

D1 ALARM AND CONTROL CIRCUIT AND ORDER WIRE CIRCUIT GENERAL DESCRIPTIVE INFORMATION

CONTENTS	PAGE
1. GENERAL	1
A. Scope	1
B. Functions	1
C. Description	1
D. Supplementary Information	4
2. OPERATING PRINCIPLES	4
A. General	4
B. Alarm and Control System	4
C. Order Wire	8
D. Transmission Aspects of Over-all System	10
3. EQUIPMENT ELEMENTS	13
A. General	13
B. Main Station Unit	13
C. Substation Unit	14
4. METHOD OF OPERATION	17
A. General	17
B. Orders	18
C. Automatic Identification and Scanning	22
5. MAINTENANCE	26
A. Transmission Circuits	26
B. Signaling Circuits	26
C. Relay Circuits	26
6. GLOSSARY	26

1. GENERAL

A. Scope

1.01 This section describes the D1 alarm and control system and associated order-wire arrangements used for operation and maintenance of short haul microwave radio relay systems.

B. Functions

1.02 This system has three functions:

(a) To transfer detailed alarm and supervisory information from unattended radio stations to an attended point called an alarm center.

(b) To transmit remote control signals from the attended point to the unattended stations.

(c) To provide the telephone order circuit facilities for voice communication between stations.

1.03 This system is similar in function and application to the C1 alarm and control system and associated order circuits used with the TD-2 radio system. The primary application of the D1 system is to the TJ radio system, but it is also applicable to other short haul microwave systems, including those of non-Western Electric manufacture. Since it is used with short haul radio systems, the D1 alarm and control system provides a substantially smaller number of alarms and control functions than the C1 alarm and control system.

C. Description

General

1.04 Fig. 1 shows a typical geographical layout of a short haul radio relay system and associated alarm, control, and order circuit facilities. Most radio stations of such a system are operated on an unattended or partially attended basis. Because of this, facilities are required for reporting trouble conditions that occur in these stations to an attended alarm center. Facilities are also required for remote supervision and control of equipment at the unattended stations. All radio stations, the alarm center, and certain other points are re-

This material is for the use of Bell System employees only, and for Bell System purposes only, and its distribution is in no sense a publication. Neither the material nor any portion thereof is to be reproduced in any form without the written permission of the American Telephone and Telegraph Company.

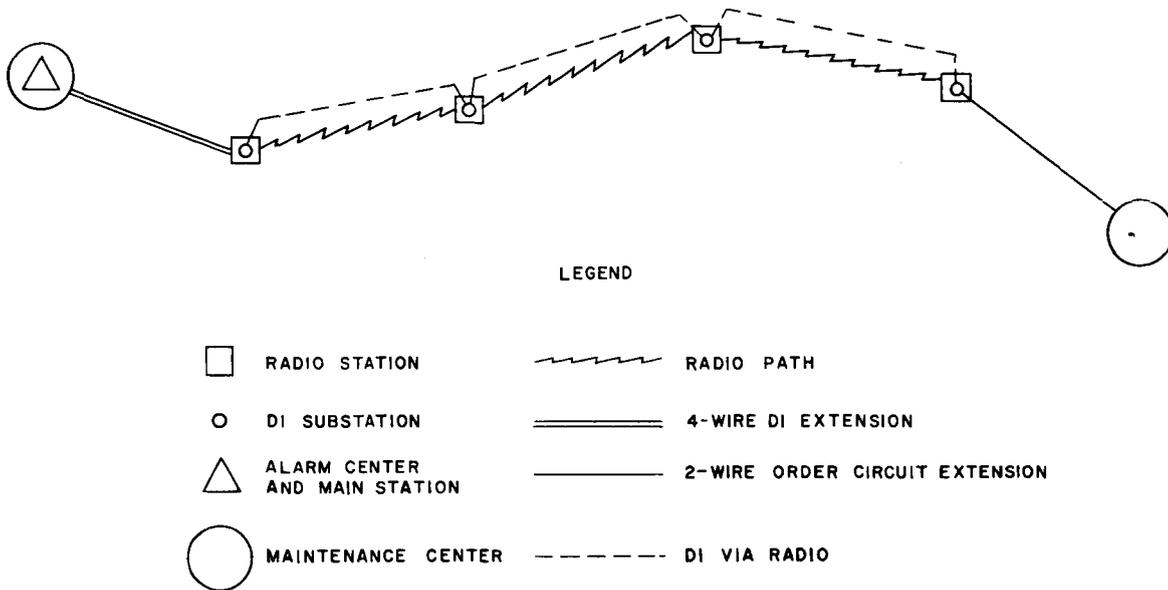


Fig. 1 – Typical Geographical Layout of Alarm, Control, and Order Circuit Facilities of Short Haul Radio System

quired to be linked by an order circuit for voice communication between stations. The personnel assigned to maintain a group of stations have headquarters in a maintenance center, which may be at the same location as an alarm center or at any other location convenient to the radio route.

1.05 The equipment associated with the order-wire, alarm, and control facilities located in an alarm center is called a main station; the corresponding equipment located in an unattended radio station is called a substation. An alarm section comprises a main station together with the several substations under its control. The maximum number of substations that can be associated with a given main station is seven. The various substations along a radio route are interconnected by 4-wire line facilities, and must be arranged in a straightforward string fashion. The substation farthest from the main station is designated the far-end substation. All others are called intermediate substations.

Line Facilities

1.06 The signaling for this system is on an in-band, single-frequency, ac basis. The same 4-wire, 2-way channel that comprises the order circuit carries the alarm and control signaling. Line facilities therefore may be physical or car-

rier wire circuits, radio circuits, or combinations of these, but must not have excessive roll-off above about 2800 cycles. When short haul radio systems of the remodulating (base-band) repeater type such as the TJ radio system are used in telephone message service, the alarm and order circuit normally is derived from the voice-frequency (vf) part of the radio base band on a drop-and-reinsert basis, by means of split-apart filters, with wire-line extensions as required. This type of layout is indicated in Fig. 1.

Alarm and Control

1.07 In this system, the basic mechanism for transmission of alarm and control information is the action of relay and rotary selector switch circuits at the attended and unattended points, together with an interchange of vf tone signals between these circuits. Single frequency (SF) signaling circuits of the standard type used on trunks provide means for passing signals between stations. The 2-way signaling path, shown in Fig. 2, is in the form of a party-line loop, beginning at the main station signal transmitter, passing through each substation on the outgoing path of the order circuit, passing through each substation again on the incoming path of the order circuit, and ending at the main station signal receiver. The loop normally is closed at the far-end substation. The main

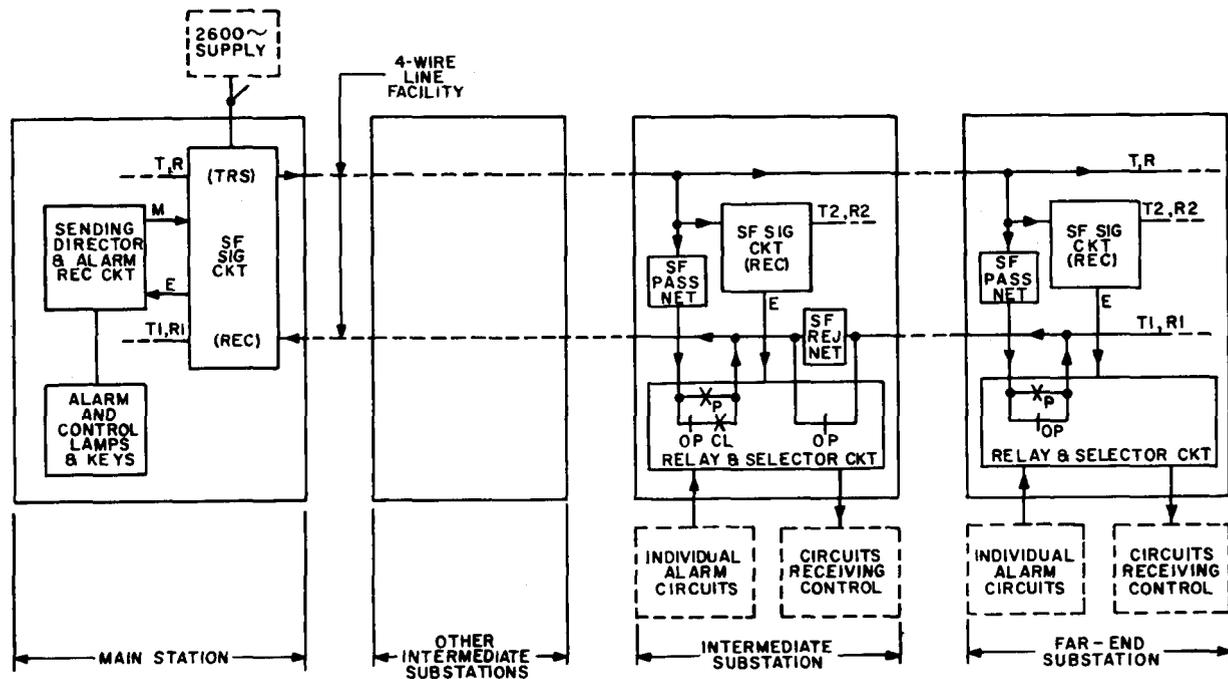


Fig. 2 – Simplified Schematic of Alarm and Control Signaling System

station transmits signals to the substation in the form of dial-pulse code digits. Signal receivers are bridged onto the outgoing path at each substation. Substations interrupt the incoming path of the signaling loop to signal the main station. Other signals from substations toward the main station are in the form of reverted pulses.

1.08 Alarms: When an alarm condition arises at an unattended station, the main station sending director circuit is called into action automatically to identify the station at which the trouble occurred and to check the status of all of the individual alarm circuits at that station. This action results in the lighting of a lamp display at the main station that identifies the unattended station and indicates the status of its alarm circuits; it also effects the operation of major or minor audible alarms in the office in which the main station is located. A maximum of 18 distinct alarm functions may be assigned to each radio station. In addition to the alarms, six indications are provided at each unattended station. These indications differ from the alarms in that they do not represent troubles and do not register at the main station unless an order is sent to the substation. On TJ radio systems these functions are used to remotely supervise the status of diversity switching circuits. The

alarm system is self-alarms in the event of failure of the alarm line or substation equipment.

1.09 Controls: Remote control signals (orders) are transmitted to a substation by operating keys, which control the action of the sending director circuit. This process is in two steps: (1) selective signaling of the particular station to which the order is directed, and (2) signaling that performs the desired function at that station. Five orders are used to perform certain functions which are part of the internal operation of the alarm and control substation circuits. For example, the status of the individual alarms at a substation may be verified at will by sending the order alarm scan to that station. A maximum of five additional orders are provided to control various operations in the radio station, such as starting the emergency engine-alternator.

Order Wire

1.10 The order wire provides a means of voice communication among the various stations of a radio route. Although intended primarily for service between radio stations and between these stations and maintenance or alarm centers, as shown in Fig. 1, the order wire may

be extended to other stations off the radio route. Each substation and the main station are equipped with a telephone set circuit and a loudspeaker for voice communication on the order circuit. Voice calling to loudspeakers is employed between all stations, but substations normally ring down the main station by a process similar to the station identification involved in transmitting alarms. The same line facilities used for alarm and control signaling comprise the talking path between stations.

