DIRECTOR MULTI-EXCHANGE AREAS

CONTENTS

Fig. 7 and the trunking diagrams LTK 205001 and LTK 341001 are appended to this pamphlet.

INTRODUCTION

This pamphlet is concerned only with the trunking and a general outline of the Director System, the circuit details of many of the facilities to be discussed are described in other pamphlets in this series. Both the local dialling and subscriber trunk dialling aspects of the facilities offered by the director scheme are also considered. A director multi-exchange area comprises a complete linked numbering scheme containing many exchanges. Reference to a local call in respect of the director scheme means that the called subscriber is situated within the boundary of the multi-exchange area and not necessarily connected to the same exchange as the caller.

SWITCHING ARRANGEMENTS

Within the area embraced by a city or a large town, the number of telephone subscribers is such that more than one exchange is necessary if there is to be an economic use of exchange equipment and line plant. An exchange having an ultimate capacity of 10,000 subscribers is considered to be the largest economic unit. It is undesirable, however, to have a number of self contained numbering and junction dialling code schemes within an area where there is a wide community of interest, because of the resultant complicated dialling and directory arrangements. For example, a subscriber requiring to call, say, multiple number 2345 on a particular exchange would dial that number only when originating the call within that exchange area; if, however, the call is originated from any other exchange the multiple number must be prefixed by a series of digits which will route the call to the particular exchange. The routing code for a particular exchange will most likely be different from one exchange to another, consequently a subscriber must consult a list of dialling codes before making any but the most familiar calls. In a town or city the exchange areas will be small and not clearly defined, therefore when a subscriber makes a familiar call from another telephone it can easily lead to a misrouting because of the use of the incorrect dialling code.

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In practice the burden placed on the subscribers in respect of the numbers they are required to dial in a 'multi-exchange' area is reduced by the use of a common or 'linked' numbering scheme. Each subscriber is allotted a number which is unique within the area, and the exchange trunking schemes are arranged so that this number is dialled from any exchange in the area. The number, although it is not advertised as such, can be considered in two parts,

(i) a number of digits sufficient to route the call to the particular exchange,

and (ii) the subscriber's multiple number.

Thus if the telephone density is such that each exchange has an ultimate capacity of more than 1000 subscribers, every subscriber in the multi-exchange area must have a number which has more than 4-digits. The number of additional digits required will depend primarily on

(a) the number of exchanges in the area, and

(b) the services and exchanges outside the area which can be dialled directly.

Consider a 5-digit numbering scheme. An outline of the trunking arrangements in a typical exchange is shown in Fig. 1.

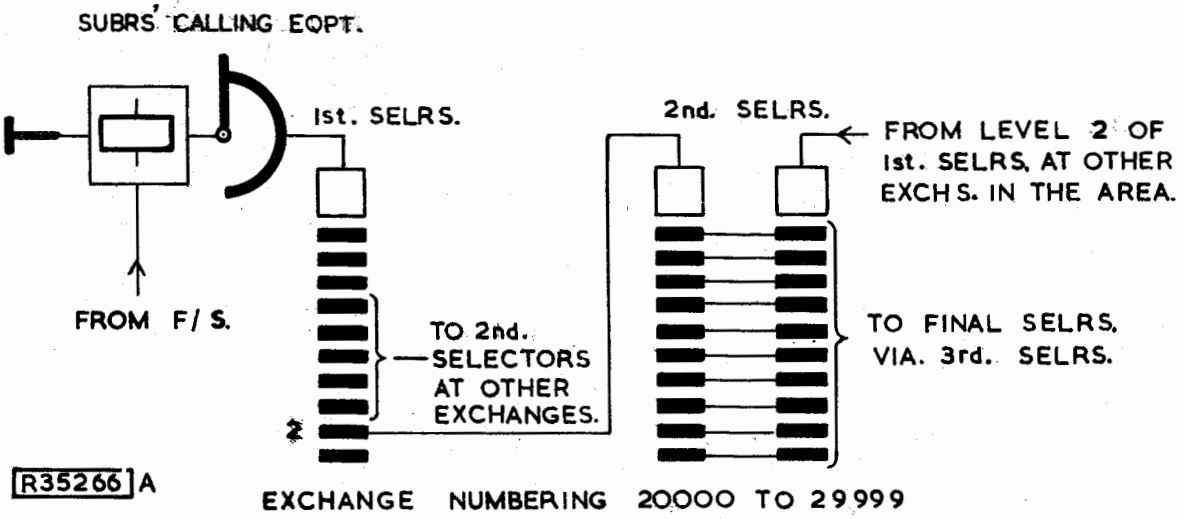

Fig. 1

It is likely that levels 1, 8, 9 and 0 of the 1st selectors will be required for access to services and exchanges outside the area, consequently only the digits 2 to 7 can be used as initial digits in the 5-digit numbering scheme. Such a restriction reduces the capacity of the system to 6 exchanges, each having a multiple of 10,000 numbers as indicated in Fig. 1. The complete number range of the scheme is 20000 to 79999.

The most straight-forward way to increase the capacity of the area is to introduce an additional rank of selectors placed between the 1st and 2nd selectors shown in Fig. 1. Each initial digit of the 5-digit scheme can now be followed by an additional routing digit in the range 1 to 0, thereby increasing the possible number of routing codes, i.e. exchanges, to 60 but also introducing an additional digit to each subscriber's number. An outline of the trunking arrangement in a typical 6-digit exchange so formed is shown in Fig. 2. The 6-digit scheme has a complete number range of 200000 to 799999, i.e. 600,000 numbers, and this will satisfy the anticipated requirements of all the multi-exchange areas in the United Kingdom with the exception of London. The requirements of London are exceptional, but they could be met by the use of a 7-digit numbering scheme in which the first three digits of each number act as routing digits, thereby providing codes for 600 exchanges.

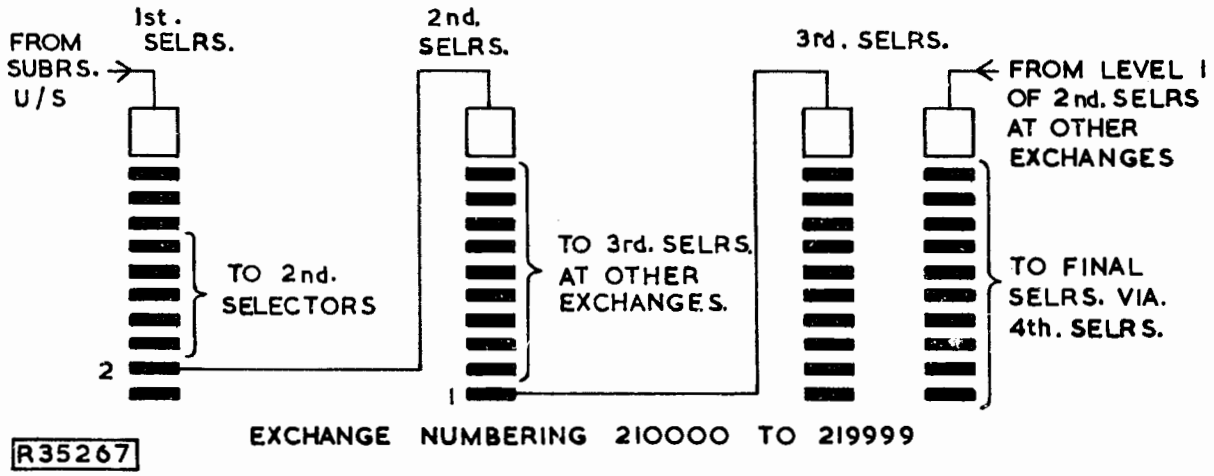

Fig. 2

Some of the advantages of the straight-forward trunking arrangements so far considered are as follows

(a) the system is easy to follow in that at each rank the selector is under the direct control of the subscribers' dial,

(b) lack of complex equipment makes for easy maintenance,

(c) the switching is completed as soon as the last digit is dialled thereby a positive indication is given without delay as to the condition of the connexion, and

(d) it follows from (c) that the holding time of unsuccessful calls will be short.

The trunking arrangement of the system, however, requires that there is a group of junctions between each and every exchange in the system, and as the number of groups is equal to $n(n-1)$, where n is the number of exchanges, a very large number of groups is required when there is a large number of exchanges. As an

example, an area similar to, say, Leeds which has 10 exchanges requires 90 groups of junctions, but an area similar to, say, Birmingham which has 40 exchanges requires no less than 1560 groups of junctions. Both areas are within the capacity of a 6-digit straight-forward system and the application of such a system to a small multi-exchange area is discussed in Education Pamphlet - Draft Series - TELEPHONES 3/7, the suitability of the system for the larger areas will now be considered.

