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The Institution of Post Office Electrical Engineers.

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H. E. FRANCIS, A.M.I.E.E.

A Paper read before the Harrogate Sub-Centre on the 18th November, 1943, and at other Centres during the Session.

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1. Introduction.

In this paper a general review is made of the conditions which it is expected will exist in the early post-war period, and of the effect they are likely to have on the design and provision of automatic telephone exchanges. It is unlikely that manpower will be available during the war to develop new telephone systems or equipment, so that the solution of the various problems must be found in the better use of existing designs. The subject is dealt with from this point of view, and proposals are put forward for the simplification of exchanges by a reduction in the variety of items of equipment in use, concentrating manufacture on those which have general application. A small modification to the wiring of selector racks is suggested, however, as it is considered to be justified by the greater flexibility given to the cabling scheme.

A possible solution to the acute shortage of accommodation in some non-director exchanges is proposed, and attention is drawn to certain trunking problems that need early attention either by Headquarters or the Regions.

2. Post-War Conditions.

Before any plans can be made for the post-war era it is necessary to consider in what way conditions may differ from those before the war.

First, there is the question of the growth in the number of subscribers' lines and the amount and distribution of the telephone traffic. In normal times a reasonably accurate estimate was difficult enough to obtain as is shown later, but with the many variable factors likely to be encountered in the future, short-term forecasts can only be treated as guides and not as accurate data. Some of the factors whose effect it will be difficult to assess are:—

(*a*) *Distribution of Population.* Town Planning Schemes are being prepared by Local and National Authorities, and as far as can be foreseen many changes in the pre-war distribution of the population and industry are likely to occur. Some of these changes have already been brought about in war time, but as only vital war needs have been met, the peace-time telephonic requirements are still in doubt.

(*b*) *Telephone Habits.* The Fighting Services have made great use of the telephone and have educated hundreds of thousands of people to become regular telephone users. It is likely that this will be reflected in increased demands for telephone facilities after the war, and (as in the case of the shilling night call) the increase might be from an unexpected direction. An increase of 15 to 20% in either the busy-hour calling rate, or duration of calls, would involve major extensions and rearrangements in practically every exchange in the country.

(*c*) *New Facilities.* The general introduction of new services such as the Speaking Clock, Weather Reports, Information or Encyclopædic services might also create an entirely new class of traffic.

(*d*) *Tariff Revisions* have occurred from time to time and it would be unsafe not to allow for some further alterations in the future. As in the past, this may have far-reaching consequences, and the possibility of tariff changes as part of a policy not directly connected with attempts to stimulate telephone business cannot be ruled out.

From the point of view of manpower, the war has caused a reduction and dispersal of many of the specialised staffs and it will be necessary to introduce a scheme of intensive training of the personnel concerned before any large programme can be attempted. This means that under present procedure appreciable delay will occur before manufacturing details can be given to the contractors.

On the manufacturing side, the Equipment Contractors have been concentrating on munitions of war and no doubt it will be of great assistance to them in planning a turn-round of their factories for peace-time production, if they are given definite orders for telephone equipment immediately on the cessation of hostilities.

The prospective subscriber will also have to be considered. In war time it has been possible largely to suspend the provision of service to ordinary civilian users, concentrating almost entirely on circuits vital to the war effort. The general public has accepted the position as a war-time necessity, but will no doubt expect the Department to make special efforts both to restore the peace-time facilities and to provide service to all who require it. On the basis of the trend of development both after the last war and after the slump of the early 1930's, there will be sufficient demand for new lines to ensure a return to pre-war development forecasts within about five years of the end of the war (Fig. 1). As very little development

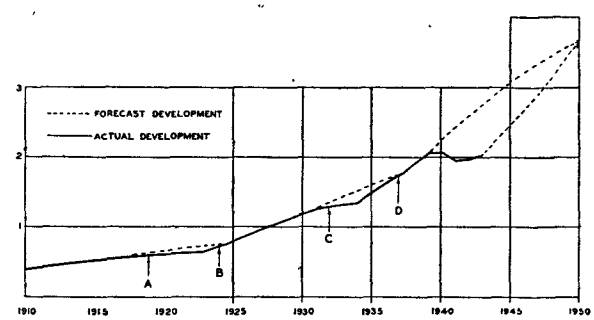

FIG. 1.—INCREASE IN EXCHANGE LINES.

has taken place since 1939, taking the country as a whole, it is obvious that every effort will have to be made to speed up the provision of new lines.

Post-war conditions may therefore be summarised as:—a greater uncertainty of development, a need

for increased speed of provision of equipment, a shortage of specialised staff, and the desirability of ensuring plenty of work for the manufacturers.

3. Current Practice in Exchange Design.

The forecasts of development and traffic are prepared by Telephone Managers and forwarded to the Engineering Branch of the Regional Director's Office in the form of Traffic Data. Traffic data are only an estimate, however, and are unlikely to forecast the actual conditions within ± 15%. This point has not always received sufficient attention by Engineering officers in their endeavour to keep the initial cost of exchanges to a minimum.

It is instructive to see what degree of success has been achieved in the past in estimating development. An analysis has been made of all exchanges installed during the period between 1929 and 1934 where extensions had been carried out up to 1940. Only extensions involving switching equipment or multiple installed by contract were considered. During this period it may be assumed that equipment was provided on the average to meet the estimated 4-year requirements. The results are given in Fig. 2 and

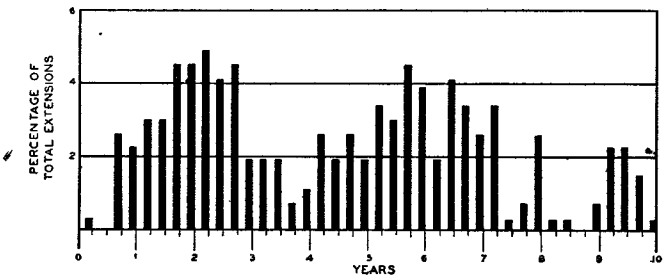

FIG. 2.—PERIOD BETWEEN EXTENSIONS.

speak for themselves. In only 15% of the cases did the equipment suffice for a period within a year of the estimated date. The difficulties associated with estimating development have obviously yet to be overcome.

It is of interest to note the methods which have been adopted in the past to meet the uncertainty of development figures. Prior to 1934, equipment was provided on a 4-year basis. During the trade depression of the early 1930's, however, when development did not come up to expectation, there was an apparent over-provision of equipment, and, to combat this, the provision period was reduced to three years. The trade revival of 1935 onwards caused an excessive number of extensions, so the provision period was amended again in 1936 to five years. It would seem that five years is about the optimum period, striking a fair balance between too much capital lying idle in spare equipment, and the interference with the smooth maintenance of an exchange by having the contractors continually on site. It should be remembered that there is no appreciable difference in the amount of design work required to engineer an extension of (say) 300 lines or one of 500 lines, and therefore short planning periods become uneconomical on these grounds alone.

4. Flexibility.

When an exchange has not developed as anticipated, expensive rearrangement of equipment with consequent interference to service and normal maintenance has resulted. The full effect of such rearrangements is difficult to assess in terms of money, but in some extensions it has amounted to as much as 8% of the value of the total exchange equipment, while altogether probably £50,000 was spent annually before the war on rearrangements.

This amount represents the value of labour and new cable, and would not have been required had either the traffic estimate been correct or the equipment been sufficiently flexible to meet the changed conditions.

