

## HOUSE EXCHANGE SYSTEM NO. 4

## Circuit Operation

1. **General.** This Instruction describes the circuit operation of the House Exchange System (H.E.S.) No. 4. The facilities provided by this equipment are detailed in Q 1015 which contains definitions of the terms used in the following paragraphs.

The diagrams quoted in the paragraph headings are wiring, cabling and schematic diagrams. Circuit element diagrams are listed below.

Q 580 Multiple stations. Exchange line speech, ringing and signalling circuits.

Q 581 Multiple stations. Intercom signalling and speech circuits.

Q 582 Non-multiple extensions. Intercom signalling and speech circuits.

Q 583 Non-multiple extensions. Exchange line calls.

Q 584 2nd-choice main station.

Diagram Q 502 illustrates the layout of typical installations.

2. **Contents.**

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## INTERCOM CALLS

3. **Multiple station calling multiple station (Dgms. Q 503 and 540).** - Removing the handset at the calling station operates the CS springs.

CS1 disconnects the buzzer from the home multiple pair and connects the telephone circuit to the local keys (1KL-10KL).

CS2 and 3 complete the transmitter-feeding bridge circuit.

Depressing a local key (KL) connects the telephone circuit to the multiple pair of the called station, overpress of the local key operates the KCL spring-set.

KCL2 disconnects the telephone circuit from the multiple pair of the called station and substitutes a battery connected 430-ohm resistor (R5) to the A wire of the multiple pair.

KCL3 similarly disconnects the telephone circuit and substitutes an earth connexion to the B wire of the multiple pair.

4. *Called station free.* The buzzer at the called station is operated by the earth on the B wire, resistance battery on the A wire, via the diode in the buzzer in the forward conducting direction. When the overpress of the local key at the calling station is released, KCL springs restore. KCL2 and 3 remove the signalling earth and resistance battery and restore the telephone circuit. The polarity of the station multiple pair is now earth A wire, battery B wire. The diode in the buzzer circuit at the called station will not conduct and the buzzer ceases to operate.

When the called station answers, the lifting of the handset operates the CS springs which connect the transmitter-feeding bridge. Conversation can now take place between the two stations.

5. *Called station engaged on an intercom call.* The CS springs at the called station will be operated. The buzzer is disconnected by CS1 (operated) and will not operate. Release of the overpress of the local key at the calling station will restore the telephone circuit, the calling station thus joins the connexion between the two other stations.

6. *Called station engaged on an exchange call.* Springs KHA or KHB at the called station will be operated. Dependant upon the strapping of terminals T2, T3 and T4 in the called station instrument either an engaged signal will be returned to the calling station, or the buzzer at the called station will operate.

(a) *Engaged signal returned to calling station.* The earth connected to the B wire of the multiple pair of the called station by the overpress of the local key at the calling station will be diverted, via either KHA2 or KHB2 and the strap between terminals T3-T4, to the C wire. The C wire at the calling station is connected by contacts KCL1 (operated) to the buzzer. The buzzer at the calling station will operate indicating an engaged condition.

(b) *Buzzer at the called station operates.* The earth connected to the B wire of the multiple pair of the called station by the overpress of the local key at the calling station will be connected to the buzzer, via either KHA2 or KHB2 (operated) and the strap between terminals T2-T3. The buzzer will operate as described in par. 4.

To answer the intercom call the local key at the called station must be operated to release the depressed exchange key and either KXA or KXB springs and to operate the local KL1 and 2 springs. The circuit for conversation between the two stations is now established via the A wire of the intercom circuit, T20, telephone loop, T6, KL1 (operated), additional strap from the KL1 terminal (i.e. for station 1 T44) to T21, to the B wire.

7. *Release of connexion.* - At the termination of an intercom call both stations replace their handsets which restore the CS springs and release all operated keys.

If one of the stations is holding an exchange line, the exchange line button is pressed to re-connect the exchange line.

8. *Multiple station calling non-multiple extension* (Dgms. Q 503, 519, 540 and 550).

*NOTE:-* In the following explanations involving non-multiple extensions an installation with two or more extensions and Control-unit Q 537 is envisaged. Installations with only one non-multiple extension use Control-unit Q 535.

At the calling multiple station, after the handset is lifted, the local key (KL) associated with the required non-multiple extension is fully depressed, operating the KCL springs. The earth applied to the multiple pair B wire by KCL3 and the resistance battery connected to the multiple pair A wire by KCL2, operate relays F and RR in the Relay-unit Q 519. Relay F is operated directly by the earth on the B wire and relay RR by the earth on the B wire and resistance battery on the A wire via diode D1 in the forward conducting direction. Contact RR1 (operated) connects 25 Hz earthed ringing current, obtained from a Converter, Ringing, No. 7, to the A wire of the non-multiple extension line to operate the instrument bell. When the overpress of the local key at the calling station is released the multiple pair returns to normal polarity, earth A wire, battery B wire. The diode D1 ceases to conduct and relay RR releases. Contact RR1 disconnects the ringing current from the A wire of the extension line. Relay F holds to the earth from the calling station transmitter-feeding bridge via the telephone loop.

