Telephone Transmission—VI.

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THE main principles upon which transmission systems are based should now be understood from the previous articles in this series. It remains to apply them to the line network so as to design the plant in a sound manner.

In this country the lines connecting towns, exchanges and subscribers are classified as follows:

Long trunks (over 25 miles radial distance).
Short trunks (under 25 miles radial distance).
Junctions.
Subscribers' lines.

Junctions connect together exchanges whose distance apart is such that not more than two unit fees are involved (the unit fee being one penny). This definition is being modified to meet future conditions whereby the junction will cover four unit fees.

It will be evident that traffic as a whole can be divided into types in the same manner and indeed the engineering and traffic aspects naturally run together.

A town may have one or more local exchanges and from the normal intercourse of the population, together with the small fee chargeable, the traffic will be large. After the immediate environs of the township are passed the traffic falls into the short trunk group where, with a lesser community of interest and a higher fee, the volume of traffic becomes reduced. Cases, of course, do arise in certain areas where two large townships fall within the short trunk fee range, but these are not very numerous. In large cities the local fee area may be more extensive than in small towns, London having a radial distance of 12½ miles from Oxford Circus for a 2d. fee, whereas in smaller towns this distance becomes 7½ miles.

Beyond the short trunk limit comes the main trunk service. The fees being proportionately increased and the community of interest less, the volume of traffic is smaller in amount than on the short trunk service. The proportion of circuits provided in each group will naturally vary with the traffic demand and therefore in general terms the further the lines are projected the smaller will the number of such lines be.

It is a generally accepted fact in all communication systems that long distance traffic must take precedence over short distance traffic, since the cost of long distance communication both to the vendor and the consumer is greater. Taking railways as an analogy, an expensive and high-speed express, carrying as it does valuable traffic, must take precedence over slow trains. In the same manner a long distance telephone line held up for a local line clearance is most undesirable because its greater revenue-earning capacity is being wasted. It pays, therefore, to foster the long line and spend money upon it with greater freedom. Faults on long lines are expensive luxuries, therefore more expensive terminating, protection and switchroom gear must be used.

For these reasons the backbone system of long distance trunks has been provided on a firm and sound basis with the most efficient plant that can be obtained consonant with the ability of the circuit to give its proper financial return. As the grade of circuit decreases in importance money can be saved by cheaper construction.

Turning now to the transmission aspect, the main backbone circuits are relatively few compared with junction and subscribers' lines. If then by suitable technical methods the backbone trunks can be made very efficient in transmission, for the same overall efficiency the junctions and subscribers' lines can be made up from lighter guage conductors. Since the latter are so very much more numerous a very great economy can be realized.

The general lay-out, therefore, for an economical transmission scheme is to provide for the long distance trunks connecting the main cities on a "zero" loss basis as described in Article V, and to throw back towards the subscriber's line as much as possible of the total permissible transmission loss.

The British Transmission System.

The ideal of providing all exchanges with direct lines to all other exchanges to which there may be traffic is impracticable. A system whereby traffic is segregated into definite channels by collecting and distributing networks is therefore necessary.

The country has been divided up into a number of units called *groups* of exchanges, the groups themselves being further grouped into a considerably smaller number of *zones*. Each group of exchanges is made dependent on one exchange usually in the largest central town available. This exchange is known as the *group centre* and acts as a collecting and distributing centre for all traffic circulating to and from all exchanges outside the group. The size and shape of the group will depend on the density of population, community of interest and geographical features of the locality. Some groups in the more populated areas are so small geographically that they embrace an area of only 100 or so square miles; on the other hand some groups cover large tracts and have lines from the group centre to outlying exchanges of 100 miles in length.

The zones have a *zone centre exchange* in a large central city to collect and distribute traffic from and to a number of groups. Every group centre has lines direct to its zone centre and also to every exchange in the group where the cost can be reasonably justified. In principle every zone centre should have direct connexions to every other zone centre, but in practice owing to lack of direct traffic this has not been found economical in certain cases.

Fig. 1 shows the present zone centres and the method of routing the traffic between them. The letter D indicates that direct lines already exist.

Fig. 3 shows the existing group centres.