If, however, the fallibility of traffic data is accepted as a normal condition, it is obviously desirable to build an exchange where flexibility is the keystone. It is on this basis that the design of post-war exchanges has been approached, and the various proposals outlined later are put forward with this end in view. Owing to the present shortage of manpower, it has not been possible to consider new equipment or circuit designs to help solve the problem, and the proposals involve the use of existing types of equipment only, except for small changes to rack wiring.

One of the methods of achieving flexibility is to reduce the number of items of equipment in general use, concentrating production on those which have universal application. For instance, both 100-outlet and 200-outlet group selectors are used in some exchanges, as a small saving in capital cost can be shown by this arrangement over the universal use of the 200-outlet type. But this is not the full story.

Transfers of selectors from one group in an exchange to another group are continually being made as the traffic fluctuates. If there are two types of group selector involved, the choice of movement is limited and it often happens that additional selectors of one type have to be purchased although there are spare selectors of the other type available. In addition, two sets of diagrams and specifications have to be maintained. When the case is reviewed over a number of years it is probable that the small initial saving is more than counterbalanced by subsequent expenditure.

Another type of case, but one unfortunately requiring a considerable amount of redesign-work, is that concerned with the ever increasing number of relay-sets. No immediate solution seems probable as it is largely bound up with the question of reviewing and simplifying the facilities provided on the different types of call.

However, it would be possible to reduce the number of main items of equipment by

(*a*) fitting uniselectors in all cases (instead of the present policy of providing uniselectors or line-finders depending on the calling rate of the exchange),

(*b*) using only 200-outlet group selectors,

(*c*) using only P.B.X. types of Final Selectors (instead of providing some Ordinary and some P.B.X. type as at present).

In each case a particular arrangement of the bank wiring is proposed, so that four rack and bank

arrangemnts (one each for group selectors and final selectors, and two for uniselectors because of the different types of metering used) would be substituted for the 40 or so in use at present.

Apart from the reduction in the number of items of equipment, some method of dealing with the present rigidity of the cabling scheme had to be devised. The problem is mainly one of producing a universal cabling layout, so that whatever alterations have to be made in the use and grouping of the various racks of selectors to meet traffic fluctuations, they can be carried out merely by jumper changes, thus avoiding recabling and interference with working equipment. A number of ideas were considered before a really satisfactory solution was obtained by the use of specially-wired racks and the abandonment of the centralized T.D.F.

Details of these proposals and their economic repercussions are given later, but their main justification lies in the fact that they produce sufficient flexibility in the exchange equipment to avoid all recabling work whatever fluctuations the traffic may take, while at the same time permitting full use to be made of all the equipment installed, due to its interchangeability.

Having achieved this flexibility and simplification, other advantages accrue which may be summarised as:—

(*a*) Simplified Traffic Data can be used.

(*b*) Steady flow of work can be given to the contractors by means of annual Bulk Orders.

(*c*) Equipment can be manufactured for a common pool and installed in those exchanges where it is most urgently required.

(*d*) Urgent cases can be proceeded with in advance of detailed design.

5. Distribution of Calling Rates.

In carrying out an investigation of the cost of the various proposals it soon became obvious that, as cost was often a function of calling rate, a knowledge of the number of times any particular calling rate may be expected to occur was essential. An analysis was made therefore of all exchanges in the country over 300 lines, and a graph produced showing the number of lines at each calling rate. The result is shown in Fig. 3, and was used in computing the costs quoted later.

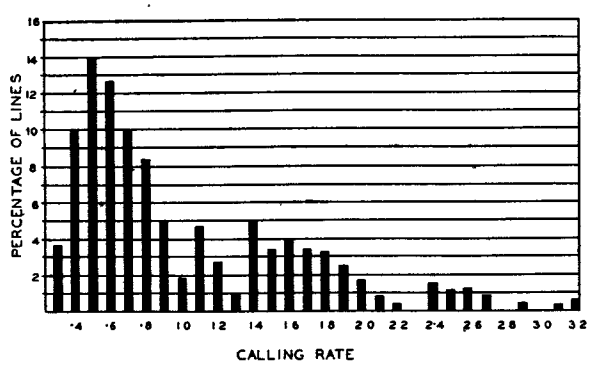

FIG. 3.—DISTRIBUTION OF CALLING RATE.

6. Uniselectors versus Line-finders.

There are two methods in use in the Department for connecting a subscriber to a 1st selector when he wishes to make a call, one by means of a uniselector which is individual to each subscriber and the other by means of a line-finder, which is a piece of common apparatus available to a group of subscribers. Of the two, the line-finder scheme is more efficient and, except for the higher calling rates, its initial cost is less. The higher traffic efficiency of the line-finder, however, means that it is more liable than the uniselector to give a poor service during periods of exceptionally-heavy traffic, such as may occur in an emergency. This is shown in Fig. 4. It follows that any under-estimate

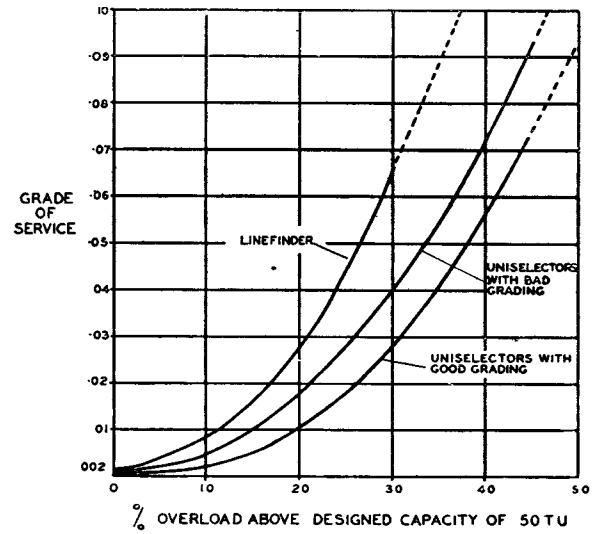

FIG. 4.—EFFECT OF TRAFFIC OVERLOAD ON THE GRADE OF SERVICE.

of traffic will be more serious in a line-finder exchange than in one fitted with uniselectors. Another point in favour of the uniselector is its simplicity, two relays and a simple mechanism, compared with the complicated line-finder with partial secondary working. Several types of switch have been used as line-finders in the past, but the Department standardized the two-motion selector for this purpose about ten years ago and it is with this type that the comparison is made.

Experience has shown that the line-finder has not come up to expectations, for, apart from early teething troubles, the cost of maintaining it has proved to be between two and five times as much as that of the equivalent number of uniselectors. The fixed bank-multiples of the line-finder have also proved an embarrassment where an increase in calling rate has taken place, and there are many exchanges throughout the country where not more than 160 lines can be used in each 200-line group.

Full flexibility could be given with uniselectors by adopting a new cabling scheme and dispensing with the centralized T.D.F., as described later. Rearrangements to meet any calling rate could be made merely by jumpers and " piano wire " connexions on the rear of the rack.

