

PRIVATE SERVICE SYSTEMS  
 LINK AND CONTROLLER CIRCUIT  
 FOR COMMON USER GROUP  
 AIR-GROUND VOICE COMMUNICATION SYSTEM

SPARE

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SECTION I - GENERAL DESCRIPTION

## 1. GENERAL METHOD OF OPERATION

The major functions of this circuit are to connect levels (channels) to verticals (trunks) with either the channel or the trunk initiating the action. A call initiated by the action of a channel looking for a trunk is an OUT call (at the calling end); one initiated by a trunk looking for a specific channel is an IN call (at the called end).

For an OUT call, the grounding of a start lead from a channel causes this circuit to lock out later bids temporarily and connect testing relays to the busy test leads of all the trunks. When an idle trunk is selected, crosspoints are closed on a crossbar switch to connect the channel to the idle trunk. The controller then releases to admit and serve other calls.

If a trunk grounds a start lead the same lockout occurs but in this case a particular channel is wanted and the trunk sends a coded signal corresponding to the level to which the trunk is to be connected. The controller makes certain tests and closes the crosspoints joining the trunk to the indicated channel, to complete the action for an IN call.

In the event of trouble, a trouble indicator is called in before the controller releases. In general this results in an attempt to set up the call using the other controller. If neither can set a call, a major alarm is given.

The circuit is also arranged to dispose of calls to busy levels on IN calls, to handle false start conditions, and to take specific action for the all trunks busy condition.

## 2. CONTROLLER SET-UP

The controller can be considered to be composed of three distinct sections; one common section, and controller A and B sections.

## 2.1 Common Controller

The common controller generally makes use of double wound relays to provide maximum protection against an open multiple or a blown fuse on either side of the coil. Start leads from the channels and trunks initiate controller action by first appearing in the common part of the controller.

## 2.2 Controller A or B

Controller A and controller B form the rest of the unit. The controllers A and B are identical with the exception of interconnections to the trunk and level

testing relays. The differences are for the purpose of changing the preference of trunks and channels served. Either the A controller or B controller can be used on any call, and, in general, they are used alternately. If one is in trouble, all calls can be handled by the other.

## 3. COMMON CONTROLLER ACTION

## 3.1 Group Start

The start leads from channels and trunks are divided into groups of ten. When a request for service is received, the group which includes the channel or trunk will be "preferred", that is, given service by the controller if there are no other requests at the same time. Other requests subsequently received before the controller function is complete will be locked out. If there are other requests, and they are in other groups, one of the groups, the "lowest" numbered, is preferred, and the call in that group is served first. The lowest numbered groups comprise the channel circuits, hence these receive preference when trunks and channels compete for service. The group number also serves to indicate whether the call is an incoming or outgoing call.

On simultaneous seizures (two or more calls placed before a busy condition could be encountered) the group relays serve one call in each waiting group before serving a second call in any group, and lock out all new calls requesting service.

Any simultaneous waiting call can be released without using a controller if it is abandoned before it becomes preferred. A call of this nature once released can only rebid for service in the normal way.

## 3.2 Controller Selection

When the common section operates, it has a choice to pick controller A or B to complete the connections required of this circuit. For this purpose a "WZ" relay combination is used. At the direction center, and for IN calls at the radio site, the action of this "WZ" combination picks controllers A and B alternately. For OUT calls at the radio site, the "WZ" combination chooses each controller two times in succession before picking the other controller. This different action plays its part in setting up a different trunk selection pattern, to be described. Either controller A or B can be made busy if maintenance work has to be done. For this condition the preference circuit chooses the one controller that is available. If for any reason, the other controller is made busy the controller will automatically free the previously made busy controller, it being impossible to make both controllers busy at the same time.

### 3.3 Control

A ground from the test circuit through the "WZ" preference circuit causes the common controller to direct the call to the specific A or B controller. Upon this selection the circuit then operates common connectors to gain access to circuits connecting the levels of the switches for eventual connection to trunk circuits.

### 3.4 Alarms

The alarm cycle will be started if the chain circuits of the common part of the controller remain open for a longer period of time than required for the timing tubes to fire and bring in an alarm. Normally, calls will be completed before sufficient time has elapsed for the alarm timers to complete their function.

## 4. LINK ACTION

Selection of controller A or controller B will be followed by the operation of connectors which close various leads from the chosen controller to trunks, or to channels through the common unit.

### 4.1 Out Calls

#### 4.1.1 Channel Selection

Leads from ten channels of the preferred group will be closed to ten level selection relays, one or more of which will operate. One of the operated relays is the preferred level, and the select magnet associated with that level operates. Calls in the A controller give preference to the lowest level of a group, whereas the highest level is preferred in the B controller.

#### 4.1.2 Trunk Selection

On outgoing calls, all trunks are tested to select an idle trunk. A selection from one of the available trunks is then made. In the case of calls in the A controller, the preference is from the lowest to the highest, and is reversed in the B controller. Alternate calls start their preference from the "end" of a chain, followed by a start from the "middle" of a chain. This gives four different orders of preference.

For OUT calls at the radio site, two calls in the same controller are handled before transferring to the opposite controller. This is to give a different trunk selection pattern at the radio site than at the direction center. By so doing, simultaneously originated calls at the radio site

and direction center, which perchance seize the same trunk, will not make successive trunk selections in exactly the same pattern.

