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THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

# Phonogram Automatic Distribution

## Part 2.—Basic Circuit Features

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U.D.C. 621.395.341.8 : 621.394

**The previous part of this article described the field trial installation, and the facilities provided. This part describes the basic circuit elements employed in connection with incoming calls, including those concerned with their queueing, storage and distribution and the adjustment of queue size in relation to the number of available staffed positions.**

THE predominant features of interest in the design of this equipment are undoubtedly those concerned with the arrangements for the queueing, storage and distribution of *incoming calls*. A brief description of the basic circuit elements employed in this connection is, therefore, given below. Restriction of space has precluded the description of other features, including the means of originating outgoing calls, although the arrangements in this respect will be reasonably apparent from Fig. **3** and the associated text in Part 1 of this article.[1]

The circuits, which employ P.O. standard uniselectors, 3000-type relays and high-speed relays as the major components, have been designed to follow the general lines of automatic telephone exchange practice. Battery-testing arrangements using high-speed relays are employed throughout for the various uniselector testing and switching circuits.

### Queueing, Storage and Distribution Arrangements

Fig. **6** shows the basic circuit elements employed for incoming calls and, inset, in block schematic form, the manner in which the various relay sets and uniselectors are inter-connected.

Access to the auto-distribution equipment is over two-wire circuits, phonogram calls from ordinary subscribers being routed from level "90" relay sets at Newcastle telephone exchange, and from C.C.B. subscribers via direct jack-ended circuits from the auto-manual switchboard. Telephone-telegram calls are received either via level "951" relay sets at the auto exchange (i.e., exchange telephone-telegram service for sub-post offices not having sufficient traffic to justify a direct circuit to the phonogram appointed office) or by direct telephone line from sub-post offices with sufficient traffic to justify their provision, but insufficient traffic to warrant a teleprinter circuit.

Each two-wire circuit is connected to an incoming line relay set with associated line uniselector, which exercises the joint function of queue and position finder. The common equipment, comprising the queue forming and storage relays, the queue distributor and the position marker, provides the means for arranging and, if necessary, storing the calls in chronological order and for their subsequent distribution to free staffed operators' position circuits in cyclic order. The system is such that all incoming calls enter the queue first and are subsequently discharged to free operators' positions as they arise. The early contacts of the line uniselector are used for access to queue storage positions, and the later contacts are used to provide access to the phonogram operators' positions.

[1] *P.O.E.E.J.*, Vol. 42, p. 149.

The operation of the various circuit elements is as follows.

*Incoming Line Relay Set* (*Fig.* **6** (*a*)).

From the circuit elements of the relay set it will be seen that relay L operates to the calling condition (which may be loop or battery) and, providing the line uniselector wipers are on the home position, completes an operating circuit for relay LL at L1.

Relay LL operating, completes a drive circuit for the uniselector driving magnet at LL3 and at LL4 connects the testing relay TRA to wiper P1. The uniselector steps to find the bank contact with a marking condition (550 ohm battery via Figs. **6** (*b*) and (*c*)) denoting the next available queue storage position. Relay TRA then operates with its windings in series, and TRA1 cuts the drive circuit, at the same time removing the short-circuit from relay H, which now operates in series with the driving magnet.

Contact H1, operated, returns ringing tone to the calling subscriber, and the call is thus held in storage until a free operator's position has been allotted to it by the functioning of the common equipment and the resultant connection of 550-ohm battery (Fig. **6** (*d*)) to the appropriate P2 bank contact of the line uniselector. At the same time the marking battery extended over the P1 bank of the line uniselector is replaced by an earth to short-circuit relay TRA which releases. Contact TRA1 via H5 now operates relay HA. Relay H is released at HA2 and at H5 completes a circuit for the uniselector driving magnet which again drives and at the P2 wiper searches for the marking battery of the allotted operators' position circuit. Relay TRA again operates when this marking battery is encountered and at TRA1 cuts the drive circuit and also removes a short-circuit from relay K which operates in series with the driving magnet. K2 maintains the holding circuit of relay LL. K3 and 4 release relay L and extend the incoming positive and negative leads to the allotted position circuit. K6 operates relay KR which, among other features, disconnects the ring tone from the circuit.