9. *Non-multiple extension answers.* - The extension answers by lifting the handset and pressing the EXTN button, connecting the telephone circuit to the line. Relay A in the Relay-unit Q 519 operates to the telephone loop via RR1, RR2, relay D coils, EX1 and EX2, operated. (Relay D is differentially wound and does not operate.) A3 (operated) disconnects relay RR and completes the connexion of the transmission bridge to the multiple pair. Conversation between the calling multiple station and the called non-multiple extension can now proceed.

10. *Non-multiple extension engaged on an intercom call.* - Relay A in the Relay-unit Q 519 will be operated. A3 (operated) prevents the operation of relay RR. When the overpress of the local key at the calling station is released the calling station joins the connexion.

11. *Non-multiple extension engaged on an exchange call* (see pars. 32 and 33). - Relay B in the Relay-unit Q 519 will be operated. B1 (operated) disconnects the A wire of the multiple pair. B2 (operated) switches the B wire from relays F and RR to the C wire. Thus the buzzer in the calling station instrument will be operated via KCL1 (operated).

**12. Release.** - When the handset at the non-multiple extension is replaced the loop operating relay A in the Relay-unit Q 519 is removed and relay A releases. When the handset at the multiple station is replaced the removal of the telephone loop releases relay F.

If the handset at the multiple station is replaced first relay F holds to contacts F1 and A1 (operated) preventing a false call to the main station. When the non-multiple extension clears relay A releases, A1 releasing, releases relay F.

**13. Non-multiple extension calling main station - (Dgms. Q 503, 519, 537, 540 and 550).** - The handset at the non-multiple extension is lifted and the EXTN button is depressed. The telephone loop is connected to the line operating relay A in the Relay-unit Q 519, via RR1, RR2, coils of relay D, EX1 and EX2 operated. A2 (operated) extends the earth from D1 to operate relay AL via F3, EL2 and B4. A3 (operated) connects the transmission bridge to the multiple pair. AL1 (operated) connects the Control-unit Q 537, AL and AL2 leads together to operate the buzzer. AL2 connects the AL and AL1 leads together causing the call lamp to glow.

The main station answers the call, after lifting the handset, by depressing the local key (KL) associated with the non-multiple extension. KL contacts connect the telephone loop to the multiple pair operating relay F. (Relay RR is disconnected by A3 operated). F3 (operated) releases relay AL. AL1 and AL2 releasing the disconnect the call lamp and buzzer in the Control-unit Q 537. Conversation between the main station and the non-multiple extension can now proceed.

**14. Non-multiple extension calling a multiple station.** - The non-multiple extension calls the main station as described in par. 13 and the main station calls the required multiple station as described in par. 3. When the main station operates the local key to call the required station the local key associated with the calling non-multiple extension will restore, removing the telephone loop from the multiple pair of the calling extension. (Relay F will hold via contacts F1 and A1 operated). When the required station operates the local key associated with the non-multiple extension a three-way conversation can take place. After ascertaining that the call is established the handset at the main station is replaced.

**15. Non-multiple extension calling non-multiple extension.** - The non-multiple extension calls the main station as described in par. 13 and the main station calls the required non-multiple extension as described in par. 8. When the main station operates the local key to call the required extension the local key associated with the calling non-multiple extension will restore, removing the telephone loop from the multiple pair of the calling extension. (Relay F will hold via contacts F1 and A1 operated). After the required extension has answered the CONNECT and TEST keys (KCA or KCB) on the Control-unit Q 537 of both extensions are operated in the same direction, either upwards or downwards. (Two connecting circuits are provided in the Control-unit Q 537). The extensions can now speak. The handset at the main station is replaced, relay F in both Relay-units Q 519 holding via F1 and A1 contacts (operated). The circuit for conversation between the two extensions is via the AC and BC leads in the Relay-units Q 519 to the Control-unit Q 537, thence via either KCA or KCB keys (operated). (Resistor R3 or R4 provide a wetting current for the key contacts.)

**16. Release.** As each extension handset is replaced the removal of the telephone loops releases the A relays in the Relay-units Q 519. A1 contacts, releasing, release the F relays. A2 and F6, releasing, extend the D1 earths to the BZ leads which are connected to the S leads by either KCA or KCB keys operated.

The earths on the S leads operate the AL relays in the Relay-units Q 519. AL1 and AL2 (operated) cause the call lamps of each extension to glow and the buzzer to operate. When the KCA or KCB keys are restored the AL relays release disconnecting the call lamps and the buzzer.

**17. Conference calls.** - The multiple station first calls the stations or non-multiple extensions concerned as described in pars. 3 or 8. The conference key at the organizing station is then operated followed by the operation of the local keys of the stations or extensions previously called. The local keys will all lock in the operated position. If the conference key is first operated followed by the operation of the local keys, difficulty in operating the buzzers will be experienced. This is due to the transmitter-feeding bridge of the first, and subsequently called stations, masking the call condition.

