AUTOMATIC TELEPHONY—NON-DIRECTOR MULTI-EXCHANGE AREAS

Trunking Principles

INTRODUCTION

In making provision for automatic telephony in this country there are three distributions of community to be considered, as follows :—

(*a*) Large towns of differing telephone density. Usually, each town is served by a number of non-director exchanges, and is known as a " non-director multi-exchange area." The trunking, that is, the interconnexion between the various ranks of selectors in each exchange, and the interconnexion of exchanges of this type, is dealt with in this Pamphlet.

(*b*) Small towns and villages of low telephone density mainly served by Unit Automatic Exchanges, the trunking of which is dealt with in Educational Pamphlet, Telephones 4/1.

(*c*) Very large cities which, owing to their high telephone density and consequent large number of exchanges, need a special system. This system, known as the " director system," is dealt with in Educational Pamphlet, Telephones 5/1.

TELEPHONE REQUIREMENTS PARTICULAR TO NON-DIRECTOR MULTI-EXCHANGE AREAS

Usually, non-director multi-exchange areas have a business and industrial centre or centres, surrounded by a belt containing residential and small business communities. The number of telephones per unit area, known as the " telephone density," is highest in the centre of such towns where factories and business houses are located, while in the residential belt the telephone density is usually comparatively low.

The telephone needs of such an area could be met either by providing one large exchange to serve the whole of the area, or by providing a number of exchanges each situated near the centre of the particular community it serves. The economics of the two methods of provision are studied to decide which arrangement is suitable, taking into account the cost of cabling (both existing and new), buildings, switching equipment, etc. If the area to be served is geographically small, and the telephone density diminishes fairly smoothly from the centre of the area, it is usual to provide a single exchange ; if, however, the area is large and the telephone density distinctly high in different parts of the area, it is usual to provide two or more exchanges.

Although a number of exchanges may be necessary to serve the subscribers in a large town it is not essential that each exchange should have its own self-contained numbering scheme. Usually the whole of the area is served by one numbering scheme, e.g. 2,000 to 8,999, of which, say, 2,000–5,999 is allotted to exchange A and 6,000–6,999, 7,000–7,999 and 8,000–8,999 to exchanges B, C and D, respectively. A scheme such as this is known as a " common " or " linked " numbering scheme, as distinct from a self-contained numbering scheme in which the same group of numbers may be used for more than one exchange. It will be apparent that so far as the subscribers are aware, they are all connected to one exchange, as exchange names are not used in passing calls between subscribers in the same area. This simplifies the subscriber's operations, and is usually economical from an engineering aspect. There is a limit to the size of the area that may be thus treated and, as explained in E.P. Telephones 5/1, the director system is employed for areas in which the telephone density is very high and in which there is a large number of exchanges.

Fig. 1 shows a typical non-director multi-exchange area served by four exchanges, A, B, C and D. As exchange A serves the dense central portion of the area and is normally the largest of the four exchanges, it is known as the " main " exchange. Exchanges B, C and D share the numbering scheme with the main exchange and are known as " satellite " exchanges. They may be regarded as isolated portions of the main exchange equipment linked to that exchange by means of junction routes, indicated by the full lines in the figure. The advantage of isolation is a reduction in the average length of subscribers' lines.

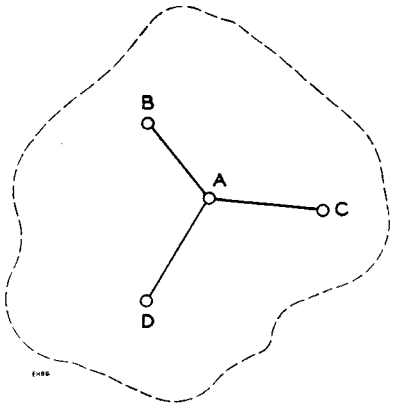

FIG. 1

Outside the area served by the common numbering scheme there are usually small towns and villages, the telephone needs of which are met by exchanges having self-contained numbering schemes. Communication between the large town and these self-contained exchanges is effected over junction routes to which the subscribers gain access by dialling a code number (dialling-code), followed by the called subscriber's number.

RESTRICTIONS TO THE NUMBERING SCHEME OF MAIN AND SATELLITE EXCHANGES

The numbering scheme of a main exchange and its satellites is restricted owing to the reservation of certain of the selector levels for special services, junctions, etc.