The provision of "Call Count" and "Time to Answer" meters will be noted, also alarm facilities which operate to indicate PG conditions, or the failure of a call to be taken into the queue within 9 seconds.

*Queue Storage Relays* (*Fig.* **6** (*b*)).

These relays function to form the queue on the P1 bank of the line uniselector, and to hold the calls in storage pending their discharge by the queue distributor (Fig. **6** (*c*)). As many queue relays are needed as the maximum number of calls to be held in queue storage, although only one relay (and

storage position) is available to incoming traffic at any instant, these being opened sequentially either by the successive operation of the queue relay contacts, or the stepping of the queue distributor. At Newcastle, 15 queue storage relays are provided, these being connected to contacts 1-15 of the P1 bank of the line uniselector, and contacts 1-15 of the D1 bank of the queue distributor.

Assuming a period with no calls held in storage, all queue relays would be unoperated, but the contact on which the D1 wiper of the queue distributor is resting would predetermine the queue relay next to be operated. For example, AQ would be operated by the first call, and at AQ2 would connect 150-ohms battery to the next storage relay (BQ), to mark this queue position against the receipt of a further incoming call. Thus subsequent calls are switched to successive queue positions as marked by contacts of preceding queue relays.

The marking condition on the contacts of P1 bank is effectively 550 ohms (NI), composed of 400 ohms (NI) shunting the queue relay, and 150 ohms (NI) connected by the preceding queue relay contact, or wiper D1 of the queue distributor, and it is to this battery that the high-speed drive-cutting relay TRA in the individual line relay set operates. Earth fed via the low-resistance winding of relay TRA constitutes the effective operating path for the queue relay associated with the marked outlet.

The call at the head of the queue, which is always determined by the position of the queue distributor, is discharged to the next operator's position to become free by the connection of an earth over the D1 bank of the queue distributor, which causes relay TRA to release, and the line uniselector to search for the free position circuit. The queue relay (e.g., AQ) is also released and at AQ2 disconnects the marking battery from relay BQ. Should a further call already be in the queue, however, relay BQ would hold over BQ1 to relay TRA in the line relay set associated with the further call, pending its discharge in the manner above described to the next free position circuit. The queue distributor steps to the next queue relay position on the release of AQ5.

*Queue Distributor and Position Marker* (*Fig.* **6** (*c*)).

The queue distributor and position marker exercise independent functions as indicated below, but as the

