected to the second stage. This arrangement ensures that each 8-by-8 switch in the first stage has access to each second-stage 8-by-8 switch in the concentrator group, and that network hot spots, ie, switches that have a concentration of very busy lines and trunks, will have a minimum effect on service provided by other switches in the network.

D. Test Vertical

2.05 Extra verticals on the stage II switch assemblies provide access for the test vertical circuits (Fig. 9). The verticals provide operator

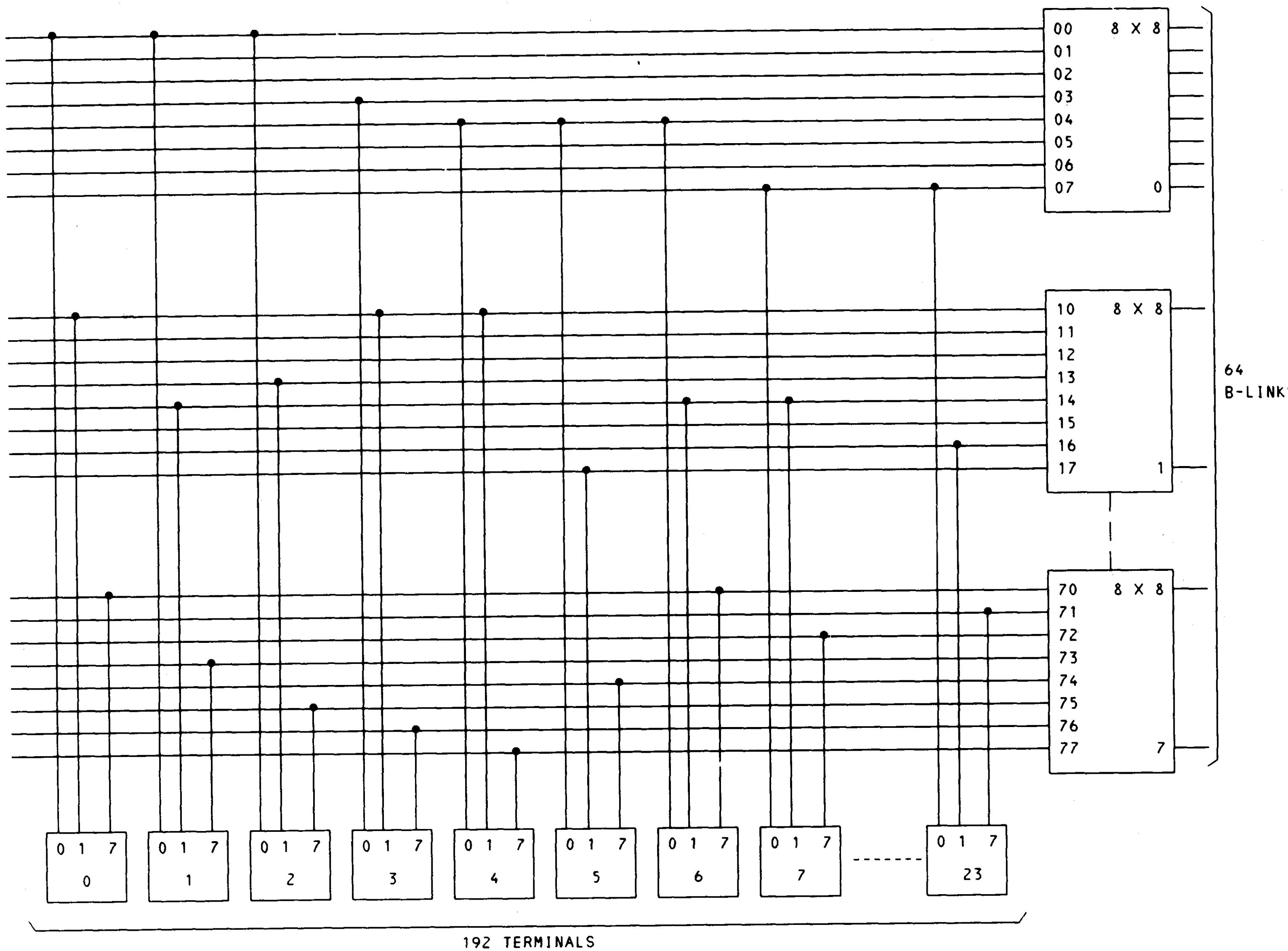


Fig. 4—No. 3 ESS 192-By-8/64 Random Slip Multiple Concentrator

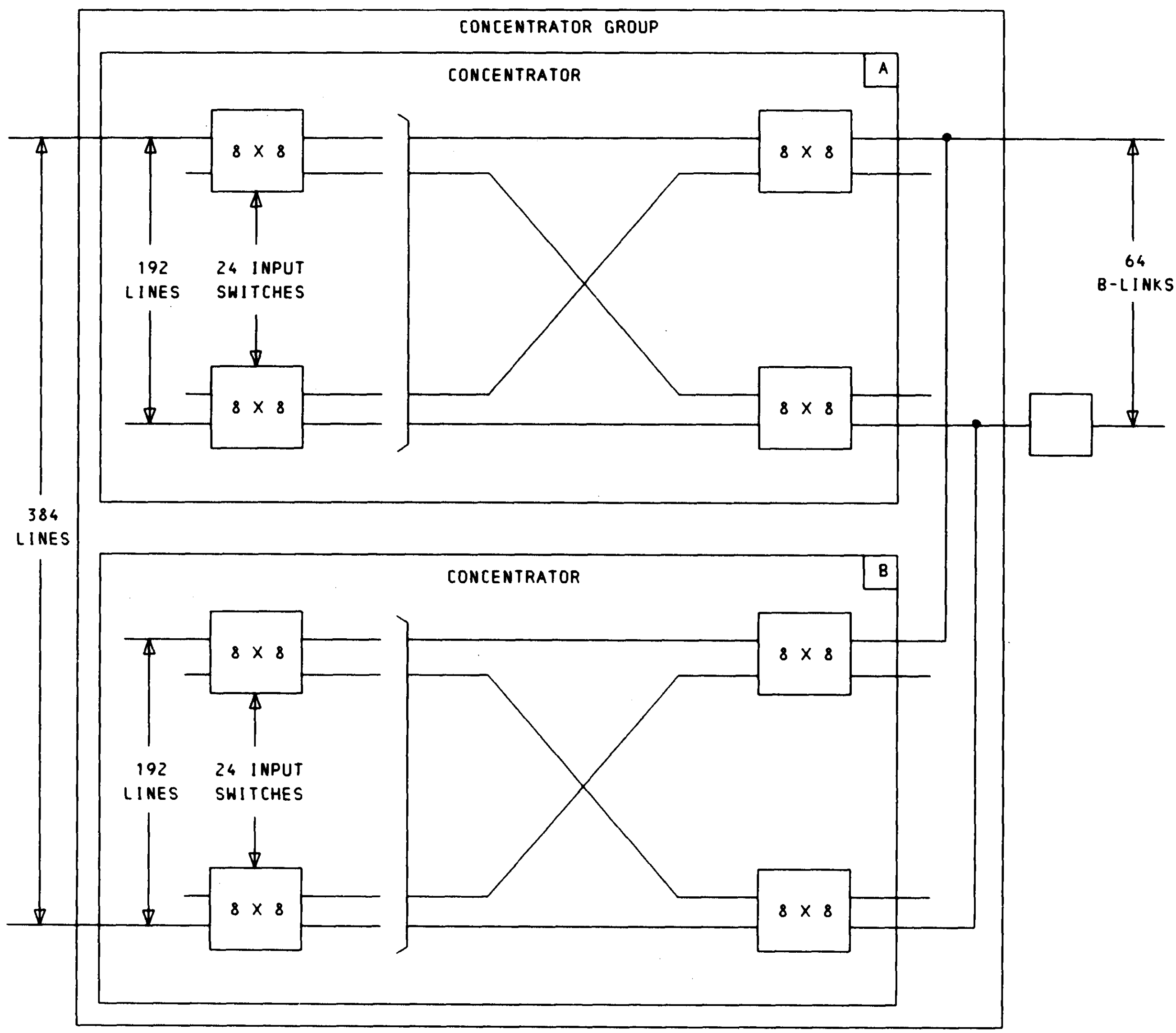


Fig. 5—No. 3 ESS Concentrator Group

access for busy verification, coin collect and return, as well as access for the following software-controlled tests that are performed at every call origination:

(a) False cross and ground (FCG) test

(b) Power cross (PC) test

(c) Restore verify (RV) test.

E. Junctor

2.06 Each concentrator group contains 32 junctor circuit packs. Each junctor circuit pack contains all the components for that one junctor (Fig. 10) (ie, three state relays designated A, B, and C control the junctor states necessary for processing calls). Two ferrod sensors in the scanner controller are used to report supervisory changes to the 3A CC via the scanner. The remaining components are used as follows: C1 through C4 for DC blocking; L1 and L2 for a high impedance

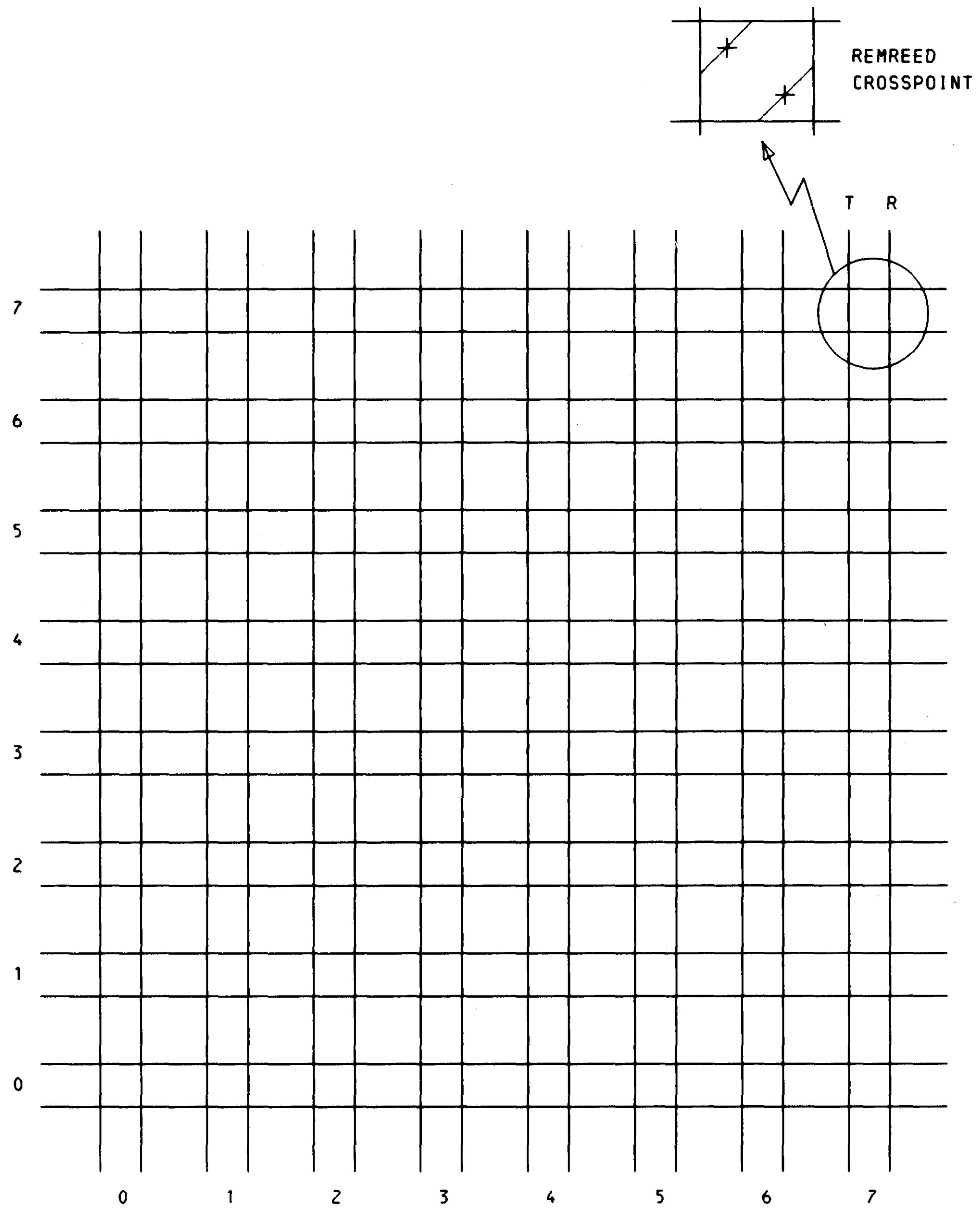


Fig. 6—Tip and Ring Schematic for Half of a Remreed Switch Package

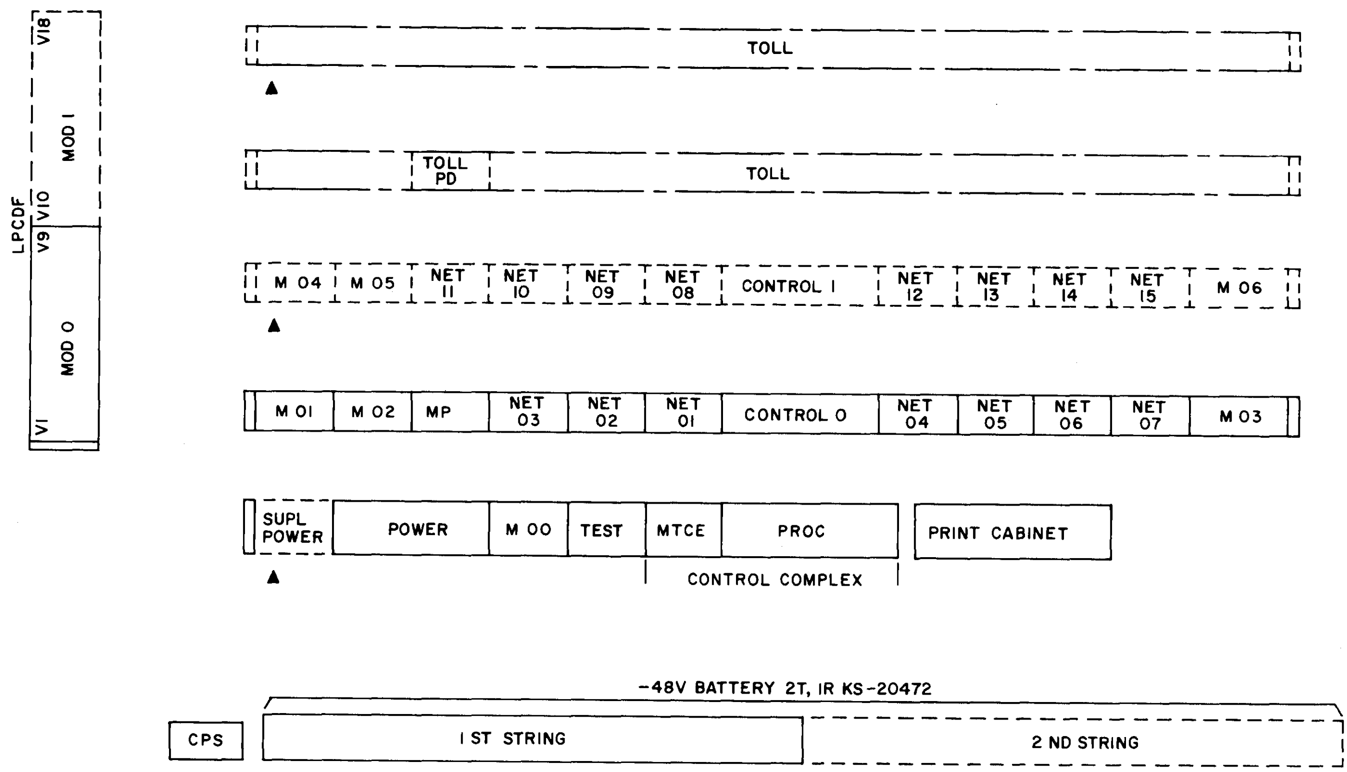
to prevent the voice signals from being shunted out; and N1, N2 and RV1, RV2 to limit excess voltage which can damage the state relay contacts.