INDIRECT ROUTING

Observations show that small groups of trunks are inefficient with respect to the traffic carried per trunk for a given grade of service. The straight-forward trunking arrangement of the type shown in Figs. 1 and 2 is, therefore, economic in the use of equipment and line plant when:-

(a) the traffic originated at each exchange is high,

(b) the major portion of the traffic originated at each exchange is to subscribers on the other exchanges in the area, and

(c) the traffic between each and every exchange is at a high level, thereby allowing the use of large groups of junctions between each and every exchange and large groups of trunks between the ranks of the selectors employed to route the calls.

It should be remembered, however, that the individual nature of the exchange equipment makes the space required considerable in all but the smallest exchanges. The necessary traffic conditions would most likely occur in an area which has a large and evenly distributed population and or business activity, but the composition of the large areas in the United Kingdom is such that, in general, the traffic conditions are,

(a) very high between each and every exchange within some central area,

(b) high between the majority of the remaining exchanges and those within the central area,

(c) high between each exchange and its neighbours, and

(d) relatively low between the widely separated exchanges which are situated outside the central area.

The pattern is, of course, liable to be upset by high levels of traffic between widely spaced exchanges which have or develop some common interest. If, therefore, the 6-digit straight-forward, or individual control, system is applied to an extensive area a large number of the long junction groups which link the outlying exchanges, and the associated exchange equipment will be inefficiently employed. Economies in line plant can be made by combining the lightly loaded groups into one group which terminates at a switching centre, or tandem exchange, where selectors then route the calls to the particular exchanges. The outline trunking of such an arrangement is shown in Fig. 3. It can be seen that there is no saving in exchange equipment and that the subscribers will be required to dial the additional digits necessary to route the call through the tandem exchange. As an example, when the junctions are routed directly the dialling code for a particular subscriber is, say, 723476, if, however, tandem working is adopted

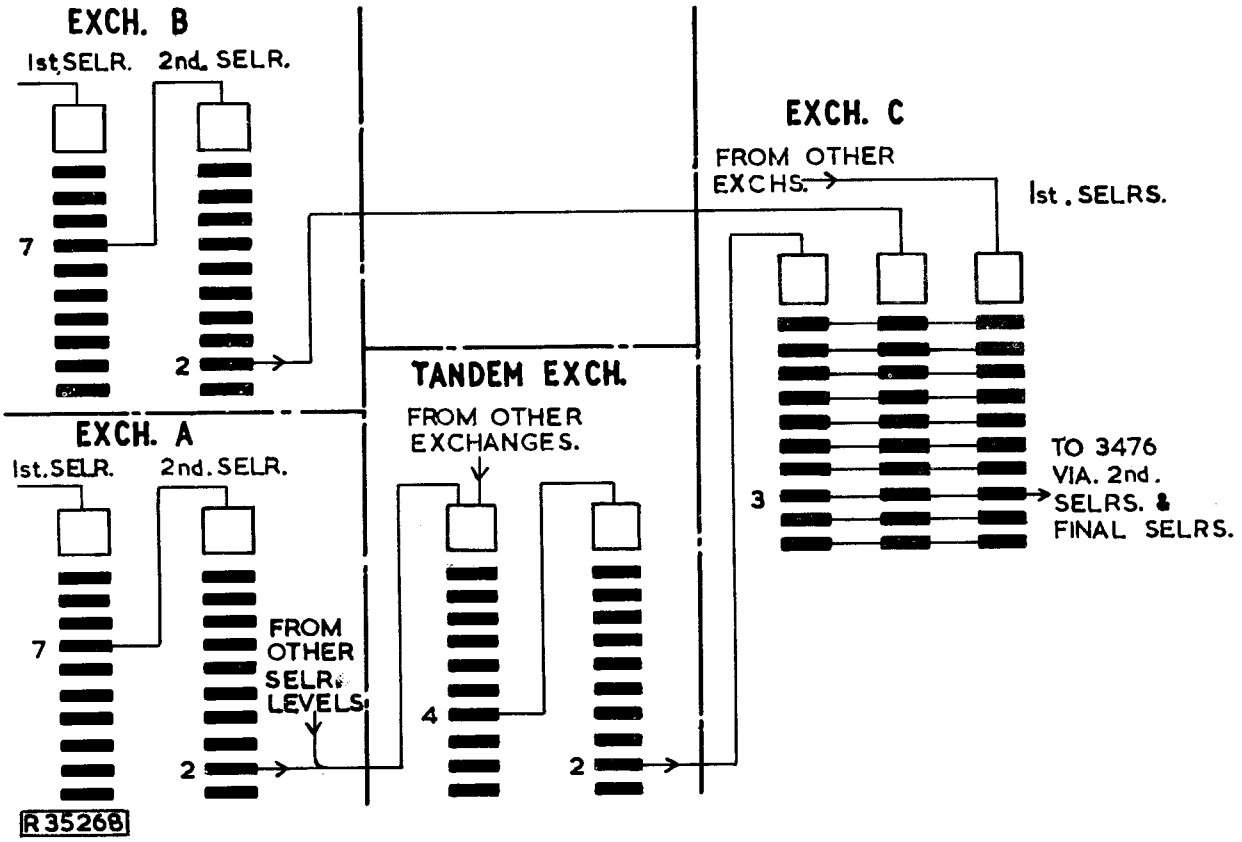

Fig. 3

additional digits, say 4 and 2, are required to route the call through the tandem exchange. Moreover, as it will be economic to provide direct junctions to the particular exchange from some exchanges, B in Fig. 3, and not from others, A in Fig. 3, the initial intention, i.e. a uniform dialling arrangement over the whole area, is defeated because the dialling code for the subscriber in the example is 723476 from exchange B and 72423476 from exchange A. A dialling code such as that from exchange A would be unacceptable in a local telephone system because of the burden it places on the subscribers. The foregoing objections to the 6-digit system are also valid when considering the use in London of a 7-digit individual control switching system.

The switching system used in the larger multi-exchange areas in the U.K., i.e. London, Edinburgh, Birmingham, Glasgow, Liverpool and Manchester, employs an electro-mechanical register-translator, termed a director, in which is vested the control of routing and switching. The translator section of the director allows for a uniform dialling arrangement over the whole area and also for dialling codes which bear no direct relation to the layout of the switching and line plant. It also affords complete flexibility in the use of direct and indirect routing and, when changes in routing are necessary, allows them to be made without involving any change of the subscriber's directory entry. The numbering and trunking arrangements of the Director System will now be considered.

DIRECTOR DIALLING CODES

GENERAL

In a director multi-exchange area each exchange has an ultimate capacity of 10,000 numbers, and each subscriber has a 7-digit number which consists of a 3-digit routing code followed by the 4-digit multiple number. The dialling codes are allocated arbitrarily in that regard is not paid to the position of the exchange in the junction network or to the grouping of the exchanges into sub-areas. The burden placed on the subscribers in dialling a 7-digit number is eased by allocating a name to each exchange and, with the aid of a suitably labelled dial, making the first three letters of the name represent the routing code.

The letters Q and Z are omitted from the dial, Fig. 4, it being unlikely that codes with such letters will be required; on the B.P.O. 700-type telephones, however, the letter Q is associated with the numeral 0 in anticipation of future trunk dialling requirements. The letter O is placed with the numeral 0 so that dialling errors, due to confusing the letter with the figure, may be avoided. When dialling a letter the pulses equivalent to the associated numeral are, of course, sent, i.e. in dialling H, four pulses are sent. The routing code dialled by a subscriber controls the director equipment which translates the code into the appropriate routing digits, consequently the names of exchanges within the same multi-exchange area must be chosen so that there is a different numerical combination for each exchange code. Two such names as HAMmersmith and HAMpstead cannot, therefore be used in the same director area, nor may the area contain both of such names as VICtoria and THAmes as, numerically, their codes are the same, i.e. 842. It is for the foregoing reasons that exchanges are not necessarily named after a district, but often after a local feature such as a park, road or river.

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Fig. 4

CAPACITY OF THE SYSTEM

The digits 1 and 0 are not used as the initial digit of an exchange routing code, thus there are eight digits, or groups of letters, which can be used as the initial digit of an exchange code. The digit 1 is also not used <u>within</u> the director area for the second and third digits of an exchange.