A recent cost comparison taking all these factors into consideration has shown that uniselectors are

more economical for calling rates of 0.4 and over and, as this figure includes 96% of the lines in the country, it is not worth maintaining a second standard for the remaining 4%. A curve showing the relative cost is given in Fig. **5**, while in Fig. **6** the effect of increase

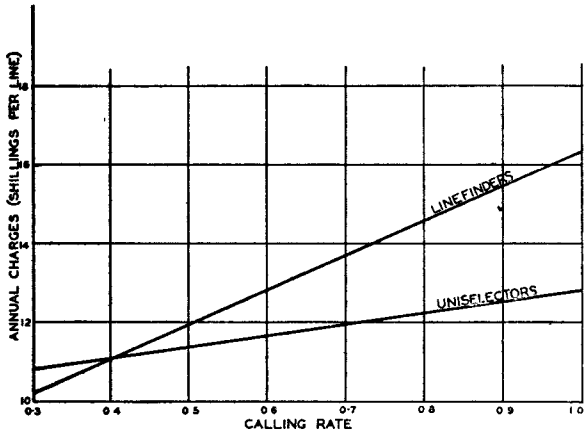

FIG. 5.—RELATIVE COSTS OF UNISELECTORS AND LINEFINDERS.

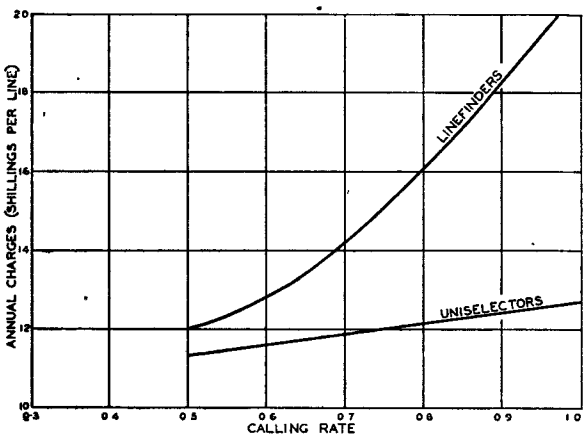

FIG. 6.—EFFECT OF INCREASE OF CALLING RATE ABOVE THAT FOR WHICH THE EXCHANGE WAS DESIGNED. (DESIGNED C.R. = 0.5).

in calling rate above that for which the exchange is designed is depicted.

In view of the revised cost figures and the other advantages of uniselectors, it is proposed that uniselectors be used in all exchanges. Two types of uniselector racks will need to be manufactured depending upon whether positive-battery or 4th-wire metering is to be employed, and it is suggested that each rack be fully equipped initially.

The possibility of a better line-finder scheme using a more suitable switch mechanism—and, let it be hoped, without the complication of secondary working —cannot be ruled out for the future, but for immediate post-war requirements uniselectors have undoubted advantages.

7. 200-Outlet Group Selectors.

The 200-outlet group selector was introduced because of the economic advantage given by increasing the availability from 10 to 20. The economic advantage is only obtained, however, when the average number of outlets per level exceeds a certain number, dependent upon the relevant cost of the next rank of switches or junctions. When the outlets are trunked to group or final selectors the critical figure is 14 or 13 respectively, but in the case of junctions it is something less than this, and in the extreme case where costly circuits are involved, 200-outlet selectors are justified as soon as the number of circuits exceeds 10.

For internal circuits between selectors these limits are usually exceeded, so that it is standard practice to fit 200-outlet selectors in these cases. For outgoing junctions and 'level 9' services in non-director exchanges, the average number of circuits is often small and 100-outlet type selectors are sometimes provided. Taking the country as a whole however, 70 selectors of the 200-outlet type are provided for every one of the 100-outlet type, and as the difference in cost between the two types is only small, the increase in cost resulting from using only the 200-outlet type would be negligible. Therefore, in view of the advantages of interchangeability obtained by using only one type, it is proposed to standardise the 200-outlet type selector for all cases.

8. P.B.X. Type Final Selectors.

The P.B.X. subscriber with a large number of lines will still require to be connected to an '11 and over' P.B.X. type unit, and each exchange where this class of subscriber exists will have to be considered separately. The proposal here refers to fitting 2/10 P.B.X. type units instead of a mixture of ordinary and 2/10 P.B.X. types.

The proposal is really in two parts, each designed to overcome difficulties which have arisen in practice. They are:—

(*a*) Manufacture only one standard final-selector rack and bank-multiple arrangement suitable for all classes;

(*b*) Fit only P.B.X. type equipment.

The difficulties which have arisen in practice are concerned with increases in calling rate and number changes. When the traffic to a final-selector unit increases, a condition is reached where traffic congestion arises due to the limitation in the number of final selectors that can be fitted. In the early exchanges a margin of 10% bank capacity over selectors was allowed for possible increases in traffic, but this was soon increased to 27½%. Despite this, trouble is still being experienced and a way out has to be found, either by removing busy subscribers from the unit or by providing additional banks in another part of the exchange. The subscriber objects to the first solution, because it means changing his number, while the provision of additional banks produces maintenance difficulties.

To overcome this difficulty, the author proposes that the rack should be provided with two multiples of 10 banks and two of 20 banks, as shown in Fig. **7**. With this arrangement, bank multiples of 20, 30 or 40 could be obtained by suitably arranging the tie-cables on the rear of the rack. It will be seen that no pro-

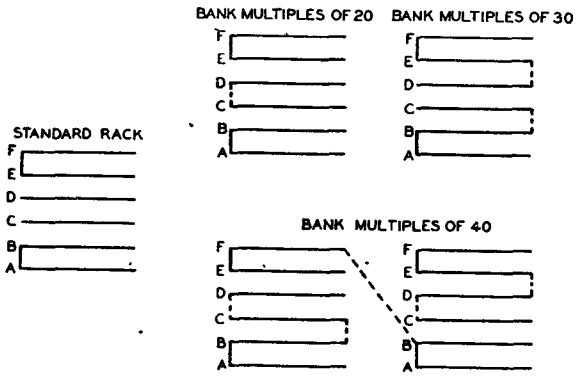

FIG. 7.—PROPOSED STANDARD FINAL SELECTOR RACK.

vision has been made for the odd 5-bank multiple case, as in practice the number of additional tie-cables required makes the saving produced by their adoption almost negligible. The use of this rack would make it possible to increase bank multiples at some future date, should an increase in calling rate occur. As a result, the 27½% margin for final-selector bank multiples can reasonably be reduced to 10 or 15%.

When a subscriber is connected to an exchange he is allotted a number on a P.B.X. unit if it is thought likely that he will require a second line at some future date. Unfortunately it is not always possible to anticipate every case, and then a change of number becomes necessary. Sometimes a subscriber refuses to rent additional lines if a number change is involved. Making every unit of the P.B.X. type does not necessarily solve this problem as there may not be a spare number available in sequence for the additional line, but there is always the possibility of the following line becoming available due to cessations. The fitting of P.B.X. units in all cases would, however, be a great advantage on conversion from manual to automatic working as it would avoid the wholesale change of subscribers' numbers which is necessary when the P.B.X. lines have to be congregated in certain 100 multiples.

The cost of fitting all units of the P.B.X. type varies with the calling rate and the percentage of the total subscribers who require P.B.X. facilities. It varies from a saving of 0.3% to an increase of 2% on the cost of the exchange, with an average increase of 0.65%, an amount which should be offset by the additional facilities offered (Fig. 8).