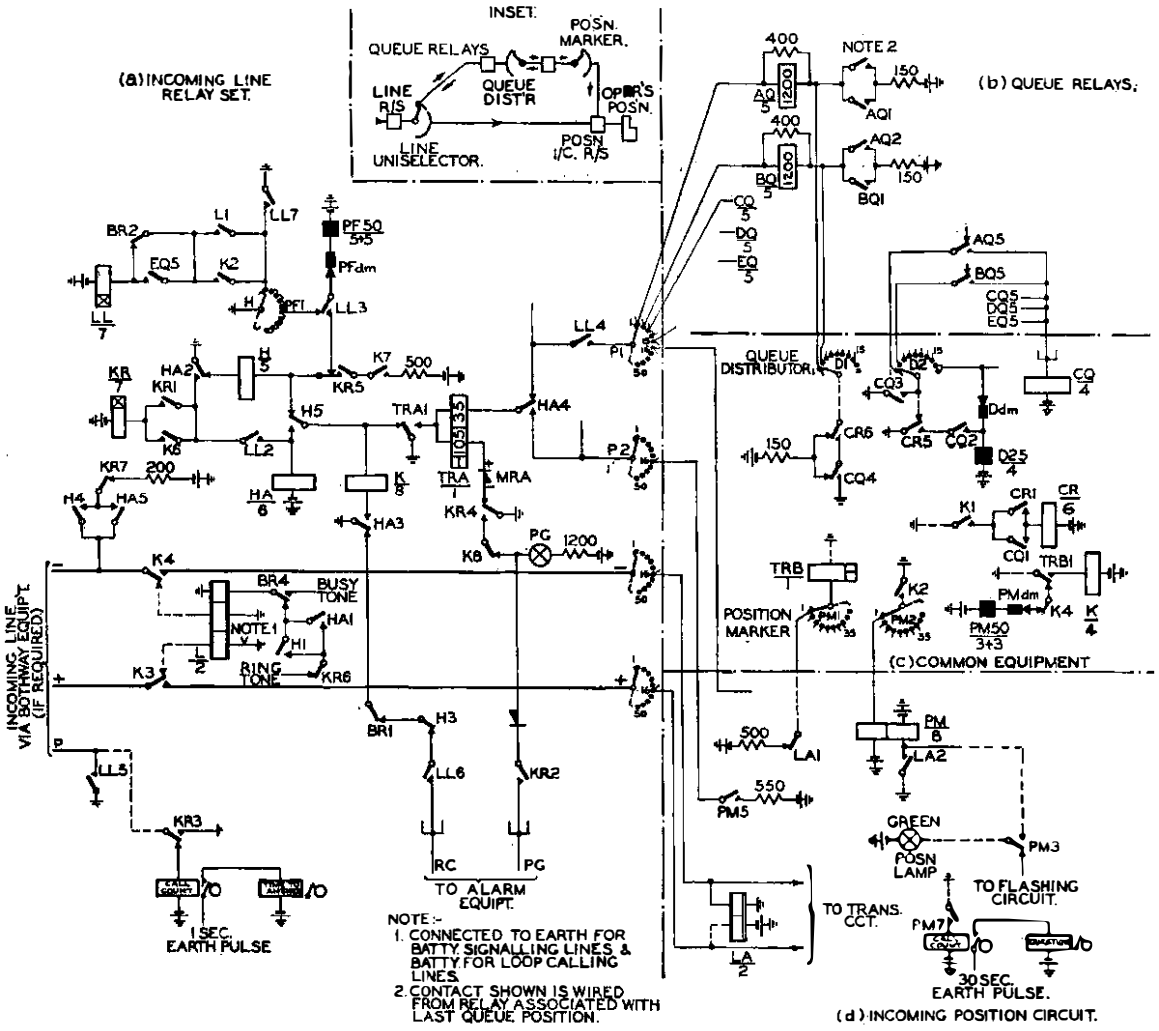


FIG. 6.—CIRCUIT ELEMENTS FOR QUEUE STORAGE AND DISTRIBUTION OF INCOMING CALLS.

controlling relays are closely interconnected, these are mounted on a common relay set base.

The queue distributor controls the initial formation of a queue, and subsequently ensures that all queued calls are discharged in the order of arrival. The bank contact on which the D1 wiper is standing at any instant indicates the head of the queue and the call next to be discharged.

The position marker preselects and marks the first operator's position to become free, and after doing so causes the queue distributor to discharge the call from the head of the queue. This call is then routed to the free position. The queue distributor steps and the next call becomes the head of the queue, awaiting discharge to the next free operator's position, to which the position marker now steps.

Referring to Fig. 6 (*c*), relay TRB will be operated from contact LA1 (Fig. 6 (*d*)) of the first free operator's position to which a stored call is to be routed, and at TRB1 cuts the position marker drive circuit and operates relay K. The presence of a call in the queue storage will be denoted by the operation of relay CQ, the operating path for which is completed by a contact (e.g., AQ5) of the queue storage relay at the head of the queue (e.g., relay AQ). CQ1 operated, via K1 operated, completes an operating circuit for relay CR, which locks via CR1, whilst CQ3 prepares a holding circuit for relay CQ against the operation of CR5.

Contacts CR5 and CQ2 energise the queue distributor driving magnet, whilst CR6 and CQ4 connect an earth via the D1 bank of the queue distributor to short-circuit and release relay AQ, and to cause the line uniselector to hunt for the marked free operator's position. The release of AQ5 releases relay CQ, and at CQ2 causes the queue distributor to step to the next contact. Relay CR remains held, however, until the call has switched to the free operator's position, when the operation of relay LA and contact LA1 (Fig. 6 (*d*)) ensures the successive release of relays TRB, K and CR.

K4 completes a circuit for the position marker to self-drive to the next free staffed position (although arrangements are made for this to be restrained during a period when all staffed positions are engaged), when the re-operation of relay TRB causes the above cycle to be repeated, subject to a call being in queue storage, as denoted by the operation of relay CQ.