The digits 1, 9 and 0 cannot be used as the first digit of a subscriber's number, for the following reasons :—

(*a*) Level 1 of the 1st selectors at the main exchange is always connected to N.U. tone because it is reached as a result of dialling any number commencing with '1' and there is a possibility of calls being misrouted over this level by a false impulse which may be produced by line faults (e.g. an intermittent short-circuit), or by an accidental flick of the telephone rest as a subscriber lifts the receiver to make a call.

(*b*) A number of special services such as 'Test Desk,' 'Service P.B.X.,' 'Directory Inquiry,' 'Phonograms,' etc. must be provided and access to any one of these is obtained by dialling '9' followed by an additional digit or digits, depending on the particular service required ; these calls are routed via 1st and 2nd selectors at the main exchange and, if the number of services exceeds ten, through 3rd selectors.

(*c*) The assistance of an operator is required by subscribers for toll and trunk calls, etc. and it is desirable that access to the auto-manual switchboard shall be gained with a minimum of dialling. It is therefore arranged that subscribers obtain the assistance of the operator by dialling the single digit 'O.'

From the foregoing it will be seen that seven levels of the 1st selectors remain available for local calls and calls to other exchanges in the area. As a result of this the digits 2–8 only may be used, either as initial digits in the subscribers' numbering scheme or as the code prefix for the routing of junction calls.

MIXED FOUR- AND FIVE-DIGIT NUMBERING

In deciding the numbering scheme for an automatic exchange area, allowance is made for the number of lines which will exist in the area ultimately (i.e. say twenty years after the area is converted to automatic working). It is therefore necessary to adopt, at the outset, a numbering scheme which can easily be expanded to meet the growing needs of an area, so that it will not be necessary to change the subscribers' numbers when additional exchanges are provided, or as the number of subscribers' lines in existing exchanges increases.

It is not always possible, however, to forecast with certainty the requirements of an area or exchange, and, in a particular case, it may be found necessary to increase the number of lines connected to an exchange above that for which the switching equipment and numbering scheme were originally designed. **Fig. 2** shows a trunking diagram of a main and a satellite exchange. Levels 2, 3, 4 and 5 of the selectors at the main exchange are in use, and the selectors at the satellite exchange are fully equipped with final selectors (the need for the reservation of level 'O' will be made clear later in this Pamphlet).

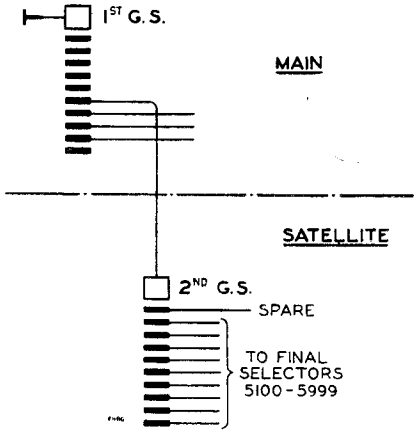

FIG. 2

The numbering range of the satellite is 5,100–5,999, and 900 lines are thus available. Suppose it is desired to increase this number to 1,500 ; as level 6 is spare at the main exchange, a separate group of junctions could be provided from this level, to an additional rank of 2nd selectors at the satellite exchange, and the six additional groups of final selectors could be served from the banks of these selectors (see **Fig. 3**).

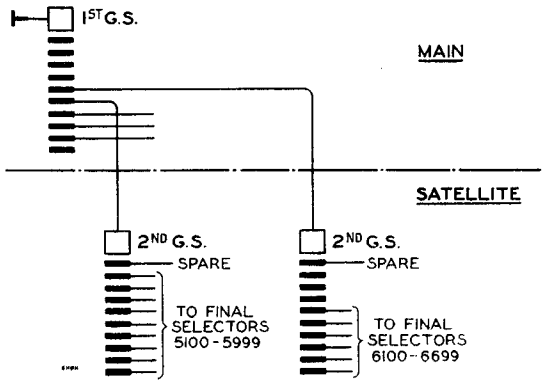

FIG. 3

This method of providing the additional equipment, however, has serious objections. Level 6 at the main exchange is no longer available should a junction route to a new exchange be needed, and the splitting of the traffic to the satellite over two groups of junctions necessitates a larger number of junctions than would be required if they were all in one group. The reason for this increase in the number of junctions is that the traffic-carrying capacity of a junction

group is not directly proportional to its size; for example, a group of five junctions will carry only 0·9 traffic unit, but seven junctions will carry 1·8 units, i.e. twice as much.