For long distance traffic the normal routing is as

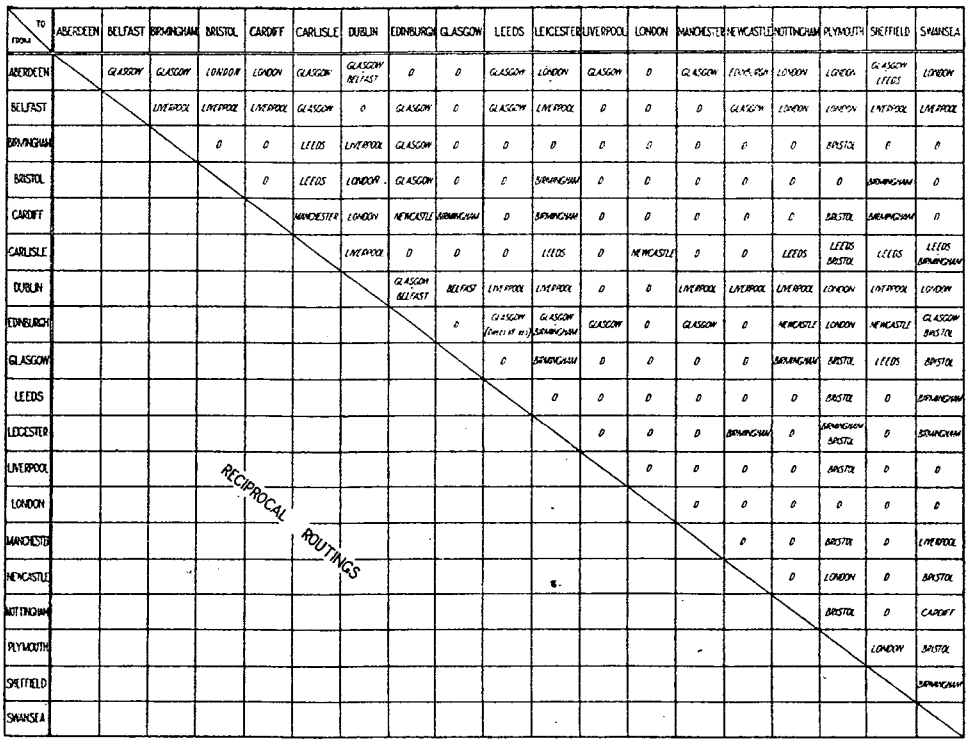

FIG. 1.—ZONE TO ZONE PRIMARY ROUTING.

follows :—The subscriber at an exchange is switched *via* his group centre to the zone centre and thence *via* the remote zone centre to a second group centre and on to the requisite exchange to which his correspondent is connected. This is shown diagrammatically in Fig. 2.

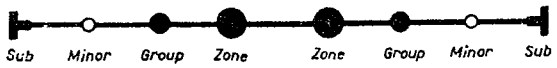

FIG. 2.—NORMAL ROUTING OF LONG DISTANCE TRAFFIC.

In theory all long distance communication should conform to the routing shown; in practice, however, there are variants which alter the problem. It is clearly reasonable to set up trunk circuits in addition to the foregoing where the traffic justifies this action, and in practice many zone centres are provided with direct circuits to group centres in other zones and conversely some group centres have lines to several zone centres. London has direct circuits to group centres such as Middlesborough, Hull, Hanley, Exeter, etc., and Derby as a group centre has lines to London, Manchester, Leeds, Sheffield, Nottingham and Leicester as well as to its proper zone centre, Birmingham. The elimination of unnecessary operating together with the speed of service will justify this course where the community of interest is such that heavy traffic exists.

Provision and Method of Operation.

The provision of trunk and junction circuits must be regulated on some definite plan so as to avoid wastage of plant. The junction and trunk circuits from the local exchanges to the group centre are provided on what is known as a " No delay " basis, that is to say the number of circuits on a route is increased when the times that all circuits are engaged becomes noticeable.

No delay circuits are worked, with few exceptions, on a junction signalling basis.

The trunk service between zone centres is operated on a Demand basis, where a certain large percentage of the calls are put through on Demand, that is to say, the subscriber is not released but obtains his call without having to hang up. The basis of provision is such that less trunks are used than with the " No delay " service.

Toll Areas.

Associated with the larger zone centres situated in big commercial cities are a number of group centres at no great distance from the zone centre and each other. The community of interest between these exchanges is great and the traffic correspondingly heavy. It pays therefore to set up rapid communication facilities covering the area concerned and to work a group to group service direct or *via* the zone centre exchange on a no delay basis. An area thus constituted is termed a Toll area. The London Toll area comprises roughly the counties of Kent, Sussex, Surrey, Essex, Middlesex, Hertford and parts of Bucks, Berkshire and Hampshire.

Transmission Design.

It has been laid down that as a basis in this country the line transmission loss between any two exchanges should not exceed 15 db. except in the obviously difficult sparsely populated areas where a small proportion of subscribers on an exchange cannot otherwise be served except at prohibitive cost.