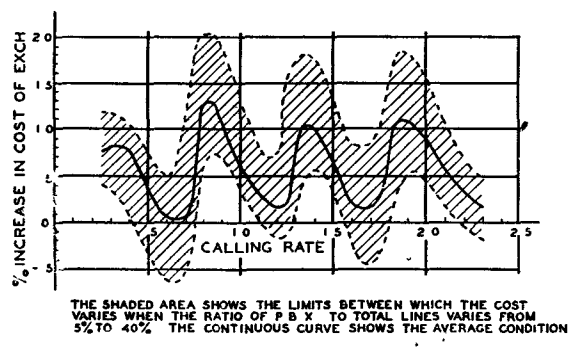

FIG. 8.—COST OF FITTING ALL UNITS OF THE P.B.X. TYPE.

9. New Cabling Scheme.

Several attempts have been made since grading was first introduced to find the most satisfactory method of cabling between one rack of selectors and the next. In the early days, the double-sided board, where each shelf of selectors was brought out to a trunk distribution frame (T.D.F.) mounted on the end of the board, allowed easy rearrangement of the graded groups, but difficulty was experienced with the tie-cables required between the various boards. There was also a limitation in the allocation of the outlets from a grading. With the introduction of single-sided racks, the shelves of selectors were grouped together by means of tie-cables at the back of the rack and a cable was taken from each group to a centralized T.D.F. The first arrangement of this scheme used a T.D.F. similar to the standard I.D.F., but later, a special rack was developed. In the centralized T.D.F. scheme, modifications to the groups of the grading cannot be made without interfering with the permanent cabling, but it has the advantage that a full picture of the grading is obtainable.

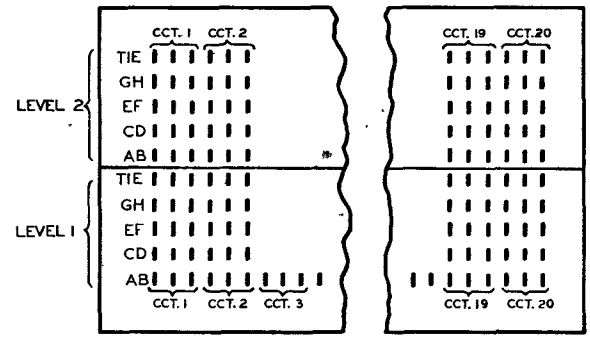

FIG. 9.—PROPOSED GROUP SELECTOR RACK-ALLOCATION OF THE CIRCUITS ON THE TAG BLOCKS.

The proposed scheme is based on using the rack of selectors as a unit; the grouping of the shelves being carried out on the back of the rack by means of bare-wire connexions similar to a grading frame. The

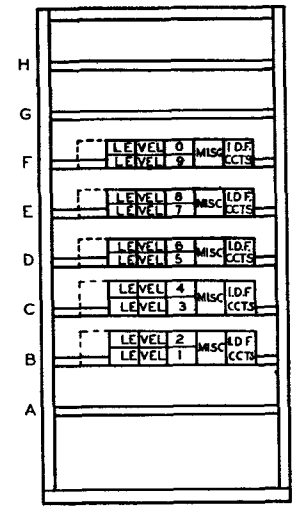

FIG. 10.—POSITION OF THE TAG BLOCKS OF THE PROPOSED GROUP SELECTOR RACK.

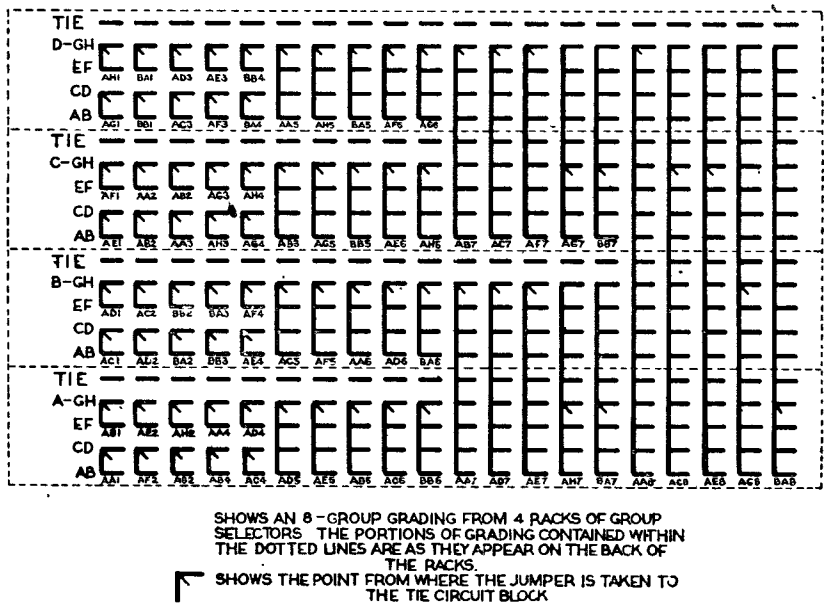

FIG. 11.—TYPICAL GRADING.

scheme is applicable to 1st-code, A-digit, and uniselectors as well as group selectors, but it will suffice to show the principles if its application to the latter is described.

The 2000-type group selector rack has eight shelves on which are fitted four sets of 20 bank multiples. The rack wiring has been modified so that the corresponding levels of each set of banks are brought out to

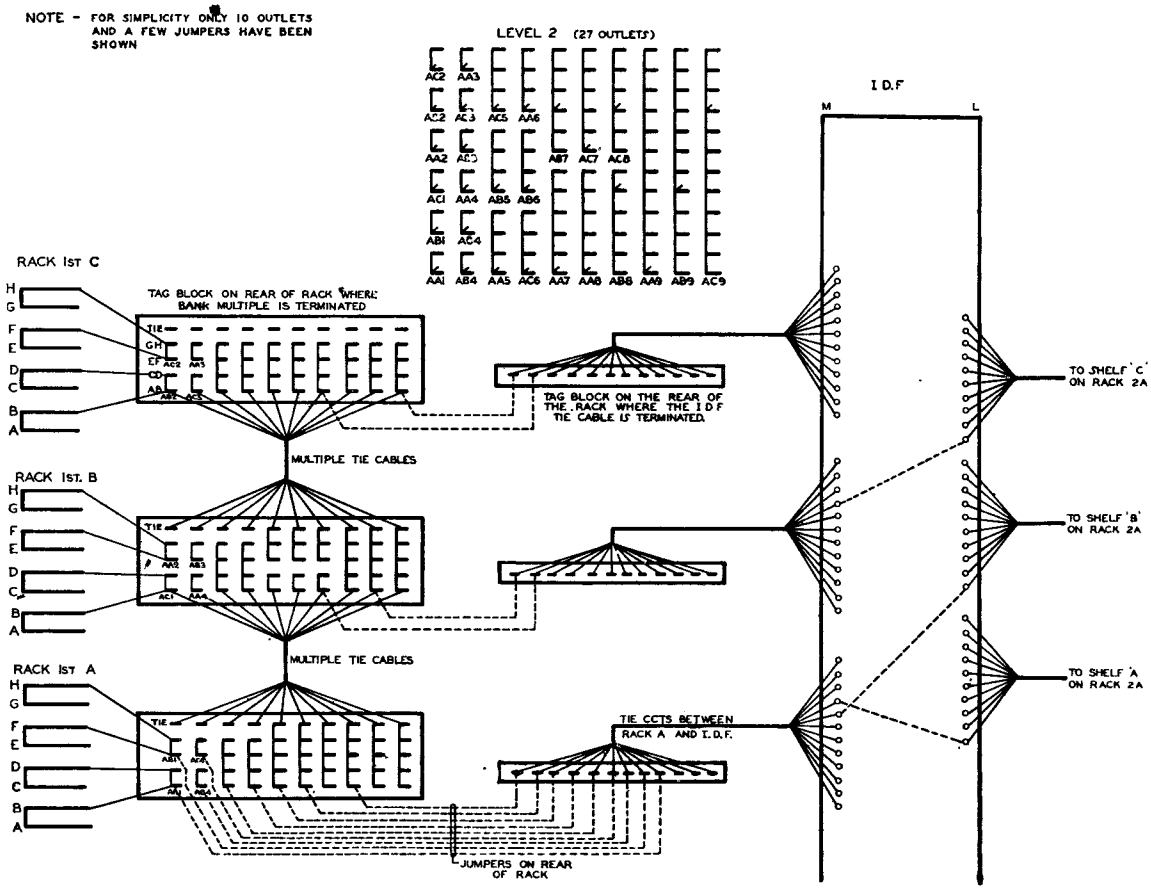

FIG 12.—PROPOSED GRADING AND JUMPERING SCHEME.

