AN OUTLINE OF THE PUBLIC TELEPHONE SYSTEM

CONTENTS

INTRODUCTION

The public telephone system consists essentially of a large number of single telephones unevenly distributed throughout the country, each being connected to a switching centre, termed a telephone exchange, in the particular locality. Each exchange has lines to some other exchanges and also to a suitably positioned trunk centre which, in turn has lines to all the other trunk centres in the system. Thus a telephone connected to one exchange can be connected at will to any other telephone in the country; facilities also exist for establishing a connexion to a telephone in the system of another country.

The public system in the United Kingdom, with the exception of Hull, has been operated exclusively by the Post Office since January 1st, 1912. The history of the system up to the time it came under the control of the Post Office will now be briefly considered. The first telephone service to the public in the U.K. was provided in 1879 by the Telephone Company Ltd., who installed exclusive private circuits from one point to another. The telephones used were fitted with the Graham Bell type receiver and transmitter which had been invented in 1876. The advantages of the telephone exchange had already been exploited in the U.S.A. when, in August 1879, the Company opened the first telephone exchange in the U.K. at premises in Coleman Street in the City of London. The exchange originally gave service to seven or eight renters of telephones and lines, but by the end of the year two other exchanges had been opened and the number of 'subscribers' had increased to some 200. The performance of the Bell telephone was greatly improved when late in 1879 it was fitted with a carbon type transmitter patented earlier by Francis Blake. Late in 1879, the Edison Telephone Co. also began operations and opened a small exchange in the City of London. The telephone used had the original carbon type transmitter invented by Edison and a cumbersome and inefficient receiver.

At the time the first telephone was demonstrated in the U.K. the Post Office was operating an extensive public telegraph system, and it was not until 1880 that they offered telephone facilities to subscribers on a few of the larger provincial telegraph exchanges. The telephone used was a modified Bell instrument known as the Gower-Bell telephone. The Telegraph Acts of the 1860's had given the Post Master General the monopoly of the public telegraph system. In 1880, on the grounds that a telephone message came within the scope of the Telegraph Acts, the Crown challenged the right of a private company to operate a telephone service. The result of the action gave the Post Master General the monopoly of the telephone system but the private companies were allowed to operate under licence. The terms of the licence required the payment of an annual royalty and confined the companies to areas of two to five miles in radius. The construction of lines between towns was not allowed.

Various companies obtained licences and by 1884 there were some 12,800 subscribers in the U.K. of which 3,800 were in London. In some towns different companies operated exchanges and the lack of inter-exchange connecting facilities restricted the flexibility of the system, it was, therefore, not uncommon for a person to be a subscriber on each exchange in the town. In 1884 the terms of the licence were changed to allow a private company to operate over any area in the U.K. and to construct lines between towns. At this period there was an extensive trunk network for the P.O. telegraph system which employed overhead wiring in the country and underground wiring in the towns. The difficulties experienced by the private companies, however, to obtain 'wayleaves', that is rights of way, for underground circuits and the types of cable available led to the development of an almost wholly overhead telephone external wiring system.

On the 1st May, 1889, the majority of the private companies amalgamated and took the name of one of the larger companies, the National Telephone Company (N.T.C.). The expansion of the trunk network by the N.T.C. was restricted by wayleave difficulties and because of this, the Post Office took over the trunk system in 1892. A programme of trunk circuit expansion was formulated and by the end of the century an extensive overhead trunk system was in operation. Overhead wiring was necessary because of the very heavy gauge conductors required to keep the received speech on long circuits at an audible level.

A Select Committee of the House of Commons was set up in 1898 as the result of requests from municipal bodies and others for licences to compete with the N.T.C. The terms of reference were basically "to inquire and report whether the telephone service is, or is calculated to become, of such general benefit as to justify its being undertaken by municipal and other local authorities". The outcome of the Committee's report was that the Post Office started to provide telephone facilities in competition with the N.T.C., and several local authorities obtained licences to provide a local service.

Although the Post Office and N.T.C. were in competition, both had exclusive areas of development in London, and for the convenience of all subscribers there was a system of intercommunication between the exchanges of both undertakings. In the Provinces the Post Office mainly developed systems in the less densely populated areas whilst the N.T.C. developed the systems they had already established in the larger towns.

The licences issued to the private companies expired on the 31st December, 1911 and on that date the telephone system in the U.K., except for the municipal undertakings at Hull and Portsmouth came under the unified control of the Post Office. By far the largest system was owned by the N.T.C. and it consisted of some 1,500 telephone exchanges, half a million telephone installations, and one and a half million miles of external wiring, some 60 per cent of which was in cable form. The municipal system in Portsmouth was taken over in 1913, but the system at Hull is still operated by the local authorities.

THE SUBSCRIBER'S EQUIPMENT

The majority of telephone subscribers rent a single telephone and line which is identified by the name of the telephone exchange to which it is connected and a number. The equipment provided at the subscriber's premises consists basically of a telephone, bell and when necessary a unit containing lightning protectors. Direct current, supplied from a battery at the exchange, is used for signalling between the subscriber and the exchange but alternating current at a frequency of 17 c/s or 25 c/s is extended from the exchange to operate the subscriber's bell. The signals necessary to call the exchange and to clear the line are automatically established when the telephone receiver is lifted from, and replaced on, the instrument. Such signalling arrangements have been in use since the early days of the telephone system, although one system of working, known as magneto, which was in extensive use required the subscriber to operate a hand generator to both call the exchange and clear the line. The hand generator, when operated, generated a low frequency a.c. which actuated signalling devices in the exchange. The magneto system is now obsolete for public exchanges in the U.K. but is still extensively used on point to point circuits.

The transmitter and receiver employed in the modern telephone are in principle similar to those employed in the early telephones, that is a carbon granule microphone and a Bell type receiver. The latest type of telephone, however, uses a receiver which has a cone shaped diaphragm and a system of movement which makes it far more sensitive than the improved Bell types. As early as 1900 one manufacturer produced a telephone in which the transmitter and receiver were mounted at opposite ends of a bar, so forming the 'hand microphone' which is a feature of the modern telephone. The transmitter used however, would work efficiently only when held in a particular position, consequently the telephones which were developed for general use had the transmitter fixed to the body of the instrument. The standard table model for many years was in the form of a pedestal, or candlestick, with the transmitter pivoted at the upper end. The receiver normally rested on a lever which controlled a set of contacts mounted within the pedestal, and the bell was mounted with the induction coil in a separate cabinet.

In 1930 a change in transmitter design allowed again the use of the hand microphone, or handset, which is both convenient for the subscriber and controls the speaking distance from the transmitter. The first handset type telephone was so made that it could be fixed to the case of the bell and so form a 'combined set', later designs have the bell-set incorporated in the same case as the telephone. The telephone in general use is shown in Fig. 1 and with the cover removed in Fig. 2, the telephone dial is attached to the cover. The latest type of telephone with and without the cover is shown in Figs. 3 and 4 respectively.

R31449

Fig. 1

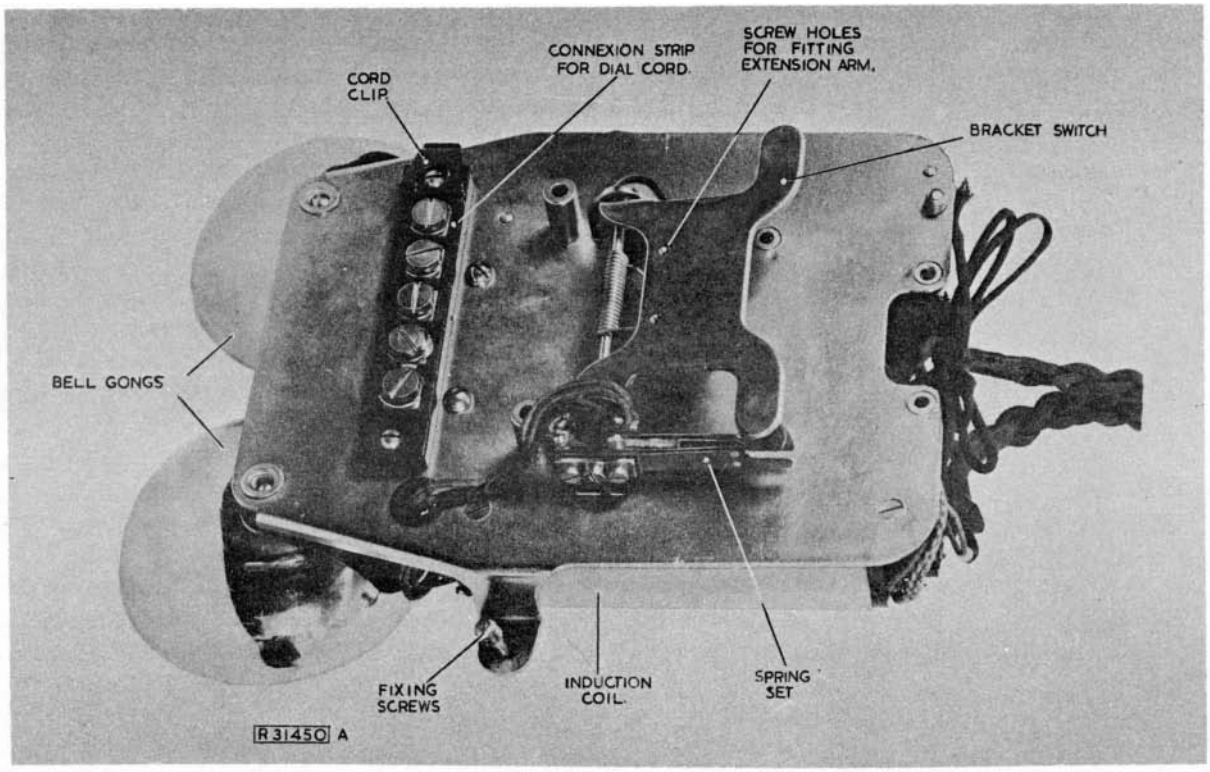
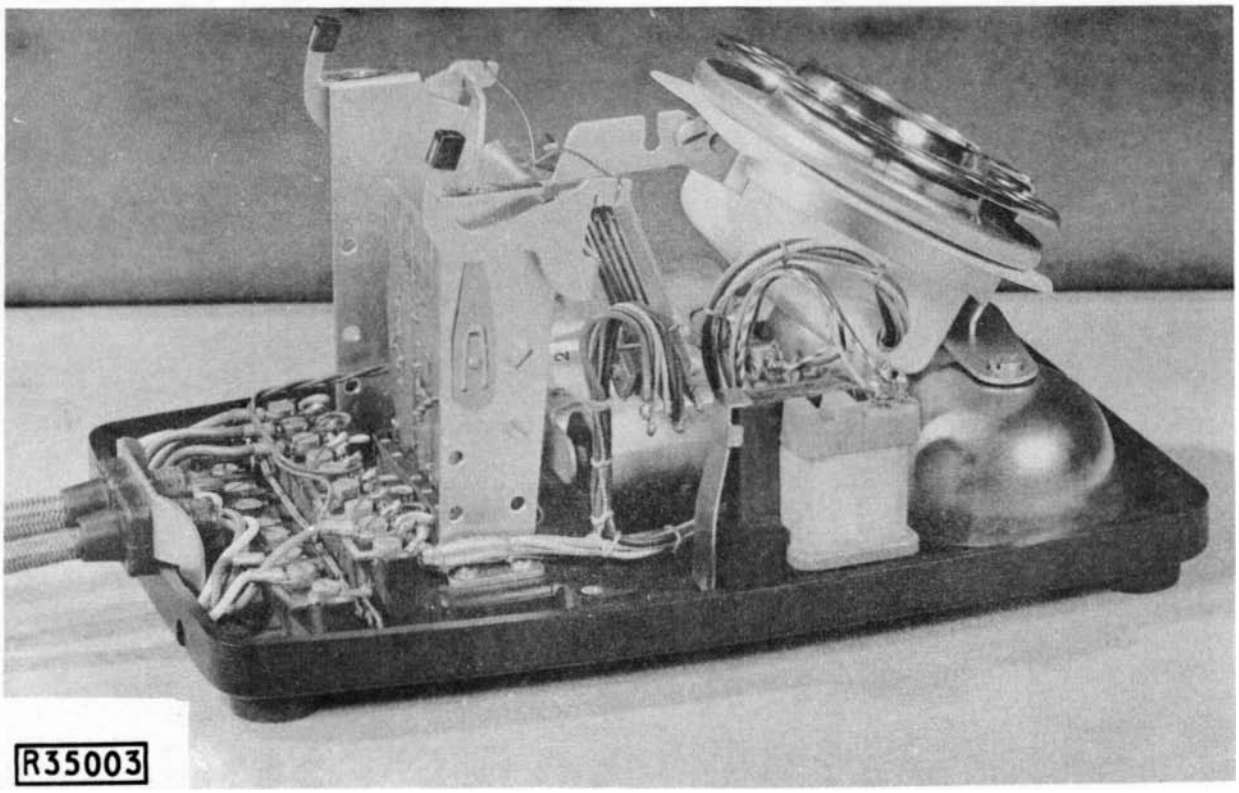