CONTROL FRAME

2.07 The control frame (Fig. 11) houses the third-stage remreed switch of the switching network. This stage is joined to the second stage of the network by B-links (paths). Additional units associated with the network and located on the control frame are the network controller and the network pulser. The peripheral controllers contain the network controller along with other controllers. Optional trunk and service circuits are located on control frame 0. Only optional trunk circuits are located on control frame 1.

A. Third-Stage Switch

2.08 The third stage of the remreed switching network consists of thirty-two 8-by-8 switches.



NOTES:
1. SOLID LINES INDICATE 2100 LINE OFFICE.
2. DASHED LINES INDICATE GROWTH TO A 4500 LINE OFFICE.
3. MINIMUM REQUIRED FLOOR SPACE IS 22 FT. X 41 FT. 8 IN.

LEGEND:
PROC - PROCESSOR FRAME
MTCE - MAINTENANCE FRAME
M 00-06 MISCELLANEOUS FRAME
MP - MISCELLANEOUS POWER FRAME
NET (01-15) NETWORK FRAMES
LPCDF - LOW PROFILE COMBINED DISTRIBUTING FRAME
PD - POWER DISTRIBUTION
MOD - MODULE
V - VERTICAL
CPS - CIRCUIT PACK STORAGE
▲ - DENOTES MAINTENANCE AISLE (FRAME EQUIPMENT FACES THIS AISLE)

Fig. 7—No. 3 ESS Equipment and Growth Floor Plan

Half of the outputs of a concentrator group are distributed (one each) via wire B-links to the inputs of the 32 third-stage switches. The other half of the outputs are connected via circuit B-links (junctors) to the outputs of the third-stage switch. This arrangement allows the third stage to accommodate, without link rearrangement, up to seven concentrator groups or 2688 terminals.

B. Network Controller

2.09 The remreed switches are controlled by the network controller. The network controller for the first seven concentrator groups is located on control frame 0. Control frame 0 controls only seven concentrator groups because part of its capacity is used in conjunction with the master scanner. Control frame 1 controls the next eight concentrator groups. Each controller is physically constructed of the following circuits:

(a) Control logic and transmit register (FA1001)

(b) Timers and guards (FB421)

(c) Input level and miscellaneous decoder (FA998)

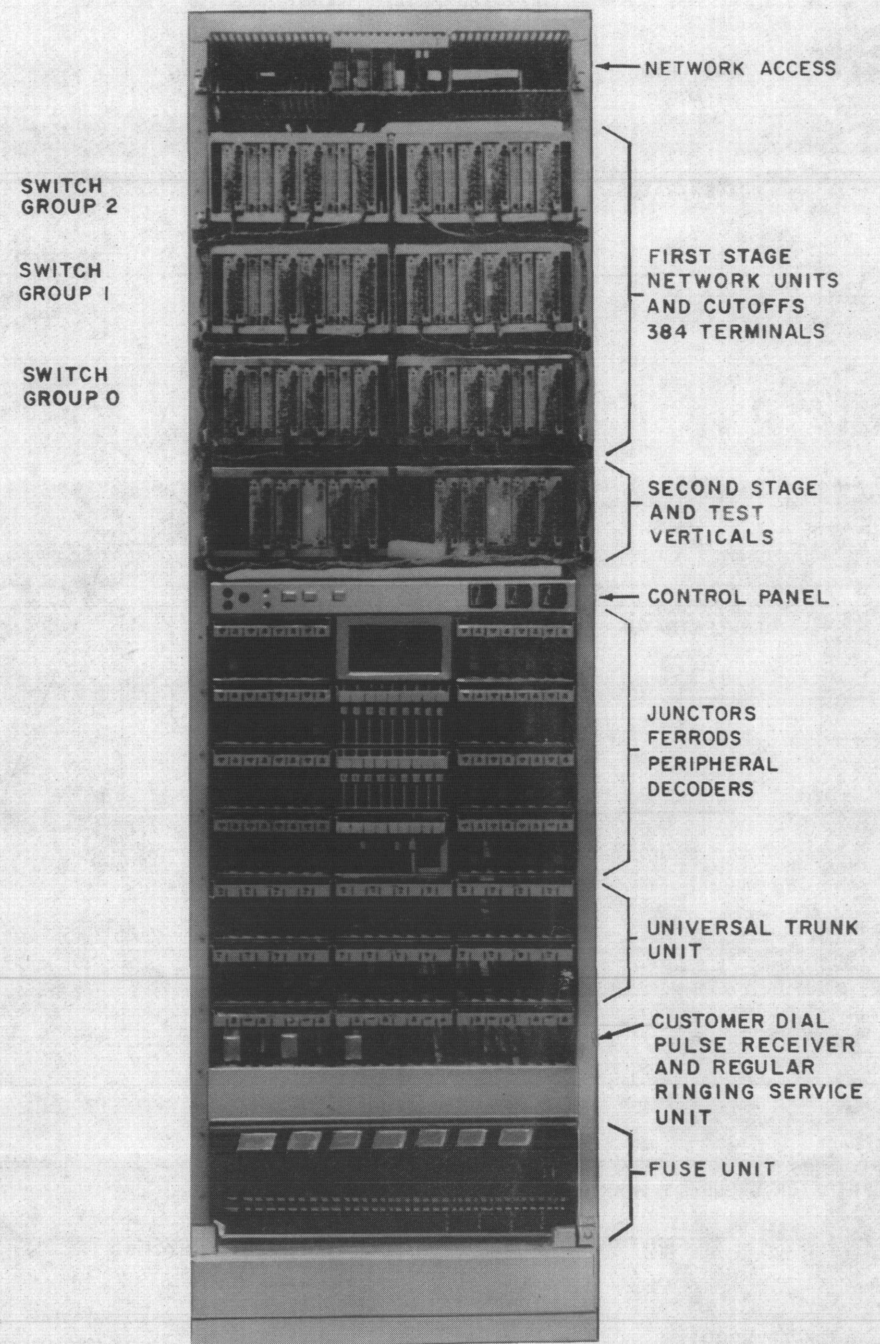


Fig. 8—Network Frame

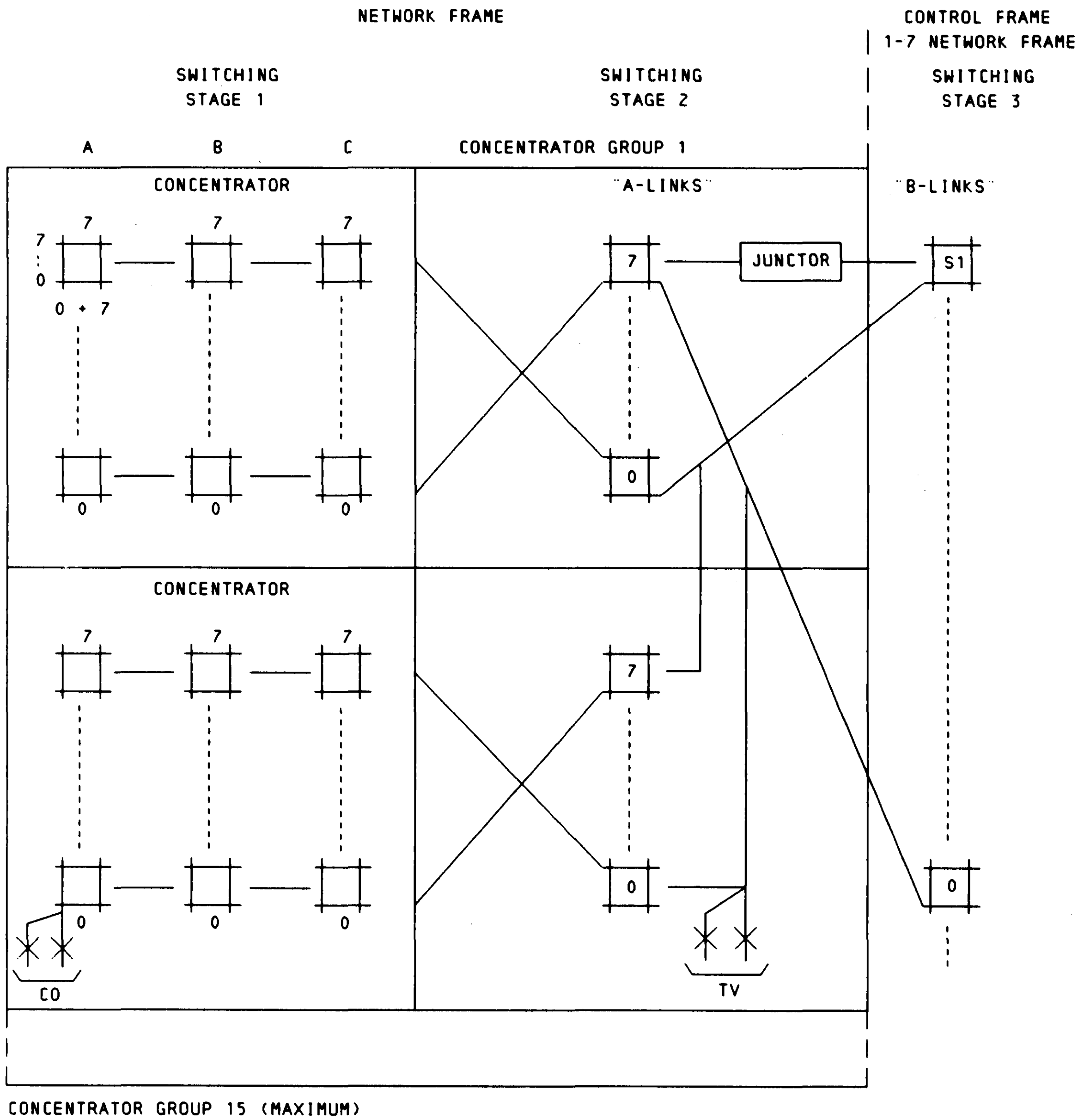


Fig. 9—Detailed Remreed Switch Organization

(d) Level decoder (FA999)

(e) Concentrator and input switch group decoder (FA1000)

(f) Input group selector (FB404)

(g) Power and dummy load control (FB409)

(h) Output group selector (FC188)

(i) Third stage group select (FB406)

(j) Input and output node selects (FC193)

(k) Input/output gate group select (FC307)

(l) High and dry select (FB405)

(m) Time control (FB421)

(n) Voltage source (FC229)

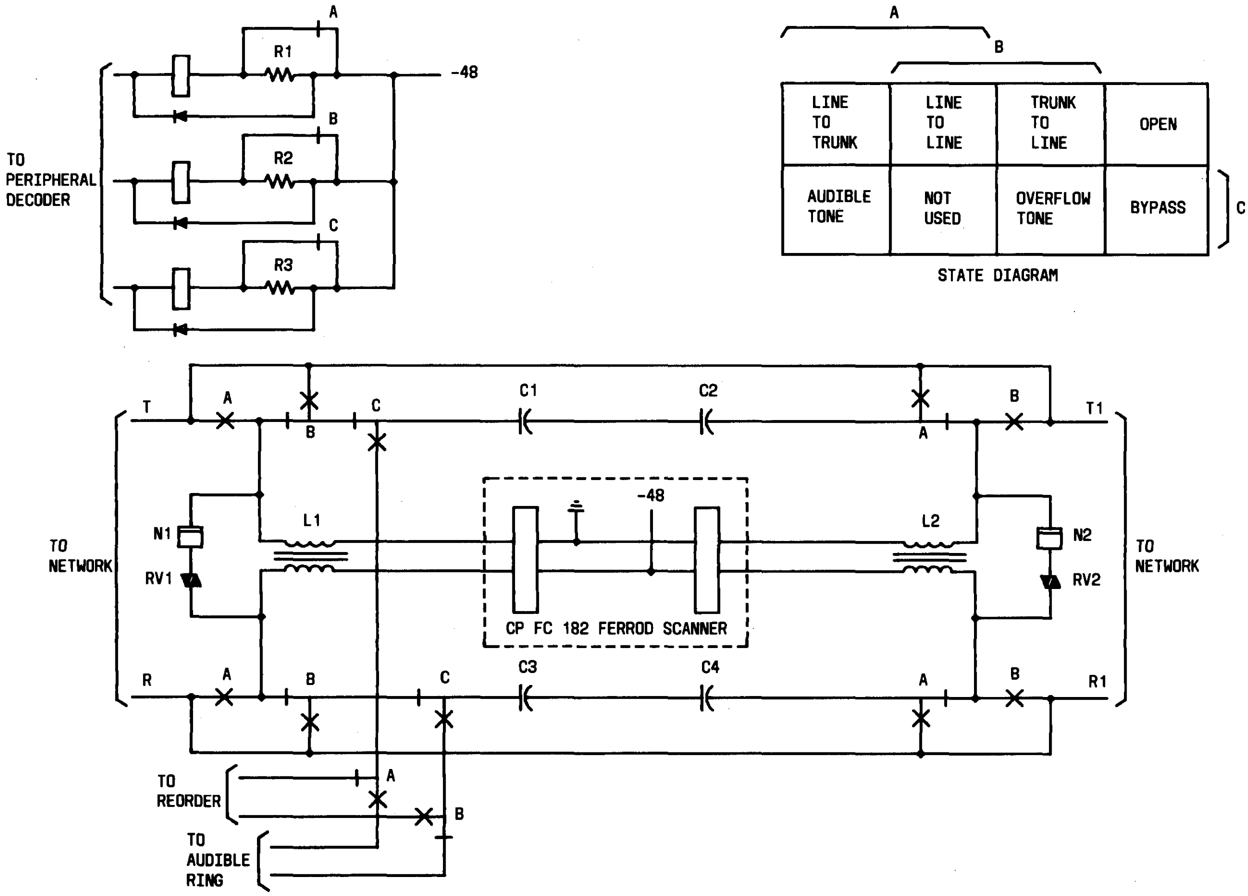


Fig. 10—Junctor Circuit

(o) Group check detectors (FC219)

(p) Input level select (FC192)

(q) Output level select (FC191)

(r) Stage III level select (FC190).