### 4.1.3 Controller Release

When the trunk selection is made, a path to the associated hold magnet is closed, completing the connection to the originating channel. A check that the hold magnet is locked is made, that the trunk relay is locked, that the trunk is busy, and that the channel is busy. A start signal to the channel is then given, and the controller releases.

### 4.2 In Call

#### 4.2.1 Trunk Selection

An incoming call will ground a start lead to the controller when a complete code has been received from the distant end. Where such a call is the only call requesting service, the group with which it is associated will become preferred and be served. Otherwise, one OUT call in each waiting group will be served first. In any case, when an IN call is preferred, leads from only one group of ten trunks will be connected to the trunk selection relays. If there is more than one trunk in the same group having an IN call, the lowest numbered trunk becomes preferred in the A controller, and the highest in the B. A relay in the chosen trunk closes code leads to the controller.

#### 4.2.2 Level Selection

Code relays in the controller operate in response to the code from the trunk. The proper level can then be identified, and the associated select magnet operated. The operation of the select magnet is checked and at the same time a check of the code is made.

### 4.2.3 Controller Release

If the code checks, the hold magnet of the selected trunk is closed, and the check for the hold magnet locking path is made. The controller release action then takes place as for an outgoing call.

### 4.3 Busy Levels

To provide for the case where a channel at the direction center and the same channel at the radio site both originate calls at the same time, the controller action is different at the two locations. At the direction center, the controller finding a

"busy level" (channel already in use) on an IN call does not complete the connection. At the radio site, a signal is given to the busy channel to release, and allow the incoming connection to be set up. The effect of these actions is to allow the direction center originated call to be completed, while the radio site originated call is abandoned.

Each occurrence of this type is scored on a register. This makes it possible to check abnormally high readings for otherwise undetected trouble conditions.

#### 4.4 False Starts

Where a grounded start lead has started the controller, but a subsequent check indicates the start lead is no longer closed, the controller is released and a register scores. As for the busy level register an abnormally high registration will indicate the existence of possible

trouble conditions. Registration occurs for either a false channel or trunk start.

#### 4.5 Trunk Busy

A connecting circuit, the trunk and channel alarm and control circuit, continuously monitors the trunks and identifies an all trunks busy condition when the last trunk has been seized. Action is then initiated by the connecting circuits, which should result in one or more trunks being made available. In most cases, this action will proceed independently of the controller action, so that the controller will not usually find a busy trunk condition when it seeks an outgoing trunk. In some cases, such as where the trunk release action has not been completed before another outgoing call is set up, the controller will find busy trunks. A register is then scored and the controller released. As for the busy level and false start registers, an abnormally high reading of this register also indicates possible trouble.

SECTION II - DETAILED DESCRIPTION

The details of controller operation are covered by the sequence charts (SC's - SD-1G024-01 - E1 to E13). The sequence charts are best used in conjunction with the operational schematics (OS's - SD-1G024-01 - D2 to D11). The following paragraphs describing controller operations also refer to the OS's and SC's.

## 1. POWER ON

SC1(E1T3), SC2(E2T3)

Immediately when power is applied to the Common User Group (CUG) the chain checking CH1 to CH5 relays operate, and remain operated with the controller in the normal condition.

## 2. OUT CALL (SC1 - E1)

Assume a call is originated by the director assigned to Channel 3. (The operation at the direction center and radio site is quite similar for this type of call, so essentially the same operation takes place for a channel originated call at the radio site). A ground will appear on the ST3 lead (OS1 - D2B0) as a request for service.

## 2.1 Seizure and Lockout

The start leads from the channels (or trunks) are carried through back contacts of relays GE- in groups of tens OS1(D2H2). Each group of ten is then multiplied and a lead taken from each end of the multiple to separate windings of an associated G- relay through back contacts on relays COA and COB. This double circuit is intended to provide maximum protection against an open in the multiple or winding. Each winding of the double wound G- relay is associated with a different fuse to assure continued operation of the G- relay if one of the fuses is blown. When the start lead for channels is grounded, relay G3 operates and locks through a contact on relay GRL. It also bridges contacts on relays COA and COB. This is not necessary when only one start lead is grounded but is used when simultaneous start closures occur in more than one group, which action will be described later. Relay G3 in operating also opens the two chains to relays CH1 and CH2 which release and operate relays COA, COB, FS and GS. The COA and COB relays operated lock out further calls.

## 2.2 Controller Selection

With the exception of OUT calls at the radio site, the controllers are used alternately as controlled by the position, (both operated or nonoperated) of the CW and CZ relays. Either the LA or LB relay will operate, establishing connection to either

the A controller or the B controller, respectively. The operation of the CW, CZ relays on alternate calls will be described later.

## 2.3 Connection of Controller to Channel and Trunk Circuits

For this call, the operation of relays COA and COB operate the GEO relay (associated with the preferred group), and causes the operation of the associated GCO relay in the selected controller SC1(E2). GCO relay operated in turn operates the group connector check relay GCK, and drops the FS relay to check that the GCO relay has operated. The GEO relay also transfers the start leads to the test circuit for certain tests when that circuit is in use. Relay GCO operates relays SMA, BYA and SSA which connect to the select magnets and the BY and SS leads of the channels corresponding to the ten start leads in the first group. If a channel at a site is being served, relay CLA(OS1 - D3Q8) is also operated to connect the ten CL leads OS10(D10G5). Relay LA or LB, operated as described above, causes the operation of relays IC(A-H) - OS2(D4F3). The operation of these relays completes the connection of the control leads from the channel and trunk circuits to the active controller. With GO and LA operated, the OUT and BTC(A-D) relays operate connecting the trunk busy test leads to the controller. The LA or LB relay also causes the operation of the TT- relays and subsequently a trunk is chosen as described later.