adjacent tags on a tagblock, as in Fig. **9**. Levels 1 and 2 are accommodated on tagblocks behind shelf B, levels 3 and 4 behind shelf C, and so on. (Fig. **10**).

Provision is also made for the termination of the tie-cables from adjacent racks to rows of tags on the top and bottom of the block. Commoning of the outlets from the different shelves and to the rack-to-rack tie-circuits is done by bare-wire connexions. This can be seen in the typical grading shown in Fig. **11**. The graded outlets are jumpered straight from the appropriate tag direct to the tagblock, mounted further along the shelf on which the tie-circuits to the I.D.F. are terminated. (Fig. **12**).

It will be seen that the number of tie-circuits to the I.D.F. need only be sufficient to cover the number of working outlets. Investigation of a number of cases showed that the number of outlets required fall into two fairly-well-defined groups, depending upon the use made of the selectors. The number of levels in use does not have much bearing on the case. The two groups consist of 1st selectors with 50 to 80 circuits per rack, and other cases with 120 to 160 circuits per rack. It is therefore suggested that a standard of 100 circuits in the first case, and 200 in the second case, be adopted. This will meet all exchanges and save the provision of detailed cabling schedules at the design stage. The slight over-provision in some cases can easily be justified, as it is much simpler and cheaper to provide the cable initially than to add tie-cables at a later date.

The scheme has the advantage of the old double-sided boards in that the groups of a grading can be rearranged to meet traffic fluctuations, while the routing of the tie-circuits via the I.D.F. ensures complete flexibility in the allocation of the outlets. A disadvantage over the present scheme is that, as the grading is carried out on the various racks, a complete picture of the grading is not obtainable.

In large exchanges, the I.D.F. is already somewhat cumbersome in size so that the provision of additional verticals to cater for tie-circuits does not at first appear very attractive. An examination of the use made of the I.D.F., however, suggests an easy division into line and equipment sections. The line I.D.F. would be located near the M.D.F. uniselectors and final selectors, and serve subscribers' lines only, while the equipment I.D.F. would serve group selectors, relay-sets and junctions, and could be located amongst this part of the exchange equipment. The scheme is outlined in Fig. **13**.

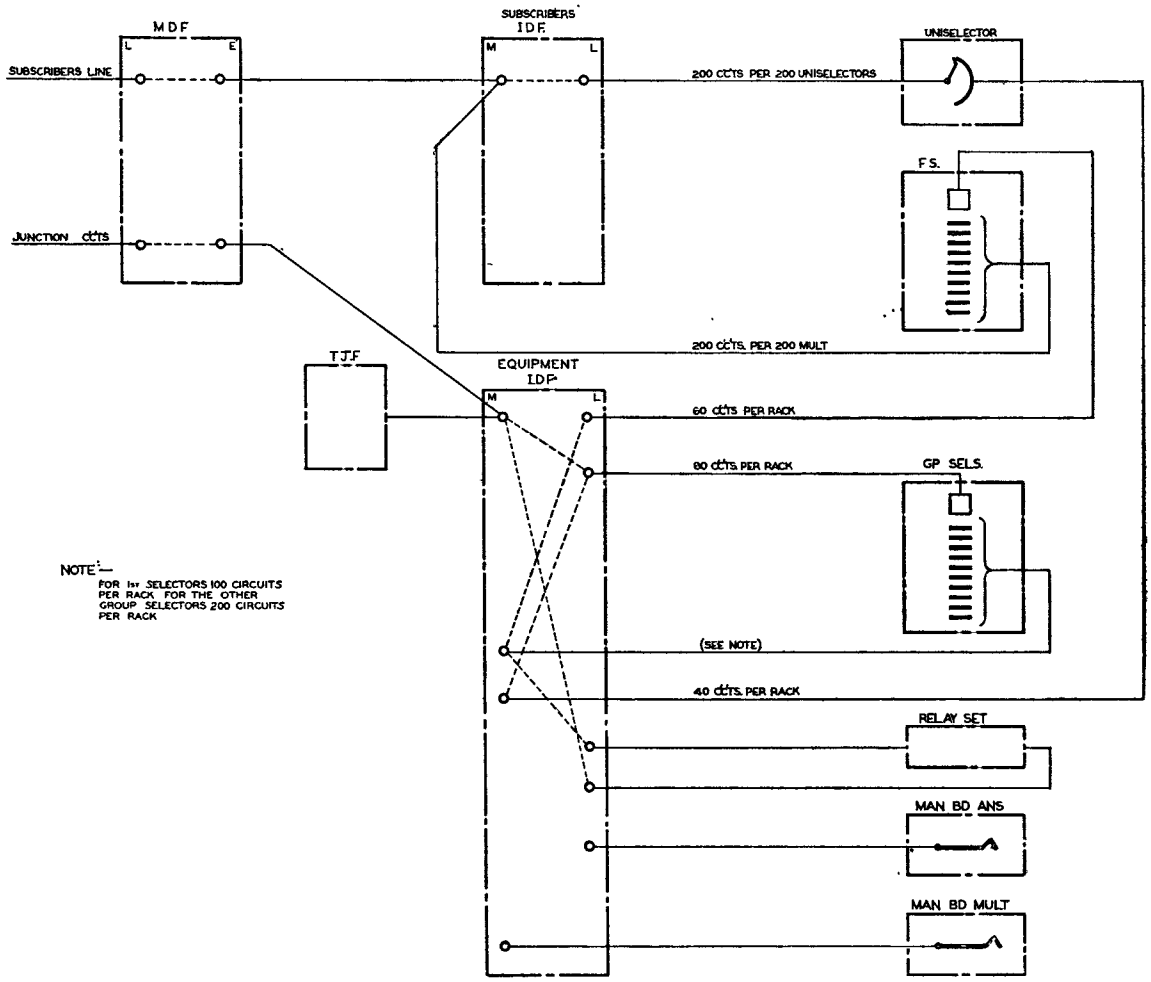

FIG **13**.—PROPOSED CABLING SCHEME.

10. Traffic Data Simplification.

As already mentioned, it is unlikely that the Traffic Data will be very reliable in the immediate post-war period, and it was partly to overcome this difficulty that proposals for making the exchange equipment more flexible were developed. The question therefore arises as to whether the extensive special records which have at present to be taken, and the minute detail contained in the traffic data, are still justified.