These circuits are mounted on plug-in circuit packs and have designated numbering and lettering schemes associated with them.

INTERFACES

2.10 The network controller is not equipped with a decision-making capability and can only execute orders under direction of the 3A CC. The relationship of these units is shown in Fig. 12. Subscriber loops, trunks, and service circuits are connected to the network stage I switches via the low profile conventional distributing frame (LPCDF). The scanner controller (SC) detects a service request at a ferrod sensing element and transfers this information to the 3A CC. The required network path closures are determined by the call processing program in the 3A CC, and this information is sent to the network controller via the frame input/output controller (FIOC). The network controller then executes these closure orders. The peripheral pulse distributor (PPD) receives junctor and other orders from the 3A CC which sets the junctors to states specified by the order.

3. FUNCTIONAL DESCRIPTION

3.01 The network controller receives orders from the 3A CC via the FIOC. It then performs the required functions by converting the received data to control signals which activate a specified network path.

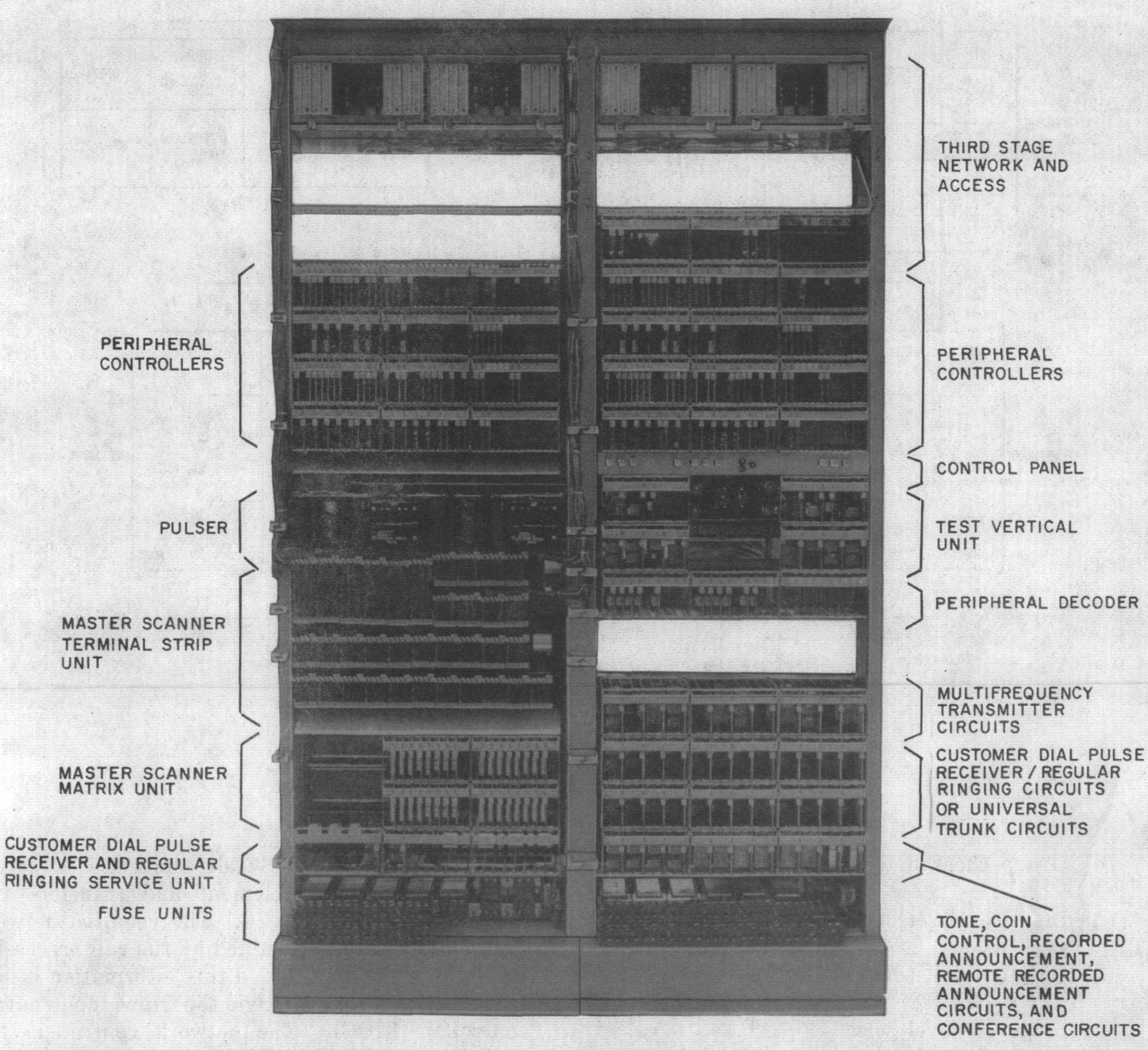
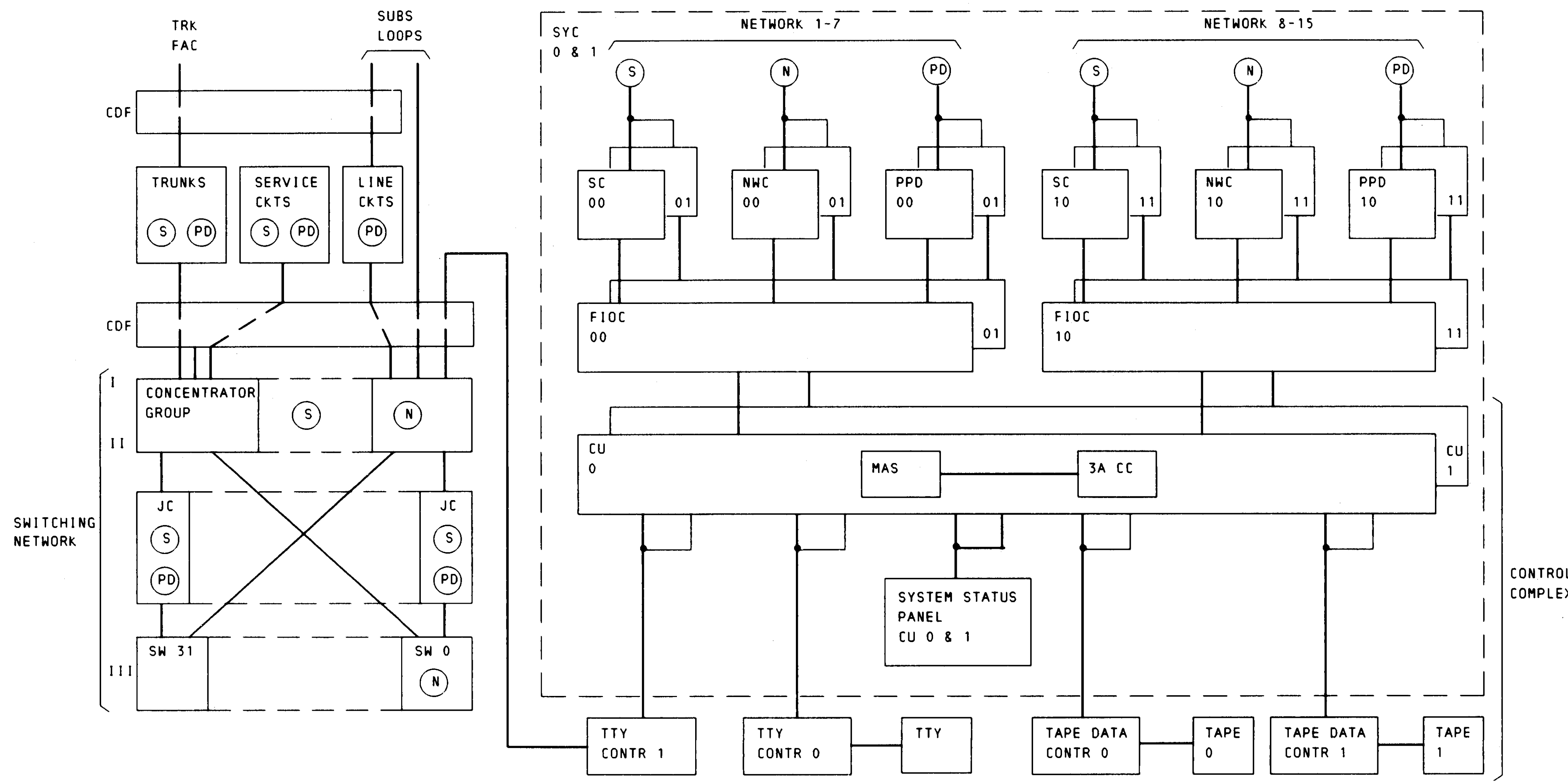


Fig. 11—Control Frame

3.02 One network order requires two serially transmitted words. These words provide the necessary information to determine a path through the A-links for switching stages I and II. Additional orders provide information necessary to operate the third-stage switch.

3.03 The network controller can be broken down into the following major functional parts (Fig. 13):

(a) Registers



PD = PERIPHERAL DECODER POINT
S = SCAN POINT
N = NETWORK CONTROL POINT
JC = JUNCTOR CIRCUIT
SW = SWITCH

SC = SCANNER CONTROLLER
NWC = NETWORK CONTROLLER
PPD = PERIPHERAL PULSE DISTRIBUTOR
FIOC = FRAME INPUT OUTPUT CONTROLLER
MAS = MAIN STORE

3A CC = 3A CENTRAL CONTROL
CU = CONTRON UNIT
SYC = SYSTEM CONTROL

Fig. 12—No. 3 ESS Block Diagram

(b) Control logic and transmit register

(c) Decoders

(d) Drivers

(e) Group checks

(f) Group, level, and node selectors

(g) Guards and timer

(h) Pulser. (This is not physically part of the controller.)

3.04 The parallel data from the FIOC is received in the register and the control logic transmit register circuit.

REGISTERS

3.05 The registers receive data pertaining to the selection of a particular path through the network. The information determines which of the following functions are to be performed.

(a) For first and second network stages:

(1) Selection of concentrator group or junctor

(2) Designation of one of the two concentrators

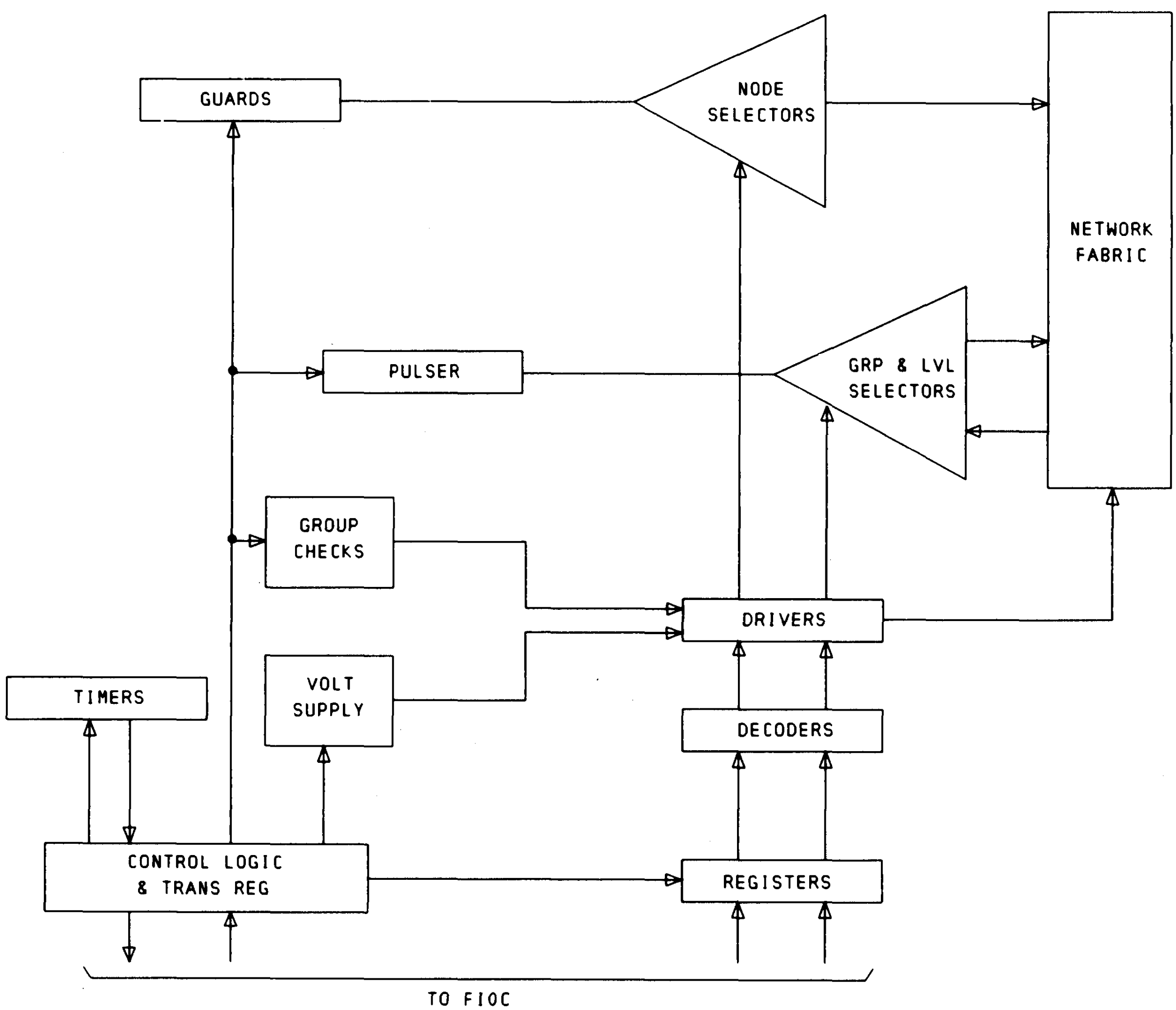


Fig. 13—Network Controller Functional Diagram

(3) Selection of input switch group A, B, or C

(4) Selection of one input switch

(5) Selection of input switch level

(6) Selection of output switch in the second-stage switch

(7) Selection of output level.

