attached to the right-hand side of the switchboard. Whenever a keysender is fitted, an emergency dial is held in reserve at the P.B.X. In the event of failure of the keysender the dial is plugged into the switchboard. The circuit arrangements are as shown in Fig. 340. Additional contacts are provided on the cord circuit dialling keys and a relay

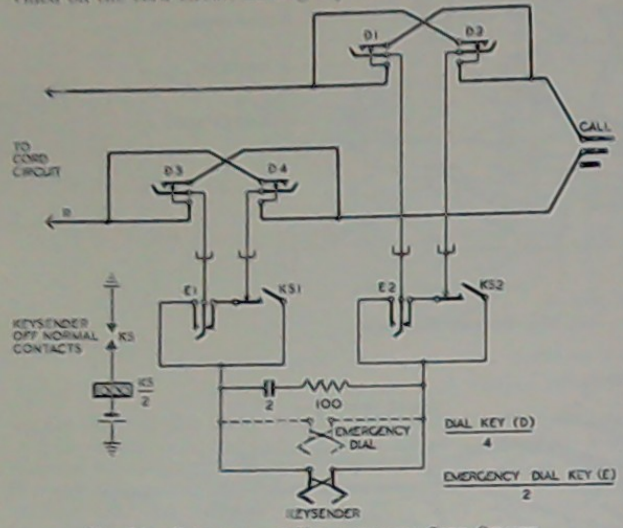

Fig. 340. Connexion of Keysender to Cord Circuit

is introduced into the keysender circuit so that at the completion of pulsing out, the cord circuit is restored to normal without the necessity of immediately restoring the dial key. An emergency dial key is provided to change over from the keysender to the emergency dial when necessary.

The House Exchange System. The House Exchange system combines the facilities of the earlier house telephone system with direct access from the stations to the public exchange. It was introduced several years ago to meet the requirements of subscribers who would otherwise be faced with the installation of a private intercommunication system to cater for a large internal traffic together with a public service telephone or private branch exchange. The following facilities are standardized for the system:

(1) The same instrument is used irrespective of the type of public exchange. This instrument is designed on C.B. principles and, where a house exchange system is required in conjunction with a magneto or C.B.S. public exchange, special conversion units are fitted at the public exchange.

(2) There are two arrangements of equipment to cater for:

(*a*) One exchange line and a maximum of six extensions (including one external extension).

(*b*) Two exchange lines with eleven extensions (including one external extension).

Both instruments have the same general appearance but the number of press buttons differs.

(3) Any instrument of the system may be used as the master station. An auxiliary unit is fitted at the master station, which provides calling indicators for the exchange lines and for an external extension (when fitted).

(4) In order to cater for times when the master station is unattended, a second choice master station may be provided by the fitting of a similar auxiliary unit at the selected second choice station. A transfer key fitted on the first choice main station switches the exchange and extension calling signals to the second choice station.

(5) Exchange calls are secret and cannot be overheard by any of the extensions on the system. By suitable strapping, however, supervision on exchange lines may be given to any selected station.

(6) An engaged test is provided on "busy" exchange lines.

(7) An exchange line may be held whilst a second call is made on another exchange line or on an internal extension.

(8) Exchange calls (which are normally answered at the main station) may be transferred direct from one station to another. This facility is also available for originated exchange calls.

(9) The master station is provided with trunk offering facilities where the required extension is speaking on a local call.

(10) Exchange calls may be entirely barred to any specified station, or alternatively exchange calls may be allowed only at the discretion of the master station.

(11) The system provides for direct calling and clearing from any station to the exchange.

(12) Local calls are non-secret.

(13) Conference facilities are provided so that any number of stations may be connected together.

(14) Apart from the night service facilities provided by the second choice main station, the external extension may be allowed direct access to the exchange line under night service conditions.

(15) The equipment provides for the provision of extension bells from any instrument.

Apparatus. The house exchange instrument *Telephone Intercommunication No. 2*) is illustrated

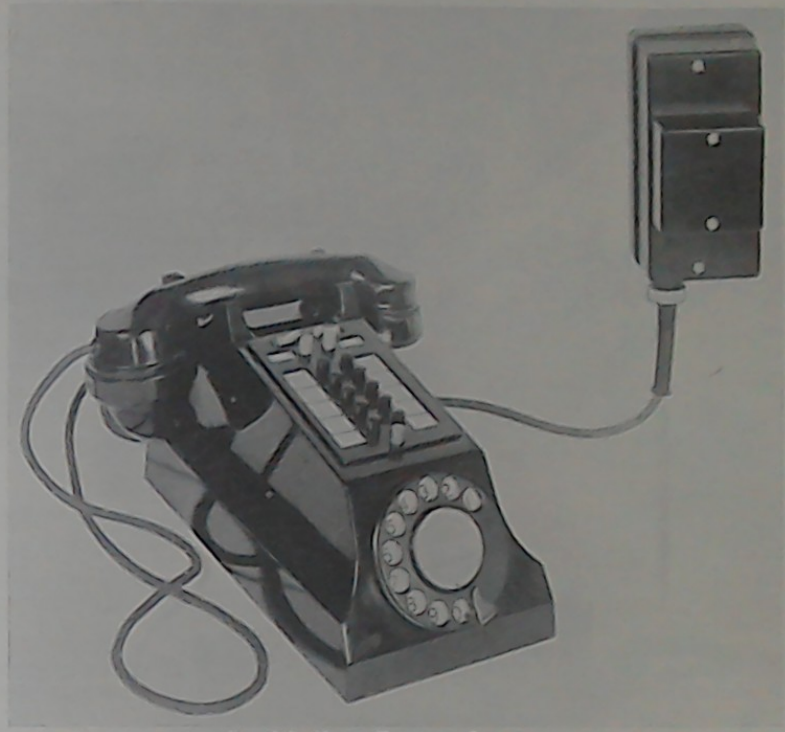

Fig. 341. House Exchange Instrument
(Telephone Intercom. No. 2.)

in Fig. 341. The design follows similar lines to that of the standard one-piece instrument described in Chapter IX, but has in addition the required press buttons for establishing local calls. The instrument illustrated has two exchange line buttons, ten extension buttons, a conference button and a small trigger key associated with each exchange line. The instrument provided on smaller installations employs the same standard casework but only one row of keys (i.e. one exchange, five extension, and one conference). Figs. 342 and 343 show the internal arrangements of the telephone from which it will be noted that the lay-out has been designed to give the maximum accessibility to all parts for maintenance purposes. The complete button mechanism may be removed as a unit leaving in situ the spring banks and cabling. Each spring bank is removable as a unit and the relays (which are of the 600-type) are mounted on separate brackets so that they can readily be swung clear of the mechanism for adjustment purposes. The calling buzzer is dissociated from the telephone and is incoprorated in the external connecting block in order to facilitate adjustment without interference with the instrument proper. A further feature is that the connecting block is made in the form of a plug and jack so that the complete instrument may be removed at will.

An auxiliary unit known as a *Unit Transfer Intercommunication* is required at the main station (i.e. that chosen to answer exchange calls). The unit accommodates the exchange line calling

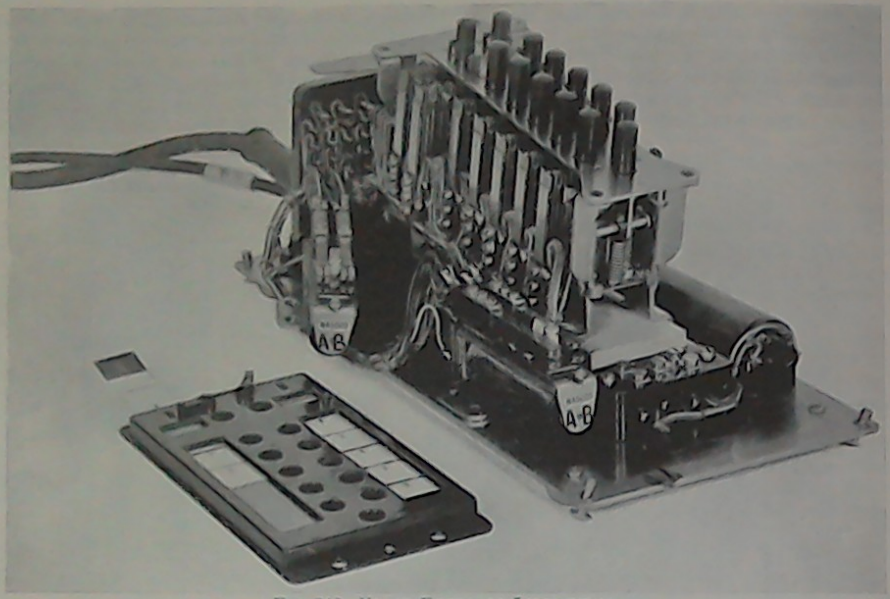

FIG. 342. HOUSE EXCHANGE INSTRUMENT
Chassis removed from case.