## 2.4 Switch Level Selection (OS3,D4)

Before the controller was seized, the chain through the back contacts of relays SM- is closed and relay CH4 operated. With this relay operated, relay BTE operates as soon as the controller is seized and connects the start leads to the SM- relays (E3R7). For the call under discussion, SM3 will operate if the A controller has been selected SM6 will operate if the B controller is in use. Operation of the SM- relay opens the chain circuit through its own locking contact, releasing the normally operated CH4 relay, in turn releasing BTE. Relay BTE released opens the start leads, so that any subsequently grounded start leads will not interfere. The operated SM- relay, say SM3, locks to an RL back contact, so that it remains operated. Relay STK now operates to the selected start lead to serve as a later check that the originating circuit removes this ground. The operation of the SM3 relay causes the operation of the select magnet corresponding to the level assigned to this particular start lead (OS4-DS), namely S3. Depending on the number of trunks there are two, three or four select magnets on each level and these are all operated in parallel. When they have all operated,

relay SMK operates as a check. As this is an outgoing call the code checking network used on incoming calls, is by-passed, through the OUT relay operated.

## 2.5 Trunk Selection

Operation of the LA or LB relays operate TT(A,B) (also TTD, TTD when furnished) in addition to the BTC- relays mentioned previously. These relays operated close paths from the trunk busy test leads, which will be grounded for an idle trunk, to the T- relays. (OS6-D6). All T- relays will operate that correspond to available trunks. Operation of one or more T- relays releases CH5, which drops the TT- relays.

For the case where the A controller is in use, Z relay normal, and trunks 0-4 busy, T5 operates and locks through Z and RL normal. Relay T5 operated opens the locking path to higher numbered relays, which will then release when TT- releases. For these conditions, trunk 5 becomes the preferred trunk. Other trunks will be preferred for other conditions, to be described, so that in the event of trouble, the same trunk will not be continually chosen. Relay BTK operates through T5 operated to the BT5 lead.

## 2.6 Hold Magnet Operation

With CH5 released, a path is closed through T5 to operate the F(A,B) relays in the selected trunk. (OS7-D7). Contacts on these relays operate relay TK as a check that the trunk is attached. When relay BTK operated it operated relay BTK1. With relay BTK1, TK and STK operated and relay BY released relay HO can operate (OS8-D8). Relay HO operated locks through itself to a BTK1 operated. Relay HO operated, indicates that all conditions are satisfied for operating the hold magnets except one. These conditions are STK operated, indicating that the start lead is still closed. BTK1 - that an idle trunk has been found, TK - that the trunk common leads have been closed and BY - that the selected level is not busy. When relay SMK operates ground through the primary winding of relay HMT operates that relay and starts the operation of the hold magnet. The operation of this magnet is slow enough so that relay HMT has time to operate relay HMT1 which locks.

## 2.7 Controller Release

On outgoing calls, the primary winding of relay OCT is connected to the winding of the OC relay in the trunk, operating both relays. When the cross points close locking ground is applied to the hold magnet causing current to flow in the secondary winding of relay HMT (D8C6). This results in negative ampere turns in the relay causing it to release. At about the same time

the trunk is applying locking ground to the trunk OC relay causing relay OCT to release in a similar manner, (D8A6). The channel is made busy when it is connected to the trunk and an indication is received over the BY lead operating relay BY. This operates relay HMK. With relays HMK, OCK, and HO operated and relay OCT released, ground is connected to lead SS which results in the removal of ground from the ST lead and the release of relay STK OS3(D4B8). Relay BTK released previously when relay OCT operated the trunk OC relay. With relays HMK and TK operated and relays STK and BTK released relay RL operates. This operates relay GRL and releases the controller. Relay GRL releases the GO relay in the common circuit, OS1(D2B4). Relay GO releases relay GEO. Relay GRL removed the direct ground for relay GEO but diode GE will allow current to flow until relay GO breaks the circuit. This will prevent a new "ST" lead in that group from relocking relay GO if relay GEO should be faster in releasing than relay GO. Relay RL releases when the controller is released and to ensure the complete release of the controller as well as the advance of the preference circuits, in some instances, this relay is locked to key relays.

## 3. IN CALL (SC2 - E2)

Assume a call, made from Channel 19 at the distant end, comes in on trunk 20. Code pulses, signifying Channel 19 will be received and stored in the code receiver associated with trunk 20. When a complete complement of pulses has been received, trunk 20 grounds its start lead to the controller.

### 3.1 Seizure and Lockout

Ground on start lead 20 results in operation of the G5 relay, if the controller is idle. Relay G5 locks to GRL, CH1, CH2 and CH3 release, COA, COB operate, followed by operation of GE5, in a manner similar to that described for an outgoing call.

### 3.2 Controller Selection

Controller A or B will be chosen, depending on the position of the CW and CZ relays. Assume again that LA operates for this call.