(b) For third network stage:

(1) Selection of input switch level

(2) Selection of group

(3) Selection of switch

(4) Selection of output switch level.

CONTROL LOGIC AND TRANSMIT REGISTER

3.06 The control logic and transmit register circuit receives the data specifying the type of order being sent and provides the decoder and driver circuit with information to perform the following actions:

(a) For first and second network stages:

(1) Check FCG.

(2) Close first- and second-stage switches.

(3) Verify high and dry.

(4) Open first- and second-stage switches.

(b) For third network stage:

(1) Open third-stage switch.

(2) Close third-stage switch.

DECODER AND DRIVER CIRCUIT

3.07 The decoder determines from the information supplied by the registers which switch (first-, second-, or third-stage) is to be selected. This information is passed to the network fabric via a driver circuit. The decoder circuit also receives information regarding the selection of a particular crosspoint (level selection) within the designated switch. The decoder receives information that not only identifies the concentrator group (0 through 7) and concentrator (0 or 1) selected but also identifies the switch group (A, B, or C) within the concentrator when a first-stage switch selection is made. The decoded information is then gated via the driver circuits to the group level and node selection circuits.

GROUP, LEVEL, AND NODE SELECT CIRCUITS

3.08 The group, level, and node select circuits provide access for the pulser circuit to a particular network path as identified by input received from the decoder and driver. The pulser sends a current pulse to operate the crosspoints associated with the selected path (Fig. 14).

GROUP CHECK CIRCUIT

3.09 The group check circuit verifies that only one path exists and that only one circuit will be operated in each of the path selection circuit groups. This circuit communicates with the control logic transmit register circuit and the driver circuit.

GUARD AND TIMING CIRCUIT

3.10 The timing circuit works in conjunction with the group check circuit. The proper timing interval is required for a verification of the group check to determine that a valid group check was made. The guard circuit, along with associated node circuitry, isolates the pulse path from ground during pulsing.

PULSER

3.11 ➧The pulser circuit generates a high current pulse of 4.5 amps. After the electronic path switches (SCRs) are operated and all of the integrity checks are made, a start pulse is sent to the pulser. When the pulser fires, the high current (4.5 amp) pulse follows the network path previously selected and provides coincident current at the crosspoint to operate the remreed switch. Once operated, residual magnetism generated by the coincidence pulses holds the switch operated until another set of pulses is sent to neutralize the switch (thereby releasing it).➧

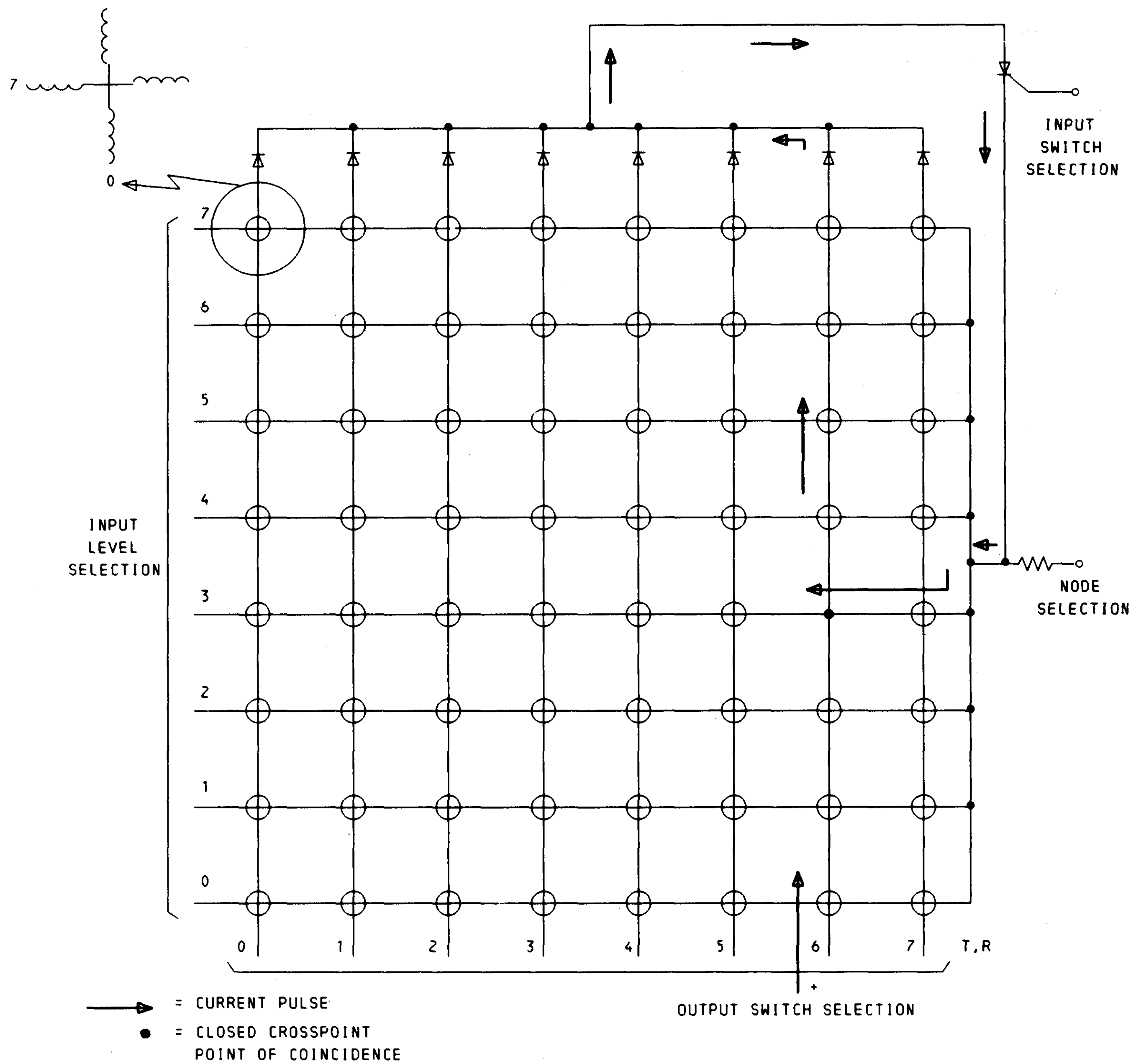


Fig. 14—Stage 1 Switch Control Path for 8-By-8 Remreed Switch

4. THEORY OF OPERATION

NETWORK FABRIC

A. Introduction

4.01 The network fabric consists primarily of remanent reed switch grids interconnected by A- and B-links. Remreed switches are used in the tip and ring switching path and as test verticals (TVs); however, the TV switches are not arranged in a matrix configuration. The line cutoffs and no-test access are also part of the remreed switches.

4.02 Stage I input switches are arranged and packaged as a 15A grid. Three 15A grids (switches) are required for each concentrator or six per network frame.

4.03 The second stage of the concentrator consists of two 15B grids. Two concentrators are used for each concentrator group.

4.04 Stage III switches are located in the control frame and consist of four 15C grids.

B. Signal Circuits

4.05 All office terminals are provided access to the network via a stage I switch. Eight terminals can be connected to the eight input lines of an input switch, and each in turn can be switched to any of the eight output lines of the same switch. There are 24 input switches contained in a concentrator (Fig. 4), providing an input line capacity of 192 terminals. Each output line of the stage I switches is multipled with the output lines of two other stage I switches and connected to the input of a stage II switch via an A-link. Since stage I output switches are multipled in groups of three, only eight stage II switches are required and a concentration ratio of 3 to 1 is generated. The No. 3 ESS A-link multiple provides that no A-link connects the same combination of input switches. This type of grouping is referred to as a 192 by 8/64 random slip multiple concentrator (Fig. 4) (192 input lines access eight stage II switches, having 64 output lines).

4.06 When the 64 output lines of a concentrator are multipled one to one with another concentrator, a concentrator group is formed (Fig. 5). The result is 48 input switches having a line capacity of 384 (48 by 8) terminals. The 384 input lines have access to any one of 64 B-links (since stage II switch outputs are multipled), and a concentration ratio of 6 to 1 now exists. Functionally, the concentrator (Fig. 15) is subdivided as follows:

(a) Each concentrator group is comprised of concentrators 0 and 1.

(b) Concentrator 0 contains stage I switches 0 through 7 (A), 16 through 23 (B), and 32 through 39 (C).

(c) Concentrator 1 contains stage I switches 8 through 15 (A), 24 through 31 (B), and 40 through 47 (C).

(d) Each concentrator (0 and 1) contains 8 stage II switches.

Because of the functional grouping of the concentrator, several orders must be used for the switch selections to establish a complete path through the concentrator. The input switch 1/48 selection combines IN SW and IN SW GRP. Bit 11 of IN SW identifies the concentrator (0 or 1), and the remaining three bits identify one of the eight switches in A, B, or C. IN SW GRP identifies the A (00), B(01), or C(10) group of switches. To identify input level 1/16, IN LVL is used. The CO bit in this field is used to operate or release the CO contact which effectively reduces the 1/16 selection to 1/8 while the other three bits identify the 1/8 switch level. The output level 1/16 selection is also reduced to 1/8 by the previous concentrator selection. The TV bit in the OUT LVL field is used to operate or release the test vertical, and the other three bits in this field identify the output level. OUT SW uses three bits to identify the one of eight output switches to be used, and CONC GRP uses three bits to identify the network frame (concentrator group) to be used.

4.07 The outputs of stage II switches are connected to stage III switches through either wired B-links or junctor circuit B-links (Fig. 16). Since the wired B-links connect to the row side of the stage III switches and the circuit B-links connect to the column side of the switch, any connection made through the network will be via junctors. An expansion of these connections is depicted in Fig. 17 with a call originating at A through network frame 0 and terminating into B through network frame 0. The completed path is connected through stage I and II switches, a junctor, a stage

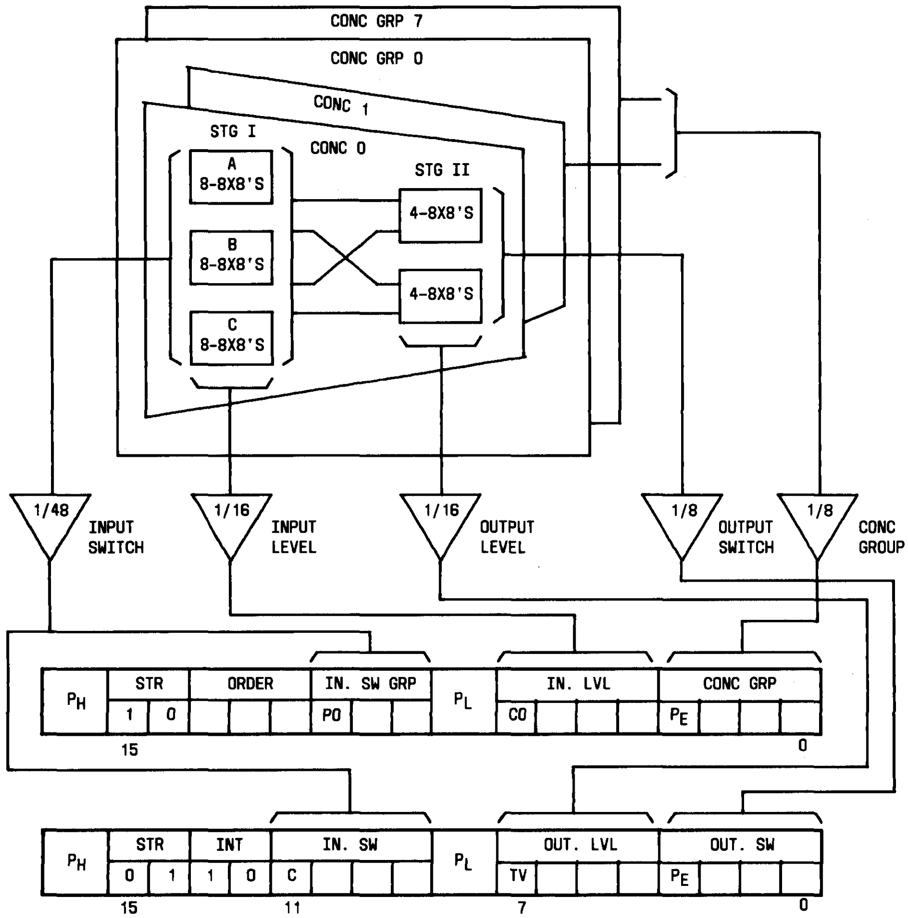


Fig. 15—No. 3 ESS Concentrator Selection

III switch in the control frame, and a wire B-link and back through stage II (IV) and I (V) switches.