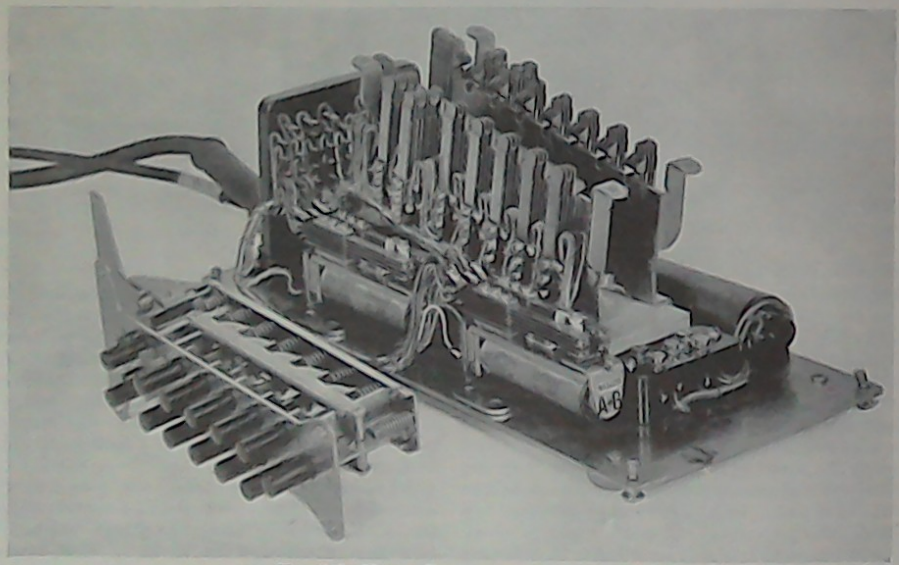

FIG. 343. HOUSE EXCHANGE INSTRUMENT
Chassis with press-buttons detached.

indicators, the external extension indicator and the associated keys. The facilities provided vary with different installations but all conditions are met by the use of one of four standard designs (Nos. 1, 1A, 2, and 3). All the four units are similar in appearance, but the number of calling indicators and keys varies. Fig. 344 illustrates Unit Transfer Intercommunication No. 1A which accommodates eyeball indicators for one exchange line and one external extension together with a transfer key, the exchange to extension key, and the night service key.

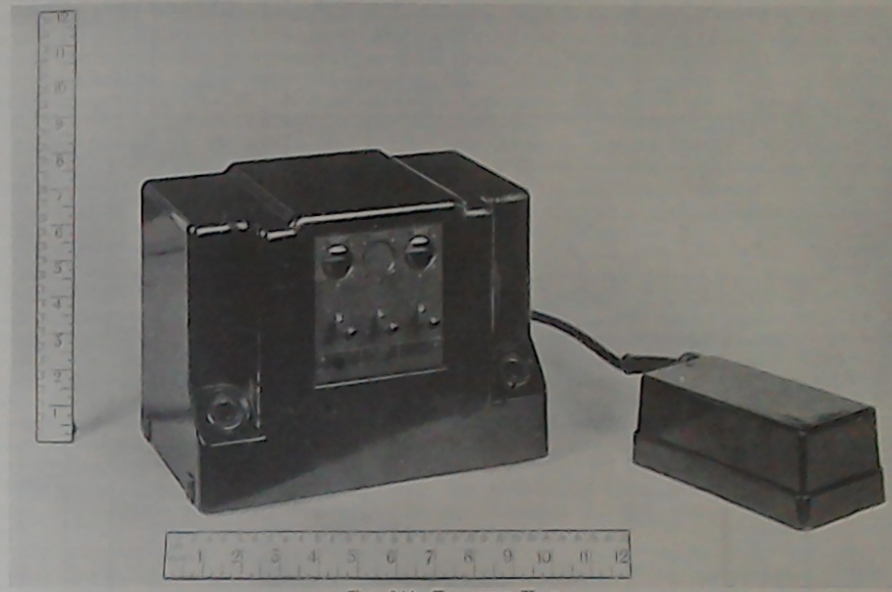

FIG. 344. TRANSFER UNIT
(Unit transfer intercom. 1A.)

Circuit Description—Internal Calls. Figs. 345 and 346 show complete circuits for a 1 + 5 type intercommunication telephone and for a Transfer Unit (No 1A) suitable for use at a main station where there is one exchange line and an external extension. Fig. 347 shows the circuit elements involved on local station to station calls with the exchange line switching details omitted for clarity.

To call any internal extension, the originating station removes the microtelephone thereby allowing the *HM* springs to operate, and then fully depresses the local key adjacent to the number of the required extension. Springs ***CB*** and ***L*** are thereby operated and an earth is extended from ***HM2*** via ***CB2*** to the *B*-line of the required extension. Contacts ***CB1*** extend the buzzer *BZ* to the common wire. If the called extension is free, the earth placed on the *B*-line is extended to the *R*-wire of the called extension circuit and thence via *HM*1 to the buzzer. The called extension's buzzer is therefore actuated for the period during which the caller has the appropriate local button fully depressed. When the called extension answers by removing the handset from its rest, the ***HM*** springs operate and the telephone circuit is connected to the *HL* and *R* wires via ***HM1***, the buzzer circuit being disconnected at the latter contacts. When the caller's finger is removed from the local key, the latter partially restores to the speaking position. The *L* springs remain operated in this position, but the common bank spring set (*CB*) is released. A separate transmitter feed bridge is provided for each telephone by the application of earth at ***HM2*** via *RA* to the *A*-line and a battery through the remaining coil of *RA* via ***HM1*** to the *B*-line. If the called extension is engaged on a call to another extension, the earth on the *R*-wire incoming from the calling extension will not operate the buzzer at the called extension due to the disconnexion at ***HM1***. When the local key on the calling extension's