### 3.3 Connection of Controller to Channel and Trunk circuit

Operation of COA and COB cause the operation of GE5, which in turn operates GC5 in the selected controller. Relay G5 operated also operated the IN relay when LA operated. The BTC- relays will not operate on this type of call, and the SM-, BY-, SS- and CL- relays are not operated until the code is received. The operation of GC5 closes trunk start leads for the 20-29 group of trunks to the controller.

### 3.4 Trunk Selection

The TT- relays operated when LA closed. With the trunk start leads closed by the G05 relay, a path to the T- relays OS6, is closed. For this call, assume again Z normal, so T20 operates and locks. With T20 operated CH5 releases, releasing the TT- relays, and opens the paths for all other start leads. Relay BTK operates to the start lead for this call. Relay TK2- operates from T20 operated. A path to the F- relays of trunk 20 is closed when CH5 releases, operating them. Their operation is checked by closure of the TK relay.

### 3.5 Level Selection

When the F- relays in the trunk close, for general case, relays L0, L1, L2, L4, L7, L00, L10 and L20 will operate in some pattern representing a number from 0 to 29 (OS-10). The tens digit of the code is used to select the group of ten levels by operating the proper SM-, BY-, SS-, and CL- relays; relay L10 operates SMB, BYB, SSB and CLB for this call (OS1). Contacts on the L0, L1, L2, L4 and L7 relays ground one of ten 0-9 leads (OS10 to OS3), operating one at the ten SM(0-9) relays. For channel 19, L2 and L7 are operated, ground the "9" lead, operate SM9. SM9 operated with SMB closes the select magnets for level 19, OS4. Contacts of the select magnets are connected through SMB operated through a network on the L- relays to the SMK. However, relay SMK will operate only if there are exactly 2 out of 5 relays L0, L1, L2, L4, L7 operated and exactly one of L00, L10, L20 operated (D5). The code is as follows:

Relays	Digit
L4, L7	0
L0, L1	1
L0, L2	2
L1, L2	3
L0, L4	4
L1, L4	5
L2, L4	6
L0, L7	7
L1, L7	8
L2, L7	9
L00	0-9
L10	10-19
L20	20-29

If there are an incorrect number of code leads grounded from the trunk, SMK fails to operate, and the call blocks.

### 3.6 Hold Magnet Operation

For an IN call, STK operates to the grounded lead from the L-relays. BTK operated operates BTK1, TK operated from the trunk F- relays. Relay H0 is then operated. With H0 operated, a path through SMK is closed to operate the hold magnets as for

an out call. In this case, the BTK relay holds to the start lead of the trunk, so a path through IN operated completes the circuit.

### 3.7 Controller Release

For an IN call, operation of the hold magnet operates trunk relays which complete the lock path for the hold magnet as well as opening the code leads. This causes release of the STK relay. Relays HMT and HMT1 operate, followed by the HMT release as for an out call. BTK will release when the trunk start lead is opened. With the trunk-channel connection closed, the channel operates the BY relay. A path to the RL relay is then complete, which opens lock paths to restore the controller as for out calls.

## 4. SIMULTANEOUS CALLS

### 4.1 Group Preference

Where start leads are grounded in two or more different groups simultaneously, the G- relays corresponding to each group operate. The lowest numbered G- relay operated becomes the preferred group, and that G- relay locks to the GRL relay. Any other G- relay operated locks around the contacts of the COA, COB relays to the start lead (OS1). The controller proceeds to serve the call in the preferred group, as described in the preceding sections (OS2). Calls in nonpreferred groups can be released without using a controller if they are abandoned before they become preferred. The call in the next higher G- group will be served after the controller releases from the first call (OS2). Relays COA, COB remain operated to lock out further calls until one call has been served in each of the groups that were locked in (OS1).

### 4.2 Typical Operation SC3

SC3 illustrates the sequence for an out call and in call started simultaneously at the direction center. Because of the chain circuit on contacts of the G- relays which operate the GE- (OS1) and GC- relays (OS2), out calls are preferred over in calls.

### 4.3 Preference within a Group

In case two calls in the same group start simultaneously, one call will be served, and GRL will operate. The waiting call will then come in as a new call.

### 4.31 Out Calls

For calls from the channels, the lowest numbered call is served first in a group when the A controller is in use. The highest numbered is preferred when the B controller is in use. This is caused by

the "turnover" in the leads between Fig. 1 and the 2nd Fig. 2, OS3, and a similar turnover in OS4.

#### 4.32 In Calls

For competing In calls in the same group, the lowest numbered trunk is preferred in the A controller, and the highest in the B controller. Details of the circuit arrangement are covered in a later section on trunk selection.

### 5. CONTROLLER SELECTION

#### 5.1 IN or OUT Calls at the Direction Center or IN Calls at the Radio Site SC11(E13)

For relays CW and CZ normal, the first call is placed in the A controller and the associated IN or OUT and LA relays are operated. The IN or OUT relay operates the CW and W(A) relays. When the controller releases from the call after general relay operations as shown on SC1 or SC2, the IN or OUT and LA relays release. The release of the IN or OUT relay operates the CZ and Z(A) relay. The LA relay operates if the CW and CZ relays are normal, but LB relay operates if the CW and CZ relays are operated. Four such calls would be necessary to complete one full cycle of operations of the CW, CZ, W, and Z relays.