D. Supplementary Information

1.11 General descriptive information concerning the SF signaling system for toll trunks, which has been adapted to the D1 alarm and control system, is covered in Section 975-215-100.

2. OPERATING PRINCIPLES

A. General

2.01 The alarm and control system is functionally distinct from the order wire, although there are common circuit and transmission aspects, and common equipment and line facilities. In this part, the alarm and control system and the order wire are treated first as separate entities; transmission aspects of the over-all system then follow.

B. Alarm and Control System

General

2.02 Alarm reporting and remote control is fundamentally a signaling process, since signaling may be broadly defined as the act of effecting control or passing information from one point to another. Practical signaling techniques allow only a relatively small number of different types of signals. In this system only two are used, tone-on and tone-off. A single signaling frequency is employed. To represent the quantity of information required, it is necessary to encode the information and transmit it over the signaling medium in sequence. Alarm information and information used to effect control is encoded and interpreted by relay and selector circuits that are joined to signaling circuits. The signaling circuits in turn provide the means of passing signals between stations. There are thus these two aspects of system operation: (1) signaling circuits and the techniques of passing

signals between stations, and (2) the relay circuits of the main station and substations and their functions.

Signaling

2.03 SF signaling circuits of the standard type used on trunks provide the means of passing signals between stations of the alarm and control system. Certain departures from the standard method of application of SF signaling are necessary in this system; however, to clarify the signaling principles of the alarm and control system, there follows a brief description of SF signaling as it is used on trunks.

2.04 The SF signaling system is designed to pass signals over the vf line facilities between the terminals of telephone trunks without mutual interference between signaling and speech transmission. The system accepts and delivers signals in dc form on the trunk relay circuit side and transforms them to and from ac form on the line side. A single distinctive frequency in the voice band is employed for one direction of signaling. Signal tone (2600 or 2400 cycles) is applied or removed at one trunk terminal to operate or release a relay at the far end, thereby providing two alternate signal conditions. Steady tone is applied to the line when the trunk is idle and removed when it is busy. This choice of signal conditions enables continuous signaling for reliability without conflict between voice and signal transmission, because speech and signal transmission normally are not required at the same time. The additional signals in the form of pulses required to set up a call after the trunk is made busy cause no conflict for the same reason. The guard channel principle is employed to avoid false operation of the signal receiver. Such false operation may be caused by signal frequency present in speech to which the receiver is exposed because of its necessarily continuous association with the line. The guard channel uses frequencies outside the signal frequency. The SF terminal inserts a narrow band-elimination network centered on the signaling frequency in the voice path when the receiver is operated, in order to confine the signal tone within the trunk. Normally, when speech is present, tone is off; for this signal condition the network is removed and has no effect on voice transmission. On the few occasions when speech and signal frequency are on the line together, the network causes a slight im-

pairment of voice transmission by attenuating signal frequencies present in speech along with the signal itself.

2.05 Although 2600-cycle SF signaling units are used without modification in the alarm and control system, the manner of use differs somewhat from the situation on trunks just described. A simplified block diagram of the signaling arrangement is shown in Fig. 2. It is impracticable to set up an exclusive signaling path or link between the main station and each of the plurality of substations. The main station, therefore, transmits information to all substations on a broadcast basis. All substation signal receivers, which are bridged on the outgoing line, are operated or released together by application or removal of 2600-cycle tone by the main station signal transmitter. Signal frequency of 2600 cycles is also used to signal from substations toward the main station, since line facilities are 4-wire. However, the use of common signal frequency in this direction imposes the constraint that substations must signal the main station individually and sequentially.

2.06 Depending on the function being performed, signaling may be either one-way or 2-way. Purely control functions require only that information be transmitted from the main station toward the substations. The method used to transmit alarm information, however, employs 2-way signaling in the form of reverting pulsing. In either case signals from the main station toward the substations are in the form of dial-pulse code digits. Substations respond by reverting certain of these pulses if alarm information is to be transmitted to the main station. Pulses are reverted at a substation by closing a path from outgoing line to incoming line at the appropriate time under control of the substation relay circuit. This path includes a selective network that passes signal frequency while attenuating other frequencies in the vf band.

2.07 In the normal state of signaling, continuous tone is applied to the outgoing line at the main station. This holds all substation signal receivers operated. Under these conditions the reverting path is closed at the far-end substation and open at all others. As a result, signal tone traverses the entire loop and holds the

main station receiver operated. The main station interprets initial release of its signal receiver as an alarm alert and acts to identify the trouble by reverting pulsing. Substations initiate an alarm alert by blocking the tone as it passes through the station on the incoming line. Tone is blocked by insertion of a 2600-cycle band-elimination network in the line under control of the substation relay circuit. Any interruption of the loop by a line fault also acts as an alarm alert. After all alarms have been identified, steady tone is reapplied by the main station. The main station 2600-cycle supply is the only source of signal tone in the system. The closed-loop mode of operation described above is the basis of fail-safe operation of the alarm system.

Relay Circuits

2.08 Operation of the alarm and control system depends on an interchange of information between the relay circuits of the main station and the substations. The main station relay circuits are called the *sending director and alarm receiving circuit*. The corresponding circuit at each substation is called simply the *substation relay circuit*. In addition to relays, both main station and substation circuits include a ten-position rotary selector switch.

2.09 The major functional operations of these circuits are identification, scanning, registration, and selection. These operations are performed in several steps, each of which is associated with the transmission of a particular code digit from the main station. Whenever a change occurs in the status of an individual alarm circuit at a substation, the main station sending director circuit, acting in conjunction with the relay circuits of the substations, automatically *identifies* the station concerned and *scans* all of the alarm circuits at that station. This information is received and *registered* by the alarm receiving circuit at the main station and displayed on lamps. Alternatively, when orders are sent to a substation, the sending director circuit broadcasts a code digit that *selects* a particular substation. All substations receiving nonvalid codes are made nonresponsive to further digits in the series. Subsequent steps depend on the type of order. If the order is to control operations in the radio station, a second digit is sent that *selects* the desired order function, that is, operates a specific order relay at that station. If the order is for the purpose of

checking indications at a substation, the second digit *selects* a particular order relay that transfers six contacts of the selector from alarm leads to indication leads. A third digit is then used to *scan* these leads, which results in *registration* of the indications at the main station on lamps. If the order is to verify the alarms standing at the substation, the second digit, and possibly a third digit (depending on the number of alarms assigned), is used to *scan* the alarms. Orders are initiated by manually operating station keys and function keys which control the operation of the sending director. Table A summarizes the alarm and control features and the operational characteristics of each.

2.10 Identification and Scanning: These operations are performed by a revertive pulsing technique which functions as follows: To identify the station having an alarm, the sending director, in response to an alarm alert (or start signal), starts to transmit pulses. These pulses are passed over the signaling link and advance the selectors at each substation in synchronism with each other and with a locally operated selector at the main station. When the selector at the substation having an alarm reaches a position unique to that station, a relay operates, closing a pulse-reverting path. This causes the next pulse to be reverted to the main station, stopping the pulse generator and operating a station relay and lamp. The particular station relay operated at the main station depends on the position of the main station selector when the pulse is received. The sending director subsequently and automatically scans the alarms at the station identified. Substations whose selectors did not stop on identifying positions are locked out during this last step. Scanning may also be initiated manually by the main station after first selecting the substation. Let it be assumed that the substation has been identified or selected. The second or scanning digit then drives the main and substation selectors through a complete cycle. As the substation selector passes over levels (or bank contacts) 1 through 9, it looks for ground or no ground as determined by the status of the individual alarm circuits and alarm relays associated with the switch. Each ground causes the pulse-reverting path to be closed momentarily, so that the following pulse is reverted to the main station. These pulses are received by the alarm receiving circuit of the main station. By commutative action of the se-

lector therein, the particular pulse or pulses reverted are registered on relays; these light alarm lamps corresponding to the alarms standing at the substation.

2.11 Selection: One or more steps of selection are involved in the transmission of orders. The first step of selection is for the purpose of gaining access to the desired station. Each substation is assigned a distinctive number code. Operation of a station key causes the sending director to pulse the code number of that station. This drives all substation selectors to the position corresponding to this code. When the selector at the wanted substation stops at this position, relays operate that prepare the substation circuits for reception of subsequent order digits. When the selectors at all other substations stop on this position, a lockout circuit is operated to make the relay circuits at all of these stations nonresponsive to further digits for the duration of the call. All selectors restore to normal during the first interdigital interval. If an order relay is to be operated after having gained access to the substation, a second step of selection follows. This step is initiated by operating the appropriate order-function key at the main station, causing the sending director to pulse a code corresponding to the desired function. These pulses drive the substation selector to the position corresponding to the function. When the selector stops on this level an order relay operates, which in turn provides operating ground to execute the desired control at the remote location. This relay optionally supplies steady or momentary ground to the circuit to be controlled. After the order relay operates, the sending director and all substation circuits restore to the idle condition.

2.12 Whenever the sending director is called into operation, the main station SF transmitter first removes tone for a timed interval. This off-hook or seizure signal is recognized by the substations, which prepare to receive pulsing. Pulsing consists of alternate application and removal of the tone at the main station and directly controls the rotary selector at each station. Pulsing is at the rate of 8 pulses per second. Since this type of selector has ten levels, and since the main station selector is stepped 1 pulse behind the substation selectors, digits are quasi-decimal, that is, 11 pulses are required to complete a full cycle of both selectors. Depending

TABLE A
ALARM AND CONTROL FEATURES AND THEIR CHARACTERISTICS

ORDER	NUMBER OF PULSES PER DIGIT			DIGITS OF REVERTED PULSE	VISUAL REGISTRATION (LAMPS)	KEY DEPRESSED		
	1ST DIGIT	2ND DIGIT	3RD DIGIT			1ST DIGIT	2ND DIGIT	3RD DIGIT (AUTOMATIC)
Alarm Scan	2—8	11	11*	2nd & 3rd	Alarm	Station (1—7)		Scan
Close Loop	2—8	8				Station (1—7)		Close Loop
Indication Scan	2—8	7	11	3rd	Indication	Station (1—7)		Indication Scan
Open Loop	2—8	9				Station (1—7)		Open Loop
Orders 1 through 5	2—8	2—6				Station (1—7)		Order
Roll Call	10	11		2nd	Station	Roll Call		Scan
AUTOMATIC IDENTIFICATION & SCANNING								
Automatic Alarm Scan	2—8	11	11*	1st, 2nd, 3rd	Station Alarm			
Equipment Failure	11				Line Open			
Line Open	11				Line Open			
Service Call	9	11		1st	Answer	Signal Main Station		

* This digit generated only for substations requiring more than nine alarms.

on the type of operation being performed, the number of digits and the number of pulses in a given digit are variable (see Table A). A timed tone-off period is recognized by a substation as the end of a digit or interdigital interval. During this period the selector restores to normal, and response to its operation is transferred from one of the two banks of the selector to the other; or, alternatively, a different set of ten leads are connected to the same bank, the selector being re-used on successive digits as required for the different steps of a given operation. After the required number of digits have been pulsed, the sending director causes the main station SF transmitter to apply steady tone to the line. This constitutes an on-hook or disconnect signal that causes all substations to restore to normal, provided an alarm condition has not originated during the signaling cycle. If a change occurs in the status of alarms at a substation while it is in the off-hook condition, the substation will not attempt to give an alarm alert by blocking tone on the incoming line to the main station, but will store the information until the on-hook condition occurs. This obviates possible interference with pulses reverted by other substations.