#### EXCHANGE CALLS

**18. Exchange line circuits.** - The exchange lines enter the system at the IN terminals of the first multiple station and, after passing through the KHA (line 1) or KHB (line 2) spring-sets, leave the station via the OUT terminals. The OUT terminals of station 1 are wired to the IN terminals of station 2, thus the exchange lines pass through the multiple station instruments in numerical order. The OUT terminals of the last multiple station are wired via a Box, Connexion, No. 7A, or Block, Terminal, No. 36A, to the Relay-unit Q 516. The non-multiple extension Relay-units Q 519 are connected to the exchange lines in the Box, Connexion, No. 7A. Operation of an exchange button at a multiple station disconnects the exchange line from the stations beyond it in the multiple and the Relay-units Q 516 and Q 519.

**19. Multiple station engages exchange line 1 - (Dgms. Q 503, 516 and 540).** - The handset is lifted and the exchange line 1 button is pressed operating the KXA and KHA springs. KHA5 (operated) disconnects the negative wire of the exchange line from succeeding stations and KXA1 connects it to the telephone circuit. KHA1 and KXA2 (operated) switch the positive wire into the telephone circuit. The transmitter-feeding bridge and intercom circuit are disconnected from the telephone circuit by KXA2 and KXA4 operated. KHA3 (operated) disconnects the XA lead from succeeding stations and connects it to earth via lamp LP3 and shunt-resistor R8, operating relay XA in the Relay-unit Q 516. KXA3 (operated) earths the LPAC lead operating relay FLA in the Relay-unit Q 516. (The lamps LP1 and shunt-resistor R6 in each station instrument are wired in series to a battery connexion at station 1. Current for these lamps is controlled to  $100 \pm 5$  mA by a Regulator No. 4A in the Relay-unit Q 516). FLA2 (operated) switches on the Regulator No. 4A causing lamps LP1 to glow at all stations indicating that exchange line 1 is engaged. XA4 (operated) disconnects the series bell circuit (see par. 22).

**20. Multiple station engages exchange line 2.** - The circuit operation is identical to that for exchange line 1 using different components. Keys KXB, KHB replace keys KXA, KHA; relays FLB, XB replace relays FLA, XA; leads XB, LPBC replace leads XA, LPAC; lamps LP2, LP4 replace lamps LP1, LP3; resistors R7, R9 replace resistors R6, R8.

**21. Release.** - At the end of the call the handset is replaced releasing CS springs and restoring the operated exchange line button. All operated spring-sets and relays will release.

**22. A.C. bell circuit.** - Each multiple station instrument incorporates a magneto bell and bell on-off key (KB). Station bells are wired in series to an earth connexion at station 1. Detection of ringing current on an exchange line results in the connexion, in the Relay-unit Q 516, of the negative wire of the line

to the series bell circuit. In the station instruments KB1 (operated) in series with the strap between telephone terminals T34 and T35 completes the short-circuit across the bell which is connected to terminals T33 and T34. The strap between terminals T34 and T35 must be removed at the main station so that the bell will always ring.

**23. Incoming call on exchange line 1 - (Dgms. Q 503, 516 and 540).** - Ringing current operates relay PGA in the Relay-unit Q 516. RGA2 (operated) connects the series bell circuit via XA4 and capacitor C3 to the negative wire of the exchange line in parallel with relay RGA. RGA1 (operated) switches on the Regulator No. 4A associated with the LP1 lamps. At all multiple stations except those with their bells short-circuited, lamps LP1 will flash to the ringing cadence and bells will ring.

**24. Incoming call on exchange line 2.** - The circuit operations are the same as for a call on exchange line 1. Relay RGB in the Relay-unit Q 516 will operate to the ringing current. RGB3 (operated) will connect the bell circuit via XB5, strap between terminals 47 and 48, RGA2 and capacitor C3. RGB1 (operated) controls the Regulator No. 4A associated with the LP2 lamps.

**25. Multiple station answers an exchange line call.** - The circuit conditions described in par. 19 for exchange line 1, or par. 20 for exchange line 2, will apply.

**26. Multiple station makes an intercom call while holding an exchange line.** - Depressing the local key (KL) of the required station or extension restores the operated exchange line button and KXA or KXB springs. KHA or KHB springs will remain operated. For exchange line 1, KXA1 connects hold resistor R3 across the exchange line in place of the telephone. KXA2 and KXA4 connect the telephone circuit to the transmitter-feeding bridge and intercom circuit. KXA3 removes the earth from the LPAC lead. Relay XA in the Relay-unit Q 516 is still held operated by the earth from lamp LP3 and shunt-resistor R8 via KHA3 operated. Removal of the earth from the LPAC lead releases relay FLA. With XA1 operated and FLA1 releasing, relay FLA will interact with FLA1 approximately 2-3 times per second (see par. 38). FLA2, pulsing, causes the Regulator No. 4A to flash the LP1 lamps indicating that the exchange line is being held. To return to the exchange call the exchange button is pressed.