There are, therefore, eight different digits available for the first digit, and nine different digits available for the second and third digits, thus making a theoretical maximum number of 8 x 9 x 9 = 648 three digit codes. In practice, however, only about 300 of the letter equivalent of the digit codes are suitable for exchange names.

The multiple numbering on any particular exchange is limited to 10,000 numbers, i.e. 0000-9999, hence the theoretical maximum limit to the number of subscribers' numbers in a director area is 648 x 10,000 = 6,480,000, and the practical maximum is of the order of 300 x 10,000 = 3,000,000.

On this basis it is forecast that with the present rate of development of the existing numbering scheme will be exhausted by 1970 in the London area.

To meet the London area requirements beyond 1970, the subscribers' numbers within the scheme are to consist of a three-letter code as at present plus either four or five numerical digits, growing ultimately to a wholly 3 + 5 scheme with a capacity of approximately 30 million connexions.

Apart from the increase in numbering capacity achieved by this scheme, it has the service advantage over other possible schemes in that subscribers' dialling procedure is not changed from that used at present. Because the scheme permits an individual exchange to grow beyond the nominal 10,000 lines capacity, junction plant savings can be expected from the overall reduction in the ultimate total number of exchanges in the director area.

In introducing five-figure numbers into London, it will be necessary to modify directors and incoming register translator equipment in London exchanges and trunk units. Minor modifications will also have to be carried out to controlling-type and fringe area type register-translators in exchanges outside London. At the present stage only the necessary changes to the circuit diagrams are in hand.

DIRECTOR EQUIPMENT

GENERAL

Director equipment is provided at each automatic exchange in a director multi-exchange area. Fig. 5 shows the basic trunking between a calling subscriber's line and the director equipment but omits the means by which the association is made. On the origination of a call, the subscriber's line is extended via its uniselector to a special type of group selector known as a 1st code selector. The associated director equipment returns dial tone to the calling subscriber. The wipers of the 1st code selector do not respond to the pulse trains from the subscriber's dial, but the selector repeats the pulses to the director equipment. Immediately the third digit of the number, i.e. the last routing code digit, has been received, a predetermined train of up to six routing digits, known as the translation, is sent from the director equipment. During the time that the routing digits are being sent, the numerical digits, i.e. the actual multiple number, are received by the director equipment and then pulsed-out on the completion of the sending of the translation. The director is, therefore, able to simultaneously receive and send trains of pulses.

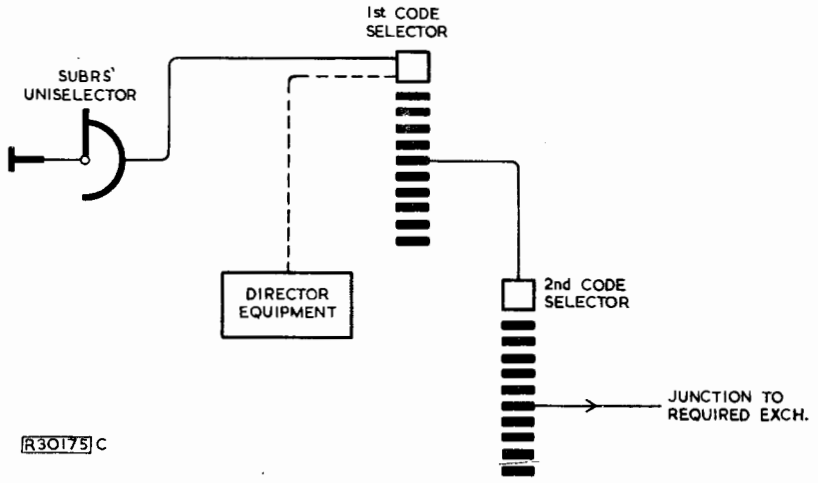


Fig. 5

The routing of a call to the objective exchange is carried out over the levels of 'code selectors' within the originating exchange and, if the call is indirectly routed over the levels of 'tandem selectors' in a tandem exchange. These selectors are, of course, actuated by the digits in the translation. The routing is effected by not more than three stages of code selectors in the originating exchange and three stages of tandem selectors.

It is expensive both from the provision and maintenance points of view to carry a large volume of traffic through a number of switching stages. Advantage is taken, therefore, of the translation facility to save equipment by trunking the busiest routes, i.e. those to the tandem exchange and certain of the closely connected exchanges, direct from the levels of the 1st code selectors. Thus the translation for a call to a closely connected exchange will consist of one digit, and that to exchanges via the tandem will be one digit plus the digits required in the tandem. The remaining levels of the 1st code selector will be trunked to 2nd code selectors to provide sufficient levels to accommodate the remaining groups of junctions and services. In the busier exchanges where it is economic to have a large number of direct junction routes, ranks of 3rd code selectors may also be necessary to provide sufficient levels for the outgoing routes.

At the objective exchange the routing of the call to the called subscriber is completed over three stages of selectors, i.e. two group selectors, known as 'numerical selectors', and a final selector. The selectors are actuated by the numerical digits which are sent from the director equipment following the last translation digit.

The director equipment is required only during the routing of a call, therefore the equipment is caused to release after the last numerical digit has been sent, thereby becoming available for the routing of other calls.

Local calls

The director is used for local calls and is arranged to provide a single digit translation, usually 1, on receipt of the local exchange code. The local numerical selectors are, of course, trunked directly from the appropriate level of the 1st code selector.

Periodic metering for local calls is provided by means of auxiliary equipment called the "local-call timer" (L-CT). This equipment is mounted in the 1st code selectors of new design. For the older type of selectors local-call timers are mounted separately and cabled directly to the 1st code selectors.

Coin-box calls

The basic trunking arrangement for coin-box lines includes "coin and fee checking" (C.F.C.) equipment situated between the outlets of subscriber's uniselectors and the 1st code selectors. For this reason it is more convenient to restrict coin-box lines to particular groups of subscriber's uniselectors. The actual position of the coin and fee checking equipment is not shown in the trunking diagrams in Figs. 5 and 6 but it should be remembered that coin and fee checking equipment is included in the connexion between the outlets from C.C.B. groups of uniselectors and 1st code selectors.

The general facilities of both local-call timers and coin and fee checking equipment are discussed later in this pamphlet.

ARRANGEMENT OF EQUIPMENT

The complete arrangement of the director equipment, code selectors and numerical selectors in a director automatic exchange is shown in Fig. 6. It is uneconomic to provide as a single piece of equipment an electromechanical register-translator which will provide a translation for each and every one of the 648 possible dialling codes. The director equipment is, therefore, arranged as shown in Fig. 6, so that each register-translator, termed a director, is required to handle not more than 81 different codes and their translations. The director is preceded by a two-motion selector, termed an A-digit selector because it is actuated by the first, or A-digit, dialled by the calling subscriber, and the directors are trunked from the levels of this selector as indicated in Fig. 6.

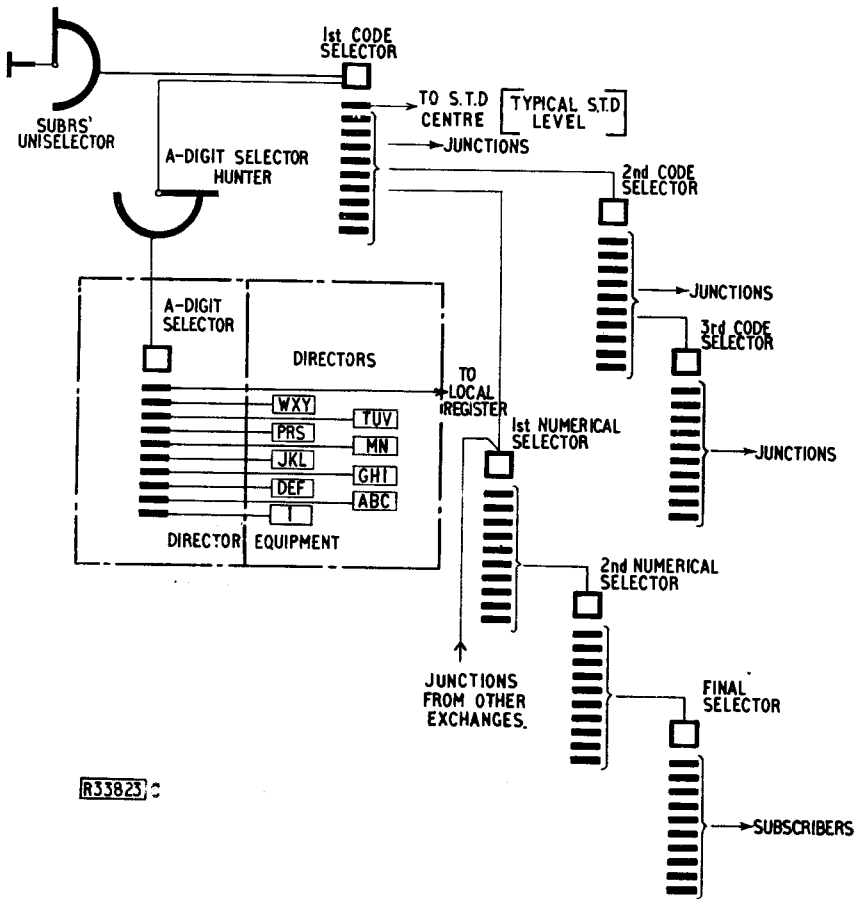


Fig. 6

The directors connected to a particular level, therefore, need to be arranged to handle only the last two letters of codes commencing with one of a particular group of letters. As an example, the directors connected to level 7 of the A-digit selector are required to handle only the last two letters of codes commencing with P, R or S.