For the sake of clarity only one queue distributor and position marker equipment has been shown, but in practice a duplicate, stand-by equipment is provided, with automatic change-over facilities in the event of the failure of the regular equipment. The circuit arrangements are such that the position of the stand-by queue distributor uniselector, upon taking over, is made to agree with that of the regular queue distributor uniselector, thus ensuring that the correct sequence of discharge is maintained for any calls in storage.

*Incoming Position Circuit* (*Fig.* 6 (*d*)).

The position marker, having preselected the next free staffed operator's position as described above, will cause relay PM of the position circuit concerned to be operated from K2 (Fig. 6 (*c*)). Contact PM5 connects 550-ohm battery to the P2 level of the line uniselector to mark the outlet to which the next call to be discharged from a queue position should switch. The consequent extension of the calling condition from the calling line to the position circuit causes relay LA to operate. LA2 locks relay PM, and at the same time completes a circuit via PM3 to cause the position lamp (green) to glow. LA1 breaks the operating circuit for relay TRB, allowing the position marker to step to the next free staffed position. The 500-ohm battery condition extended via LA1 normal to the appropriate bank contact of level PM1 of the position marker, to indicate a free staffed position, is disconnected (by contacts not shown) when the position is unstaffed, i.e., plug of the operator's headset is not inserted in the instrument jack.

The line relay set and position circuit are both held for the duration of the call by the calling subscriber. On the release of the connection by the subscriber, relays LA and PM in the position circuit are released due to the disconnection of the calling condition. PM5, released, removes the negative battery from the P2 level and thereby releases relay TRA in the line circuit. Relays K, LL, HA and KR subsequently release and the line uniselector returns to the home position in readiness for the next call. The position circuit, however, is automatically busied to further incoming calls to enable the operator to complete the form on which the message has been received (i.e., time of receipt, etc.) before a further incoming call is offered. The green position lamp continues to glow until the operation of the position release key by the operator, which also causes the position circuit to be opened for further calls. If, however, the operator fails to operate the position release key within a period of 15 seconds after the clear-down of the calling subscriber, a uniselector timing arrangement, which is individual to the position, causes the green position lamp to change from a steady glow to a flashing signal. The attention of both the operator and the section supervisor is, therefore, called to the excessive guard period and the non-operation of the position release key.

### Arrangements for Controlling Queue Size

The effect of calls held at queue storage positions can be regarded, perhaps, as having a "reservoir" effect in smoothing out short-term inequalities between the supply of operators, and the demand for them occasioned by incoming calls. This effect could, however, in some circumstances be considered undesirable, as for instance where a sustained traffic overload occurs during a period with only a few operators on duty, when the establishment of a queue of maximum size would result in unduly long time-to-answer periods. By limiting the size of the queue in accordance with the number of staffed positions available to incoming traffic, and arranging for the return of busy tone on all calls arriving whilst the queue (as restricted) is full, the time-to-answer period may be itself restricted to an acceptable figure. In determining the relationship between the permissible queue size, and the number of staffed positions, regard has also to be given to the number of

calls which may be lost as a result, a factor which clearly operates in an opposite sense to that of the time-to-answer duration.

Arrangements have been incorporated in the field trial equipment to enable the queue size to be limited, either manually, by means of a rotary switch, at the discretion of the Chief Supervisor, or automatically, in accordance with the number of staffed incoming positions as determined by the Staffed Position Count Circuit.

*Staffed Position Count Circuit.*

This circuit, shown in skeleton form in Fig. 7, in addition to fulfilling its obvious function of counting the number of staffed incoming positions, provides for an appropriate marking condition to be extended to the queue limit circuit when the Auto Queue Control key is operated, in order that the queue size shall be limited to a predetermined value. It also provides for a lamp display to be given at the Chief Supervisor's desk when the Staffed Count Display key is operated. The operation of either or both of these keys causes the initial functioning of the count circuit by reason of the operation of the start relay ST, which at ST2 operates relay P. Relay S operates via contact P6 and uniselector arcs C3 and M3 (with wipers on corresponding outlets) which operates relay PW at S1 and relay S holds at PW3. PW4 operates relay B, contacts of which connect the H uniselector driving magnet to the H3 wiper, and relay PC to the H5 wiper, and release relay P at B6.