It has already been stated that all zone to zone links are now planned on a basis of zero loss and therefore the full 15 db. is available for distribution elsewhere in the system. The group is thus the unit area for transmission purposes. Every exchange in a group must thus be able to reach the zone centre with a total loss of 7.5 db.

In many cases zone to group circuits are now provided by means of light guage cables and amplifiers. Circuits so set up can be operated at " zero " loss if worked on a four-wire basis, but should oscillation occur during operating due to temporary discon-

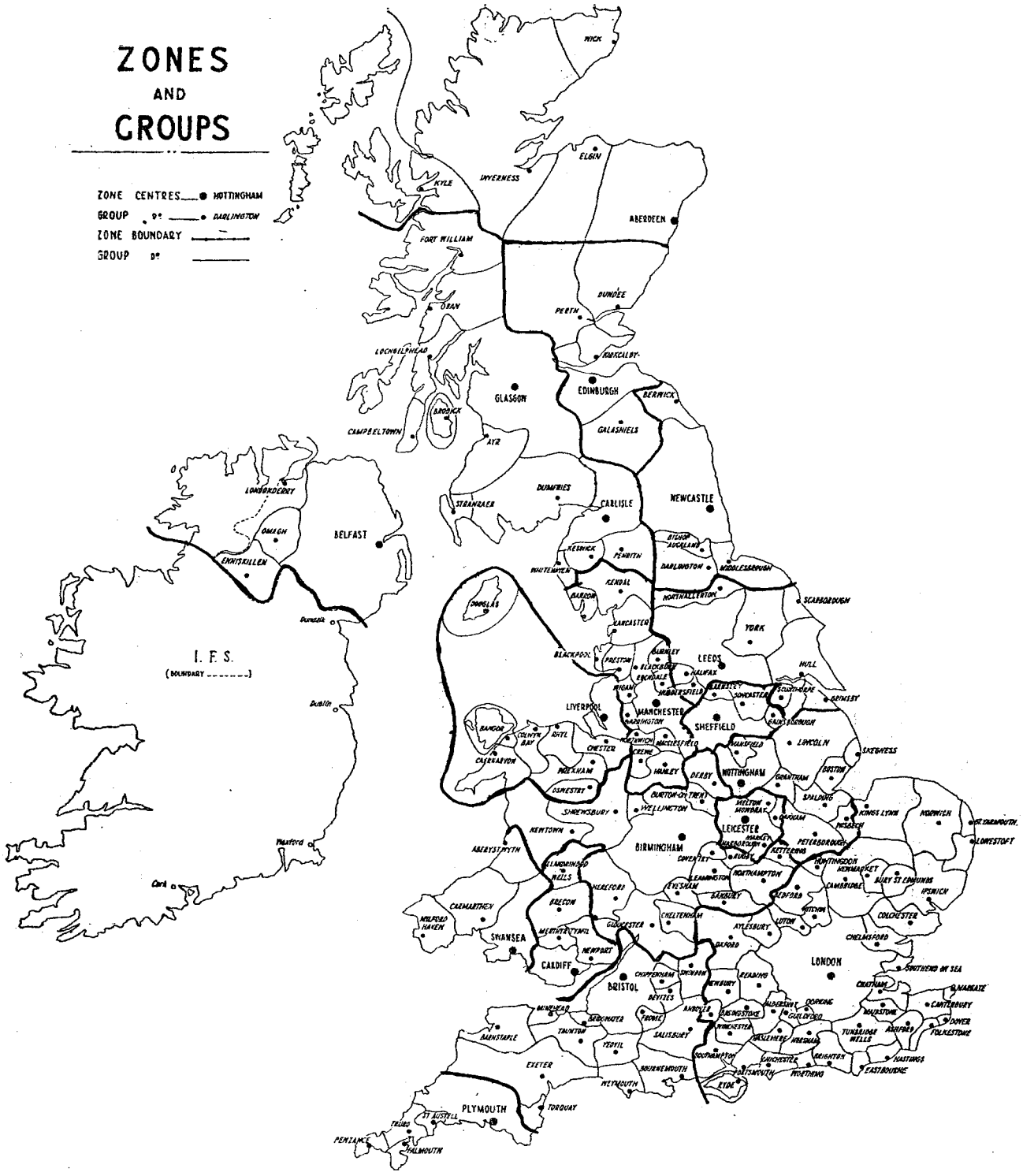

FIG. 2.

nexions at one end the resulting disturbance to subscribers and other circuits in the cable would be severe. Were it possible to use echo suppressors on all these circuits this difficulty would be avoided, but as this is ruled out on grounds of expense the safe limit has been found in practice to be 3 db. This link may thus be set down as having a maximum permissible loss of 3 db.