4.08 The No. 3 ESS network B-link pattern (Fig. 18) shows the number of possible paths available through the network to connect terminal A to terminal B. Terminal A has eight possible paths through the stage I switch. This allows terminal A to be connected to any one of the eight stage II switches. There are then eight output paths available through the second-stage switch, the selection of which determines the stage III crosspoint. The path continues through a stage II (stage IV) switch and through a stage I (stage V) switch where the line is terminated into terminal B.

4.09 The test vertical (TV) provides a means for connecting test circuitry and provides operator and test desk access to the tip and ring leads at the output of the stage II switches (Fig. 19). Capability also exists through the TV for performing the following line tests:

(a) False cross and grounds test verifies that the line is not shorted or connected to ground.

(b) Power cross (PX) determines that no foreign potential exists on a customer line.

(c) Restore verify checks that the line sensor is restored across the line after the customer goes on-hook.

The second word of concentrator path selection (Fig. 15) contains the TV set bit. When bit 7 (TV bit) of word 2 is a 1, the TV is connected into the system. A 0 defines the TV as released.

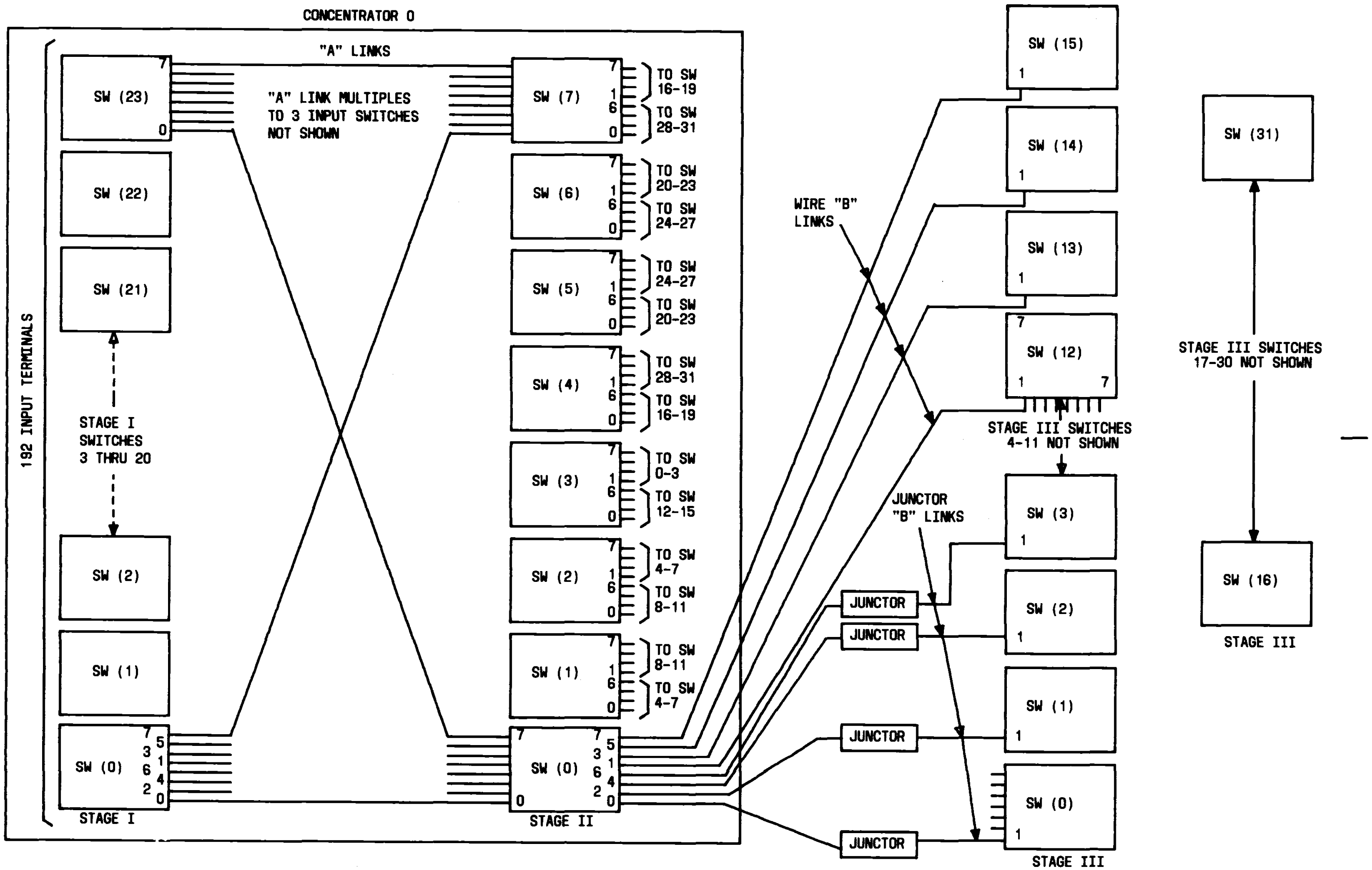


Fig. 16—No. 3 ESS Network Topology

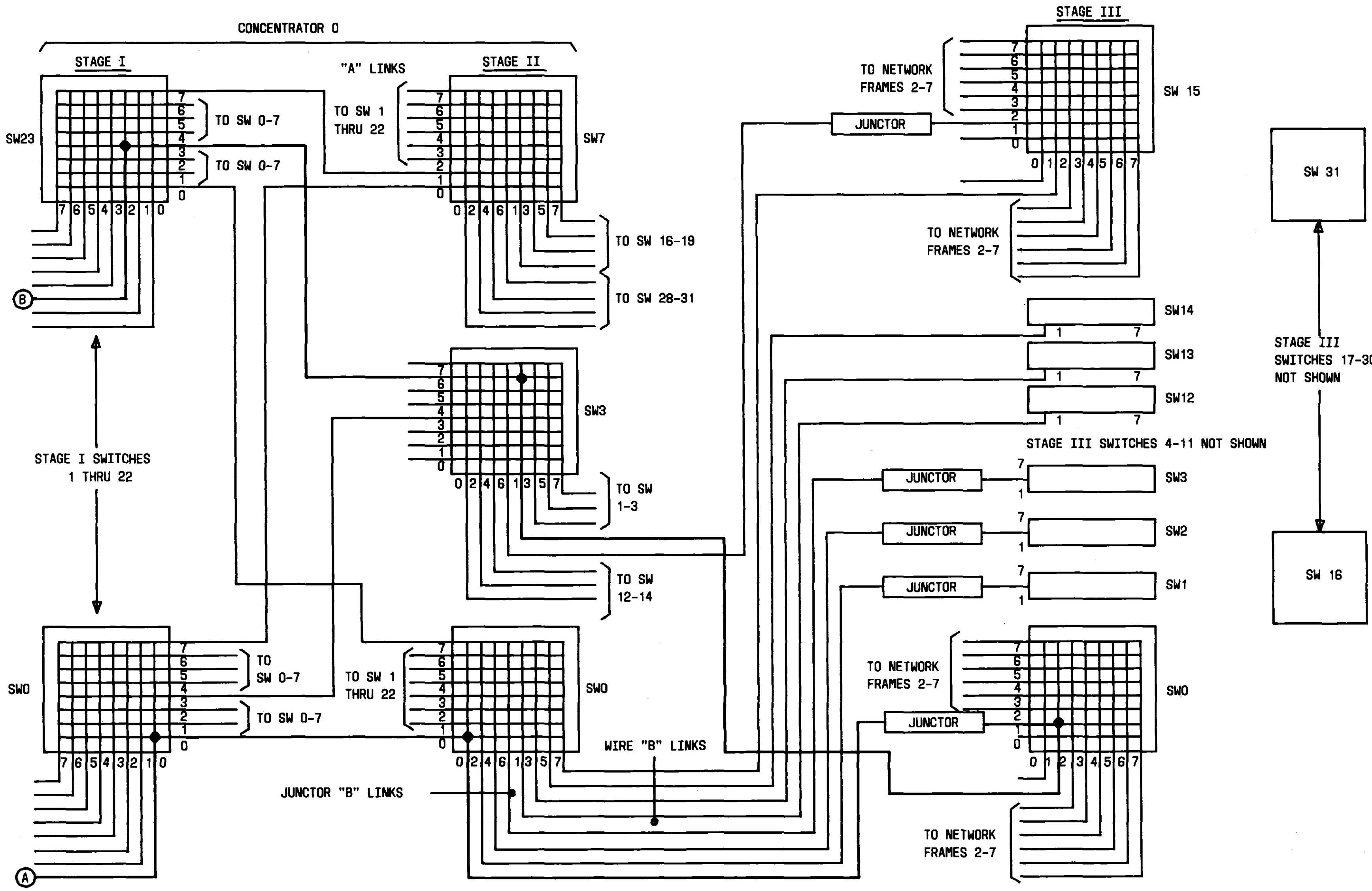


Fig. 17—Folded Network

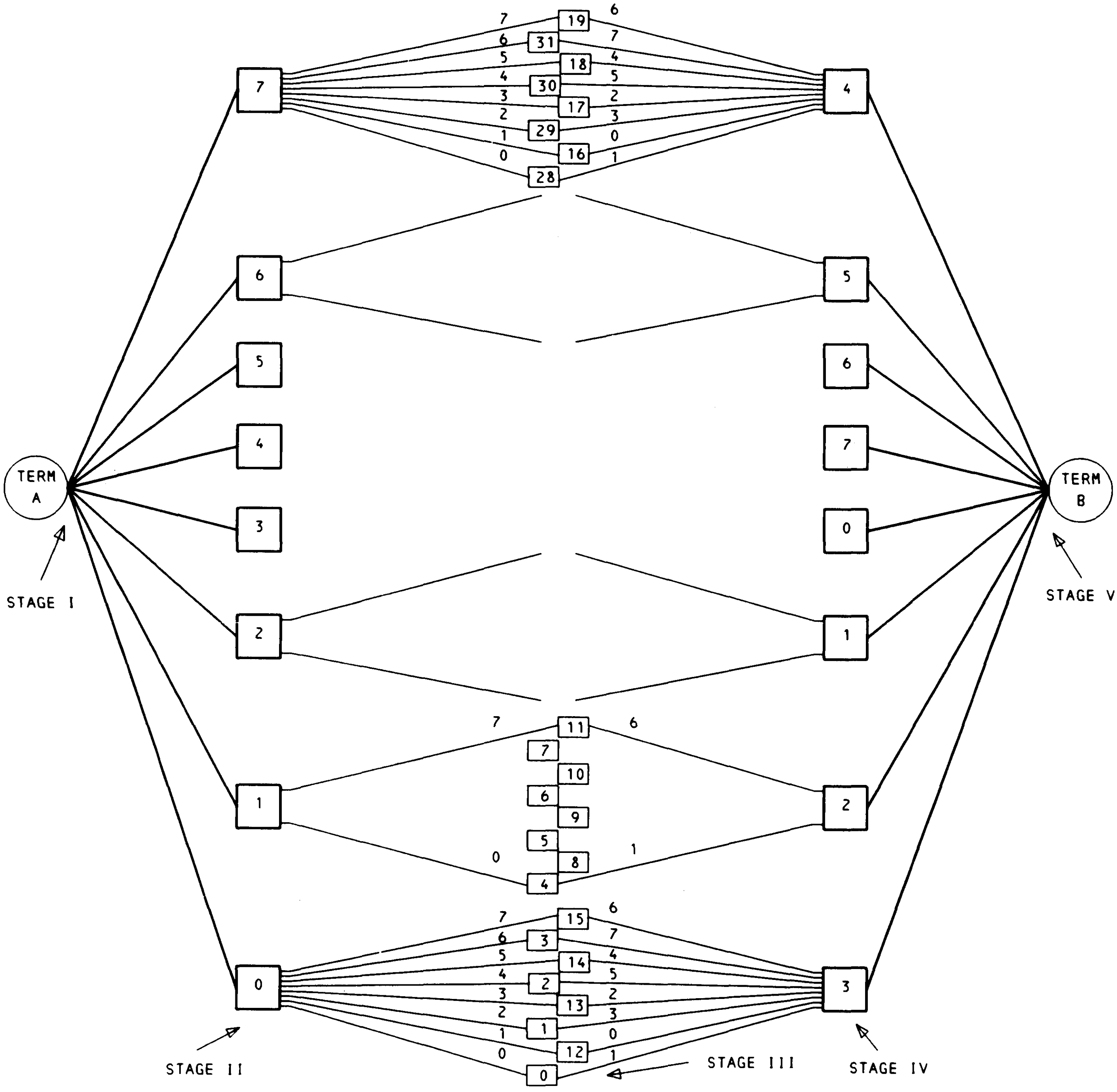


Fig. 18—No. 3 ESS Network B-Link Pattern

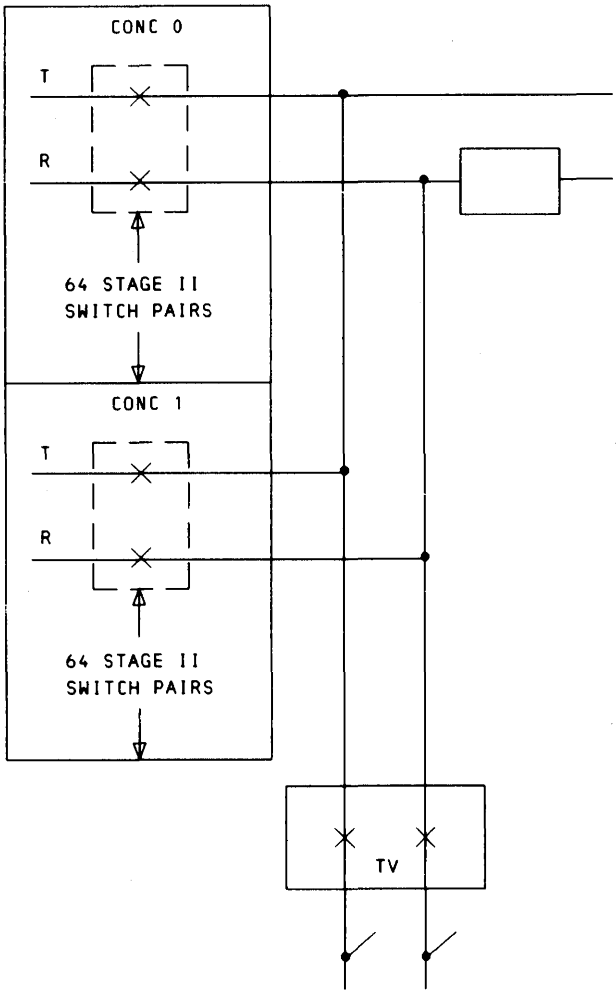


Fig. 19—Test Vertical

NETWORK CONTROLLER

A. Introduction

4.10 The No. 3 ESS network controller receives words (as parallel data) from the FIOC that provides instructions whereby the controller opens and closes crosspoints, performs checks, etc. The word received from the FIOC consists of 19 binary bits. Sixteen bits are used for information, two bits are reserved for parity, and one bit is for signaling. Two successive words are sent to the network controller. After each word, a response is returned from the network controller to the 3A CC via the FIOC. A third word (interrogate) is sent 10 milliseconds later to the network controller, and a response is returned to the 3A CC. This response indicates whether the network controller successfully carried out the order dictated by the first two words.