Fig. 2

R35001

Fig. 3

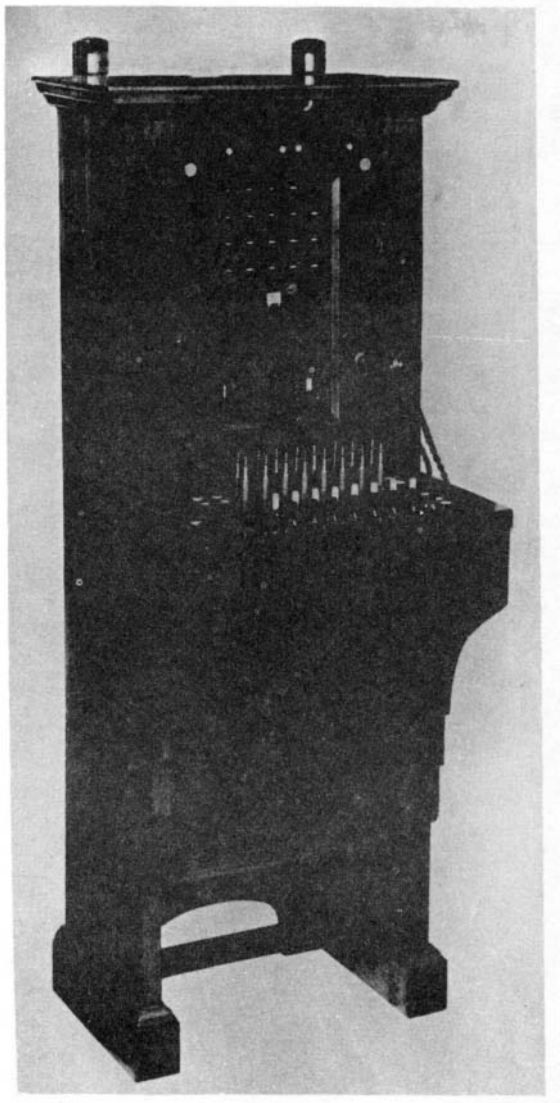


R35003

Fig. 4

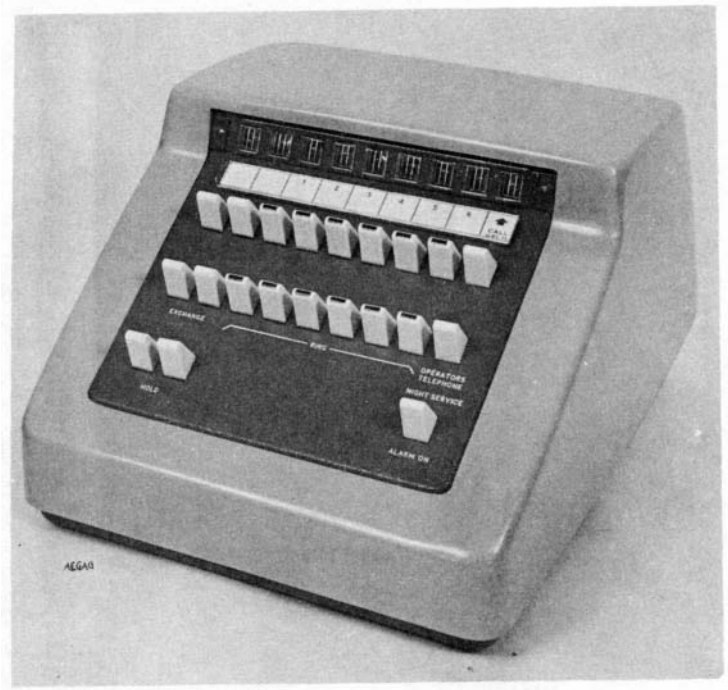
EXTENSIONS AND SWITCHBOARDS

Arrangements, termed 'plan-numbers', are available whereby additional telephones and bells can be associated with the normal telephone and line. The plan-number arrangements only provide for communication between the extension telephones and the normal, or main, telephone and the exchange. When it is required that the extensions can be connected one with another independent of the line to the exchange, a switching arrangement is fitted at the subscriber's premises. Such an arrangement is known as a Private Branch Exchange (P.B.X.). The line, or more usually lines, from the exchange and the extensions terminate on a switchboard which allows for extension to extension, exchange line to extension, and extension to exchange line cross connexions. Switching between exchange lines and extensions is carried out manually but a number of systems exist whereby extension to extension and extension to exchange connexions can be completed without the intervention of an operator, that is 'automatically'. Most types of P.B.X. employ all manual switching and range from switchboards designed for installation on a table and with a capacity of up to three exchange lines and nine extensions, to free standing switchboards which may be arranged in suites to accommodate tens of exchange lines and hundreds of extensions.



R 33338

Fig. 5



R35917

Fig. 6

A small switchboard in general use and which has a capacity for 5 lines to the exchange and 20 extensions is shown in Fig. 5. Cross connecting is by means of flexible plug ended conductors as in a public manual exchange. The latest type of table switchboard which has capacity for 2 lines and 6 extensions is shown in Fig. 6; cross connecting is by means of key operation.

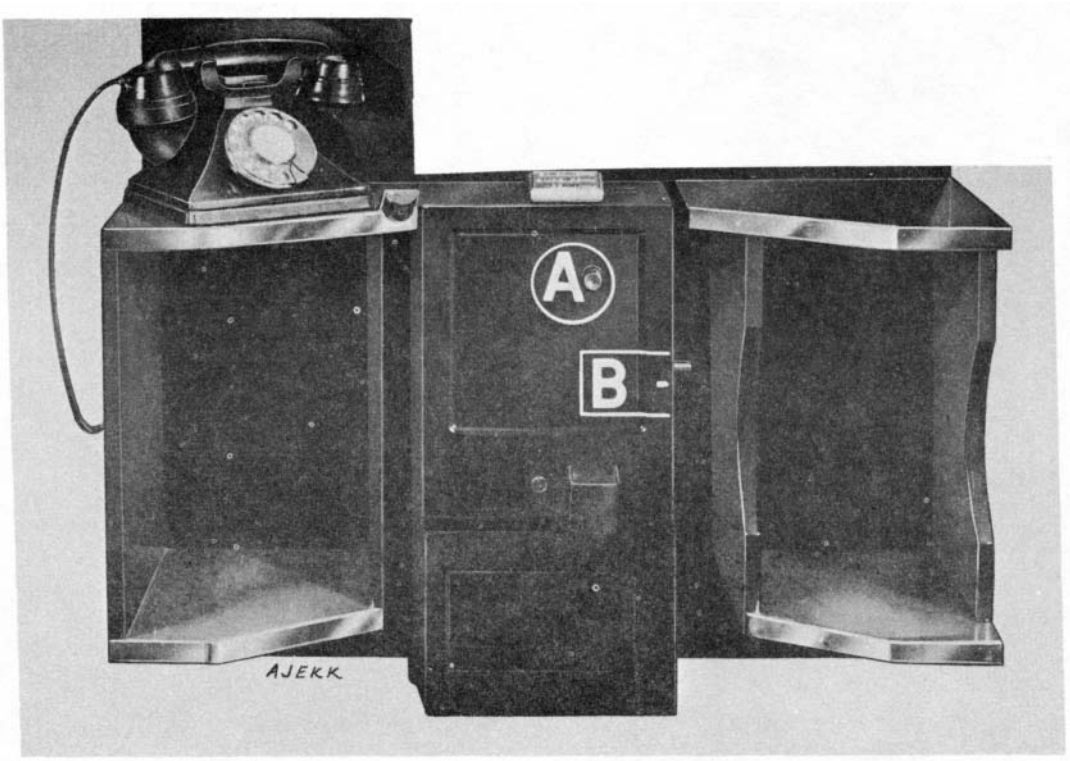
It should be noted that when a subscriber has more than one line, it is usual for them to be given consecutive exchange numbers to facilitate the connexion at the exchange of a call incoming to the subscriber. The subscriber's advertised telephone number is then the first one in the group or in the case of very large groups of lines, an easily remembered number in the group.

In addition to lines to a public telephone exchange, subscribers can rent private circuits, called 'private wires', to connect their premises with another fixed point; this facility and also the one whereby one P.B.X. may have a direct line to another P.B.X. are in common use by business concerns.

CALL OFFICES

Telephone facilities are made available to all by the provision of public call offices at convenient points in most parts of the U.K. The equipment provided in a call office consists basically of a telephone and a mechanism which accepts coins and controls the connexion between the telephone and the exchange.

The call office equipment which has been in general use since 1935 is shown in Fig. 7. The coin-box has slots which accept shillings, sixpences and pennies.



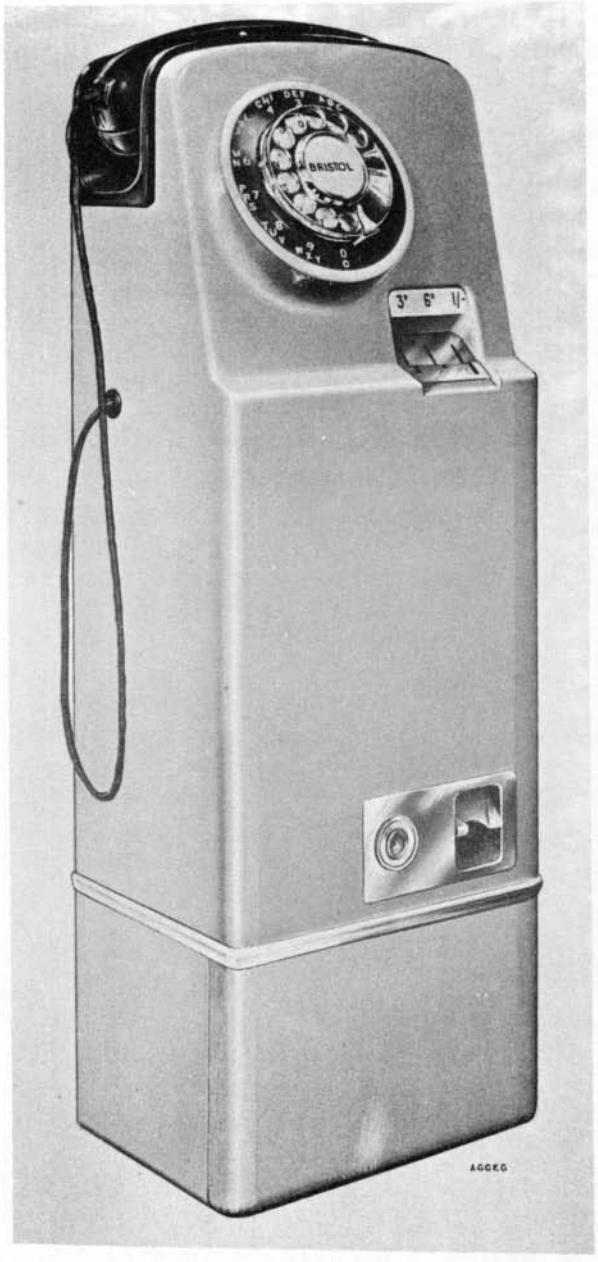
R35918

Fig. 7

When four pennies are inserted they operate the mechanism and allow the caller to dial numbers on the local and certain other exchanges or, in manual telephone exchange areas, to establish connexion with the exchange operator. Button A must be pressed before the caller can speak to the called subscriber, and this action

causes the coins to pass from the mechanism to the cash-box. If a connexion is not established the caller can regain the coins by pressing Button B. In automatic exchange areas the telephone circuit is so arranged that coins do not have to be inserted into the box to establish connexion with the operator or emergency service (999). The shilling and sixpenny slots allow for operator assisted trunk calls to be made from the call office.

The introduction of the system whereby subscribers on certain automatic telephone exchanges are able to directly dial both local and trunk calls, required that call office equipment be redesigned. The telephone and coin-box are combined into a single unit as shown in Fig. 8, it should be noted that the coin slots accept shillings, sixpences, and threepenny pieces. The system of working is known as 'pay-on-answer' and an outline of how a call is made is as follows. The receiver is removed from the rest and the required number is dialled; subsequently the called subscriber answers, it is important that he or she should answer by stating the telephone number; a distinctive tone, termed 'pay-tone', is then automatically applied to the circuit and the caller must insert the minimum of threepence to establish the connexion for speech. At the end of a period dependent on the distance to the called subscriber, the pay-tone is reapplied and the caller must insert more money to continue the conversation. The provision of slots for sixpences and shillings allows multiples of threepence to be inserted, thereby increasing the period before pay-tone is applied. Facilities are provided whereby the caller can establish a connexion with the operator or emergency service without inserting money into the box. It should be noted that once money has been inserted it cannot be refunded, hence the importance for the called subscriber to answer by stating their telephone number.