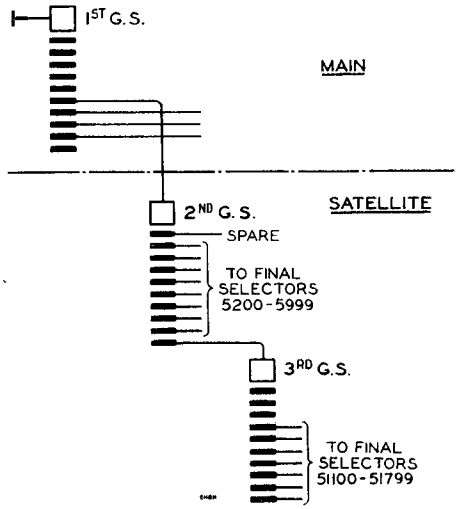

FIG. 4

An alternative method of providing the additional equipment is shown in **Fig. 4.** At the satellite, the first level of the 2nd selectors, which in Fig. 2 is connected to one group of final selectors, is now connected to 3rd selectors, which have access to seven groups of final selectors. As three switching stages are needed to obtain access to any of the seven groups, the subscribers' numbers in these groups will contain five digits, viz. 51,100–51,799. The final-selector groups served directly from the banks of the 2nd selectors provide access to four-digit numbers, viz. 5,200–5,999, as only two switching stages are necessary to reach them. This method is free from the disadvantage of that shown in Fig. 3, because the main-exchange equipment is not affected and only one junction group to the satellite is necessary.

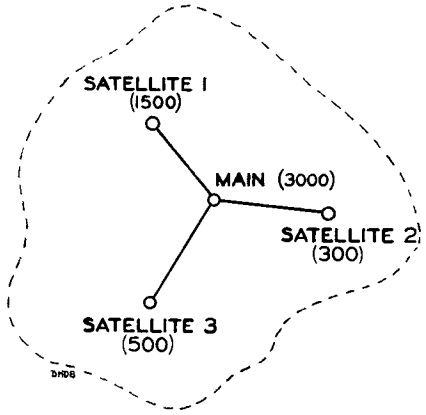

FIG. 5

TRUNKING SCHEMES FOR MAIN AND SATELLITE EXCHANGES

The problems associated with the trunking scheme of a main exchange and its satellites will be studied for the typical area shown in **Fig. 5.** This shows a main exchange and three satellites, the figures in brackets indicating how many numbers are to be assigned to each exchange. Consideration will first be given to traffic originated at the main exchange.

Provision must be made for a total of 5,300 numbers in the area and a four-digit numbering scheme could be used. A simple method is to allocate one or more blocks of 1,000 numbers to each exchange, so that the first digit causes the call to be routed from a level of a group selector at the main exchange to a 2nd selector in the required exchange. A trunking scheme employing this method is shown in **Fig. 6.**