At present, details of every class of call have to be given, because of their various holding-times. Investigation shows that the bulk of the calls can be classified either as auto. dialled or trunk and junction via the manual board and that if an average holding-time for these two classes of call can be obtained, a graph can be drawn giving the direct relationship between percentage trunk and junction traffic and average holding-time for the exchange. This is shown in Fig. **14**. A large number of cases was used to test the accuracy of the curve and, although the latter did not fit all cases, the deviation was not greater than that obtained from any one exchange between successive records. In the circumstances, the curve is considered sufficiently accurate for application generally.

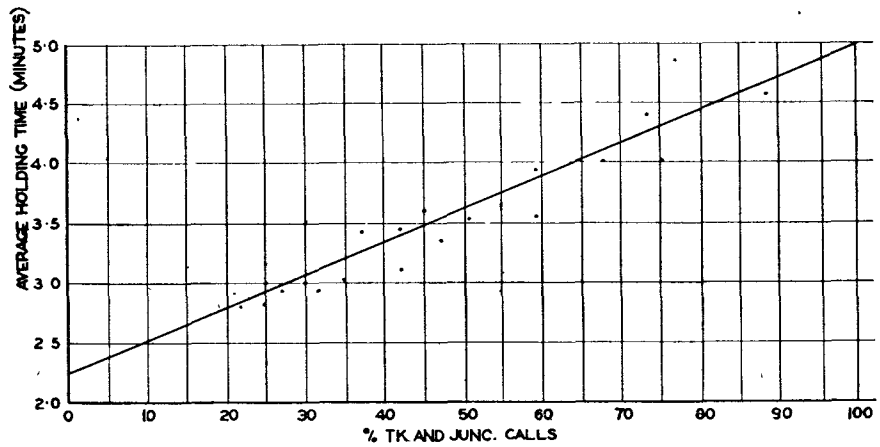

FIG. 14.—VARIATION OF AVERAGE HOLDING TIME WITH PERCENTAGE OF TRUNK AND JUNCTION CALLS.

With this simplification, it would be possible to dispense with much of the detail in the Traffic Data so far as the design engineer is concerned. The information that would be required in the non-director case is summarized in Table 1, and it will be seen that much of this is already given in existing records.

TABLE 1.

Item.	*Initial Period (5 Year).*	*Ultimate Period (20 Year).*
Number of C.C.B. lines	×	×
Number of other lines	×	×
Calling Rate, Originating, C.C.B. (B/H)	×	
,, ,, ,, other (,,)	×	
,, ,, ,, Day	×	
,, ,, ,, Incoming (B/H)	×	
Schedule of Junction Routes, and Incoming and Outgoing Traffic	×	
Details of large-group P.B.X. subscribers	×	×
List of Circuits to and from the manual board to auto. equipment	×	
Number of Manual Board Positions ...	×	
Size of O.J.M. and Answering Equipment	×	
Details of Miscellaneous Circuits	×	

11. Reduction of Engineering Work.

The adoption of an average holding-time and the principle of unit rack construction would mean an alteration in the method of design. The total quantity of equipment to be installed would be calculated much as previously, but details of cabling, grading, etc., would await the more-accurate information available when the opening-date traffic data were prepared about nine months before transfer.

Opportunity has been taken to review the work of preparing exchange specifications in an endeavour to cut down the time taken in its production. Some modification and simplification have taken place but, as it will still be necessary to schedule all the items of the equipment to be installed, further reduction in size is improbable.

The power engineer, in calculating the size of the power plant, makes use of much of the detail at present contained in the Traffic data. Before suggesting the use of simplified data therefore, the present method of calculating the current consumption by considering each class of call, was reviewed. It was found that a simpler method was available and gave results comparable with those obtained from the present method.

There is a direct relation between the ampere-hour load on an exchange and the traffic carried, measured in traffic units. The equipment installed is also based on the traffic carried, so that it is possible to assess the ampere-hour load from a knowledge of the quantity and type of equipment. For example, the current taken by all group selectors in an exchange can be found by using the formula $I = N \times A \times K$, where I is the total current, N the number of selectors, A the current drawn by one selector, and K the average occupancy time (0.5 in the case of selectors). Simple calculations of this type will enable the design engineer to calculate the total current and ampere-hour loads, and thus save a certain amount of the present duplication of work.

12. New Development.

One of the problems which has always confronted the equipment engineer has been the constant stream of small amendments to Circuit Diagrams and Equipment Layouts. This has involved continual alteration to contracts during manufacture and installation and

has resulted in many minor differences between one exchange and another, making interchange of equipment difficult.

It is proposed therefore, that, except where fundamental changes are concerned, no new modifications should be introduced during the five-year period after the war. It is hoped that this procedure would continue thereafter, the accumulated improvements of the preceding period being incorporated at five-yearly intervals. Apart from the advantages that the equipment engineer would derive from this arrangement, the fact that diagrams and standard specifications would not be amended more frequently than once every five years should save both Drawing Office staff and paper.

The proposal is not a new one, but, as in the post-war period the emphasis will be on the provision of exchange equipment rather than on the inclusion of the latest ideas, the argument for the restriction of modifications to five-yearly intervals is much stronger.

13. Bulk Orders.

The idea of exchange equipment being ordered in bulk, so that it can be requisitioned when required, has always been attractive. For small exchanges—both auto. and manual—this method is in use, but for the larger exchanges the equipment is manufactured for each job. This has been necessary because the exchanges have been individually designed, and so manufacture could not commence until many details such as the size and grouping of selector-bank multiples had been settled.

With the adoption of the proposals outlined earlier, however, this disability would be removed, all group-selector, final-selector, uniselector racks, etc., being identical no matter what exchange they are intended for. The limitation of modifications to five-yearly periods would also remove another objection to manufacturing in advance of specific details. It would therefore seen reasonable for an estimate to be made annually of the number of racks of each type of equipment that will be required during the year, and for these supplies to be ordered in bulk from the contractors. Allocation of the racks to the various jobs could be made as required, and the equipment installed as at present. From the contractor's point of view, the scheme would mean a steady flow of work, enabling him to plan for maximum efficiency in the factory.

For the Department it would mean that a detailed list of equipment would not have to be given until installation was about to commence, *i.e.*, about 12 to 15 months later than under the present arrangement. With the rapidly-varying conditions of the post-war period, this would be a distinct advantage. It could also be arranged for a small number of racks to be held by the Stores Department, for installation by local staff where urgent extensions are required.