In the smaller director areas the number of exchanges is such that it is not always necessary to have a separate group of directors for each set of initial letters as shown in Fig. 6. If the dialling codes are allocated so that no two combinations of the second and third letters, termed the B and C digits respectively, of, say, groups MN and WXY are the same, the levels 6 and 9 of the A-digit selector

can be trunked to the same group of directors. Such an arrangement combines the traffic of two separate levels and therefore improves the efficiency of working with a consequent saving in the number of directors required to handle the total traffic.

The use of digit "0" as an initial digit indicates that an S.T.D. call is required by the caller. Hence, outlets of level 0 of the A-digit selector are connected to local registers in preparation for the connexion of the caller to the trunk network.

OUTLINE OF OPERATION OF LOCAL CALL CONNEXIONS

The 1st code selector circuit includes a transmission bridge, manual hold facilities and the metering control arrangements, also associated with each 1st code selector is a uniselector, known as an 'A-digit selector hunter', by means of which access is obtained from the 1st code selector to the director equipment. When a subscriber originates a call a 1st code selector is seized and the associated A-digit selector hunter searches for, and seizes, a disengaged A-digit selector. Dial tone is returned to the subscriber from this selector.

The loop-disconnect pulses from the subscriber's dial are repeated by the 1st code over a single wire to the A-digit selector and to the director as earth-disconnect pulses, i.e. $33\frac{1}{3}$ mS earth, $66\frac{2}{3}$ mS disconnexion. The passing of the digits from the 1st code to the director equipment is termed 'pulsing in'. The dialling of the 'A' digit causes the wipers of the A-digit selector to be stepped to the level serving the group of directors dealing with calls to exchanges having codes which commence with the particular digit dialled. The wipers of the A-digit selector then hunt for a disengaged director in the particular group. The B and C digits are received in the selected director and operate the vertical and rotary magnets respectively of a two-motion selector, termed the 'BC-switch', which is arranged to have six wipers each associated with a 100-outlet contact bank. The bank contacts are wired out to a 'translation field' which provides the means whereby any selected set of bank contacts will provide a train of up to 6 routing digits, i.e. the translation.

As an example, suppose the last two letters of the exchange are AM and the junctions are routed direct from level 3 of the 2nd codes which are trunked from level 6 of the 1st codes. The B and C digits will position the BC-switch wipers to level 2 contact 6, and the six bank contacts appropriate to this position will be so wired that the required routing code, 63, is sent from the director.

Immediately the C-digit has been pulsed into the director, the translation is sent, usually termed 'pulsed out', as trains of loop-disconnect pulses which have a minimum inter-digital pause of 800 mS. The first digit of the translation positions the wipers of the 1st code to the appropriate level, and the subsequent digits position the other code and or tandem selectors required to route the call. All the foregoing selectors have the normal group selector type rotary testing circuits, the 1st code selector, however, is provided with a forward holding feature on the P-wire to hold, when required, the 2nd and 3rd code selectors.

The four numerical digits dialled by the subscriber are stored, or registered, on four uniselectors, known as the M, C, D and U switches. There is no translation associated with the numerical digits, they are merely stored and then sent from the director after the last digit of the translation. The director circuit however includes a feature which requires the pulsing-in of the hundreds digit to have commenced before the sending of the thousands digits, and so on. Such an arrangement prevents the pulsing-out circuit catching up with the pulsing-in circuit with the consequent possibility of mis-operation.

An explanatory diagram of the director is shown in Fig. 7 (appended). The U switch performs two functions, one of which is to extend the dialled digits to the appropriate operating magnet and the other is to store the units digit train of pulses. The dual functions of the digit distributor switch enable economy in components to be made. The BC-switch magnets are connected to the first and second contacts of the digit distributor, and when the wipers of this switch step to the third outlet the 'start sending' signal is established.

The control switch extends in turn a 'stop sending' signal (operation of relay SL) over the appropriate BC-switch wiper and translation field, or register wiper and bank contact, to the appropriate bank contact on the send switch which counts the pulses sent out for each digit. After the last digit has been sent the control switch extends a signal which initiates the release of the director equipment.

If an unallotted code is dialled the appropriate BC-switch bank position is not connected on the translation field and the stop sending condition is consequently not extended to the bank of the send switch. Such a condition results in a 'forced release' which causes the director equipment to release and the number unobtainable tone to be returned from the 1st code selector, which is now positioned outside level 0, to the calling subscriber. It should be noted that if an unallotted number is dialled the director functions in the normal way and the number unobtainable tone is returned from the final selector.

The circuits of the A-digit selector and the director both include a timing arrangement which guards against delayed dialling or excessive delay during dialling. Such an arrangement is necessary for equipment which is common to all subscribers and allocated on the basis that it will be in use only for a certain period during each call. The director equipment is in use for approximately 20 seconds during each call. The circuit provides for a forced release condition back to the 1st code and consequent release of the director equipment if dialling is not completed within a period of 30 sec minimum and 60 sec maximum. Number unobtainable tone is returned to the caller for delay during dialling but not for delay before dialling. The pulsing in, pulsing out, forced release, and normal P-wire testing facilities between the 1st code and director equipment require a 5-wire connecting circuit.

The use of the director, or of any arrangement in which the dialled digits are stored before being transmitted, introduces a delay period between the end of dialling and the receipt of a supervisory tone, e.g. ring tone, by the calling subscriber. In the director system because the hundreds digit cannot be sent until the start of the receipt of the units digit, the delay is always not less than the time taken by the director to transmit the units digit plus the time taken for the equipment to extend the connexion to the calling subscriber. Moreover, the circuit arrangement of the director is such that there is a 800 mS delay at the end of sending before the release sequence commences. The minimum delay period occurs when the translation consists only of one digit, i.e. the translation is pulsed out as the thousands digit is pulsed in. The delay period will, therefore, increase as the number of digits in the translation increases. As an example, if the translation consists of four digits, each of five pulses, the time period between the end of the receipt of the C-digit and the commencement of sending of the thousands digit will be about 4 to 5 seconds. It is likely that, assuming the subscriber is dialling without undue delay, all the numerical digits will have been pulsed in during this period, thus the delay period will be equal to the time taken for the director to pulse out the numerical digits plus the release time.

Code only calls

In certain cases (e.g. calls to 100, DIR, TIM) no numerical digits are required and the subscriber dials only the code digits. The director must therefore transmit the necessary routing translation and then release without waiting for numerical

digits to be dialled. This is arranged by the method of connexion, in the translation field, of the BC-switch bank positions appropriate to these codes.

AUTO-MANUAL SWITCHBOARDS

Switchboards are provided in a director area for dealing with inquiries, special services, etc. Access to these switchboards is obtained by the dialling of special codes as already considered. The auto-manual switchboards may, if convenient, be centralized in one building as is done in some of the smaller director areas, or they may be partially centralized as in the London director area.

A separate group of 1st-code selectors is provided in the exchange where the switchboard is situated for the outgoing traffic from the auto-manual switchboard positions. These selectors are arranged to pass the necessary supervisory signals to the position cord-circuit. To save the operator utilising code selectors and director equipment when setting up a call to a subscriber on an exchange associated with the switchboard, direct access is provided between the switchboard positions and a group of 1st numerical selectors at each such exchange.