The H3 and H5 wipers are now connected, via outlet 1, to the HC and C leads of the first operator's position, and if this position is unstaffed, or not available for incoming traffic, then the contacts of the associated OR relay will be normal, as shown. Earth from OR5 contact is, therefore, connected via H3 wiper to the driving magnet of the H uniselector and the uniselector steps to the next outlet. Should the OR relay of the operator's position connected to this outlet also be normal, the H uniselector again steps, and so on, until an outlet is reached where the OR relay connected to it is operated, which indicates a staffed position available to receive incoming traffic. OR5, operated, disconnects earth from the HC lead, and the H uniselector drive circuit, and connects it to the C lead, thereby operating relay PC via H5 wiper. PC1 energises the C uniselector driving magnet and PC2 energises the H uniselector driving magnet. Relay PC releases when the interrupter springs of the C uniselector open, causing both uniselectors to step to the next outlet.

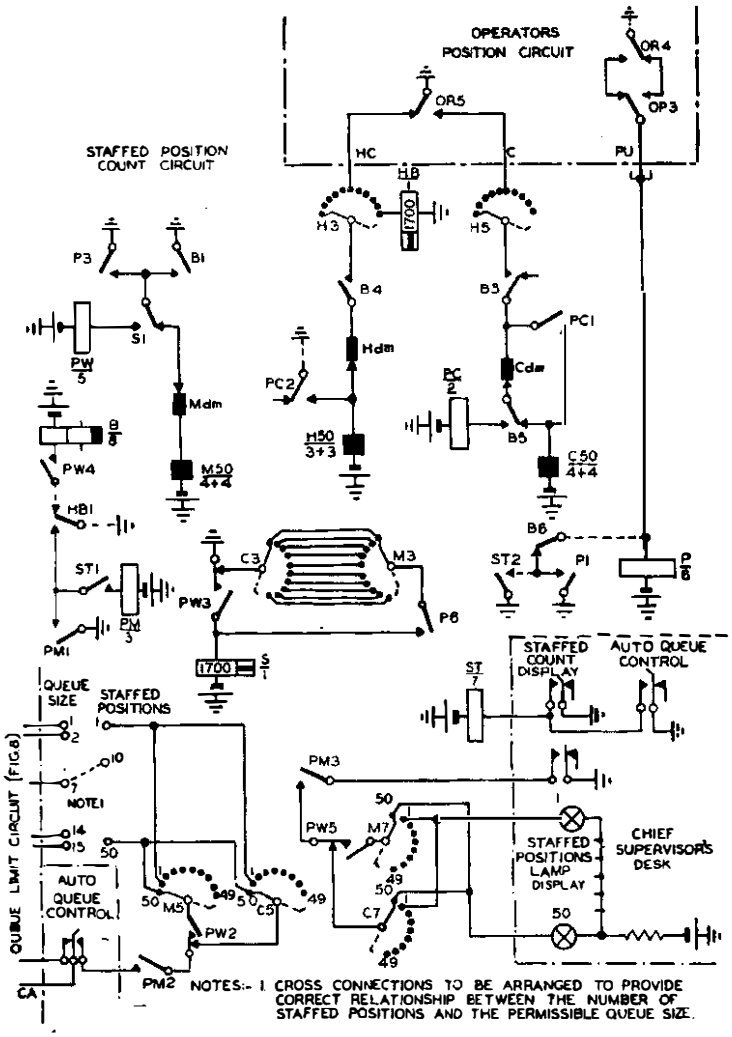


FIG. 7.—THE STAFFED POSITION COUNT CIRCUIT ELEMENTS.

The H uniselector continues to step as described until outlet 50 is reached, when relay HB operates, operating relay PM and releasing relays B, PW and S, in that sequence, thus disconnecting the uniselector drive circuits and marking the end of the count cycle. Circuit arrangements (not shown) prevent the re-operation of relay P at contact B6 and also cause the H uniselector to step to outlet 1 in readiness for the next count cycle, with consequential release of relay HB. The position of the wipers of the C uniselector, which has stepped once per staffed position, provides the appropriate count indication for extension to the queue limit and lamp display circuits, at wipers C5 and C7 respectively.

