No. 163

The Institution of Post Office Electrical Engineers.

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H. E. FRANCIS

A Paper read before the Scotland East Centre of the Institution on the 21st April, 1936, and at other Centres during the Session.

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Synopsis.

This paper deals with the practical application of trunking principles to the design of automatic exchanges. It covers all types of modern exchanges and shows how trunking schemes and exchange plant provision are derived from the traffic data supplied to the Engineering Department. Owing to the large scope of the subject all detail work has been placed in the appendices while the paper itself deals chiefly with principles and contains information gained from experience over several years in the design of automatic exchanges. The various types of trunking schemes at present in use have been dealt with fully. As the design of a director exchange is in many respects very different from that of a non-director exchange, examples of each type have been used throughout to illustrate the various points. It is hoped also that the many schematic diagrams employed will be useful in following the various phases of the subject outlined in the paper.

Introduction.

(*a*) *General.*

The design of Automatic Exchanges is similar in many respects to the work done by an architect in designing a large building. An architect must know what accommodation and requirements he is expected to provide. His materials consist of steel, concrete, bricks, etc., and it is his job to use them in such a way that the building shall be of the correct size and give all the facilities required in the most economical manner. The design of an exchange has a similar objective. Certain fundamental information has to be obtained, such as the number of lines to be catered for, the traffic that they are likely to originate and receive, and a list of the required facilities. To enable this to be done the designer has at his disposal certain types of automatic exchange apparatus, each part having definite functions, and he has to utilise these in such a way—*i.e.*, in amount and arrangement—as to provide the desired facilities. This is termed trunking, and it is the object of this paper to show how the " trunking architect " uses his " materials " and knowledge of trunking principles to produce a design for a modern type of Automatic Exchange.

(*b*) *Traffic Studies.*

Most Automatic Exchanges are either conversions from existing manual exchanges, or new ones created by dividing up existing manual exchange areas. In either case the number of working subscribers, their type (Coin Box, P.B.X., etc.) and their probable originating and incoming traffic can be found by taking records from the manual exchange or exchanges concerned. An estimate has to be made of the growth of new subscribers' lines and of their probable type of traffic.

Usually a detailed survey is made of the telephonic possibilities of the existing property in the district, and enquiry made as to any future development such as town planning schemes or the building of factories which are likely to affect the case. This work is carried out by the District Manager's staff and, however carefully it is done, it is the point at which most error in the design is likely to arise.

The information is summarised and supplied to the Engineering Department in the form of Traffic data, examples of which are given in Appendix 1.

(*c*) *Design Periods.*

The economic life of Exchange Equipment is at least 20 years and therefore the future requirements for many years ahead have to be catered for. Individual cases may have to be treated specially, but usually a building site is acquired to provide for 20 years' growth from the date of opening of the exchange plus 50% increase of the essential requirements, while the building is erected to meet requirements for 20 years and should be capable of extension, either laterally or vertically.

Exchange equipment has in the past been installed for the three year period for racks, banks, cabling, etc., while selectors have been provided for two years' growth for new exchanges and one year for extensions. With this scheme a major extension should be required at each exchange every three years, but small additions of selector equipment will be required at frequent intervals to meet growth. The planning periods are, however, being reviewed at the present time.[1]

Trunking Schemes.

(*a*) *General.*

In the early exchanges, the numbering scheme constituted the subscribers' numbering range, together with one or two service codes such as enquiry and phonograms. As automatic exchanges grew in number and type, however, it became desirable that calls between adjacent exchanges should be dealt with on an automatic basis. In addition, in large towns which were more economically served by several exchanges, it became evident that some form of common numbering scheme was required. For example, two subscribers situated on opposite sides of the same street, but connected to two separate exchanges would expect to have the same telephone instructions, and to dial the same digits to obtain a third party.

Thus the early type of numbering scheme which allowed all the junction traffic to circulate *via* the manual board has given way to the more general type covering several exchanges. One method by which this has been achieved is by including the sub-

[1] Since the writing of this paper it has been decided that racks and banks shall be provided for 5 years and switches for 3 years on new exchanges and on extensions of exchanges.

scribers' numbers of the exchanges concerned in a common numbering range, *i.e.*, no two subscribers may have the same number even though they are connected to separate exchanges. This involves the use of 4 or 5 digit numbers, but even with a 5-digit scheme only about 50,000 or 60,000 numbers can be obtained, as the following levels of the 1st Selectors are unavailable for subscribers' numbers :—

Level 1 is never used as a first digit owing to false impulse difficulties. (There is an exception, however, in the 100 line type U.A.X. when it is reaching its capacity.)

Levels 7 *and* 8 are usually required for dialling out codes to exchanges within the 15 mile area.

Level 9 is required for access to special services.

Level 0 is always allocated for direct access to the manual board.

For very large areas such as London, Glasgow, Manchester, etc., where upwards of a million or more lines may be expected within the designing period, a 6 or 7 digit scheme becomes necessary. It is realised, however, that to remember a number of more than 5 digits, is too much to expect of the average subscriber. Therefore letters, as well as figures have been introduced and numbers of 3 letters and 4 digits are employed as in the Director system.

With the advent of Multi-Metering, the distance over which calls can be effected automatically has been increased to 15 miles, and as through dialling from Manual boards has also been applied on many exchanges recently, it will be appreciated that many different considerations have to be taken into account.

To avoid changing subscribers' numbers, it is usual to design a numbering scheme to meet all requirements during the economic life of an exchange and as much flexibility as possible is given to allow for contingencies.

(*b*) *Non-Director Area.*

At the present time trunking schemes for non-director exchanges are undergoing a big change, primarily on account of the introduction of multi-metering, and through dialling from manual and automatic exchanges. In view of this state of flux, many temporary arrangements are being used to meet the interim period before the change is complete, and are therefore only of passing interest. Throughout this paper an attempt has been made to anticipate the conditions which are likely to exist in the near future, but it is thought that this will not detract from its usefulness as a record of present day practice. The type of multi-metering equipment which has been assumed is similar to that used on the latest type of U.A.X. and is associated with the outgoing junctions.

In director areas multi-metering is already in use and the pending introduction of a mechanical toll scheme would not involve any new principles, so that there is little likelihood of any great change in this direction for some time. The principles involved in the formation of a trunking scheme are more easily explained by means of examples, and for this purpose a slightly modified arrangement of the Derby area has been taken. The area consists of a main exchange, four satellites, and two U.A.X's, while there are two existing manual exchanges which will be converted to U.A.X. type equipment at a later date. In addition, subscribers will be able to obtain automatically the 20 exchanges in the 5-15 mile belt, and other exchanges will require access to 13 routes beyond 15 miles. The main and satellite exchanges will come within a common subscribers' numbering range, codes being dialled to obtain all other exchanges. Table 1 shows the initial and ultimate multiple numbers required on the five exchanges and it will be seen that they total 5,100 and 10,700 respectively for the two periods.

TABLE I.

Numbering Scheme

Exchange	Initial Period.		Ultimate Period	
	Multiple	Numbering Scheme	Multiple	Numbering Scheme
Derby	3700	2000— 4999 50000—50699	7500	2000— 4999 50000—54499
		PBX 2/10=20, 22, 32, 36, 38, 42, 504 PBX 11/20=44		P.B X's ‡
Spondon (Satellite)	600	57100—57599 57700—57799 PBX 2/10=572 PBX 11/20=574	1200	57100—57599, 58000—58599 57700—57799 P B.X.'s ‡
Allestree ,,	300	59100—59399 PBX 2/10=592	700	59100—59799 P B X 's ‡
Mickleover ,,	300	55100—55399 PBX 2/10=552	800	55100—55899 P B X 's ‡
Alvaston ,,	200	56100—56299 PBX 2/10=562	500	56100—56599 P B.X 's ‡
Total	5100		10700	

‡ Ult P B X Units depends on how units are to be introduced in future extensions

DIALLING OUT CODES.

Exchange	Code Initial	Code Ult	Exchange	Code Initial	Code Ult	Exchange	Code Initial	Code Ult
0—5 miles.			*7½—10 miles*	D I only		Nottingham	81*	81
Duffield	61*	†	Ambergate	65	†	*Over 15 miles*		
Chelleston	66	†	Castle Donington	83	†			
Breadsall	67*	*†	Ilkeston	63	†	B M Toll	03	
Kirk Langley	68	†	Long Eaton	75	†			
						Buxton	012	
5—7½ miles.			Ripley	73	†			
						Chesterfield	07*	07
Belper	72	†	*10—12½ miles*			Claycross	011	
Brailsford	86*	†	Ashbourne	62	†	Hanley	04	04
Etwall	74	†	Ashby de la Zouch	78	†	Leak	09	
Horsley	88	†	Burton-on-Trent	71*	71	Leicester	05*	05
Melbourne	64	†	Kegworth	85	†	Loughborough	08	
Repton	76*	†	Leabrooks	77	†	Mansfield	013	
Shardlow	84	†	Worksworth	82	†	Matlock	02	
			12½—15 miles.			Sheffield	06*	06
			Alfreton	87	8			

† Ult codes 60—89 will depend on the sequence of conversion from manual to auto
* Followed by Subscriber's number

Before any further step can be taken in the design of a numbering scheme, it is essential to see what provision is required for dialling-out codes. For exchanges which are outside the 15 mile area codes commencing with the digit " 0 " are given.[2] For this purpose a group of 2nd selectors is connected to the " 0 " level of the dialling-in exchange group of 1st selectors and the code " 00 " is used for gaining access to the Manual Board. This arrangement has the advantage that it does not restrict the range of numbers available to subscribers.

Considering the exchanges within the 15 mile area it is desirable to limit the dialling-out codes to 2 digits wherever possible, and as there are 24 routes including the 4 within the 5 mile circle, three groups of 2nd selectors will be required. These have been connected to levels 6, 7 and 8 of the 1st selectors, which leaves only levels 2, 3, 4 and 5 available for subscribers' numbers on the main and satellite exchanges. With a 4-digit system the maximum multiple numbers obtainable are 4,000 which is inadequate to meet the requirements. A 5-digit numbering scheme would cater for 40,000 lines, but this would be uneconomical as it provides for a considerably larger multiple than is required. In the circumstances, a mixed 4 and 5-digit scheme has been chosen as giving the best arrangement.

The main exchange traffic is usually much heavier than that of any of the satellites; it is more economical therefore to allot the 4-digit numbers to this exchange. In the present example, 3,000 4-digit numbers can be used at Derby, the remaining 4,500 for the ultimate period having the 5-figure numbers 50,000-54,499. The other 5-digit numbers are allotted to the satellites as shown in Table 1.

[2] This practice has been discontinued since the writing of this paper, and the routes beyond 15 miles are found 2 or 3 digit codes commencing with 6, 7 or 8 as for the routes within the 15 mile circle.

It must be remembered that there is direct switching from level " 0 " of the discriminating selectors at the satellites to the manual board, so that this level cannot normally be used in the local number range. For example, at Spondon satellite exchange the digits 57 are absorbed and the discriminating selector (DSR) is then used as a third selector on levels 571, 572, etc. (Fig. 8). The level 570 is unavailable as such from the D.S.R., it already having been used as level 0. The same applies to levels 576 and 578, the levels having been used as 56 for direct switching to third selectors at Alvaston exchange and as 58 for switching to local third selectors. If at some future period, however, the exchange becomes short of multiple numbers, there is a method of utilising these levels by the use of two junctions, as in a straight satellite. The DSR is arranged to discriminate after the third digit has been dialled so that it is possible to route local calls to levels 576, 578 and 570 over the junction hunters to the main exchange and then back to third selectors at Spondon.

So far it has been assumed that all satellite traffic circulates by the main exchange. This is very often the case, but, where traffic conditions warrant it, direct trunking between satellites is provided. In the present case a large proportion of the junction traffic from Spondon exchange is to Alvaston, both exchanges being satellites. The total length of the junctions is considerably shortened by the provision of a direct route, while there is an additional saving in cost resulting from the use of smaller gauge conductors and the omission of first and second selectors at the main exchange on these calls. Therefore, direct routing has been adopted and is obtained by switching after the second digit from the DSR at Spondon to third selectors at Alvaston.

The additional facility of direct switching to second selectors at the main exchange may also be provided where the main exchange traffic forms the greater part of the total junction traffic. It is only practicable where the main exchange numbering range is confined to one particular initial digit, as in a universal 5-digit numbering scheme; otherwise, the large number of routes required defeats its object. This is so in the Derby area where, although direct switching is justified on traffic grounds, the fact that a large number of initial digits is involved precludes its adoption. When a manual exchange, which subscribers on an adjacent automatic exchange have been accustomed to obtain by means of a dialling-out code, is converted to automatic working, it will be necessary for the automatic exchange subscribers to dial the full number. The usual practice in these cases is to arrange for another code to be allotted as a reminder of the new conditions, and stray calls to the old code are passed to the manual board. Fig. 1 is a schematic representation of the numbering of the area. For the sake of clearness, only a few of the dialling-out codes have been shown.

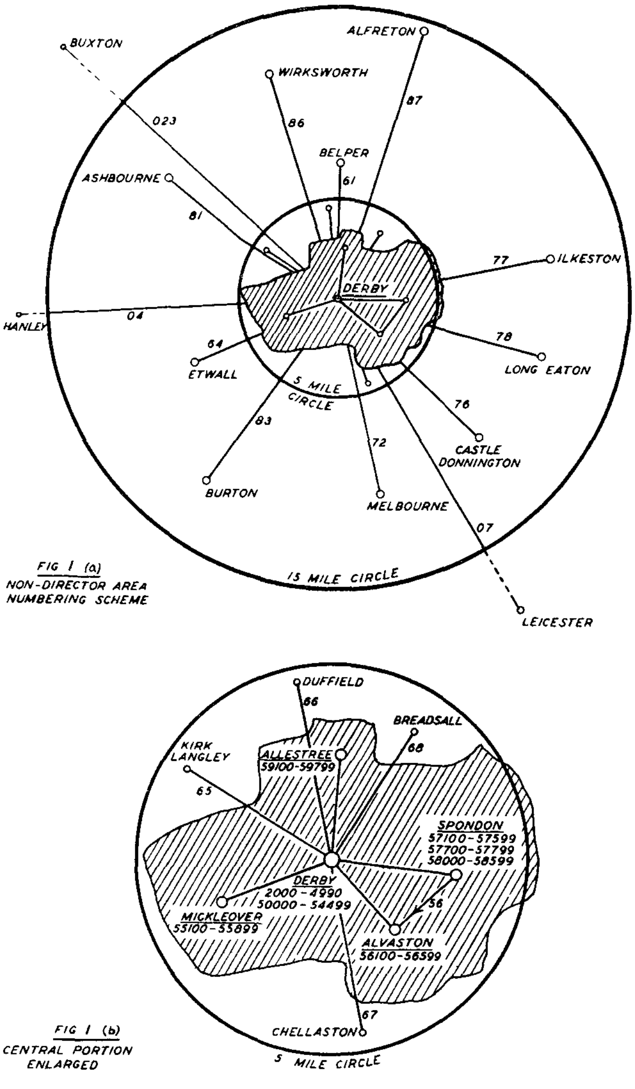


Fig. 1.

(c) "Self-contained" Exchanges.

Of recent years a large number of self-contained exchanges have been installed. They have independent numbering schemes, while dialling-out codes are used for all junction traffic. In the larger exchanges standard non-director equipment is used, but for exchanges where both the number of lines and the calling rate is small, U.A.X. type equipment is installed. The manual board is often situated in a remote building and where this is the case the 9 level is not reserved for gaining access to special services, as in the standard non-director area.

A small number of direct routes to nearby exchanges can be obtained by means of dialling-out codes, but the access to the 15 mile area traffic is *via* level 9 and first selectors at its parent exchange, where the manual board is situated. Therefore the dialling-out routes of the parent exchange become available by prefixing the codes with 9. This is shown schematically in Fig. 2 where exchange A is the one under consideration and exchange B is the parent. Certain routes obtainable by the parent exchange subscribers will be outside the 15 mile area of the dependent exchange. In such cases, NU tone is returned to the subscribers from the multi-metering equipment should the codes be dialled in error. Where the dependent exchange is a U.A.X. a combined route for levels 9 and 0 is provided with discriminating equipment at the distant end.

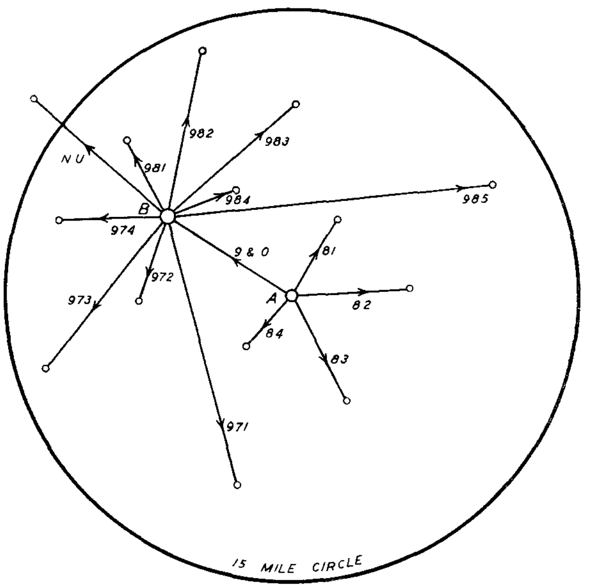


Fig. 2.—Self-contained Exchange "A" with Manual Board and Junction Centre at "B."

The figures represent the Codes to be dialled from "A" to obtain the various Exchanges.

If conditions require it, other tandem routing centres may be used, but the parent exchange will be the one which deals with its manual board traffic. A special case of this is where a self-contained exchange is on the fringe of a director area and with which it has a large community of interest. Level 7 is reserved as a dialling-out code to the area and the junctions are terminated at the distant end on a first code selector in any convenient director exchange. As much of the director area as is within the 15 mile circle can thus be obtained by prefixing the exchange code and number by 7.

(*d*) *Director Area.*

All the exchanges in a director area have numbering ranges which are entirely independent of one another, but at the same time they possess a system of "dialling-out" codes which is universal in the area. This scheme is approaching the ideal from a subscriber's point of view, especially as it is coupled with the additional advantage that the code forms the first three letters of the exchange name (Fig. **3**). The three-letter code is used entirely for routing purposes and it is followed by a 4-digit number. Therefore, it is possible for each exchange to have 10,000 numbers, *i.e.*, 0000-9999, and as many as required up to this number can be allotted. The subscriber's multiple limitations of the non-director type equipment regarding the reservation of certain levels are not present in this case, as the numerical digits form the later digits of the train.

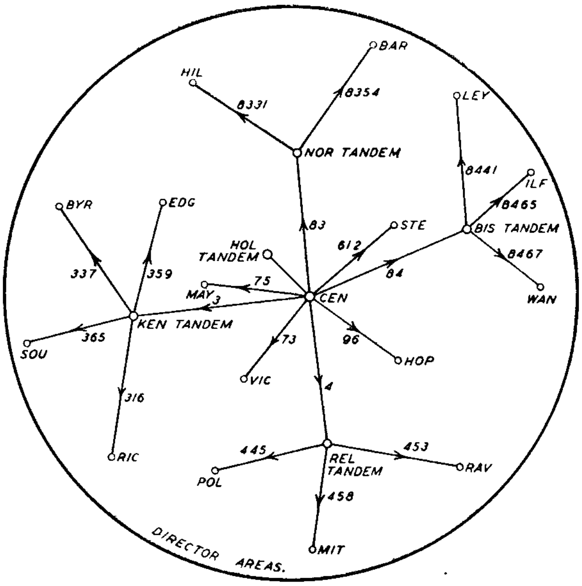


FIG. **3**.—DIRECTOR EXCHANGE "CENTRAL," showing the translated digits necessary to route calls to other exchanges, either direct or *via* a Tandem Centre. For the sake of clarity the routes from Holborn Tandem have been omitted and only a proportion of the other routes shown.

Most of these advantages could be given by standard non-director equipment, but it would entail junction routes between each exchange in the area and a large number of code selector groups in each exchange to feed them. Alternatively, if a satellite scheme were developed, the number of direct routes between adjacent exchanges would have to be reduced to a far fewer number than is economical. A translation scheme is therefore used which enables the most economical routing to be employed. This involves the use of a tandem or "junction lending" exchange and where the traffic is small between two exchanges, the calls are routed *via* the tandem.

In large areas, several tandem exchanges may be provided and the extreme flexibility of the director system allows calls to be routed *via* any particular one as the case demands. At the present time, tandem exchanges work independently of each other, but it could be arranged that calls would pass through two or more if line plant conditions were suitable.