LOCAL JUNCTION ARRANGEMENTS

DIRECT JUNCTIONS

Fig. 8 shows typical routings from a director exchange A to director exchanges B and C. Junctions to exchanges B and C are connected to 2nd code selector levels at A, and 1st numerical selectors at B and C. When a call is passed from A to B, the exchange code is translated to the routing digits 86. These cause the 1st code selector wipers to step to level 8 and the 2nd code selector wipers to step to level 6, and the call is thus passed to a 1st numerical selector at B. The wipers of the 1st numerical selector at B respond to the 'thousands' digit transmitted by the director, and the call passes via a 2nd numerical and a final selector to the called subscriber's line. Calls to exchange C are routed by the translation of the exchange code to routing digits 58.

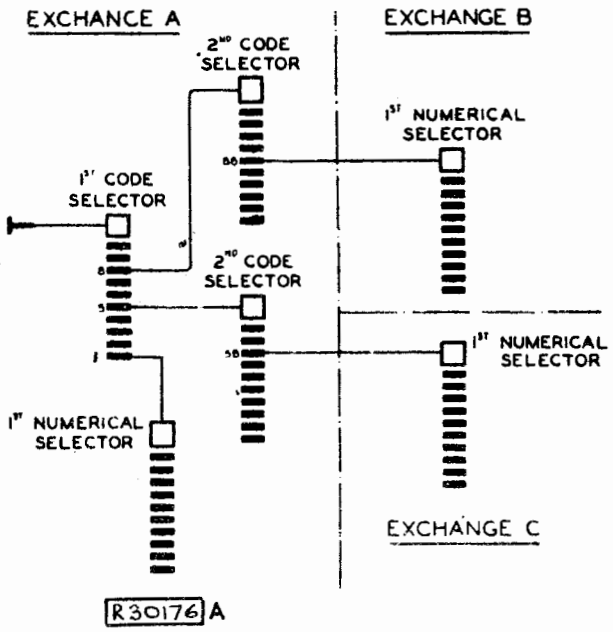


Fig. 8

Local calls between the subscribers of exchange A are routed via the first level of the 1st code selector therefore the translation for the local exchange code is the digit 1. Such a translation is very common in practice for local calls.

TANDEM JUNCTION WORKING

Direct junctions between exchanges are provided only when justified by the amount of traffic between the particular exchanges, or in the exceptional circumstances where the traffic is very light but the distance between the exchanges is very short. Where direct junctions are not provided the traffic is routed over a group of junctions, which also carry the outgoing traffic to several exchanges, to a junction switching centre. In the switching centre the traffic divides and is routed to the particular exchanges over groups of junctions which also carry the traffic from other exchanges. Such an arrangement where the traffic passes over two junction routes, or links, is known as 'tandem working' and the switching centre is known as a 'tandem exchange'. It should be understood that a tandem exchange is not directly associated with subscribers, neither is it an integral part of a normal exchange although it may be on the same floor.

The routing of the traffic from exchange A, through a tandem exchange T to exchanges D and E is shown in Fig. 9.

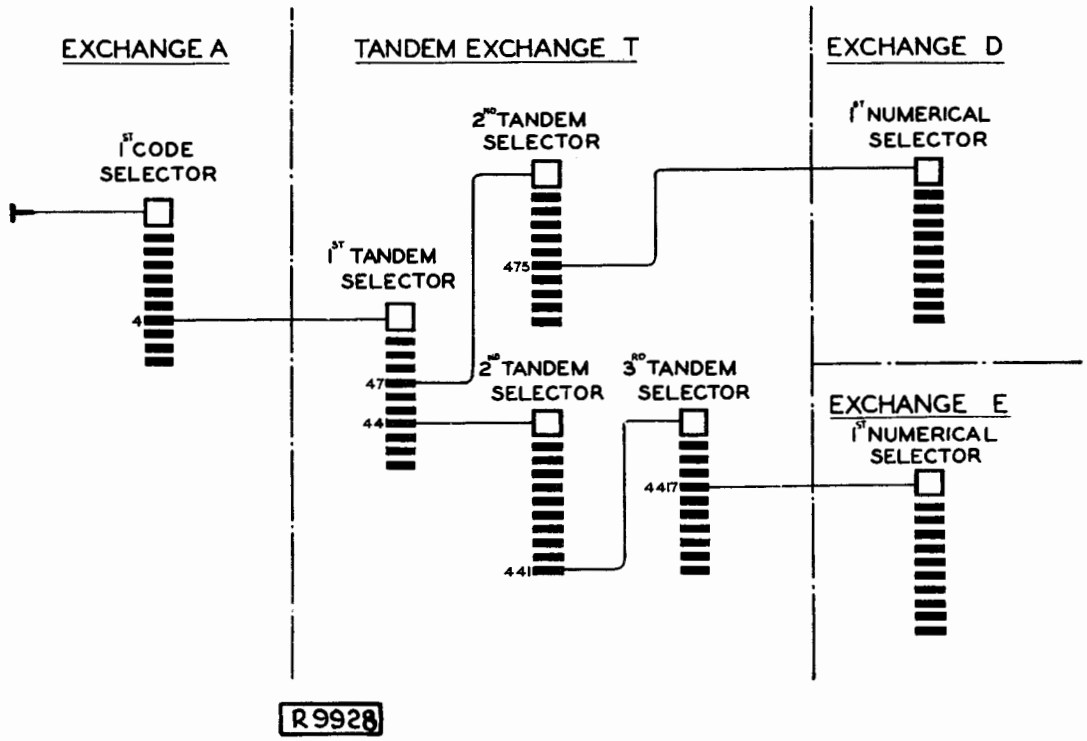


Fig. 9

Access to the tandem exchange junction group is obtained from level 4 of the 1st code selector at exchange A, therefore the translation for the codes of both exchanges D and E has the initial digit 4. At the tandem exchange, access to the junction group to exchange D is obtained from level 5 of the 2nd tandem selectors which are trunked from level 7 of the 1st selectors. Hence the complete translation for the code of exchange D must be 475. By similar reasoning the complete translation for the code of exchange E is 4417. It should be appreciated that a third rank of selectors is required only when there are a large number of exchanges in the area, two ranks of selectors are sufficient to provide access to 100 junction groups.

An outline of the trunking arrangements within a tandem exchange is shown in Fig. 10. The junction routes from the various exchanges terminate on 1st tandem

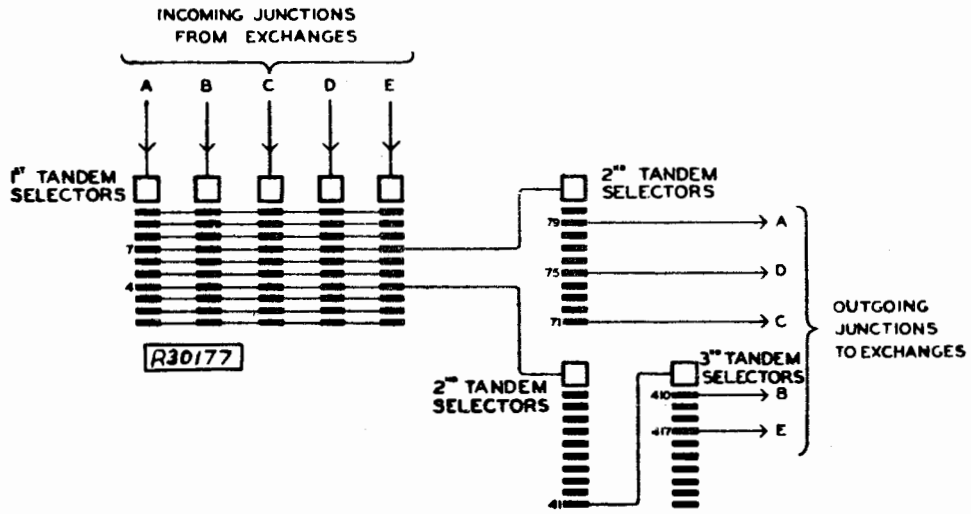


Fig. 10

selectors and the outgoing junctions are trunked from the levels of the 2nd and 3rd tandem selectors. In the older, i.e. pre-2000 type, tandem exchanges the 1st selector circuit is arranged to perform the functions of both a group selector and an auto to auto relay-set. The 2nd and 3rd selectors are normal type group selectors, and the 1st selector provides the earth on the P-wire to hold the selectors when the connexion is established. Modern practice is to use normal type group selectors throughout the connexion and to insert an auto to auto relay-set in the trunks between the 1st and 2nd selectors. The relay-set provides the earth on the P-wire to hold the selectors.