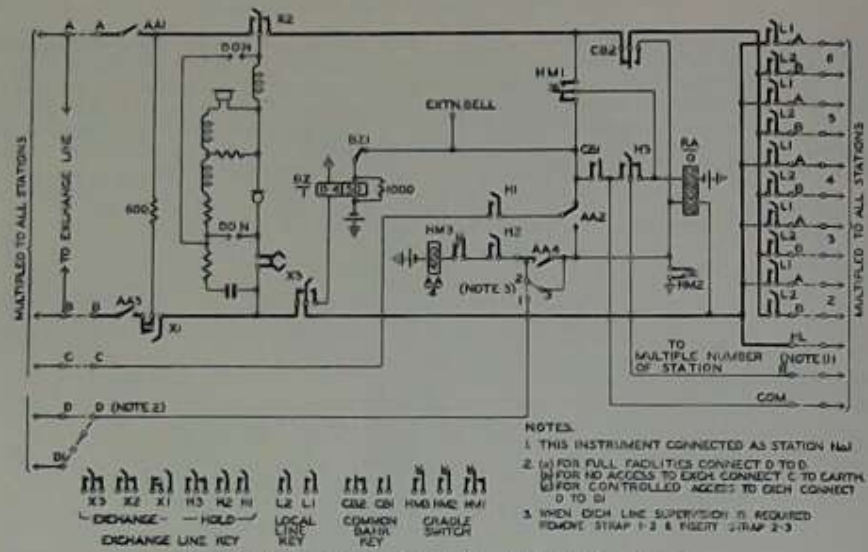

FIG. 345. CIRCUIT OF FIVE-STATION HOUSE EXCHANGE INSTRUMENT

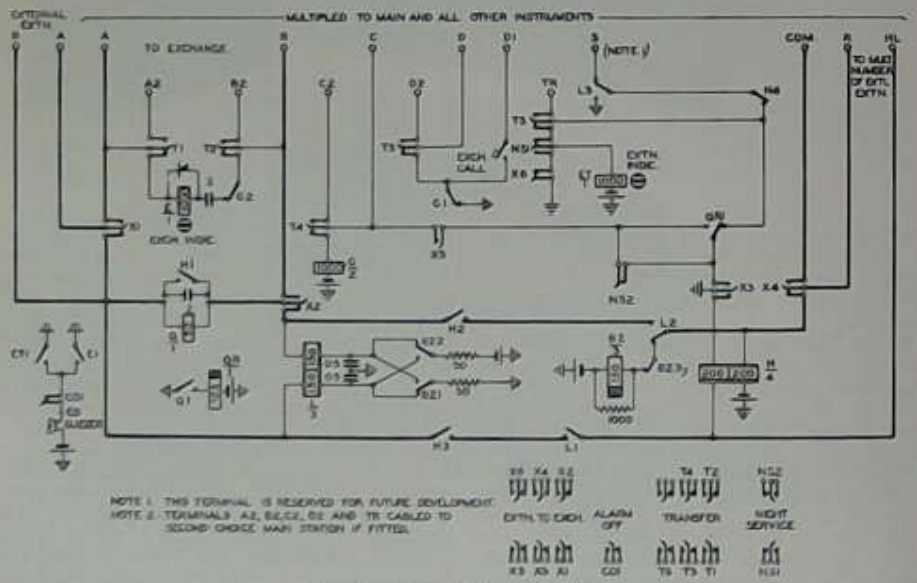

FIG. 346. CIRCUIT OF TRANSFER UNIT
(No. 1A.)

telephone set restores to the speaking position, however, the telephone circuit is connected to the *A*- and *B*-wires as described above. A caller is therefore able to break into any connexion between two other local extensions. If the called extension is engaged on an exchange call, the hold springs (*H*) on the appropriate exchange key will be operated and at ***H3*** the *R*-wire will be connected to the common (Fig. 348). When the caller fully depresses the appropriate local key the earth placed on the *R*-wire of the called extension is returned to the calling station on the common wire and operates the caller's own buzzer via ***CB1***. On the termination of a call all keys are restored mechanically to their normal position by the replacement of the microtelephone on the rest.

Internal Extension Calling External Extension. When the calling extension removes the microtelephone from its rest and fully depresses the appropriate local key an earth is extended to the *B*-line in the usual way. This earth is received on the *R*-wire of the external extension circuit and operates relays *H* and *BZ* in the Transfer Unit at the main station (Fig. 347). ***H2*** and ***H3*** extend the *R* and *HL* wires, and ***H4*** disconnects the external extension indicator in readiness for the operation of relay *L*. ***H1*** similarly shortcircuits relay *Q* which is not required on this call. If the external extension is free, relay *BZ* alternately operates and releases by breaking its own circuit at ***BZ3y***. ***BZ1*** and ***BZ2*** reverse the earth and battery connexions to relay *L* and thence to the external extension instrument. These reversals of potential across the bell of the extension instrument are the equivalent of normal alternating ringing current and energize the bell in the usual way. During the ringing period the 0·5 μF condensers act as a spark-quench to contacts *BZ1* and *BZ2*. Relay *L* does not operate until the external extension answers and a d.c. loop is provided. If the calling party takes his finger from the external extension button before the external extension answers, *H* continues to hold from its own battery via the loop of the calling extension and the second coil of *H* to earth. Relay *BZ* is designed not to hold under these conditions, and therefore removes the ringing current from the external extension line. The operation of *L* when the external extension answers disconnects relay *BZ* and switches through to the calling line at *L1* and *L2*. ***L3*** is ineffective due to the previous operation of ***H4***.

If the external extension is engaged on a local call the operation is similar except that relay *BZ* cannot operate due to the disconnexion of its circuit at ***L2***. If, however, an external extension is engaged on an exchange call spring *X4* will be operated, thereby connecting the *R*-wire to the common (Fig. 348). Thus, when a caller fully depresses the local button his own buzzer will operate as described previously.

External Extension Calling Internal Extension. It is not possible on economic grounds to extend the main multiple of the internal stations to the external extension. There are therefore only two wires between the external extension instrument and the main station, and it is not possible to give the external extension the facility of direct access to all internal extensions. All such calls are obtained via the main station. When the external extension lifts his receiver from the rest relays *L* and *Q* operate from the battery and earth at *BZ1* and *BZ2* via the loop of the calling telephone. Relay *Q* (Fig. 346) has no function, but contact ***L3*** completes the circuit for the extension indicator and ***L1*** and ***L2*** prepare for the extension of the calling line to the main instrument. An audible alarm is provided from the local contacts of the extension indicator. The main station answers by removing the microtelephone and depressing the local key corresponding to the external extension number. The telephone loop of the main station is thereby connected to the *A* and *B* multiple wires of the external extension which are strapped to the *R* and *HL* wires of the Transfer Unit. The loop therefore operates relay *H*. ***H1*** short-circuits the *Q* relay, whilst ***H2*** and ***H3*** complete the circuit to the external extension. ***H4*** disconnects the external extension indicator circuit.

After ascertaining that an internal extension is required the main station calls the required extension in the usual way and the called extension upon answering is requested to call the external extension. The main station operator then replaces the microtelephone.

Conference Facilities. If a conference of several internal extensions is required, the main station calls each of the required extensions individually and each extension is advised to "hold on." When all required extensions have been called the conference button is pressed and each individual local station button is pressed for the second time. The mechanical arrangements are such that when the conference button has been pressed it is possible to press consecutive local buttons and leave them in the operated position until such time as the microtelephone is replaced on the rest. If a mass call were made instead of first calling the extensions individually, as soon as one station answered the buzzers at all the other called extensions would continue to operate until answered, even although the caller had removed pressure from the local keys. The earth from ***HM2*** of the first telephone to