(*e*) *Hypothetical Exchanges.*

When it becomes economical to divide up an exchange area and serve it by two or more exchanges, it is usual, some years before the actual change takes place, to set up a hypothetical exchange on the existing one. This consists of setting aside a certain portion of the multiple and giving it the name and numbers of the new exchange. New lines are given their future numbers and the numbers of existing subscribers can be changed piecemeal to fit in with issues of the directory. This method greatly facilitates the opening of new exchanges. By their nature it follows that no particular trunking arrangements are required, an exchange with two names being the best description.

Sometimes new exchanges are designed with hypothetical exchanges working on them from the start. The equipment is so arranged that the hypothetical portion can be absorbed easily by the exchange proper when the occasion arises.

Design.

(*a*) *General.*

For the purpose of design, exchanges fall into two classes, namely, director type and non-director type, which differ widely in detail. In addition, the large exchange brings problems which are quite distinct from those of the small exchange. For these reasons it is considered desirable to use two examples, one a large director exchange and the other a medium sized one of the non-director type. It is proposed, however, in this paper to deal only with the salient points, and all work involving calculations has been relegated to the appendices. Typical non-director traffic data together with a complete design for the exchange is given in Appendix 1. The designs were based upon Derby and London Central Exchanges, but they have been altered from the original in one or two details either to cut out any unnecessary complication or to accentuate some point.

The traffic data supplied to the Engineering Department often contains information in greater detail than is necessary for engineering purposes. The essential information can be summarised under the following headings :—

(1) The number and type of lines to be catered for.
(2) The number and destination of all originating and incoming calls.
(3) The average holding time of each class of call.
(4) Details of any special circuits.
(5) Details of the lay-out of the manual board if provided.

The information under the first three headings is obtained by the District Manager from the traffic studies, while under headings 4 and 5 items required for service purposes are given.

In the example taken the traffic data has been prepared to give this information in the simplest form.

The calculation of the quantities of exchange equipment follows well-defined principles, but as no two cases are exactly alike some portion of practically every exchange has to be treated as a special case. To obtain a perfect design it would be necessary to see into the future and obtain the actual conditions that will exist in five, ten, fifteen or twenty years ahead. It is not very difficult to produce a design which meets immediate requirements, but one of the essential points is that the equipment must be capable of extension easily and without a large amount of rearrangement. Naturally it is not possible to meet every contingency that the future may reveal, but more than a little "intelligent anticipation" must be used if future trouble is to be avoided. More particularly does this apply to the lay-out of the equipment on the racks and the cabling from the racks to the Trunk Distribution Frame (T.D.F.).

Before the calculation of equipment quantities can begin, it is necessary that one or two points about the exchange be settled. The first of these is the size of the multiple, except in director exchanges where this is supplied by the District Manager. In either case it is determined from the following principles and a typical example is given in Appendix 1.

The exchange multiple is based on the number of lines, but the type of line has a large bearing on the result. For this purpose subscribers are divided into four classes[3] :—

(1) *Ordinary subscribers, i.e.,* those with a single line.

(2) 2/10 *P.B.X. subscribers, i.e.,* those who do not require automatic hunting facilities on more than ten lines within ten years of the opening of the exchange.

(3) 11/20 *P.B.X. subscribers, i.e.,* those who require hunting facilities on more than ten lines, but not more than 20 lines within the ten year period.

(4) *Over* 20 *P.B.X. subscribers, i.e.,* those who require automatic hunting facilities on more than 20 lines within the ten year period.

The ideal conditions would be those where every multiple number could be allotted to subscribers. In practice, however, a certain percentage of spares has to be left to allow for unavailable lines due to number changes, etc., test lines, and numbers held spare to enable existing P.B.X. groups to grow.

It has been calculated that the most economical condition occurs when the following average loadings are applied :—

Ordinary units = 97 lines.[1]
2/10 *P.B.X. units* = 39 ordinary lines and 49 P.B.X. lines.

On an 11/20 P.B.X. type unit one subscriber per level on the switch can be allotted, or a total of ten. Normally, however, not more than eight groups are allotted per unit. The loading of the over 20 P.B.X. type units depends entirely on the number of subscribers' lines and each case has to be treated on its merits.

In small exchanges the number of exchange lines at the ultimate date is determined by the development figures for the area, and for Derby it is estimated that 6970 lines will be required. Where an exchange is in a congested area the size of the exchange is limited by the multiple numbers available. For a director exchange this is 10,000 and growth above this number is catered for by providing another exchange in the same or a remote building. Owing to the fact that a certain number of spares have to be available for number changes, etc., it is usually assumed that only 94% of the multiple numbers are available for use at any one time. The number of direct exchange lines that can be accommodated from this consideration, therefore, is 9,400.

The over 10 P.B.X. type units, however, are capable of accommodating 200 lines, that is 100 multiple numbers and 100 auxiliary numbers outside the ordinary number range. It is estimated that the average loading will be 150 lines per unit, and if many such units are fitted, the number of lines per exchange of 10,000 multiple will greatly exceed 9,400. In Central Exchange there are 17 such units and the total number of direct exchange lines to be catered for at the ultimate date will therefore be :—

$$17 \times 150 = 2550$$
$$83 \text{ @ } 94\% = 7800$$
$$10{,}350$$

This figure is used in the calculation of the ultimate number of calling equipments.

At other parts of the exchange the increase in calling rate has also to be taken into account. An ultimate date factor is therefore evolved, and in these particular cases will be :—

For Derby.

$$\frac{0.85}{0.80} \times \frac{6{,}970}{3{,}396} = 2.18$$

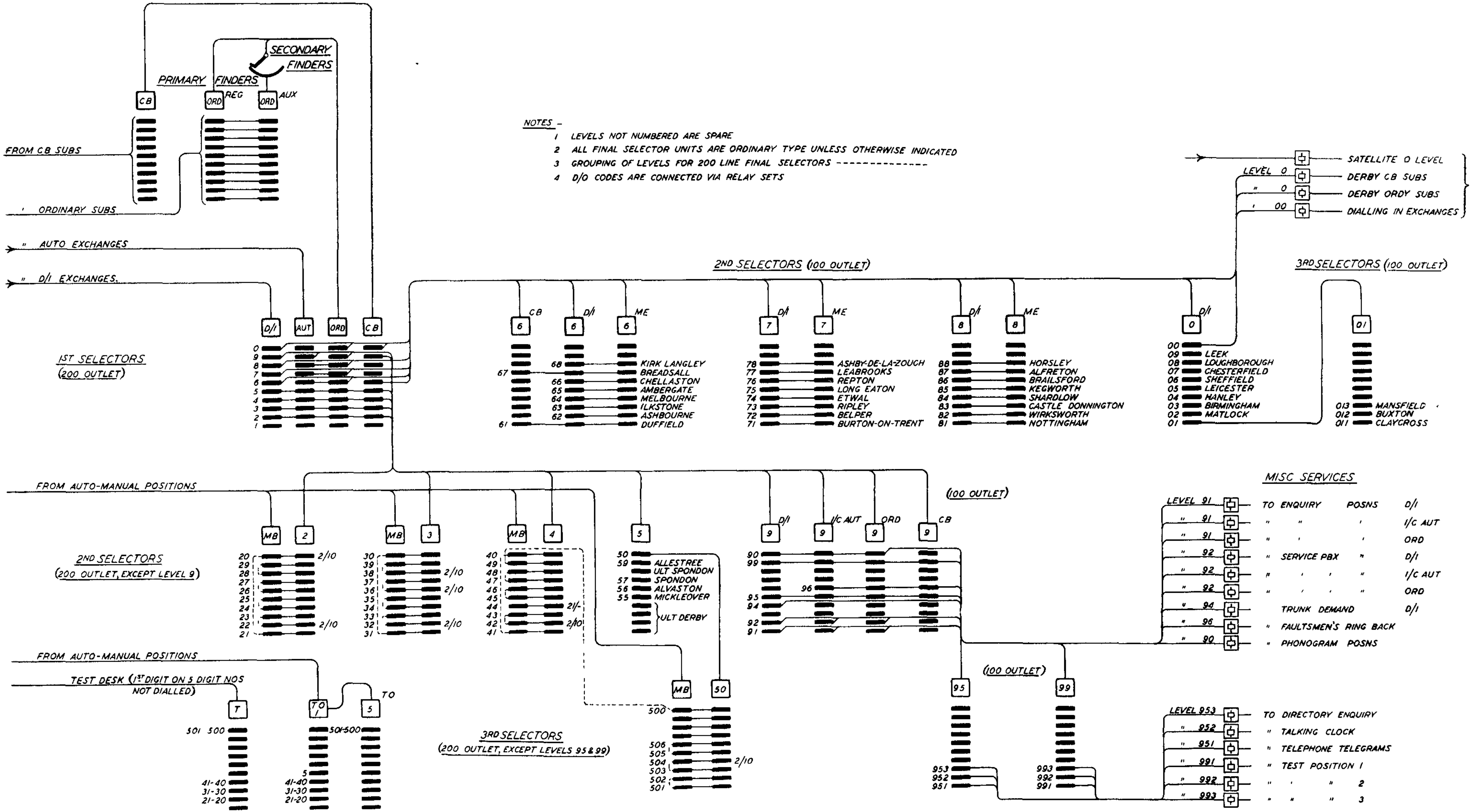
For Central.

$$\frac{2.3}{2.1} \times \frac{10{,}350}{8{,}301} = 1.365$$

0.80 and 2.1 being the initial, and 0.85 and 2.3 being the ultimate calling rates for the two exchanges, while the initial number of lines are 3396 and 8301 respectively. It would be more accurate to use average traffic unit figures per subscriber instead of

[3] In the 2000 type equipment the functions of the 11/20 P.B.X. and over 20 P.B.X. Final Selectors have been merged into one switch.

[1] The new Standards are :—Ordinary units 92 lines and 2/10 P.B.X. units 37 ordinary lines and 49 P.B.X. lines.



SECONDARY FINDERS
PRIMARY FINDERS
CB
ORD REG
ORD AUX
FROM CB SUBS
" ORDINARY SUBS
" AUTO EXCHANGES
" D/I EXCHANGES.
NOTES -
1 LEVELS NOT NUMBERED ARE SPARE
2 ALL FINAL SELECTOR UNITS ARE ORDINARY TYPE UNLESS OTHERWISE INDICATED
3 GROUPING OF LEVELS FOR 200 LINE FINAL SELECTORS
4 D/O CODES ARE CONNECTED VIA RELAY SETS
SATELLITE O LEVEL
LEVEL 0 DERBY CB SUBS
" 0 DERBY ORDY SUBS
" 00 DIALLING IN EXCHANGES
TO MANUAL BOARD
2ND SELECTORS (100 OUTLET)
3RD SELECTORS (100 OUTLET)
1ST SELECTORS (200 OUTLET)
D/I AUT ORD CB
6 CB 6 D/I 6 ME
68 KIRK LANGLEY
67 BREADSALL
66 CHELLASTON
65 AMBERGATE
64 MELBOURNE
63 ILKSTONE
62 ASHBOURNE
61 DUFFIELD
7 D/I 7 ME
78 ASHBY-DE-LA-ZOUCH
77 LEABROOKS
76 REPTON
75 LONG EATON
74 ETWAL
73 RIPLEY
72 BELPER
71 BURTON-ON-TRENT
8 D/I 8 ME
88 HORSLEY
87 ALFRETON
86 BRAILSFORD
85 KEGWORTH
84 SHARDLOW
83 CASTLE DONNINGTON
82 WIRKSWORTH
81 NOTTINGHAM
0 D/I
00
09 LEEK
08 LOUGHBOROUGH
07 CHESTERFIELD
06 SHEFFIELD
05 LEICESTER
04 HANLEY
03 BIRMINGHAM
02 MATLOCK
01
01
013 MANSFIELD
012 BUXTON
011 CLAYCROSS
FROM AUTO-MANUAL POSITIONS
MB 2 MB 3 MB 4 5
2ND SELECTORS (200 OUTLET, EXCEPT LEVEL 9)
2/10
21/-
50
59 ALLESTREE
ULT SPONDON
57 SPONDON
56 ALVASTON
55 MICKLEOVER
ULT DERBY
(100 OUTLET)
9 D/I 9 I/C AUT 9 ORD 9 CB
MISC SERVICES
LEVEL 91 TO ENQUIRY POSNS D/I
" 91 " " " I/C AUT
" 91 " " " ORD
" 92 " SERVICE PBX " D/I
" 92 " " " " I/C AUT
" 92 " " " " ORD
" 94 TRUNK DEMAND D/I
" 96 " FAULTSMEN'S RING BACK
" 90 " PHONOGRAM POSNS
FROM AUTO-MANUAL POSITIONS
TEST DESK (1ST DIGIT ON 5 DIGIT NOS NOT DIALLED)
T TO/I 5 TO
501 500
501-500
41-40
31-30
21-20
3RD SELECTORS (200 OUTLET, EXCEPT LEVELS 95 & 99)
MB 50
500
506 505 504 503 502 501
2/10
(100 OUTLET)
95 99
953 952 951
993 992 991
LEVEL 953 TO DIRECTORY ENQUIRY
" 952 " TALKING CLOCK
" 951 " TELEPHONE TELEGRAMS
" 991 " TEST POSITION 1
" 992 " " " 2
" 993 " " " 3

FIG. 4.

calling rates, but in the absence of details of the variation in the average holding times between the initial and ultimate dates, the calling rate has to be used.

The number of junctions on any particular route is based on the average traffic over the busy hour for that route. The busy hour for all junction routes may not coincide, however, and if equipment which is common to several junction routes were provided on the sum of the group busy hour traffic, over-provision would result. To avoid this a " group to exchange " busy hour ratio is supplied in the traffic data and is used on code selectors, directors, etc. This method of applying an average ratio may not always be strictly correct, but it is contended that the total equipment on any rank of switches will be right, although slight alteration among the various groups may become necessary under actual traffic conditions. In non-director exchanges the main exchange is usually much larger than its dependents, and it is fairly safe to assume that its busy hour is the controlling influence on the local junction routes. Exchange busy hour traffic may, therefore, be used for both selector and junction provision.

At the present time exchange equipment is provided so as to meet growth for a period of three years after the opening date with the exception of selectors, where provision is made for a two year period only.[5] The traffic data therefore gives information for the three year period with a reduction factor to give two year conditions.

(*b*) *Non-director.*

In Fig. **4** is shown the complete trunking scheme for Derby. On the left are the primary and secondary finders connected to first selectors. It will be noted that the coin-box subscribers are given a separate group, so that their fee traffic may be segregated from that of the ordinary subscriber. In smaller exchanges, where the total number of coin-box lines does not exceed 100 at the ultimate date, it is more economical to provide a " mixed " primary finder group, the coin-box lines being confined to certain levels of the finder and a marking signal passed forward to give discrimination. This scheme has the disadvantage that the availability of the first and second selector levels over which discrimination is required is reduced from 20 to 10 outlets per level except for " 0 " level calls. The ordinary subscribers are distributed over 17 groups of primary finders (Fig. **5**), and partial secondary working has been introduced, *i.e.*, a certain proportion of the finders in the primary groups are connected to the banks of secondary finders. An interconnection scheme of this type means that a subscriber may appear in any one of the secondary groups, and in a large exchange where upwards of 50 first selector racks are concerned, difficulty in tracing calls is apt to arise. The exchange is, therefore, divided into parts in a similar manner to that which used to be adopted with gradings. Seven secondary groups is taken as the maximum per division, but the number of primary finder groups and first selectors to serve them will vary widely. Partial secondary working is not adopted with the coin-box lines unless there are more than 600 such subscribers, as the heavy traffic usually encountered makes secondary working an uneconomical proposition.

In referring again to Fig. **4** it will be observed that apart from those serving primary finders there are two other groups of first selectors, one connected

[5] See footnote on page 3.

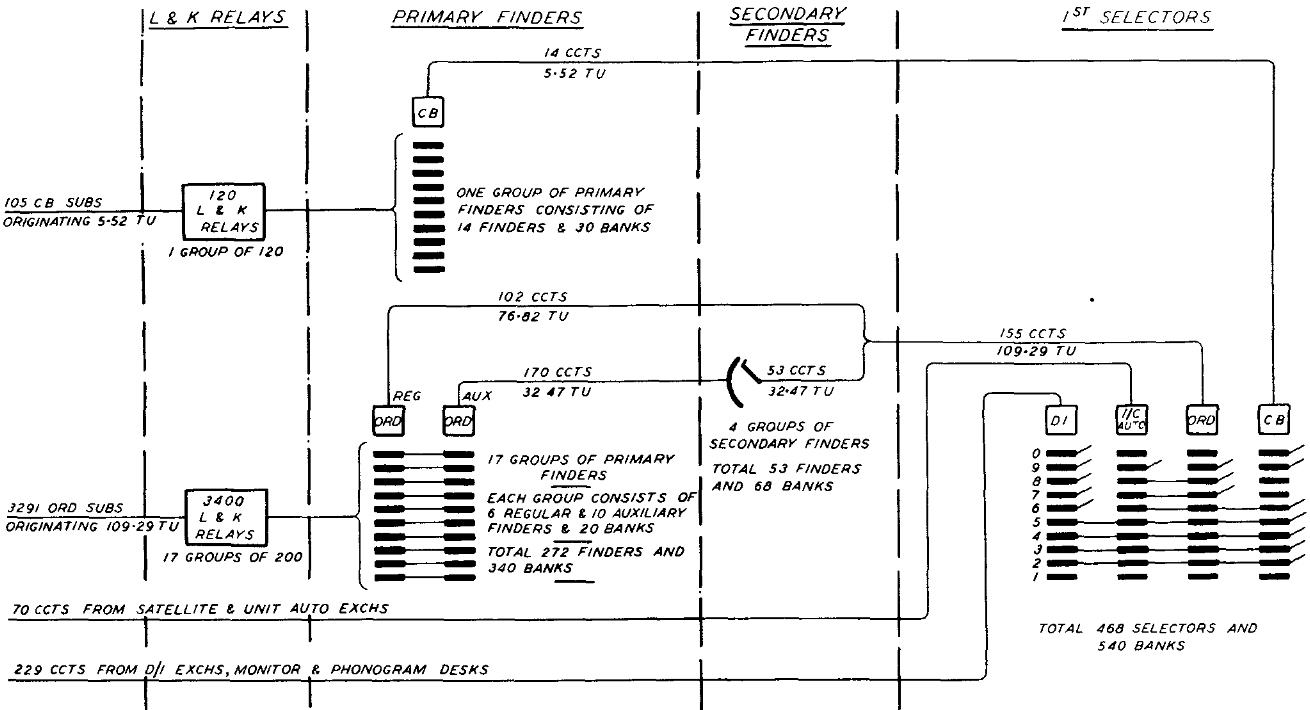


Fig. 5.

to junctions from automatic exchanges and the other to junctions from manual exchanges. It is necessary that this segregation into four groups be made, for the following reasons :—

1. The "0" level traffic for the coin-box and ordinary lines must appear as separate circuits on the manual board.
2. The "0" level for the incoming auto exchange group must be left disconnected, this traffic being direct from the originating exchange to the manual board, usually on higher grade junctions.
3. The "0" level of the dialling-in group is trunked to second and third selectors to obtain access to exchanges outside the 15 mile circle.
4. Where metering is not required on automatic calls, *i.e.*, on certain service levels, a separate group of circuits is necessary to give supervision back to the originating dialling-in exchange.
5. It is essential that coin-box lines be barred access to all fee routes.

The trunking of the first selector levels is shown in Fig. **6** together with the traffic and number of circuits on the levels.

saving in the number of switches of the succeeding rank becomes greater than the extra cost of the 200 outlet switch and bank.