For exchange line 2, the operation is identical except that keys KXB, KHB, relays XB, FLB, lead LPBC, lamps LP2, LP4, resistors R4 and R9 will be involved.

**27. Multiple station transfers an exchange line call to a multiple station.** - An enquiry call is made to the required station as described in par. 26. When the station accepting the exchange call presses the exchange line button, springs KXA, KHA, or KXB, KHB, will operate, as described in par. 26. The earth applied to the LPAC or LPBC leads will cause the flashing of the exchange line lamp to change to a steady glow. This indicates to the holding station that the call has been accepted. To complete the transfer the holding station must replace the handset or, if holding another call, operate the release key adjacent to the hold exchange line button. Either of these operations will release the KHA or KHB springs by removing the hold resistor from the exchange line.

**28. Multiple station transfers an exchange line call to a non-multiple extension.** - Transfer of exchange line calls to a non-multiple extension can only be accomplished from the main station. Multiple stations wishing to transfer an exchange line call to a non-multiple extension must, therefore, first transfer the exchange line call to the main station as described in par. 27.

29. Main station transfers a call on exchange line 1 to a non-multiple extension - (Dgms. Q 503, 516, 519, 537, 540 and 550). - The main station calls the non-multiple extension as described in par. 8. When the extension answers the CONNECT and TEST key (KCA/KCB) on the Control-unit Q 537 associated with the extension is operated, either up or down, depending upon which connect circuit is used. Assuming that the CONNECT and TEST key is moved upwards (KCA), the TRANSFER 1 (1KTA) key, which is non-locking, is operated. 1KTA and KCA1 (operated) connect an earth to the X1 lead of the non-multiple extension Relay-unit Q 519. The earth operates relay LA to the 750-ohm resistor (R5) in the Relay-unit Q 516 via F4, diode D2, relay LA high-resistance coil, LB3 and LA lead to Relay-unit Q 516. The earth on the X1 lead is also extended to the XA and LPAC leads to operate relay FLA in the Relay-unit Q 516, so causing the exchange line lamps to change from a flashing signal to a steady glow. LA2 (operated) operates relay B in the Relay-unit Q 519. B1 and B2 (operated) disconnect the intercom multiple wires from the transmission bridge. B2 also connects the B wire of the intercom circuit to the common C wire to indicate engaged condition to calling multiple stations. B3 with EX3 (operated) connect hold resistor (R4) across the exchange line circuit in preparation for operating relay S. B5 (operated) connects earth to the low-resistance coil of relay LA to provide a hold circuit and also prevent other LA relays from operating, and calls being established, on exchange line 1. B7 extends the D1 earth to the BZ lead, which is connected via KCA5 (operated) to the S lead, to operate relay AL. AL1 and AL2 (operated) connect the AL lead to the AL1 and AL2 leads causing the call lamp to glow and the buzzer to operate in Control-unit Q 537. The TRANSFER 1 (KTA) key is now restored. 1KTA, restoring, removes the earth from the X1 lead. Relay LA holds via low-resistance coil, B5 and LA1 operated, LB3 normal, LA lead to resistor R5 in Relay-unit Q 516. The earth on the XA and LPAC leads is maintained by B8 (operated). The CONNECT and TEST key is restored, releasing relay AL. AL1 and AL2, releasing, disconnect the call lamp and buzzer. (After the TRANSFER 1 key, but before the CONNECT and TEST key, has been restored the TEST 1 lamp will glow; this is of no significance at this stage.)

At the main station the handset is replaced or, if holding another call, the release key adjacent to exchange line 1 button is operated. KHA springs, releasing, in the main station telephone switch the exchange line to the Relay-unit Q 519 operating relay S. S1 (operated) operates relay SR. SR5 (operated) releases relay EX. EX1 and EX2, releasing, switch the extension line from the transmission bridge to the exchange line. Relay A releases. EX3 disconnects the hold resistor (R4) from the exchange line. A1, releasing, releases relay F.

30. Main station transfers a call on exchange line 2 to a non-multiple extension. - The non-multiple extension is called and the CONNECT and TEST key operated by the main station as described in par. 29. The TRANSFER 2 (2KTA) key, which is non-locking, is now operated. 2KTA and KCA2 (operated) connect an earth to the X2 lead to operate relay LB via diode D3, F5 (operated) and LA5 in Relay-unit Q 519. LB6 (operated) extends the earth on the X2 lead to operate relay LA to the 750-ohm resistor (R6) in the Relay-unit Q 516 via high-resistance coil of relay LA, LB3 operated and the LB lead. The earth on the X2 lead is also extended to the XB and LPBC leads to operate relay FLB in the Relay-unit Q 516 to change the flashing hold signal of the exchange line lamps to a steady glow. The circuit operations are now similar to those described in par. 28, except that the extension is connected to exchange line 2 via contacts LB1 and LB2 operated.