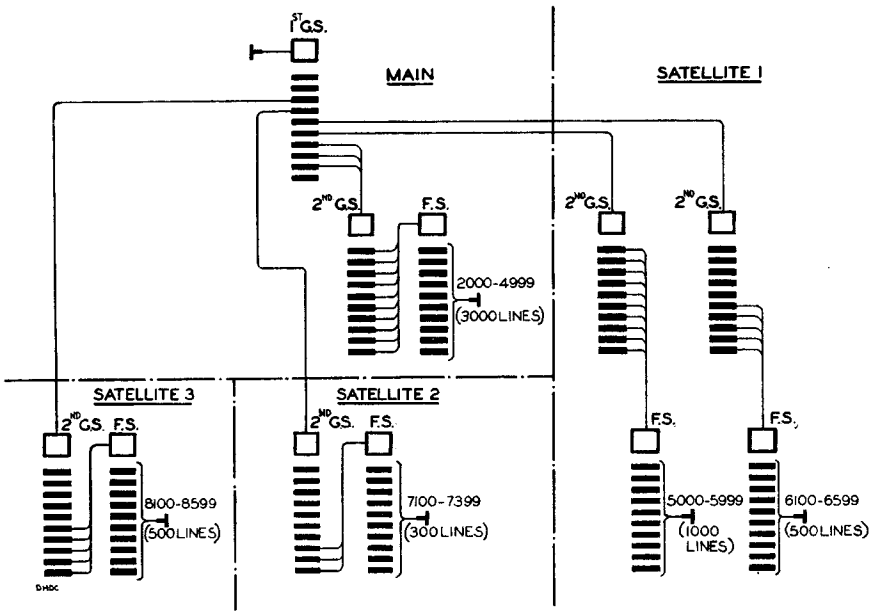

FIG. 6

There are, however, certain disadvantages in the scheme shown in Fig. 6. All the available levels of the 1st selectors at the main exchange are in use (1, 9 and 0 being permanently allocated), so that no further levels are available for outlets to other exchanges. Further, of the 1,000 numbers allocated to satellite 2 only 300 will be required and the remaining 700 will not be available for the future development of another exchange. Similarly, a total of 1,000 of the numbers allocated to satellites 1 and 3 are tied up for the use of these satellites only.

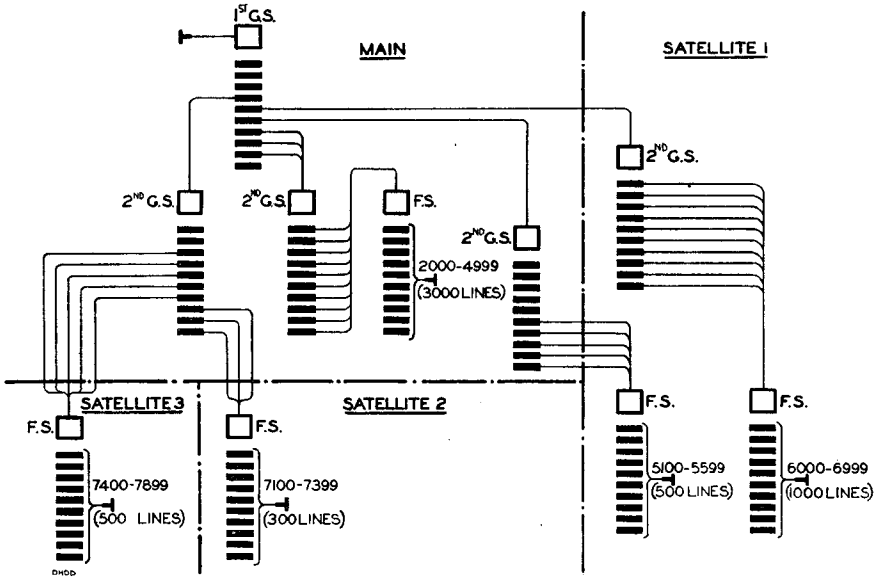

FIG. 7

An alternative arrangement, which overcomes these objections, is shown in **Fig. 7.** Calls to satellites 2 and 3 and to 500 lines in satellite 1, are routed via 2nd selectors at the main exchange, this being equivalent to moving certain of the 2nd selectors from the satellites to the main exchange. By changing the numbering scheme of satellite 3 from 8100–8599 to 7400–7899, level 8 of the 1st selectors is made spare and, in addition to this level, seven levels on the 2nd selectors are freed for other uses, such as future development.

This scheme has the disadvantage that fourteen separate junction groups are required, as compared with the four groups of the arrangement shown in Fig. 6. As already explained, a junction in a large group has a greater traffic-carrying capacity than one in a small group, so that to obtain maximum efficiency from a given number of junctions it is essential that the number of junction groups formed shall be kept to a minimum.

A more flexible numbering scheme is necessary to overcome the disadvantages of the foregoing trunking arrangements and can be obtained by using both 4-and 5-digit numbers, i.e. a mixed numbering scheme. A trunking diagram in which this principle