In Fig. 10 there are junction routes shown outgoing to all the exchanges from which there are incoming routes, therefore by a suitable translation one exchange can gain access to any other via the tandem selectors. As an example, at exchange B, assuming the tandem junctions are trunked from level 2 of the 1st code selectors, the translation necessary for the code for exchange E is 2417 if access to that exchange is to be obtained via the Tandem. If, however, the conditions are such that it is economic to route the calls to exchange E over direct junctions, the translation at exchange B will be arranged accordingly. Thus, although it is possible for any one exchange to connect with any other exchange via the tandem selectors, it does not follow that this will always be done.

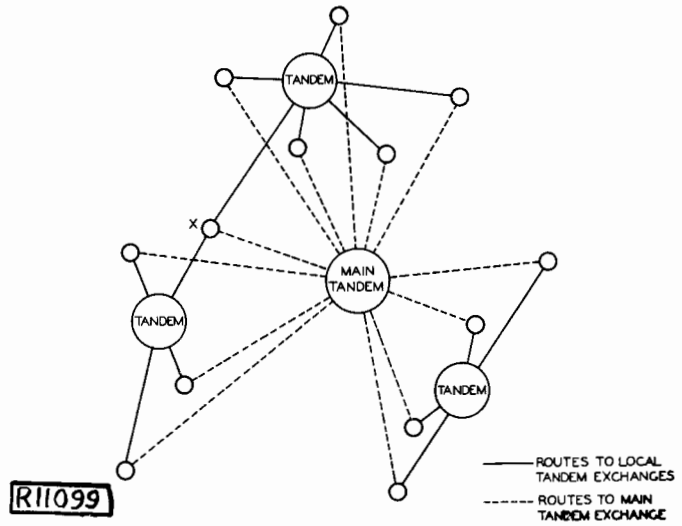


Fig. 11

The scheme shown in Fig. 11 has been developed by the addition of several small tandem exchanges, so located that they relieve the main tandem exchange of much of the semi-local traffic passing between the exchanges which they serve. This arrangement permits the main tandem exchange to deal primarily with calls passing across the main area and effects a further saving in junction cabling.

In the London area the traffic from exchanges situated in the inner part of the area is such to warrant these exchanges having routes to more than one of the local tandem exchanges. The provincial director areas originally had only one tandem exchange, but in recent years local tandems have been introduced. Further to this, as a means of relieving the central tandem some routings involve two tandem links. The auto to auto relay-sets at the second tandem are equipped with pulse regenerators or special pulse repetition circuits. It is not likely that two tandem links will be used on routes within the London area.

ECONOMIC CONSIDERATIONS

Consideration will now be given to the line plant and equipment in an originating exchange which is saved by tandem working. The trunks required for given volumes of traffic which are quoted in this section are taken from 'smooth traffic' tables appropriate to selectors having a maximum availability of 20.

Consider an exchange from which 20 of the direct junction routes would be offered not more than 2 erlangs each during the average busy hour. If individual routes were provided 20 levels from 2nd code or 3rd code selectors would be required, and the trunking arrangements could be

(a) two 1st code levels trunked to 2nd codes, the junctions then being connected to the twenty 2nd code levels so formed, or

(b) one 1st code level trunked to a 2nd code, and two levels of the 2nd code trunked to 3rd codes, the junctions then being connected to the twenty 3rd code levels so formed.

If trunking arrangement (a) was used and the traffic was equally divided between the two 1st code levels, 34 trunks would be required from each level to the 2nd code selectors to carry the 20 erlangs at a grade of service of .002. The total traffic would, therefore require 68 trunks and consequently 68 2nd code selectors. With arrangement (b) the number of trunks from the level of the 1st code selectors would depend on the traffic carried by all the levels of the 2nd code selectors. 34 trunks, however, would be required to the 3rd code selectors from each of the two 2nd code levels. The combined traffic would, therefore, require 68 3rd code selectors.

Each junction group would require 8 circuits to carry 2 erlangs at a grade of service of .002, the 20 groups will, therefore, require a total of 160 circuits.

Consider now the effect of routing the traffic to the 20 exchanges via a tandem exchange. The total traffic offered to the tandem exchange junctions will be 20 x 2 erlangs, i.e. 40 erlangs, and 61 circuits will be required to carry this traffic at a grade of service of .002. Access to the junction group will be from a single level of the 1st code selectors and the 61 circuits will be graded to this level. Thus, there appears to be a saving of 99 junction circuits, a number of 2nd and or 3rd code selectors and the 99 1st numerical selectors on which the junctions would have terminated.

When assessing any savings effected by tandem working, however, the equipment required in the tandem exchange and the junction groups to the objective exchanges must be considered. Each exchange in the area has a junction group to and from the tandem exchange, but the number of exchanges to which any exchange is connected via the tandem will depend on local conditions. It may be assumed, however, that each junction route to and from the tandem exchange is carrying traffic which would otherwise be divided over a number of direct routes. There will be, therefore, a very large saving of junction circuits, code selectors, and 1st numerical selectors when the area is considered as a whole, and this saving more than outweighs the cost of the tandem exchange.

The number of auto to auto relay-sets required and the amount of work involved in junction rearrangements in the tandem exchange is kept to a minimum by inserting the relay-sets in the trunks between the 1st and 2nd tandem selectors. Consider the conditions whereby the ten-junction routes connected to the levels of a particular group of 2nd tandem selectors each carry 6 erlangs at a grade of service of .002. Each junction route will require 15 trunks, hence if relay-sets were connected in the individual junction circuits a total of 150 auto to auto relay sets would be required. The total traffic, i.e. 60 erlangs, incoming to the group of 2nd selectors is, however, carried by a common group of trunks, and only 88 trunks are required for a grade of service of .002. There is, therefore, in this example a saving of 62 relay-sets by connecting them in the 1st to 2nd selector trunks. A diagram showing the two trunking arrangements is shown in Fig. 12, it is assumed that the 2nd selectors are trunked from level 4 of the 1st selectors, and for the sake of clarity only one junction group is shown.

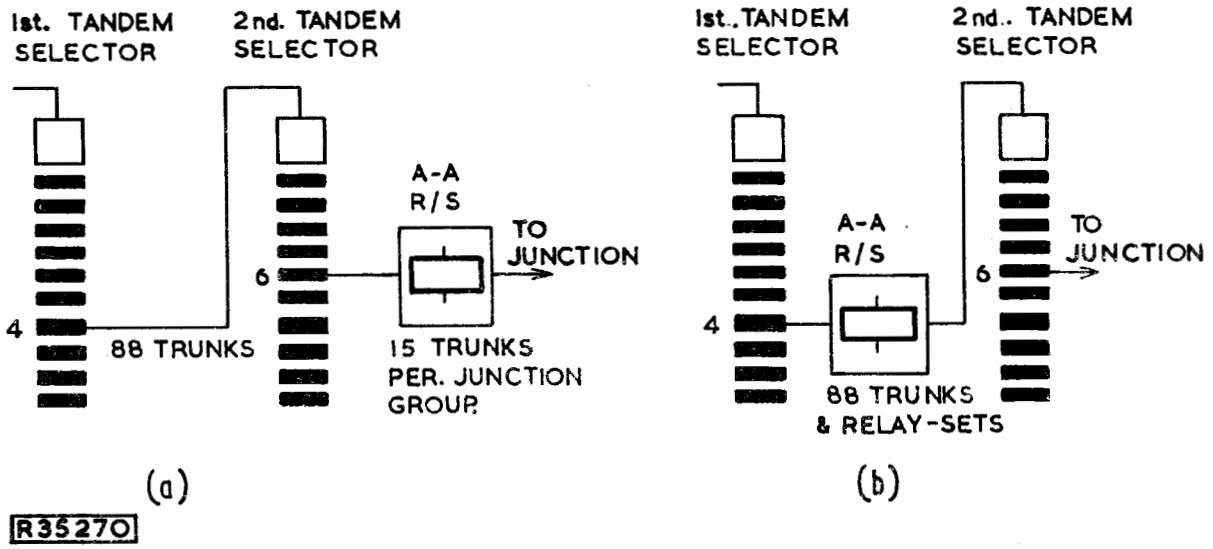


Fig. 12

SUBSCRIBER TRUNK DIALLING

The initial digit of national telephone numbers commences with a digit-0. When an S.T.D. call is originated by a caller the A-digit wipers are stepped to level-0 after the initial digit has been dialled. The remaining digits to be dialled by the caller are received and temporarily stored in the local register. The two typical trunking arrangements expected in practice are illustrated in Fig. 13 and 14. The setting-up and control of routing and charging of S.T.D. calls are under the control of register-translators situated at trunk switching centres. It is not essential for register-translators to be situated at each director exchange. In fact, the maximum efficient use is made of register-translator equipment by concentrating them at a central point. This means that most director exchanges in a multi-exchange area obtain access to S.T.D. equipment via junctions. The instance will arise where a director exchange is situated in the same building as the trunk switching centre. Fig. 13 illustrates the case where a director exchange is remote from the trunk switching centre and Fig. 14 shows the director equipment and the trunk switching equipment to be situated in the same building. One level of the 1st code selector is allocated for access to junctions via auto-auto relay-sets to a register access relay-set. Where junctions are not used auto-auto relay-sets are not required.