31. *Non-multiple extension engages an exchange line.* - To originate an exchange call the handset at the extension is lifted followed by the depression of the non-locking EXCH button. Mechanical linkage operates the locking EXTN button to connect the telephone circuit to the line and a spring-set of the EXCH button connects an earth to the telephone loop. When the EXCH button is released the earth is removed from the telephone loop.

When exchange line 1 is not in use XA2, normal, in the Relay-unit Q 516 earths the EA lead common to all Relay-units Q 519. If exchange line 1 is engaged but line 2 is free, XA2 (operated) removes the earth from the EA lead and connects it to the EB lead via XB4. Should both exchange lines be in use relays XA and XB will be operated and both the EA and EB leads will be disconnected.

32. *Non-multiple extension engages exchange line 1.* (Dgms. Q 503, 516, 519 and 550). - The handset is lifted and the EXCH button is depressed at the extension operating relay A and differentially connected relay D in the Relay-unit Q 519. D1 (operated) via EX4 (operated) and SR3 operates relay EL. EL1 (operated) via diode D2 and LB3 completes the circuit for the operation of relay LA to the earth on the EA lead, resistance battery on the LA lead, from the Relay-unit Q 516. LA2 (operated) via SR4, RC4 and A5 (operated) operates relay B. B1 and B2 (operated) disconnect the intercom multiple wires from the transmission bridge. B2 also connects the B wire of the intercom circuit to the common C wire to indicate an engaged condition to calling multiple stations. B3 with EX3 (operated) connect resistor R4 across the exchange line to seize the exchange equipment and operate relay S. B5 (operated) connects earth to the low-resistance coil of relay LA to provide a hold circuit and also prevent other LA relays from operating, and calls being established, on exchange line 1. B8 (operated) earths the XA lead via LB5, the LPAC lead via LB5 and RC6, to operate the XA and FLA relays in the Relay-unit Q 516. A contact of FLA controlling the Regulator No. 4A causes the engaging lamps to glow at multiple stations for exchange line 1. S1 (operated) operates relay SR. SR3 (operated) releases relay EL.

Release of the EXCH button at the extension removes the earth from the telephone loop releasing relay D. D1 releasing, releases relay EX which was being held via EX4 (operated) and diode D12. EX1 and EX2 switch the extension line from the transmission bridge to the exchange line via the coils of relay S which will hold, relay A will release. EX3 in releasing disconnects hold resistor R4 from the exchange line.

During dialling relay S will pulse but relay SR remains operated.

33. *Non-multiple extension engages exchange line 2.* - The operation of the circuit is similar to that described in par. 32. Relays A and D operate to the earth loop from the extension telephone, D1 operating relay EL. Relay LA cannot operate via the EA lead due to the disconnection of the earth at XA2 (operated) in the Relay-unit Q 516. Relay LB operates to the earth on the EB lead via diode D4, EL3 (operated), F5 and LA5. LB3 switches the operate circuit of relay LA to the LB lead. Relay LA will now operate via EL4, LB6 and LB3, all operated. LB4 provides a hold circuit for relay LB via LA3 operated. When relay B operates, LB5 diverts the B8 earth to the XB and LRBC leads to operate relays XB and FLB in the Relay-unit Q 516. An FLB contact controlling the Regulator No. 4A causes the engaging lamps to glow for exchange line 2.



34. *Both exchange lines busy. Non-multiple extension attempts to engage an exchange line.* - Relays A, D and EL operate as previously described in par. 32. Relays LA and LB cannot operate due to the absence of earth on the EA and EB leads, relays XA and XB being operated in the Relay-unit Q 516.

The extension does not receive any tone.

35. *Release of connexion.* - Replacing the handset at the extension releases relay S. S1 releases relay SR, SR5 releases relay B. B5 releases relay LA. B6 releasing, operates relay EX to the D1 earth via diode D11. B8 releasing, removes the earth from leads XA, LPAC, (line 1) or XB, LPBC (line 2). Relays XA, FLA (line 1) or XB, FLB (line 2) in the Relay-unit Q 516 release. FLA or FLB contacts darken the exchange line engaging lamps. LA3 releasing, releases relay LB.

36. *Non-multiple extension makes an intercom call while holding an exchange line call - (Dgms. Q 503, 516, 519, 537, 540 and 550).* - The non-multiple extension can hold an exchange line call and at the same time make an intercom call. Relays S, SR, LA and B, plus LB if exchange call is on line 2, will be operated in the Relay-unit Q 519 as described in pars. 32 and 33. The EXCH button at the extension is depressed to earth the telephone loop and operate relay D. D1 (operated) via EX4 operates relay RC. RC1 (operated) connects resistor R4 across the exchange line to hold the call and relay S. RC2 (operated) disconnects the hold earth to relay B which releases. Contacts RC6 and RC5 disconnect the B8 and SR1 earth from either lead LPAC (line 1) or LPBC (line 2). Relay FLA or FLB in the Relay-unit Q 516 pulses causing the exchange line lamps to flash, indicating a held call to multiple stations. B1 and B2 releasing, reconnect the intercom multiple wires to relay RR and the transmission bridge. B2 also disconnects the common C wire from the B wire of the intercom pair.