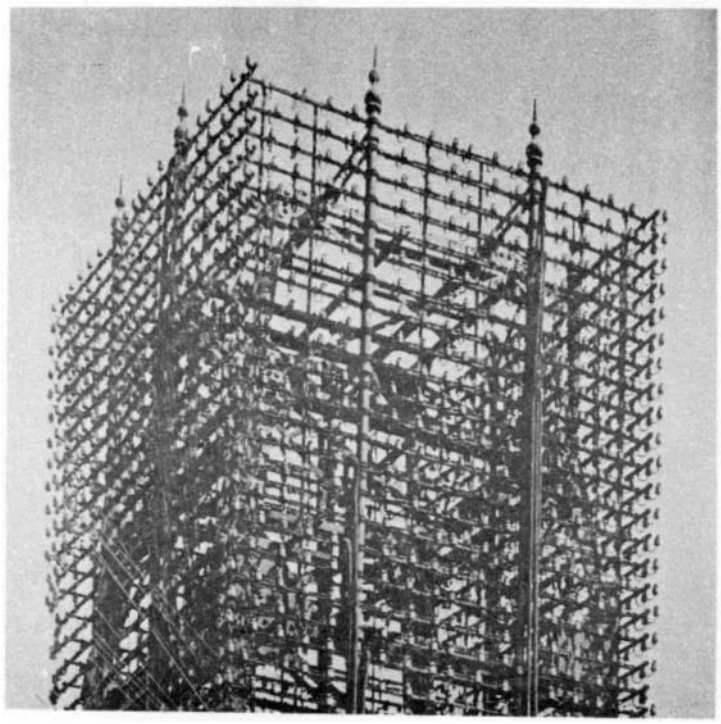
In addition to call office equipment being provided in street kiosks, cabinets at Post Offices and railway stations, it may also be rented by private subscribers; there is in fact little difference in the number of public kiosks and cabinets, and rented call offices.

R35919

Fig. 8

THE SUBSCRIBER'S LINE

Originally all subscribers' telephones were connected to the exchange by bare galvanized iron, bronze or copper wires carried on insulators fixed on arms which are in turn fixed to poles. Whilst the number of telephones connected to each exchange was small this method was adequate, but as exchanges grew practical complications, as shown in Fig. 9, arose at the point above the exchange where the wires converged. Present practice is to run subscribers' lines in multipair cables contained in buried earthenware or metal conduits, from the exchange to suitably positioned 'distribution points'. The cables consist either of paper insulated annealed copper conductors enclosed in a lead sheath, or polythene insulated annealed copper conductors enclosed in a polythene sheath. The lead sheathed cables in general use have conductors weighing either 4 lb, 6½ lb, 10 lb or 20 lb per mile and are made in various sizes, the largest having 1800 pairs of 4 lb conductors. Polythene sheathed and insulated cables are now coming into general use, and where conditions permit are often laid directly in the ground.

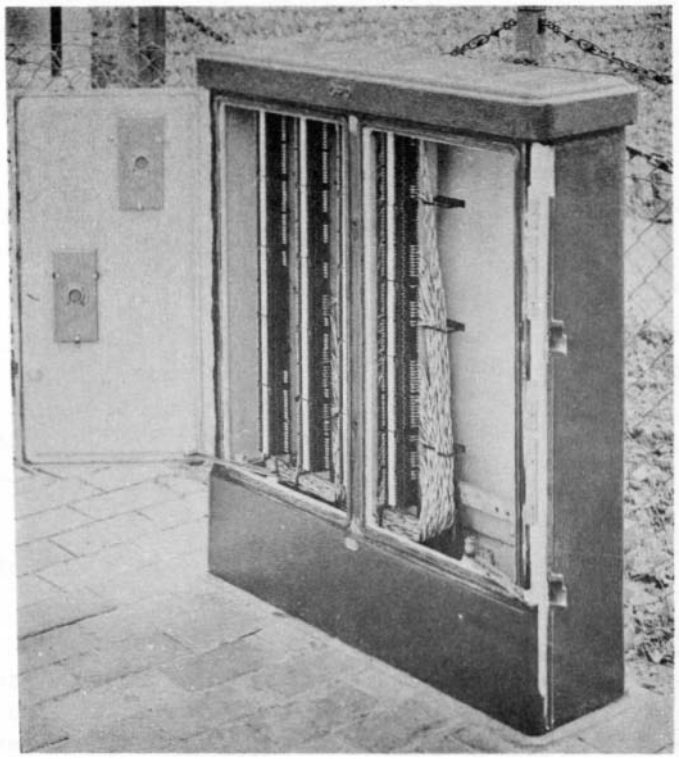


R 34537

Fig. 9

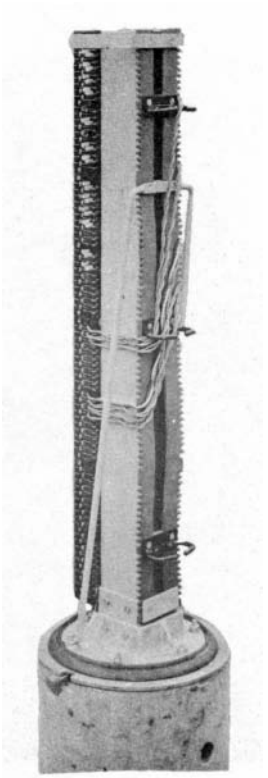
In certain circumstances both types of cable are run overhead supported by a steel wire fixed to wood poles. Overhead wiring is restricted, except in rural and exposed areas, usually to a few spans of 40 lb per mile bare cadmium copper wire from the subscriber's premises to a distribution point. Cadmium copper wire is used because it has a greater mechanical strength than copper wire of a corresponding weight.

The modern method of distributing pairs of wires from the exchange to the subscribers is known as the cabinet and pillar system; the principles of the method are as follows. A large capacity main cable is run from the exchange to serve a particular section of the area, and at a suitable point terminates on connexion strips mounted in a metal cabinet, Fig. 10. The conductors of the main cable are cross connected as required to the conductors of a number of branch cables which radiate from the cabinet. Each branch cable terminates on a suitably positioned pillar, and the conductors are cross connected to several distribution cables. A pillar, with the hexagonal asbestos-cement cover removed, is shown in Fig. 11.



R 34538

Fig. 10



R 34539

Fig. 11

In residential areas where the telephone density is high, distribution is effected by ring type distribution poles erected at suitable intervals along the streets. Each pole is served by an underground cable, (usually of 10 to 15 pairs capacity) which terminates at the top of a pole on a terminal block. Overhead

wires radiate from the pole for one span to the various subscribers' premises; the overhead wires can take the form of bare cadmium copper wires or covered wire. Fig. 12 gives a picture of such a pole with open wire distribution. A 'covered wire drop', as it is termed, consists of either a one pair cable enclosed in a black braiding or, more recently, a p.v.c. insulated pair in a p.v.c. covering. It should be pointed out however that drop wire distribution, although a sound and economic method of distribution, can become unsightly because of the greater visibility of the covered wire in comparison with open wires. On these grounds it is often objected to by local authorities. In certain districts the subscribers' telephones are served directly by one pair cables from the distribution cable, so dispensing with overhead wiring. Large commercial buildings and blocks of flats are served by a distribution cable which terminates at a convenient point in or on the building. The various individual telephones and switchboards are then served by the appropriate size and type of cable from the D.P.

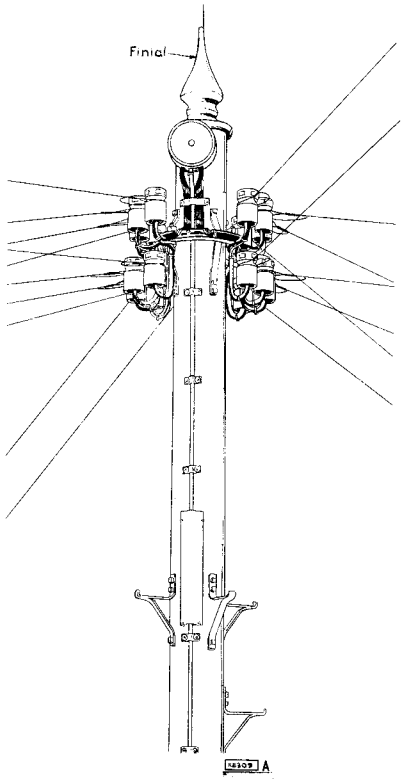


Fig. 12

For purposes of identification each main cable is allocated a letter code and the pairs within a cable are numbered. The distribution points are also numbered, thus a subscriber's line can be identified by the particular main cable code and pair number, and the D.P. number and pair number at the D.P., e.g. B567, DP42, Pair 4.

The provision of underground line plant is expensive because the ground has to be dug up, the plant laid, and the ground reinstated to its former condition. Underground plant is, however, more economical than open wire overhead plant when a large number of circuits have to be provided over the same route. There are various factors which contribute to this saving. The wires can be of much lighter gauge when laid underground, since overhead wires are stretched taut between poles and have to support their own weight as well as the forces exerted upon them by weather conditions. Overhead wires are erected singly and each pole in the route has to be climbed, whereas many wires are laid when a multipair cable is drawn into ducts or laid into the ground. The fault or damage liability is much less with underground plant than with overhead plant. Underground plant is, however, liable to damage by flooding and by electrolytic and chemical corrosion.

In certain parts of the country consent to the provision of overhead plant is not given because the beauty of the locality would be regarded as spoilt by visible telephone wires. In general, underground plant is provided in the larger towns and places of beauty, and overhead plant is used for local distribution and in districts where there are too few lines over any route to justify the cost of underground plant.

THE TELEPHONE EXCHANGE

At the present time the public telephone system in the U.K. has some 6,000 exchanges, each serving as the switching centre for the telephones in a specified area. The system of connexions between the exchanges is governed by the nature of the telephone traffic and is such that usually each exchange has direct lines to and from its neighbours and at least one group of lines to a switching centre for inter-exchange circuits.

The country is divided into clearly defined exchange areas so that the appropriate exchange to which any new subscriber should be connected can be readily determined. The area boundaries are chosen wherever possible to correspond with features such as railway lines, rivers or roads, and in order to keep the average cost of providing a subscriber's line low, the exchange is positioned as near the centre of telephone density as practicable, this position is not necessarily the geographical centre of the area. Adjustments are made to the boundaries from time to time to allow for industrial and residential development, and also to allow for the introduction of an additional exchange to the system. The size of the area served by an exchange is in part governed by the maximum economic size of the exchange and the density of telephone subscribers in that part of the country. In a rural area one exchange may serve a number of small villages whilst in very large towns it is not unusual to have several suitably positioned exchanges; an extreme example of this is in London, where there is of the order of 170 exchanges within a radius of 12½ miles of Charing Cross.

Originally the switching operations within a telephone exchange were carried out by operators at the verbal request of the calling subscribers, but as early as 1889 a mechanism was invented which under the control of electrical signals generated by the caller, would 'automatically' complete the desired connexion. It was not until 1912, however, that the first public automatic telephone exchange in the U.K. was opened. At the present time some 4,000 of the 6,000 exchanges in the public system have automatic switching equipment. Generally a new exchange, whether to serve as a replacement for a manual exchange or a new area formed from portions of adjacent areas, is of the automatic type. The two types of exchange switching will now be considered separately.

MANUAL SWITCHING

General

At a manually operated telephone exchange the subscribers' lines terminate on a switchboard which is equipped so that one line can be cross-connected to another by an operator at the verbal request of the calling subscriber. There are two distinct types of manual switchboard, one known as the 'plug and cord' and the other as the 'crossbar' or 'cordless'. On the original crossbar switchboards the lines terminate on vertical metal bars, behind which are positioned horizontal metal bars acting as cross connecting circuits. A connexion between two subscribers is established by connecting the appropriate vertical bars to the same horizontal bar by means of metal pegs. Operating and mechanical complexities occur when handling a large number of lines and cross connexions, consequently the method was not adopted for public exchanges. The crossbar principle is, however, still widely used for small switchboards at subscribers' installations. The connexions between the connecting circuits and lines on the switchboards are made by multi-contact keys.

On the plug and cord type switchboard, Fig. 13, each subscriber's line terminates on a jack and indicator, and plug-ended flexible conductors, termed cords, are used to connect together the appropriate jacks when establishing a connexion between two subscribers. The switchboard has proved suitable to accommodate a very large number of lines and to handle high rates of calling, consequently it is the standard type of manual switchboard used by the British Post Office in public telephone exchanges.