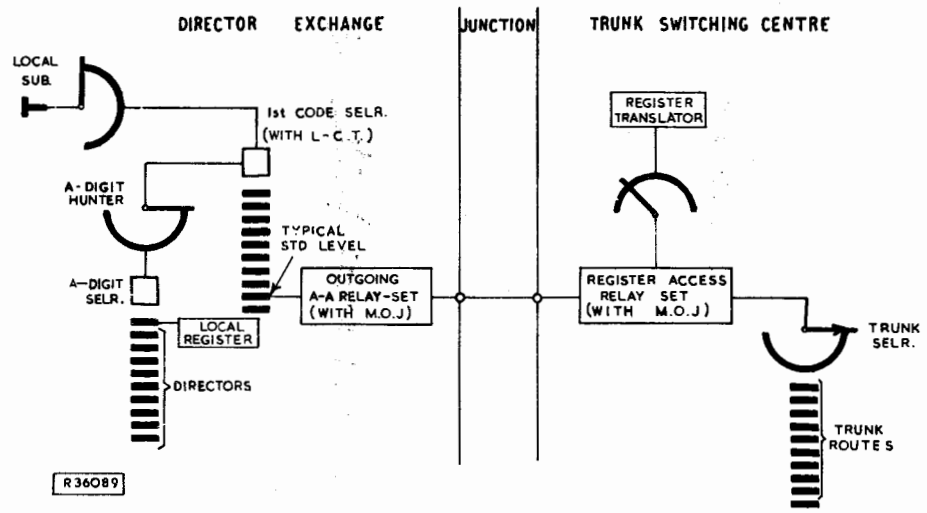


Fig. 13

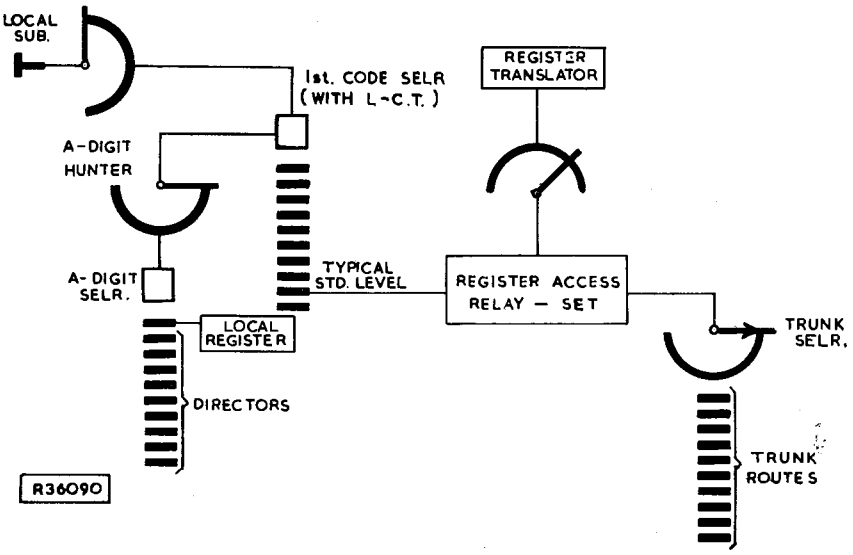


Fig. 14

The functions of the local register in the director exchange are to,

(1) transmit a predetermined digit to position the 1st code selector wipers on the level allocated for access to S.T.D. equipment. This facility is delayed until the caller commences to dial the following digit.

(2) provide a temporary store for the subsequent digits dialled by the caller.

(3) repeat all the digits it has received to the register-translator which is seized via a register access relay-set when the junction to the trunk switching centre is seized.

The local register is arranged to provide a 1200 m second pause between the end of sending the routing digit to the 1st code selector and the commencement of sending the stored digits. This allows sufficient time to elapse for the rotary stepping of the 1st code selector and for the seizure of a register-translator at the trunk switching centre to be completed. The long pause of 1200 m second is thus shown to be essential due to the relatively long time required to prepare the equipment. The inter-digital pause between subsequent digits sent by the local register is only some 300 m second. The inter-digital pause is reduced to less than the normal period to take advantage of the fact that there is no selector search between digits, and this speeds up retransmission of information. The reduced inter-digital pause also allows the local register send-control element to follow closely behind the receive element. However to ensure that the send-control does not over take the receive element it is arranged that the inter-digital is extended where necessary to prevent retransmission commencing whilst a digit is being received.

The maximum number of digits to be dialled to complete an S.T.D. call is 9, the minimum being 7. On international subscriber trunk dialling, I.S.D., (prefix code 010) the maximum number of digits to be dialled is 15. Thus, for any call which the local register is expected to handle the variation in the number of digits received can vary between 7 and 15. Discrimination becomes necessary so that the local register can distinguish between the types of call being handled at any particular time. This is necessary because the digit receiving switch may perform more than one complete revolution.

The local register is restored to normal by a forced release condition under a time pulse control. In practice, on S.T.D. calls a forced release period of 16 to 32 seconds is provided up to the receipt of the 7th digit and a period of 4 to 5 seconds between receipt of subsequent digits. The local register and in turn the A-digit selector and hunter are, therefore, released some 4 to 5 seconds after the last digit of the national number is received. It is found that the time period 16 - 32 seconds allows sufficient time for subscribers dialling unfamiliar codes and an unaccustomed number of digits but is shorter than the equivalent period for the controlling register-translator so that, in general, forced release is applied by the local register. The time period 4 to 5 seconds in turn allows adequate time for retransmission of digits from the local register to be complete.

METERING

Subscriber call charges are registered on an electromagnetically operated counting mechanism of the Veeder type. These meters are used to indicate a bulk recording for both local and S.T.D. calls against the subscriber who originates calls. The principle of meter recording depends upon the periodic operation of the callers meter at a rate which varies from a few seconds to several minutes. The rate is determined by the changeable distance over which the call is made. The method is referred to as periodic metering and it is applicable to both local and trunk calls that are dialled by the subscriber.

METERING OF TRUNK CALLS

During the period that the call is being set up it has been shown that a register-access relay-set is associated with a controlling register-translator. The register-translator determines the tariff rate and this information is transmitted to the register-access relay-set and during the remainder of the chargeable time in which the register-translator is no longer in circuit, metering is controlled by the register-access relay-set. On receipt of an answer signal the register-access relay-set sends one meter pulse which is converted to a suitable form in the 1st code selector to operate the caller's meter. This in effect registers an initial charge irrespective of the periodic metering rate applicable. The pulses which follow are arranged at a fixed interval and each in turn operates the caller's meter in a similar manner to the initial meter pulse.

When meter pulses are returned to a director exchange which is not situated in the same building as the S.T.D. equipment each pulse is conveyed to the director over a two wire junction. For this reason the register-access relay-sets and the auto-auto relay-sets which terminates each end of these types of junctions (Fig. 13) incorporate a method of translating meter pulses from the line to pulses on the incoming P-wire. The meter pulses applied to the junction consist of line-current reversals. Due to their periodic nature and their presence during conversational periods, care is taken to prevent annoyance or distraction to subscribers.

METERING OF LOCAL CALLS

The registering of charges for local calls follows a similar pattern to the method adopted for S.T.D. calls. Control of metering is centred on the "local-call timer" equipment situated in the 1st code selector. When a local-call is answered an initial meter pulse is transmitted in the normal way by, say, a final selector and this pulse is registered on the subscriber's meter to charge for the first chargeable period. The meter pulse is also detected in the local-call timer where it is used as a signal to connect a pulse supply running at 10 times the local metering rate. The supply pulses are counted on a ratchet relay in the local-call timer and a meter pulse is conveyed to the P-wire for every 11 pulses received.

CONCLUSION

The trunking diagrams of two exchanges in the London director area are appended to this pamphlet. The arrangements for Woolwich and Plumstead indicate that the subscribers have S.T.D. facilities and the Plumstead subscribers use the same A-digit selectors as the Woolwich subscribers. The Plumstead unit is equipped with its own 1st-, 2nd-numerical, etc. selectors. In the Woolwich exchange C.C.B. lines still using the old type prepayment coin boxes are connected to a separate group of 1st code selectors. The barred levels to these lines are connected directly to the manual board (100).