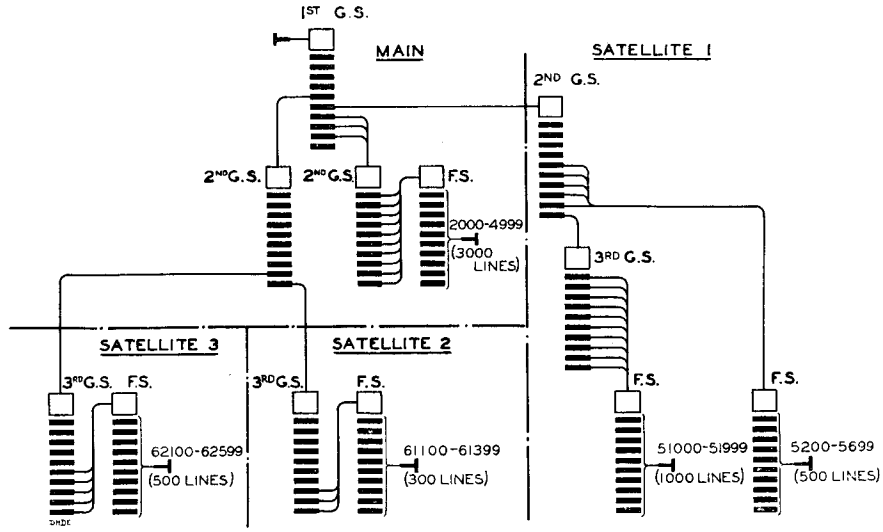

FIG. 8

is used is shown in **Fig. 8.** Calls to the small satellites 2 and 3 are routed through the 2nd selectors at the main exchange as in Fig. 7, but the use of 5-digit numbers in the satellites allows all calls to be routed over a common junction group in each case. The 1,500 subscribers in satellite 1 are served from level 5 of the 1st selectors, only one junction group to this exchange being required as compared with the two groups of Fig. 6 and six groups of Fig. 7. It is not necessary, however, to give every subscriber in satellite 1 a number having five digits; some final-selector groups are connected direct to 2nd-selector levels, and subscribers served by these groups will have four-digit numbers.

These arrangements are summarized in Tables 1 and 2. The arrangement illustrated in Fig. 8 is typical of the trunking of a non-director area.

Satellite Exchanges

Outgoing calls from subscribers connected to satellite exchanges could be routed via selector levels at the satellite exchange to junctions giving direct access to the other exchanges in the area, but this would require a large number of small junction routes which would not be economical. An alternative method of working which overcomes this objection is shown in **Fig. 9.** All outgoing calls originated by satellite subscribers are connected via junctions to 1st selectors at the main exchange. Two groups of junctions are then required between each satellite and the main exchange, one group carrying outgoing and the other incoming traffic. Local calls thus pass to the main-exchange selectors for switching, and require an outgoing and an incoming junction for completion. This method of working, in which all calls are routed via the main exchange, is known as "full-satellite working."

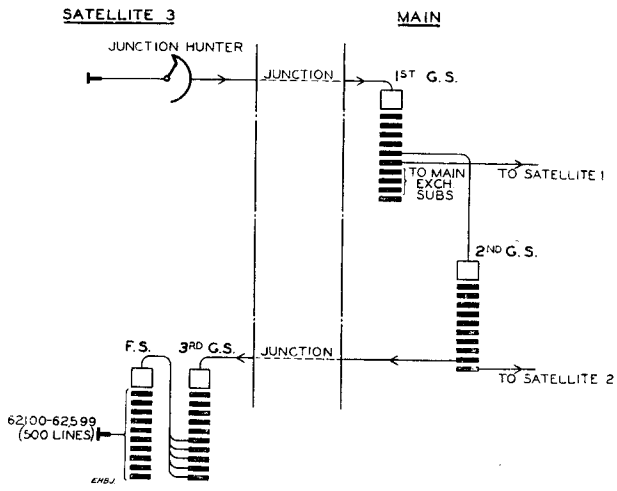

FIG. 9

TABLE 1

Exchange	Subscribers' Numbers		
	Scheme Fig. 6	Scheme Fig. 7	Scheme Fig. 8
Main	2,000–4,999	2,000–4,999	2,000–4,999
Satellite 1	5,000–5,999 6,100–6,599	5,100–5,599 6,000–6,999	51,000–51,999 5,200–5,699
Satellite 2	7,100–7,399	7,100–7,399	61,100–61,399
Satellite 3	8,100–8,599	7,400–7,899	62,100–62,599

TABLE 2

Junction Groups from Main Exchange to :—	Scheme Fig. 6	Scheme Fig. 7	Scheme Fig. 8
Satellite 1	2	6	1
Satellite 2	1	3	1
Satellite 3	1	5	1

A method of working which dispenses with the use of junctions for local calls is shown in **Fig. 10.** The routing of the calls is controlled by a selector at the satellite exchange. This selector is equipped with apparatus which discriminates between local calls and calls for other exchanges and is, in consequence, known as a " discriminating selector." When the discriminating selector is seized, a junction hunter associated with this selector connects the calling line to a junction terminated on a 1st selector at the main exchange. The calling line is thus connected to a selector in both exchanges; the call is partially set up in each exchange and, when sufficient digits have been dialled to indicate the destination of the call, the unwanted portion is released.