When the EXCH button at the extension is released the removal of the earth from the telephone loop releases relay D. D1 releasing, operates relay EX via B6 and diode D11. EX1 and EX2 operating, switch the extension line to relay A which will operate. A2 (operated) operates relay AL. AL1 and AL2 connect the AL lead to the AL1 and AL2 leads causing the call lamp to glow and the buzzer to operate in the Control-unit Q 537. A3 (operated) completes the connexion of the intercom wires to the transmission bridge and disconnects relay RR. The main station answers the call as described in par. 13.

To return to the exchange line, the EXCH button at the extension must be re-pressed earthing the telephone loop and operating relay D in the Relay-unit Q 519. D1 (operated) via EX4, RC2 and SR5 (operated) operates relay B. D1 also disconnects the earth to relay RC which releases. B1 and B2 (operated) disconnect the intercom circuit. B3 prepares to hold the exchange equipment and relay S against release of RC1. RC6 and RC5 reconnect the B8 and SR1 earth to either lead LPAC (line 1) or LPBC (line 2). Relay FLA or FLB in the Relay-unit Q 516 will cease pulsing and remain operated, altering the flashing hold signal of the exchange line lamps to a steady glow.

When the EXCH button at the extension is released the earth is removed from the telephone loop releasing relay D in the Relay-unit Q 519. D1 releases relay EX, which was being held via EX4 (operated) and diode D12. EX1 and EX2 switch the extension circuit to the exchange line, releasing relay A. EX3 disconnects the R4 hold resistor from the exchange line.

**37. Non-multiple extension transfers a held exchange call to the main station.** - Having called the main station while holding an exchange line call (see par. 36) the extension can transfer the exchange call to the main station in either of two ways.

*(a) Non-multiple extension replaces handset immediately after requesting the main station to accept the held exchange call.* - Relays S, SR, LA, RC, EX, A, F, plus LB if call on exchange line 2, will be operated. When the extension replaces the handset the removal of the telephone loop releases relay A. The exchange call is now held by the main station via the Relay-unit Q 519 in the following manner. Relay F holds to an earth from the main station transmitter-feeding bridge via the telephone loop. F7 (operated) holds relay RC to the D1 earth via B6 normal, SR2 and RC3 operated. RC1 (operated) holds the exchange equipment and relay S via hold resistor R4. S1 (operated) holds relay SR. SR6 (operated) holds relay LA via LA1 (operated) to the resistance battery on the LA or LB leads from the Relay-unit Q 516. Relay EX holds via diode D11, B6 and D1 normal. If the call is held on exchange line 2, relay LB will be operated and holds via LB4, to LA3 and SR4, operated.

The CONNECT and TEST key (KCA) is now operated on the Control-unit Q 537. KCA1 and KCA2 (operated) connect the TEST lamps LP1 and LP2 to the X1 and X2 leads of the Relay-unit Q 519. If the call is held on exchange line 1, earth via SR1 (operated), LB5 normal, and resistor R2, will be connected to the X1 lead causing the TEST 1 lamp to glow in the Control-unit Q 537. Similarly, a held call on exchange line 2 will cause the earth via SR1 and LB5 (operated) to be connected to the X2 lead via resistor R1, causing the TEST 2 lamp to glow. After identification of the held exchange line the CONNECT and TEST key is restored. The main station now takes over the call by operating the appropriate exchange line button on the station instrument. KHA or KHB contacts disconnect the exchange line from the Relay-unit Q 519 releasing relay S. Operation of the exchange button on the instrument also releases the operated local key, releasing relay F. The condition of the exchange line will now be as described in pars. 19 or 20. All relays in the Relay-unit Q 519, except EX, will release.

*(b) The non-multiple extension holds on to make an intercom call after the main station has dealt with the transfer of the exchange call.* - Relays S, SR, LA, RC, EX, A, F, plus LB if call on exchange line 2, will be operated. The CONNECT and TEST key (KCA) on the Control-unit Q 537 is now operated, to identify the held exchange line. As described in sub-par. (a) an earth on the X1 lead from the Relay-unit Q 519 will cause the TEST 1 lamp to glow and an earth on the X2 lead will cause the TEST 2 lamp to glow. The CONNECT and TEST key is now restored. The exchange line button for the held line is now operated on the main station instrument. KHA or KHB contacts disconnect the exchange line from the Relay-unit Q 519 releasing relay S. Operation of the exchange button also releases the operated local key but relay F in the Relay-unit Q 519 holds via F1 and A1 operated. The condition of the exchange line will now be as described in pars. 19 or 20. In the Relay-unit Q 519 contact S1 releases relay SR. SR2 releases relay RC. SR6 releases relay LA. LA3 releases relay LB if the held call was on exchange line 2. Relays EX, A and F remain operated and the extension waits until the main station returns to the extension circuit. Relay operations will then be as described in pars. 14 or 15 depending upon whether the extension wishes to call a multiple station or a non-multiple extension.