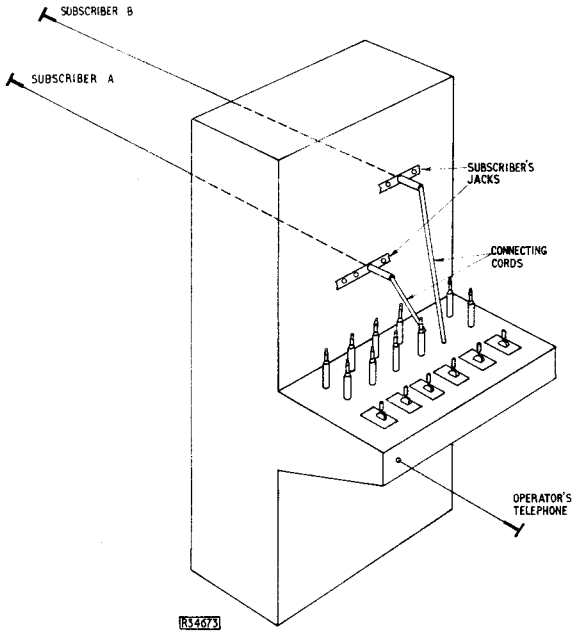


Fig. 13

Types of exchange working

There are three distinct types of exchange working; Magneto, Central Battery (CB) and Central Battery Signalling (CBS).

Prior to 1900 the magneto system was in use for all public manual exchanges. The system employs hand generated low frequency alternating current signals between subscriber and operator and vice versa; the signals operate electromagnetic calling indicators at the exchange and magneto bells at the subscribers' telephones. Primary cells are installed at the exchange and subscribers' premises to provide current for the telephone transmitters. The equipment is bulky and the use of hand generators by the subscribers to both call the exchange and signal the end of a connexion does not lend itself to a high speed of working, consequently the system has now become obsolete for public exchanges.

The central battery system, originally known as the common battery, was invented in the U.S.A. about 1892 and first used for a public exchange at Bristol in 1900. A battery of secondary cells at the exchange provides the direct current for signalling between the subscriber and the exchange and both the subscriber's and the operator's telephone transmitters. Small lamps are employed as the signalling devices in the exchange, thus making the switchboards more compact than those used in the magneto system. Alternating current to ring subscribers' bells

is generated by a machine at the exchange and applied to individual circuits when required by means of keys. Both calling and clearing signalling is automatic, thereby allowing for a high speed of working; consequently this system became standard for all large public telephone exchanges.

The central battery signalling system was designed by the B.P.O. to take advantage of the CB system of working in areas where there were not economic means of maintaining secondary cells. It should be appreciated that in 1900 only large towns had a public electricity supply mains and that portable or prime mover generators were by no means commonplace. The signalling in the most commonly used CBS arrangement is the same as that used in the CB system. High resistance electromagnetic indicators at the exchange and a local primary cell battery at each telephone are used, however, so that only a primary cell battery is required at the exchange to supply the signalling current. Subsequently secondary cell batteries were fitted at exchanges. The system has been widely used for exchanges estimated not to exceed 800 subscribers and a considerable number of these exchanges are still in service.

The switchboard

In the early days of telephony the number of subscribers connected to each exchange was such that a switchboard having one or two operator's positions was sufficient. The operating procedure on such a switchboard was simple because all the subscribers' jacks and indicators were within sight and reach of both operators. Complications arose, however, when operating positions were added to the switchboard to accommodate the increasing number of subscribers. The problem of completing a connexion between two subscribers terminating at opposite ends of the switchboard was resolved by providing 'transfer circuits' between positions, but this arrangement was inefficient in the use of operators and equipment, and extremely cumbersome. A great, perhaps the greatest, advance in switchboard design and one which made possible large switchboards capable of handling a high calling rate was the multiple system.

In the multiple system of working, each subscriber's line is connected to a number of jacks, one of which is associated with the calling indicator and a label on which is engraved the subscriber's number. The remaining jacks, known as multiple jacks, are positioned around the switchboard so that at least one of them is within the reach of any one operator. An explanatory diagram of a portion of the face equipment of a typical multiple type switchboard is shown in Fig. 14.

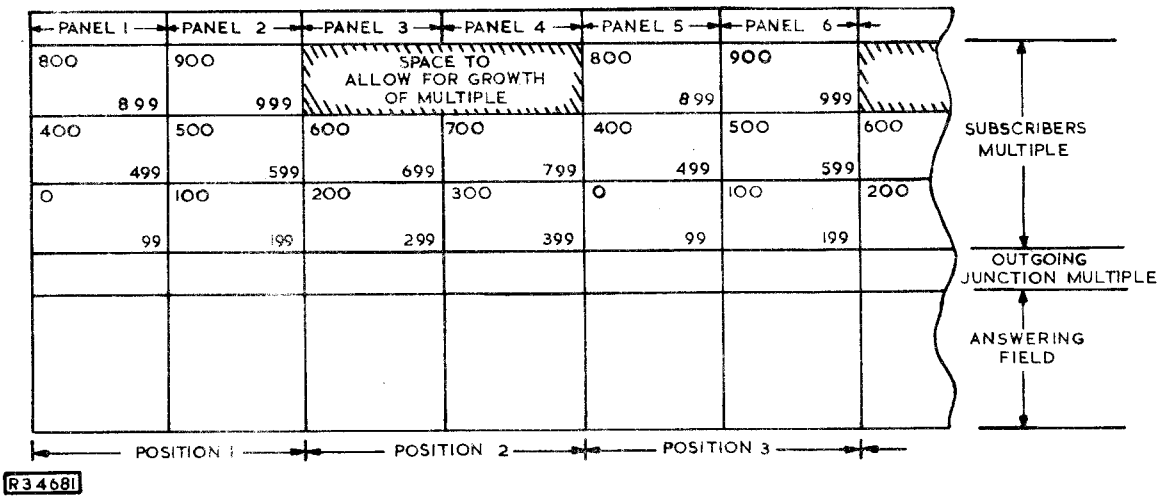


Fig. 14

The answering equipment is made up from strips of jacks, calling indicators and number labels, and the subscribers are connected to them so that over a given period each operator handles the same amount of traffic. Thus at first sight the subscribers would appear to be distributed at random over the answering equipment. The number of subscribers proper to one operator's position usually comes within the limits 60 and 120, the actual number being dependent on the calling rate of the subscribers. The other jacks associated with the subscribers' terminations are arranged in numerical order and positioned in the upper portion of the switchboard panels as indicated in Fig. 14, which shows a typical arrangement for an exchange having an ultimate capacity for 1,200 subscribers. In the example shown, each subscriber's jack is repeated every fourth panel, in larger exchanges the multiple jacks have a 6, 8 or 9 panel repetition.

For the efficient connexion of calls it is necessary for each operator to have easy access to the lines, known as junctions, to other exchanges. To this end the outgoing junctions are accommodated on strips of jacks positioned as shown in Fig. 14 and repeated at not more than 6 panel intervals. The junctions incoming to the exchange may be handled on special positions or, in smaller exchanges, on the same positions as those having subscribers' answering equipment.

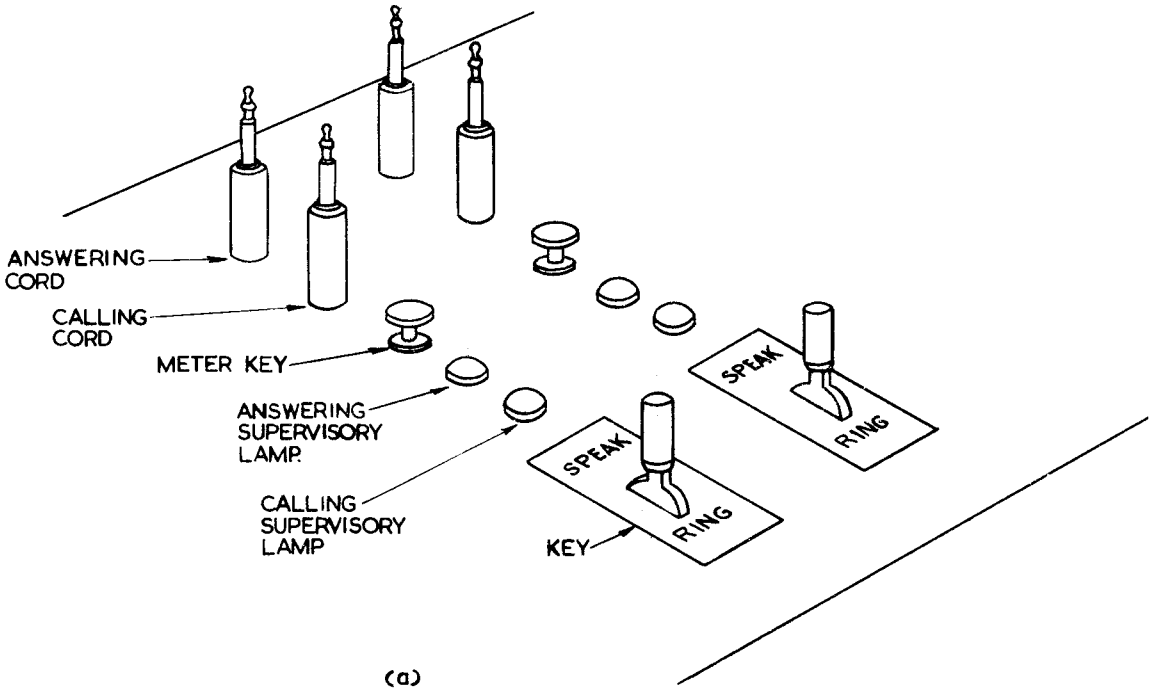
Each operator's position is provided with a number of cross-connecting circuits, known as cord circuits, to effect the cross-connexion between any two subscribers. Each cord circuit terminates on a pair of plug-ended flexible cords, known as the answering and calling cords, and at a modern exchange includes the following equipment,

A key-type switch, the operation of which connects the circuit either to the operator's telephone or a source of alternating current to ring the called subscriber's bell;

Two lamp-type indicators for supervisory purposes, one indicator is under the control of the calling subscriber and the other is under the control of the called subscriber, the individual control is allowed for by a circuit arrangement known as a 'transmission bridge' which also supplies d.c. for the telephone transmitters;

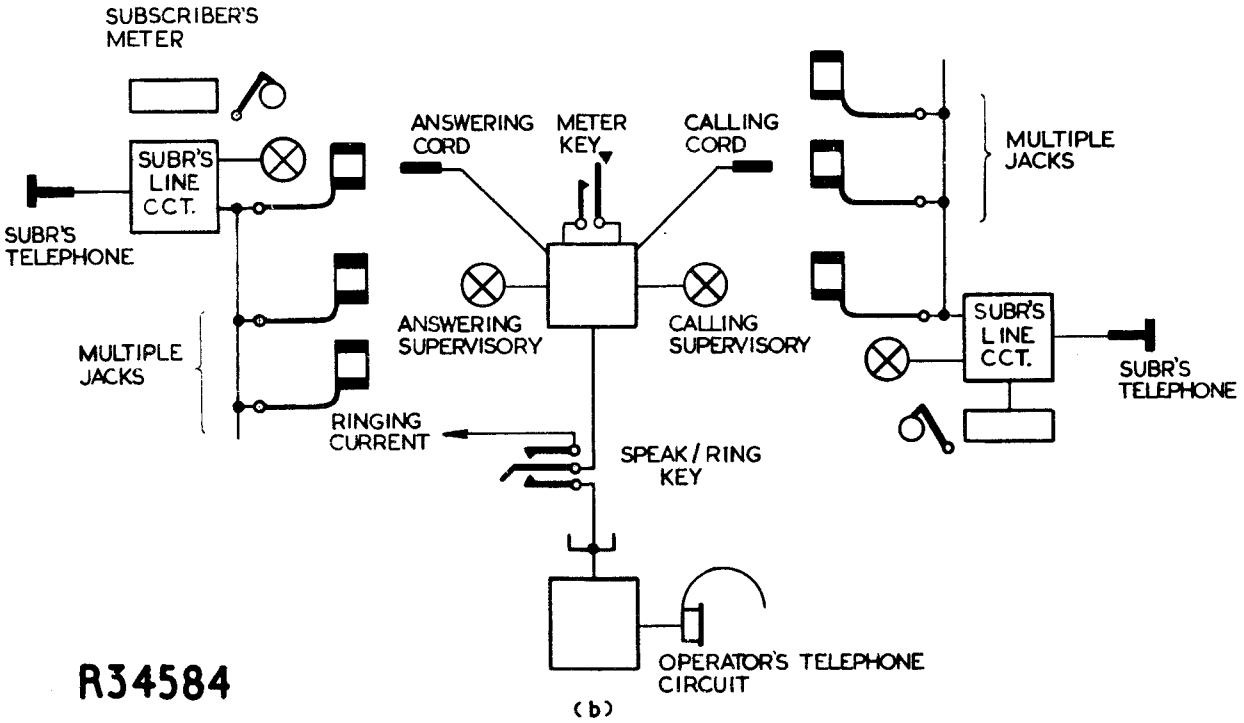
A meter key, the operation of which causes an effective call to be registered against the calling subscriber.

This equipment is mounted on the switchboard keyshelf and one operator's position can contain up to 17 cord circuits. The arrangement of the equipment associated with 2 cord circuits is shown in Fig. 15a.