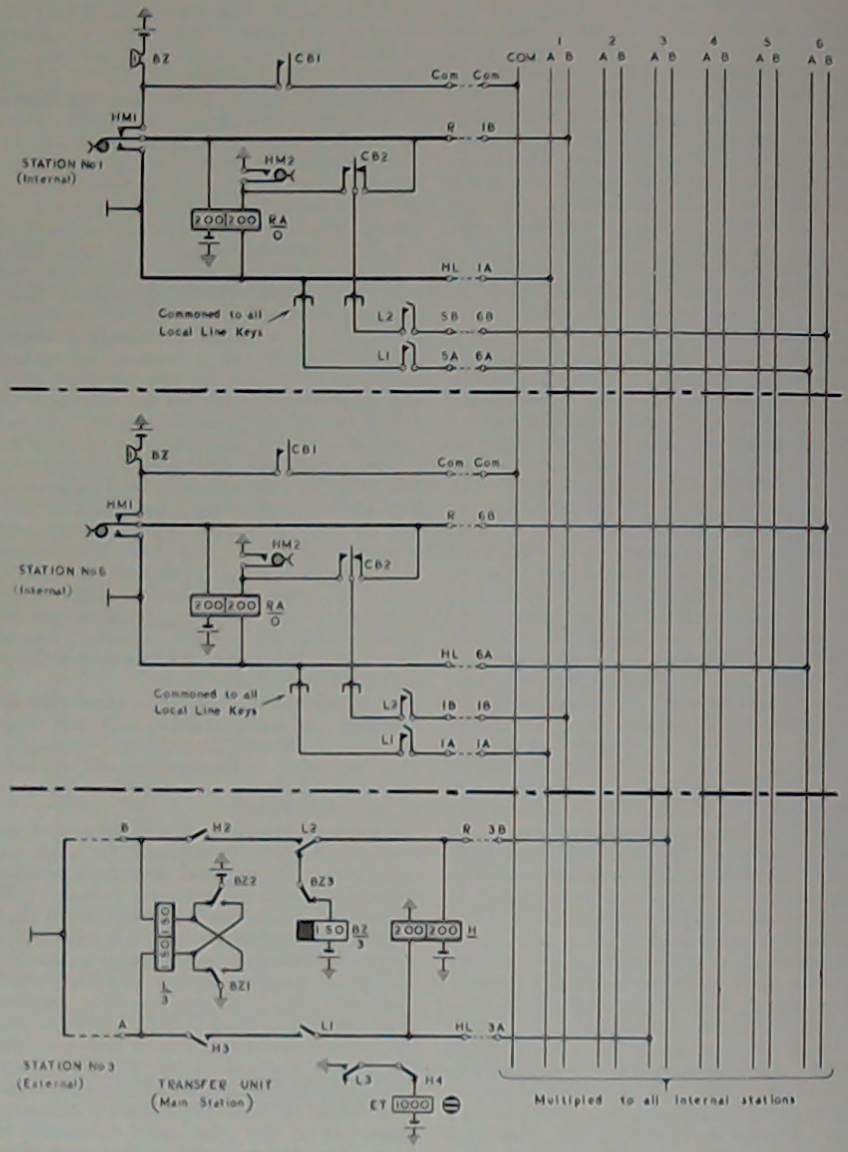

FIG. 347. CIRCUIT ELEMENTS FOR STATION-TO-STATION CALLS
House exchange system.

answer is extended via the coil of *RA* to the *B*-lines and buzzers in parallel. Continuous operation of the buzzer until an extension answers is undesirable, and in the operating instructions it is laid down that a mass call should be made only after it has been ascertained that a person is in attendance at all the called extensions.

Internal Extension Calling the Exchange. Fig. 348 illustrates the switching elements for exchange calls. It will be noted that, in addition to the *A*- and *B*-wires of the exchange line, three control wires (*C*, *D*, and *D*1) are multipled to all internal stations. To call the public exchange the internal extension station removes the microtelephone thereby operating the *HM* contacts. He then depresses the exchange key, thus operating the *X* and *H* springs. These spring piles are mechanically so arranged that the *X* units can be released by the depression of any other key on the telephone. The *H* springs, however, are not released when a second key is depressed but can only be restored either by the replacement of the hand microtelephone or the operation of the trigger key associated with the exchange line in question. Contacts ***H3*** disconnect the buzzer circuit from the *R*-wire and loop the latter to the common wire, thereby providing an engaged test to any callers. If the exchange line is free, relay *AA* operates via ***HM3***, ***H2***, and the *D*-wire of the multiple to the earth at *G*1 in the Transfer Unit. A locking circuit is provided for relay *AA* at ***AA4***. ***AA1*** and ***AA3*** extend the telephone loop (via ***X1*** and ***X2***) to the exchange line. ***AA2*** similarly extends the earth from ***HM2*** via ***H1*** to the *C*-wire of the multiple. This earth operates relay *G* in the Transfer Unit. *G* in turn removes the earth from the *D*-wire at ***G1*** in order to engage the exchange line to all other callers. ***G2*** removes the exchange indicator from across the speaking circuit. The call is set up in the usual manner and release is effected by the restoration of the *X* and *H* spring sets when the microtelephone is replaced.

If the exchange line is engaged, the absence of earth on the *D*-wire prevents the operation of relay *AA*, whilst the presence of an earth on the *C*-wire (from the ***HM2*** contacts of the engaging telephone) operates the local buzzer of any testing instrument via contacts ***H1*** and *AA*2.

External Extension Calling Exchange. To gain access to the exchange line the external extension must first call the main station. The main station, having ascertained that an exchange call is required, proceeds to test the exchange line by depressing the exchange line key on the main instrument. If the line is free, it is switched to the external extension by throwing the "extension to exchange" key on the auxiliary unit. Contacts ***X3*** and ***X5*** operate relay *G* and, at the same time, apply an engaging earth to the *C*-wire of the multiple. ***G1*** as usual prevents access to the exchange line by other parties. The main station now replaces the microtelephone and the external extension is extended to the exchange line at ***X1*** and ***X2***, whilst relay *Q* operates in series with the loop. A slow-to-release relief relay *QR* is introduced so that contacts ***QR1*** do not respond to the dialled impulses during the setting up of a call. At the end of the call, through clearing from the external extension is provided by the release of *Q* and *QR*, whilst the restoration of *QR*1 operates the extension indicator as a clearing signal. The main station now restores the "extension to exchange" key.

Incoming Exchange Call. All incoming exchange calls are received at the main station. The exchange indicator (*E*) is of the doll's-eye type and is shunted by a metal rectifier to give continuous operation from the received alternating ringing current. Local contacts of the exchange indicators provide an audible alarm. The main station answers by removing his microtelephone and depressing the appropriate exchange key. If the call is to be extended to an internal extension, the main station depresses the local key corresponding to the number of the extension required. This operation mechanically restores the exchange line key to the hold position but the *H* springs remain operated. The exchange line is now held by the 600 Ω resistance. The called extension is requested to pick up the exchange line by depressing the appropriate exchange key at the extension station. Due to the fact that the exchange line is engaged the buzzer at the extension will operate as described previously, and tone is passed back to the main station from the 0·4 Ω coil of the extension buzzer via ***X3***, the *A*-wire and the appropriate ***L1*** springs to the telephone circuit. On receipt of this tone the main station replaces the microtelephone on its rest, which restores all keys to normal and removes the busy conditions from the *C*- and *D*-wires. The *AA* relay at the extension station now operates to earth on the *D*-wire and so connects this extension to the calling exchange line. If the required extension is engaged on a local call, the main station can break into the connexion (there is no secrecy) and offer the exchange call to the extension concerned. If the call is destined for the external extension the main station calls the latter by depressing the appropriate local key, the exchange line being held meanwhile. The external extension is advised that an exchange call is waiting and the main station then throws the appropriate extension to exchange key.

An exchange call can be transferred from station

to station if desired in exactly the same way, with the one exception that an exchange call cannot be transferred direct from an internal extension to an external extension except via the main station. If it is desired to transfer a call from an external extension to an internal extension, the external extension flashes the main station and the latter carries out the transfer.

On installations with two exchange lines it sometimes happens that the main station is talking on one line and a call is received on the second line. The main station may temporarily abandon the call on the first line and by depressing the second exchange key may accept the call on the second line. This second call can then be transferred to some other station. In these circumstances it is necessary for the main station to release his hold on the second exchange line but at the same time to maintain the holding condition on the first exchange connexion. To enable this to be done a special trigger key is provided so that by operating this key it is possible to release one exchange line without releasing the other.