#### 5.2 Successive OUT Calls at the Radio Site - SC12(E13)

If the CW, CZ, W and Z relays are all normal when an OUT call is placed at the radio site, the A controller will be selected and the associated OUT relay and LA relay will be operated. The OUT relay operates the W(A) relay. When the controller releases this call after general relay operations as shown by SC2, the OUT and LA relays release. The release of the OUT relay operates the Z(A) relay. A subsequent OUT call at the radio site will select the A controller again and operate the associated OUT and LA relays. The A controller was selected again because the CW and CZ relays were still normal. The OUT relay releases the W(A) relay and now the CW relay operates thru a break of W and a make of Z. When the controller releases this call after general relay operations shown by SC2, the OUT and LA relays release which release Z(A) and operate CZ. With CW and CZ relays operated, a subsequent OUT call will be placed in the B controller. A hypothetical case of four successive OUT calls would be necessary to complete one full cycle of operations of the CW, CZ, W, and Z relays, returning these relays to normal. This

action plays its part in the general pattern of preference should both radio site and direction center seize the same trunk simultaneously as described elsewhere.

#### 5.3 Trouble Condition

If a trouble occurs in the A or B section of the controller the corresponding TRA or TRB relay will operate. If the TRA relay operates, all subsequent calls are restricted to the B section of the controller until the TRA relay is released. This function of the TRA and TRB relays permits maintenance on a controller without removing the entire controller from service. The TRA or TRB relays may also be operated manually by operation of the MBA or MBB key.

### 6. TRUNK SELECTION

#### 6.1 Out Calls

For the single out call previously described, controller A with Z normal was assumed. These conditions (OS6) gave preference to the lowest numbered trunk. For the B controller, a "turnover" is introduced between the BT leads and the T relays. Where Z is normal, the lowest T relay operated locks. Another "turnover" between the chain contacts of the T relays and the trunks (OS7) is used. Hence the ground from the lowest T-relay operates the highest numbered trunk, giving preference to that trunk.

The Z relay operated, as determined by controller usage, will apply locking ground (OS6) to a point at or near the center of the contact chain as specified by different figures. For example, where 20 trunks are specified, Fig. A or D connects the locking ground to the T10 relay contact. Where 40 trunks are specified, the ground enters the chain at T20. For 30 trunks, the "split" is made at the T10 relay, because it is not feasible to split the trunk group at any other points than at those corresponding to the controller groups: This gives an effective "split" in the B controller between 19 and 20.

In any case, with both controllers functioning, four choices of trunks are available to outgoing calls. As an example, for 20 trunks, a typical sequence of trunk choice on successive calls for the direction center is given below, with the equivalent choice at the radio site:

<u>D. C.</u>	<u>R. S.</u>
00-09; 10-19	00-09; 10-19
19-10; 09-00	10-19; 00-09
10-19; 00-09	19-10; 09-00
09-00; 19-10	09-00; 19-10

With this arrangement; a different choice will be available should a simultaneous seizure from both the radio site and direction center occur.

## 6.2 IN Calls

For IN calls, only 10 leads to the T-relays, corresponding to the group being served, are connected. Hence, where the IN calls in the same controller group request service, the lower numbered will be preferred in the A controller, and the higher numbered in the B controller.

## 7. ALARMS

SC4(E5Y18)

A comparatively long cycle is associated with the common part of the circuit. If any of the three chain circuits are opened either due to a trouble or because the circuit is in use or relays COA or COB operate, relay GS operates and starts the alarm. The minimum time is approximately 1.8 sec. If this time is exceeded condenser GT charges to a potential sufficient to fire tube GT and operate relay GA OS9(D9B0). This relay sounds a major alarm and calls in the trouble indicator. The trouble indicator will operate the proper RL relay and the other controller will be made available to the common circuit. If the trouble was in the A or B controller, calls can be served but if the trouble was in the common part of the circuit, maintenance will be required.

Each controller has a three part alarm circuit; one functions while no busy condition exists with a minimum time of .38 second, the second while a busy condition exists with a minimum time of .72 second, and the third provides for the time for a test call to release in favor of a service call or when the test circuit is making a transfer test (release time of the trunk-to-channel connection may be as long as 0.9 sec.) with a minimum time of 1.54 seconds. The timers operate in the same fashion, and are started by relay ASA which operates when relays LA (or LB) is operated or when either of chain relays CH4 or CH5 are released OS9(D9D4). Tube CT1 will fire OS9(D9B5) operating relay AA, when condenser CT1 reaches a certain voltage unless prevented by the operation of relay BY (before HMT1 has operated), relay RL or the release of relay ASA. Tube CT2 will fire OS9(D9B3) if relay BY is operated or will fire after a longer period if relays BY and SR are operated. Each time relay AA will operate. In either case relay AA signals the trouble indicator which takes a record, makes the controller busy and releases it, permitting the call to pick the other controller. A lamp is lighted on the

link frame and a minor alarm is given if both controllers were previously in service. If one of the controllers were busy it was freed and the other one made busy. In this case a major alarm is given.

## 8. CONNECTION TO THE TROUBLE INDICATOR

SC4(E5Y18).