(a)

CALLING SUBSCRIBER CORD CIRCUIT CALLED SUBSCRIBER



(b)

Fig. 15

Outline of operation

A subscriber initiates a call by removing the handset from the telephone; this action causes the lamp associated with the subscriber's answering jack at the exchange to glow. The operator answers the signal by inserting the answering plug of a cord-circuit into the jack, this action extinguishes the lamp, and by operation of the key to the 'speak' position connects her telephone to the circuit. At this stage the answering supervisory lamp is not glowing because the subscriber's handset is off the telephone.

At the operator's request the subscriber gives the exchange name and telephone number of the required subscriber. If this subscriber is connected to the same exchange, the operator, after ascertaining that the subscriber is free, inserts the calling plug of the cord-circuit into the appropriate jack in the multiple. Further operation of the cord-circuit key causes the called subscriber's bell to ring. When the called subscriber answers, the calling supervisory, which has been glowing since the calling plug was inserted into the multiple jack, darkens.

At the conclusion of the call both supervisory signals glow when both subscribers have replaced the handsets of their telephones. Before the operator removes the cord-circuit plugs from the jacks, she actuates the meter-key associated with the cord-circuit to cause the call to be recorded on a meter in the calling subscriber's line circuit.

An explanatory diagram of a connexion between two subscribers on the same exchange is given in Fig. 15b; for the sake of simplicity only two multiple jacks are shown to be associated with each subscriber.

When the required subscriber is connected to another exchange the operator extends the call over one of the circuits in the outgoing junction multiple and obtains a connexion, either directly or indirectly, with the required exchange. Dials are provided on operator's positions so that subscribers on certain automatic exchanges can be contacted without the intervention of another operator. When the other exchange is manual, the call is completed by an operator in that exchange at the request of the calling subscriber's operator.

AUTOMATIC SWITCHING

General

The first patented device for mechanically connecting the calling to the called subscriber without the intervention of an operator, was invented by an American, A.B. Strowger, about 1889. The device can be considered to be the mechanical equivalent of an operator lifting a set of contacts, known as wipers, to one of 10 equally spaced rows of contacts forming a 'bank' and then moving the wipers to a set of contacts in the selected row. Thus if there are 10 rows of 10 contact sets, the mechanism is a 1 out of 100 selector or it can be arranged

to be a 1 row, or level, out of 10 selector the 10 contact sets in the selected level.

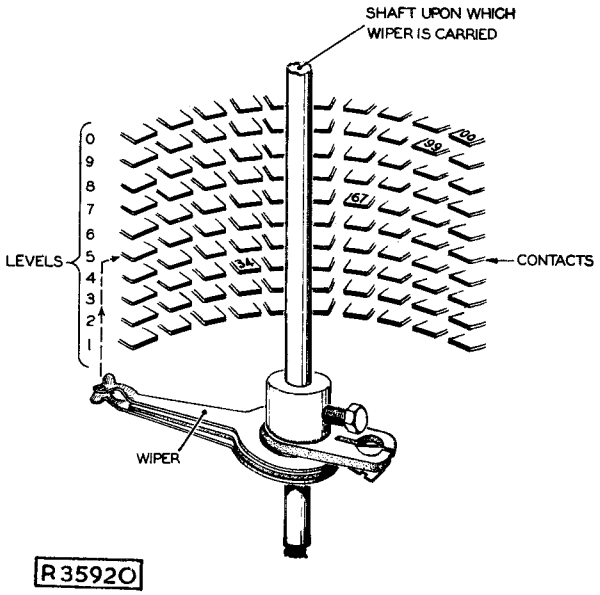
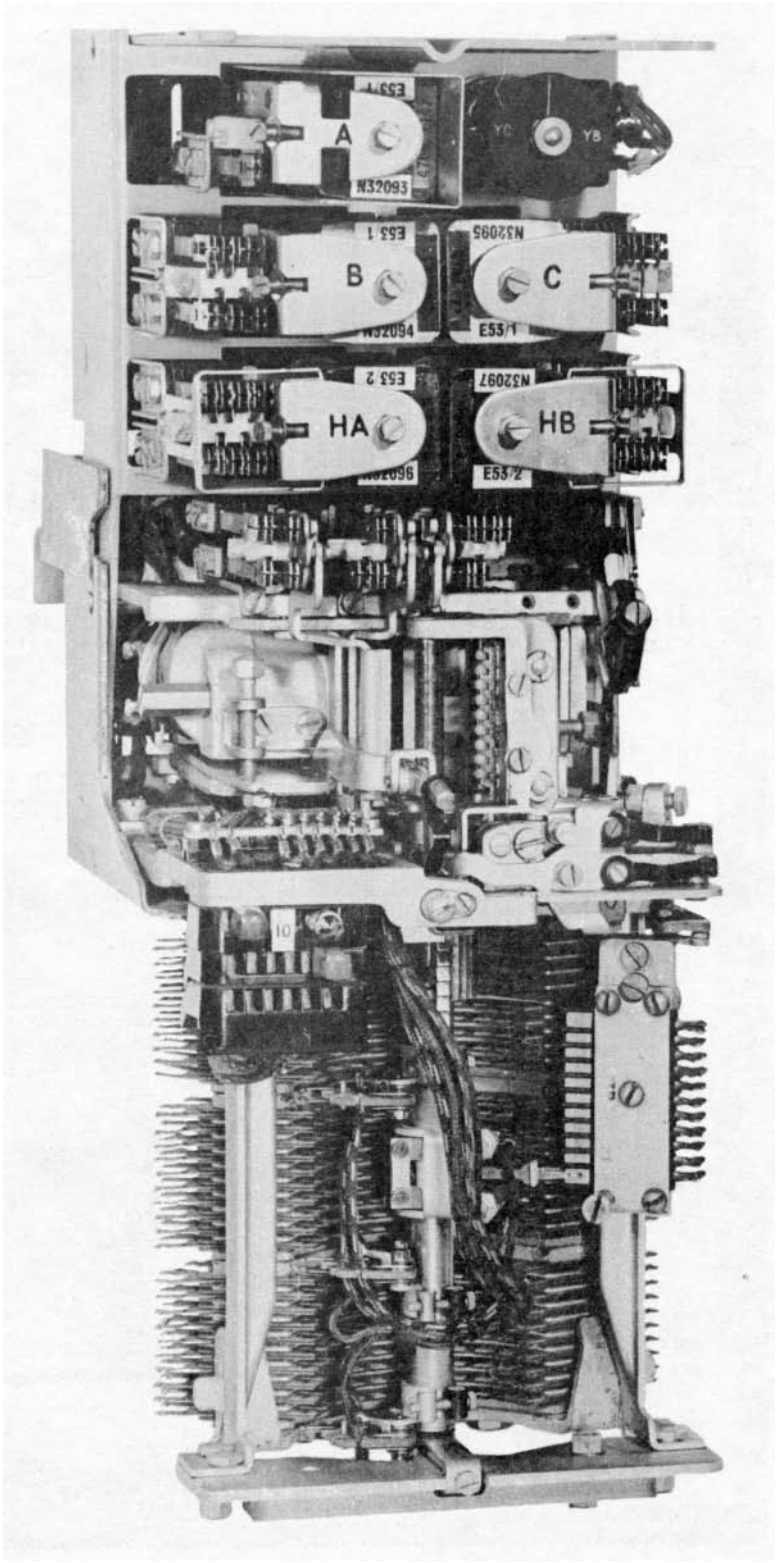


Fig. 16

with automatic choice of any one of The arrangement of the wipers with respect to the sets of contacts and the contact numbering system is shown in Fig. 16. It should be noted that the tenth level is designated '0'.

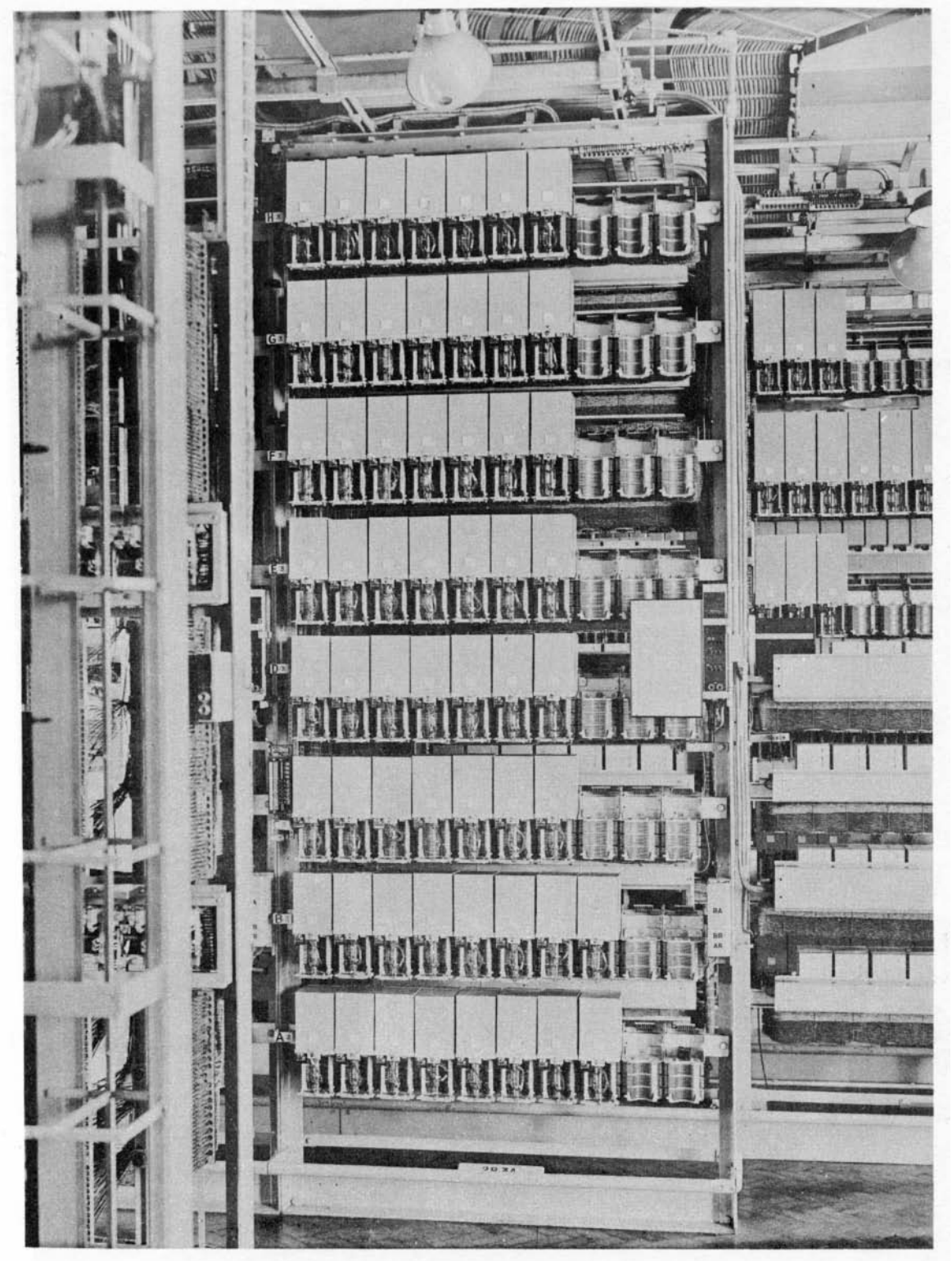
The movement of the wipers is controlled by ratchet and pawl devices, and is such that the wipers step one level or set of contacts at a time, consequently the action has become known as the 'step-by-step'. Subsequently another selecting mechanism, known as a uniselector, whose wipers move only in one plane over sets of contacts, was introduced. The original mechanism then became known as a two-motion selector.

The Strowger step-by-step system of automatic switching was developed first in the U.S.A. and in 1912 two automatic exchanges using this system were opened in the U.K. One exchange was for public use at Epsom and the other for private use at the Post Office Headquarters both exchanges having an ultimate design capacity of 1,500 lines. Subsequently other automatic exchanges using mechanical systems based on a different approach to the switching problem were opened for public use; one such exchange opened at Fleetwood in 1922 employed only relays to effect the switching. A relay is an electrically operated device which causes changes in the condition of other circuits and is the most numerous item of equipment in normal automatic exchanges. During the 1920's, the Strowger step-by-step system became established as the public automatic switching system in the U.K., and by 1930 there were 147 exchanges using this system. In general all new large public exchanges were of the Strowger step-by-step system, manual switching only being used for small lightly loaded exchanges. At the present time there are some 6,000 exchanges in the U.K., some two-thirds of which are automatic, and all new exchanges employ automatic switching. It is anticipated that within the next decade all exchanges will be automatic.