C. Order Wire

Transmission Features

2.13 The order wire conforms to the loop configuration of the alarm-signaling path. A schematic representation of the order-wire arrangement is shown in Fig. 3. Substations employ 4-wire telephone sets, the transmitter circuits of which are connected to one side of the 4-wire line and receiver circuits connected to the other. At the main station the two paths, incoming and outgoing, are connected together through a 2-wire bridge having five legs. This bridge also provides the means of connection to the 4-wire main station telephone set and to the toll testboard. Except for the termination in this bridge of the incoming and outgoing paths at the main station, the talking path between the main station and any substation is a straight-forward full 4-wire layout. Since the substation telephone sets are also 4-wire, this layout affords no local connection between transmitter side of the circuit and receiver side of the circuit for sidetone. A talk-back path is provided, however, by the 5-leg bridge at the main station. Substation sidetone transmission is therefore via the same paths as the direct transmission between a substation and the main station.

2.14 The talking path between two substations is coincident with the sidetone path, since at all substations the transmitters are connected to the incoming line and the receivers are connected to the outgoing line. The talk-back path normally is via the main station bridge, but in the event of line faults an auxiliary talk-back path may be enabled at any substation by operating the line-bridging key so as to permit communication between substations, even though they may be cut off from the main station by the fault.

2.15 Net Loss: Since sidetone and direct transmission traverse the same paths and therefore suffer the same transmission loss, it is necessary to operate the system at a net loss such that the talker sidetone level is not excessive and the received volume supplied to the listener is ample. A net loss of 12 db between telephone sets at any two stations has been chosen as such a compromise.

2.16 Singing Margin: Because of the loop nature of the alarm signaling circuit and the order circuit, there exists a potential singing configuration involving the pulse-reverting path of the substations (see Fig. 2 and 3). When the alarm circuit is idle, this path is enabled at the far-end substation to close the alarm loop. During signaling, the reverting path, and thus the loop, is opened at the far-end substation, but may be closed momentarily at any substation (including the far-end one) to revert pulses to the main station. When enabled, any of these paths, the main station talk-back path, and the 4-wire line form a closed loop. However, the net loss around this loop normally is sufficient to provide adequate singing margin. The margin is enhanced by a 2600-cycle band-pass filter in the reverting path in combination with the complementary band-elimination filter in the through-signal path of the SF receiver. The net loss around the loop through these networks is at least 20 db at all frequencies.

Signaling and Order Circuit Interference

2.17 A major problem of in-band signaling is that of mutual interference between signaling and voice communication. On trunks this problem is mitigated by the fact that speech and signal transmission normally are not required at the same time. In the D1 system, however, alarm signaling is essentially independent of

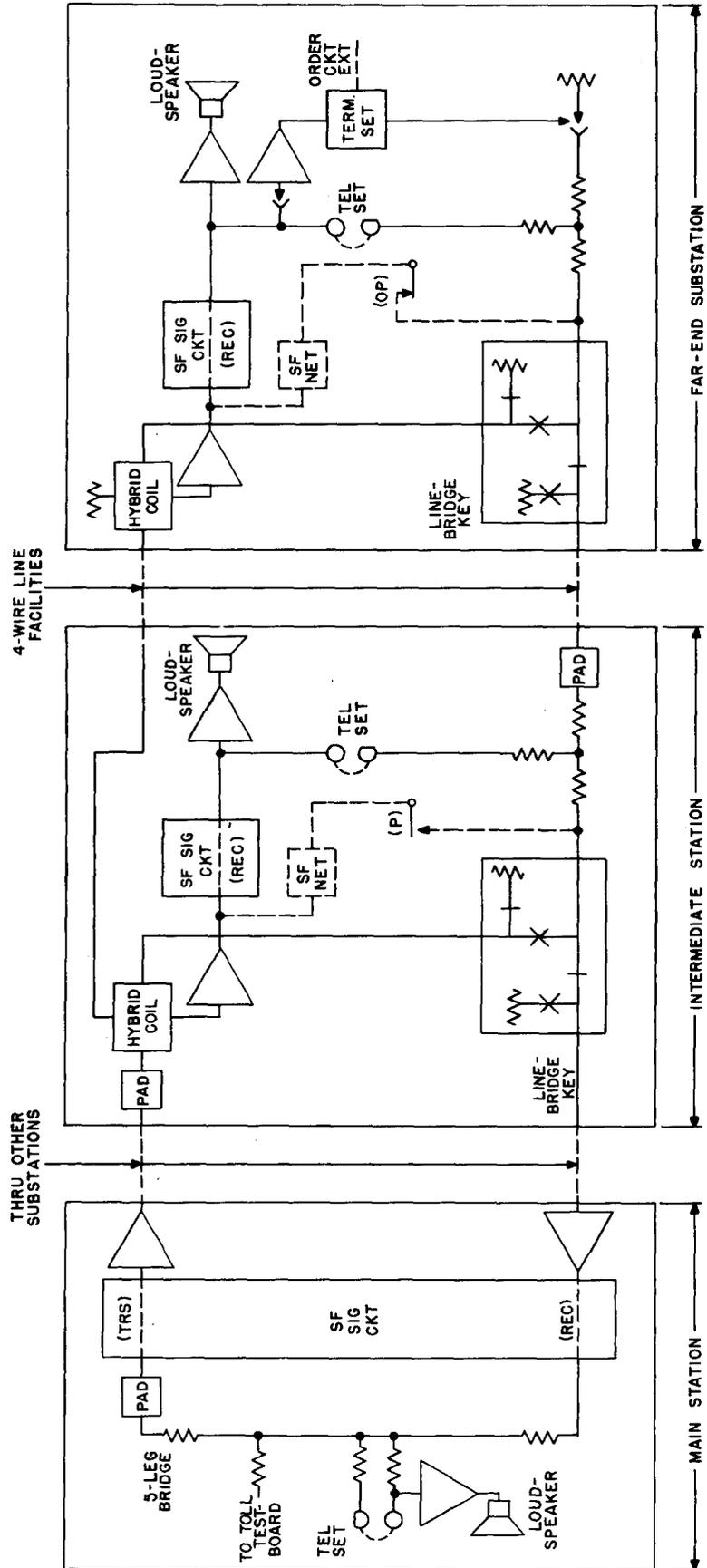


Fig. 3 -- Simplified Schematic of Order Circuit

order-wire communication, and it is necessary to give signaling precedence over calls on the order wire in certain circumstances.

2.18 When no signaling is taking place, continuous tone is present on the line, but is rendered barely audible in the telephone receivers of the order circuit by the through-signal network (band-elimination network) that is switched into the speech path by the SF receiver when the receiver is operated. The interfering effect of this continuous low-level tone is negligible to a listener. A slight distortion impairment results from the attenuation of speech components at or near signal frequency, but this is also considered negligible for an order circuit.

2.19 During alarm and control signaling the tone is pulsed, and in addition the signal power is increased 12 db over the power of the steady tone in the idle condition. The interfering effect of these high-level pulses is too severe for the order circuit to be used for talking at the same time. The intervals during which signaling interferes with calls on the order circuit are short enough that such interference is considered unobjectionable.

2.20 Protection against false operation of signal receivers by voice is provided by the guard action of the receiver in the normal way. During pulsing, additional protection is gained by preventing speech from being introduced on the line. This action is accomplished by disabling the substation telephone transmitter circuit during the pulsing interval by means of the D relay of the substation relay circuit. This relay holds operated over the pulse train but is otherwise released. As explained in 2.19, the order circuit cannot be used for talking during this time in any case, because pulsing is audible in the telephone receiver.

D. Transmission Aspects of Over-all System

General

2.21 An over-all block schematic and transmission-level diagram is shown in Fig. 4. The levels shown in this figure, transmitting to or receiving from the line, are applicable to the case where the line facility is derived from the vf part of the TJ radio base band. As will be discussed, these levels may be altered, where appropriate, for other types of line facilities.

2.22 The 0-db transmission level point is taken as (1) any substation telephone transmitter, or (2) the testboard outlet of the main station talk-back bridge. The order-wire receiving level is uniformly -12 db at every station, except when the substation local talk-back path is enabled, in which case receiving level is 3.5 db lower.

Main Station Levels

2.23 At the main station the SF signal transmitter is inserted at a -29-db level. The normal signal power at the -29-db level is -36 dbm. The C amplifier gain is adjusted to 26 db for a -3-db level on the line. The A amplifier gain depends on the line-receiving level and is adjusted for a 0-db level at the input to the signal receiver. The blocking amplifier in the latter is adjusted (by means of the TL potentiometer) to unity gain.

Substation Levels

2.24 At a substation the level at the A AMP OUT jack is normally -9 db; the corresponding signal tone power is -16 dbm. The gain of the A amplifier is adjusted so that reverted tone on the line incoming to the main station (for example, at the BRDG OUT jack) is of this same magnitude relative to any equal level point on this line.

Other Line Facilities

2.25 As mentioned in 2.21, line levels may be adjusted as appropriate for line facilities other than those derived from TJ radio. Therefore, since the network in the reverting path has a fixed 27-db loss, line transmitting levels other than those shown require a corresponding adjustment of the A amplifier, but in no case should the level at A AMP OUT be less than -12 db. To maintain a uniform level of -12 db at the telephone receiver, the signal receiver blocking amplifier is then adjusted accordingly. The minimum line transmitting level (for example, at the EQPT OUT or BRDG OUT jack) is limited by the gain of the near-end substation B amplifier. The 89-type resistors in the A and B line pads depend on the line levels and take into account the 3.5-db loss of the hybrid, or the telephone transmitter bridge, respectively. An A LEV potentiometer is associated with the telephone transmitter bridge. For any given line

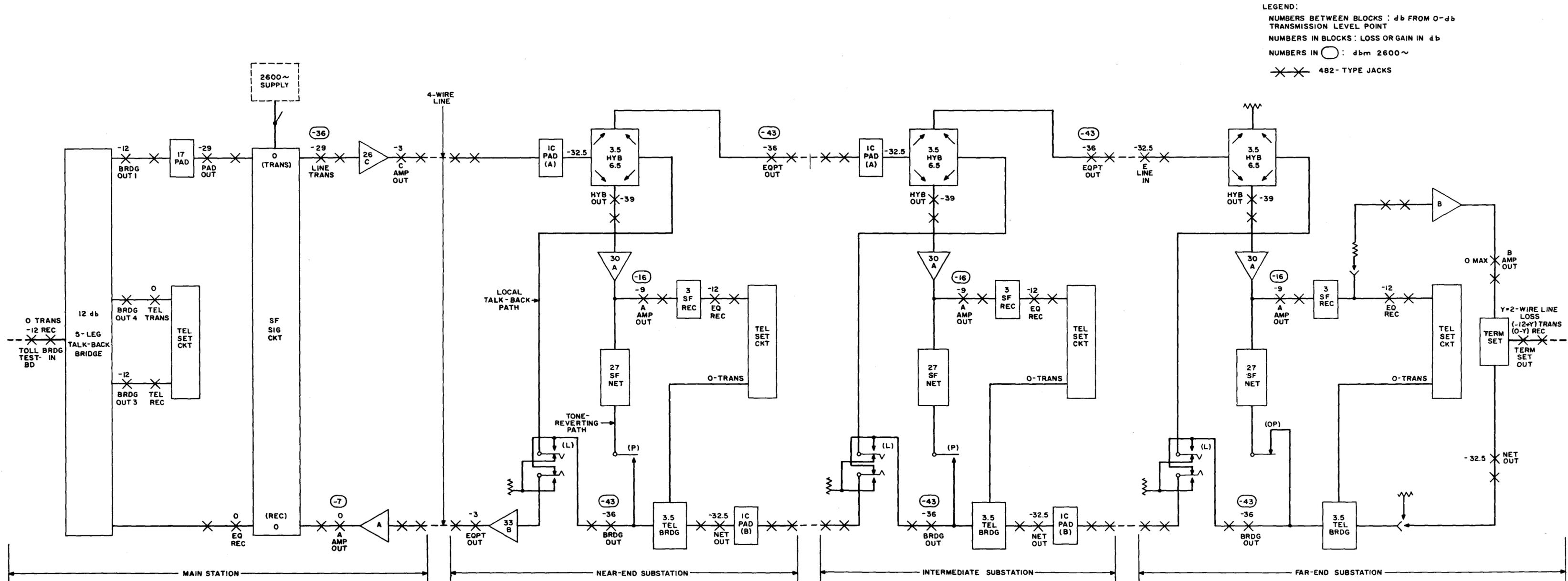


Fig. 4 - Block Schematic and Level Diagram of D1 Alarm and Control Circuit and Order Wire

transmitting level toward the main station, this is adjusted to maintain the transmitter circuit as a 0-db transmission level point.