The lay-out of the second selectors is determined by the numbering scheme and the chief considerations have already been dealt with under that heading. The various groups of selectors fall easily into two distinct classes. One class is that which feeds the final selector groups and in this case 200 outlet type switches are warranted. The other class is formed from the 2nd selectors which serve outgoing junction routes and are equivalent to the code selectors in a director exchange. 100 outlet type switches are being used here as the number of circuits per level is small and it appears that this condition is likely to remain so for some time. On level 6 (Fig. **4**) a separate group of switches has been provided for the coin-box lines. This is to enable access to be given to the two automatic exchanges in the unit fee area and at the same time to bar the coin-box subscribers from obtaining calls to the other exchanges. Later, when Chellaston and Kirk Langley are converted to U.A.X. working, the coin-box lines can easily be given access to them. On levels 7 and 8, N.U. tone is applied to coin-box subscribers from the 1st selectors, should attempts be made to pass calls to the fee exchanges served from

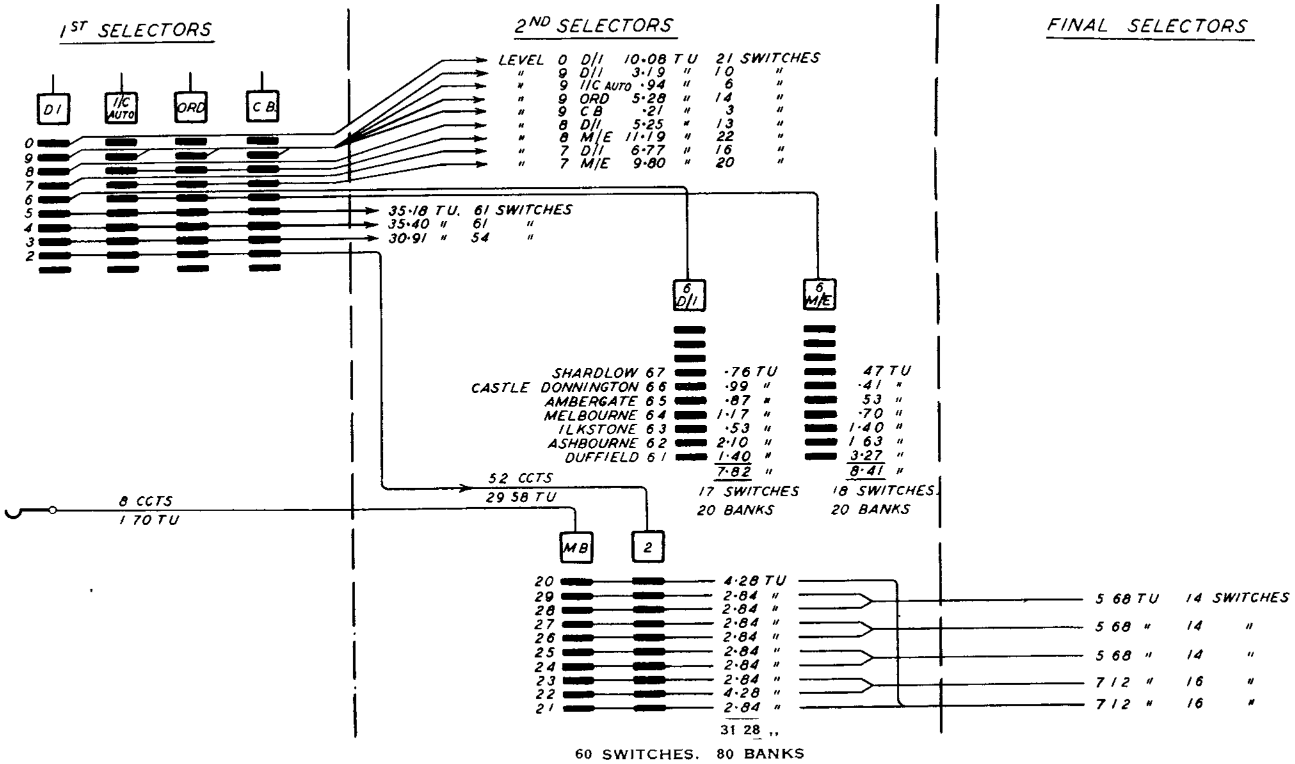


FIG. 6.

The question of 100 outlet or 200 outlet hardly arises with 1st selectors, as the various groups to 2nd selectors are usually large. The deciding factor for 200 outlet switches is when an average of 14 or more outlets per level are required, or are likely to be required in the near future. At this point the

these levels. Level 9 which takes all the special service traffic has 4 sub-groups of switches, so that each class of call may be kept separate for both service and circuit reasons.

In every case the switch quantities are determined by totalling outgoing traffic on each level. Appendix 1, tables 13-15, show this in detail. Where Manual Board 2nd selectors are used as in groups serving levels 2, 3, 4 and 50, it is the practice to distribute them over the shelves used by the graded switches; a uniform distribution of traffic is thus obtained.

As already mentioned subscribers are divided into four classes as far as final selectors are concerned. For the large type units, *i.e.,* 11/20 and over 20 P.B.X. types, the switch quantities depend upon the traffic of the individual subscriber, and each unit must be dealt with separately. For the ordinary and 2/10 P.B.X. type subscribers the traffic is averaged out over the units and an average traffic load for each type of unit obtained. Under certain conditions units of this type may be grouped in pairs, with a resultant saving in switches, as one large group replaces two small groups. This is done in the Derby case where 200 line final selectors are used, either made up of 2 units of ordinary lines or one unit each of the ordinary and 2/10 P.B.X. type. Owing to bank limitations of the present standard equipment, it is not possible to have a 200 line final selector serving two units of the 2/10 P.B.X. type.[6] Therefore, the maximum number of 2/10 P.B.X. units obtainable under this scheme is 50% of the total, excluding those of the large type, and where a greater number than this is required, as in Central Exchange, it is necessary to revert to the 100 line type of final selector.

It is essential that all circuits to and from the manual board and all outgoing junctions shall have relay sets associated with them. In addition, a large proportion of the incoming circuits require relay sets. The determination of the quantity and type of relay set forms a much more important part of the design of a non-director exchange than it does in the design of a director exchange. On junction routes the type of exchange at the distant end and the junction resistance determine the type of relay set which should be used. Table 17 in Appendix 1 shows the various types required at Derby. One or two particular cases are shown schematically in Fig. 7, and it will be noted that several relay sets are often required. For circuits to and from the manual board the facilities required become the governing factor.

It has been mentioned previously that for the purpose of this paper, multi-metering conditions have been assumed. The multi-metering equipment will be associated with the outgoing junctions, being in the form of common equipment connected to the junction by a finder until metering has been carried out. In the absence of complete details, however, calculations of the quantities of this equipment have been omitted. The type of relay set on the outgoing junctions may also have to be modified to meet multi-metering conditions.

At the present time, inter-dialling from one auto area to another as shown in Fig. 7(*b*) is not permitted, all such calls being passed *via* the local manual board. A similar scheme is in use for U.A.X's, however, and it may reasonably be expected that the facility will be extended with the introduction of multi-metering. With unit fee metering the need for it hardly arises as auto areas are seldom within 5 miles of each other. Fig. 7(*b*) must, therefore, be taken as tentative for the present.

The automatic equipment for a non-director exchange is summarised in Table 20 of Appendix No. 1, and as the number of the circuit diagram and specification concerned has been added, it contains all the information that the Contractor will require to enable him to instal this portion of the equipment.

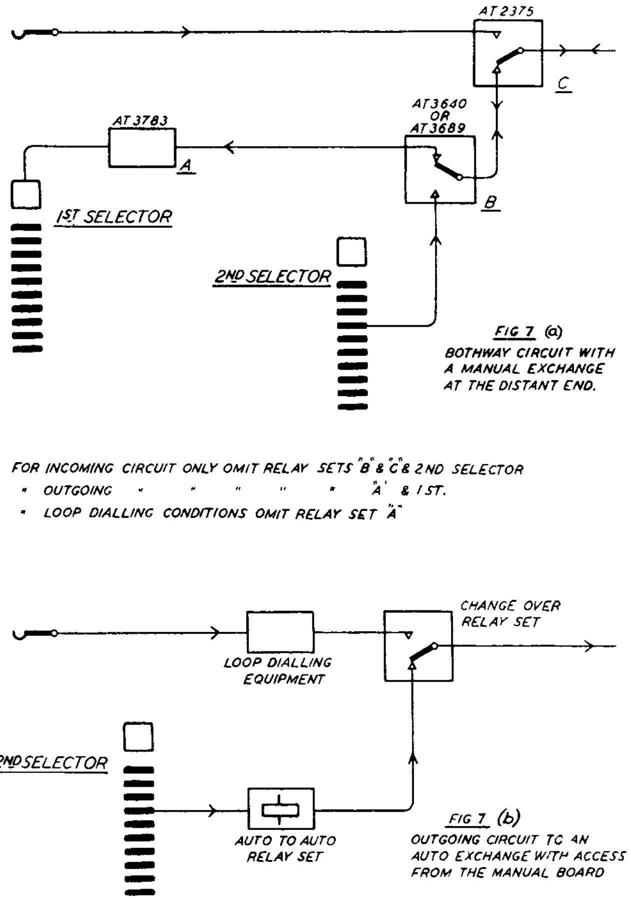


FIG. 7.—SHOWING TYPICAL ARRANGEMENTS OF RELAY SETS ASSOCIATED WITH JUNCTIONS.

(*c*) *Satellite Exchange.*

The trunking arrangements at a satellite exchange are slightly different from those at the main exchange, the scheme being built up around the discriminating selector. Fig. 8 is a modified trunking diagram for Spondon Satellite Exchange. The primary finders have been omitted as the arrangement is similar to that already shown in Fig. 4 for the main exchange. The ultimate conditions have been included, and show how it is necessary to split the incoming routes into two groups when the exchange grows beyond the point where all the levels of the discriminating selectors are in use. As the

[6] In the 2000 type equipment two 2/10 P.B.X. type units may be grouped together.

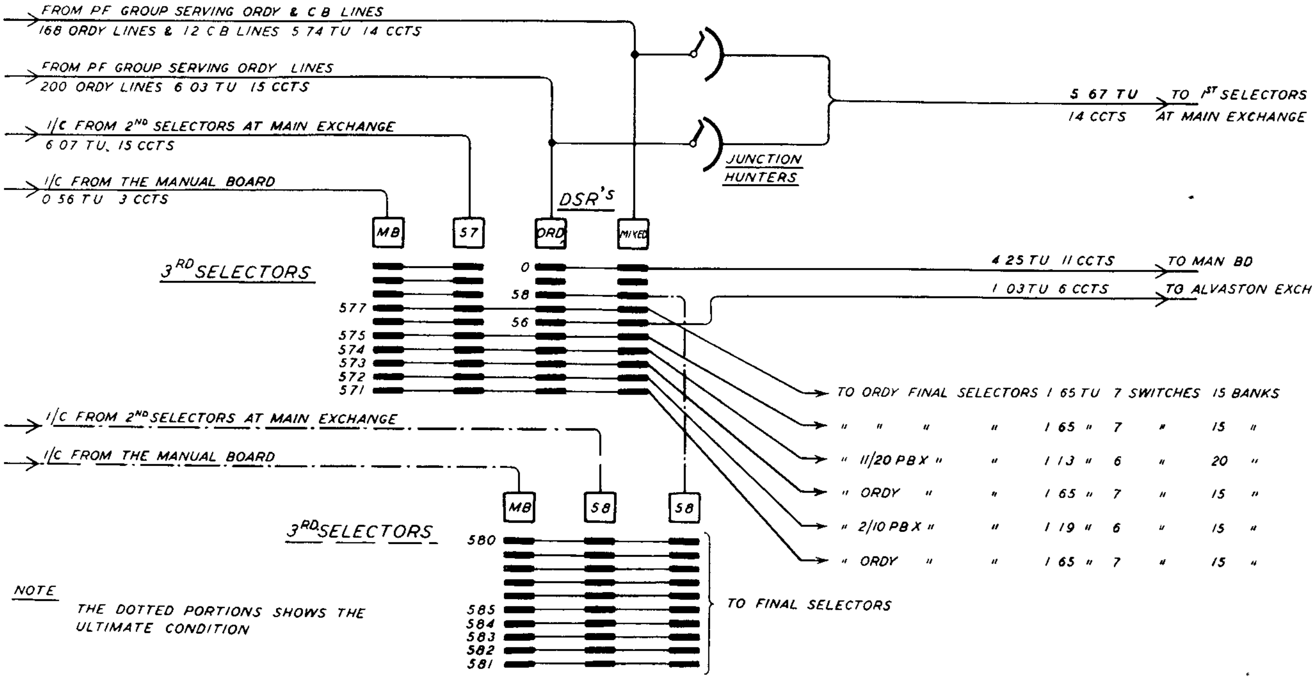


Fig. 8.

circuits to the main exchange *via* the junction hunters are held until discrimination has taken place on all local calls, " 0 " level calls, and calls to Alvaston Exchange, an allowance of 0.17 mins. is made on each of these calls, and the extra traffic taken into account in the calculation of the number of circuits to the main exchange.

The design of an exchange of the " self-contained type " is similar to the non-director main exchange, but it is simplified by the omission of satellite working. It is not necessary, therefore, to make any further mention of this type, the chief differences being apparent from Fig. **9** which is a trunking diagram of a typical self-contained exchange on the fringe of a director area.

(*d*) *Director.*

A director exchange may be divided into two parts from the point of view of design. The primary finders, code selectors, directors, etc., are determined from the originating traffic, while the numerical and final selector quantities are based on the incoming traffic. The same is true of the non-director exchange, although the point is masked by the fact that there are first and second selectors belonging to each division. Fig. **10**, which is a typical trunking diagram for a director exchange, well illustrates this point, the top half of the diagram representing the equipment associated with originating traffic, while the bottom half shows the equipment required for incoming traffic. Further details are shown in the trunking diagrams, Figs. **11**, **12**, **13**, and **15**.

The calculation of primary finders and first code selector quantities is similar to that in the non-director case. The term " Barred Trunk " in place of " Coin Box " is used. This is because in London,

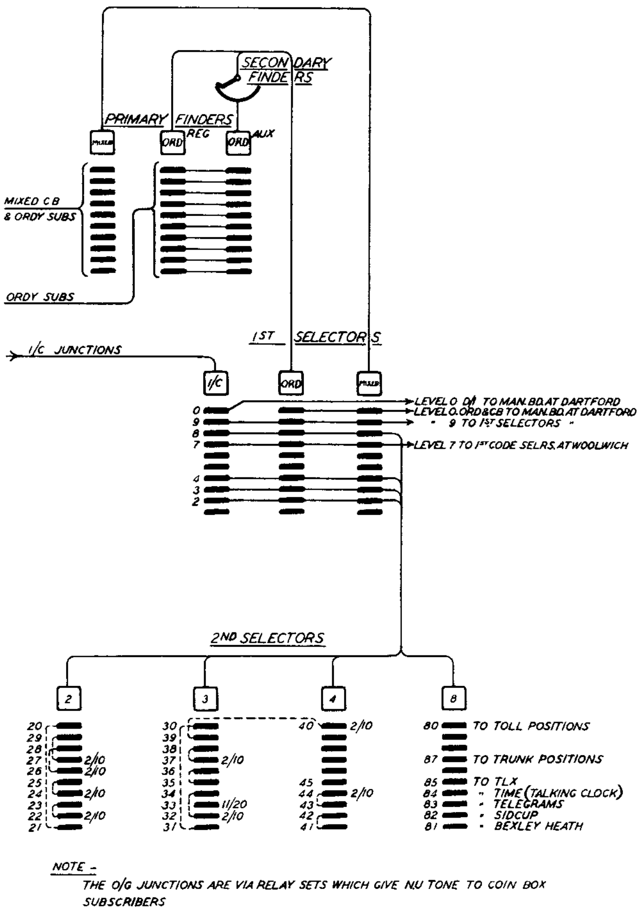


Fig. 9.—Trunking Diagram for a " Self Contained " Exchange on the Fringe of a Director Area.

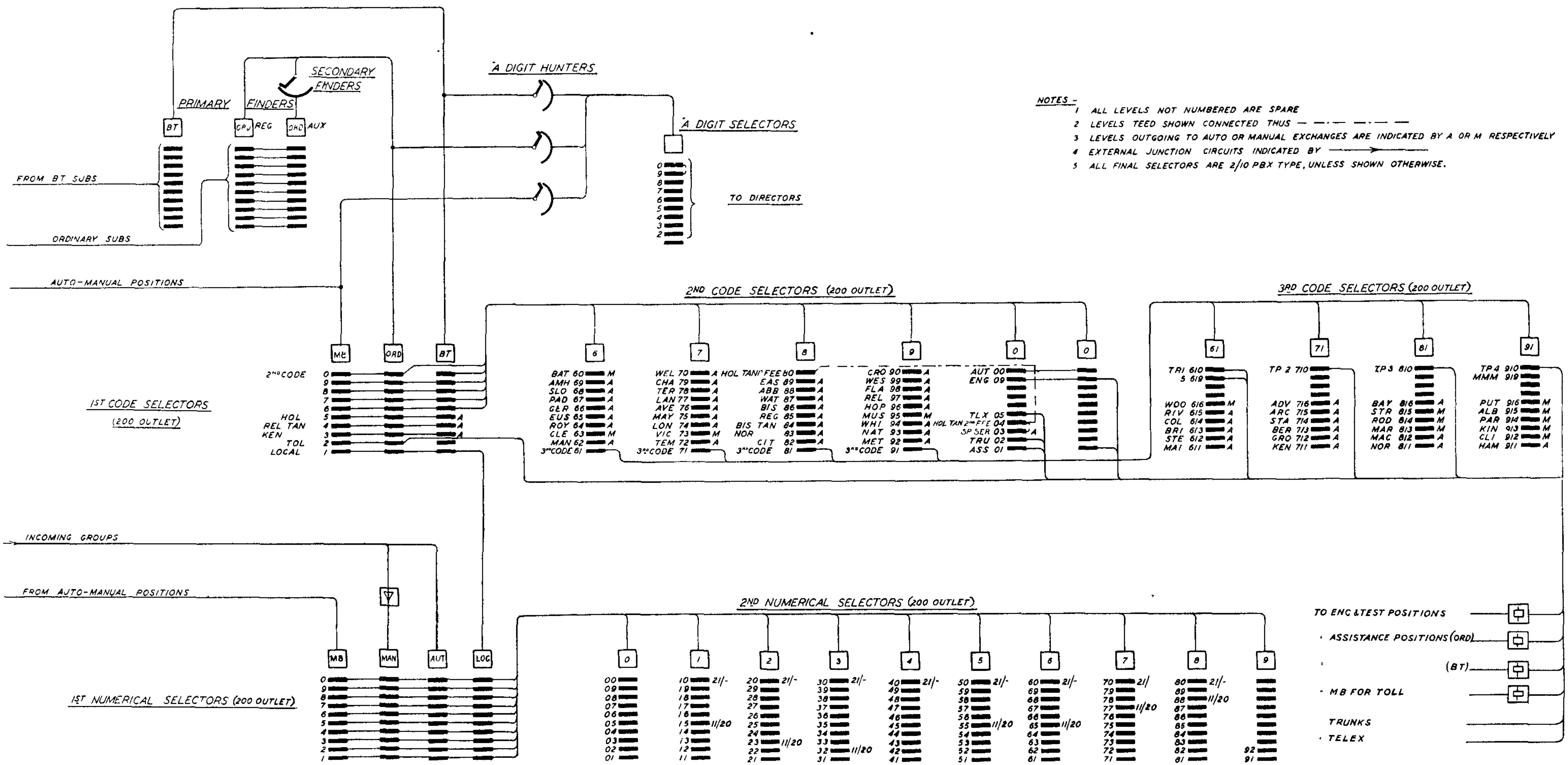


FIG. 10.—TRUNKING DIAGRAM FOR DIRECTOR EXCHANGE.

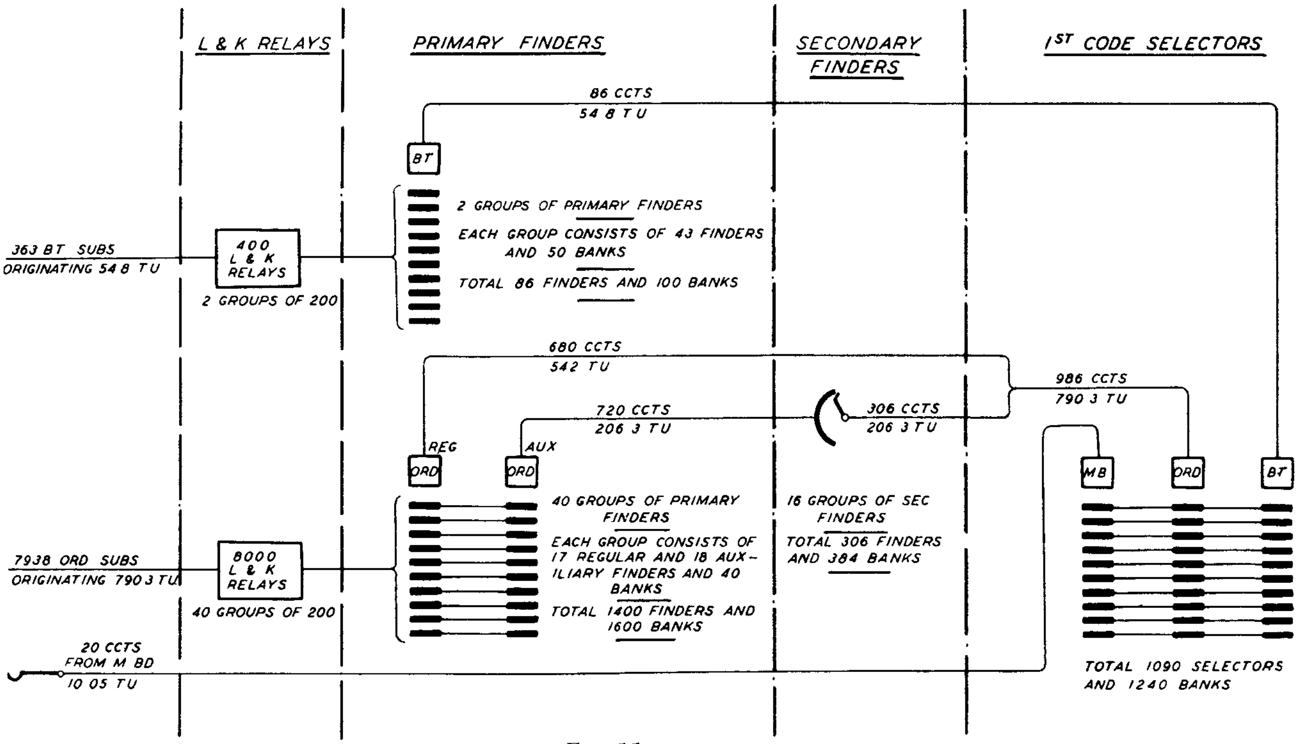


FIG. 11.

the group contains a proportion of subscribers who do not require trunk facilities, and although for trunking purposes they are similar to coin-box subscribers, they do not have coin boxes fitted. The manual board 1st code selectors, by which the operator gains access to the director area, are of a different type to those serving subscribers and must therefore be fitted on separate shelves.