B. Control Circuits

4.11 The No. 3 ESS peripheral system is shown in Fig. 20. The data transfer from the FIOC to the network controller is via a 19-bit data bus which is common to the scanner and pulse distributor controllers. Reponses containing 17 bits are returned to the 3A CC from the network controller via the FIOC. Orders to set up a connection through the network are sent to the network controller in the following discrete steps:

(a) An order to connect terminal A to a specified B-link.

(b) A set of orders to connect terminal B to a specified B-link.

(c) Finally, an order is sent to close the specified stage III switch which will connect the required B-links specified by the previous orders.

4.12 The information required to implement each of the above orders is sent to the network controller in two 19-bit words. The format and response for these words are shown in Fig. 21 through 23 and Fig. 25 and 26. The two instruction words are sent in rapid succession (within microseconds) with the response occurring after each word. After 10 milliseconds, word 3 is sent to interrogate the network controller.

4.13 The network concentrator normal order and response, word 1, are shown in Fig. 21 and formatted as follows:

(a) ST2 bit is a start bit and specifies whether the word is a normal (0) or maintenance (1) instruction.

(b) Bits 0 through 3 select one of eight concentrator groups.

(c) PE is even parity bit for the first 4-bit positions.

(d) Bits 4 through 6 select one of eight input levels (the A-link to be used).

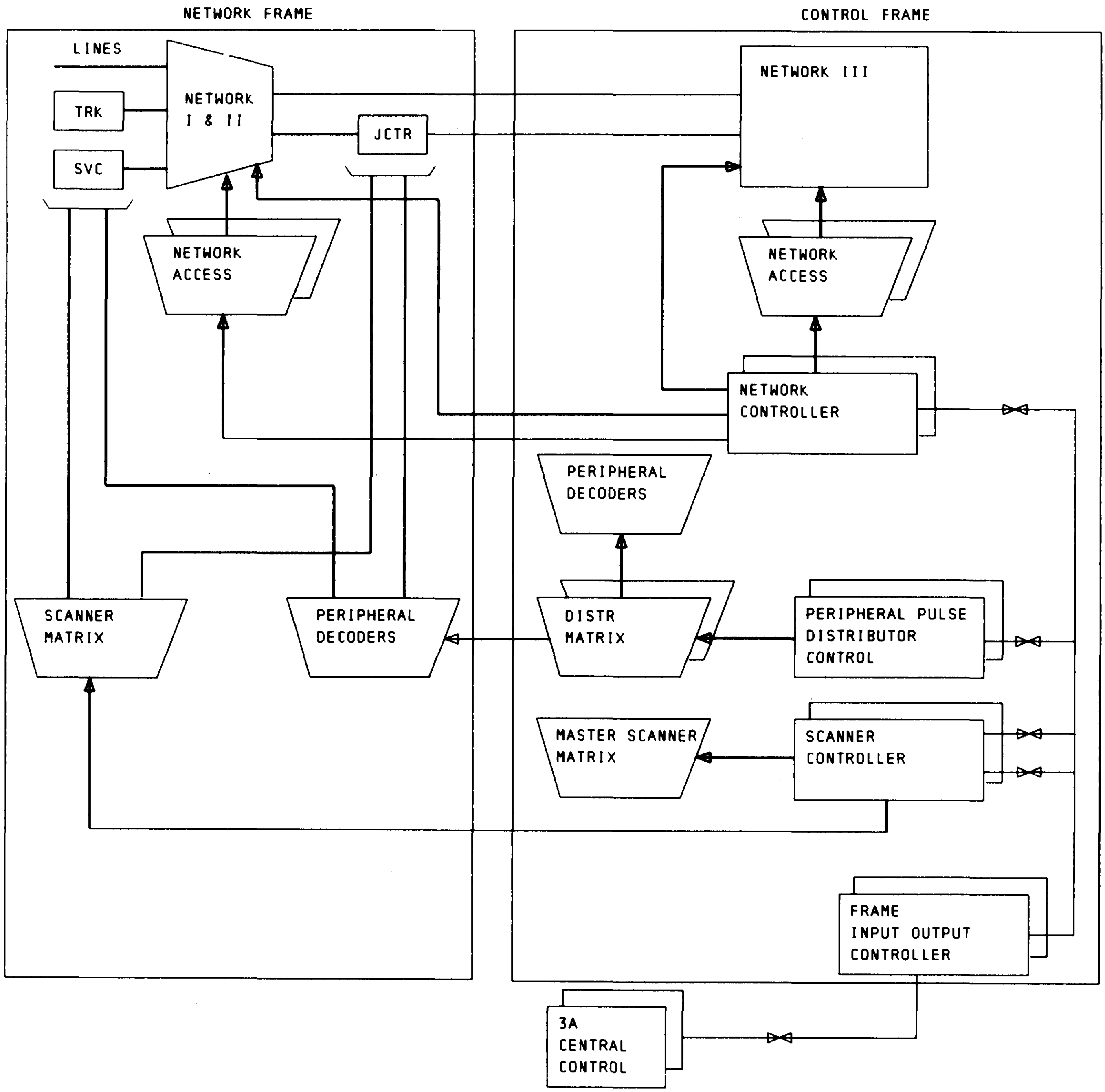


Fig. 20—No. 3 ESS Peripheral System

(e) Bit 7 determines opening or closure of cut-off contacts.

(f) PL is odd parity for the first eight bit positions.

(g) Bits 8 and 9 select input switch group A, B, or C and, in combination with four bits of word 2, make a one of 48 selection.

(h) Bit 10 is odd parity for bits 8 and 9.

(i) Bits 11 through 13 are the orders shown under these bits.

(j) Bits 14 and 15 denote the word number being transferred (1, 2, or 3).

(k) PH is the odd parity bit for bits 8 through 15.

4.14 The response is used to signal the 3A CC via FIOC that the word was received and the orders are recognized. STRG of the response should be the same STRG of the order to denote proper word received. The required bit pattern is shown below. Bits 0 through 7 (Fig. 21) indicate that the proper order was received. All 1s in bits 8 through 15 indicate that the group check registers are cleared. The format for concentrator word 2 and its response are shown in Fig. 22. Four bits (1 parity) are used to select the output switch (stage II). Five bits (1 parity) are used to select the output level. Bits 8 through 11 are the remaining bits necessary to select the input switch crosspoint. Bits 12 and 13 determine if the word is interrogate (10) or clear (01).

4.15 The response shown (Fig. 22) denotes that the group check and progress mark registers are cleared to store data needed by the interrogate word. A zero in bit 7 (SCR gate supply off bit) denotes that the voltage supply for the group check SCR gates has been turned off. This is required since the group check path is checking that only one route exists through the pulse path. The route must be isolated from ground before the high-current, crosspoint-operate pulse is applied.

4.16 The third-stage network order and response format is similar to the concentrator word format. Word 1 is shown in Fig. 23. One of four switch groups (Fig. 24) is selected by bits 0 and 1, while one of eight input levels is selected by bits 4, 5, and 6. The order code and response decoded order are also shown in Fig. 23 and 25. Bits 4 through 7 of word 2 (Fig. 24) specify the output level of a stage III 8-by-8 switch. Four bits (8 through 11) of word 2 are required to specify one of 16 switches (Fig. 24) in the group previously selected (bits 0 and 1 of word 1). INT bits 12 and 13 identify the word function as interrogate (10) or clear (01). The stage III, word 2, response is identical to the concentrator, word 2, response.

4.17 Word three is used only as an interrogate or clear word. The responses shown in the word 3 format (Fig. 26) indicate that the functions specified have been successfully completed. The INT bits and STRG bits, word 3, in combination with the ST2 bit, word 3, indicate whether the registers are to be cleared after the response. Normal orders clear the registers 150 nanoseconds after a response. The registers can be maintained if further interrogation is desired by changing ST2 bit to 1. Word 3 is further broken down as follows:

(a) Start timer—Timer which controls sequences, etc, has been started in the network controller.

(b) Gate window—This is the time frame in which the group checks must be made and stored in buffer before the pulser can be started.

(c) Start pulser—The pulser was given a start indication.

(d) 1-amp level—The pulser was turned on, and the pulse output reached a level of 1 amp.

(e) Pulser ok—The pulse reached the required 4-amp amplitude.

(f) Bit 7 indicates that a clear signal was properly received.

(g) All zeroes in bit positions 8 through 15 indicate group checks normal.

Word 3 can be sent a second time to interrogate the network controller. If the normal order mode is a "start with clear," the second response will indicate that the group check and progress mark registers were cleared. In the maintenance mode (ST 2, 1 and INT-1, 0), word 3 will be sent before words 1 and 2. This provides a means to interrogate further the network controller.

4.18 The orders sent to the network controller from the FIOC are stored in the following circuit packs:

- FA998—Input level and miscellaneous decoder
- FA999—Level decoder
- FA1000—Concentrator and input switch group decoder

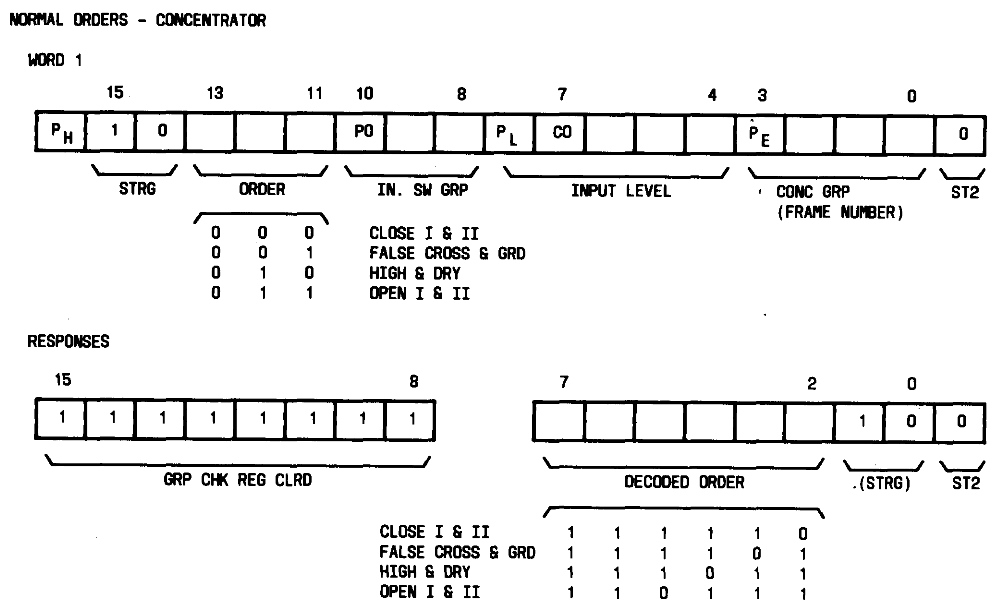


Fig. 21—Normal Orders—Concentrator (Word 1)

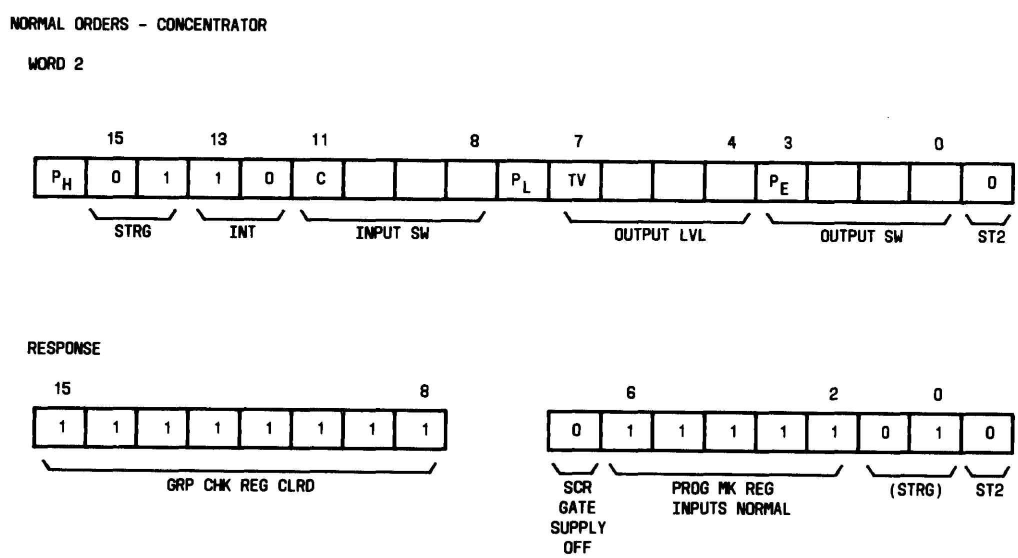


Fig. 22—Normal Orders—Concentrator (Word 2)

- FA1001—Control logic and registers.

Appropriate bits are decoded to establish gate voltage to the PNPN device used to establish the pulse path. The PNPN circuit selectors are as follows:

(a) FB404—Input group selector for concentrator

(b) FC188—Output group selector for concentrator

(c) FB406—Third-stage group select.