Two-wire Extension

2.26 At a far-end substation where the talking path is extended 2-wire, the B bridging amplifier and/or the included receiving pad of the terminating set are adjusted as required, depending on the line loss. This loss, together with the 4-wire-line transmitting level, determines the terminating set transmitting pad.

SF Receiver Operate Sensitivity

2.27 The operate sensitivity of the SF receiver is adjusted to -28 dbm, which is the same as required on trunk applications of SF signaling when line facilities are 2-wire and the level at the receiver is $+4$ db.

3. EQUIPMENT ELEMENTS

A. General

3.01 The two major subdivisions of equipment comprising the D1 alarm and control circuit and order wire circuit are the main station unit and the substation unit. The main station unit is located in an alarm center, which is an attended office. It provides the equipment required to transmit orders to and receive alarms from a number of substations and for talking and monitoring on the order wire. A substation unit is located at each of the various unattended radio stations along a radio route. This unit provides the equipment required at these points to transfer alarms to and receive orders from the main station and for talking and monitoring on the order wire.

B. Main Station Unit

3.02 This unit consists of a number of individual assemblies mounted on a pair of special adapters to form a completely assembled unit. The unit is designed to be mounted on a 19-inch duct-type framework on which it occupies a space of twenty-two 1-3/4-inch mounting plates. All individual components are fixed in position except the SF signaling unit, which is arranged for plug-and-socket mounting. This unit is secured to the panel in which it is mounted with quarter-turn, anchored screw fasteners to facilitate removal for maintenance. The

main station is intended to be mounted in miscellaneous rack space and to operate from office battery.

3.03 The principal functional elements of the main station unit are shown in Fig. 5. A front view of the main station unit is illustrated in Fig. 6; the various units incorporated into the frame are indicated in this figure. The sending director and alarm receiving circuit, together with the associated SF signaling circuit, are the heart of the main station. The former consists principally of a number of basic relays plus a rotary selector switch. Associated with the alarm receiving circuit are the station and alarm register relays and lamps. Major and minor alarm leads from the alarm receiving circuit connect to the office alarm circuits. Leads to provide ringing signal to the toll testboard appearance of the order wire are also brought out from the alarm receiving circuit. Station and order-function keys and miscellaneous lamps and keys are associated with the sending director. The sending director is joined to the SF signaling unit by the E and M leads. The 4-wire transmission leads of the SF unit connect to the talk-back bridge on the office side and to line amplifiers on the line side.

3.04 A supply of 2600-cycle signal power is required for each installation of a main station unit but is not a part of this unit. Where available, the same supply oscillators and distribution circuits associated with other 2600-cycle SF equipment in the office are used also to supply the alarm and control system; otherwise a supply oscillator is installed expressly for the alarm and control system on a miscellaneous basis. Normal signal power applied to the line amplifier at the output of the SF transmitter is -36 dbm. A plug-in pad between the talk-back bridge and the SF transmitter permits adjustment of order-wire transmission level in relation to the fixed signal power at the SF transmitter.

3.05 The order wire talking and monitoring circuits consist of the talk-back bridge, telephone set circuit, monitoring amplifier, and loudspeaker. In addition to the main station order-wire appearance, the bridge provides an outlet for extension of the order wire to a toll testboard on a 2-wire basis. The loudspeaker is arranged so that it may be turned on or off with a key as desired. In addition, the loudspeaker is enabled automatically by the sending director

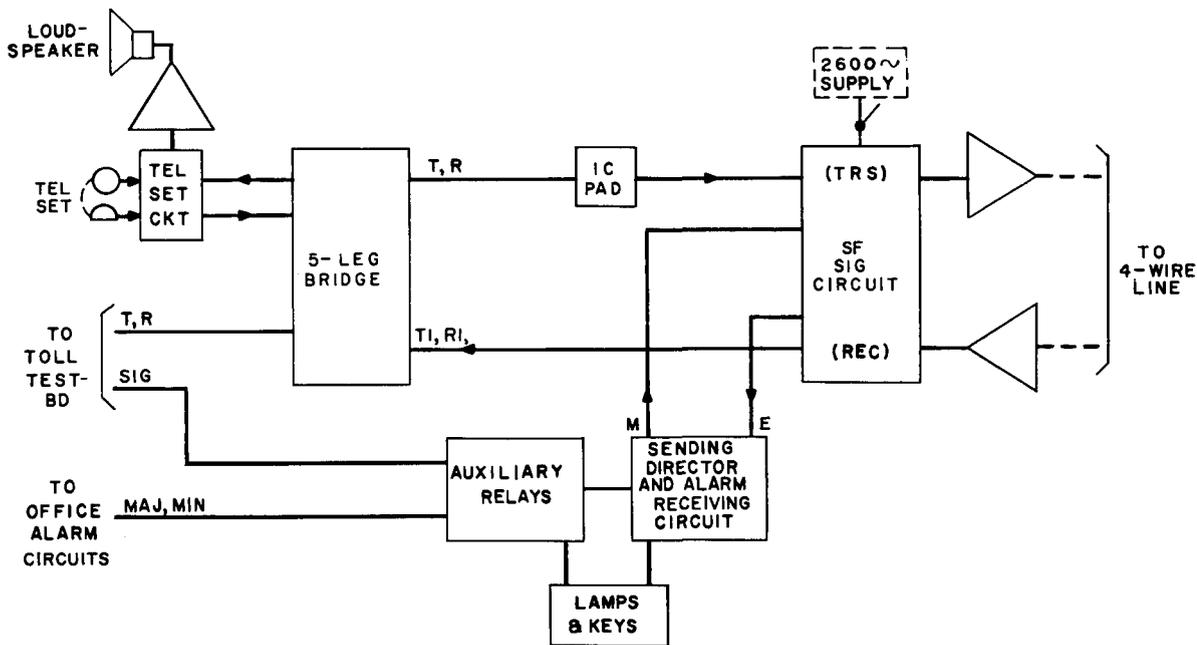


Fig. 5 - Principal Elements of Main Station Unit

whenever an interruption of alarm line continuity, with attendant disabling of the normal means of ringing the main station from substations, is recognized. A number of jacks, not shown in Fig. 5, are provided in the main station transmission circuits for line-up and maintenance purposes. All amplifiers are the same plug-in type used in the V3 repeater.

C. Substation Unit

3.06 This unit consists of apparatus mounted on a 14-1/4-inch by 19-inch panel and box assembly adapted for mounting on standard 19-inch framework. A front view of the substation is shown in Fig. 7. The unit is equipped with slide assemblies to allow single-side maintenance from the front of the bay. An SF signaling unit is part of the substation unit. It is arranged for plug-and-socket mounting and may be removed for maintenance. When the substation unit is associated with TJ radio equipment it is powered by rectifiers. In this case the substation unit and the rectifiers are part of the TJ order wire, alarm, and control bay. The substation unit may be powered by office battery, when available.

3.07 Substation circuits have options that differ according to location of the unit in the system. Since signaling is on a selective basis, each station is arranged to respond to a different

number code for purposes of identification or selection. Normally the substations are numbered in order, beginning with No. 1 for the one nearest the main station. Also, the last, or far-end, substation differs slightly from all other, or intermediate, substations. The far-end circuits are arranged so that the tone-reverting path is normally closed during the idle signaling condition, which is the converse of the situation at the intermediate substations. The order-wire talking path may be extended 2-wire from the far-end substation, in which case a 4-wire terminating assembly external to the substation is used. This assembly, not shown in Fig. 7, requires an additional panel space of 2 inches by 23 inches.

3.08 The block diagram of Fig. 8 shows the principal elements of the substation circuit. Incoming signaling and voice are tapped off the line outgoing from the main station by the hybrid coil and amplified to a level suitable to operate the SF signal receiver and telephone receiver. Up to this point the transmission path is common to both speech and signaling tone. Speech passes through the SF receiver voice path to the order wire monitoring circuit. Tone signals at the amplifier output are transformed by the SF receiver to dc signals on the E lead or, alternatively, enter the tone-reverting path. A