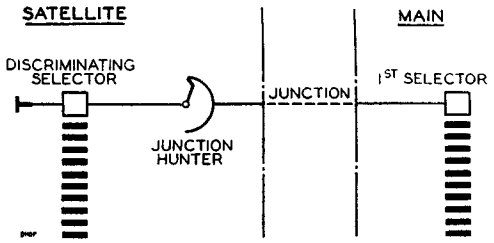

FIG. 10

The use of apparatus at the satellite exchange for discriminating between local calls and calls which must be routed via the main exchange obviously involves additional expenditure on switching equipment. On the other hand, this scheme will require fewer junctions than full-satellite working, since the local calls are not routed via both an outgoing and an incoming junction. The more economical scheme for a particular case can be determined by comparing the saving due to the provision of fewer junctions with the expense of providing additional switching equipment.

A trunking diagram suitable for the numbering scheme of satellite 1 and using discriminating selectors is shown in **Fig. 11.** The discriminating selector at the satellite exchange and the selector at the main exchange both respond to the first digit dialled by a calling subscriber at the satellite. If this is '5,' the discriminating selector releases the junction and routes the call to the local 2nd selector. If the first digit is other than '5' the junction route to the main exchange is held, the local route set up to the local selectors is abandoned, and the discriminating selector serves only to repeat impulse trains to the selectors at the main exchange.

Consideration of Fig. 11 shows that 2nd selectors are connected to only one level of the discriminating selectors, and, as all the numbers in the satellite have the same initial digit, i.e.'5,' this digit need serve only to discriminate between local- and main-exchange calls. The use of selectors solely to gain access to one rank of 2nd selectors is not necessary therefore, and an economy in switching plant can be obtained by arranging for the discriminating selectors to effect discrimination and then to respond to the second digit dialled, i.e. to act as 2nd selectors. With this arrangement, the initial digit is said to be " absorbed."

The trunking scheme rearranged to take advantage of the digit-absorbing facility is shown in **Fig. 12.** It should be noted that the first level of the discriminating selector is in use (since it is reached by the second digit dialled, and not by the first), and that some 2nd selectors are required for calls incoming to the satellite.