For director provision, it is necessary that the originating calls be summarised for each " A " digit selector level. The group to exchange busy hour ratio is applied and the average holding times

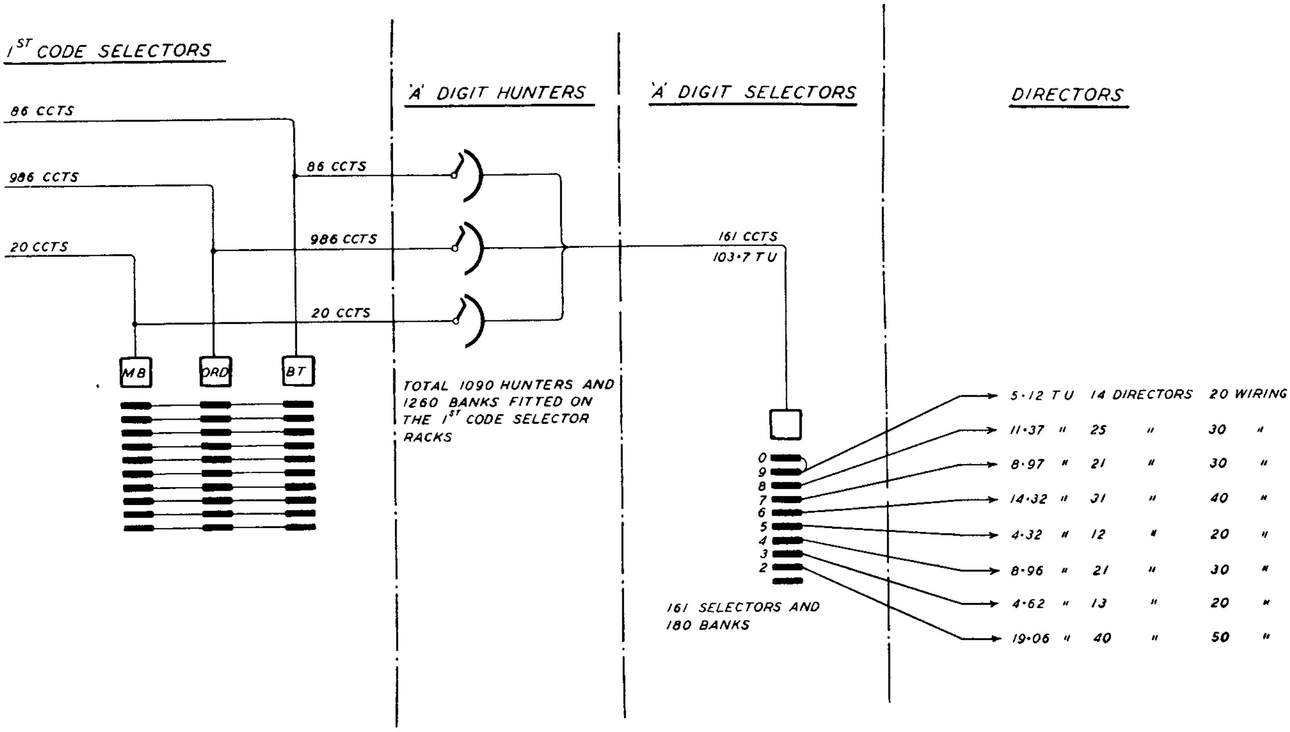


FIG. 12.

assumed are 16 secs. for ordinary calls and 5 secs. for " 0 " level calls where the translation is sent out immediately the director is seized.

The " A " digit selectors are provided on the group busy hour calls, the slight increase in equipment given by this means has been found in practice to off-set any shortage that would arise from the presence of " P.G." conditions, of which no account is taken in the traffic. An interesting point with regard to " A " digit selectors is that they must be provided on the pure chance traffic capacity curve, while the smooth traffic curve applies to the second code selectors, which are also graded from the 1st code selector banks. The reason is that the 1st code selector shelves are balanced for traffic assuming the standard average holding time for the exchange, but there is no guarantee that they are balanced for the 20 sec. holding time used for " A " digit selectors.

the use of level 1, and for the sake of uniformity the allotment of this level is standardised. The director and 1st code selector routiners influence the position of the 2nd code groups. The director sends out the translation 098765 for routining purposes if xXY be dialled in error. In order to avoid ringing a subscriber which might occur if a junction route were connected to level " 0," one of the 2nd code groups is connected to this level and the ENG service connected to level 09 of 2nd code selectors—stray calls thus being routed to the ENG positions.

When routining 1st code selectors it is desirable that level 9 be used. If a 2nd code group therefore is connected to level 9, a level on this group can be allocated for routining purposes. Level 99 of 2nd code selectors is used when only 2nd code groups are fitted, and level 919 when 3rd code selectors are supplied. This means that levels 0 and 9 must be allocated for 2nd code selectors and therefore to keep

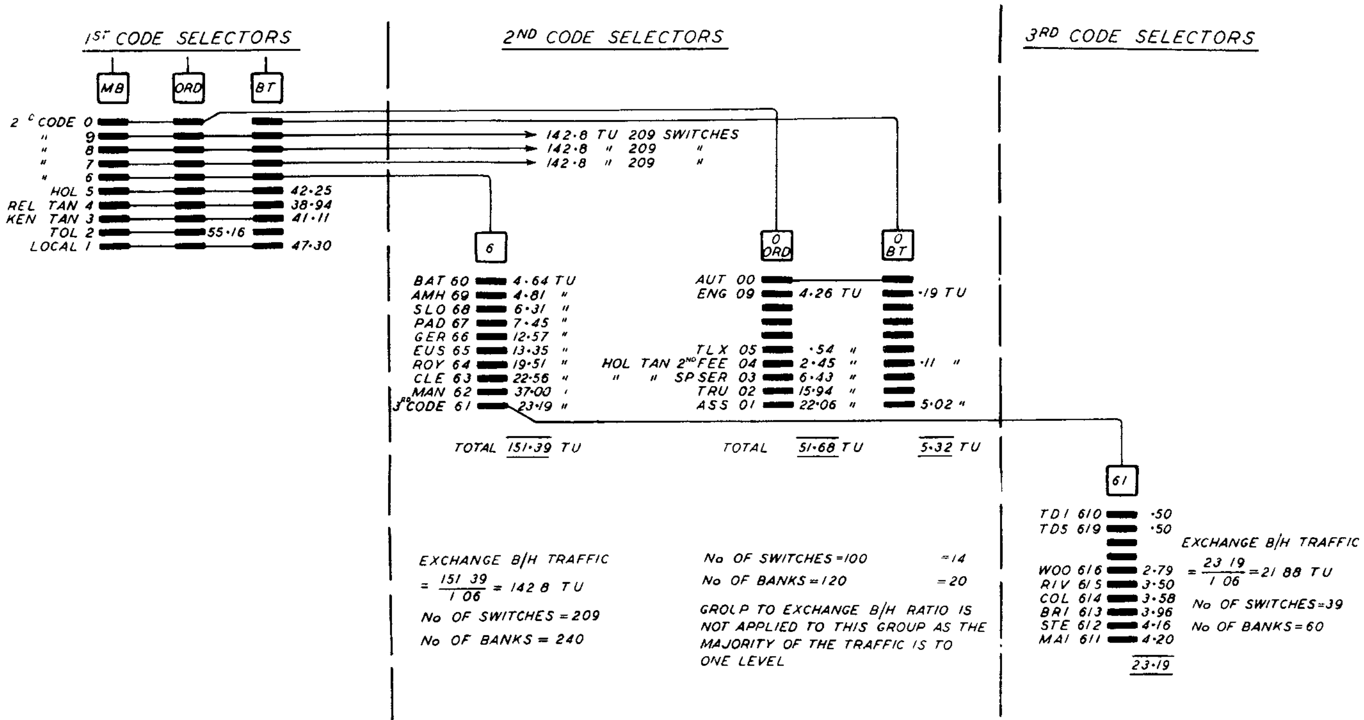


Fig. 13.

Before the design can proceed further, it is necessary to decide on the routing of the junction traffic. This is carried out by the Lines Branch of the Engineering Department (or the London Telecommunications Region), who make a cost comparison of each route to determine whether direct junctions or a tandem routing shall be employed.

It will be necessary at this stage to deal a little more fully with the principles involved, as a large wastage of equipment may result from a bad design.

Certain allotments of code levels have been standardised in all director exchanges. These are level 1 for the local level, level 0 for the " split " group of 2nd code selectors, level 09 for ENG and either levels 99 or 919 for the 1st code routiner. In most exchanges the amount of local traffic justifies

the sequence on the racks, levels 8, 7, 6 also have been used. As at some future date it might be necessary to provide an additional group of 2nd code selectors in the example illustrated, the single route to Holborn has been allocated to level 5 (*i.e.*, the next level on which 2nd code selectors would be provided), in preference to Reliance Tandem, there being fewer translations to modify if and when an additional 2nd code group is added.

On the 2nd code selectors, the 3rd code groups are always connected to level 1, otherwise the routes are allocated on the principle of the heaviest traffic on the lower levels. This gives the advantage of less mechanical wear on the switch and to some extent a saving in battery current. The traffic to each 2nd or 3rd code group is arranged to be nearly the same, as several groups of equal size are more efficient than unequally sized groups. This does not apply to the level " 0 " group, however, as only 10 contact availability can be given from this particular 1st code level, the other circuits being used for multi-metering purposes.

The external junction routes to be accommodated on the code levels number 65 while extra levels are required for special services, test circuit, etc., which brings the total to 78. On a number of these, the barred trunk lines must not be given the same facilities as the ordinary subscriber. The routes concerned are :

Toll,
Assistance,
Trunks,
Telex,
Special Services *via* Holborn Tandem,
Second Fee Exchanges *via* Holborn Tandem,

and ENG which has a two-group grading so that one individual circuit can be allocated to the barred trunk lines.

It is the practice to provide for these routes on 2nd code levels connected to level " 0 " of 1st code selectors. This has been done in the present case with the exception of Toll which, owing to the heavy traffic justifies a 1st code level. As the local 1st numerical selectors are also connected to a 1st code level, there are therefore 70 levels still to be allocated. To allow for any possible increase in the number of direct routes, 10% is added to this number so that 77 levels are required. It is possible to cater for these in several ways by means of 2nd and 3rd code selectors, while a few of the larger routes can be accommodated on the 1st code levels. The arrangement which requires the minimum number of selectors is the one usually provided, although where the cost between two schemes is small, the one which gives the cleaner lay-out and is more easily adaptable for extensions, is chosen.

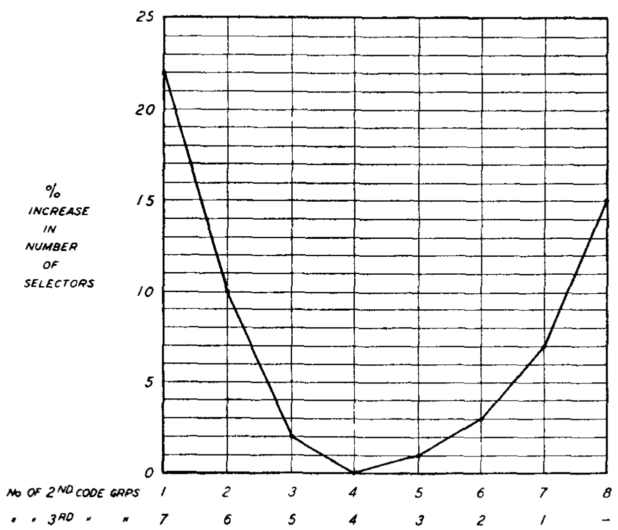


FIG. 14.—SHOWING THE % INCREASE IN SELECTORS DUE TO DIFFERENT ARRANGEMENTS OF THE 2ND AND 3RD CODE SELECTORS. THE LEVEL " 0 " GROUP OF 2ND CODE SELECTORS HAS NOT BEEN TAKEN INTO ACCOUNT.

In the present case four 2nd code (5, including level " 0 ") and four 3rd code groups have been provided, while three routes carrying the heaviest traffic are allocated levels on the 1st code selectors.

Fig. 14 shows how the number of selectors varies with the different arrangements of 2nd and 3rd code levels, the increase in the selector provision being as much as 22% in one case as compared with the arrangement chosen. The importance of arriving at a correct lay-out is therefore apparent.

Without working out each individual case it is not possible to show which arrangement is the most economical, but the figures given in Table 2 are based on a large number of cases, and may be used as a starting point. The number of routes ignores those connected to the level " 0 " group, but includes those associated with the 1st code selector levels.

TABLE 2.

Showing the number of 2nd and 3rd Code groups required for different numbers of routes. The figures given are average and are not necessarily correct for any particular case.

No. of routes (excluding those connected to the Level " O " Group)	*No. of Groups of*	
	2nd Code Selectors	*3rd Code Selectors*
Up to 15	1	—
16 ,, 23	2	—
24 ,, 31	2	1
32 ,, 40	3	1
41 ,, 49	3	2
50 ,, 58	4	2
59 ,, 67	4	3
68 ,, 76	4	4
77 ,, 84	5	4
85 ,, 93	5	5

The 1st numerical selectors are all in one group, even the local selectors being taken *via* the I.D.F. and distributed over the racks in a similar manner to the incoming routes. This method has two distinct advantages. Firstly, the shelves of 1st numerical selectors are evenly loaded with traffic, which makes for easy grading to the 2nd selectors and, secondly, it becomes a simple matter to make additions as required.

The two year reduction factor has not been applied in full to the 1st selectors. The correct procedure would be to apply a special reduction factor on each route and if necessary amend the routing. This is hardly justified, however, and in practice it has been found convenient to apply only half of the reduction that would be brought about by applying the factor to the total switches. It would appear at first that this provision is on the lavish side, but it must be remembered that the majority of the routes are small groups of junctions, and the traffic capacity-switch

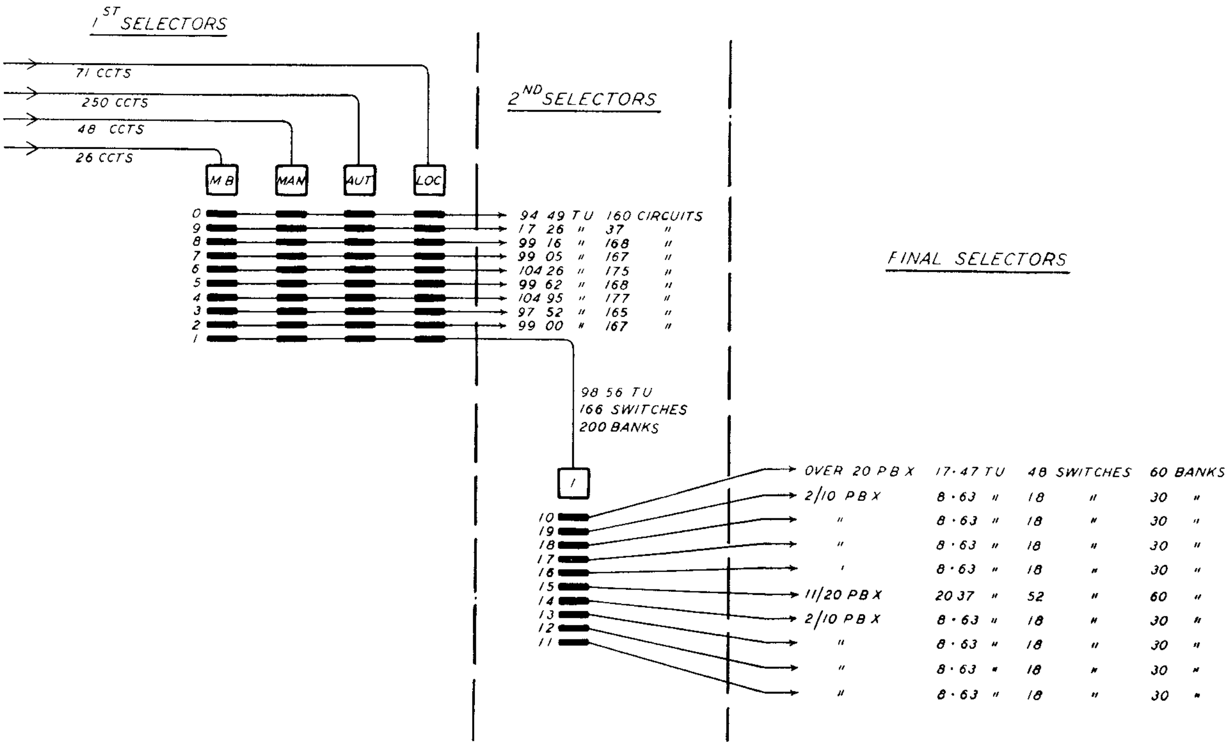


Fig. 15.

provision curves are by no means straight at their lower ends.

There is, however, a point in favour of a slight over provision at this point. 1st numerical selectors are of the group selector type and therefore suitable for use at many other parts of the exchange. Any overloading of these other ranks of selectors can easily be met by utilising spare 1st numerical selectors, no grading changes being involved by their withdrawal.

The provision of the 2nd numerical and final selectors is similar to the non-director case and needs no special mention.

With director equipment, under full automatic conditions, it will be necessary to have relay sets only in circuits to the manual board, the 1st code selector giving transmission, holding and metering facilities for originating calls, while the transmission bridge and holding facilities on incoming calls are given from the final selector. While manual exchanges exist in the director area, however, it is necessary to pass traffic to and from them. On calls outgoing from automatic exchanges, C.C.I. working is used, which allows the calling subscriber to dial the exchange code and number in the same way as on calls to automatic exchanges. The call is routed by the director in the normal way and after passing through a C.C.I. relay set and coder at the automatic exchange, appears as a " display " at the distant end. The equipment at the automatic end is shown schematically in Fig. **16**(*a*).

On incoming calls from manual exchanges straightforward junction working is employed, and it is usual to couple this with a system of Voice

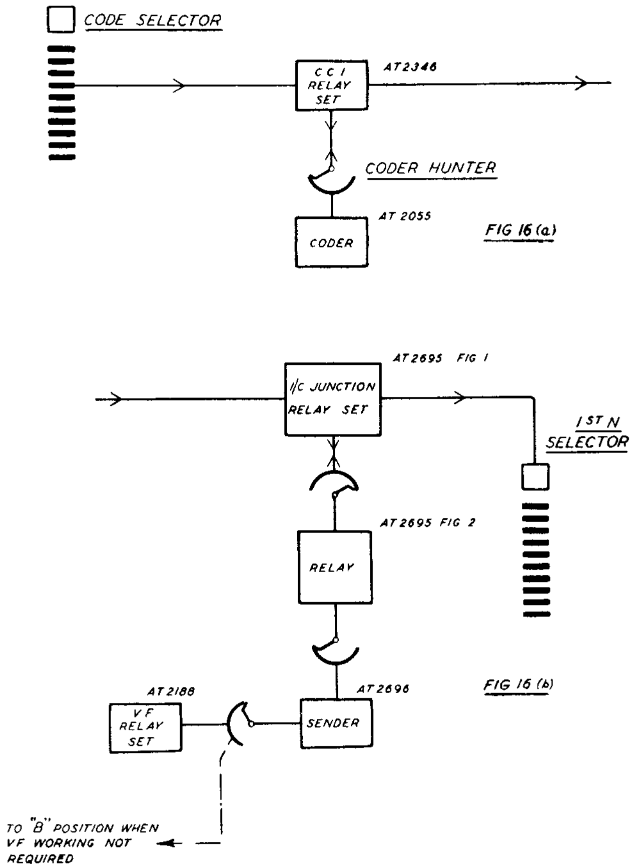


Fig. 16.—Showing Typical Arrangement of Relay Sets for C.C.I. & S.F.J. Working.

Frequency keysending. Fig. **16**(*b*) indicates the arrangement of the various portions of the equipment.

Appendix 4 summarises the automatic equipment required for a " Director " exchange.