**38. Pulsing circuit of FLA and FLB relays in Relay-unit Q 516 - (Dgm. Q 516).** - The pulsing circuits for the control of the exchange line lamps of the two exchange lines are identical. The description that follows is for exchange line 1, but similar components are used for exchange line 2.

The coils of relay FLA are differentially connected. When contact XA1 is operated, but there is no operating earth on the LPAC lead, (see par. 26), capacitor C5 discharges via XA1 (operated), FLA1, resistor R4 and the 2000-ohm coil of relay FLA. The operation of relay FLA will be delayed until the discharge current has reduced. When the relay operates, FLA1 cuts-off the operating earth but the relay holds to the charging current to capacitor C5 via both relay coils in series. The relay will release when the charging current has sufficiently reduced and the cycle will be repeated. The pulsing rate is 2-3 p.p.s.

The primary function of resistors R1, R4, and capacitor C7 is to prevent voltage surges from being induced into other wires of the multiple cable by the LPAC lead.

#### ADDITIONAL FACILITIES

**39. Night service.** - Incoming exchange calls can be extended under the control of the NIGHT SERVICE key in the Control-unit Q 537 to pre-determined non-multiple extensions. Ringing current, indicating an incoming call, will operate relay RGA (line 1) or RGB (line 2) in the Relay-unit Q 516. RGA3 and RGB2 connect earth to the NA1 and NB1 leads to the Control-unit Q 537. Operation of the NIGHT SERVICE (KNS) key connects leads NA1 and NB1 to leads NA and NB, which are common to all Relay-units Q 519. The NL1 lead from the Control-unit Q 537 to the Relay-unit Q 516 is also earthed by KNS contacts. In the Relay-unit Q 516 the NL1 lead is connected via XB2 and RGA4 to the NL lead which is also commoned. By provision of straps the NA, NB and NL leads can be extended into the circuit of a Relay-unit Q 519.

The descriptions that follow assume that a Relay-unit Q 519 has been strapped to receive night service calls on either exchange line.

**40. Night service call on exchange line 1 - (Dgms. Q 503, 516, 519, 537 and 550).** - The earth connected to the NA lead will operate relay RR in the Relay-unit Q 519 in cadence to the ringing current. RR1 operating, extends ringing current from a Converter, Ringing, No. 7 to the A wire of the extension line to operate the instrument bell. To answer the call the operations are as described in par. 32. A6 operating, disconnects the operate circuit for relay RR, B3 operating, connects resistor R4 across the exchange line to trip the incoming ring.

**41. Night service call on exchange line 2.** - The earth connected to the NB lead will operate relays RR and LB in the non-multiple extension Relay-unit Q 519. Relay RR is operated via diode D15, LA4, F2 and A6. Relay LB is operated via diode D10, F5 and LA5, and holds via LB7 and diode D9 to the earth on the NL lead. RR1 contact extends ringing current to the extension. Circuit operations when the extension answers will be similar to those described in par. 33.

The RGA4 and XB2 contacts in the Relay-unit Q 516 providing the connexion between the NL1 and NL leads are required for the following reasons.

Assuming exchange line 1 is in use, an incoming call on line 2 will operate the LB relays in all connected Relay-units Q 519. If the call is abandoned the LB relays will remain operated. When the line 1 call has cleared incoming calls cannot be answered, or calls originated, from the non-multiple extensions on line 1. RGA4 in operating releases any held LB relays.

If in the above instance the incoming call on line 2 were answered the LB relays of the other extension relay units would remain held. XB2 in operating releases these held LB relays.

42. **2nd-choice main station - (Dgms. Q 505, 519 and 537).** - When a 2nd-choice main station is provided the change-over control, in the form of an ON-OFF (KCO) locking press switch, is located in the Control-unit Q 537 at the main station. To change-over all facilities, except night service control, to the 2nd-choice main station, the press switch at the main station is operated to the ON position. Contacts of the switch operate the single relays in Relay-unit Q 539 (1-2 extensions) and when provided in Relay-unit Q 538 (3-4 extensions), which are mounted within the Control-unit Q 537. (For ease of explanation contacts in Relay-unit Q 539 are designated COA and those in Q 538 are designated COB). Assuming an installation with four non-multiple extensions, COA1 (operated) connects make contacts of KNS, KCA, KCB and KAO keys to the CO1 lead. If either of these keys at the main station is operated in error the buzzers at both the main station and the 2nd-choice main station will operate. COA2 (operated) switches the earth common from the TRANSFER keys at the main station to the 2nd-choice main station via the CO3 lead. COA3, COA4, COB1 and COB2 switch the AL1 leads from the Relay-units Q 519 of extensions 10, 9, 8 and 7, to the 2nd-choice main station.