R34515

Fig. 17



R34517

Fig. 18

The exchange equipment was designed, manufactured and installed by several contractors, and consequently differed from one contractor to another in both mechanical and circuit detail. Siemens Bros. installed their own system, the No. 16, which is essentially a step-by-step system but has particular mechanical and circuit principles not found in other makes of equipment. The system is still giving service in some large provincial exchanges but never became standard for B.P.O. public exchanges.

The first act to standardize the design of step-by-step exchange equipment occurred in 1930 when a standard series of equipment racks and mounting arrangements were introduced, and this was soon followed by standard types of uniselector and relay. A two-motion selector mechanism designed and manufactured by the Automatic Electric Company was, after some modification, adopted by the B.P.O. as standard for all new work. A series of racks to the standard sizes but with many new features were introduced with the selector, and the first exchange to have this '2000-type equipment' was installed at Rugby in 1936. A photograph of the two-motion selector mechanism, contact banks (three in this case) and control circuit relays is shown in Fig. 17. In practice the selectors and contact banks are mounted on channel iron shelves which are fixed to the uprights of angle iron frames. Each shelf usually has mountings and contact banks for 10 selectors, but the number of selectors provided depends on the exchange requirements. A rack of selectors is featured in the view of exchange equipment shown in Fig. 18.

In recent years new types of standard uniselector and a two-motion selector which is interchangeable with the 2000-type, have been introduced. The new two-motion mechanism, designated the 4000-type, was designed in its original form by the General Electric Co. Ltd., and is standard for most new installations.

Strowger step-by-step selection

In the Strowger step-by-step system of automatic switching the required line is selected by a process of decimal selection. In such a system the exchange numbering scheme is broken down into groups of 10; thus 10,000 lines can be considered as 10 groups each of 1,000 lines, and each 1,000 lines can be considered as 10 groups each of 100 lines, and finally the 100 lines can be divided into 10 groups of 10 lines.

A basic 100 line automatic exchange can be formed by employing one stage, or rank, of two-motion selectors and allotting each subscriber a number in the range 00 to 99. Each subscriber's line is connected to the wipers of a selector and also to the bank contact appropriate to the allotted number; the first digit of a number indicates the contact level and the second digit the contact in the level to which the particular subscriber is connected. In the basic arrangement considered, each subscriber has the exclusive use of a two-motion selector, thus 100 are required, and the bank contacts of one selector are wired to the

corresponding contacts of the other banks. A trunking diagram of the exchange, in which only the connexions appropriate to subscribers 00, 49 and 99 are given, is shown in Fig. 19.

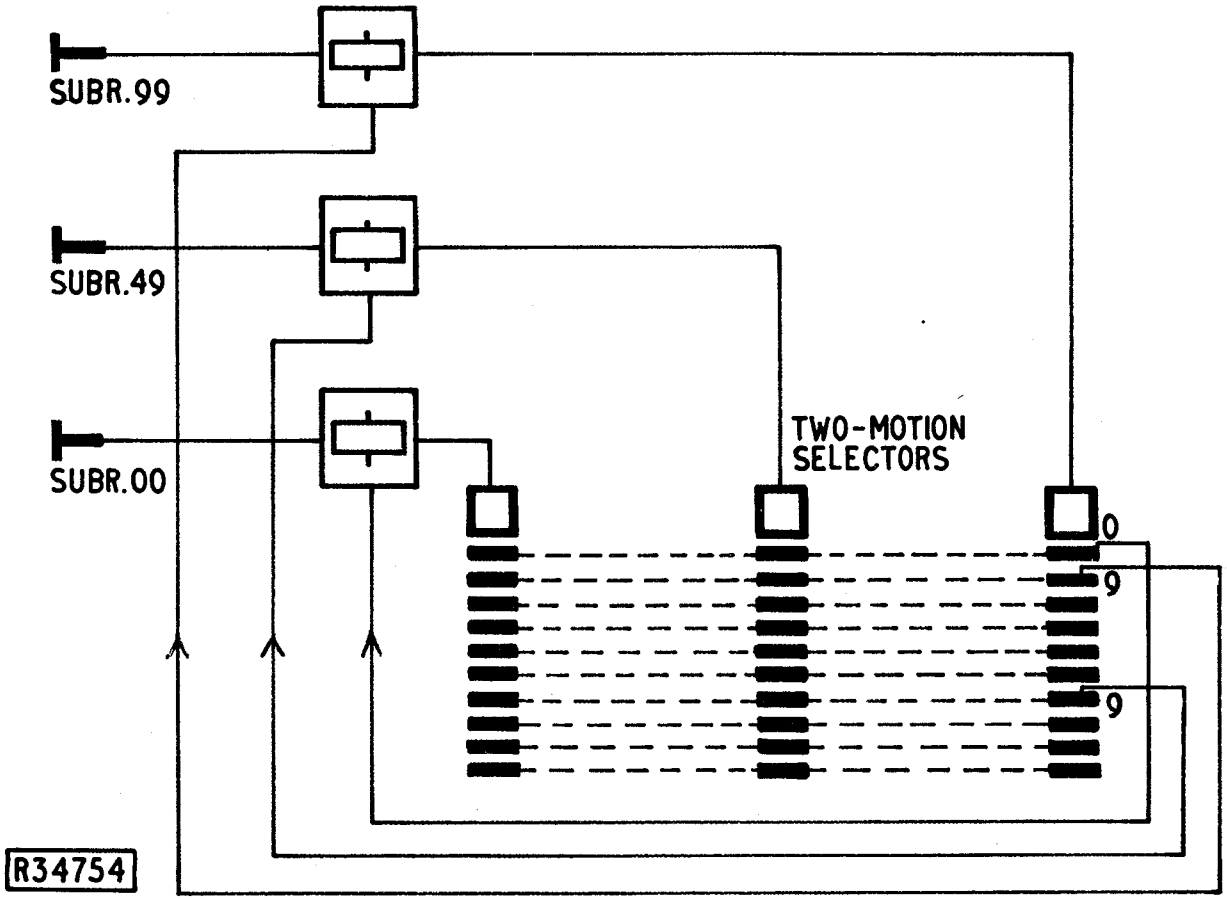


Fig. 19

To call, say, subscriber 49 the originating subscriber dials 4 followed by 9. The process of dialling causes signals to be generated in the calling subscriber's line and these signals actuate a relay circuit in the selector which in turn controls the movement of the wipers. The dialling of the digit 4 causes the wipers of the selector to which the caller is connected to be raised one level at a time to level 4. During the pause between the dialling of the two digits, changes are automatically effected in the selector circuit so that the second digit dialled, 9, causes the wipers to step over the level to the 9th contact. The selector circuit is arranged to test the called subscriber's line for the engaged condition; if the line is not engaged current is extended to ring the subscriber's bell and ring tone is returned to the caller. When the called subscriber answers, the selector circuit is automatically rearranged to supply current to the subscribers' telephones and form a transmission bridge; in effect the selector circuit is then similar to the cord circuit in a manual switching system. The circuit also causes a meter in the calling subscriber's circuit to record the call when the called subscriber answers. If the called subscriber's line is marked by a busy condition, busy tone is returned by the selector circuit to the caller and the call is not recorded.

When the calling subscriber replaces the telephone handset at the conclusion of the conversation, the selector mechanism restores to normal in readiness to deal with other calls.

The capacity of the exchange can be increased to 1,000 lines by connecting each subscriber to a 1 out of 10 selector, known as a group selector, and then connecting each of the 10 output paths to a 100 line switching arrangement similar to that already described. The subscribers are allotted numbers in the range 000 to 999 and the first digit dialled by a caller actuates the group selector which then extends the connexion to the 100 line switching arrangement appropriate to the called number. The last two digits dialled complete the routing of the connexion to the called subscriber as previously described.

It follows that the capacity of the switching arrangement can be increased in powers of 10 by the addition of ranks of group selectors. Thus a 10,000 line exchange will have two ranks of group selectors and a 100 line switching arrangement which is generally termed a final selector. In practice two-motion selectors are used as group selectors to allow those at one stage to share at each level the use of a number of selectors at the next stage.

The group selector wipers are stepped to a level by the dialled digit and, during the period before the next digit is dialled, are caused to step automatically over the contacts in the level until a free outlet to the next stage is found. Such an arrangement for the group selectors is necessary in the design of an economic switching system.

The switching arrangements so far considered provide only for selecting any one number out of some power of 10; a public telephone exchange, however, must provide each subscriber with access to an operator for assistance purposes and it is desirable that they be able to directly dial subscribers on as many other exchanges as possible. Access must also be provided so that other exchanges can dial subscribers connected to the exchange being considered.

A trunking diagram of a 4-digit number switching arrangement which has been widely used, is shown in Fig. 20. A description of the setting up of the connexion between subscribers 6436 and 2508 which is indicated in Fig. 20 will be described first, the other facilities provided will then be considered.

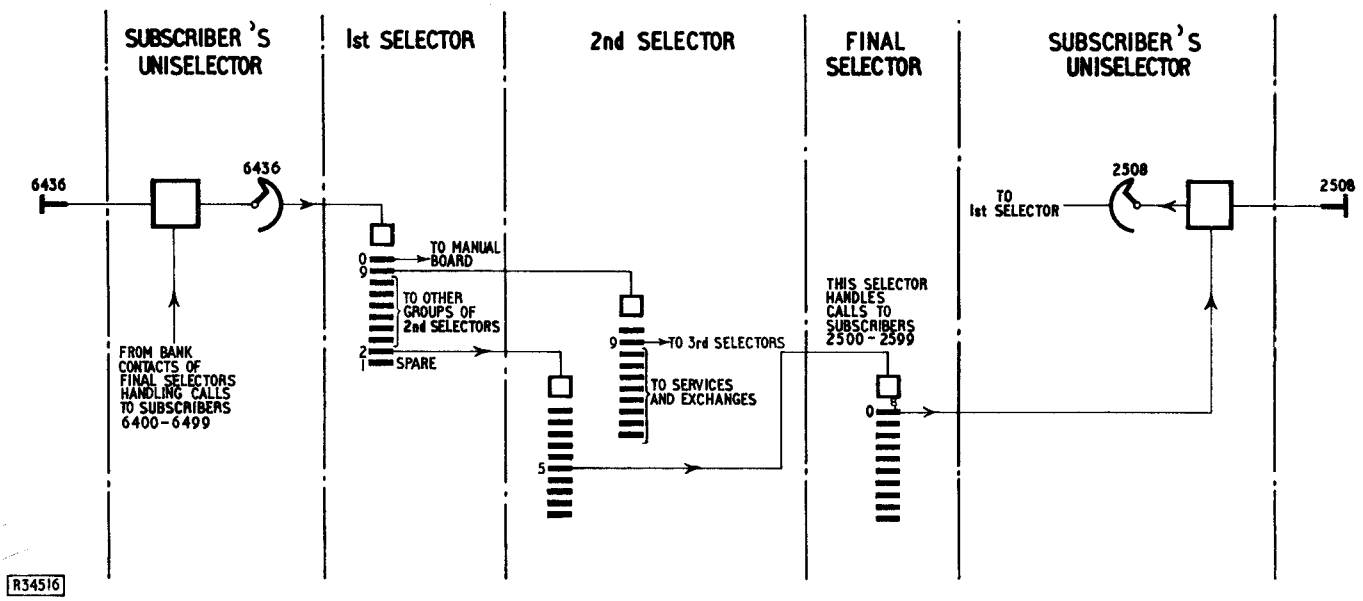


Fig. 20

Each subscriber's line is connected at the exchange to the wipers of a uniselector and a set of contacts in the banks of the final selector serving the particular hundreds group of numbers. Two-motion group selectors are expensive, consequently in practice only sufficient 1st group selectors to handle the anticipated outgoing calls during the busiest hour of the day are provided, and a subscriber is extended to one by means of a uniselector only when originating a call. When the calling subscriber, 6436 in this example, removes the handset from the telephone, his uniselector, which shares access to a number of two-motion selectors at the first stage with other subscribers' uniselectors, steps its wipers over the bank contacts until a disengaged '1st selector' is found. A distinctive tone, dial tone, is returned from the 1st selector to the caller, indicating that dialling may now commence.

The first digit dialled is 2, this is done by the subscriber rotating the finger plate of the dial clockwise from 2 to the finger stop and then allowing it to return to normal at its own speed. During the return to normal the dial transmits 2 pulses which cause the 1st selector wipers to step vertically to level 2 of the contact bank. The mechanism of the dial is so arranged that the time, termed inter-digit pause, between the transmitting of successive digits is sufficient to allow the wipers to rotate automatically step-by-step over the level to find a free outlet to a 2nd selector. If all the 'outlets' on the level are engaged, busy tone is returned from the 1st selector to the caller, who will then replace the handset on the telephone. The uniselector and 1st selector automatically restore to the normal position.

If busy tone is not received the second digit, 5, is dialled and the 2nd group selector wipers step vertically to level 5 and then step over the sets of contacts in search of a free final selector. Busy tone will be returned to the caller if all final selectors are busy and the subscriber will release the connexion as before.