After the initial count, subsequent operation of the circuit takes place only when an alteration to the number of staffed positions occurs, this being signalled automatically by the insertion or withdrawal of the plug of an operator's headset from the position instrument jack, which causes the sequential operation (or release) of relays OP and OR in the position circuit concerned. A pulse earth is thus connected via contacts OP3 and OR4 to the common PU lead, which results in the pulse operation of relay P which locks at P1. The M (marking) uniselector is now caused to drive at contact P3 so that its wipers take up a position corresponding to that of the C (count) uniselector, the drive circuit being cut at contact S1

due to the operation of the high-speed relay S via contact P6 and wipers M3 and C3. Relay PW is also operated at contact S1 ; PW2 and PW5 transfer the marking conditions established via wipers C5 and C7 to wipers M5 and M7 respectively. The conditions set up by the initial count are thus maintained during the recount cycle.

The operation of relay B at PW4 is restrained until the C uniselector has been restored to its home position (by circuit arrangements not shown), after which the functioning of the circuit is exactly as described above. The release of relay PW at the end of the recount cycle (PM still being held operated at ST1) restores the queue limit and display circuits to wipers C5 and C7 respectively, which will now be resting at the outlet corresponding numerically with the changed number of staffed positions. The queue size and lamp display will be altered accordingly, and the count circuit will continue to function automatically in this manner so long as one of the control keys on the Chief Supervisor's desk remains operated.

*Queue Limit and Lamp Display Circuit.*

The circuit as illustrated in skeleton form in Fig. 8 has two functions, firstly to establish conditions whereby the number of calls accepted into queue storage is limited to a predetermined value, and secondly to provide a visual indication of the instantaneous value of the queue size, both at the operator's position and the Chief Supervisor's desk.

The first function may be controlled either manually or automatically, as previously mentioned. For the purpose of the initial description, manual control will be assumed, the rotary type switch on the Chief Supervisor's desk being set at position 6, with the object of limiting the size of the queue to six stored calls. It will also be assumed that the wipers of the queue distributor are positioned initially on outlet 1, thereby pre-selecting at wiper D1 (Fig. 6 (*c*)) queue relay AQ as the next to be operated.

The equipment shown in Fig. 8 is brought into operation only when all staffed positions available to incoming traffic are engaged, when relay PC in the position control circuit is operated, extending an earth at PC2 to prepare for the operation of the start relay ST. An incoming call arriving at this stage will operate queue relay AQ, which at AQ4 operates the common relay QQ. QQ1 completes the operating circuit for relay ST, which locks at ST4, and extends a marking earth to the D4 wiper of the queue distributor. Contact ST1 causes the SA uniselector (which is of non-homing type) to drive until its wipers reach contact 1, where the high-speed relay SA on the SA1 wiper operates to earth via the D4 wiper of the queue distributor. SA1 cuts the drive circuit and connects earth to the SB uniselector which drives in turn to line up with the queue distributor and SA uniselector. Relay SB on the SB1 wiper operates when the SB uniselector reaches contact 1, to disconnect the drive circuit and connect earth to relay LA which operates and locks to ST2. The operation of relay LA causes the first queue display lamps on the operators' positions, and also the Chief Supervisor's desk, to glow via contacts LA2 and LA3 respectively, to indicate that one call is held in storage.

If a further incoming call arrives, the next queue relay in sequence (relay BQ) operates, extending earth via BQ3 to relay LB, via outlet 1 of SA2 arc. Relay LB operates and LB3 transfers earth from lamp No. 1 on the Chief Supervisor's display circuit to lamp No. 2 which now glows, and at LB2 causes the second lamp of the operator's lamp display to glow. Due to the " slipped " bank wiring of the SA2—8 and SB2—8 arcs, succeeding incoming calls operate relays LC, LD, etc., to cause the lamp display at the Chief Supervisor's desk, and the sequence of lamps at the operators' positions, to glow accordingly. It should be noted that the circuit arrangements are such as to ensure that, irrespective of the sequence in which the queue relays are operated, the queue count relays shall, nevertheless, operate in the numerical sequence