To restore control to the main station the press switch is restored to the OFF position, releasing relays COA and COB. If the KNS, KCA, KCB or KAO keys are operated at the 2nd-choice main station, the CO2 lead will be earthed operating the buzzer at the main station via COA1 and at the 2nd-choice main station via COA1 and the CO1 lead. COA2 switches the earth common from the TRANSFER key at the 2nd-choice main station to the main station. The remaining contacts of relays COA and COB switch the AL1 leads of the extensions to the main station.

43. *Changing-over control when a non-multiple to non-multiple extension call is in progress.* - The main station calls the 2nd-choice main station and indicates which keys (KCA or KCB) are operated. When the same KCA or KCB keys at the 2nd-choice main station are operated the buzzers at both stations operate via the CO2 lead, COA1, and CO1 lead. The change-over switch is now operated to the ON position at the main station operating relays COA and COB. The buzzers at both stations continue to operate, the main station via COA1 operated and the 2nd-choice main station via COA1 and the CO1 lead. To complete the change-over the operated KCA or KCB keys at the main station must be restored; the buzzers at both stations will now cease to operate.

To restore control to the main station the operations given above are reversed.

44. **Exchange service restricted.** - A multiple station or non-multiple extension can be restricted from exchange line service. To originate an exchange call the restricted station or extension must first call the main station for assistance as described in pars. 3 or 13.

45. *Exchange service restricted multiple station - (Dgms. Q 516, 527 and 540).* - The main station nominates the exchange line to be used and then presses the BAR 1 (exchange line 1) or BAR 2 (exchange line 2) button on the main station instrument. Assuming that exchange line 1 is free the BAR 1 (1KBR) button earths the BA lead operating relay 1BR at the restricted station. Operation of the exchange line 1 button at the restricted station operates the KXA and KHA spring-sets. KHA4 (operated) provides a hold circuit for relay 1BR via 1BR2 and CS1 operated. KHA3 (operated) switches the XA lead to the earthed LP3 lamp and shunt-resistor R8 via CS1, KHA4, 1BR2 (operated), and diode 1D2. KXA3 (operated) connects an earth to the LPAC lead, to operate relay FLA in the Relay-unit Q 516, via CS1, KHA4, 1BR2 (operated), and diode 1D2. 1BR1 and 1BR3 (operated) switch the exchange line into the telephone circuit. 1BR4 removes a short-circuit from the magneto bell. The BAR 1 button at the main station is released when the exchange line engaging lamp glows, due to the operation of relay FLA in the Relay-unit Q 516.

When the restricted station transfers or releases the exchange call, release of the KHA springs disconnect the hold circuit for relay 1BR at KHA4, which releases.

Diode 1D1 prevents the holding earth for relay 1BR from being connected to the BA lead, causing false operation of 1BR relays at other restricted stations. Diode 1D2 prevents false operation of relay 1BR to an earth connected to the LPAC lead by another multiple station.

The circuit operation for exchange line 2 will be similar to that previously described.

46. *Exchange service restricted non-multiple extension - (Dgms. Q 516, 519, 527 and 550).* - Assuming that exchange line 1 is free, BAR 1 (1KBR) button on the main station instrument is operated earthing the BA lead. As the line is free relay XA in the Relay-unit Q 516 will be normal, XA3 extends the earth on the BA lead to the BA1 lead. In the Relay-unit Q 519 relays A, F and EX will be operated. The EXCH button on the extension instrument is operated connecting an earth to the telephone loop to operate relay D in the Relay-unit Q 519. D1 (operated) operates relay EL. EL5 (operated) connects the earth on the BA1 lead to the LA relay which operates to the resistance battery on the LA lead from the Relay-unit Q 516. The circuit operation will be similar to that described in par. 32 except that relay A will be released when EX1 and EX2 contacts release. A1 releasing, will release relay F. When contact B8 operates, the earth connected to the LPAC lead operates relay FLA in the Relay-unit Q 516. FLA2 (operated) causes the exchange line engaging lamps to glow at all stations. The BAR 1 button at the main station can now be released, removing the earth from the BA1 lead.

47. *Exchange service during power failure - (Dgms. Q 519, 540 and 550).* - Power failure, either in the mains supply or in the Power-unit No. 52A, will result in the failure of all lamp signals and intercom calls. Incoming exchange calls on either line will be signalled by magneto bell only at multiple stations. Incoming or outgoing calls can be answered, or originated, on either line at multiple stations except those that are exchange service restricted.

In all Relay-units Q 519 the normally operated EX relays will release, connecting the non-multiple extension telephones in parallel with each other to exchange line 1. Extensions can originate exchange calls, the Thermistor No. 1A-1 in each bell circuit preventing bell tinkle. The bell circuit of each extension is connected between the A wire of the line and earth, thus the bells will not operate to ringing current of an incoming call.

If a non-multiple extension has engaged exchange line 1 during a power failure, restoration of power will cause the operation of relays S, SR and B. SR1 or B8, operated, earth the LPAC lead to cause the exchange line engaging lamps to glow indicating an engaged line.

Reference:- Q 1015  
(S1/2)

E N D