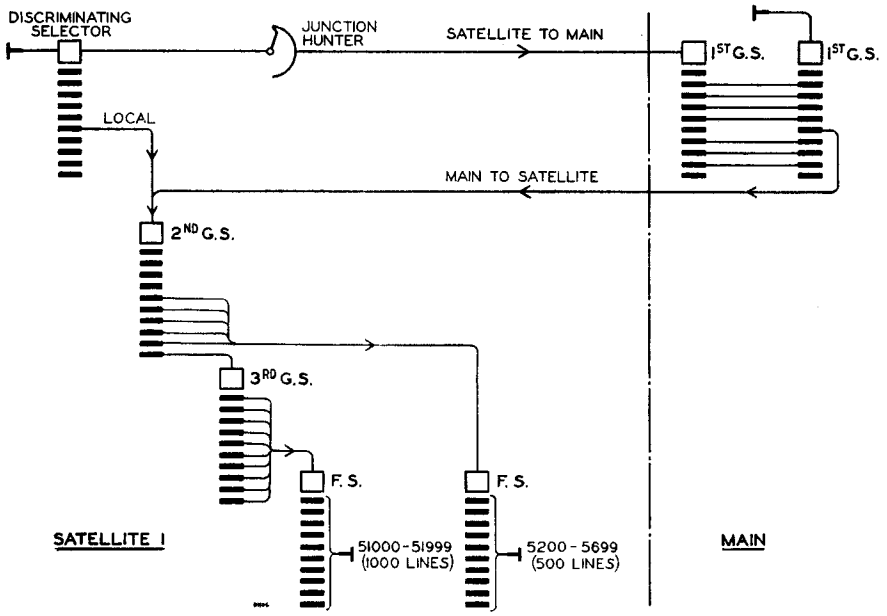

FIG. 11

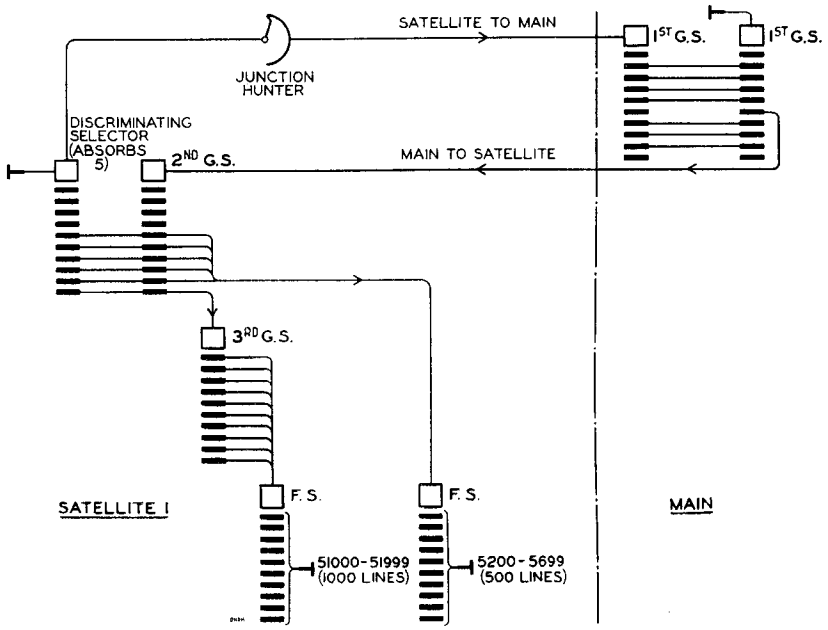

FIG. 12

A trunking diagram for satellite 2 is shown in **Fig. 13.** As the initial digit '6' is allocated to more than one exchange, the second digit indicates the destination of any call commencing with '6'; consequently, discrimination does not take place until the second digit has been dialled. In satellite 2, all numbers commence with '61,' and therefore both these digits are absorbed by the discriminating selector, which afterwards responds to the third digit dialled, i.e. acts as a 3rd selector.

The trunking arrangements for satellite 3 are similar to those of satellite 2, with the exception that local discrimination occurs when '62' is dialled.

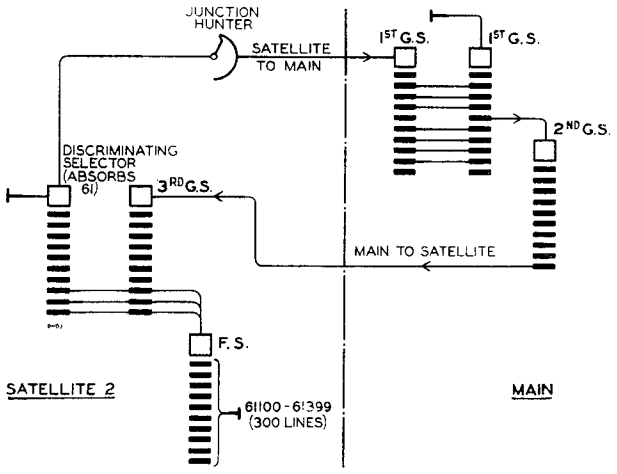

FIG. 13

AUTO-MANUAL SWITCHBOARDS

Manual switchboards are necessary for dealing with inquiries, special services, long-distance calls, etc. even when an area is converted to automatic working. These switchboards are known as "auto-manual switchboards." Subscribers gain access to the auto-manual Positions dealing with the class of service required by dialling special codes such as '0' for Toll or Trunk calls, '90' for Phonograms, '91' for Inquiries, etc.

The '0'-level circuits are used for originating trunk calls and, if such calls were routed through the 1st selectors at the main exchange in common with other junction traffic, all the outgoing junctions served by the satellite junction hunters would have to be of high transmission efficiency. These high-grade junctions are more expensive than normal junctions, however, and it is uneconomical to use them for every type of call; a separate junction group is therefore provided for '0'-level traffic, these junctions being connected to the '0' level of the discriminating selector, as shown in **Fig. 14.** When a caller dials '0,' local discrimination takes place, and a junction on the '0' level of the discriminating selector is engaged. For similar reasons a separate group of high-grade junctions is provided for calls incoming to the satellite exchange from the auto-manual switchboard, as shown in Fig. 14. It should be noted that, by routing traffic to the auto-manual switchboard over the '0' level, a restriction is placed on the satellite numbering scheme as the '0' level is reserved for this purpose. For example in satellite 1, numbers commencing with '50' cannot be used. A further point of interest is that the out-