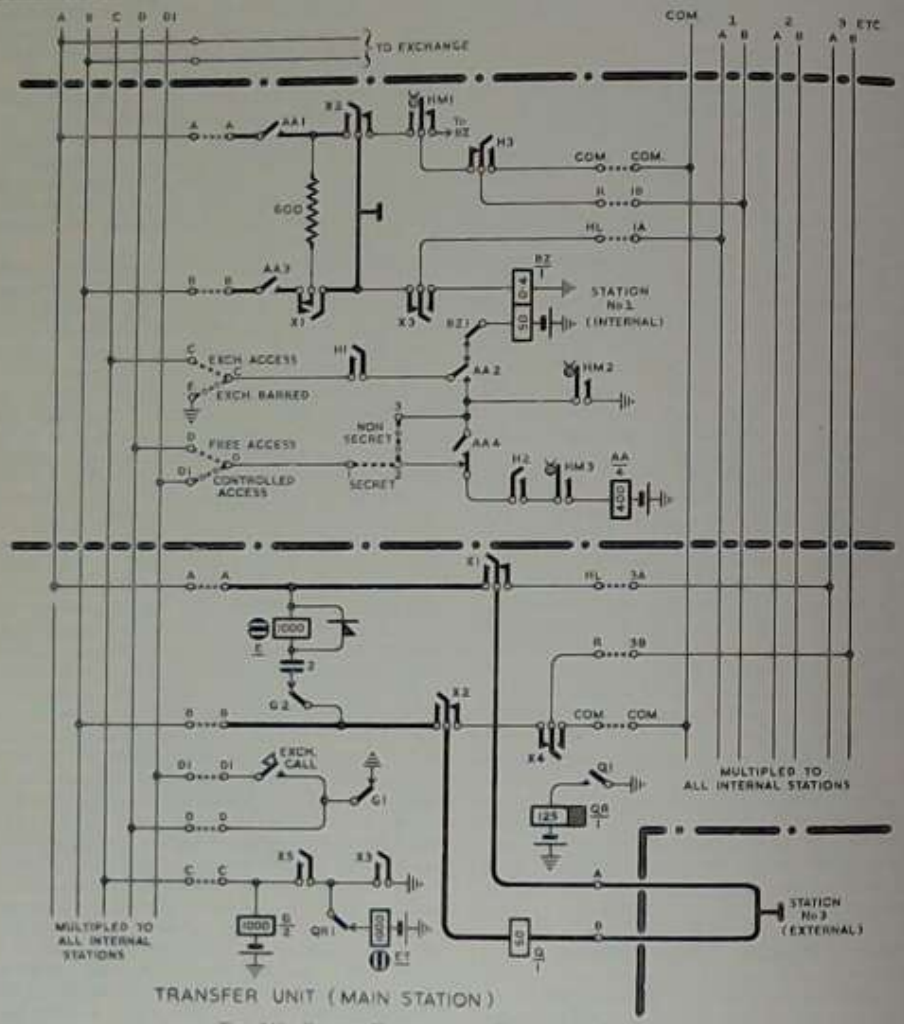

FIG. 348. CIRCUIT ELEMENTS FOR EXCHANGE LINE CALLS
Room exchange system.

Exchange Calls Barred. Any internal extension may be barred the facility of direct access to the exchange line (Fig. 348). This facility can readily be provided by disconnecting the *C*- and *D*-wires of the instrument from the multiple. The *C*-wire of the instrument is then earthed and the *D*-wire is left disconnected. The depression of the exchange line key will thus always encounter engaged condition. More often it is desirable to arrange that an extension shall not have unrestricted access to the exchange, but exchange calls may be allowed at the discretion of the main station operator. At these extensions the *D*-wires of the instruments are cross-connected at the junction box to the corresponding *D*1-wires and not to the *D*-wires as usual. The *D*1-wire is normally disconnected from earth, but by the operation of a press button labelled "Exchange Call" situated on the main station unit the *D*1-wire may be temporarily earthed and thus allow the *AA* relay to operate on the exchange barred extension. To make an outgoing call, therefore, the extension first calls the main station in the normal way. If an exchange call is to be allowed the main station operator tests and engages a free exchange line. The extension is then instructed to depress the appropriate exchange key and on receipt of buzzer tone from the extension, the main station operator holds down the appropriate Exchange Call button and at the same time replaces the main station microtelephone.

Monitoring Exchange Calls. Secrecy is normally given on exchange calls. Monitoring facilities may, however, be allowed at the main station or at any of the internal extensions. By removing the strap between terminals 1 and 2 in the *D*-wire circuit (Fig. 348) and inserting a strap between terminals 2 and 3 it is possible to provide monitoring facilities from that instrument. Under these conditions the lifting of the microtelephone and the operation of the exchange key provides an operate circuit for *AA* independent of the condition on the *D*-wire, and thereby enables the caller to break into an engaged exchange line.

Second Choice Main Station. By the operation of a key labelled "Transfer" at the first choice main station unit, the functions of that station may be transferred to the second choice main station. The spring units of the transfer key (*T1*, *T2*, *T3*, and *T4*) extend the *A*-, *B*-, *C*-, and *D*-wires to the second main station unit (Fig. 346). *T5* extends the extension indicator circuit in a similar manner. The second choice main station can then carry out the normal duties of the first choice main station. Arrangements are not provided, however, for the switching of the extension-to-exchange key leads and if the external extension requires a call it is necessary for the operator at the second choice main station to go to the first choice main station.

FIG. 349. HOUSE EXCHANGE JUNCTION BOX

Night Service. The external extension station may be permanently switched to an exchange line at night by the operation of the extension-to-exchange key and the night service key on the main station unit. The operation of the former key gives the external extension direct access to the exchange and the night service key prevents the operation of the extension indicator and of the local audible alarm. The *NS2* contact prevents the *C*-wire of the multiple from being permanently earthed so that the exchange line will test free to an

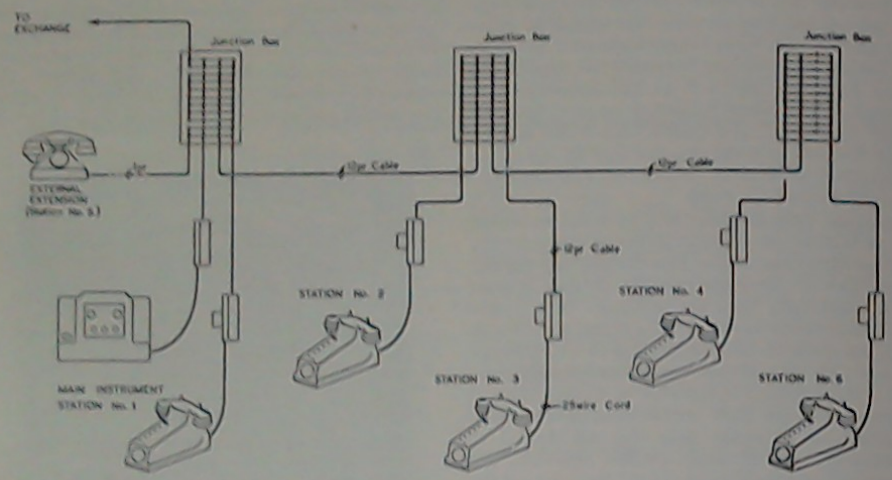

Fig. 350. Typical Cabling Arrangements of House Exchange System

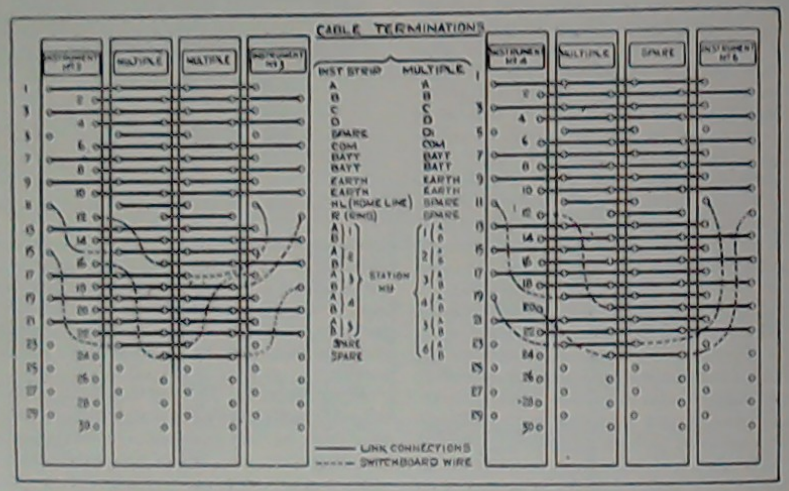

Fig. 351. House Exchange System
Cross-connexions at Junction Boxes for Stations 2, 3, 4, and 6

internal extension when it is not in use by the external extension.

Cabling. In addition to the special plugs and jacks of the instruments themselves, junction boxes are provided for the termination of the multiple cables and on which the necessary cross-connexions can be made. These boxes are made up in two sizes, 30-way and 48-way, the former being used throughout the five-line system and also as an auxiliary box when required on the ten-line system which is normally served by the larger size.