The junction or short trunk circuits from the group centre to the dependent exchange can thus have a maximum limit of 4½ db.

These allowances are sufficient for traffic circulat-

ing throughout the entire system and circuits having losses not exceeding these figures are suitable for long distance or inter-zone work and may be called " Z " circuits.

Since the group is the unit area for transmission purposes it follows that the allowances quoted are suitable not only for the long distance traffic, but also for inter-group or " G " traffic within a zone.

Within a multi-office area any two exchanges must be able to communicate without exceeding the standard allowance, but since the junction circuits provided for " Z " and " G " traffic have losses of only 4.5 db., plant based on this figure would be wasteful. Any two junctions which may have to be connected in tandem can be provided on a maximum basis of 6.5 db. for each junction. This gives a margin of 2 db., but allows of an economical guage of cable. Such junctions are called " G_2 " circuits.

Circuits handling direct traffic (" D ") only between two exchanges in such an area and not available for tandem switching are allowed a maximum allowance of 12 db.

Fig. 4 and the following table show typical connexions together with the line allowances. It will be noticed that in cases where the local exchange has not direct connexion to its group centre the junction allowance must still be within the 4.5 db. figure. All figures quoted are maxima.

Circuit.	*Type.*	*Allowance db.*
Zone centre to zone centre	Z	0
Zone centre to group centre in another zone	Z	3
Zone centre to group centre in the same zone	Z	3
Group centre to group centre	G	3
Group centre to minor exchange	Z & G	4.5
Group centre to dependent exchange *via* a minor exchange	Z & G	4.5
Group centre to minor exchange for switching in multi-office area ...	G_2	6.5
Any two exchanges for terminating traffic only ...	D	12

This then is the transmission plan for this country. The new figures have only been adopted recently and although very much transmission upgrading has been done years will pass before all the links are within the limits set down. Old plant with useful life cannot be ruthlessly scrapped nor can it always be modified to work satisfactorily on modern lines, but as opportunity occurs the work is undertaken to bring the lines within standard.

It will no doubt be realized that the huge majority of calls do not incur the whole transmission loss of 15 db. For instance, more than 75% of calls between say London and Liverpool exchanges are to and from subscribers in these cities, thus one and more often both zone to group links are cut out. Transmission upgrading was started with the inter-zone links so that the maximum benefit would be realized both in transmission of long distance calls and in economies in local networks. It may be assumed that, taking average transmitters and receivers, 90% of traffic in this country is within the standard thus described.

The transmission plan as outlined above is not in any sense a finality. Unquestionably in the near future a zero loss zone to group link will be possible. Transmission losses can then be expended entirely in what may then be called the local system. It is ever the desire of the transmission engineer to throw

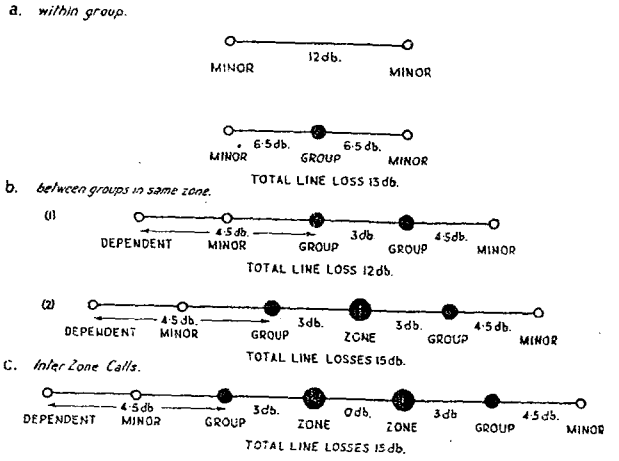

FIG. 4.—TYPICAL CALLS. REVISED TRANSMISSION STANDARDS.

these losses further and further back so that he may realize a great economy in the cheapest possible local line network.

The future inevitably holds enormous changes both in technical advance and methods of construction. Good transmission is not only a necessity, but a valuable and sound business investment. The work already done on the present plan in giving really first class transmission on the trunk system has, together with the demand service of rapid connexion, been the greatest aid in keeping the British telephone service ever expanding during the recent years of depression. These two factors have made the service not only popular but a business necessity, and have had no small influence on the telephone surplus.

Conclusion.

These articles have been compiled with the hope that the subject of Transmission in its widest sense, both theoretical and applied, may become more popular and intelligible to those whose work is both too arduous and removed from the subject to study the more academic and mathematical works on the theme. The author hopes that by keeping each article to a short length and by treating the matter in a rather different manner from the usual the interest of readers may have been stimulated.

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