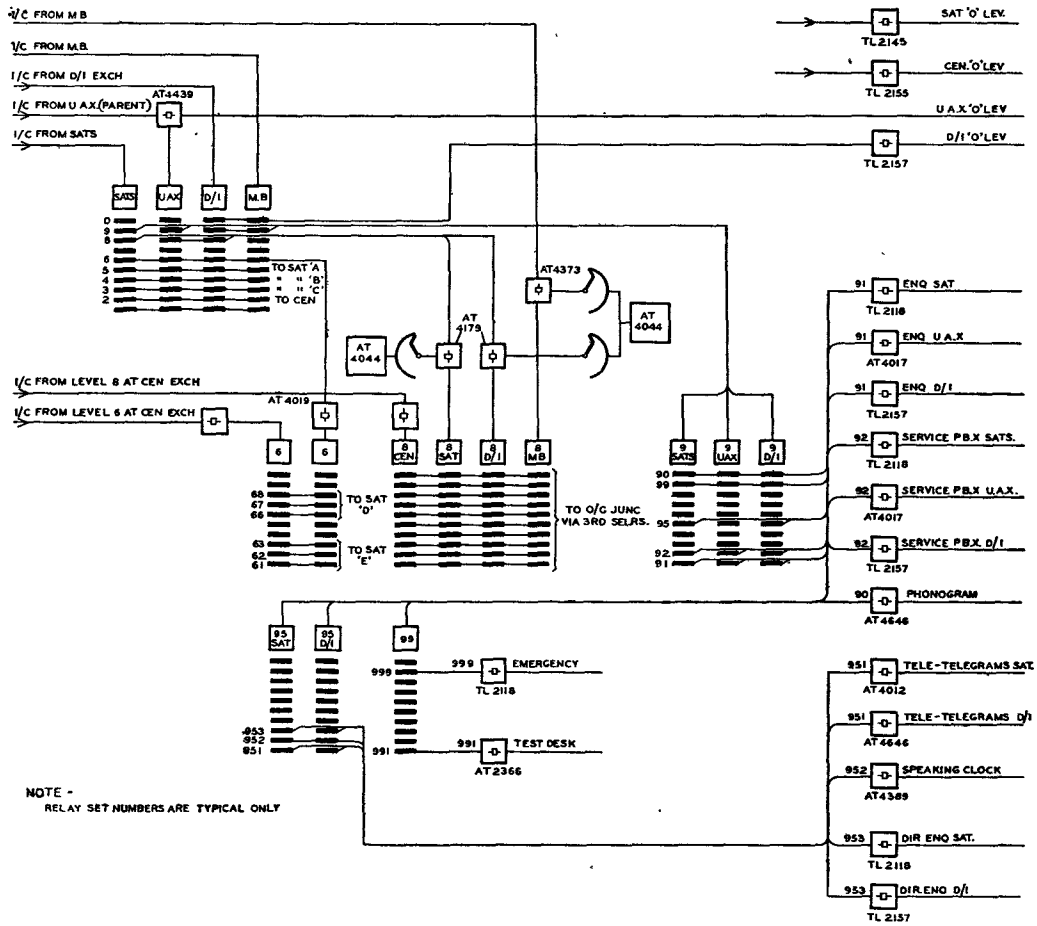

FIG. 15.—TRUNKING SCHEME AT NON-DIRECTOR TANDEM EXCHANGE.

14. Accommodation.

One of the most acute problems likely to be encountered in the future is shortage of accommodation. For new exchanges where no suitable accommodation exists it is obvious that new buildings will be required, and it is possible that this will absorb most of the Department's allocation of building materials and labour.

There is, however, a number of exchanges in the country where the accommodation has become exhausted and extension of the buildings is not possible. The normal procedure would involve the provision of a new exchange and building on another site; if obsolete equipment is involved, this is no doubt the best solution. But there are cases where both the building and exchange could last many years if the accommodation problem could be solved. The majority of the cases concerned are the non-director main exchanges with manual boards, and a solution could be found by removing the manual board to a new and smaller building, thus enabling the automatic equipment to grow and meet the needs of subscribers' line development for some time ahead. The objection to this scheme in the past has been the limited facilities available; for example, no joint access on the junctions, or circuit complications due to only two-wire circuits being available between the manual board and the auto. exchange.

These objections would be overcome if the incoming and tandem selectors were moved along with the manual board, leaving the auto. exchange for subscribers' traffic only. Standard circuits can then be used and standard facilities given. The scheme outlined in Figs. **15** and **16**.

The present arrangement of placing the tande equipment with the main exchange in non-direct cases has developed naturally from a few dialling-routes connected to the early exchanges. The ma exchange site is chosen for its position at the cent of gravity of the subscribers' lines in the area it serve but it does not follow that this is also the centre of t junction network, particularly since war-time nee have produced decentralized repeater stations a ring cables. The manual board—which in future w deal mainly with trunk and toll traffic—could ther fore, with advantage, be located on the outskirts of town, and this arrangement may become standa policy quite apart from its attractiveness in meeti immediate post-war accommodation problems.

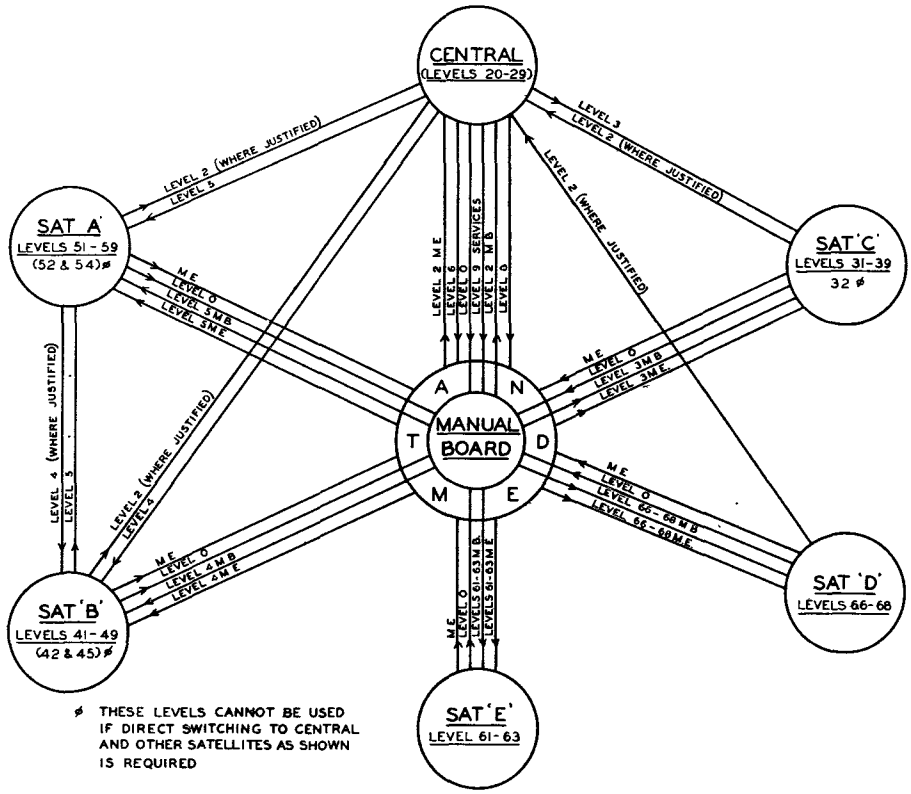

FIG. 16.—NON-DIRECTOR M.E. AREA WITH REMOTE TANDEM AND MANUAL BOARD.

If the manual board is located apart from the mai exchange, the question arises as to whether there need any longer to fit first selectors in the mai exchange while the satellites use discriminators. would seem logical to fit discriminators at all th exchanges. From the point of view of cost there little in it, one scheme or the other being cheape depending upon what use can be made of the digi absorbtion facility given by the discriminator.

15. Numbering Schemes.

The introduction of long-distance dialling and th proposed introduction of multi-metering has brough to light several trunking problems involving som of the older exchanges. The chief difficulties a

included in any new exchange area, but, as it is very desirable to clean up existing areas at the earliest opportunity, it may be helpful to outline some of the points:—

(*a*) *Mixed 4- and 5-digit schemes.* When trunk calls are routed via a director-type zone centre, the total number of digits dialled should be seven, *i.e.*, three code-digits and four numerical digits. If a call is routed to a 5-digit number then a 2-digit code is used, the first digit of the number acting as the third code-digit. For an exchange with both 4- and 5-digit numbers, this scheme cannot be followed, and as there are service objections to allocating two codes (one 2-digit and the other 3-digit) for the same exchange, a temporary scheme has been evolved where the trunk operator dials a 3-digit code and then waits until the director has "pulsed out" before proceeding to dial the 4- or 5-digit number. This means a special and slower operating procedure on these routes and, in addition, the loss of director impulsing limits over the junctions. This latter point has had the effect of preventing dialling over a number of routes.