The arrangements of a typical 30-way junction box are shown in Fig. 349. In this illustration separate strips are utilized for the incoming and outgoing multiple cables and two further strips are connected to instruments Nos. 2 and 3. It is a feature of the house exchange system that all cables are terminated on individual terminal strips, and the necessary commoning is done by means of square-section bare wire. When other cross-connexions are required they are carried out in switchboard wire.

Two sizes of cable have been standardized—a 12-pair cable for the five-line system and a 20-pair cable for the larger system. The conductors are of No. 23 S.W.G. and are tinned and enamelled, with an outer covering of two lappings of cotton laid on in opposite directions. Standard colours are utilized for the outer cotton lapping, and a helical lapping of white tape is laid over the outer layers of the conductors. The whole cable is waxed and lead sheathed. The use of twisted pairs throughout in a system of this kind is essential if crosstalk is to be avoided. A typical cabling lay-out for a six-station installation is shown in Fig. 350, whilst Fig. 351 shows, in more detail, the cross-connexions in two of the junction boxes. This lay-out may be considerably varied to suit the individual lay-out of stations. The cross-connecting of a $10 + 2$ system follows the same principle as that of the five-line except that at the main station it may be necessary to have a 30-way auxiliary junction box in addition to the 48-way main box owing to the number of cables to be accommodated.

Power Supply. The power for a house exchange system is normally obtained over a power lead from the public exchange (Chapter XX), but where this is not practicable a battery of primary cells or a trickle-charged secondary cell installation may be employed. The system is designed to operate with a nominal 24 V, but the factor of safety is sufficient to permit its use on any voltage between 18 and 28 V. The maximum current consumption is approximately 1·3 A for a fully equipped $10 + 2$ installation. A 10 μF condenser should be connected across the power lead in order to reduce to a minimum any crosstalk due to battery feed resistance.

EXERCISES XI

1. State the advantages and disadvantages of providing through clearing facilities at subscribers' private branch exchanges.

Describe, with the help of circuit diagrams, the way in which through clearing is provided:

(*a*) On cordless switchboards, and

(*b*) On double cord switchboards at private branch exchange installations.

(*C. & G. Telephony, Grade II*, 1940.)

2. Show by means of circuit diagrams what happens when the Night Service key of a 25-line P.M.B.X. is operated.

3. Explain why, on a 65-line P.M.B.X., a clearing signal is not given to the exchange whilst a call is being extended to an extension and before the extension replies.

4. Compare the supervisory signal arrangements of a 25-line and a 65-line P.M.B.X.

5. Describe, with the help of simplified diagrams, the stage by stage progress of an extension to exchange call on a P.M.B.X. No. 1A.

6. Explain what happens if, on a P.M.B.X. No. 1A, an exchange line is taken into use for an incoming call before the previous connexion has been taken down by the P.M.B.X. operator. Draw the circuit elements concerned.

7. Describe the main features of switchboard equipment suitable for a large private manual branch exchange at which multiple facilities are required. Give diagrams of the line and cord circuits. Assume that the exchange lines are connected to an automatic exchange. (*C. & G. Telephony, Grade I*, 1941.)

8. Give a diagram and explain the salient features of the terminal equipment at a P.M.B.X. No. 1A, on a d.c. signalling private wire.

9. Enumerate the facilities provided by the House Exchange System.

10. Explain with simple diagrams how an incoming exchange call is passed to an internal station of a House Exchange installation.

11. Give the circuit elements of a House Exchange system by means of which:

(*a*) A station can be given free access to the exchange line.

(*b*) A station can be barred access to the exchange line.

(*c*) A station can have access to an exchange line only after receiving the permission of the main station.

(*d*) A station can monitor any exchange call.