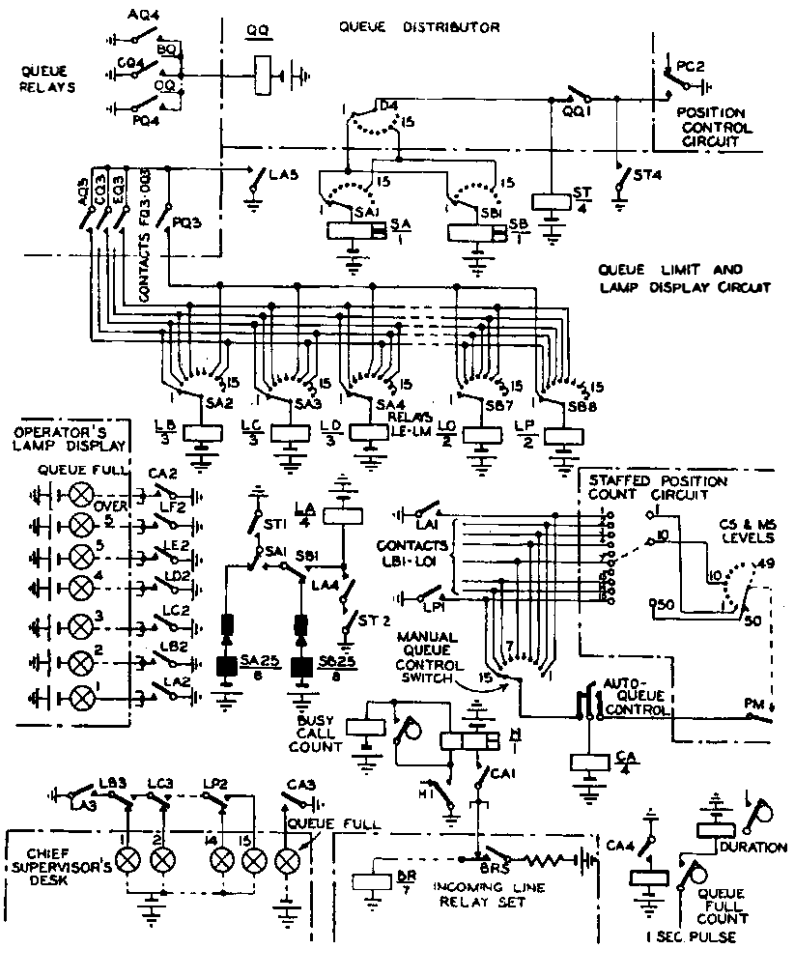


FIG. 8.—QUEUE LIMIT AND LAMP DISPLAY CIRCUIT ELEMENTS.

LA, LB, etc., required for lamp display and queue control purposes.

Relay LF operates when the sixth incoming call arrives, and in addition to lighting the display lamps at LF2 and LF3, also causes relay CA to operate from earth at LF1 contact, via the sixth contact and selecting finger of the manual queue control switch. Contacts CA2 and CA3 operated cause the " Queue Full " display lamps to glow, while CA4 causes the " Queue Full Count " meter and " Duration " meter to operate. CA1 connects relay H to the common lead associated with the BR5 contact of each incoming line circuit to prevent any further calls being stored whilst the queue full condition exists. Thus, any further call arriving would connect the associated BR relay coil in series with the H relay coil, causing both relays to operate. Relay BR locks in the operated condition via BR5 contact and returns busy tone to the calling subscriber. H1 contact operates the " Busy Call Count " meter in series with a holding coil of relay H, the release of both meter and relay being delayed until the meter is fully energised and its contacts short-circuit the H relay winding.

When a position becomes free to accept another incoming call, the longest waiting stored call, as marked by the position of the queue distributor, will be discharged from the queue in the manner described earlier. Thus, relay AQ releases, but relay QQ is held by the remaining operated queue relays. The queue distributor steps to the next contact, thus releasing relays SA and SB and causing uniselectors SA and SB to drive, as previously described, to the corresponding contact (i.e., outlet 2). Due to the effect of the slipped multiple, the stepping of the wipers SA2-SB8 to outlet 2, with the five queue relays BQ-FQ operated, will cause the queue count relay LF only to release, LB to LE being retained operated by contacts CQ3-FQ3, and relay LA continuing to hold via ST2 and LA4 contacts. The release of relay LF also releases relay CA, and the " queue full " condition and lamp display are adjusted accordingly.

The queue distributor uniselectors SA and SB continue to step once for each call discharged from the queue; the discharge of the last stored call releases relay QQ and at QQ1 causes the start relay ST to release. With the release of LA at ST2 the circuit returns to normal to await the next operation of relay PC.