When either of the alarm relays GA or AA operate, resistance battery is closed to the trouble indicator over lead TA or TB (OS9). In case relay GA initiates the action the condition of relays LA, LB or CZ shows which controller is to be indicated. When the trouble indicator has functioned the action taken depends on the previous conditions. If both controllers were in operation relay TRA will operate if lead TA was closed or TRB if TB was closed. The trouble indicator will cause the proper RL relay to operate releasing the controller and indirectly itself. Relay GRL does not operate, however, as the preferred group is to be given another chance to complete with the other controller.

If one of the controllers is out of service ground on lead TRB, for example, will operate relay MA through contacts on relays TRA which is operated OS1(D2C6). Relay MA allows relay TRB to operate. This breaks the locking circuit for relay TRA which releases and closes the locking circuit for relay TRB and MA. When relay RL operates, relay GRL will operate through contacts on relay MA-(OS1(D2B7)). In this case the group is released in the hope that the controller just made available can serve some calls in the other groups.

## 9. PROTECTION AGAINST OPEN CHAIN CIRCUITS AND PERMANENTLY GROUNDED START LEADS

### 9.1 Open Common Group Chain Circuits

The chain circuits of the common equipment is monitored by chain testing relays CH1, CH2 and CH3 - OS1(D2H4). They are normally operated relays and start the group timing cycle if they release for any reason OS9(D9D1). In normal service the timer will be recycled by the chain circuits reclosing when all group relays release after serving a call in each group.

### 9.2 Open Selection Chain Circuits

The selection chain circuits of the controllers are similarly monitored by relays CH4 and CH5 - OS3(D4D9) and OS6(D6G4). Other chains are not monitored as the other controller should be able to handle the calls until the first controller is cleared of trouble.

### 9.3 Grounded Start Leads

The hazard of permanently grounded start leads, which could cause the complete tie-up of a link, is minimized by the use of the alternate preference and preference split arrangements already described. To make best use of this protection, the trunks should be spread over the 2, 3 or 4 switches as evenly as possible.

#### 9.31 Channel Leads

A permanently grounded start lead from a channel circuit will cause the link to time out repeatedly if this start lead is the only one grounded. A minor alarm will be given on the first attempt, changing to a major alarm on the second. If there is another start lead properly grounded but of lower preference in the same group, the first controller will time out and release but will not release the group relay. The other controller will now try to set up the call and as the leads to the test relays of the second controller are reversed with respect to those of the first the "good" start lead will be preferred and the call set up. The group circuit will now serve one call in each remaining group. When the permanently grounded start lead is encountered the second time a major alarm will be sounded, the controller made busy and the other controller released for service. A key is provided per "ST" lead to cut off the lead in trouble and connect it to a guard lamp. The operation of any of these keys will cause a major alarm whether a "ST" lead is grounded or not.

#### 9.32 Trunk Leads

A grounded start lead from a trunk is treated similarly; the chain here, however, is so long that the leads are not only reversed to make one controller "hunt" in the opposite direction but a W and Z relay combination is used to change the preference from the end of the chain to the middle on alternate calls.

### 10. BUSY LEVELS

#### 10.1 Incoming Call - Direction Center - SC5E8

If a busy level is encountered by an incoming call at the direction center and the test circuit is not in use, register BL is operated operating relay BL - OS8(D8E3). The hold magnet is then operated without any select magnet and the controller releases in the normal manner - SC5(E8AB26). When the test circuit is in use ground is passed to that circuit which releases. If the level was in use by the test circuit relay BY will release and allow the call to proceed before relay SR releases. If the test circuit was not making the level busy and

the busy condition persists, relay SR will release, register BL and relay BL will operate as above.

#### 10.2 Incoming Calls - Radio Site - SC6E9

If a busy level is indicated by an incoming call at the site end, register BL will operate - OS8(D8E3). The channel should already be releasing due to ground from relay IN over the CL lead. When the busy condition is removed relay BY and register BT release and the call is set up in the regular manner. Test calls are handled as in the above paragraph.

#### 10.3 Out Calls

Busy levels on an outgoing call will cause a trouble indication.

#### 10.4 Recycle

Any busy level indication recycles the alarm system by shifting from one alarm tube and network when relay BY operates and back to the original tube and network when it releases. The condenser that is not in use is discharged immediately when its cycle is no longer wanted.

### 11. FALSE START

#### 11.1 Channel - SC7E10

The release of relay CH1 and CH2 when a call is started operates relay FS. This relay when operated, closes a short on its secondary winding causing the relay to be slow in releasing when the circuit to the primary is opened later and closes the circuit to relay LA or LB as a check that relay FS is not permanently released. The operation of any GC- relay causes the operation of relay GCK which starts the release of relay FS. If the start lead from the channel is no longer closed and ground has not been closed to hold magnet when relay FS closes its back contact, register FS will operate followed by the operation of relay RL.

#### 11.2 Trunk SC8E11

If the start lead from a trunk is opened before the trunk is locked in, relay BTK1 will be normal when relay FS releases. This will result in the operation of register FS followed by the operation of relay RL.

### 12. ALL TRUNKS BUSY

#### 12.1 Direction Center - SC9E12

In most cases, on all trunks busy condition will first be detected by the connecting circuit, the trunk and channel alarm and control (hereinafter abbreviated as the TACAAC) circuit. Whenever this occurs,

ground is applied to the TBO lead from the TACAAC circuit, operating the TB(A-C) relays which lock to HT normal. Operation of the connecting circuits should then free trunks not actually in a talking condition. When this occurs, ground is restored to the TBN lead, which applies ground to the HT coil, operating it after several seconds. The TB- relays operated apply ground to the TBT leads to the channel circuits. These grounds are removed when HT operates to release the TB- relays. The action of the TB- and HT relays proceed whether or not the controller is busy on a request for service.