(*b*) *Satellite Exchanges with their own charge lists* were sometimes provided, particularly when they were situated four or five miles from the main exchange. With the re-defining of the multi-exchange area to approximately three miles radius many of the exchanges will be converted to U.A.X.s or independent non-director exchanges, but it is essential that those which remain shall conform to the new standards. Naturally the simplest way is to have a common charge list for all exchanges in the linked numbering scheme, but if there are serious objections to this, then each satellite with a separate charge list must be allotted a 1st-selector level to itself. The reason for this is that fraudulent dialling may arise from other exchanges dialling into the area unless the 3-digit exchange code includes a distinguishing digit for each exchange. In these cases the 3-digit code is made up of the two code-digits and the first digit of the subscriber's number. If there are many such satellite exchanges in an area, serious limitations to the numbering scheme will arise.

16. Trunk Network.

So far this paper has dealt with proposals which are under consideration by the Engineer-in-Chief, and which if approved will be applied to local exchanges. As regards trunk traffic, however, it is unlikely that any firm decision will be made in time for inclusion in the immediate post-war plans, but it is of interest to speculate on the possibilities from a trunking point of view that are opened up by dialling over the trunk network. There are no doubt several schemes that can be devised, but a translation scheme would probably be the easiest to apply to the existing exchange associated with mixed 4- and 5-digit numbering schemes and with satellite exchanges which have a separate "charge list" from the main exchange. Under present policy, neither of these features will be

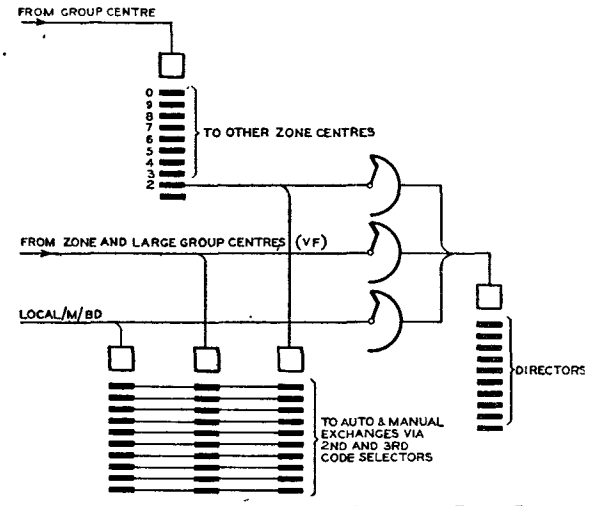

FIG 17 —TRUNKING DIAGRAM OF PROPOSED ZONE CENTRE.

equipment and trunk cable layout. There are less than 6,000 exchanges in the country so that, even if an allowance is made for an increase of 30% in this number, a 4-digit code scheme would suffice for the whole country.

It is suggested that the country be divided into nine large zone centres (assuming level 1 is not used), each having equipment of the director type, similar to that at present in use for 2-V.F. equipment at London, Manchester, etc. Each exchange in a zone would have a 3-digit code, and a distant zone operator could obtain access by dialling the three code-digits as at present. Operators at group centres would have to dial a 4-digit code on a circuit to their own zone, the 1st digit merely selecting a circuit to the distant zone centre where the remaining three code-digits would be received. While it is not proposed to describe the scheme in detail, some of the main points are given below:—

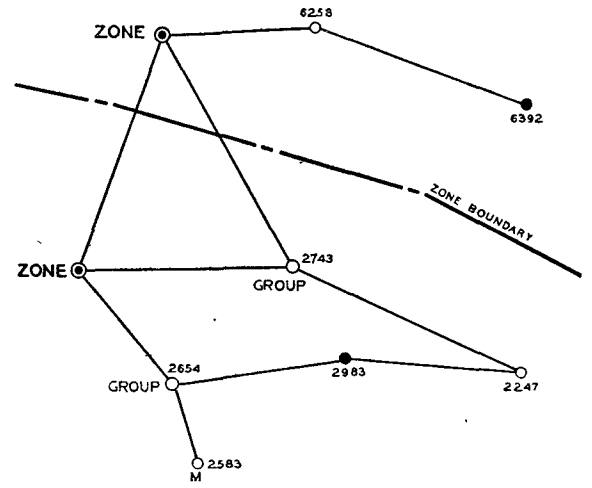

FIG. 18.—ROUTING OF TRUNK CALLS.

(*a*) 4-digit code for each exchange in the country, and this need never be changed (except as in (*h*) below).

(*b*) Zone centres, and large group centres which could justify a separate route to other zone centres, need only dial the last three digits of the code on these routes.

(*c*) As a translation scheme is employed, the zone centre equipment could be dispersed between buildings in different towns if required for security or other reasons. Thus existing zones such as Leeds, Sheffield, and Newcastle could be grouped together to form a North-East zone, but the trunk equipment could still be located in the three towns.

(*d*) Alteration in routings could be made without changing the code.

(*e*) Similar operating procedure on all calls.

(*f*) Existing equipment in the director zone centres could form a nucleus of the scheme.

(*g*) It should be possible to use the existing trunk cable layout.

(*h*) A zone boundary could not be modified to include or exclude a particular exchange without changing the exchange code.

(*i*) On junction routes to nearby exchanges, 2- or 3-digit codes which were different from the National 4-digit codes would be used as at present.

It is suggested that before further automatisation of the Trunk and Toll network takes place, a general plan for the country as a whole should be adopted. The above is put forward to direct attention to some of the possibilities available.

17. Conclusions.

Proposals have been put forward for the simplification of exchanges by reducing the variety of major items of equipment in use and the standardisation of a new cabling scheme for grading purposes. In particular it is proposed that uniselectors, 200-outlet group selectors and P.B.X. final selectors be standardised for all exchanges together with a layout of bank multiples on the group and final selector racks that will meet all conditions.

It is claimed that with the adoption of these proposals, main exchange equipment could be manufactured in bulk to an annual estimate of requirements; that the equipment could be installed without detailed design and to simplified traffic data; that the grading and jumpering could be left until the opening-date traffic data were available, and that subsequent changes due to variations in calling rate or traffic conditions could be met merely by jumper and grading changes.

A possible solution of some of the acute accommodation problems in the provincial non-director exchanges which may reduce the immediate need for new building has been suggested. Attention has also been drawn to some trunking problems, particularly those which involve revision of numbering schemes at an early date.

In conclusion, the author wishes to thank his friends and colleagues, especially those in the Equipment Branch of the Engineer-in-Chief's Office, for the valuable assistance rendered in the preparation of this paper. Thanks are also due to the Automatic Telephone & Electric Co. Ltd. for the use of a slide showing the proposed group-selector rack.

NOTE. Since this paper was written, the Post Office has adopted the proposals contained in paragraphs 6, 7, 9, 10 and 11, while some of the advantages anticipated in paragraph 8 have been obtained by having a more liberal provision of P.B.X. units and abolishing the 5-bank multiple. The arrangements outlined in par. 14 may also be adopted when necessitated by local conditions.

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