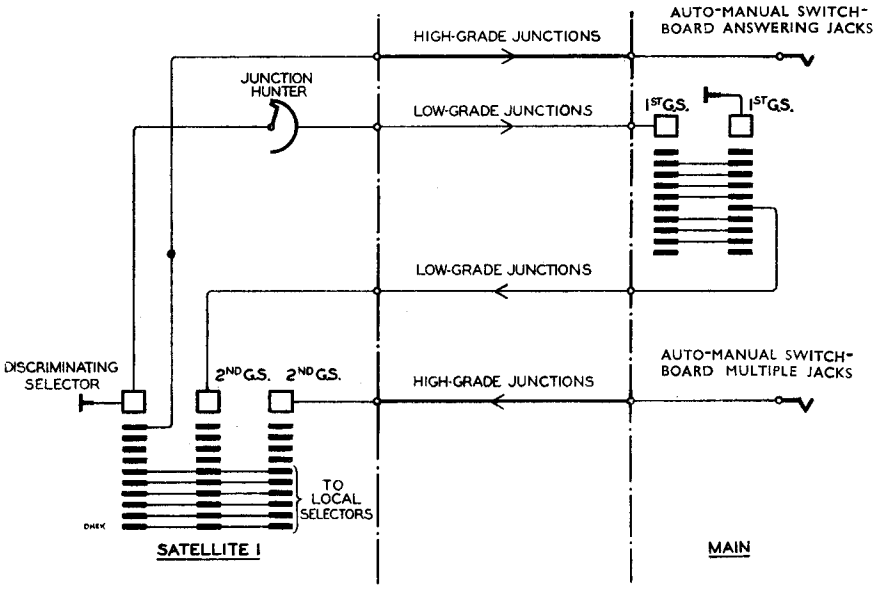

FIG. 14

going multiple jacks at the auto-manual switchboard can be connected direct to 2nd selectors, in which case the operator does not dial the initial digit of the subscriber's number.

Coin-box Lines

When a call to the auto-manual switchboard is originated on a coin-box line, it is essential that the operator should be made aware of the class of line being used, so that any fee necessary for the call may be collected from the user. Two methods of working are adopted to effect distinction at the auto-manual switchboard between calls from ordinary and calls from coin-box lines :—

(*a*) separate groups of '0'-level circuits are provided from 1st selectors for ordinary and for coin-box lines ; thus, there are 1st selectors individual to each class of line as shown in **Fig. 15.**

(*b*) common circuits are provided, each having two separate calling lamps ; the circuits of the line and '0'-level calling equipments being arranged so that one lamp lights for calls from ordinary lines and the other for calls from coin-box lines.

Method (*a*) is generally used where the routing is purely internal. Where junction circuits are involved, however, method (*b*) is usually more economical than (*a*).

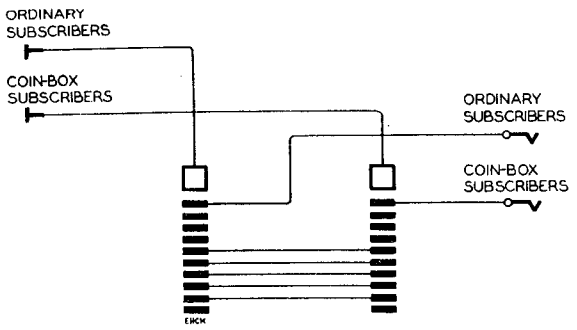

FIG. 15

END

LONDON
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses
York House, Kingsway, London, W.C.2 ; 120 George Street, Edinburgh 2;
26 York Street, Manchester 1; 1 St. Andrew's Crescent, Cardiff;
80 Chichester Street, Belfast;
or through any bookseller
1939
[Price 4d. net.]

Printed under the authority of His Majesty's Stationery Office
by HARRISON & SONS, LTD., 44 to 47, St. Martin's Lane, London, W.C.2.

S.O. Code No. 43-159 3 1

(404/8870) Wt. 3488—542 27,500 3/39 H & S Ltd. **Gp. 404**