As mentioned above, the action of the connecting circuits should free one or more trunks, so an OUT call will normally find an idle trunk. If the action has not been completed, or a trouble exists in the connecting circuits, no trunk will be available. Hence, if a controller is setting up an OUT call, but no idle trunk has been found by the time the select magnets have been operated and checked, relay HO would not have operated when relay SMK operates SC9(E12R10). In the all trunks busy condition there are no grounds present on any of the BT leads to the trunks. Because of this none of the T relays operate and this indicates that no trunks are idle. Hence, CH5 remains operated. For these conditions, a path from ground on OS8, through LCF operated, OCT, HO normal, through other operated relays is closed to operate BTA or BTB, OS12. Operation of the BTA relay SC9(E12R11) operates the TBT relay of the TACAAC circuit. With TBT operated OS12(D116C) ground is returned on the TBO lead. The TBO ground operates the TB(A-C) relays, if not already operated; and removal of ground from TBN recycles the HT timer. With BTA or BTB, and the TB(A-C) relays operated, a path from the SMK contact is closed through to the TACAAC circuit on the BT lead; and will

be returned on the BT1 lead if a check is met in that circuit. This causes the BT register to score and operate the HMK relays. This causes the connecting channel circuit to open its start lead, and hold it open for the duration of the ground signal on the TBT- lead, provided that no "push-to-talk" indication is received. (If one is received, successive attempts, in competition with other calls, as determined by the group preference, are made until either the call is completed, or the push-to-talk indication is removed.)

Operation of the TACAAC circuit TBT relay from the controller BTA or BTB relays should not occur frequently. It does occur when an attempt to originate is made during the time the "all trunks busy" action is in progress. The number of such occurrences should be relatively small. For some trouble conditions, such as an open contact in the trunk path associated with the controller busy test, the controller will first detect the "all trunks busy" condition. Where this occurs, the BT registrations will be much greater than normally experienced. Hence, an increase in such registrations is an indication of possible trouble.

## 12.2 Radio Site - SC10E12

For most cases, the action described for the direction center should relieve the all trunks busy condition so that the radio site controller should seldom encounter such a situation. When it occurs, however, a path (OS8-D8) to the BT register through HO, OCT normal, and the OUT, CH5, SMK, BTC-, TT-, and LCF relays operated is closed. A path to the RL relay is closed when the BT register scores, releasing the controller.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.1 This circuit is arranged to work in local circuit on voltages of 45-50 and 125-135.

2. FUNCTIONAL DESIGNATIONS

DESIGNATION	FUNCTION
<u>Relays</u>	
AA	Alarm
ACO	Alarm cutoff
AR	Alarm Release
ASA	Alarm (Timing) start
BT(A,B)	Trunks busy memory
BTC(A-D)	Busy test lead connector
BTE	Busy test end
BTK	Busy test check. Start lead check from trunks
BTK1	Busy test check auxiliary
BY	Busy level test
BY(A-C)	BY lead connectors
CH(1-5)	Chain circuit checks
CL(A-C)	CL lead connectors
CO(A,B)	Cutoff (ST leads)
CW	Common W (part of W&Z)
CZ	" Z
FS	False start (timing)
G	Release "glare" condition
G(0-6)	Group
GA	General alarm
GAL	" " auxiliary
GC(0-6)	Group connector
GCK	" " check
GE(0-6)	Group end
GRL	Group release
GS	Group start (alarm)
HMK	Hold magnet check
HMT	Hold magnet test
HMT1	" " auxiliary
HO	Operate hold magnet
HT	Hold timer
IN	IN call (toward channel)
L(0,1,2,4,7,00,10,20)	Level (code)
LA	Link - controller A
LB	Link - controller B
LC(A-H)	Link Connectors
MA	Major alarm
OCK	OC lead check
OCT	OC lead test
OUT	Call from channel to trunk
RL	Release link (controller)
SM(0-9)	Select magnet selection
SM(A-C)	Select magnet connectors
SMK	Select magnet check
SR	Slow release
SS(A-D)	SS lead connectors
STK	Start lead check from channels
T(0-39)	Trunk testing
TB(A,B)	Trunks busy
TK	Trunk check
TK(0-3) (A,B)	Trunk connectors

TT(A,B)	Trunk test connectors
TRL	Trouble release
TR(A,B)	Transfer relays
W	W (part of W&Z)
Z	Z (part of W&Z)

Lamps

ACO	Alarm cutoff
G	Guard on ST leads
MA	Major alarm
TRA	Transfer - A controller busy
TRB	Transfer - B controller busy

Electron Tubes

BT	Busy timing when all trunks are busy
GT	Group timing - common circuit
CTL	Controller timing - general
CT2	" " for busy levels

Keys

ACO	Alarm cutoff - minor alarms
AR	Alarm release - major alarms
CUTOFF	Cut off for falsely grounded St leads
MBA	Made busy for A controller
MBB	" " " B "
RL	Release for busy condition on either controller

Message Registers

BL	Busy levels
BT	Busy trunks - all trunks busy
FS	False start

3. FUNCTIONS

- 3.01 To recognize ground on the start leads as a request for a connection and to set up these connections in an orderly manner.
- 3.02 To serve one call in each waiting group before serving a second call in any group.
- 3.03 To lock out all new calls to any group while calls are being served.
- 3.04 To allow any call in a group that is not presently being served by a controller to be abandoned.
- 3.05 At the direction center, to select one of the two controllers, using the controllers on an alternate basis.
- 3.06 At the radio site, for outgoing calls, to select the same controller twice in succession, for the purpose of giving a different trunk selection pattern than at the direction center.