This information then sets up a pulse path to the proper row and column of the correct 8-by-8 remreed switch. A generalized diagram of the pulse circuit is shown in Fig. 27. The pulse must be directed

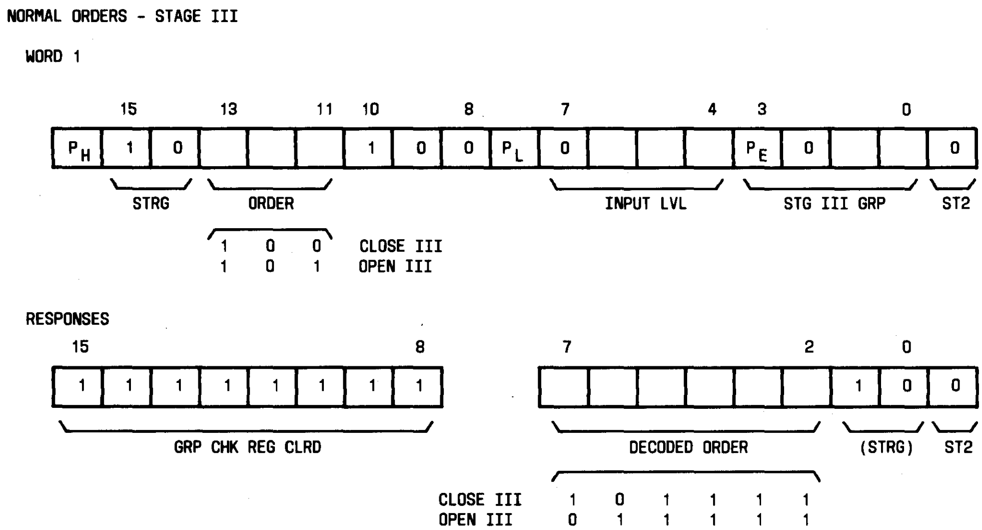


Fig. 23—Normal Orders—Stage III (Word 1)

to one switch, as shown in Fig. 14, in order to close the desired crosspoint. Here the PNPN path has been enabled to line 6 via the decoded output switch selection. The input switch selection has been decoded to select one input switch by applying gate voltage to turn on the PNPN device associated with this switch. The decoded input level selection has turned on the proper PNPNs to complete the pulse circuit to the negative side of the pulser via line 3. The PNPNs provide coincidence-current in the remreed coils at the crosspoint shown in Fig. 14 when the circuit is pulsed.

4.19 Before the pulser is turned on, it must be determined that only one path is selected. The resistance to ground is monitored to determine that the 1/N selection was made (proper current value). The group check circuits and the PNPN gate supply must be on. The stage I, II, and III crosspoints and group checks are all made in a similar manner, utilizing the proper decoded bits to set up the proper PNPN pulse paths.

5. POWER

THEORY OF OPERATION—POWER AND ALARM CIRCUIT

5.01 ***Power Requirements:*** Power for the switching network is obtained from the control frame. (See Fig. 28).

5.02 ***Power and Alarm Circuits:*** The +3 volt power converter J87389F, +3 volt power reference and filter circuit pack (FC21), and one +12 volt power reference circuit (FB152) are supplied in the peripheral control unit. The -48 volts supplied by the power plant to the control frame is converted by the converter J87389F to the +3 volts required by the network.

5.03 All the circuits in a peripheral control unit have their own power system: two J87389F, +3 volt power converters; one FC21, +3 volt power reference and filter circuit pack; and one FB152, +12 volt power reference circuit pack. The power system also distributes +24 volts, +3 volts, and ground (GRD) to the peripheral controllers circuit packs via the multilayer printed wiring boards (MLPWB) (Fig. 6). The control frame circuit also provides +24 volts and -48 volts to the two J87389F power converters.

5.04 The control frame circuit provides power control, fusing, and alarms for the peripheral controllers. The power control and alarm circuit consists of four circuit packs: two FB414, 3-volt power control 0 and 1; and two FB415, alarm 0 and 1. Associated with the control frame power is a control panel and two fuse panels. The control panel has three nonlocking (nlk) keys (ON, REQ, and OFF) and two lamps (OOS and PWR OFF) which are duplicated for peripheral controller 0 and 1. The fuse panel contains power fuses for

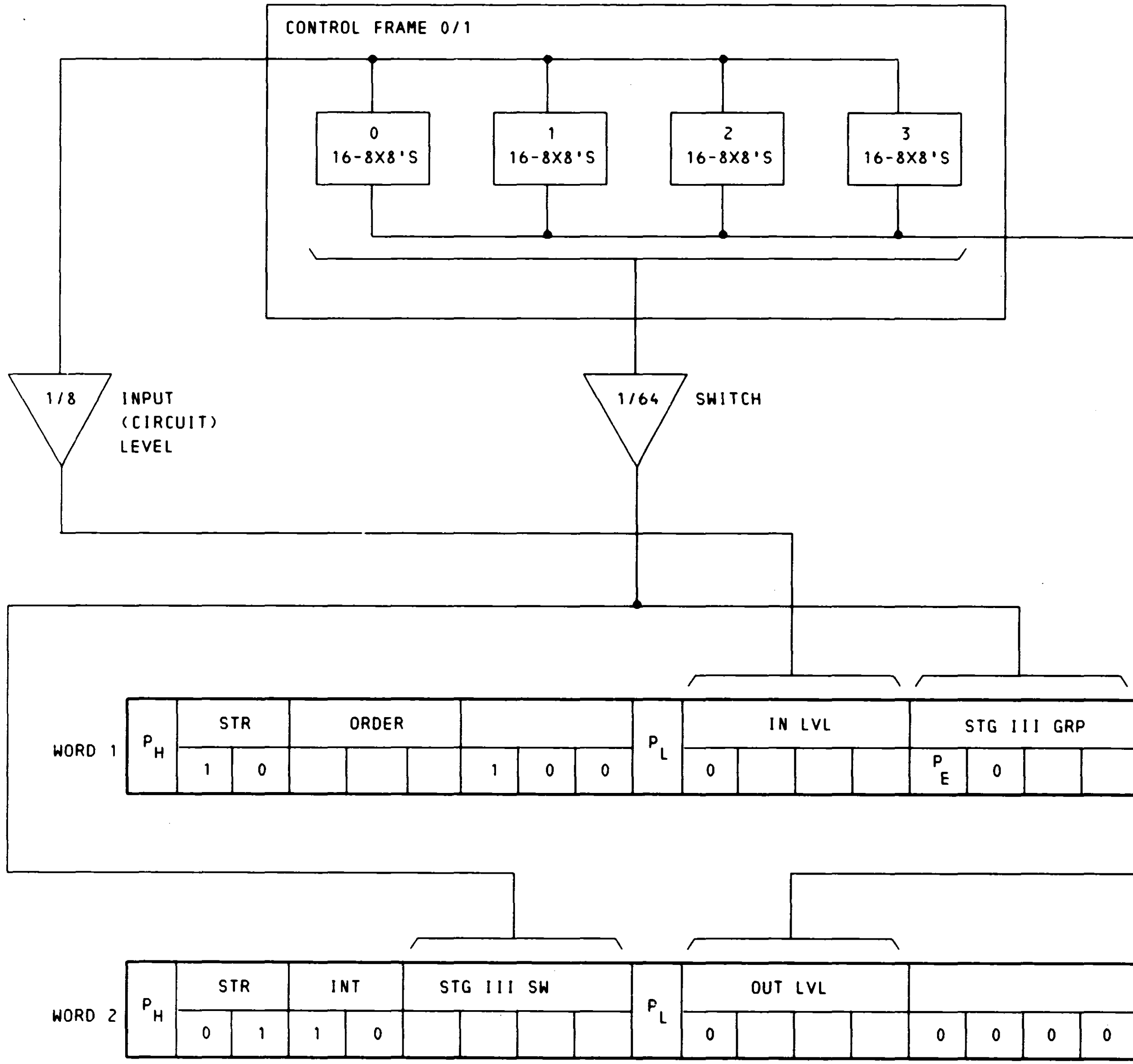


Fig. 24—No. 3 ESS Stage III Path Selection

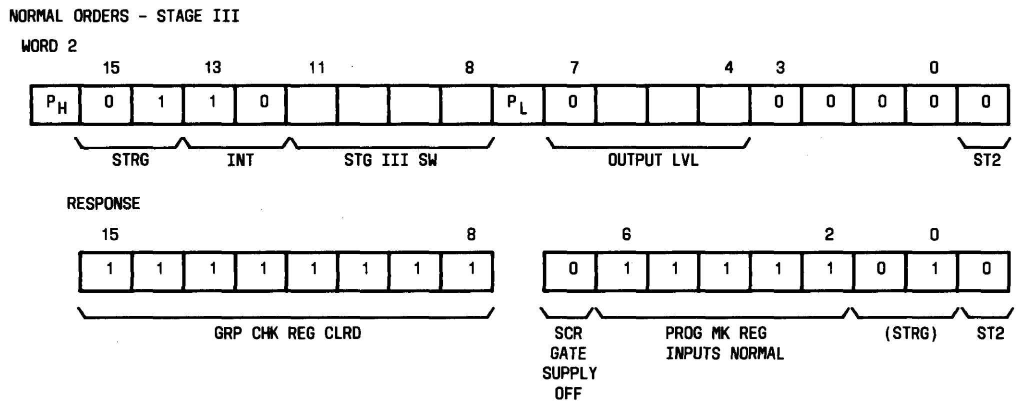


Fig. 25—Normal Orders—Stage III (Word 2)

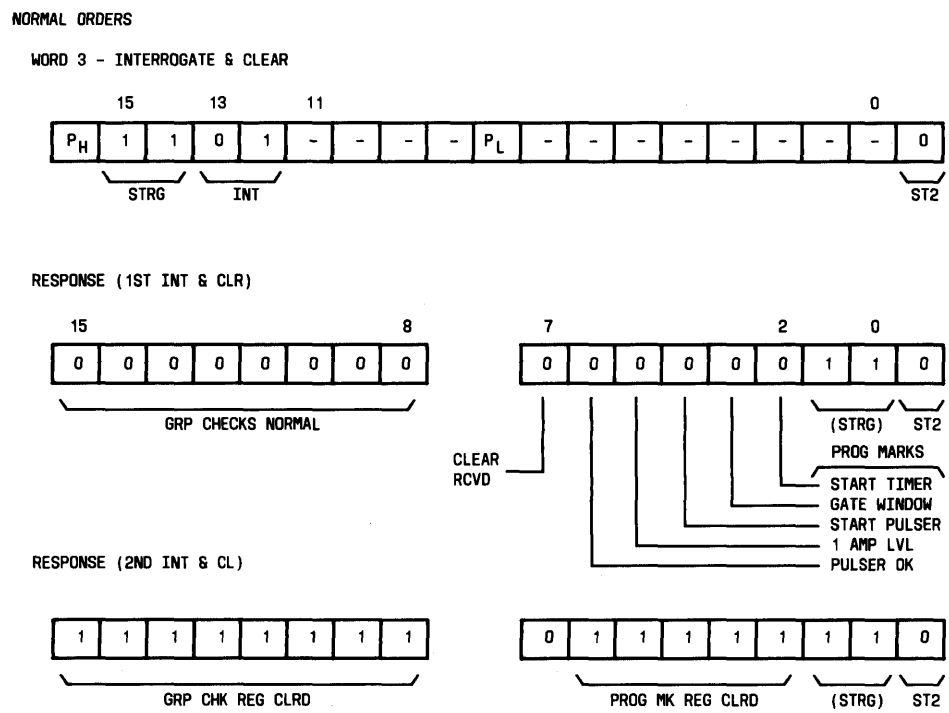


Fig. 26—Normal Orders—Word 3

protecting each controller in the periphery. The control frame circuit (SD-3H902-01) contains the following power-related functional schematics: FS41 - +24 volt power control, fusing, and alarms; FS42 - -48 volt power control, fusing, and alarms; FS43 - power sequencing; FS44 - alarm and test; and FS45 - scan points. The various circuits associated with SYC 0 and SYC 1 are duplicated.

+24 VOLT POWER CONTROL, FUSING, AND ALARMS

5.05 The control frame circuit separately distributes +24 volts to each MLPWB in the peripheral control unit when each PWR relay is operated. Each power lead is fused with a 70-type fuse. When the fuse opens, an auxiliary circuit is completed which provides +24 volts to operate