The Bushey Heath exchange is not converted to S.T.D. working. In this exchange the routes barred to coin-boxes are teed to code 100 trunks. At Woolwich exchange only the level giving access to S.T.D. equipment is barred to lines equipped with the old type coin-boxe. When one of these lines dials 0 as a first digit it is routed to code 100 trunks.

Access to the manual exchanges, i.e. those exchanges followed by (M) on the appended diagrams, is obtained by

(a) dialling a 3-digit code and then verbally passing the subscriber's number to the manual exchange operator; such a call is treated by the director as a code only call, or

(b) dialling a normal 7-digit number the four digit numerical portion of which is suitably converted at the originating automatic, or at the tandem exchange if so routed, to provide the number as an illuminated display at the manual exchange. Such an arrangement is known as "Coded Call Indicator" and provides connexion to a manual subscriber without the caller being aware of the intervention of an operator.

The exchanges given in full, e.g. Watford and Dartford, are outside the director area and, in the main, Level 5-digit numbering schemes. Direct dialling facilities are provided to such exchanges on the dialling of special codes followed by the 5-digit number, e.g. WAxxxxx for a Watford subscriber. When the numbering scheme for an exchange of this type has a subscriber multiple numbering scheme which may begin with one of two digits, e.g. WA2xxxx and WA3xxxx, the two possible BC switch positions are 22 and 23. It is arranged for the last digit of the translation to be the same as the initial digit of the called subscriber's multiple number and this digit steps the 1st selector at the objective exchange. The remaining 4 digits are only stored and are repeated by the director to step the 2nd-, 3rd-, and final-selectors.

When the numbering scheme at the objective exchange is not made up of 5 digits, the dialling code from the director area contains sufficient code digits to ensure that the number of digits dialled is 7. If less than 7 digits are dialled into a director, it appears to the director as though incomplete dialling has taken place. For example the dialling code for a connexion to a U.A.X. No. 14 has a dialling code made up of three digits. Similarly, the code for a U.A.X. No. 12 subscriber contains four digits.

It will be noted that the smaller exchange has no routes to a local tandem, all the indirectly routed traffic being passed over one group of junctions to the main tandem, i.e. Holborn-Museum. The tandem is so named because the equipment is housed in two buildings, consequently although it can be considered as the same tandem the traffic is divided over two junction routes. On the selector levels, however, the junctions are not necessarily grouped, i.e. outlet 1 may go to Holborn tandem and outlet 2 go to Museum tandem.

FACILITIES OF DIRECTOR SYSTEM

The director system provides the most suitable switching scheme for large areas having an uneven telephone density, where a linked numbering scheme is essential. The facilities available are as follows.

(a) Economy of junction line plant. The facility of translating the code digits into from one up to six trains of pulses for routing, enables economy to be effected in the junction provision as calls can be routed in the most economical way and tandem exchanges used where necessary.

(b) Economy in code selectors. The translation facility permits very busy routes to use only one code selector stage, whilst less busy routes can be routed via several selector stages. By this means fewer code selectors are required and their traffic efficiency is increased.

(c) Uniform numbering scheme. Each subscriber's number consists of a three letter code followed by four numerical digits and the digits dialled for a particular subscriber's number are the same irrespective of where the caller is located within the area.

(d) Flexibility of routing. The routing between any two exchanges can be readily altered by changing the translation without in any way affecting the directory numbers.

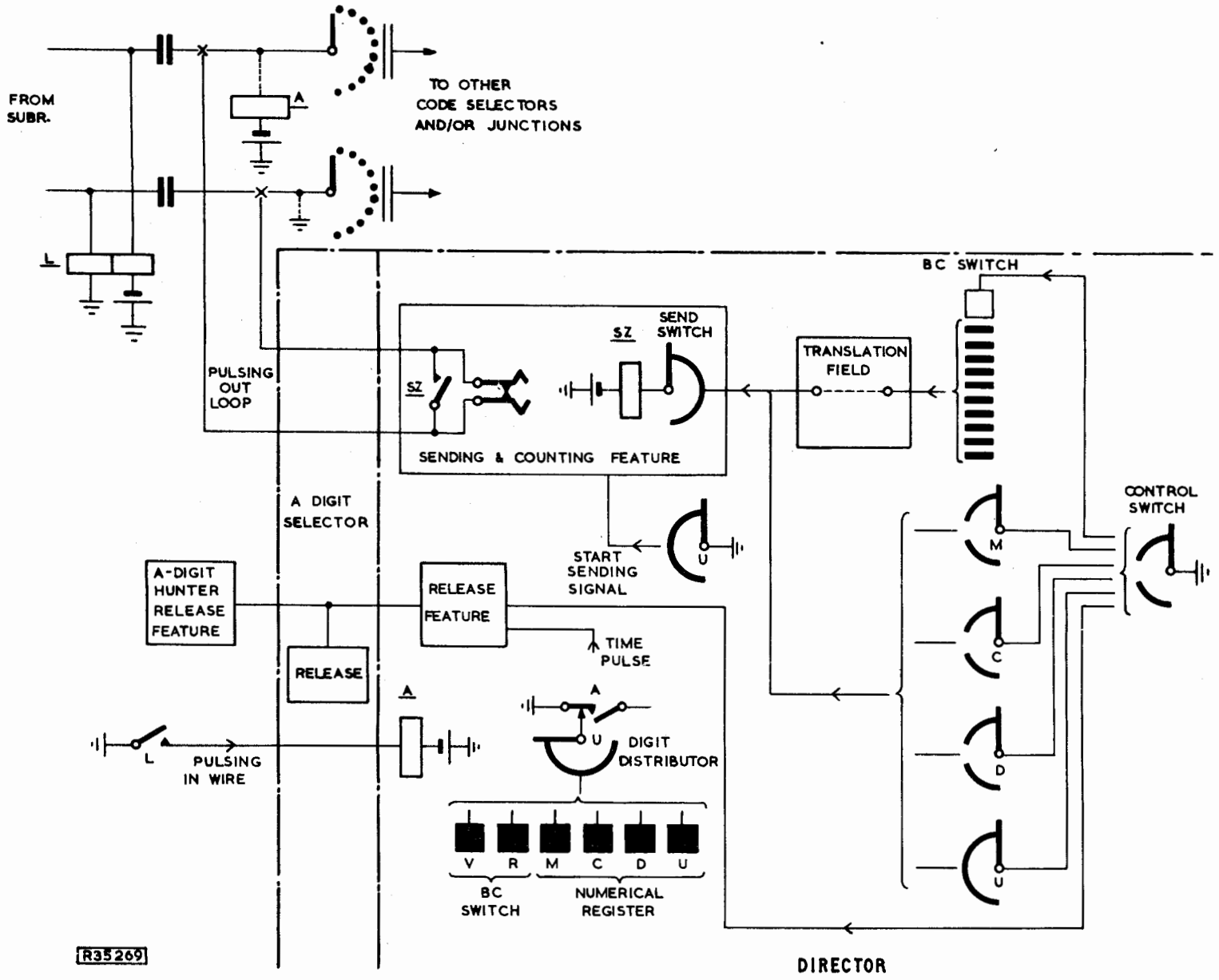
(e) Permits gradual conversion of a large area. The retention of exchange names and the use of codes consisting of the first three letters of each exchange name permit gradual conversion of an area from manual working without special directory entries.

(f) Facility of operation. As the three code digits are arranged as the initial letters of an exchange name, the seven digits are more easily remembered than seven figures.

(g) Better pulse characteristics. The pulses sent out by the director are generated by closely controlled machine-driven springsets which are maintained to closer limits than subscribers' dials.

END

REFERENCES: E.P. - Draft Series TELEPHONES 3/7


FROM SUBR.
A
TO OTHER CODE SELECTORS AND/OR JUNCTIONS
L
BC SWITCH
SZ
SEND SWITCH
TRANSLATION FIELD
PULSING OUT LOOP
SZ
SENDING & COUNTING FEATURE
A DIGIT SELECTOR
CONTROL SWITCH
M
START SENDING SIGNAL
U
A-DIGIT HUNTER RELEASE FEATURE
RELEASE FEATURE
TIME PULSE
RELEASE
C
A
A
U
DIGIT DISTRIBUTOR
L
PULSING IN WIRE
D
V R M C D U
BC SWITCH
NUMERICAL REGISTER
U
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DIRECTOR

Fig. 7