*Automatic Control of Queue Size.*

It will be seen from Fig. 8 that the only effect of operating the Automatic Queue Control key is to transfer the operating path of relay CA from the manually controlled finger of the switch to the automatically controlled wiper C5 of the count uniselector in the staffed position count circuit, and thus via a cross-connection field to the LA1-LP1 contacts of the queue count relays. The circuit operation is otherwise exactly as described above except that the automatic adjustment of the C5 wiper to a new position on the bank, as staff changes occur, determines, via the cross-connection field, the appropriate limiting value for the queue size.

*Position Control Circuit.*

One facility required of the system is that calls arriving when all incoming positions are engaged shall first seek a disengaged position among the bothway positions before passing to queue storage. This " overflow " facility, as well as other requirements mentioned below, is provided by the position control circuit shown in skeleton form in Fig. 9.

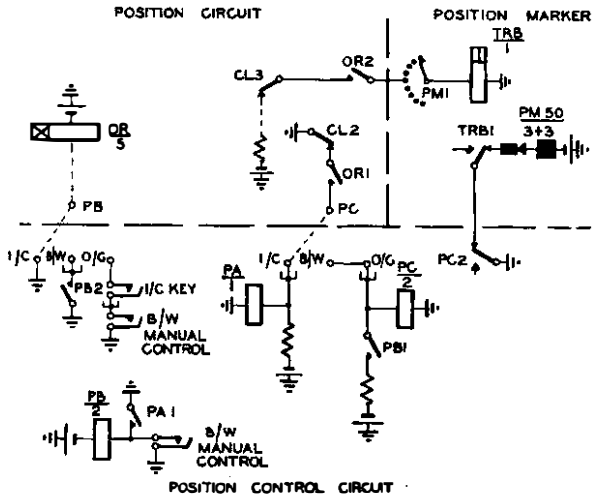


FIG. 9.—POSITION CONTROL CIRCUIT ELEMENTS.

Each operator's position is identical from an equipment viewpoint, but the particular straps employed between the PB and PC terminals of each position and the respective I/C, B/W or O/G terminals of the control circuit predetermine its normal function.

Relay OR in the position circuit is connected to its PB terminal during the period a position is staffed. Thus all staffed incoming positions will have their OR relays operated directly by earth connected from the control circuit, opening them for incoming traffic by extending marking battery via contacts OR2 to the PM1 arc of the position marker. The connection of an incoming call to the position causes relay CL (not shown) to operate and hold during the total position-engaged period, thus removing the marking condition at CL3.

Considering relay PA in the control circuit, this is short-circuited to earth via contacts OR1 operated and CL2 normal until such time as *all* staffed incoming positions are engaged, when earth is removed at the last CL2 contact to operate and relay PA operates. Contact PA1 operates relay PB, which at PB2 causes the OR relays of all disengaged staffed B/W positions to operate, and to open them at contact OR2 for the receipt of incoming calls.

Contact PB1 prepares an operating path for relay PC, which is short-circuited, however, via the OR1 contacts of B/W positions until all are engaged. The operation of relay PC disconnects at PC2 the drive circuit for the PM uniselector (for all available positions are now engaged and further incoming calls are stored) and extends earth to the queue limit circuit (Fig. 8). The release of an incoming or bothway position at this stage causes relays PA and/or

PC to release and the longest waiting call is discharged from the queue (as already described) to the position concerned, when relay PC again operates.

The bothway positions are included in the cyclic distribution of calls by the operation of the " B/W Manual Control " key which, when operated, operates relay PB to operate the OR relays of the free staffed bothway positions. Individual outgoing positions may also be included in the cyclic distribution of calls at this stage by the operation of the I/C key associated with a particular outgoing position. The keys mentioned above are all mounted on the Chief Supervisor's desk.

*Conclusions.*

A further material advance can undoubtedly be claimed in the modernisation of the Telegraph Service with the introduction of the phonogram automatic distribution equipment at Newcastle, which has functioned satisfactorily in service and meets without qualification the primary objective of eliminating the unfortunate call and of providing an improved service to the public. The employment of cordless type operating positions also enables the phonogram operators to enjoy more congenial working conditions than with the double-tier ancillary switchboard equipment which the automatic distribution equipment replaces.

*Acknowledgments.*

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