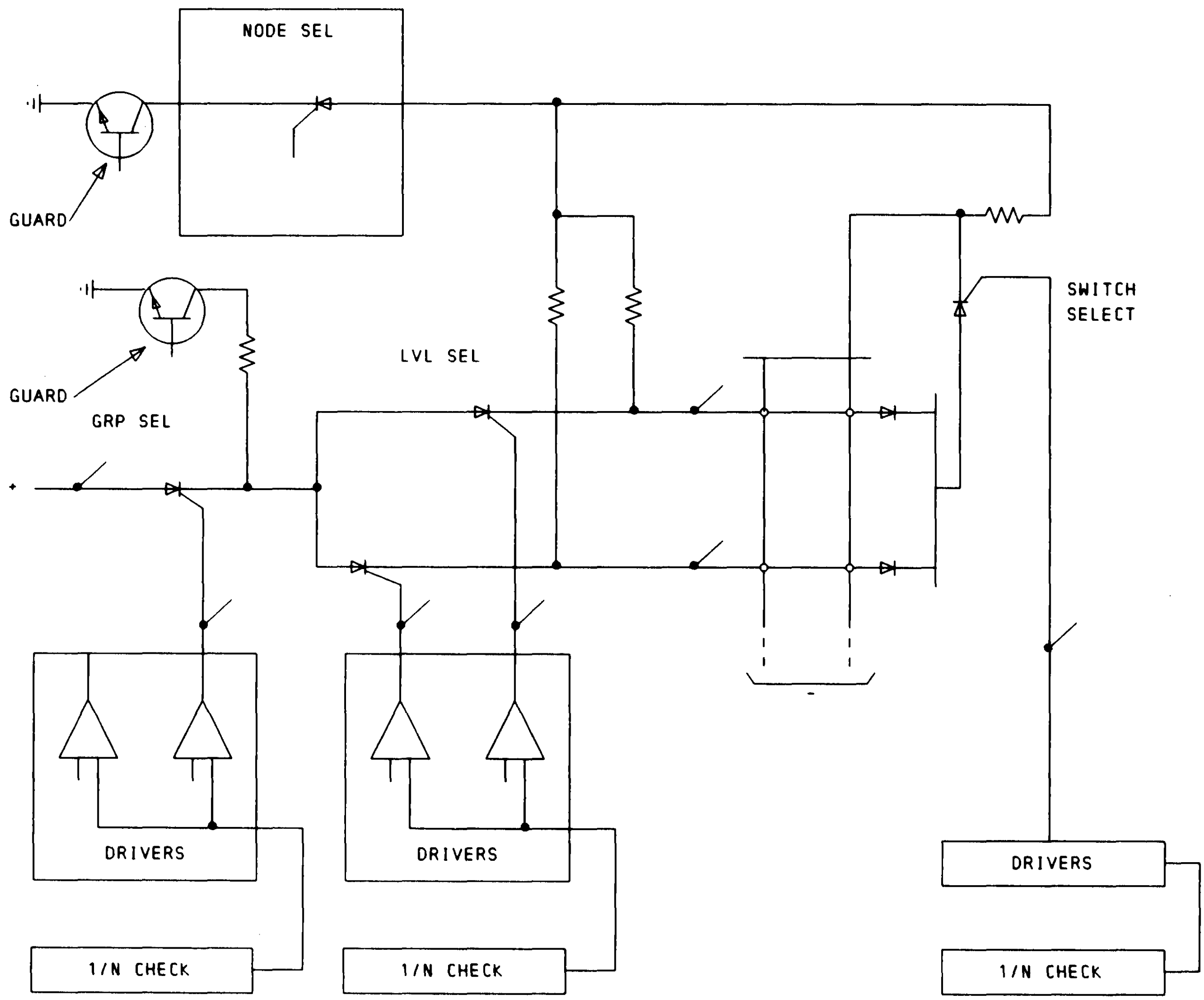


Fig. 27—No. 3 ESS Control Path Group Check

one of the 24FA relays. Separate fuses exist in the fuse panels for peripheral control circuit 0 and 1. In addition to distributing +24 volts to all four J87389F power converters, the control frame circuit starts the converters by switching +24 volts to their 24VST lead. The switching occurs under the following conditions: The 24ST relay operated, the 24FA relay released, and the 48FA relay released.

-48 VOLT POWER CONTROL, FUSING, AND ALARMS

5.06 The control frame circuit separately distributes 48 volts to a large number of individually fused circuits in the periphery. If a fuse opens, the auxiliary circuit operates one of the 48FA relays or one of the SFA relays. The 48FA relays are only operated by the fuses on the lines distributing -48 volts to the J87389F power converters. An open fuse in any of the remaining -48 volt fuses will cause the SFA relays to operate.

POWER SEQUENCING

5.07 Each set of J87389F power converters is started by depressing the associated ON (nlk) key on the control panel which provides a ground path to operate the associated 24ST relay. The associated set of power converters must supply +3 volts to a transistor circuit before it provides a ground path to operate the appropriate PWR relay. This relay keeps the 24ST relay operated

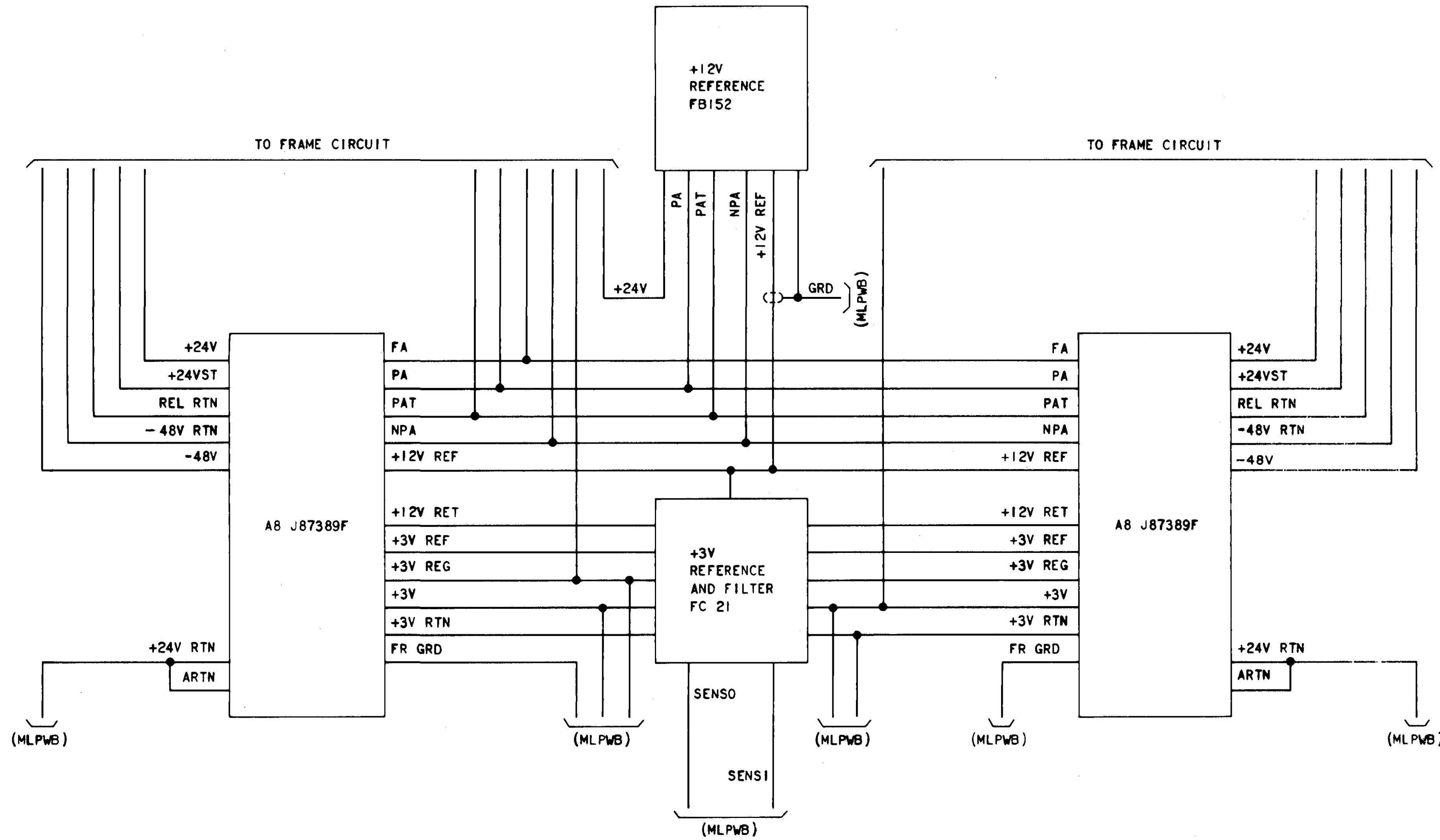


Fig. 28—+3V and +24V Power Distribution

after the ON (nlk) key is released. The PWR OFF lamp is extinguished while the (out-of-service) OOS lamp remains lighted. When the REQ (nlk) key is depressed, the request ferrod scan point notifies software to run diagnostics on the peripheral controller. Once diagnostics are complete, the controllers are restored to service. The OOS lamp is extinguished when the peripheral decoder releases the OOS relay. The circuitry for removing power operates much in the same way. When the REQ (nlk) key associated with the off-line peripheral controllers is depressed, software responds by removing the controllers from service and lights the OOS lamp. Once the OFF (nlk) key is depressed, a transistor circuit releases the PWR and 24ST relays. The PWR OFF lamp is lighted and J87389F power converters are disabled. Should emergency removal of power be required, depressing the REQ (nlk) key and OFF (nlk) key simultaneously will force the J87389F power converters to be disabled and the +24 volts to be removed from the peripheral controllers.

ALARM AND TEST

5.08 The lamp circuit has a lamp test capability. Depressing the LP & PWR TEST (nlk) key closes a circuit path to light both sets of OOS, PWR OFF, and FA lamps. Individually, the OOS lamp is lighted with the OOS relay operated; the PWR OFF lamp is lighted with the PWR relay released; and the FA lamp is lighted with the 24FA, 48FA, or SFA relay operated. The alarm circuit has the capability for a number of different alarms. The J87389F power converters have an overvoltage and overcurrent (fuse alarm) FA signal. This FA signal is sent to the alarm circuit where a transistor switch operates the CFA relay. The alarm circuit keeps the CFA relay operated until released by depressing the LP & PWR TEST (nlk) key located on the peripheral control panel in the control frame. This is necessary since the loss of one converter will shut off all power to one peripheral control circuit. The J87389F power converters and the FB152 reference board also have an out-of-voltage limits (power alarm) PA signal. Similarly, this PA signal is sent to the alarm circuit where another transistor switch operates the CPA relay.

5.09 The alarm circuit has the facility for power alarm test (PAT). The system, via the peripheral decoder, operates the PAT and OOS relays. A PAT signal is sent to the set of J87389F power converters and the FB152 board. These should respond by operating the CPA relay and thus unsaturating the PA scan point. In the alarm circuit the NPA relay operates only when a J87389F or an FB152 fails to give a PA. The NPA relay then keeps the PA scan point saturated. As the PAT relay is released, a ground is briefly applied to the NPA leads of the J87389F converters and FB152 reference board to extinguish the light emitting diodes (LEDs). When the OOS relay is released, a PAT signal can be generated by depressing the LP & PWR TEST (nlk) key. When the key is released, a ground is sent to extinguish the LEDs. When there is no PA, the associated LED fails to light. Scan points are not affected by a manual PAT.

SCAN POINTS

5.10 The scan point circuit contains three ferrods which are concerned with power control and alarms. The state of certain relays and keys determines whether current flows in the ferrod control windings. The request ferrod is saturated with the 24ST relay operated and the REQ (nlk) key released. The power alarm ferrod is saturated with the 24ST relay operated and any of the four following conditions: the LP & PWR TEST (nlk) key depressed, the REQ (nlk) key depressed, the NPA relay operated, or the CPA relay released. These two ferrods are encoded into four states (OFF, REQUEST, ON, and POWER ALARM).

When both ferrods are unsaturated, the state is OFF. With the REQUEST ferrod unsaturated and the POWER ALARM ferrod saturated, the state is REQUEST. When both ferrods are saturated, the state is ON. Finally, with the REQUEST ferrod saturated and the POWER ALARM ferrod unsaturated, the state is POWER ALARM. The major control alarm ferrod is saturated with all three CFA, 24FA, and 48FA relays released. All three ferrods are duplicated for peripheral controllers 0 and 1.

6. MAINTENANCE

INTRODUCTION

6.01 Maintenance of the No. 3 ESS network is controlled through system software. During execution of normal orders, maintenance checks are being made when the responses are returned and checked for validity. A maintenance order can also be issued to start the pulser into a dummy load. The pulse characteristics can be monitored across a resistive load without affecting any crosspoint. Maintenance orders can be issued which do not initiate crosspoint closure by inhibiting the pulser before it is pulsed into the network. This provides a means of checking operation without interfering with normal call processing.

CALL PROCESSING

6.02 After a complete or partial network tip and ring path is established, the path is tested for possible crosses and/or shorts to ground. The FCG test is performed through the test vertical in the selected switch.

6.03 A PX test is normally performed on a tip and ring network path, via a test vertical, after the FCG test. Customer lines and trunk facilities are checked during this test.

6.04 An RV test is made via the test vertical to ensure that a previously active customer line has been returned to a normal state when disconnect has occurred.

6.05 When the necessary network action is completed to provide the network path as predetermined from the network order, a pulser check is made. The pulser returns a pulse, indicating that the pulser check circuit has made a successful integrity check of the network control path.

6.06 The network controller is duplicated, and each is dedicated to a particular 3A CC. If a network controller develops a problem as indicated by invalid information returned to the 3A CC, an SYC switch becomes necessary. This is the only duplicated area in the network.

FAILURE INDICATIONS

6.07 In the event of failure returns to the network controller, the controller stops and retains all stored information. On the next interrupt cycle, the 3A CC sends an interrogate order to the network controller. The network controller responds with an indication as to whether the network order was properly executed; eg, results of group checks. This order clears the network controller, and it is ready to accept another network order.

6.08 Visual indications are given on the system status panel in the event of a system control switch due to network controller problems. The TTY provides various messages, indicating that the faulty network controller was removed from service. An audible alarm may also be sounded.

7. REFERENCES

7.01 The following list of Bell System Practices is related to this section:

Section 966-210-100—General Description, No. 3 ESS

Section 233-110-100—3A CC Description

Section 233-121-110—FIOC Description

Section 233-130-100—Power Equipment Description

Section 233-142-100—TOP Volumes

Section 233-110-000—Control Complex Description

Section 233-110-200—Control Complex Theory.

8. GLOSSARY

8.01 A glossary of terms is provided to aid in understanding definitive words used in this section.

Audible Ring—The ringing tone which is passed from the ringing circuit in the central office via the junctor to the calling party.

Coincident—When a column and a vertical within the same remreed switch are activated, the common remreed crosspoint is closed.

Concentration—The function usually associated with the first stages of a switching network and characterized by configurations possessing fewer output terminals than input terminals. This function is provided to improve network efficiency when the input terminals carry a light traffic load.

Crosspoint—A 2-state switching device possessing a low impedance in one state and a very high impedance in the other.

Link—The connection between terminals on one switch and terminals on a switch in the next stage corresponding to a single network path.

Matrix—Rectangular arrangement of elements into rows and columns.

Network Fabric—Physical makeup of the remreed switching network.

Overflow Tone—A tone circuit is connected via the junctor to provide overflow tone to the calling party, indicating that a network path is not available.

Parity Bit—A bit which can be varied to ensure that a given number of bits contain an odd or even number of ones (odd or even parity).

Stage—Those switches in a switching network which have identical parallel functions.

State Relay—Miniature wire-spring relays which provide the critical functions in trunk, service, line, and junctor circuits.

Supervision—Monitoring the status of the calling party at origination for possible return to on-hook condition and, once the call is completed, monitoring the status of both calling and called line for disconnect.

Switch—A rectangular array of crosspoints in which one side of the crosspoints is multipled in rows and the other in columns.