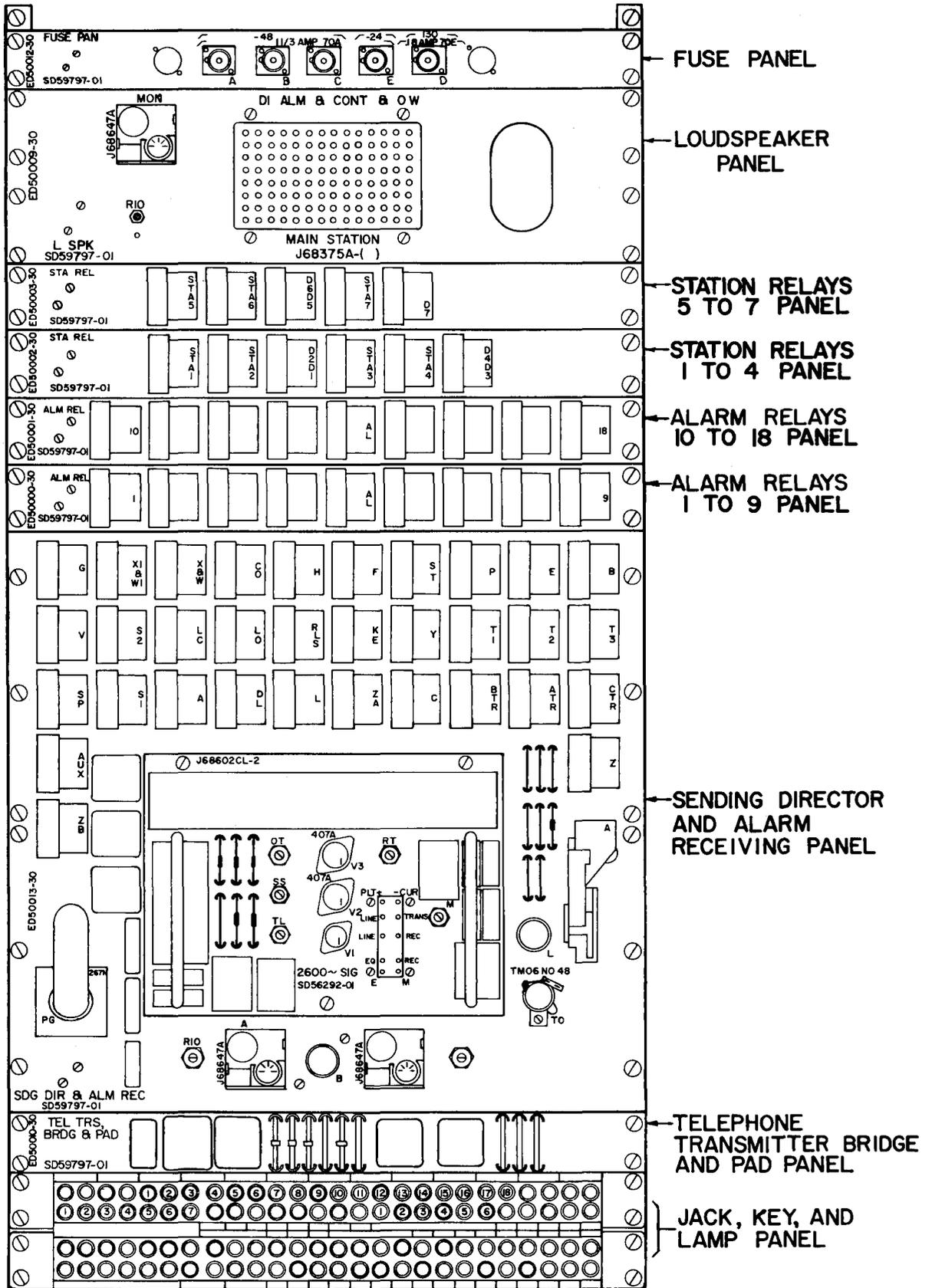


Fig. 6 - Main Station Unit - Front View

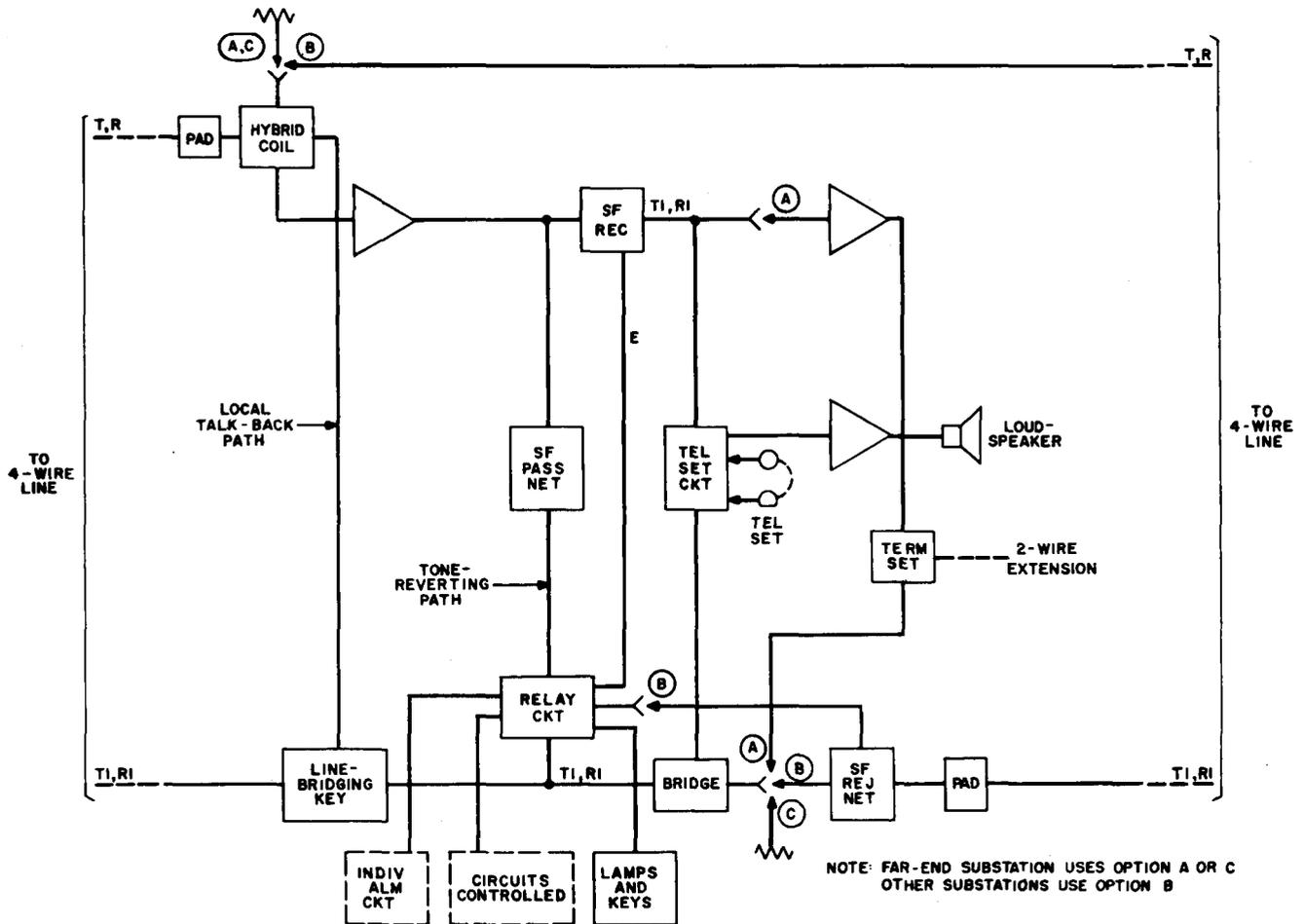


Fig. 8 - Principal Elements of Substation Unit

2600-cycle band-pass network in the latter path attenuates other speech frequencies, and, conversely, a 2600-cycle band-rejection network attenuates signal frequency in the voice path of the SF receiver. At an intermediate substation, voice and alarm tone from outlying substations are combined in a 3-arm bridge with speech generated in the local telephone transmitter circuit. Preceding this bridge is the 2600-cycle band-rejection network, which is switched in to initiate alarm alerts. Following the bridge is the line-bridging key which is used to enable a local talk-back path for the remaining section of the order wire in the event of an interruption of the line toward the main station. A number of jacks, not shown in Fig. 8, are provided in the transmission circuits for line-up and maintenance purposes. Plug-in pads in the 4-wire line allow level adjustments.

3.09 The substation relay circuit comprises a rotary selector switch, a number of basic relays, and the alarm and order relays. To these relays are connected the external individual alarm circuits and circuits controlled. Miscellaneous keys and lamps are associated with the relay circuit.

4. METHOD OF OPERATION

A. General

4.01 This section describes the method of operation of the alarm and control signaling. Operation of the order wire requires no detailed explanation except for the process of signaling the main station from a substation for service calls on the order wire, which is essentially the same as alarm signaling and therefore is covered herein.

4.02 For purposes of description the following somewhat arbitrary distinction is made: Operations in which the action of the sending director is initiated by depressing keys at the main station are described under the heading **B. Orders**. Operations in which sending director action is initiated automatically are described under the heading **C. Automatic Identification and Scanning**. The first category includes not only functions that are purely for the purpose of remote control from the main station, but also those that are for the purpose of checking trouble or supervisory indications. The second category covers all operations that begin with interruption of the alarm loop, and includes detection of a change in status of the individual alarms at a remote station, a fault in the line facilities or substation circuits, and signaling for service calls on the order wire. Table A shows the alarm and control features and the operational characteristics of each.

B. Orders

4.03 The operation of two keys is required to send any order. The first key is associated with gaining access to the wanted station, the second with a particular order function.

Gaining Station Access (First Digit)

4.04 The first step in transmitting an order to a particular substation is gaining access to the station: that is, making the selected station responsive to further signals, while at the same time preventing all other stations from responding by locking them out. An exception to this procedure is the roll call, which is performed by signaling all substations simultaneously, as discussed in 4.17. Except for this special case the first digit of an order is used to give station access.

4.05 To gain access to a particular substation the corresponding station key is operated. This action results in the main station sending first a seizure signal or tone-off interval, which prepares all substations for reception and counting of pulses, and then a variable number of tone pulses from 1 through 8, depending on the substation concerned.

4.06 Fig. 9A is a functional block diagram of the main station operation. The digit is formed at the main station in the following man-

ner: The operated station key places ground on a specific level of the local selector switch and starts operation of the pulse generator. The pulse generator advances the local selector and at the same time causes the SF transmitter to key the 2600-cycle tone, thereby applying tone pulses to the line. When the local selector finds the ground applied by the station key, the pulse generator is stopped, ending the digit, and the selector is restored to normal. A red guard lamp lights at this point to signify that a second key must be operated to complete the call.

4.07 Fig. 9B is a functional block diagram of the substation operation. Tone pulses received at the substations are translated by their SF receivers to dc pulses, which cause their selectors to advance to a position corresponding to the number of pulses transmitted. The selectors at all substations have at this time been advanced to and come to rest on the same position. At the wanted substation this operates the station relay, which establishes access to the station for subsequent operations. At all other substations, however, a lockout circuit takes effect until a disconnect signal is received, thereby making these stations nonresponsive to all subsequent digits of the call. The last pulse of the digit is followed by a timed tone-off period. Upon recognition of this interdigital interval, the selected station restores its selector to normal in preparation for subsequent digits.

Second and Third Digits of Order

4.08 To complete the transmission of an order after gaining access to the wanted substation, a second or order function key is operated, which results in the sending director pulsing one digit for some orders and two for others. During the second digit the system functions in either of two ways. If scanning and registration are involved, pulses are reverted by the substation to transmit information to the main station. If selection is involved, resulting in the operation of a particular order relay at the substation, this is unidirectional signaling, and revertive pulsing is not required. Pulses are reverted incidentally in this case, but are ignored by the alarm receiving circuits of the main station. The third digit, if transmitted, is for the purpose of scanning and registration, and therefore revertive pulsing is used.