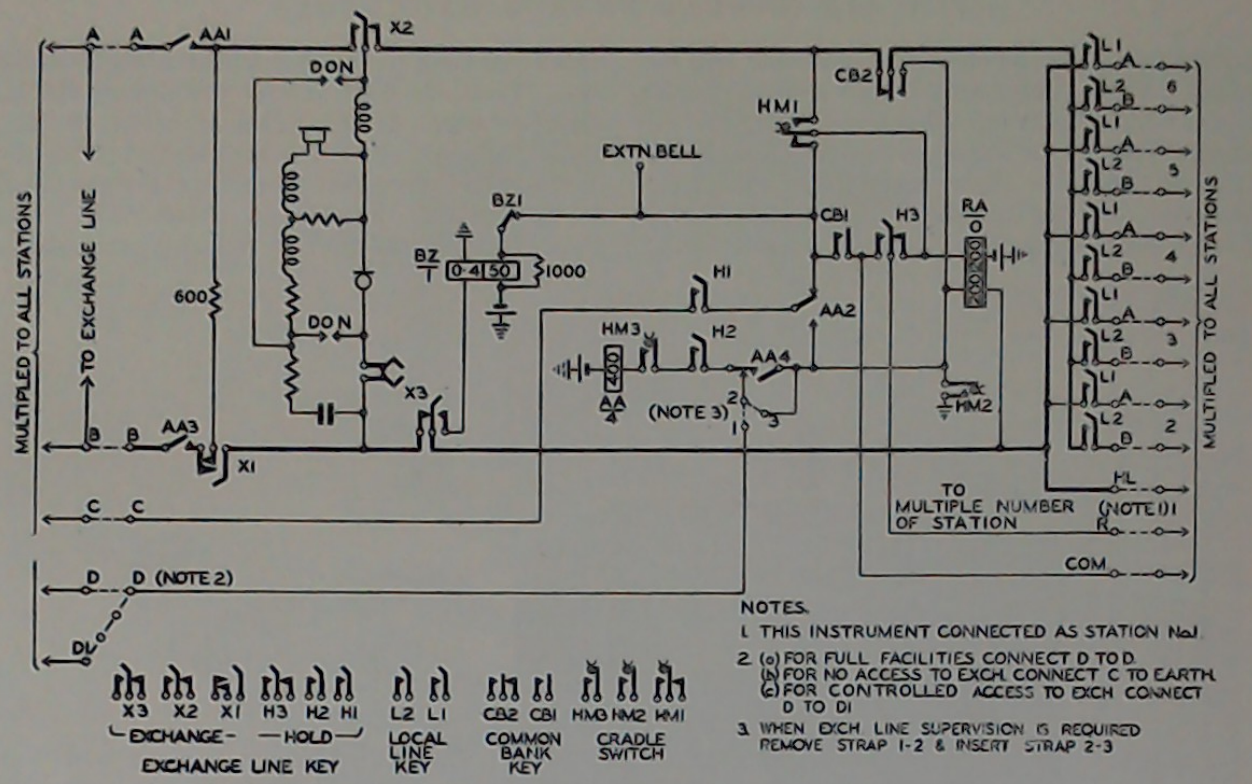

Fig. 345. Circuit of Five-station House Exchange Instrument

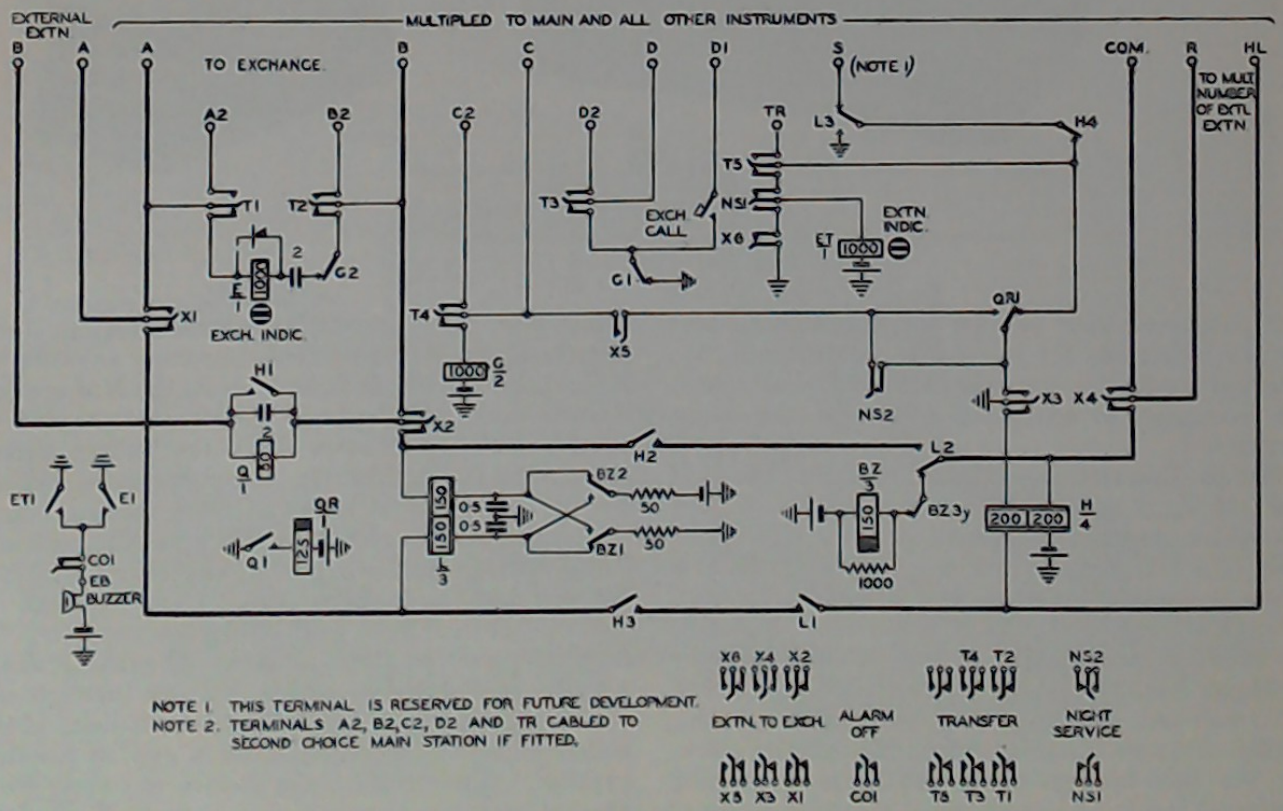

Fig. 346. Circuit of Transfer Unit
(No. 1A.)

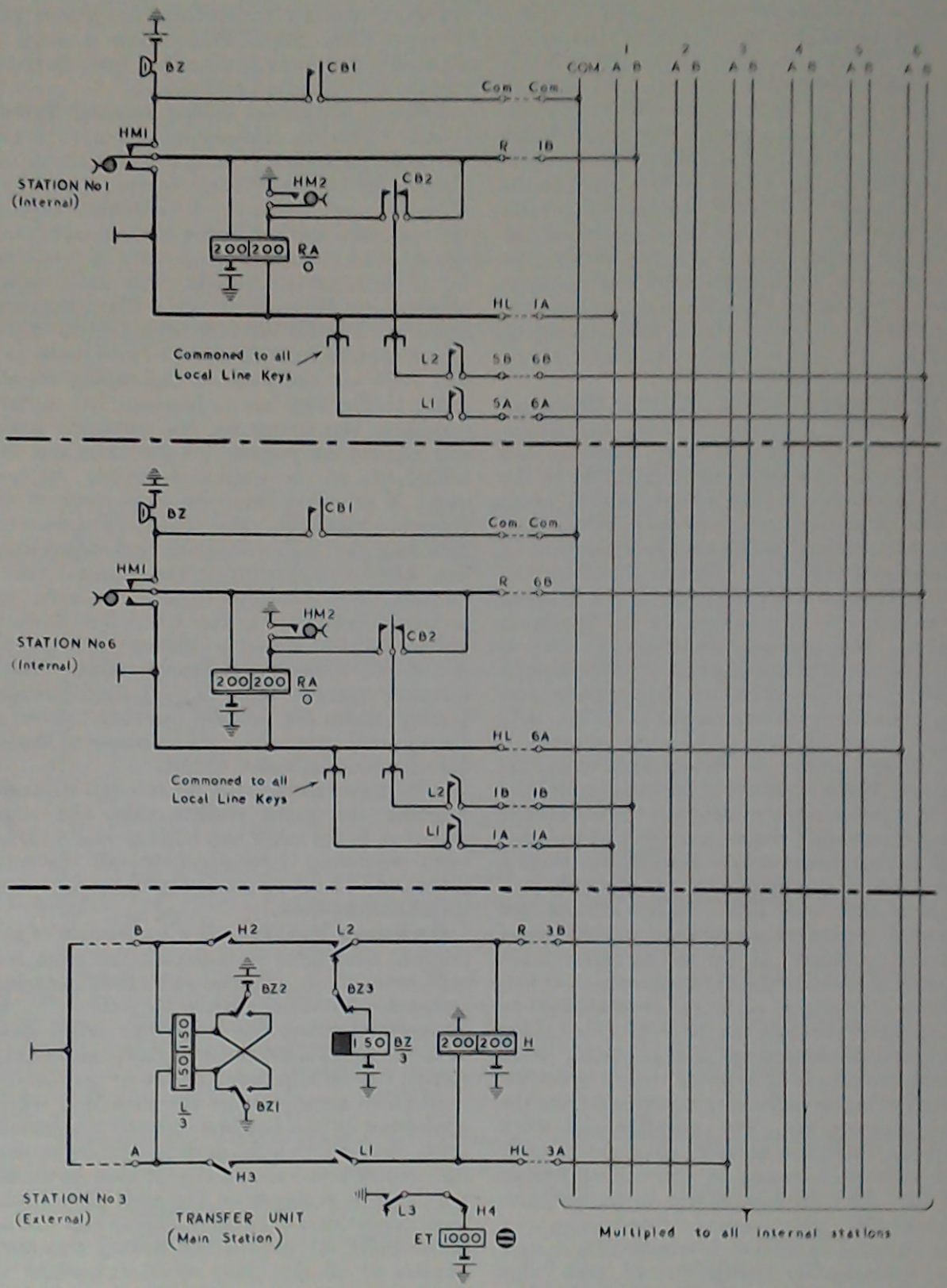

FIG. 347. CIRCUIT ELEMENTS FOR STATION-TO-STATION CALLS

House exchange system.

to station if desired in exactly the same way, with the one exception that an exchange call cannot be transferred direct from an internal extension to an external extension except via the main station. If it is desired to transfer a call from an external extension to an internal extension, the external extension flashes the main station and the latter carries out the transfer.

On installations with two exchange lines it sometimes happens that the main station is talking on one line and a call is received on the second line. The main station may temporarily abandon the