An important point should be mentioned at this stage. It will be noticed that bank multiples often have been supplied in multiples of 20 where a multiple of 10 would suffice. A typical case might be 63 switches and 80 banks, although 70 banks would have given the 10% margin. The reason is that where 200 outlet selectors are concerned, banks can be supplied in multiples of 10 or 20. The use of a 20-bank multiple saves a set of tag blocks and a tie cable, and if it is expected that the additional 10 banks will be required at the next extension in three years' time, it is cheaper to provide the full 20-bank multiple initially than to do it in two sets of 10. The annual charges for three years on the extra cost of the 20-bank multiple is less than the cost of providing two separate multiples of 10, one initially and the other in three years' time.

The 10-bank multiple is used only where it will suffice for a number of years or where it is imperative that it be provided for grading purposes.

(*e*) *Tandem Exchanges.*

Tandem exchanges, which are essential to all director areas, deal exclusively with junction traffic. Their design usually presents little difficulty except that associated with the large amount of equipment concerned. The total number of junction routes is determined by the number of exchanges in the area, but the estimated traffic on each route, contrary to the normal exchange case, has to be produced by the Engineering Department after comprehensive study of the director area traffic. In an ordinary director exchange the large variation in traffic over the junction routes enables the heavy traffic routes to be accommodated on the first code selector levels, while the routes carrying only a small amount of traffic are catered for on 3rd code selector groups. This condition seldom exists in a tandem exchange where the traffic over the various routes is much more uniform. The reason is quite obvious when it is realised that the major portion of the traffic to a large exchange is carried on direct junctions, while for small exchanges where only a few direct routes can be justified a tandem routing is used more often. The provision of 3rd tandem selectors, therefore, has not yet been resorted to except where the number of routes required necessitates it. Apart from this one point the design of tandem exchanges follows very closely the principles already mentioned in connection with code selectors.

At the present time there are two types of tandem exchange, that which deals exclusively with traffic incoming from automatic exchanges and that which deals with all classes of traffic. The first type has so far been utilised only in London at the subsidiary tandem exchanges and differs from the other type in the fact that it uses first tandem selectors containing a transmission bridge. As a result it does not require relay sets with the exception of C.C.I. equipment on calls outgoing to manual exchanges.

The more general type of tandem exchange, however, has a transmission bridge in the relay set on all outgoing junctions. Incoming traffic from manual exchanges is dealt with by keysending equipment of the 7-digit type, and for circuit reasons separate groups of 1st and 2nd tandem selectors are provided for them. In addition the outgoing junction routes are often segregated, so that for all practical purposes the exchange may be considered as two separate tandem exchanges, one serving automatic traffic and the other manual traffic.

The mechanical Trunk and Toll exchanges which will be required in the near future are a development of the tandem exchange. From a trunking aspect they are very similar, the chief difference being that the Trunk and Toll exchanges will deal chiefly with traffic from manual boards instead of dialled traffic from subscribers.

(*f*) *Rack Lay-out.*

From the point of view of easy extension the lay-out of the equipment on the racks is very important. Typical cases based upon the designs given in Appendix 1 are given in Rack Equipment Schedules 1-4. It is essential that the equipment be spaced well on the racks, and that the racks be disposed on the floor of the exchange, in such a way that the equipment will remain in its proper sequence for many years to come. A good example of this, where a satisfactory compromise has been made between good spacing and the minimum of extra rack provision at the initial period, is shown in Rack Equipment Schedule No. 3, where the lay-out of the 2nd and 3rd selectors is depicted. Levels 2, 3 and 4 each require 80 banks, both for the initial and ultimate periods; their lay-outs present no difficulty, therefore, and they justify occupying 4 racks. Level 5 requires 80 banks initially, but ultimately it will require 6 racks. Although the initial 80 banks do not fill 2 racks completely it would be unwise to fit level 6 selectors on the spare rack space, as, in order to meet future growth on level 5, it would be necessary either to re-cable the level 6 selectors to the T.D.F. or fit the additional level 5 selectors out of sequence. The former of these alternatives is costly and the second is bad on maintenance grounds. In most exchanges floor space exists to enable the four additional racks for level 5 to occupy their correct position in sequence when they are required.

It will be noted that levels 6, 7, 8 and 9 have been allocated a rack each although a rack could be saved initially by cramping the switches on to three instead of four racks. It is claimed that the lay-out shown gives a far superior arrangement, because although it will not quite meet the ultimate requirements, it will cater for growth for at least 15 years, without re-arrangements, and gives a good clean engineering job. The additional cost incurred amounts to the annual charges on one rack for a period of three years, as it is almost certain the extra rack would be required by that time.

It is considered that the 3rd selector levels 95, 99 and 01 can be provided for conveniently on the 2nd selector rack for level " 0." The groups are small and it is likely that the arrangement will not need modification for 5 or 10 years. In any case the re-cabling involved here would be small and therefore the expense of an additional rack was not considered advisable.

The lay-out of the other racks is more or less self-evident, but one further point is worthy of mention. The large type final units appear first, because all the lines on such units are treated as auxiliary lines and are segregated from the other subscribers on the M.D.F., I.D.F. and also on the meter rack, and to facilitate cabling the final selectors also are segregated. It has been found from observation of a large number of cases, that a large type unit occupies at least two racks when fully loaded. In the lay-out of the final selectors, therefore, space is left always for two racks per large type unit.

(*g*) *Cabling Details.*

The cabling in a modern exchange is of two types, one bound up with the quantity of equipment installed and the other based on the traffic carried. The quantity for the first type being invariable for a given amount of equipment need not be considered further. The second type is centred round the trunk distribution frame (T.D.F.) which is the point at which grading is carried out.

The selector banks are in multiples of 10 or 20 and are grouped together on the racks by means of tie cables, so as to form as many banks in a graded group as required. A cable is then taken away to the T.D.F., where it is terminated on strips of tags along with similar cables, ready for grading. It is the determination of the bank grouping and the number of cables to the T.D.F. which is the variable quantity.

The number of groups in any grading is estimated by a formula which gives the minimum number of groups, namely,

$$\text{Minimum number of groups} = \left\{ \frac{\text{No of outlets} \times 2}{\text{Availability}} \right\}$$

The number of groups chosen is then the next even number above that given by the formula that can be made up conveniently from the various shelves. As an example, there are 50 outlets from level 2 of the 1st selectors at Derby which means a six group grading as a minimum. However, on investigation of the cabling arrangements it was found that an eight group grading would be more suitable.

For most of the banks of selectors in an exchange an effort is made to distribute the traffic evenly over the various shelves concerned; the number of banks in each graded group will be therefore the same and no difficulty will be encountered on this score.

In gradings from 1st selector levels, however, this evening up of the traffic can be carried out only within the various groups of selectors. This is shown clearly in Fig. **17** which represents the traffic to level 2 on each 1st selector shelf at Derby. It will be seen that the average traffic for a shelf serving coin-box lines is 0.36 T.U. while shelves serving ordinary subscribers contribute 0.85 T.U. Also traffic for the shelves serving incoming automatic and dialling-in manual exchanges is different again. It is necessary therefore to group the shelves together in such a manner that the traffic from each graded group is nearly equal. In practice it is usual to keep the variations in traffic within 10% of the average, although with a regular fluctuation as would arise from graded groups containing alternatively 4 and 2 uniformly-loaded shelves, 33% variation is permissible.

The grouping of the shelves is represented in Fig. **17** by dotted lines while the traffic per group also is shown. The variation is within 10% except for the last group, but this will be remedied when additional groups are added.

When taking cables to the T.D.F., consideration

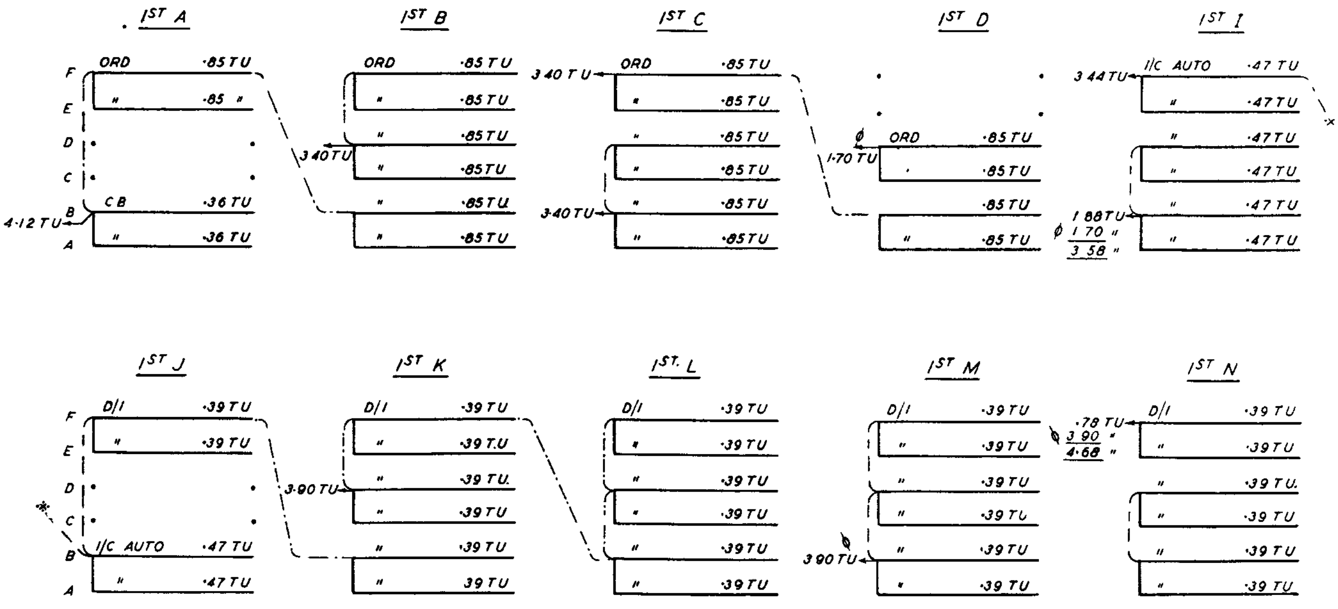


FIG. 17.—SHOWING THE CABLING OF LEVEL 2 OF 1ST SELECTORS AND THE TRAFFIC ON THE SHELVES.

has to be given to future growth. In this case space for additional strips must be left on the T.D.F. for cables which will be taken from Racks 1st E to H and for the racks which ultimately will follow 1st N. This is shown in Cabling Schedule No. 1 of the appendix which gives the complete cabling for level 2. It will be noticed that where a cable to the T.D.F. will be required ultimately, but a tie cable would meet immediate requirements, the T.D.F. cable has been provided initially, the necessary teeing being carried out at the T.D.F.

It will be apparent that the grading has to be designed before the cabling scheme can be formulated and the only other information given in the grading is the distribution of the various outlets on the shelves of the succeeding rank of switches. A typical grading is included in Appendix No. 1.

Conclusion.

It is realised that this paper has not covered completely the many varied conditions to be met with in the design of automatic exchanges. The large scope of the subject, however, has made it necessary to omit certain trunking arrangements at present in use, but only of passing interest. It is hoped that the information which is contained both in the body of the paper and in the appendices will assist those who are engaged in the work of designing exchanges, and will add to the somewhat meagre information available on the practical aspect of trunking.

Changes in policy as regards service codes and other facilities are taking place and may render out of date certain information in this paper. The essential principles of design remain unaffected and the paper should be of value in this respect.

Appendix I.

Design for a Non-Director Exchange.

Traffic Data is contained in Tables 1-7.

Design Calculations, etc., are contained in Tables 8-21.

INDEX.

TABLE 1.

PARTICULARS OF DEVELOPMENT, CALLING RATES, ETC., AT THE 3-YEAR PERIOD.

Item.	Derby.	Allestree	Alvaston	Mickleover.	Spondon	Breadsall	Duffield.
Number of Direct Exchange Lines at 3-year period.							
Ordinary	2913	221	158	265	341	79	333
Coin Box	105	4	8	5	12	4	7
2/10 P.B.X.	318	—	2	—	13	2	8
Over 20 P.B.X.	60	—	—	—	14	—	—
Total	3396	225	168	270	380	85	348
Total lines at Ultimate period	6970	652	448	735	1125	238	748
Originating Traffic.							
B/H Calling Rate, 3-year period, Coin Box lines	0.85*	1.00*	0.67*	1.80*	1.10*	0.50*	1.10*
,, ,, ,, ,, ,, Ordy. lines	0.80	0.30	0.35	0.43	0.72	0.28	0.54
,, ,, ,, ,, ,, Average	0.80	0.30	0.36	0.45	0.73	0.30	0.55
,, ,, ,, ultimate period Average	0.85	0.30	0.36	0.45	0.73	0.30	0.55
Day Calling Rate, 3-year period	4.90	2.00	2.30	3.00	4.00	2.00	2.70
3 year to 2 year reduction factor	0.96	0.91	0.92	0.93	0.92	0.92	0.94
Incoming Traffic.							
B/H Calling Rate, Ordinary lines	0.71	0.25	0.43	0.30	0.44	0.21	0.40
,, ,, ,, 2/10 P.B.X. lines	1.83	—	1.00	—	80	0.40	0.60
,, ,, ,, Over 20 P.B.X. lines	3.74	—	—	—	1.10	—	—

* In Exchange B/H only.

TABLE 2 (*a*).

ANALYSIS OF BUSY-HOUR TRAFFIC.

FROM AUTOMATIC EXCHANGE.		To										No. of Calls to or via the associated Manual Board, or to Service Levels.												
												Originated by Coin Box Lines †			Long Distance Trunk Calls.									
		Derby	Allestree	Alvaston	Mickleover	Spondon	Breadsall (U.A.X.)	Duffield (U.A.X.)	Chellaston (M.)	Kirk Langley (M.)	Calls originated by Coin Box Lines and effected automatically. †	Auto. Area (Local jct. PF, SV and LQ)	Other Jct. and Trunk	Junction and Short Distance Trunk Calls	Completed on Demand.	Recorded and completed on Delay Positions	To Phonograms via "90" level or transfer cts.	To Enquiry via "91" level.	To Service via "92" level	To Directory Enquiry via "953" level.	Originated by C.B lines to "PL" "951" level. †	Talking Clock via "952" level.	Total Originated Calls.	REMARKS.
Derby		1753	23	21	31	58	8	44	10	5	61	6	17	519	38	13	17	28	8	40	5	12	2717	† Add 25%
Allestree		42	7	1	2	2	—	1	—	—	2	—	—	6	1	—	—	1	—	1	2	—	68	† Add 25%
Alvaston		30	2	3	2	11	—	—	1	—	4	—	1	5	1	—	—	1	—	—	—	—	61	† Add 33%
Mickleover		62	3	2	18	4	—	1	—	2	7	—	1	14	2	—	1	2	—	2	1	—	122	† Add 25%
Spondon		118	4	31	3	32	1	5	3	—	9	—	3	45	6	2	3	3	1	4	1	1	275	† Add 25%
Breadsall (U.A.X.)		10	—	—	2	—	5	2	—	—	2	—	—	2	—	—	1	* 1	* —	—	—	—	25	† Add 50%
Duffield (U.A.X.)		78	3	2	3	5	2	55	—	—	6	—	1	27	1	—	1	* 3	* 1	3	1*	—	192	† Add 25%
Total		2093	42	60	61	112	16	108	14	7	91	6	23	618	49	15	23	39	10	50	10	13	3422	
Incoming Calls from Coin Box Lines (Auto)		78	1	2	3	4	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Calls via the Manual Board	From Coin Box Lines	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	* 2	* —	—	—	—	—	
	Ineffective Reversed Calls	81	1	1	2	7	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Enquiry Reversed Calls	12	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	To Service	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
	Long Distance Inc.	—	—	—	—	—	—	1	—	—	—	—	—	45	—	—	—	—	—	—	—	—	—	
	and Orig. Reversed	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—	
	Other Jct. and Tk. Calls	26	—	—	—	3	—	—	—	—	—	—	—	13	—	—	1	* 2	* —	—	—	—	—	
Dialled in from other Exchanges	Long Distance Inc. and Orig. Reversed	80	1	1	2	12	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	
	Other Jct. and Tk. Calls (*a*) From Exs inside the area	33	1	—	—	1	—	1	—	—	—	—	—	10	—	—	2	1	—	—	—	—	—	
	(*b*) ,, ,, outside ,, ,,	528	10	9	14	35	2	23	5	1	—	—	—	390	22	8	10	22	2	—	34	—	—	

(M).—Manual exchange dialled-out. †Coin box traffic, selector provision should be made for more traffic in certain cases, as shewn in Remarks column.

(U A X)—Unit automatic exchange inter-dialling with automatic area * Via transfer circuits

TABLE 2 (*b*).

ANALYSIS OF CALLS IN TABLE 2 (*a*) ORIGINATED BY COIN BOX LINES and effected automatically.

FROM AUTOMATIC EXCHANGE	To Derby	Allestree	Alvaston	Mickleover	Spondon	Breadsall (U.A.X.)	Duffield (U.A.X.)	TOTAL.
Derby	55	1	1	1	2	—	1	61
Allestree	2	—	—	—	—	—	—	2
Alvaston	3	—	1	—	—	—	—	4
Mickleover	5	—	—	2	—	—	—	7
Spondon	7	—	—	—	2	—	—	9
Breadsall (U.A X.)	2	—	—	—	—	—	—	2
Duffield (U.A.X)	4	—	—	—	—	—	2	6
Total	78	1	2	3	4	—	3	91

TABLE 3.

AVERAGE HOLDING TIMES PER CALL

Originating Calls.	
Automatic local calls*	2.0 mins.
,, junction calls	2 3 mins.
,, coin box calls	3 0 mins
Via Manual Board.	
Junction and short distance trunk calls	4 0 mins.
Coin Box calls	3 5 mins.
Long Distance trunk calls completed on Demand (" O " level)	6.0 mins.
Long Distance trunk calls recorded (subsequently completed on Delay positions) (" O " level)	2 0 mins.
Long Distance trunk calls completed on Trunk Delay positions	6 0 mins.
'90' level, Phonogram calls	2 5 mins
'91' ,, Enquiry calls	2.0 mins.
'92' ,, Service calls	3 0 mins.
'94' ,, Dialling-in exchanges booking trunk calls	2 0 mins.
'951' ,, Telephone-Telegram calls	2 5 mins.
'952' ,, Talking Clock	20 secs
'953' ,, Directory Enquiry	2.5 mins.
Incoming Calls	
Long Distance Trunk calls	6 0 mins.
Other Junction and Trunk calls	3.5 mins.
Ineffective and Enquiry reversed calls	2 8 mins.

* Includes all calls between exchanges in the local fee area

TABLE 4.

CIRCUITS FROM THE AUTOMATIC PLANT TO THE MANUAL BOARD.

Service.	No. of ccts 2-yr.	No. of ccts 3-yr.	Type of position on which the circuits are terminated.	No. of night concentration circuits to the 'A' Suite.
Level " O " Derby Ordy.	64	66	" A " Suite	—
,, ,, ,, C.B.	7	7	,,	—
,, ,, Allestree	*5	*5	,,	—
,, ,, Alvaston	*5	*5	,,	—
,, ,, Mickleover	*6	*6	,,	—
,, ,, Spondon	*11	*11	,,	—
,, ,, D I Ex anges	19	20	,,	—
,, 91 Derby Ordy.	6	6	Monitor	3
,, ,, Sat Exchanges	3	3	,,	2
,, ,, D/I ,,	5	5	,,	2
,, 92 Derby Ordy.	4	4	Service	—
,, ,, Sat Exchanges	3	3	,,	—
,, ,, D/I ,,	3	3	,,	—
,, 94 D/I ,,	6	6	" A " Suite	—
,, 90	7	7	Phonogram	2
,, 951	8	8	,,	—
,, 953	7	7	Directory Enquiry	3

* Circuits carrying Coin Box and Ordinary traffic with a discriminating feature.

TABLE 5.

CIRCUITS FROM THE MANUAL BOARD TO THE AUTOMATIC PLANT.

Circuits to	No. of Circuits. 2 years.	No. of Circuits. 3 years.
1st Selectors		
From Monitors Desk	4	4
,, Phonogram Bd.	6	6
2nd Selectors		
Level 2 (Derby)	8	8
,, 3 ,,	8	8
,, 4 ,,	8	8
3rd Selectors		
Level 50 (Derby)	7	7
,, 55 (Mickleover)	2	2
,, 56 (Alvaston)	2	2
,, 57 (Spondon)	3	3
,, 59 (Allestree)	2	2
Trunk Offering.		
To Derby	3	3
,, Allestree	1	1
,, Alvaston	1	1
,, Mickleover	1	1
,, Spondon	1	1

TABLE 6

MISCELLANEOUS INFORMATION.