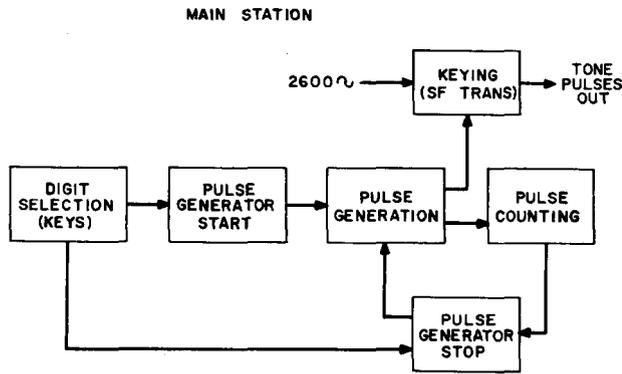


FIG. 9A - GAINING STATION ACCESS
 ORDER 1-5 2ND DIGIT
 CLOSE LOOP 2ND DIGIT
 OPEN LOOP 2ND DIGIT
 ROLL CALL 1ST DIGIT

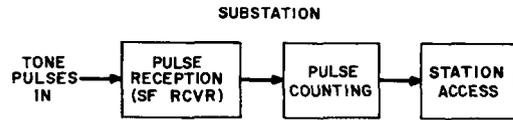


FIG. 9B - GAINING STATION ACCESS

ORDER 1-5 1ST DIGIT
 CLOSE LOOP 1ST DIGIT
 OPEN LOOP 1ST DIGIT
 ALARM SCAN 1ST DIGIT
 INDICATION SCAN 1ST DIGIT

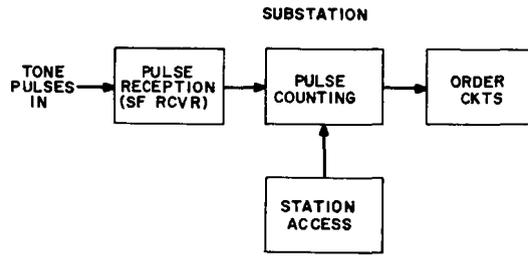


FIG. 9C - ORDER 1-5 2ND DIGIT
 CLOSE LOOP 2ND DIGIT
 OPEN LOOP 2ND DIGIT

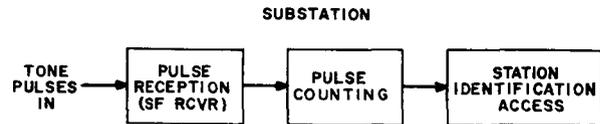


FIG. 9D - ROLL CALL 1ST DIGIT

Fig. 9 - Functional Block Diagram — Orders

4.09 A *close-loop order* will be discussed as typical of all orders in the unidirectional category. This order is used in the following manner: The alarm loop is normally closed at the far-end substation through its tone-reverting path. In the event of failure that opens the loop at some point in the system, the location of the trouble may be determined by a roll call as covered in 4.17. To alarm the substations between the main station and the point of failure, the order close loop is sent to the appropriate substation. The alarm system then functions on a shortened basis until the failure is corrected, at which time the system may be restored to normal by sending the order open loop to the appropriate substation. The open-loop order is also used to open the loop at the far-end substation preparatory to a roll call, if the loop is initially intact.

4.10 After the desired substation has been selected with the first digit, the close-loop key is depressed. Fig. 9A and C are functional block diagrams of the operation at this time. The pulse generator starts, and the sequence of operations continues at the main station as described for the first digit, but with 8 pulses being generated. Only the selector switch at the selected substation follows these pulses, by advancing to level 8. One of the two selector banks is used for both station selection and order relays. During the first interdigital interval, this bank is transferred from the station access and lockout circuit to the order relays, the close-loop order relay appearing at level 8. When the selector stops at this level rather than wiping over it, the close-loop relay operates and locks up. This causes the alarm loop to close through the substation via the tone-reverting path, completing

execution of the order. The main station and substations will now begin to restore to normal, restoring completely when steady tone is reapplied. The red guard lamp at the main station extinguishes to signify that the system is in the idle condition.

4.11 When the other orders in this category are being transmitted, the second digit will contain the number of pulses required to drive the substation selector switch to the position to which the corresponding order relay is connected. Otherwise the system operation is identical to that associated with the close-loop order just described.

Alarm Scan

4.12 The main station operation during the second and (if required) third digit of alarm scan is illustrated in Fig. 10A. The corresponding diagram for the substation operation is Fig. 10C. Let it be assumed that access to the substation has been obtained with the first digit. The alarm-scan key is then depressed, causing an 11-pulse digit to be generated. Dial pulses are transmitted to the selected substation, where

they are converted to dc pulses on the E lead that step the selector switch. The bank of the selector utilized for alarms and indications is different from that used for station selection and order relays. Nine different alarm circuits are connected to nine of the ten positions of the switch. The existence of an individual alarm causes a ground to be applied to a specific one of these nine positions of the selector switch. As the selector advances, it connects each of the positions in turn to the pulse reverting circuit, operating it every time a ground is encountered. Operation of the pulse reverting circuit closes the tone loop through the substation for approximately 125 milliseconds, so that the next pulse is returned to the main station. That is, if there is a ground on level 3, for example, when the third pulse steps the switch to this level the reverting path is enabled; but because of delay in the SF receiver and the operate time of the selector and the relay that enables the reverting path, the loop is closed too late for the third pulse to be reverted. The fourth pulse will be reverted, however, and will be received at the main station when its selector is at level 3, since this selector is one step behind.

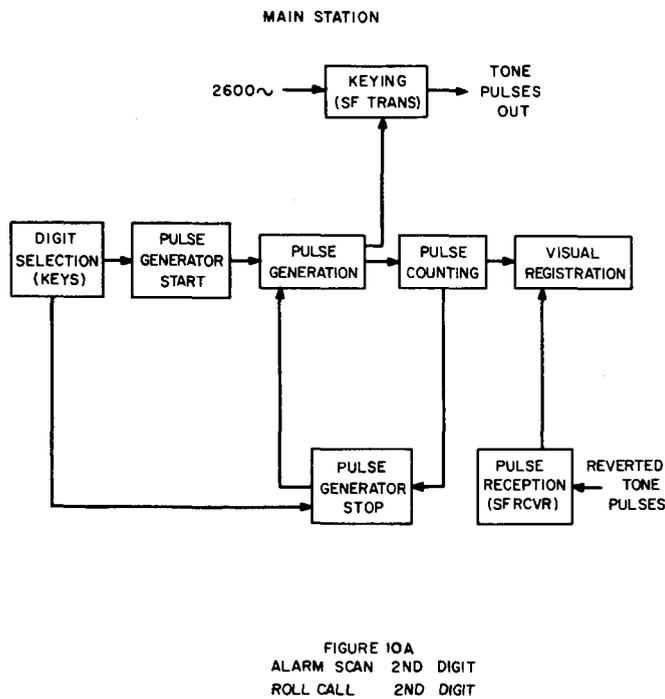


FIGURE 10A
ALARM SCAN 2ND DIGIT
ROLL CALL 2ND DIGIT

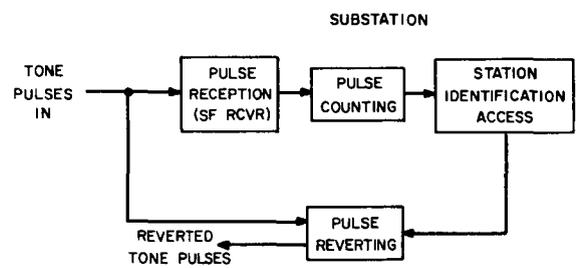


FIGURE 10B
ROLL CALL 2ND DIGIT

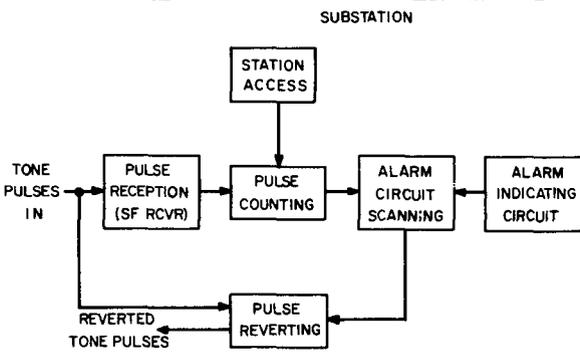


Fig. 10 - Functional Block Diagram - Orders (Contd)

4.13 The reverted dial pulses are received at the main station and converted to dc pulses used to operate alarm registration circuits. The main station selector has connected to nine of its ten positions alarm registration circuits corresponding to nine individual alarms at the substations. Each time a reverted pulse is received, while the selector is being driven locally by the pulse generator, an alarm-register relay operates and the associated lamp lights. The particular relays operated depend on coincidence of the received pulse as the selector pauses on the level to which the relay is connected. In this manner the alarm information is registered and displayed on lamps. Alarm identification is provided by individual alarm lamps, one for each alarm condition. At the end of the digit the main station and all substations begin to restore to normal, restoring completely when steady tone is reapplied to the loop. The red guard lamp extinguishes, signifying that the system has returned to the idle condition. When lighted, alarm lamps remain on under control of a common release key.

4.14 If more than nine alarms are required at a substation, the system does not restore to normal after the second digit, and a third digit will be transmitted automatically to the substation to scan the additional alarms. Operation takes place in the same way as for the second digit (first scan digit). The main station pulses the number of digits required for scanning as determined by the station key operated. At substations so equipped, nine additional alarm circuits will be switched to selector bank 2 when the second digit (first scan digit) ends, as preparation for acting on the additional scanning digit.

Indication Scan

4.15 An indication scan is performed by depressing the indication-scan key after gaining station access as described in 4.04. A second and third digit are required with this scan. The second digit serves to set up the station for the scan of the indication leads by driving the substation selector to position 7. This operates an order relay that switches selector bank 2 from alarm circuits normally occupying this bank to the indication leads. Main station and substation operation during this digit is illustrated in Fig. 9A and C, respectively. This operation is similar to the second digit of the close-loop order

covered in 4.09, except for the final circuit energized by the selector.

4.16 At the end of the second digit, the selector restores to normal and the third digit is then generated automatically. Each indication lead at the radio station will supply either a ground or no ground to its position on the selector switch, depending upon its status. The system now functions as it did for alarm scan, with pulses reverted when the selector encounters grounds, thus lighting indication lamps at the main station. Up to six indication lamps are used at the main station, one for each binary function. Two alternate conditions are indicated by a lamp on or off, respectively.

Roll Call

4.17 The roll call is made in response to a line-open alarm or when it is desired to check the internal operation of each substation or determine the location of a line fault. If the alarm loop is initially closed, the open-loop order must be transmitted to the far-end substation before calling the roll. This results in a line-open alarm, which is silenced by operating the line-open key.

4.18 The roll call is initiated by depressing the roll-call key. This causes the system to function as illustrated in Fig. 9A and D. A 10-pulse first digit is generated, applied to the line, received at the substations, and used to step the selectors of all substations to position 10. This position applies operating ground to a relay which energizes and connects the reverting path enabling circuit at each substation to bank 1 of their respective selector switches. Each station makes this connection at a different level of the selector, with the station nearest the main station connecting to level 1, the next to level 2, and so on, up to level 7. Station identification access has now been obtained, as shown in Fig. 9D. This is in preparation for subsequent scanning. The selector switches then restore to normal. The red guard lamp lights at the main station to signify that a call that has to be completed is in progress.

4.19 The scan key is now depressed at the main station and an 11-pulse scanning digit is generated. Operation during this time is illustrated in Fig. 10A and B. The pulses are sent to the substations and advance the selectors. When the near-end substation selector reaches

level 1, it enables the pulse-reverting path so that the second pulse is reverted. At the next station the reverting path is enabled when the selector advances to level 2, so that the third pulse is reverted, and so on. Each substation that is capable of receiving pulsing, responding properly thereto, and that is not prevented by a line fault from reverting pulses to the main station, will be so identified by the sending director and alarm receiving circuit, resulting in the lighting of corresponding station lamps. On the other hand, if no response is received from a given substation, the corresponding station lamp will not be lighted, indicating that either there is trouble in the substation equipment or a line fault exists between that substation and the main station, as covered in detail under 4.26 and 4.27.