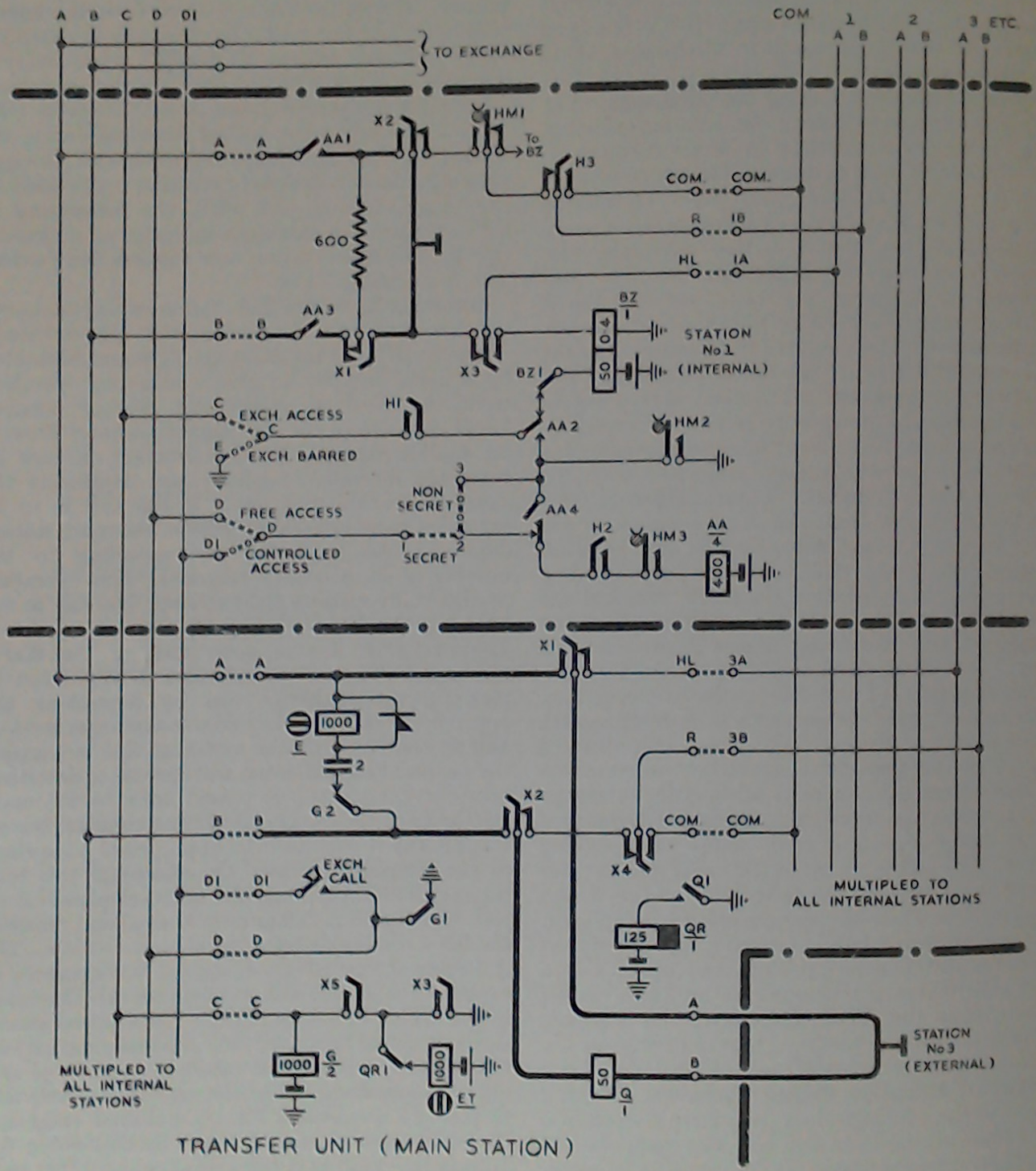

Fig. 348. Circuit Elements for Exchange Line Calls
House exchange system.

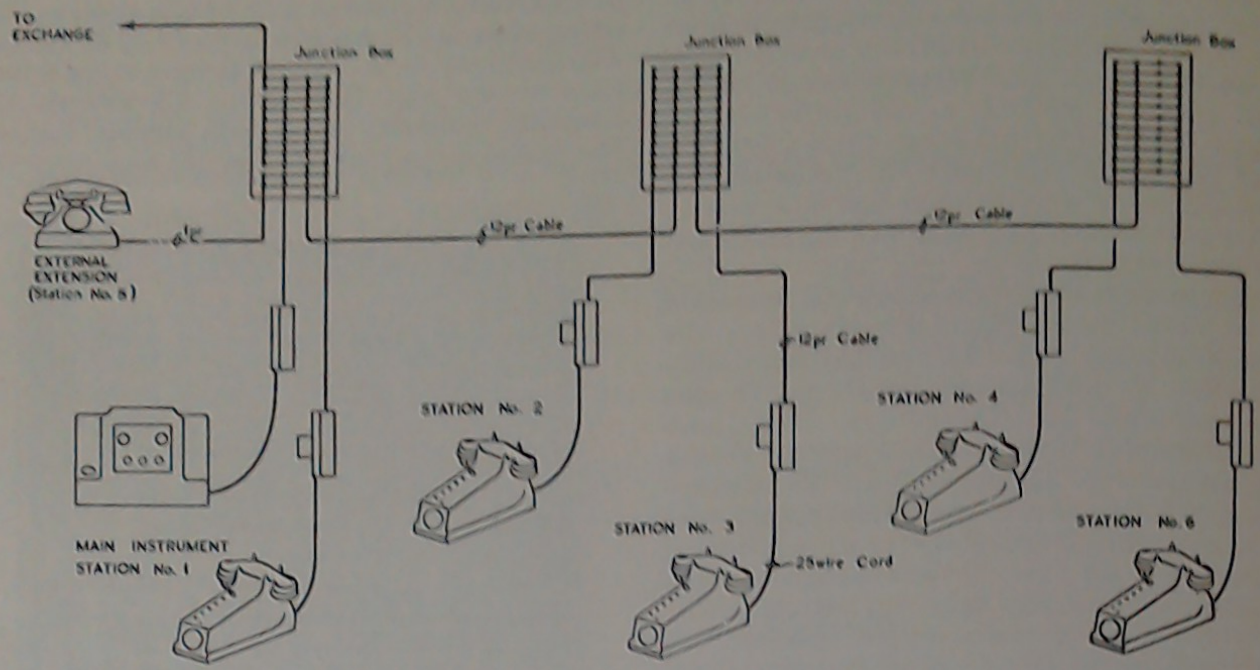

FIG. 350. TYPICAL CABLING ARRANGEMENTS OF HOUSE EXCHANGE SYSTEM

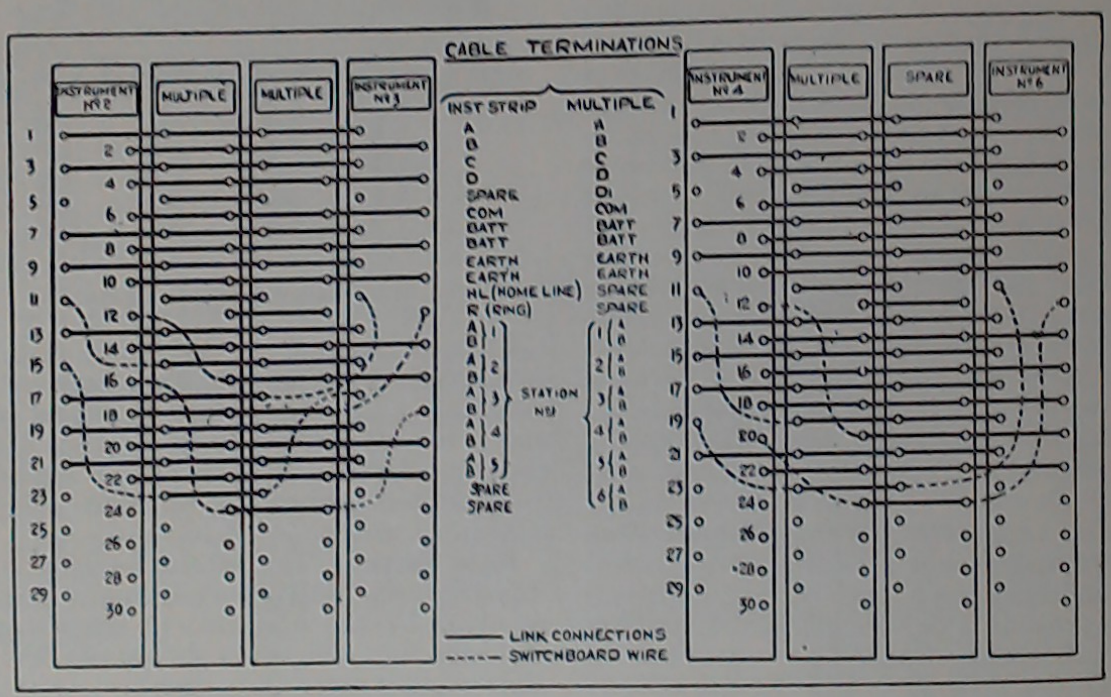

FIG. 351. HOUSE EXCHANGE SYSTEM

Cross-connexions at Junction Boxes for Stations 2, 3, 4, and 6