1 Maximum number of bothway circuits during the 3-year period

D/I—D/I	19
D/I—S/O	92
D/I—D/O	10

2. Traffic to large units

Exchange.	Unit No. and Type	Name of Subscriber.	3-year Period. No. of ccts.	3-year Period. Exch. B/H calls	3-year Period. Holding time (mins.)	3-year Period. Group to Exchange B/H ratio	No. of circuits at 10 year period.	Ultimate period. No. of ccts.	Ultimate period. B/H calls
Derby	44 Over 20 PBX type	Jones & Co.	18	77	—	—	22	25	105
		Smith & Co.	8	19	—	—	10	12	28
		Brown & Co.	14	93	—	—	22	25	166
		Robinson & Co.	12	11	—	—	13	15	14
		Green & Co.	8	24	—	—	12	14	42
	—	—	60	224	2.8	1.0	79	91	355
Spondon . .	11/20 PBX	Taylor & Co.	14	15	3.0	1.5	16	18	20

3. Interception.

Exchange.	Changed Number. No. of eqpts.	Changed Number. No. of junctions.	Service. No. of eqpts.	Service. No. of junctions.
Derby	17	3*	7	*
Allestree .	2	1	1	
Alvaston	1	1	1	
Mickleover .	2	1	1	
Spondon	2	1	1	

* Junction available to either.

TABLE 7.

ESTIMATE OF THE JUNCTION AND TRUNK TRAFFIC AND THE NUMBER OF CIRCUITS AT THE 3-YEAR PERIOD.

Exchange.	Fee.	No. of O G calls.		No. of circuits			Method of working.	
		From M E. Area.	From D, I. Exchs.	O/G.	I C.	B, W.	Out.	In.
Alfreton	4	10	4	—	—	5	S/O & D/O	D/I
Ambergate	3	9	15	2	2	2	,,	,,
Ashbourne	4	28	36	7*	7*	—	,,	,,
Ashby-de-la-Zouch	4	8	2	—	—	4	,,	,,
Belper	2	31	29	6*	8*	—	,,	,,
Birmingham Toll	—	—	17	9	11	—	,,	,,
,, Trunk	—	—	—	—	—	6	S/O	,,
Burton-on-Trent	4	62	20	9	12	—	D/I & I/D	,,
Buxton	—	—	4	—	—	4	S O & D O	,,
Castle Donington	3	7	17	2	2	2	,,	,,
Chellaston	1	14	6	5*	5*	—*	,,	,,
Chesterfield	—	—	8	5	5	—	D/I & I/D	,,
Claycross	—	—	4	—	—	3	S O & D/O	,,
Etwall	2	15	18	2	2	3	,,	,,
Hanley	—	—	17	4	4	—	D/I & I/D	,,
Horsley	2	5	8	—	—	5	S O & D/O	,,
Ilkeston	3	14	19	2	2	4	,,	,,
Kegworth	4	6	14	2	2	2	,,	,,
Kirk Langley	1	7	3	4*	3*	—	,,	,,
Leabrooks	4	8	3	—	—	4	,,	,,
Leeds	—	—	—	—	—	7	S/O	,,
Leek	—	—	6	—	—	4	S/O & D/O	,,
Leicester	—	—	12	6*	7*	—	D/I & I/D	,,
Liverpool	—	—	—	—	—	3	S/O	,,
London	—	—	—	—	—	11	,,	,,
Long Eaton	3	16	8	2	2	4	S/O & D/O	,,
Loughborough	—	—	7	2	2	2	,,	,,
Manchester	—	—	—	—	—	12	S/O	,,
Mansfield	—	—	3	—	—	4	S/O & D/O	,,
Matlock	—	—	42	8*	7*	—	,,	,,
Melbourne	2	12	20	2	2	2	,,	,,
Nottingham (Auto)	4	129	38	14	17	—	D/I & I/D	,,
,, Trunks	—	—	—	—	—	2	S/O	,,
Ripley	3	19	39	7*	6*	—	S/O & D/O	,,
Shardlow	2	8	13	—	—	5	,,	,,
Sheffield	—	—	11	6	6	—	D/I & I/D	,,
Wirksworth	4	10	15	2	2	3	S/O & D/O	,,
Total	—	418	458	108	116	103	—	—
Brailsford	2	10	9	—	—	5	D/I & I/D	I/D
Breadsall	1	See Sch	edule B	—	—	6	,,	,,
Duffield	1	,,	,, ,,	11	15	—	,,	,,
Repton	2	14	6	2	2	2	,,	,,
Total	—	24	15	13	17	13	—	—

References—D/I—Dialling In. I/D—Inter-dialling
D/O—Dialling Out. S/O—Signal Out.
* Bothway working may be required at the opening date.

TABLE 8.

SUMMARY OF ORIGINATING TRAFFIC.

Item.	A. Holding Time (Mins.)	3-year period. B. Exch. B H Calls From table 2	3-year period. C. Traffic in TU's $=\frac{A \times B}{60}$	D. 2-year period Traffic in TU's $=C \times 0.96$
Ordinary Group				
Local	2 0	1753	58 43	56.15
Outgoing ME.				
To other auto exchanges	2.0	185	6.17	
,, Manual ,,	2.3	15	0 58	
Total		200	6.75	6.48
Level 9 Services.				
Level 91 Enquiry	2 0	28	.93	
,, 92 Service PBX	3.0	8	0.40	
,, 99 Test Desk	3.0	30	1.50	
,, 90 Phonograms	2.5	17	0 71	
,, 952 Talking Clock	20 (secs)	12	0.07	
,, 953 Directory Enquiry	2.5	40	1.67	
Total		135	5 28	5 08
Level O.				
No Delay	4.0	519	34.60	
Demand Trunk	6.0	38	3.80	
Delay Trunk	2.0	13	0.43	
Total		570	38.83	37.28
Total for Ordinary Group		2658	109.29	104.99
Coin Box Group.				
Local	3.0	55	2.75	2.64
Outgoing M.E.	3.0	6	0.30	0.29
Level 951	2.5	5	0.21	0.20
Level "O"	3.5	23	1 34	1.29
Total for Coin Box Group		89	4.60	4.42
Total for Coin Box Group—25%			5.75	5.52

TABLE 9.

SUMMARY OF INCOMING TRAFFIC.

Item.	A. Holding Time (Mins.)	3-year period. B. Exch. B/H Calls From table 2	3-year period. C. Traffic in TUs $= \frac{A \times B}{60}$	D. 2-year period Traffic in TUs = Cx0.96
Local.				
Ordinary lines	2.0	1753	58.43	
Coin Box ,,	3.0	55	2.75	
Total		1808	61.18	58.79
Incoming M E.				
I C M.E. Ordinary lines	2.0	340	11.33	
,, ,, Coin Box ,,	3.0	23	1.15	
,, D/I inside ME Area	3.5	33	1.93	
Total		396	14.41	13 83
Incoming DI				
Long Distance	6 0	80	8.00	
Short Distance outside ME area	3.5	528	30.81	
Total		608	38.81	37.28
Incoming via Manual Board.				
From CCB lines	3.5	3	0.18	
,, Ineffective reversed	2.8	81	3.78	
,, Enquiry ,,	2.8	12	0.56	
,, Service	3 0	12	0.60	
,, Other Junction and Trunk Calls	3.5	26	1.52	
Total		134	6.64	6.37
Total Incoming Traffic			121.04	116.27
Total Incoming Traffic (less MB)			114.40	109.90

Ratio of Incoming (less MB) traffic to total $= \frac{114.40}{121.04} = 0.945$

Level 9 Traffic.				
I/C from Auto Exchanges Level 91	2.0	7	0.23	
,, 92	3.0	2	0.10	
,, 99	3.0	5	0.25	
,, 90	2.5	4	0.17	
,, 951	2.5	4	0.17	
,, 952	20 secs.	1	0 01	
,, 953	2.5	7	0.29	
	—	30	1.22	1.17
D/I Exchanges Level 91	2.0	27	0.90	
,, 92	3.0	2	0.10	
,, 94	2 0	8	0 27	
,, 90	2.5	12	0.50	
,, 951	2.5	34	1.42	
	—	83	3.19	3.06

TABLE 10.

SHOWING CALCULATION OF L & K RELAY AND PRIMARY FINDER QUANTITIES.

Initial calling rate = 8. Ultimate calling rate = .85. Ultimate D.E.L. = 6960. 3-yr to 2-yr reduction factor = .96.

Type of Line	A. No. of D.E.L. at 3 year period	B. No of P.F. groups	C. No of Subs. per group	L & K Relays: D. No of eqpts.	L & K Relays: E. No of ccts. wired	L & K Relays: F. No. of racks for 3 year period	G. Ultimate No. of racks	H. Total originating traffic in T.U's	Traffic per group in T.U.'s: I. 3-year period	Traffic per group in T.U.'s: J. 2-year period	K. No. of P.F.'s required at 2-year period	L. Max. traffic for a full group and ultimate calling rate	M. Max. No of P.F.'s at ultimate date	No. of P.F.: N. Banks	No. of P.F.: O. Racks for 3-yr period	No. of P.F.: P. Racks for ultimate date
	From Table 1	$= \frac{A}{200}$	$= \frac{A}{B}$	= C rounded up to nearest 20	= D rounded up to nearest 100	$= \frac{E}{900}$	$= \frac{\text{Ult. D.E.L}}{900}$	From Table 9	$= \frac{H}{\text{No. of grps.}}$	= 1 × .96		$= I \times \frac{200}{C} \times \frac{.85}{.8}$	—	M−10% and rounded up to nearest 5	$\frac{N}{50}$ *	$\frac{\text{Ult D.E.L.*}}{200} \times \frac{N}{50}$
Coin Box	105	1	—	—	—	—	—	5 75	—	—	—	—	—	—	—	—
Quantities per group	—	—	105	120	200	—	—	—	5 75	5.52	14	11 63	23	30	—	—
Equipment required	—	—	—	120	200	—	—	—	—	—	14	—	—	30	—	—
Ordinary	3291	17	—	—	—	—	—	109 29	—	—	—	—	—	—	—	—
Quantities per group	—	—	194	200	200	—	—	—	6.43	6 17	16	7 05	17	20	—	—
Equipment required .	—	—	—	3400	3400	4†	—	—	—	—	272	—	—	340	8†	—
Total Equipment	—	—	—	3520	3600	4	8	—	—	—	286	—	—	370	8	14

† includes C.B. Group

* except when N=15, then $O = \frac{N}{45}$ and $P = \frac{\text{ult. D.E.L.}}{200} \times \frac{N}{45}$

TABLE 11.

Showing Calculation of Secondary Finder and 1st Selector Quantities.

Ultimate Factor=2.18

Type of Line	A No. of P.F. Groups From Table 10	Traffic per P.F. group in T.U. B 3 yr. From Table 10	C 2 yr. From Table 10	No. of P.F.'s Connected direct to 1st Selectors D 3 yr.	E 2 yr.	Connected via S.F.s F 3 yr.	G 2 yr.	H No. of P.F. grps. per division Max. allowable so that I does not exceed 7	I No. of S.F. groups $=1+\frac{H+(F \text{ or } H)}{50}$ † (not to exceed 7)	Traffic to S.F.s J 3 yr.	K 2 yr.
Coin Box	1	5 75	5 52	14	14	—	—	—	—	—	—
Equipment required	—	—	—	—	—	—	—	—	—	—	—
Ordinary Quantities	17	—	—	—	—	—	—	—	—	—	—
per P.F. gp.	—	6.43	6 17	6	6	10	10	—	—	1.91	1.73
Division 1	—	—	—	102	102	170	170	17	4	32.47	29.41
Equipment required .	—	—	—	—	—	—	—	—	—	—	—
Total Equipment	—	—	—	—	—	—	—	—	—	—	—

Type of Line	No. of S.F.s Switches L 3 yr.	M 2 yr.	N Banks = L or M † I rounded up to 12, 17, or 24 and multiplied by I	O Racks for 3 yr. period $=\frac{N^*}{102}$	P Ultimate Racks $=\frac{N^*}{102} \times 2.18$	No. of 1st Selectors Switches Q 3 yr. =D+L	R 2 yr. =E+M	S Banks =Q×10% Rounded up to the nearest 10	T Racks for 3 yr. period $=\frac{S}{60}$	U Ultimate Racks $=\frac{S \times 2.18}{60}$
Coin Box	—	—	—	—	—	14	14	—	—	—
Equipment required	—	—	—	—	—	—	14	20	1	—
Ordinary Quantities	—	—	—	—	—	—	—	—	—	—
per P.F. gp.	—	—	—	—	—	—	—	—	—	—
Division 1	53	49	68	—	—	155	151	180	3	—
Equipment required .	—	49	68	1	2	—	151	180	3	—
Total Equipment	—	49	68	1	2	—	165	200	4	8

† Whichever is the greater.

* Except when N is a multiple of 12 then it should read $\frac{N}{120}$

TABLE 12.

Summary of 1st Selector Quantities

Item.	No. of circuits. A. 3 Yr. *	B. 2 Yr. *	3-year period C. Switches = A	D. Banks = C+10% rounded up to nearest 20	E. Racks = D/60	F. Switches for 2 year period = B	Ultimate period G. Switches = C × 2.18	H. Banks = G+10% rounded up to nearest 10	I. Racks = H/60
Coin Box Group .	14	14	14	20	†	14	—	—	—
Ordinary Group . .	155	151	155	180	4†	151	—	—	8†
I/C Auto Exch. Group.									
Allestree . . .	8	7	8	—	—	7	—	—	—
Alvaston . .	8	7	8	—	—	7	—	—	—
Mickleover .	10	10	10	—	—	10	—	—	—
Spondon . .	14	13	14	—	—	13	—	—	—
Breadsall	6	6	6	—	—	6	—	—	—
Duffield . . .	15	15	15	—	—	15	—	—	—
UAX's outside ME area	9	9	9	—	—	9	—	—	—
Total .			70	80	‡	67	153	170	‡
D/T Group.									
I/C junctions . .	116	116	116	—	—	116	—	—	—
B W ,, . .	103	103	103	—	—	103	—	—	—
Monitor ccts. . .	4	4	4	—	—	4	—	—	—
Phonogram ccts. .	6	6	6	—	—	6	—	—	—
Total			229	260	6‡	229	500	550	12‡
Total Eqpt. required .			—	540	10	461	—	—	20

† including C.B. 1st Selectors.
‡ ,, I/C Auto 1st Selectors.
* Figures from Table 7 or 11.

TABLE 13.

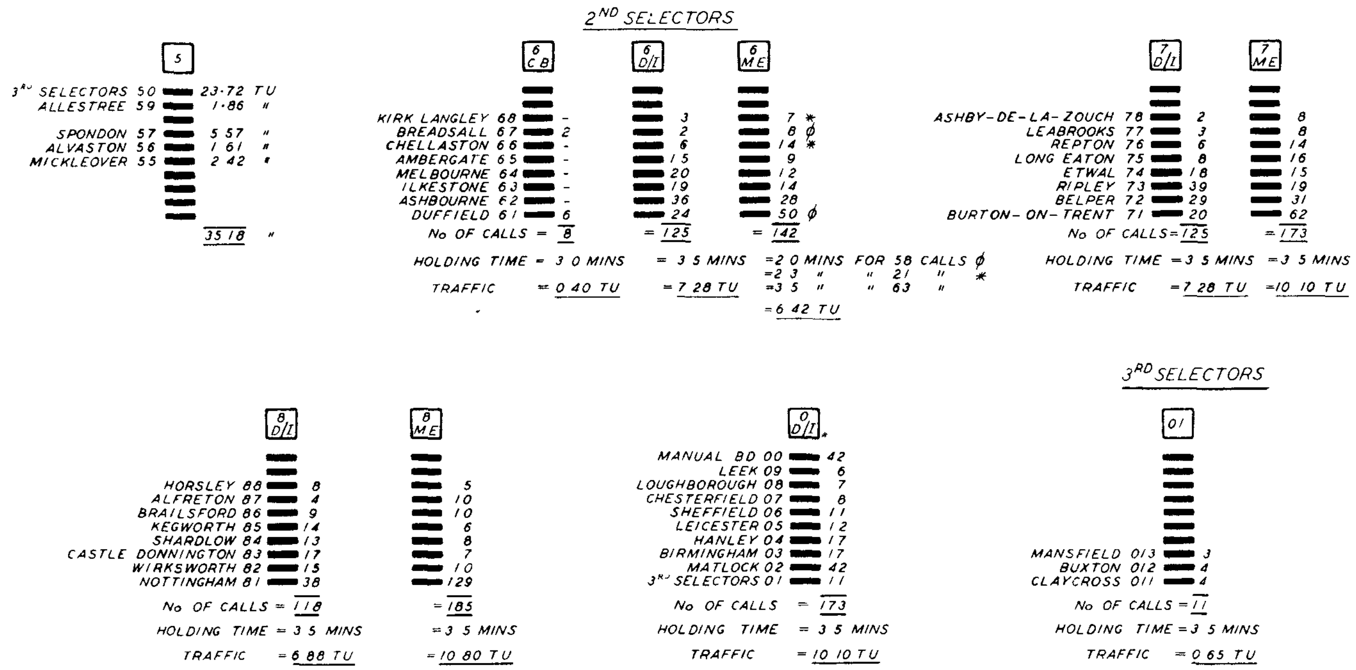


TABLE 14.

SHOWING THE CALCULATIONS OF 2nd AND 3rd SELECTOR QUANTITIES.

(GROUPS SERVING FINAL SELECTORS.)

Initial calling rate=0.8, Ultimate calling rate=0 85; 3-yr to 2-yr reduction factor=0 96, Ratio of I/C traffic (less MB) to total=0.945.

GROUP.	3 year Period. Exchange B H Traffic A. Ordinary Units	B. 2/10 P.B X Units	C. Over 20 P B X. Units	D Total A+B+C	E. Total less MB traffic =D×0 945	F. Switches Table C/20	G. Banks =F+10% Roundedup to nearest 20	H. Racks $=\frac{G}{60}$	2-year Period I. Traffic in TUs E 0 96	J Switches Table C 20	Ultimate Period. K Traffic in TUs $E\times\frac{.85}{.80}$	L Switches Table C/20	M. Banks =L+10% rounded up to nearest 10	N. Racks $\frac{M}{60}$
Level 2 Auto	8 at 2 84	2 at 4 28	—	31.28	29 58	52	80		28.39	50	31.40	55	80	
,, 2 MB	—	—	—	—	—	8			—	8	—	8		
,, 3 Auto	7 at 2.84	3 at 4.28	—	32 72	30 91	54	80	4	29 67	52	32 85	57	80	4
,, 3 MB	—	—	—	—	—	8			—	8	—	8		
,, 4 Auto	8 at 2.84	1 at 4.28	1 at 10 45	37 45	35.40	61	80		34 00	59	37 60	65	80	
,, 4 MB	—	—	—	—	—	8			—	8	—	8		
,, 5	—	—	—	—	35 18*	61	80	2	33.75	58	185†	304	340	6
Total Equipment required	—	—	—	—	—	—	320	6	—	243	—	—	—	10
Level 50 Auto	6 at 2.84	1 at 4.28	—	23.72	22 41	40	60	1	20 55	37	—	—	80	
,, 50 MB	—	—	—	—	—	7			—	7	—	—		5
Levels 51—54	—	—	—	—	—	—	—	—	—	—	—	—	320	
Total Equipment Required	—	—	—	—	—	—	60	1	—	44	—	—	—	5

* From Table 13. † Approx figure allowing for growth on Levels 51—54.

TABLE 15.

SHOWING THE CALCULATION OF 2nd AND 3rd SELECTOR QUANTITIES.

(group serving junctions)

3 Yr to 2 Yr. reduction factor=.96; Ultimate factor=2.18.

Group	3-year period A Traffic in T.U.s From Table 13	B Switches †	C Banks =B+10% rounded up to nearest 10	D Racks $=\frac{C}{70}$	2-year period E Traffic in T U s =A×.96	F Switches †	Ultimate period G Traffic in T.U s =A×2 18	H Switches †	I Banks =H+10% rounded up to nearest 10	J Racks $=\frac{I}{70}$
Level 6 CB	0 40	4	10		0.39	4	0.87	5	10	
,, 6 ME	6.42	15	20	1	6 16	15	14.00	27	30	
,, 6 D/I	7.28	17	20		6.98	16	15.86	30	40	
,, 7 ME	10.10	21	30	1	9.70	20	22.02	40	50	
,, 7 D/I	7.28	17	20		6.98	16	15.86	30	40	
,, 8 ME	10.80	22	30	1	10.37	21	23 55	42	50	
,, 8 D/I	6.88	16	20		6.60	16	15.00	28	30	6
,, 9 CB	0 21	3	10		0 20	3	0 46	4	10	
,, 9 Ordy	5 28	14	20	1	5.07	13	11.52	22	30	
,, 9 I/C Auto	1.22	6	10		1.17	6	2.66	8	10	
,, 9 D/I	3.19	10	20		3 06	10	6.95	16	20	
,, 0 D/I	10 10	21	30	1*	9.70	20	22 00	40	50	
Total Equipment required	—	—	320	5*	—	160	—	—	—	6
Level 95	3.84	11	20		3.69	11	8.37	22	30	
,, 99	1.75	7	10		1.68	7	3.82	11	20	1
,, 01	0 65	5	10		0 63	5	1 42	7	10	
Total Equipment required	—	—	40	*	—	23	—	—	—	1

† Table B/20 for ME grp., Table C/20 for D/I grp. and Table C/10 for 3rd Selectors.