4.20 During the second or scanning digit of a roll call, the operation of the main station circuits is essentially the same as that during alarm scanning discussed in 4.12 and shown in Fig. 10A.

C. Automatic Identification and Scanning

4.21 Automatic Alarm Scan: An automatic alarm scan is brought about by the onset or the clearing of an alarm condition at a substation. To report the onset of an alarm, the substation must perform the following three functions:

- (a) Signal the main station to start a scan.
- (b) Cause the main station to form the correct digit code to gain station access.
- (c) Identify the substation and scan the alarms.

The first function is performed by blocking tone to the main station; the second and third by reverting pulses.

4.22 Main station and substation operation for the first digit of an automatic alarm scan caused by the onset of an alarm at a substation is illustrated in Fig. 11A and B. When the alarm arises, an associated alarm relay energizes at the substation reporting the alarm and is locked up, to assure that if the alarm is transitory it will still be reported. At the substation reporting the alarm, the pulse reverting circuit is then switched to the selector at a position reserved for station identification. The main station is

then signaled by the insertion of a 2600-cycle band-rejection filter in the return line, toward the main station. At the main station, the SF receiver detects the loss of tone and therefore starts the action of the sending director. This results in the SF transmitter removing tone from the outgoing line as a seizure signal, to prepare all substation relay circuits for the reception and counting of pulses. At the end of the tone-off interval the pulse generator starts, and dial pulses are applied to the outgoing line. The dial pulses advance the selector switches at all substations.

4.23 When the reporting substation selector reaches the identifying position, the reverting circuit is enabled so that the next pulse is reverted. This stops the pulse generator, thereby forming the correct substation digit code. The reverted pulse is also applied to the station relays, causing operation of the particular one that is connected to the selector at that time. This will be the station relay for the reporting substation, because the main station and substation selectors have advanced in synchronism. The operated relay lights a station lamp and the station therefore is identified. The substation reporting the alarm will now energize the station access circuit while all others energize the lockout circuit. The reporting substation then prepares for the scan of alarm relays by switching the pulse reverting circuit to the selector bank 2 wiper. The individual alarm relays register their status on this bank by supplying either a ground or no ground to the positions they occupy. A ground indicates that the alarm condition exists.

4.24 An 11-pulse second digit is now generated and applied to the line. The main station and substation operation at this time is shown in Fig. 12A and B. These pulses advance the selected substation's selector switch over all levels to scan the alarms. A pulse is reverted for each ground encountered. At the main station the pulses identify the alarms by operating alarm relays. This action is similar to that of the manual alarm scan discussed in 4.12. When the digit ends, tone remains off the line for a period of time and then is reapplied to restore all stations to normal. The station and alarm lamps stay on at the main station under control of the release key.

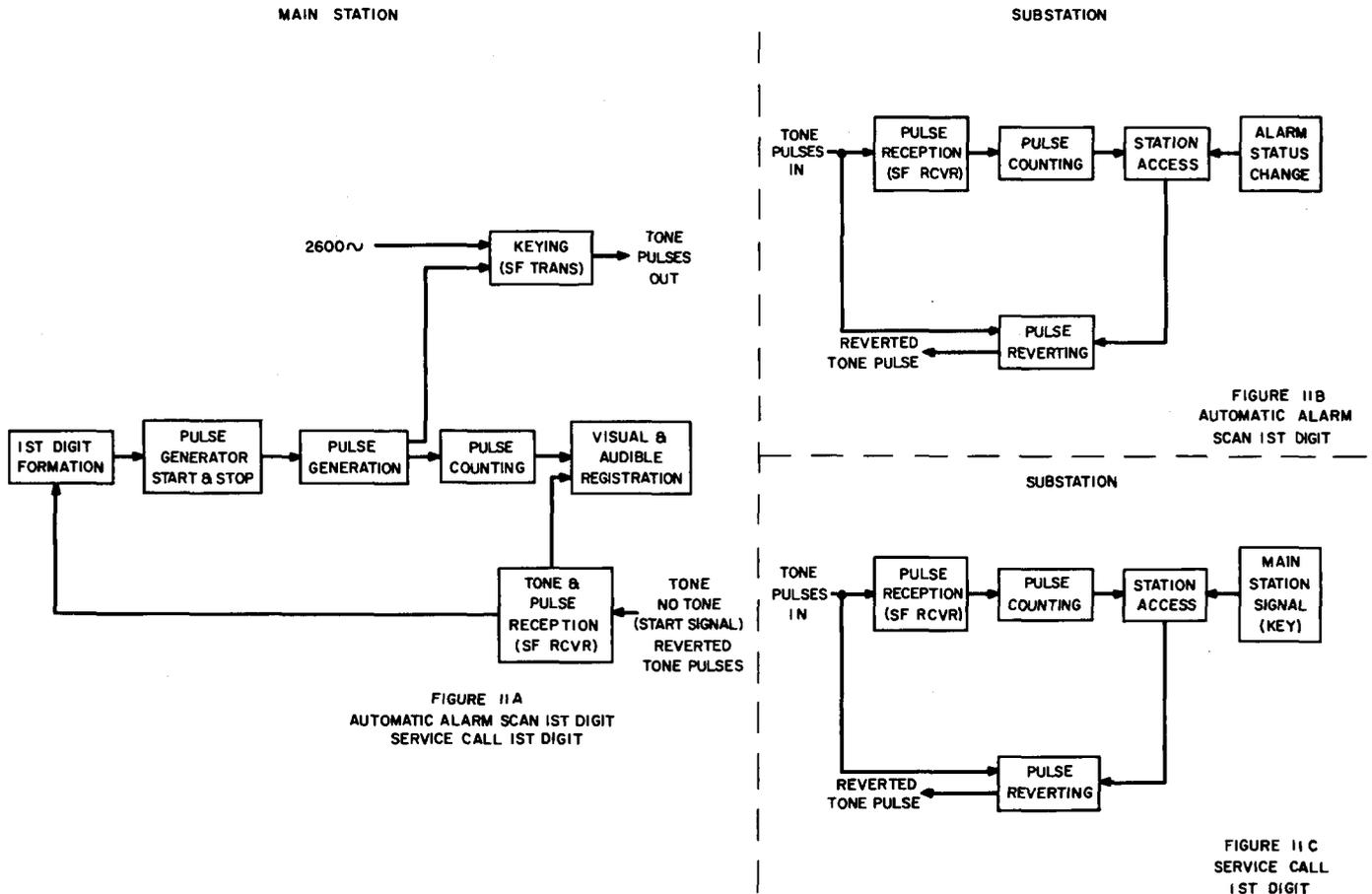


Fig. 11 — Functional Block Diagram — Automatic Identification and Scanning

4.25 As an option, the *clearing of an alarm* may be reported to the main station in a manner similar to the *onset of an alarm*. The only difference in the method of operation in this case is that when a particular alarm clears, a pulse is not reverted when the selector passes the level associated with this alarm, and the corresponding alarm lamp does not light. If a transitory alarm occurs that drops out during the initial alarm scan, a second scan takes place immediately to report the clearing of the alarm. Under these conditions, the alarm lamp is on after the second scan since the attendant has not released the lamps during the scanning process. To inform the attendant that a second scan has occurred, an alarm check lamp lights during this scan. The alarm check lamp also lights when a second alarm is reported by any substation before the first alarm registration is canceled. If the alarm check lamp is lighted, the attendant executes a manual alarm scan to determine the status of the alarm.

Line Open

4.26 A line fault that causes a break in alarm-loop continuity is reported to the main station through a line-open scan. The action that takes place is illustrated in Fig. 13. Initially the operation is the same as that occurring for an automatic alarm scan. That is, the main station SF receiver detects the loss of tone, the SF transmitter is therefore directed to remove tone, and pulsing starts. For an alarm scan a pulse is reverted to identify the substation and stop the pulse generator. Since the alarm alert in the case of the line-open scan is due to the line fault rather than to a change in individual alarm status at the substations, no pulses will be reverted, so the main station continues to produce pulses until the selector is driven to its top position. The pulse generator stop circuit then operates and a line-open lamp lights, because no reverted pulses were received on the first complete sweep of the selector. The SF transmitter then

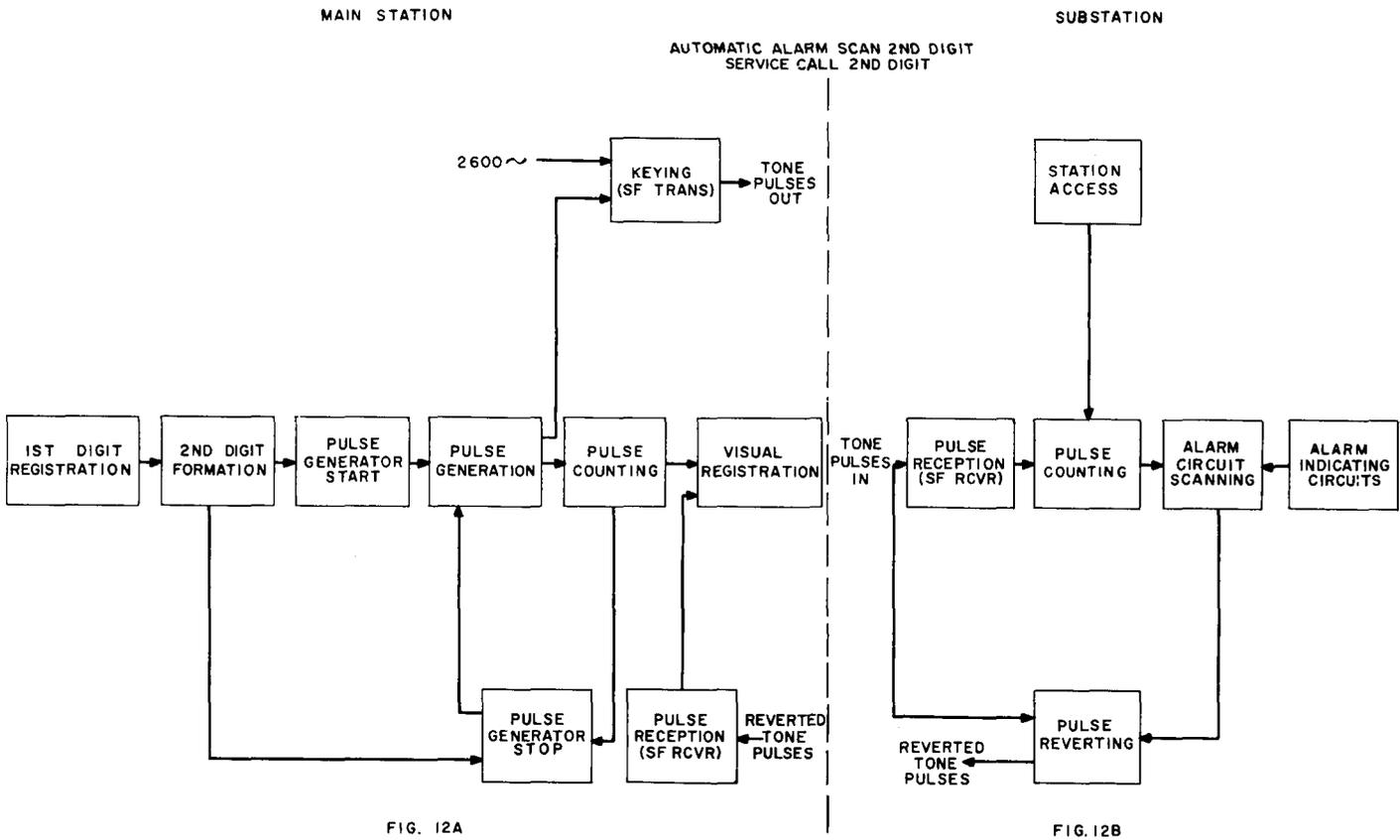


Fig. 12 - Functional Block Diagram - Automatic Identification and Scanning (Contd)

reapplies steady tone to the line to normalize the substations. Before the main station restores completely, a major office alarm is brought in to announce the line-open condition. Operating the line-open key will silence the alarm. When the line-open condition clears, tone is received at the main station and the major office alarm is again brought in. Releasing the line-open key silences this alarm and returns the system to the idle condition.