- 3.07 To work on one controller if the other is out of service.
- 3.08 To free a busy controller if the second is made busy.
- 3.09 To operate common connectors to gain access to circuits connected to levels of the switches.
- 3.10 To operate connectors in the controller in use and relays in the trunk circuits to gain access to the trunks.
- 3.11 To select the proper magnet to match the chosen start lead on an outgoing call.
- 3.12 To select the proper select magnet in response to a code on an incoming call.
- 3.13 To operate and check the proper select magnet.
- 3.14 To test that the start lead is opened before the controller releases.
- 3.15 To test that the indicated switch level is not in use before the hold magnet is operated.
- 3.16 To test that the switch level is made busy after the hold magnet is operated.
- 3.17 To check that the code for selecting switch levels is received from the trunk with the correct number of components.
- 3.18 To select an idle trunk on an outgoing call.
- 3.19 To obtain access to the indicated trunk when its start lead is grounded.
- 3.20 To change the preference on alternate calls served by a controller.
- 3.21 To provide a different order of preference in the two controllers.
- 3.22 To test that the trunk is made busy before the hold magnet is operated on an outgoing call.
- 3.23 To operate and check the proper cut in relay.
- 3.24 To check the continuity of a lead to the trunk on an outgoing call.
- 3.25 To check that the trunk relay has had locking ground applied.
- 3.26 To check continuity of the hold magnet.
- 3.27 To check that locking ground has been applied to the hold magnet.
- 3.28 To release the select magnets as soon as the connected circuit signals that the crosspoints are closed.
- 3.29 To release all connectors when all checks are satisfied.
- 3.30 To release the controller.
- 3.31 To start an alarm cycle if the chain circuits of the common part of the link go open.
- 3.32 To light a lamp if the alarm interval is exceeded.
- 3.33 To ground a lead to the major alarm if the alarm cycle is exceeded.
- 3.34 To start an alarm cycle if the controller goes off normal.
- 3.35 To ground a lead to the minor alarm if this alarm cycle is exceeded.
- 3.36 To cut off the audible alarm when a key is operated.
- 3.37 To call in a trouble indicator when any of the alarm cycles is exceeded.
- 3.38 To change a minor alarm to a major alarm if an attempt is made to make both controllers busy at the same time.
- 3.39 To provide a signal to the connected circuits if all trunks are found busy.
- 3.40 To release if the indicated level is busy (console).
- 3.41 To signal the associated circuit if the indicated level is busy (site).
- 3.42 To await the release of the associated circuit.
- 3.43 To complete the connections when the associated circuit becomes idle.
- 3.44 To recycle the alarm system when a busy level is encountered.
- 3.45 To release without operating a hold magnet if the preferred outgoing call is abandoned.
- 3.46 To provide a record of the number of false starts.
- 3.47 To provide a record of the number of busy levels encountered.
- 3.48 To provide a record of the number of times all trunks are found busy.
- 3.49 To release the controller without further tests if the trunk signals that a call is being set up in both directions.

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- 3.50 To provide connections to a test circuit for trunks and channels.
- 3.51 To provide an additional length of time before giving an alarm on encountering a busy level when a test call is being made.
- 4. CONNECTING CIRCUITS
  - 4.1 Channel Circuit - SD-1G023-01.
  - 4.2 Channel Circuit - SD-1G028-01.
  - 4.3 Trunk Circuit - SD-1G025-01.
  - 4.4 Trunk Circuit - SD-1G026-01.
  - 4.5 Trouble Indicator Circuit - SD-1G027-01.
  - 4.6 Automatic Test Circuit - SD-1G030-01.
  - 4.7 Audible and Visual Alarm Circuit - SD-96188-01.

SECTION IV - REASONS FOR REISSUE

CHANGES

B. CHANGES IN APPARATUS

B.1	Removed	Replaced by
	Fig. 2 KS-13491-L1, 510 <sup>Ω</sup> resistors HMT, Oct. (2)	Fig. 2 KS-13490-L1, 510 <sup>Ω</sup> resistors HMT, Oct. (2)

Note: This change for record only, since all units have been manufactured with the KS-13490-L1 resistors.

C. CHANGES IN CIRCUIT REQUIREMENTS OTHER THAN THOSE APPLYING TO ADDED OR REMOVED APPARATUS

The HT relay was added in the circuit requirements table to show its location on

the SD. Current flow information is not given, since no adjustment is possible other than the timing adjustment already given in the timing requirements.

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 The drawing was revised to the form using lettered groups.

D.2 Operational sketches (OS's) and sequence charts (SC's) were added for information notes for maintenance and training purposes. Previously, the SC were part of the CD.

D.3 The T1 and T2 leads, Sheet B are changed from the bracket reading "TO Fig. 2" to the one reading "TO 2nd Fig. 2".

All other headings under Changes, no change.

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