The last two digits, 0 and 8 step the final selector wipers vertically and horizontally respectively, thereby positioning the wipers on to the eighth set of contacts in the tenth level. The calling subscriber is now routed but not connected to the set of contacts on which the line 2508 terminates. The final selector control circuit tests the called subscriber's line; if the line is not engaged ringing current is extended to ring the subscriber's bell and ring tone is returned to the calling subscriber. When the called subscriber answers, the calling subscriber's meter operates to record the call. If the called subscriber's line is marked by a busy condition indicating that the subscriber is engaged, busy tone is returned by the caller and the call is not recorded. If the number is temporarily out of service or not allotted to a subscriber the number unobtainable tone is returned to the caller and the call is not recorded. It should be noted that on an incoming call the called subscriber's uniselector remains at the normal position.

When the calling subscriber replaces the handset at the conclusion of the call, the selectors restore to normal in readiness to deal with other calls.

In the switching arrangement shown in Fig. 20 level 0 of the 1st selector is connected to circuits on an auto-manual switchboard, thereby providing the subscriber with access to an assistance operator by dialling the single digit 0. In areas which have been or are about to be included in the Subscriber Trunk Dialling (S.T.D.) scheme, the code 100 is dialled for the operator and the

necessary equipment to effect the routing of the call is connected to level 1 of the 1st selectors; this level is shown spare in Fig. 20, and any subscriber dialling 1 as the first digit would receive the number unobtainable tone. In areas where S.T.D. facilities have been introduced, level 0 of the 1st selector is used to provide subscribers with access to that system.

Access to nearby exchanges is provided usually from the levels of 2nd selectors which are connected to level 8 of the 1st selectors. Thus dialling codes for other exchanges will be within the range 81 to 80. If the distant exchange is automatic, the calling subscriber dials the code followed by the required subscriber's number, but if the exchange is manual the code only is dialled and the number passed verbally when the operator answers. Level 9 of the 1st selectors is also extended to 2nd selectors to give access to services such as telegrams; levels of those 2nd selectors not used for services can, if necessary, be used to give access to other exchanges. In certain exchanges the routes to other exchanges and services make it necessary to provide 3rd selectors connected to one of the levels of a level 8- or 9- 2nd selector, Fig. 20 indicates 3rd selectors connected to level 9 of a level 9- 2nd selector.

The provision of direct dialling and service facilities means that at least levels 1, 8, 9 and 0 of the 1st selectors cannot be used for subscribers' line switching. The capacity of the arrangement is, therefore reduced from 10,000 to 6,000 lines.

The circuits incoming from other exchanges and from the auto-manual switchboard each terminate directly on 1st selectors which have access to the subscribers' numbering scheme and certain of the outgoing routes to other exchanges. Access to the outgoing routes is provided to allow the exchange to act as a switching arrangement on calls from say exchange A to exchange B, thereby dispensing with the need for direct circuits between those two exchanges. The dialling code for such a connexion will then consist of the code to route the caller through exchange A to the intermediate exchange, and another code to complete the routing through this exchange to exchange B.

Types of exchange

The switching arrangement used in a public automatic exchange must be designed to provide an efficient service at reasonable cost. The use given to the telephone, however, varies widely between one type of district and another, consequently it is not possible to have one arrangement to suit all areas. The types of public exchange in general use are classified under the following headings,

(i) Unit Automatic Exchange (U.A.X.)

(ii) Non-Director, and

(iii) Director.

The U.A.X.

There are several switching arrangements in use for Unit Automatic type exchanges although the U.A.X. No. 13 is now standard for all new work. The exchanges have been designed to serve thinly populated districts, the telephone needs of which render it difficult to provide an economic uniform 24-hour service

with a manual exchange. The subscribers can be provided with direct dialling facilities to other exchanges and the need for a local assistance operator is obviated by extending subscribers to the manual board at a larger exchange when the assistance code is dialled. In practice, the larger exchange would usually be situated in the nearest town or city and provide the U.A.X. with both normal auto-manual board facilities and, if automatic, switching equipment for the directly dialled calls to other exchanges. The U.A.X. subscriber dials the digit 9 to gain access to a 1st selector at the 'parent' exchange and follows this with the advertized code for the particular exchange. The U.A.X. No. 13 has a 3-digit subscribers' numbering scheme and the switching arrangement has been developed to allow for up to 800 subscribers. There is one group selector and a final selector used on a subscriber to subscriber local connexion. The equipment is designed on a unit basis, each unit contained in a metal cabinet suitable for installation in an unheated building.

The Non-Director

The standard type of Non-Director exchange has a switching arrangement similar to that shown in Fig. 20, and each selecting stage is actuated directly by the pulses from the calling subscriber's dial. When the number of lines provided by the 4-digit scheme is not sufficient, one or two stages of group selectors are added to the switching arrangement thereby providing exchanges which have 5- or 6- digit subscribers' numbering schemes and practical capacities of 60,000 or 600,000 lines respectively. The size of an exchange in terms of equipment and number of subscribers is governed by factors amongst which are maintenance organization, building costs and the subscribers line plant arrangements. In general, irrespective of the numbering scheme employed and the telephone density of the locality, it is not desirable to provide for much above 10,000 subscribers in one exchange. In a large town or city, however, it is likely that there will be more than 10,000 subscribers who are possibly spread over a wide area. These can easily be provided for by a number of suitably positioned exchanges, but for convenience it is required that the same digits be dialled for a particular subscriber irrespective of the part of the town or city in which the call is originated.

In practice the problem is resolved by making the area to be served into a 'linked numbering scheme'. Each of the exchanges is allocated a block of numbers in a 5- or a 6- digit scheme, and the switching is arranged so that the first one or two digits in a subscriber's number route the call over a 1st selector, or a 1st and 2nd selector, at the originating exchange to a 2nd or 3rd selector respectively in the exchange to which the particular subscriber is connected. Such an arrangement requires that there are groups of lines from the appropriate levels of the 1st or 2nd selectors at each exchange to 2nd or 3rd selectors respectively at all the other exchanges in the scheme. One exchange, usually that which serves the business area, accommodates an auto-manual switchboard which provides assistance and other facilities to the exchanges in the scheme, and also to any U.A.X. or small non-director outside the linked numbering scheme. The lines to and from other exchanges in the telephone system also terminate in this 'main' exchange.

When the linked numbering system was introduced in the 1920's, it was an economic necessity to minimize both the line plant employed between the exchanges and the number of switching stages physically employed in the exchanges. To this end a special type of two-motion 1st selector was employed at all but the main exchange and allowed for this exchange to act as a switching centre for all inter-exchange traffic. Thus groups of circuits between each and every exchange in the system were not required.

Exchanges provided with the special 1st selector, termed a Discriminating Selector Repeater, were known as 'satellite' exchanges in the linked numbering scheme. With the introduction of 2000-type equipment the satellite working arrangements were redesigned and schemes employing this and the earlier arrangements are still in service. The present standard system is that already outlined and although using more line plant, employs simpler and fewer variations of exchange plant and on a cost basis is the more economic.

The Director

The non-director type of linked numbering scheme is not suitable for the very large areas such as London because the inter-exchange line plant and exchange plant required for routing purposes is inefficiently employed. The inefficiency arises because direct routes between exchanges must be provided even when only infrequently used. The Director system has been developed to allow for direct connexions between exchanges only when justified, other connexions being indirectly completed through a special automatic switching centre termed a Tandem. Such a system, however, requires flexibility in the actual digits used to route a call from one exchange to another, thereby not allowing the common dialling code facility of the non-director linked numbering system. The flexibility and common dialling code are obtained in the Director system by providing each exchange with a device composed of selectors and relays known as a Director, which receives the digits dialled and translates them into pulse trains suitable to route the call from the particular exchange. The translation for any dialling code can be changed at will to suit changes in the routing arrangements of the system.

The Director system has a 7-digit linked numbering scheme, with each number advertized for convenience as 3 letters and 4 digits. The letters are the first three letters of the name of the exchange to which the particular subscriber is connected; a typical number is MANsion House 3946, or as dialled MAN 3946. Consequently the dial used in the Director system is labelled with both letters and figures as shown in Fig. 21.

R 31479

Fig. 21

It should be noted that in the Director system each exchange has a name, whereas in the non-director linked numbering schemes only the area has a name, usually the town or city.

Each exchange in the Director system may be considered as composed of two sections, one containing director equipment and selectors used only for routing and the other composed of an unrestricted 10,000 line switching arrangement. Lines incoming to the exchange terminate on 1st selectors in the line switching section.

London, Edinburgh, Birmingham, Glasgow, Liverpool and Manchester have Director systems, and it is not likely that any further systems of this type will be installed.

INTER-EXCHANGE CONNEXIONS

CIRCUIT ARRANGEMENT

As it is a fundamental requirement of a national telephone system that any one subscriber can be connected as required to any other subscriber, a network of lines or 'junctions' to link up the various exchanges is necessary. Moreover, such a network must be developed in accordance with a definite plan if the system is to work economically. The principles on which the network is based are as follows.

The U.K. is divided into a large number of group areas. Each area contains one particular exchange known as a group centre, which acts as a switching point for the majority of the inter-exchange traffic within its area, and also for the incoming and outgoing traffic to and from other areas. Fig. 22 shows a typical group area in which G is the group centre exchange. It should be remembered that the group centre may be the main exchange of a linked numbering scheme and not just an individual exchange as shown in the figure.

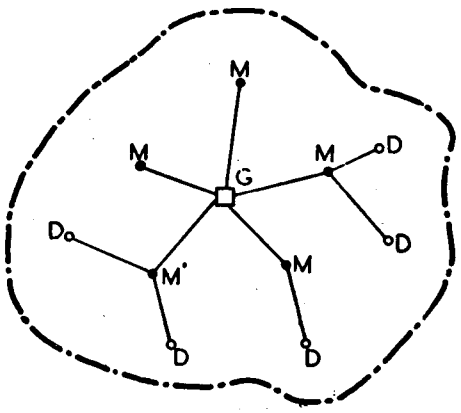


Fig. 22

It is not economical to provide direct routes between a group centre and every exchange in the area, and where direct routes are not provided traffic to the group centre is routed via an intermediate exchange having a direct route. An exchange having a direct route to its group centre is known as a 'Minor' exchange, whereas an exchange without such a direct route, being dependent on an intermediate exchange for its connexion is known as a dependent exchange. In Fig. 22 the minor exchanges are indicated by the letter M and the dependent exchanges by the letter D. Direct junctions between minor exchanges are provided only when justified by the amount of traffic.

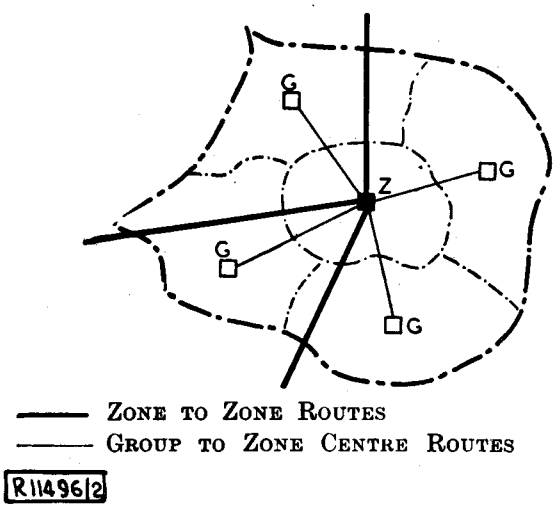


Fig. 23

As it is impracticable to inter-connect all group centre exchanges by means of direct routes, certain of the group centres which are suitably situated are selected to serve as trunk circuit, i.e. long distance junction circuit, switching centres. These selected trunk switching centres serve their adjoining group centres for calls to and from similar large areas as shown in Fig. 23. The large areas are known as zones and the trunk switching centres as 'zone centre' exchanges. Of the group centres 19 are also zone centres. The map in Fig. 24 shows the disposition of the zone centres and their boundaries.