* 3rd Selectors fitted on 2nd Selector racks initially.

TABLE 16 (SHEET 1).

Showing the Calculation of Final Selector Quantities.

Total I/C traffic = 122.75 TU
No. of calls to Over 20 PBX lines = 224
Average holding time of each call = 2 8 mins.
∴ Traffic to Over 20 PBX lines = 10.45 TU

Total I/C traffic to Ordinary & 2/10 PBX lines
= 122.75—10.45
= 112.3 TU

	3 YEAR PERIOD											
	A	B	C	D	E	F	G	H	I	J	K	L
CLASS OF LINE	No of Lines	No. of 2/10 PBX Units	Average No. of 2/10 PBX lines on 2/10 PBX units	Maximum No. of Ordy. lines on 2/10 PBX units	No. of Ordy. Units	No. of lines which can be accommodated on the Ordy. units	No of Ordy lines left for allocation on 2/10 PBX units	Average No of Ordy. lines on 2/10 PBX units	Average calling rate	No. of I C calls per B H	Proportion of I C traffic between Ordy. and 2/10 PBX lines	Average traffic per line in TU
	From Table 1	= A/49	= A/B	= B × 39	= (A—D)/97	= E × 97	= A—F	= G/B	From Table 1	= A × I	(J × 112.3)/2722	= K/A
Ordinary	3018	—	—	273	29	2813	205	30	0.71	2140	88.3	.0293
2/10 PBX	318	7	45	—	—	—	—	—	1.83	582	24.0	.0755
									(Total)	2722		

TABLE 16 (SHEET 2).

Showing the Calculation of Final Selector Quantities.

No. of Ordy. units = 29 }
„ „ 2/10 PBX = 7 }

Therefore: 7 Ordy + 2/10 PBX units and 11 Ordy. + Ordy. units.

	3 YEAR PERIOD											2 YEAR PERIOD			ULTIMATE PERIOD	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
TYPE OF UNIT	Average No of lines per unit	Average traffic per line in TU	Traffic per unit in TU	No. of lines for a full unit	Traffic for a full unit	Traffic + 27.5% for bank provision	Switches	No. of Test and T.O. Final Selectors	Bank per unit	Total banks	Racks	Traffic per unit	Switches per unit	Total Switches	Total banks	Racks
	From Sheet 1	From Sheet 1	= A × B		= (C × D)/A	= E + 27.5%	Table C/20 ϕ		= G+H rounded up to nearest 5	= IX No. of units	= J/50	= C × .96	Table C/20 ϕ	= MX No. of units	= IX No. of units	= O/50
Ordinary	97 Ordy.	.0293	2.84	100	2.93	3.74	—	—	—	—	—	—	—	—	—	—
2/10 PBX	30 Ordy.	.0293	.88 } 4.28	40	1.17 } 5.70	7.27	—	—	—	—	—	—	—	—	—	—
	45 PBX	.0755	3.40 }	60	4.53 }											
Ordy. + Ordy.	—	—	5.68	—	5.86	7.48	17	3	20	220	8	5.46	14	154	460	17
Ordy. + 2/10 PBX	—	—	7.12	—	8.63	11.01	22	3	25	175	}	6.73	16	112	350	}
Over 20 PBX	—	—	10.45	—	16.62*	—	21	2	30	30	1	10.03	20	20	40	1
Total equipment required	—	—	—	—	—	—	—	—	—	425	9	—	—	286	—	18

* Ultimate traffic = 355 Calls at 2 8 mins.
ϕ See E.I. Telephones, Traffic, B 3520.

TABLE 17.

SUMMARY OF RELAY SET QUANTITIES.

			Method of Working		No. of Junction				RELAY SETS									
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Exchange	Type	Conversion during the 3-year period to	In	Out	O/G	I C	B W	Junction Resistance	1st Selrs = F+G	D/I from Man.Ex. at 3783 — =F+G*	D/O to CB at 3640 — =E+G*	D/O to CBS & Mag. at 3689 — =E+G*	Joint access at 2375 — =E+G	O/G from UAX at 3706 — Fig. 1	I/C to UAX at 3706 — Fig. 2	Auto to Auto at 3639 —	B W 2 VF — TL 1750 ,, 1753 ,, 1754	Loop Dialling at 2121
Alfreton	CB10	—	D/I	S/O & D/O	—	—	5	200	5	5	5	—	5	—	—	—	—	—
Ambergate	CBS2	—	,,	,,	2	2	2	580	4	4	—	4	4	—	—	—	—	—
Ashbourne	CBS2	—	,,	,,	7*	7*	—	280	7	7	—	7	7	—	—	—	—	—
Ashby-de-la-Zouch	CB10	—	,,	,,	—	—	4	700	4	4	4	—	4	—	—	—	—	—
Belper	CBS2	UAX	,,	,,	6*	8*	—	216	8	8	—	6	6	6	8	—	—	—
Birmingham	Toll	—	,,	,,	9	11	—	1500	11	11	9	—	9	—	—	—	—	—
Birmingham	Trunk	—	,,	S/O	—	—	6	—	6	—	—	—	—	—	—	—	6	—
Burton-on-Trent	Auto	—	,,	D/I & I/D	9	12	—	320	12	—	—	—	—	—	—	9	—	9
Buxton	CB10	—	,,	S/O & D/O	—	—	4	220	4	4	4	—	4	—	—	—	—	—
Castle Donnington	CBS2	UAX	,,	,,	2	2	2	200	4	4	—	4	4	4	4	—	—	—
Chellaston	CBS2	UAX	,,	,,	5*	5*	—	200	5	5	—	5	5	5	5	—	—	—
Chesterfield	Auto	—	,,	D/I & I/D	5	5	—	450	5	—	—	—	—	—	—	5	—	5
Claycross	CBS1	—	,,	S/O & D/O	—	—	3	250	3	—	—	3	3	—	—	—	—	—
Etwall	CBS2	UAX	,,	,,	2	2	2	300	5	5	—	5	5	5	5	—	—	—
Hanley	Auto	—	,,	D/I & I/D	4	4	—	600	4	—	—	—	—	—	—	4	—	4
Horsley	CBS2	—	,,	S/O & D/O	—	—	5	280	5	5	—	5	5	—	—	—	—	—
Ilkeston	CBS1	—	,,	,,	2	2	4	300	6	—	—	6	6	—	—	—	—	—
Kegworth	CBS2	—	,,	,,	2	2	2	200	4	4	—	4	4	—	—	—	—	—
Kirk Langley	CBS1	UAX	,,	,,	4*	3*	—	150	3	—	—	4	4	4	3	—	—	—
Leabrooks	CBS2	—	,,	,,	—	—	4	1200	4	4	—	4	4	—	—	—	—	—
Leeds	Trunk	—	,,	S/O	—	—	7	—	7	—	—	—	—	—	—	—	7	—
Leek	CB10	—	,,	S/O & D/O	—	—	4	350	4	4	4	—	4	—	—	—	—	—
Leicester	Auto	—	,,	D/I & I/D	6*	7*	—	1280	7	—	—	—	—	—	—	6	—	6
Liverpool	Trunk	—	,,	S/O	—	—	3	—	3	—	—	—	—	—	—	—	3	—
London	Trunk	—	,,	,,	—	—	11	—	11	—	—	—	—	—	—	—	11	—
Long Eaton	CBS1	UAX	,,	S/O & D/O	2	2	4	500	6	—	—	6	6	6	6	—	—	—
Loughborough	Mag.	—	,,	,,	2	2	2	850	4	—	—	4	4	—	—	—	—	—
Manchester	Trunk	—	,,	S/O	—	—	12	—	12	—	—	—	—	—	—	—	12	—
Mansfield	CB10	—	,,	S/O & D/O	—	—	4	1200	4	4	4	—	4	—	—	—	—	—
Matlock	CB10	—	,,	,,	8*	7*	—	700	7	7	8	—	8	—	—	—	—	—
Melbourne	CBS2	UAX	,,	,,	2	2	2	200	4	4	—	4	4	4	4	—	—	—
Nottingham	Auto	—	,,	D/I & I/D	14	17	—	900	17	—	—	—	—	—	—	14	—	14
Nottingham	Trunk	—	,,	,,	—	—	2	—	2	—	—	—	—	—	—	—	2	—
Ripley	CBS2	—	,,	S/O & D/O	7*	6*	—	200	6	6	—	7	7	—	—	—	—	—
Shardlow	CBS2	UAX	,,	,,	—	—	5	200	5	5	—	5	5	5	5	—	—	—
Sheffield	Auto	—	,,	D/I & I/D	6	6	—	1100	6	—	—	—	—	—	—	6	—	6
Wirksworth	CBS2	—	,,	S/O & D/O	2	2	3	380	5	5	—	5	5	—	—	—	—	—
Brailsford	UAX	—	,,	,,	—	—	5	200	5	—	—	—	—	5	5	—	—	—
Breadsall	UAX	—	,,	,,	—	—	6	250	6	—	—	—	—	6	6	—	—	—
Duffield	UAX	—	,,	,,	11	15	—	150	15	—	—	—	—	11	15	—	—	—
Repton	UAX	—	,,	,,	2	2	2	250	4	—	—	—	—	4	4	—	—	—
Phonogram	—	—	,,	,,	—	6	—	—	6	6	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	255	111	38	88	126	65	70	44	41	44

* Depending upon type of Exchange and junction resistance.

TABLE 18.

Summary of Originating Traffic.

ITEM	A	3-year period		D
	Holding Time (mins)	B Exch. B/H Calls From Table 2	C Traffic in TUs = A × B / 60	2-year period Traffic in TUs = C × 0.92
Ordinary Group.				
Local	2.0	32	1.07	0.99
Outgoing ME				
To Alvaston	2.0	31	1.03	0.95
To Other Auto exchanges	2.0	131	4.36	
To Manual Exchanges	2.3	3	0.12	
Total (less Alvaston)		134	4.48	4.13
Level 9 Services.				
Level 91 Enquiry	2.0	3	0.10	
,, 92 Service PBX	3.0	1	0.05	
,, 99 Test Desk	3.0	2	0.10	
,, 90 Phonogram	2.5	3	0.13	
,, 952 Talking Clock	20 (secs)	1	0.01	
,, 953 Directory Enquiry	2.5	4	0.17	
Total		14	0.56	0.54
Level O				
No delay	4.0	45	3.00	
Demand Trunk	6.0	6	1.00	
Delay Trunk	2.0	2	0.07	
Total		53	4.07	3.74
Total for Ordinary Group			11.10	10.23
Coin Box Group				
Local	3.0	2	0.10	0.09
Outgoing ME.				
To Auto Exchange	3.0	7	0.35	
,, Level 951	2.5	1	0.04	
Total		8	0.39	0.36
Level O	3.5	3	0.18	0.17
Total for Coin Box Group			0.67	0.62
Total for Coin Box Grp +25%			0.84	0.77
Additional Traffic via the Junction hunters				
Ordinary Group Local & Alvaston		63		
Level O		53		
C B Group Local & Alvaston		2		
Level O		3		
	0.17	121	0.35	0.32
Total traffic via junction hunters			5.78	5.35

TABLE 19.

SUMMARY OF INCOMING TRAFFIC.

ITEM	A Holding Time (mins)	3-year period B Exch. B H calls From Table 2	3-year period C Traffic in TUs $= \frac{A \times B}{60}$	D 2-year period Traffic in TUs $= C \times 0.92$
Local.				
Ordinary lines	2.0	32	1.07	
Coin Box lines	3.0	2	0.10	
Total		34	1.17	1.08
Incoming ME.				
I/C M.E. Ordinary lines	2.0	80	2.67	
I/C M.E. Coin Box lines	3.0	2	0.10	
I C D I inside ME area	3.5	1	0.06	
Total		83	2.83	2.61
Incoming D/I.				
Long distance	6.0	12	1.20	
Short distance outside ME area	3.5	35	2.04	
Total		47	3.24	2.98
Incoming via Manual Board.				
Ineffective reversed	2.8	7	0.33	
Enquiry reversed	2.8	1	0.05	
Other Junction & Trunk calls	3.5	3	0.18	
Total		11	0.56	0.52
Total Incoming Traffic			7.80	7.19
Total Incoming Traffic (less MB)			7.24	6.67

TABLE 20 (Sheet 1).

SCHEDULE OF AUTOMATIC EQUIPMENT.

Multiple—Initial = 3700 ; Ultimate = 7500.

Description	Diagram No. AT	Switches	Banks and/or Wiring	Racks Init.	Racks Ult.	Racks Spec.	Remarks
L & K Relays							
C.B. Group	2640 Fig. 1	120	200				
Ordy ,,	,, ,,	3400	3400				
		3520	3600	4	8	1267	
Primary Finders (200 ft.)							
C.B. Group	2640 Fig 3	14	30				1 grp.
Ordy. ,,	,, ,,	272	340				17 grp. of 16/20
		286	370	8	14	1265	
Secondary Finders (50 ft.)	2640 Fig. 6	49	68	1	2	1270	4 grp.
Allotters.							
For Primary Finders	2640 Figs. 4 & 5	37	37				1 grp of 3/3; 17 ,, ,, 2/2
,, Secondary ,,	,, ,, 7 & 8	8	8				2 ,, ,, 2/2
Start Circuits.							
For Primary Finders	2640 Fig. 2	18	18				
,, Secondary ,,	,, ,, 9	4	4				
1st Selectors (200 outlet)							
C.B. grp.	1569	14	20	4	8		
Ordy ,,	,,	151	180				
I/C from Auto exchs.	,,	67	80	6	12		
I/C ,, Man. ,,	,,	229	260				
		461	540	10	20	1243	
2nd Selectors							
Level 2 Auto (200 outlet)	1569	50	80				
,, 2 M.B. ,, ,,	,,	8					
,, 3 Auto ,, ,,	,,	52	80				
,, 3 M.B. ,, ,,	,,	8					
,, 4 Auto ,, ,,	,,	59	80				
,, 4 M.B. ,, ,,	,,	8					
,, 5 ,, ,,	,,	58	80				
		243	320	6	10	1244	
Level 6 C B. (100 outlet)	1577	4	10	1			
,, 6 ME ,, ,,	,,	15	20				
,, 6 D/I ,, ,,	,,	16	20				
,, 7 ME ,, ,,	,,	20	30	1			
,, 7 D/I ,, ,,	,,	16	20				
,, 8 ME ,, ,,	,,	21	30	1			
,, 8 D/I ,, ,,	,,	16	20				
,, 9 CB ,, ,,	,,	3	10	1			
,, 9 Ordy ,, ,,	,,	13	20				
,, 9 I/C Auto ,, ,,	,,	6	10				
,, 9 D/I ,, ,,	,,	10	20				
,, 0 D/I ,, ,,	,,	20	30	1			
		160	320	5	6	1244	

TABLE 20 (Sheet 2).
SCHEDULE OF AUTOMATIC EQUIPMENT.

Description	Diagram No. AT	Switches	Banks and/or Wiring	Racks Init.	Racks Ult.	Racks Spec.	Remarks
3rd Selectors.							
Level 50 Auto (200 outlet)	1569	37	60				
,, 50 MB ,, ,,	,,	7					
		44	60	1	5	1244	
Level 95 (100 outlet)	1577	11	20				
,, 99 ,, ,,	,,	7	10				
,, 01 ,, ,,	,,	5	10				
		23	40	—	1	—	Fitted on 2nd Selr. rack
Final Selectors (200 line).							
Ordy—Ordy type	3617	151	220	9	18	1234	11 grp. of 14/20
Ordy—2/10 PBX type	3618	112	175				7 grp. of 16/25
Over 20 PBX type	3616	20	30	1	1	1238	1 grp.
Test	3650 Fig. 2	19					
Trunk Offering	,, ,, 2	19					
Selectors (Distributors).							
Test	2373	4	10	1	1		
Trunk Offering	2393	3	5				
Meters.							
For Ordy & 2/10 PBX lines		3600	3600				
,, Auxiliary		60	100				
Traffic		As required.					
		3600	3700	4	8	1126	
Relay Sets.							
Level '0' Main Exch. (Ord)	TL 1555	64	100				
,, '0' ,, ,, (CB)	,,	7					
,, 91 ,, ,,	,,	6					
,, 92 ,, ,,	,,	4					
,, '0' Direct from Sats.	AT 2415	27	30				
,, 91 (I/C Auto)	TL 1517	3	10				
,, 92 ,, ,,	,,	3					
,, '00' D/I	TL 1556	19	40				
,, 91 ,,	,,	6					
,, 92 ,,	,,	3					
,, 94 ,,	AT 2421	6	10				
,, 951	AT 1727	8	10				
,, 952	—	3	5				
,, 953	—	7	10				
,, 96 ME	AT 1827	2	3				
,, 991, 2 & 3		9	10				
,, 90	AT 1727	7	10				
D/I from Man. Exchs.	AT 3783	111	120				
D/O to C.B.	AT 3640	38	40				
D/O to C.B.S. & Mag.	AT 3689	88	90				
Joint Access	AT 2375	170	190				
O/G to UAX	AT 3706 Fig. 1	65	70				
I/C to UAX	,, Fig. 2	70	80				
Auto to Auto	AT 3639	101	120				
O/G to Auto Loop Dialling	TL 2121	57	70				
2 V.F. Signalling receiver	TL 1750	41	45	3			
,, ,, O/G to Auto	TL 1753	41	45				
,, ,, I/C & BW	TL 1754	41	45				
Ch. No. Interception Subs tapping	AT 2184 Fig. 1	20	40				
Service ,, Subs tapping	,, Fig. 1	7	10				
,, ,, Distributors	,, ,, 1A	1	1				
,, ,, Line Finder RS	,, ,, 2	3	5				
,, ,, Line Finders	,, ,, 2	3	5				
,, ,, MB relay set	AT 2406	7	10				

TABLE 21.

Showing the Calculation of the Grading for Level 2 of 1st Selectors.

1st Selector Shelves.	3 year Traffic in T U's		
	A. Total incoming From Table 9.	B. Proportion to Level 1 $= \frac{A \times 29.84}{114\ 80}$	C. Traffic per shelf. $= \frac{B}{\text{No of shelves}}$
2 Shelves serving C.B. lines	2 75	0 72	0 36
18 ,, ,, Ordy ,,	58 43	15 19	0.85
8 ,, ,, I/C Auto Exchs.	14 41	3.75	0.47
26 ,, ,, D/I Man. ,,	38 81	10.09	0 39

No. of Outlets = 50

$$\therefore \text{Minimum No of groups} = \frac{50 \times 2}{20} = 5$$

6 groups would therefore be the practical minimum
Average Traffic per group with 6 group = 4 98 T U
,, ,, ,, ,, ,, 8 ,, = 3.73 ,,
,, ,, ,, ,, ,, 10 ,, = 2 98 ,,

A suitable 10-group grading cannot be made without splitting some of the 20 bank multiples into two 10's. There is little to choose between a 6- or an 8-group grading, the grouping for an 8-group is given below.

Composition of Group.	Traffic.	Traffic per group.	% variation from average
Group No. 1 2 Shelves of C B. lines	0 72 T U's	4.12 T.U's	+10%
,, ,, 4 ,, ,, Ordy ,,	3 40 ,,		
,, ,, 2 4 ,, ,, ,, ,,	3 40 ,,	3 40 ,,	— 9%
,, ,, 3 4 ,, ,, ,, ,,	3.40 ,,	3.40 ,,	— 9%
,, ,, 4 4 ,, ,, ,, ,,	3 40 ,,	3 40 ,,	— 9%
,, ,, 5 4 ,, ,, ,, ,,	1 70 ,,	3 58 ,,	— 4%
,, ,, 4 ,, ,, I/C Auto Exch.	1 88 ,,		
,, ,, 6 4 ,, ,, ,, ,, ,,	1.88 ,,	3 44 ,,	— 8%
,, ,, 4 ,, ,, D/I Man ,,	1 56 ,,		
,, ,, 7 10 ,, ,, ,, ,, ,,	3.90 ,,	3 90 ,,	+ 5%
,, ,, 8 12 ,, ,, ,, ,, ,,	4 68 ,,	4 68 ,,	+24%

RACK EQUIPMENT SCHEDULE No 1.

Showing the Layout of the L & K Relays, Primary Finders and Secondary Finders on the Racks.