4.27 To obtain information as to the location of the fault, a roll call is made as covered in 4.17. In general, this will produce a pattern of consecutively lighted and consecutively dark station lamps. The fault may then be presumed to exist between stations indicated by the last lighted lamp and the first adjacent dark lamp; or, in the case of failure in radio line facilities, the trouble may be in either of the radio stations indicated by these two lamps.

Substation Equipment Failure Alarm

4.28 The alarm system is self-arming in the event of failure of certain major equipment elements of a substation. Such a failure manifests itself by a 10-second interruption of the alarm-tone loop, which is recognized at the main station by a line-open scan as covered in 4.26 and in Fig. 13. When subsequently a roll call is made from the main station, as is the normal procedure, all station lamps light except the one representing the substation in trouble, since that substation does not respond to reverte pulsing y reason of failure of local equipment.

4.29 The alarm alert as a result of equipment failure is produced as follows: Substation relay circuits are equipped with two thermal slow-release relays whose release times differ by 10 seconds. These relays are normally operated; but in the event of SF receiver failure,

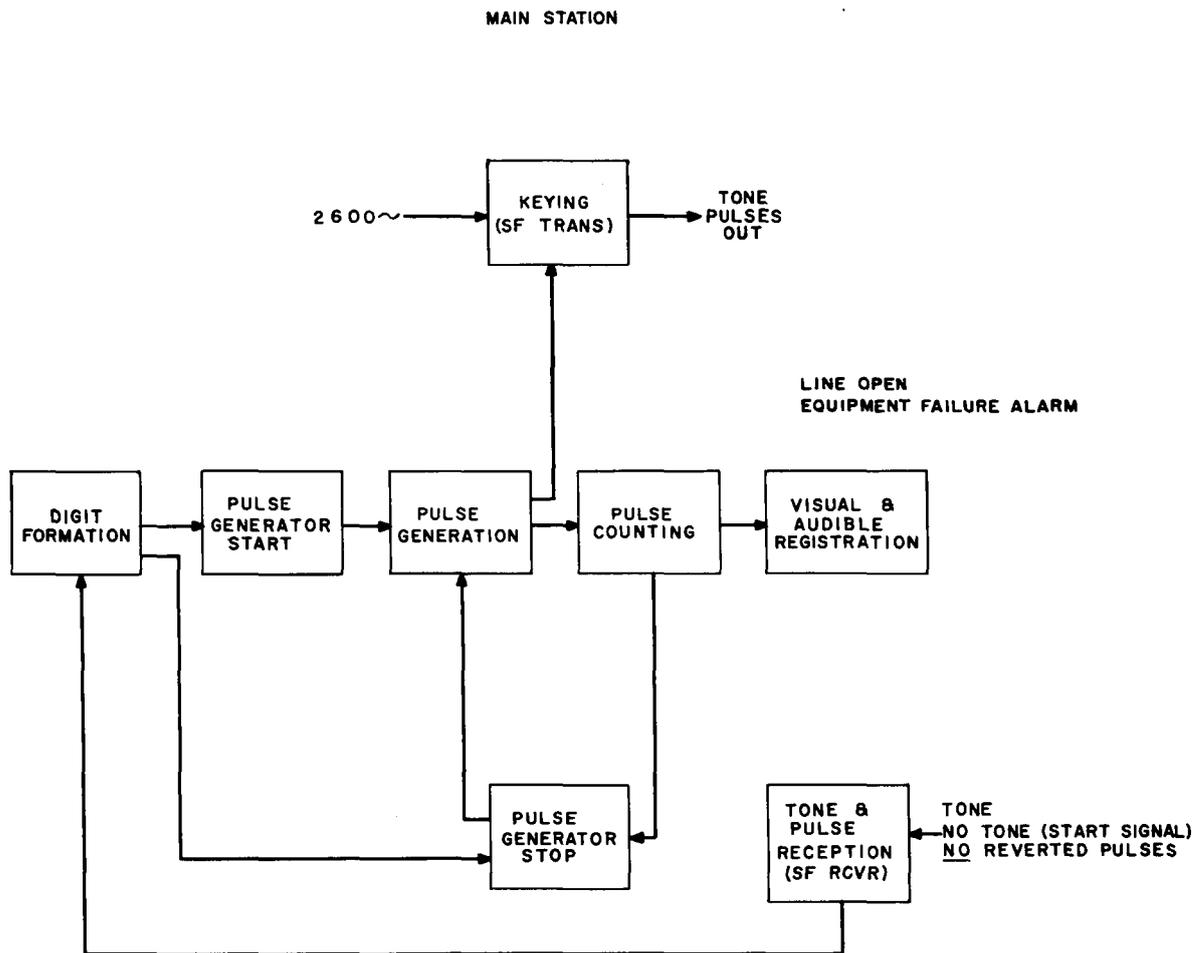


Fig. 13 – Functional Block Diagram — Automatic Identification and Scanning (Contd)

failure of the vf amplifier preceding the SF receiver, or failure of 48- or 130-volt battery, these relays will be de-energized. As a result, one relay releases after about 20 seconds and in so doing shunts a 2600-cycle series-resonant trap across the line incoming to the main station. After an additional 10 seconds the other relay releases, removing the trap. These operations result in a reduction of about 15 db in the tone received in the main station for 10 seconds. This acts as an alarm alert to which the main station responds with a line-open scan and major office alarm.

Signaling on Service Calls

4.30 Signaling from the unattended station to the alarm center for service calls on the order circuit is accomplished by methods similar to automatic alarm reporting covered in 4.22.

The essential difference is that the operation is key-initiated at the substation and, regardless of the substation concerned, it reverts the ninth pulse on the first digit. This pulse is received at the main station when its selector is at level 8. Levels 1 through 7 of this selector are reserved for station relays, but there is connected to level 8 a signal register circuit, which in turn is connected to the answer lamp and night alarm arrangements of the associated toll testboard.

4.31 The main station and substation operation for signaling on order-wire service calls is illustrated in Fig. 11A and C, respectively. Operation of the signal-main-station key at the substation inserts the band-rejection filter in the line incoming to the main station and connects the reverting path enabling circuit to level 8 of the substation selector. This initiates reverting pulsing during which the ninth pulse

is reverted. Since the main station selector is on level 8 when this pulse is received, the signal is registered as a calling-in signal at the main station and at the toll testboard. The sending director then pulses a second digit for the purpose of normalizing the system, which completes the call. Answering the call by plugging into the toll testboard order-wire jack extinguishes the answer lamp and silences the ringing, if provided.

5. MAINTENANCE

A. Transmission Circuits

5.01 A number of jacks are provided in the main station unit and the substation unit as shown in Fig. 6 and 7. These jacks permit access to the transmission circuits for test and adjustment and for over-all system line-up and maintenance. A 21-type transmission measuring set or the equivalent is used for transmission measurements.

5.02 All amplifiers used are of the plug-in type. In general, it will be advantageous to remove a unit suspected as faulty, substituting a spare amplifier. Standard test facilities and procedures exist for these amplifiers, as covered in other practices.

B. Signaling Circuits

5.03 The plug-and-jack mounting of the SF signaling units permits their removal for maintenance. Although means have been provided and procedures set up for certain in-service adjustments or checks of these units, the maintenance philosophy for the D1 system calls for signaling units to be removed for maintenance and replaced by a spare kept on hand for this purpose. This is particularly applicable to substations at remote radio locations. It is expected that one spare signaling unit will be adequate for a system. It is intended that maintenance of the SF units of the system be accomplished at locations where the standard test facilities are provided. These facilities and test and adjustment procedures are covered in the practices on SF signaling.

C. Relay Circuits

Substation

5.04 Operation of the substation relay circuit may be checked locally by use of a 52B test set. This set includes a dial by means of

which dc dial pulses may be applied to the line relay that is normally connected to the SF signal receiver via the E lead. Access to this relay is provided by the E TST jack, which is grouped with the transmission jacks. By this means all operations that would normally take place in conjunction with the main station may be simulated locally at the substation.

Main Station

5.05 Only one local test of the main station relay circuits is practicable. This is adjustment of the per cent break and pulsing rate of the pulse generator in the sending director circuit. A J94723A pulse-checking test set is required for these tests. Access to the pulse generator by the test set is provided by jacks P and BATT GR in the jack field.

5.06 In general, the proper functioning of the sending director and alarm receiving circuit is ascertained by actual operation in conjunction with a substation, since no means of local testing is provided for this purpose, except for initial adjustment of the pulse generator as covered in 5.05.

6. GLOSSARY

Alarm Alert — The means by which the unattended station invites the attention of the main station when a trouble either occurs or clears. Interruption of the alarm-tone loop constitutes an alert.

Alarm Center — A fully attended station at which alarms are received from and control orders transmitted to an associated group of unattended radio stations of a radio relay system. Ordinarily, an alarm center also serves as a maintenance center for a group of nearby radio stations.

Dial-Pulse Code Digit — The signal consisting of a train of pulses having characteristics, such as per cent break or repetition rate, similar to those generated by a telephone dial. In the D1 system, each of the ten number symbols, 0 through 9, corresponds to an item of information, such as a particular substation or alarm condition. These digits are in turn represented by a pulse code, wherein the number of equal-length pulses is the same as the numerical value of the digit represented.

Main Station — The D1 equipment, located at an alarm center, that provides for sending control orders to and receiving alarms from an associated group of substations, and for talking and monitoring on the order wire.

Maintenance Center — The home station of the force concerned with the maintenance of a group of nearby radio stations, usually coincident with an alarm center. If not located at an alarm center, a maintenance center is notified of trouble conditions by the alarm center, since the maintenance center does not receive alarms.

Revertive Pulsing — A method of signaling between offices whereby the terminating office produces a train of pulses upon receipt of a start signal from the originating office. These pulses are counted in both offices. When a stop signal is received from the originating office, the terminating office stops pulsing. The num-

ber of pulses transmitted then represents an item of information transferred from one office to the other.

Scanning — The process by which the status of individual alarm conditions at a substation is examined in succession by the main station.

SF Signaling — The signaling system used to pass supervisory and dial-pulse signals on trunks by use of a single ac signal frequency (in a given direction) within the speech-channel frequency band. The SF signaling units of the D1 system are 2600-cycle units of the most common type now used on voice-repeated and broadband carrier trunks.

Substation — The D1 equipment located at an unattended radio station, used to transfer alarms to and receive control orders from a main station, and to provide order-wire talking and monitoring facilities.