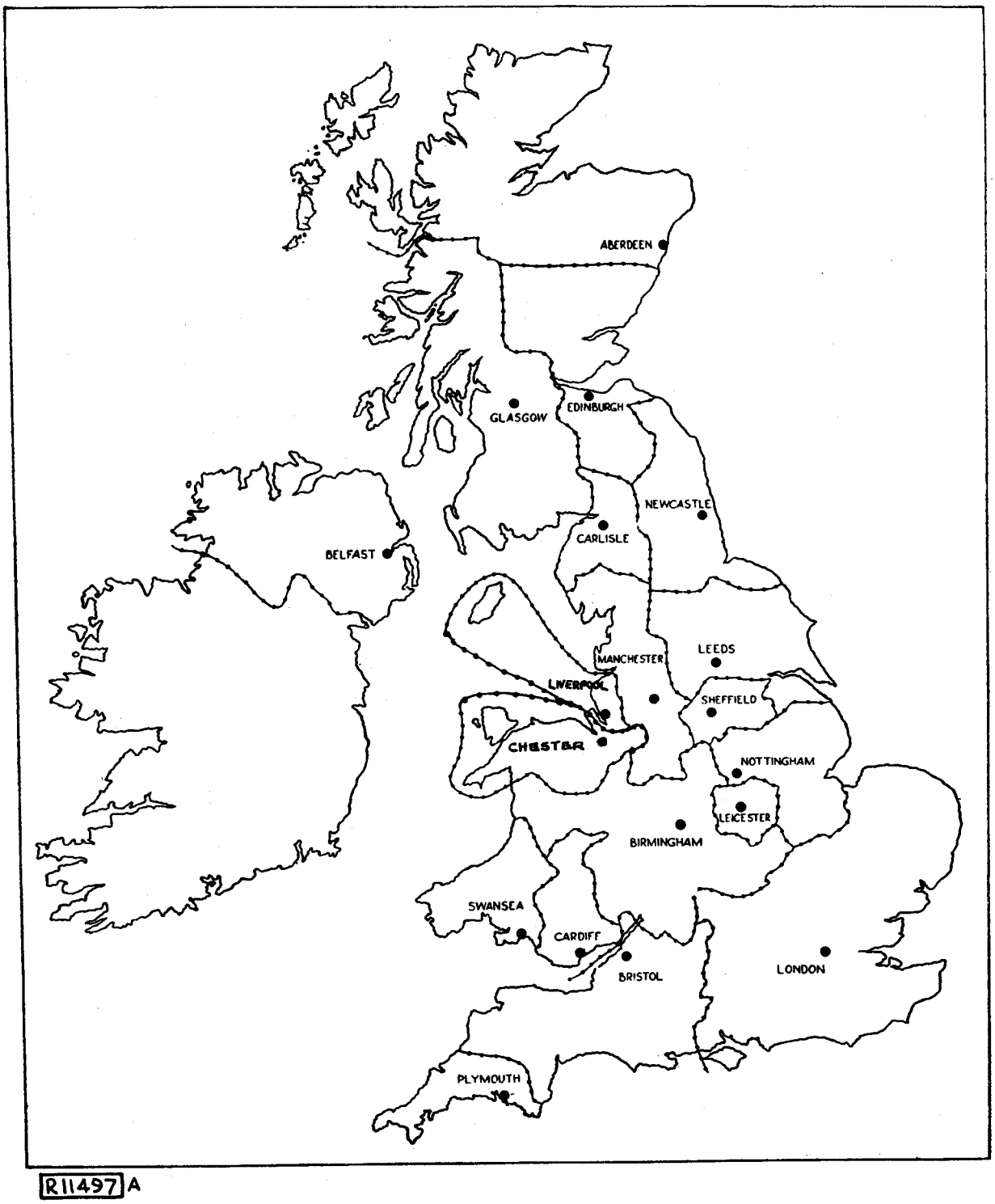

ABERDEEN
GLASGOW
EDINBURGH
NEWCASTLE
CARLISLE
BELFAST
MANCHESTER
LEEDS
LIVERPOOL
SHEFFIELD
CHESTER
NOTTINGHAM
LEICESTER
BIRMINGHAM
SWANSEA
CARDIFF
BRISTOL
LONDON
PLYMOUTH
R11497 A

Fig. 24

Group centres are connected to their appropriate zone centre by direct lines, and the zone centres are connected with each other by high grade trunk lines. Direct routes are provided between group centres when justified by the amount of traffic, as by this arrangement the inter-group traffic can be handled without being passed through zone centres. For this reason a group centre may also have routes to zone centres other than its own and to group centres in other zones.

The maximum number of inter-exchange connexions used on one call is when the call is between a subscriber on a dependent exchange in one zone to a subscriber on a similar exchange in another zone. The connexion is shown in Fig. 25.

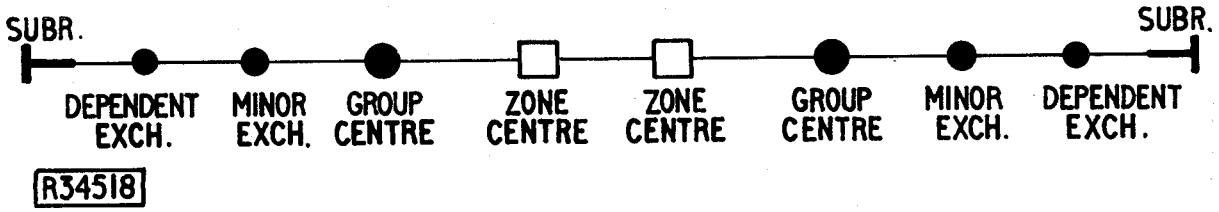


Fig. 25

Originally the trunk circuit network had its own exclusive manually operated exchanges, each of which had circuits to the public exchanges within its area. When the Post Office obtained full control of the telephone system, the number of direct inter-exchange routes were increased and the majority of the trunk exchange switchboards combined with those of the nearest public exchanges. Each trunk circuit was expensive to provide and carried only one conversation at a time, therefore to keep the cost of the service within reasonable limits enough circuits were provided to handle only the average traffic. Trunk calls were booked with an operator and the caller was rung back when the connexion had been established, usually after a delay of some 15 minutes or more during the busy hour. The method of working was known as 'Delay' and at the trunk exchanges the switchboards consisted of record, or booking, positions and a number of operating positions each having exclusive circuits to distant exchanges.

The introduction of the thermionic speech amplifier in the early 1920's, increased the transmission qualities of circuits and allowed the use on trunk circuits of 40 lb and 25 lb per mile conductors made up into underground cables. It should be appreciated that originally the only power in the line was that generated in the transmitter circuit of the caller's telephone. Thus to keep the received speech at an audible level it was necessary to use 800 lb to the mile copper conductors on the longer circuits;; one of the earlier London to Birmingham cables had 150 lb and 200 lb to the mile conductors.

The improved transmission over trunk circuits allowed the introduction of the group system as previously explained, and each operator at the group centre trunk exchange was given access by the multiple system to all outgoing circuits.

To facilitate each position working into circuits having different signalling characteristics, a new type of switchboard circuitry known as sleeve control was introduced and is now standard for all trunk and auto-manual switchboards. In 1930, with the use of improved traffic routing made possible by the group system, the delay method of working gave way to a limited amount of 'Demand' working in which the connexion is completed whilst the caller waits on the line. At the present time the whole of the trunk network, and consequently the whole of the system is worked on a demand basis.

The great step forward in the economic provision of long distance trunk circuits occurred in the middle 1930's with the introduction of carrier working. Basically, carrier working involves dividing the effective frequency band capable of being transmitted over a pair of wires into a number of channels each some 4 kc/s wide, and then by a process of frequency changing, mixing and filtering, use each channel as a speech path. After a period of development a system was evolved which provided twelve uni-directional speech paths over one pair of wires, a practical two-way arrangement being formed with two systems. In 1938 a cable capable of carrying some hundreds of speech channels on each pair of conductors was laid between London and Birmingham. Each of the four pairs of conductors in the cable consist of an inner copper wire centrally located within a copper tube, so forming what is known as a coaxial pair, or tube. At the present time there is an extensive network of coaxial systems in the U.K. and they serve as transmission paths for television signals as well as speech and music.

Circuit switching

Subscribers on manual exchanges must, of course, have the assistance of an operator to complete all calls, subscribers on even the earliest automatic exchanges, however, were given direct dialling facilities to operators at nearby manual exchanges and subscribers on nearby automatic exchanges. The operators at public and trunk exchanges were also given direct dialling facilities into automatic exchanges when there was a conducting path of a resistance suitable for one of the direct current dialling systems. The routing of a connexion over the trunk network, however, was by manual switching at each stage with the control of the connexion vested in the originating group centre operator.

The limits of direct dialling were increased by improvements to equipment and signalling techniques but did not embrace all circuits providing a d.c. path. It should be noted that amplifiers and transformers can be by-passed for the purposes of d.c. signals without interference to speech. In 1933 a system employing two voice-frequency tones, 600 c/s and 750 c/s, was introduced to provide supervisory signals on trunk circuits over which d.c. signalling was not possible. After a period of development a 2 V.F. signalling and dialling system was evolved and in 1939 introduced to enable a zone trunk operator to dial directly the subscribers on the distant zone centre exchange. As an example, the Bristol trunk operator could dial directly subscribers in the London director areas.

Within a short time, the 2 V.F. dialling facility was extended to enable zone centre operators to directly contact by dialling special codes, the operators at minor exchanges in the distant zone. The dialled codes operated selectors in an automatic switching arrangement associated with the distant zone centre trunk exchange. In 1944 a group centre in the Bristol zone was given access via selectors at the zone centre to the Bristol - London 2 V.F. route. The particular group centre operator was then able to dial directly subscribers in the London director area. At Leeds in 1947, group centre operators in the zone were given access to the zone to zone 2 V.F. routes radiating from Leeds.

It was a logical step from the extension of the 2 V.F. dialling facilities to a fully automatic trunk switching system in which a controlling operator could route a trunk call to the objective exchange without the intervention of an operator. The automatic trunk system has developed on non-director principles so that the number routing digits and therefore the equipment, required to gain access to the busy routes can be kept low. At least one non-director switching centre is provided at each zone centre, and these exchanges will provide public exchanges within the zone with access to the trunk network, and circuits from other zones with access to the public exchanges.

The main advantages offered by trunk mechanization are:-

(i) Reduction in the number of operators required to handle trunk calls; this also results in a saving of switchboards and building costs.

(ii) A reduction in the total time taken to set up a call.

The aim of a mechanized trunk system is to enable the operator who answers the calling subscriber to reach the called subscriber entirely by automatic means, this cannot of course be achieved until all exchanges in the country are converted to automatic working.

Trunk mechanization is the intermediate stage in the mechanization, or automation, of the telephone system in the U.K.; it is overlapping the local exchange conversion programme and is itself overlapped by subscriber trunk dialling (S.T.D.).

Subscriber Trunk Dialling

To obtain the maximum benefit from automatic switching equipment subscribers should complete as many calls as possible without the intervention of an operator. The scheme under which this is made possible is known as Subscriber Trunk Dialling (S.T.D.), and when completed any subscriber will have access by direct dialling to any other subscriber. Ultimately every subscriber will have a national number which will be used on trunk calls, and this number will be in two parts,

(a) A series of figures and letters to route the call and determine the call charge rate and,

(b) The existing local number.

The first digit of the national number is 0 and routes the caller to the S.T.D. group, routing and charging equipment (G.R.A.C.E.). The remaining figures and letters to identify the required exchange are received and translated by the S.T.D. equipment to a suitable train of digits to route the call; the local number is received by the equipment, stored and transmitted after the routing digits.

The national numbers of all subscribers on the London director system is 01 followed by the existing three letter and four numerical digits, e.g. London CEN 1234 has the national number 01 CEN 1234, a total of 9 digits. Other director systems such as at Manchester and Edinburgh have national numbers consisting of 0 followed by two figures and the existing seven digit numbers.

The large non-director systems in other provincial centres have national numbers in which 0 is followed by two letters, a figure and then the local number, e.g. Leeds 45678 is 0 LE 2 45678. For the purposes of S.T.D. the country has been divided into some 650 areas, the majority of which have an average radius of 7 miles, and a three digit code following 0 is allocated to each area. One or two additional code digits are then allocated to follow the three already mentioned so that the particular exchange within the area may be identified.

The use of letters in the national numbers means that eventually all subscribers' telephones will be fitted with the letter-type dial shown in Fig. 21. Because 0 is the initial digit of the national numbers the code 100 has been introduced at exchanges having S.T.D. facilities, as the code for the operator.

TELEPHONE TARIFF

The method of charging for telephone service in the U.K. is based on a system known as the 'message rate' which involves a fixed rental charge for the installation and uniform charges for effective calls. In addition to the rental and call charges, there is an initial charge to cover the cost of installing the equipment.

The main factors affecting the rental charge are as follows:-

(i) The equipment provided at the subscriber's premises.

(ii) Whether the telephone is to be used for business or private, termed residential, purposes.

(iii) The radial distance of the subscriber's premises from the telephone exchange; an additional charge is made for each furlong beyond 3 miles.

The present annual rental for a line of 3 miles or less in length and a single telephone instrument is £14 for a residential subscriber and £16 for a business subscriber.

Originally call charges were calculated on the distance between the two exchanges concerned, consequently each exchange had its own scale of charges, and time was only introduced as a charging factor when the distance exceeded some 25 miles. The present system has been designed to reduce the number of scales of charges, thereby simplifying the design of the automatic equipment required in the scheme to fully mechanize telephone switching. The exchanges in the U.K. are arranged into some 600 groups and the charges for calls other than those between exchanges in the same or adjacent groups are based on the distance between the centres of the appropriate groups. Time is a charging factor in all calls made from exchanges having S.T.D. facilities.

END