L & K1		PF1		PF2		PF3		S.F.1	
Ordy Group 4	100 100							.	.
Ordy Group 3	100/100	Ordy Grp 1	6	Ordy Grp 4	10	Ordy Grp 6	6	.	.
,,	100/100	,,	10	Ordy Grp 3	6	,,	10	.	.
Ordy Group 2	100/100	CB Group		,,	10	Ordy Grp 5	6	Grp 4	10
,,	100'100	,,	4	Ordy Grp 2	6	,,	10	Grp 3 2, Grp 4	2
Ordy Group 1	100'100	,,	10	,,	10	Ordy Grp 4	6	Grp 3	10
	100/100							Grp 2	10
C.B Group	20/100							Grp 1 3, Grp 2	2
,,	100/100							Grp 1	10

Racks L & K2, 3 & 4 are similar but fully equipped

Racks P F. 4 & 6 similarly equipped to Rack P F.2.
,, P.F. 5 & 7 ,, ,, ,, ,, P F. 3
,, P F 8 equipped with only 20 banks

RACK EQUIPMENT SCHEDULE No. 2

Showing the Layout of the 1st Selectors on the Racks

	1st A		1st B		1st C		1st D		1st I	
F	Ordy Group	8	Ordy Group	8	Ordy Group	8	.	.	I/C Auto Exch	8
E	,,	9	,,	8	,,	8	.	.	,,	8
D.		.	,,	8	,,	8	Ordy Group	8	,,	9
C.		.	,,	8	,,	8	,,	8	,,	9
B	CB Group	7	,,	9	,,	9	,,	9	,,	9
A	,,	7	,,	9	,,	9	,,	9	,,	9

	1st J		1st K		1st L		1st M		1st N	
F	D I Exchs	8	D I Exch	8	D I Exch	8	D I Exchs.	8	D/I Exch	8
E	,,	9	,,	9	,,	9	,,	9	,,	9
D.		.	,,	9	,,	9	,,	9	,,	9
C.		.	,,	9	,,	9	,,	9	,,	9
B	I C Auto Exch.	9	,,	9	,,	9	,,	9	,,	9
A	,,	9	,,	9	,,	9	,,	9	,,	9

Note.—Floor space to be left for racks 1st E, F, G, & H.

RACK EQUIPMENT SCHEDULE No. 3.

Showing the Layout of the 2nd & 3rd Selectors on the Racks.

	2A		2B/3A		3B/4A		4B		5A		5B	
F		7	Level 3	7	Level 4	8		8		7	.	.
E		7	,,	8	,,	8		9		7	.	.
D		7	,,	7	Level 3	7		8		7	.	.
C		7	,,	8	,,	8		9		7	.	.
B		7	Level 2	7	,,	7		8		7		7
A		8	,,	8	,,	8		9		8		8

	6A		7A		8A		9A		0/99/01A		50A	
G	.	.	.	.	.	.	9 D/I	5	01	5		
F	6 D I	8	7 D I	8	8 D I	8	,,	5	99	7		7
E	,,	8	,,	8	,,	8	9 I/C Auto	6	95	5		8
D	.	.	.	.	.	.	.	.	,,	6		8
C	6 M/E	7	7 M E	6	8 M/E	7	9 Ordy	6	0 D/I	6		8
B	,,	8	,,	7	,,	7		7	,,	7		8
A	6 CB	4	,,	7	,,	7	9 CB	3	,,	7		8

Note.—Space to be left for Racks 5C—F.

RACK EQUIPMENT SCHEDULE No. 4.

Showing the Layout of the Final Selectors on the Racks.

	FS1	FS2	FS3	FS4	FS5
E	. .	22 23 8 TO	28 29 8 XT	34/35 7	36/37 8 TO
D	. .	,, 5	26/27 7	,, 7 TO.XT	,, 5
C	44 1 TO	20/21X T.,T X 22/23 3	,, 7TO XT	30 31 7	32/33X T.,T.X 36/37 3
B	,, 10	20 21 8	24/25 7	,, 7 TO XT	32/33 8
A	,, 9T	,, 8 TO	,, 7TO XT	28 29 6 TO	,, 8 TO

	FS6	FS7	FS8	FS9
E	42 43 8 TO	47 48 8 XT	501 502 7	505 506 7
D	,, 5	45 46 7	,, 7TO XT	,, 7 TO XT
C	38 39XT ,TX 42 43 3	,, 7 TO XT	49 500 7	503 504 X T.,
B	38/39 8	40/41 7	,, 7 TO.XT	503 504 8
A	,, 8 TO	,, 7 TO XT	47 48 6 TO	,, 8 TO

References

T - Test Final Selr

X = Aux. Test Final Selr.

TO = Trunk Offering Final Selector

GROUPING AND CABLING SCHEDULE No. 1.

Level	Grading		Bank Multiple		CABLING					
					Circuits to T.D.F. from			No. of Circuits from T D.F. to		Ultimate T.D.F. Strips
	No	Group	Rack	Shelves	Rack	Shelf	No. of Circuits	Next rank	I D F.	
2	1	1	1st A	AB & EF						
		,,	B	AB	1st A	B	20			
		2	,,	C—F	B	D	20			
		3	C	A—D	C	B	20			
		4	,,	EF						
		,,	D	AB	C	F	20			
		5	,,	CD	D	D	20			
		6 to 11	spare initially							
		12	I	A—D	I	B	20			
		13	,,	EF						
		,,	J	AB & EF						
		,,	K	AB	I	F	20			
		14	K	C—F						
		,,	L	A—F	K	D	20			
		15	M	A—F						
		,,	N	A—D	M	B	20			
		16	,,	EF	N	F	20			
					Totals		200	80	—	20

For Level 2 MB Group. 20 circuits from the I.D.F to the T.D F.

GRADING SCHEDULE No 1

Outlets from . Level 2 of 1st Selectors to 2nd Selectors on racks 2A & B

No of Trunks = 50

up o	From Rack	From Shelves	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	1st N ,, M	A—F A—F	BB1	AA2	AD3	AE3	AA4	AF4	BB4	AA5	AD5	AE5	BB5	AB6	AC6	AD6	AE6	AF6	BA6	BB6	AA7	BA7
7	,, L ,, K	A—F C—F	BA1	AB2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
6	,, K ,, J ,, I	AB AB & EF EF	AF1	AC2	AC3	AF3	AB4	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
5	,, I ,, D	A—D CD	AE1	AD2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
4	,, D ,, C	AB EF	AD1	AE2	AB3	BA3	AC4	AE4	BA4	AB5	AC5	AF5	BA5	AA6	,,	,,	,,	,,	,,	,,	,,	,,
3	,, C	A—D	AC1	AF2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
2	,, B	C—F	AB1	BA2	AA3	BB3	AD4	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
	,, B ,, A	AB AB & EF	AA1	BB2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,

MANUAL BOARD GROUP

Circuit No.	1	2	3	4	5	6	7	8
Switch	AA10	AB10	AC10	AD10	AE10	AF10	BA10	BB10

Appendix No. 2.

SHOWING CAPACITIES OF STANDARD RACKS

Type of Rack	No. of Equipments.		Remarks
	10′ 6″ racks	8′ 6″ racks	
INDIVIDUAL RACKS.			
L & K Relays	900	700	
Primary Finders	45	40	15 bks per group
,, ,,	50	40	20 Bks. and over per group.
Secondary ,,	102	90	17 bks. per group
,, ,,	120	96	12 and 24 bks. per group
Uniselectors	200	160	
Selectors—			
1st Code and " A " Digit Hunters	30	20	
Group, 200 outlet	60	50	
,, 100 ,,	70	50	
Final, 200 line	50	40	Ordy + Ordy or Ordy.+2/10 P B X.
,, 100 ,,	60	40	Ordy or 2/10 P B X.
,, over 10 P.B.X type	50	40	11/20 P.B X or over 20 P B X
,, 10 line P B X type	60	—	Special rotary type
" A " Digit	60	50	
D.S R.	40	30	
Directors	10	5	
Coders	20	15	
Senders (4 digit)	20	—	
,, (7 ,,)	10	-	
Meters	1200	1200	
,, and rectifiers	1000	1000	
Relay Sets—			
S F J. with Junc. Finder	90	—	4 digit
S F J with Sender Hunter	50	—	7 ,,
Outlet, with Sender and V.F Hunter	56	—	Where more than 24 Senders
,, ,, ,,	48	—	Where less than 24 Senders
Voice Frequency	15	—	
C C I. and Coder Hunters	120		Without transmission bridge
,, ,, ,,	70	50	With transmission bridge.
10 relays per base	110	100	
12 ,, ,, ,,	90	80	
14 ,, ,, ,,	90	70	
10 relays per base & Repeating Coils	80	70	
12 relays per base & Repeating coils	70	60	
14 relays per base & Repeating coils	70	50	
2 VF. I/C Manual	30	20	
,, O/G ,,	25	20	
,, B/W ,,	20	10	
,, I/C Auto	25	20	
,, O/G ,,	20	15	
,, B/W ,,	15	10	
Traffic Recorders,			
Access switches	12	9	
Control switches	16	—	
,, and meters	12+ 120	—	
Routiners.			
access switch	21		
equipment	1		
T D F. Group Selector type	64 strips		640 O/G 3 or 4 wire ccts
T.D F. Uniselector type	64 strips		640 O/G 4 or 5 wire ccts
COMBINED RACKS			
Selectors,			
" A " Digit and Group	30+30	30+20	
D.S R. & Group	—	20+20	
Coders and C.C.I. relay sets	10+60		
Primary and Secondary Finders	30+36	30+12	
Traffic Recorder, Access & Control Sws. & Meters	6+1 +40	3+1 +40	

Appendix No. 3.

SHOWING THE CALCULATION OF RACK QUANTITIES FOR ACCOMMODATION PURPOSES.

Non-Director, self-contained exchanges

Data Supplied
- No of lines =4381
- Calling rate =0.62

Information obtained from "Operating Statistics" and a Study of a Map
- % junction traffic = 32
- Approx. number of exchanges that will require D,O codes } =19

Assumptions.
- Average holding time, Local calls = 2.0 mins.
- ,, ,, ,, Junction calls = 3.5 ,,
- I C traffic = originating traffic+10%
- Average lines per 100 multiple = 94
- Assume 40% of junction traffic from 1st Selector Levels

Originating Traffic

B,H calls = 4381×.62 = 2720

$$\text{Local traffic} = 2720 \times \frac{68}{100} \times \frac{2.0}{60} = 61.6\text{TU}$$

$$\text{Junction traffic} = 2720 \times \frac{32}{100} \times \frac{3.5}{60} = 50.8\text{TU}$$

Total traffic = 61.6+50.8 = 112.4TU

$$\text{L \& K Relays} = \frac{4381}{900} = 5 \text{ racks}$$

Primary Finders.

$$\text{No of grps} = \frac{4381}{200} = 22$$

$$\text{Traffic per grp.} = \frac{112.4}{22} = 5.12\text{TU}$$

∴ =14 fdrs. & 20 Bks. per grp.

Total banks = 22×20 = 440 =9 racks

Secondary Finders.

$$\text{No. of grp.} = \frac{22\times 9+22}{50} = 5$$

Total traffic = 22×1.50 = 33TU

∴ No. of finders = 54 or 3 grp. of 18,24

Total banks = 3×24 = 72 =1 rack

1st Selector.

Local grp. = 54+22×5=164 Sws. and 180 Bks

Junction Group.

I/C traffic=50.8+10%=55.9TU

$$\therefore \text{average traffic per route} = \frac{55.9}{19} = 2.94 \text{ T U.}$$

Average No. of Sws =10

Total Switches = 19×10=190

Total Banks = 190+10%+180=210+180
=390=7 racks

*Add 2 additional racks for through traffic
= 9 racks

$$\text{Multiple} = \frac{4381}{94} = 4700$$

Number Scheme.
- Subs. 2000—6699
- D O codes. Levels 7 & 8.

Final Selectors

Total I C traffic = 112.4+10%
= 123.6 T U.

$$\therefore \text{average traffic per unit} = \frac{123.6}{47} = 2.63 \text{ T.U.}$$

∴ 9 sws. = 15 banks per unit

Total Banks = 47×15 = 705 =12 racks

2nd Selectors

	Traffic	
Level 2	10 × 2.63 = 26.3 T U = 46 sws.	60 bks.
,, 3	10 × 2.63 = 26.3 T.U. = 46 ,,	60 ,,
,, 4	10 × 2.63 = 26.3 T U. = 46 ,,	60 ,,
,, 5	10 × 2.63 = 26.3 T U. = 46 ,,	60 ,,
,, 6	7 × 2.63 = 18.4 T.U. = 34 ,,	40 ,,
,, 7	$\frac{1}{2} \times \frac{60}{100} \times 50.8$ = 16.9 T U. = 31 sws.	40 bks.
,, 8	$\frac{1}{2} \times \frac{60}{100} \times 50.8$ = 16.9 T.U. = 31 ,,	40 ,,
		360 Bks.
		=6 racks.

*Add one additional rack for through traffic
∴ Total =7 racks.

*This estimate must be governed by a survey of the area.

Summary of Racks required.

D.E L.	=4381
Multiple	=4700
L & K relays	=5 racks
Primary finders	=9 ,,
Secondary finders	=1 ,,
1st Selectors	=9 ,,
2nd Selectors	=7 ,,
Final Selectors	=12 ,,
Relay Sets*	=4 ,,
Meter (4700)	=5 ,,
T.D.F.†	=9 ,,
Routiners—Traffic recorders‡	=4 ,,
Test Desk	=3 positions
Approx. number of junctions	=500

$$\text{For junctions} = \frac{\text{No. of I C+O,G junctions}}{100}$$

When the Manual Board is in the same building the number of positions is given in the data. Assume 1 relay set rack per 2 positions in addition to above.

---

* Relay Set rack provision

† T.D.F. provision.
- 2 per 1000 lines up to a calling rate of 1
- 3 ,, ,, ,, over ,, ,, ,, ,, 1

‡ Routiner & Traffic recorder provision.
- 1 per 1000 lines for small exchanges (minimum 2)
- 2 ,, ,, ,, ,, large ,,

Appendix No. 4.

NOTE—The detailed calculations to produce the quantities shown below have not been printed as they follow on similar lines to those in Appendix I.

SCHEDULE OF AUTOMATIC EQUIPMENT DIRECTOR EXCHANGE

Multiple—Initial = 9,200, Ultimate = 10,000

Description	Diagram No AT	Switches	Banks and/or Wiring	Racks Init.	Racks Ult	Racks Spec	Remarks
L & K Relays							
B T Group	2640 Fig 1	400	400				
Ordy.	,, ,,	8000	8000				
		8400	8400	10	12	1267	
Primary Finders (200 ft)							
B T. Group	2640 Fig 3	84	100	2			2 grp of 42 50
Ordy ,,	,, ,,	1360	1600	32			40 ,, ,, 34/40
		1444	1700	34	42	1266	
Secondary Finders (50 ft)							
Division 1	2640 Fig 6	135	168				7 grp.
,, 2	,, ,,	135	168				1 ,,
,, 3	,, ,,	36	48				2 ,,
		306	384	4	5	1270	
Allotters.							
For Primary Finders	2640 Figs 4 & 5	126	126				42 grps of 3 3
,, Secondary ,,	,, ,, 7 & 8	32	32				16 ,, ,, 2 2
Start Circuits							
For Primary Finders	2640 Fig 2	42	42				
,, Secondary ,,	,, ,, 9	16	16				
1st Code Selectors (200 outlet)							
B T Group	3628	84	100	4	4		
Ordy ,,	,,	946	1140	38	52		
M Bd. ,,	3683	20	30	1	1		
		1050	1270	43	57	1252	
2nd Code Selectors (200 outlet)							
Level 6	1569	203	240	4	5		
,, 7	,,	203	240	4	5		
,, 8	,,	203	240	4	5		
,, 9	,,	203	240	4	5		
,, 0 Ordy Group	2304	97	120	2}	3		Multi-metering
,, 0 B T. ,,	1569	13	20	1}			
		922	1100	19	23	1244	
3rd Code Selectors (200 outlet)							
Level 61	1569	38	60	1			
,, 71	,,	38	60	1			
,, 81	,,	38	60	1			
,, 91	,,	38	60	1			
		152	240	4	5	1244	
'A' Digit Selectors	3771	157	180	3	4	1254	
Directors							
Level 2	3934	39	50	5	6		
,, 3	,,	13	20	2	2		
,, 4	,,	20	30	3	3		
,, 5	,,	12	20	2	2		
,, 6	,,	30	40	4	5		
,, 7	,,	20	30	3	3		
,, 8	,,	25	30	3	4		
,, 9 & 0	3935	13	20	2	2		
		172	240	24	27	1255	(Fitted with MB relay)
1st Numerical Selectors	1569	1801	2020	34	46	1244	

Description	Diagram No. AT	Switches	Banks and/or Wiring	Racks Init	Racks Ult.	Racks Spec.	Remarks
2nd Numerical Selectors.							
Level 1	1569	162	200				
,, 2	,,	163	200	10	10		
,, 3	,,	160	200				
,, 4	,,	172	200				
,, 5	,,	163	200	11	11		
,, 6	,,	171	200				
,, 7	,,	163	200				
,, 8	,,	163	200	8	10		
,, 9	,,	36	60				
,, 0	,,	155	200	4	4		
		1508	1860	33	35	1244	
Final Selectors							
2/10 PBX type unit 00	3627	28	50				
,, ,, ,, ,, 01	,,	21	40				
,, ,, ,, other units	,,	1350	2250				75 grp. of 18/30
		1399	2340	39	42	1233	
11/20 P.B.X. type Unit 15	3622	51	60	2			
,, ,, ,, ,, 23	,,	41	50	1			
,, ,, ,, ,, 32	,,	32	40	1			
,, ,, ,, ,, 55	,,	50	60	2			
,, ,, ,, ,, 65	,,	35	50	1			
,, ,, ,, ,, 77	,,	55	70	2			
,, ,, ,, ,, 88	,,	57	70	2			
		321	400	11	16	1232	
Over 20 ,, ,, ,, 10	3621	47	60	2			
,, ,, ,, ,, 20	,,	54	70	2			
,, ,, ,, ,, 30	,,	61	80	2			
,, ,, ,, ,, 40	,,	80	100	2			
,, ,, ,, ,, 50	,,	53	70	2			
,, ,, ,, ,, 60	,,	64	80	2			
,, ,, ,, ,, 70	,,	31	40	1			
,, ,, ,, ,, 80	,,	45	60	2			
		435	560	15	18	1239	
Test 100 line	3650 Fig. 1	77					
,, 200 ,,	,, ,, 2	15					
Trunk Offering 100 line	,, ,, 1	77					
,, ,, 200 ,,	,, ,, 2	15					
Selectors (Distribution)							
Test	2373	9	10	1	1		
Trunk Offering	2394	3	5				
Meters							
For Ordy. & 2/10 PBX lines		7700	7700				
,, Auxiliary ,,		1485	2020				
Traffic		as required					
		9185	9720	10	11		
Senders							
V.F. group	2696	26	30				
Toll ,,	,,	7	10				
		33	40	2	—	1251	
Coders	2035	36	40	2	—	1256	
Relay Sets							
I/C junction V.F. group	2695 Fig. 1	421	450	5			
,, ,, Toll ,,	,, ,,	60	80	1			
Outlet V.F. group	2695 Fig. 2	60	80	2	—	1249	10 grp. of 6/8
,, Toll ,,	,, ,,	10	16				10 ,, ,, 5/8
Voice Frequency	2188 Figs. 1 & 2	13	15	1	—	1248	
C.C.I. & Coder Hunters	2346	398	400	4	—	1261	
Assistance B.T. Group	2467	13	20				
,, Ordy. ,,	TL 2117	40					
Toll	,,	82	140				
Excess Fee B.T.	,,	3					

Description	Diagram No.	Switches	Banks and/or Wiring	Racks Init	Racks Ult	Racks Spec	Remarks
ENG. from Selr. Levels	AT 2292	17	20				
Faultsmens lines	AT 1936	15	20				
Service P.B.X. (0101)	AT 2392	11	40				
Trunk Offering (0109)	,,	2					
Monitor (0001)	,,	20					
ENG. from M B. to Test Desk	AT 2453	2					
O/G to Auto Loop Dialling	TL 2121	29					
Ch. No. Interception.							
Subs. tapping	AT 2184 Fig 1	120	120				3 grp. of 40
Distributors	,, ,, 1A	3	3				1 per grp.
Line Finder R.S	,, ,, 2	24	30				
Line Finders	,, ,, 2	24	30				
M.B. relay set	AT 2396	24	30				
Service Interception.							
Subs. tapping	AT 2184 Fig 1	16	20				
Distributors	,, ,, 1A	1	1				
Line Finder R S	,, ,, 2	4	5				
Line Finder	,, ,, 2	4	5				
M B. relay set	AT 2406	4	5				

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