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L. MEEK, A.M.I.E.E.

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Subscribers' Cable Distribution—Recent Developments

1. Introduction.

The subscribers' line plant network, which consists of the wires between the telephone exchanges and the subscribers' premises, forms a most important part of the telephone system. In Great Britain about 90% of the total mileage of this plant is in underground cables, the remainder being either in aerial cables or open wires. The fact that the plant is mostly out of sight is apt to deprive it of its due importance and even line plant engineers who are responsible for estimating, planning and installation work are not always sufficiently aware of the size of their undertaking and of the huge capital outlay involved. Precise figures are not available, but an investigation made in 1936 shewed that the capital invested in various portions of telephone plant as at 31-3-1934 was roughly as shown in Table 1:—

TABLE I.

	£ Millions.	Percentage of total.
Exchange equipment	25.5	17
Subscribers' apparatus	10	7
Line plant—Subscribers'	60	40
,, —Junction and Trunk (including repeaters)	53.5	36
	149.0	100

These figures indicate that 76% of the total capital investment is in line plant (including repeaters), and that more than half of this is in the subscribers' line plant.

The large amount of money involved demands that the expenditure should be wisely made. The particular branch of telephone engineering dealing with underground cable layout therefore presents a large field for economic planning and for improvements in design, installation and maintenance. The steady increase in efficiency of junction and trunk circuits and of the subscribers' telephone set affords opportunities for economies in the subscribers' line plant and it is important that full advantage of these developments should be taken.

The type of cable layout and the means adopted to provide flexibility in distribution of the cable pairs have an important economic significance.

This paper compares the Post Office type of cable layout with other systems used abroad and refers to recent developments, which aim at securing the most economical layout for the subscribers' cable distribution and at the same time afford maximum flexibility in the system.

2. Forecasts of Telephone Growth.

Underground conduits and cables must be laid with sufficient capacity to cater for telephone growth for a considerable number of years ahead. For this reason detailed forecasts of growth throughout an exchange area must be prepared. Ordnance maps of the area are first divided into suitable small blocks of territory, after which a complete survey and study of the area is made, the anticipated telephone development being assessed separately for each block. At the present time every exchange in the country is being resurveyed under a revised Development Study Procedure which was introduced in November, 1936, and it is hoped that the work will be completed by the end of 1939. The results are expected to be more accurate than any hitherto obtained, but forecasting is not, and never can be, an exact science. Consequently it would be a mistake to rely entirely upon the forecast when determining plant provision.

The forecasts are based on the assumption that rentals will remain constant ; therefore an appreciable change in tariffs may completely invalidate the forecasts. This effect was experienced in a marked degree following the tariff concessions in 1934 and 1936, and it was the primary cause of the present general shortage of plant, which will not be overcome for some years. Further, the forecasts include areas such as projected housing schemes where growth is very speculative. This applies particularly to the fringes of towns.

Other factors affecting forecasts are national emergencies, booms and depressions in the business market, and the extent to which advertising and canvassing are pursued. The growth in built-up areas can be forecast more correctly, but it is well known that whereas the total growth in an exchange area or along a main cable may be forecast with reasonable accuracy, the estimate for any smaller portion, such as a D.P. area, may be very inaccurate. The cable layout should, therefore, be provided with a considerable measure of flexibility in order that departures from the estimated growth may be satisfactorily met.

In this connection the following extracts from the Telephone Development Committee's Report, dated June, 1935, are of interest:—

> Forecasts of telephone growth are not as accurate as they could be. We realise that anything like complete accuracy is unattainable, and that indeed the margin of error in particular cases is always bound to be considerable. (Para. 7.)
>
> The smaller the unit for which a forecast is made, the greater, generally speaking, is the element of speculation in it ; and when we get down to such a small area as a survey block, a twenty year forecast can scarcely be more than an intelligent guess. (Para. 35.)
>
> The Engineering Department will then have the responsibility for making suitable provision of cable plant to each distribution pole so as to ensure that ordinary fluctuations in development can be met. We are satisfied that the methods of line plant provision employed by the Engineering Department are sufficiently flexible to enable this to be done without serious difficulty. (Para. 41.)

These extracts define the position with regard to forecasts and the responsibility which rests upon the Engineering Department.

3. Planning Periods for Underground Plant.

By "planning period" is meant the number of years' growth for which provision is made in underground plant.

Economic studies, together with practical considerations, indicate that ducts should normally be laid with capacity for 20 years' growth, but so far as cables are concerned there is, theoretically, a different planning period for every rate of growth. A reference to Table 2 will explain this feature.

TABLE 2.
ECONOMIC PLANNING PERIODS FOR UNDERGROUND CABLE.

Growth per annum.	Economic planning period 10 lb. conductors.
Circuits.	Years.
2½	20
5	15
7½	13
12½	12
15	10
25	8

When, however, practical considerations are taken into account it is both necessary and economical to restrict the number of planning periods. For many years three periods were used as follows:—

Main cables—9 years.
Branch cables—14 years.
Distribution cables—20 years.

The chief disadvantage of these periods was that relief fell due at different dates in each of the three subdivisions of plant, involving frequent relief schemes and considerable rearrangements of plant.

To secure an improved cable layout, which could be more easily relieved, and to assist in the more general introduction of methods of flexibility (*i.e.*, teeing and auxiliary joints), it was decided in 1929 to reduce the planning periods to two as under:—

Main cables—11 years.
Branch and distribution cables—16 years.

It was considered that these periods would facilitate the provision of flexibility and ensure a more economical layout. They were reduced temporarily to 8 and 12 years respectively in 1934 owing to the large amount of spare plant existing at that time, mainly due to a period of trade depression.

The question was again fully examined in 1938 and the investigations shewed that it is more economical to provide distribution cables on an ultimate (*i.e.*, 20 year) basis. A careful examination of the practical aspect shewed that if main cables were planned on an 8 year basis and distribution cables on a 20 year basis, a more suitable ratio of cable pairs in the two portions of the cable layout would be secured for the installation of auxiliary joints. It was also considered that these planning periods would be more suitable from the point of view of the provision of relief cables.

4. B.P.O. Type of Cable Layout.

(*a*) *General Description.*

Since the introduction of underground plant many years ago the usual practice in this country has been to provide, from an exchange, main cables of relatively high circuit capacity, gradually diminishing in size at each point where branch or distribution cables leave the main, the cables being finally terminated at distribution points. A distribution point may be a terminal block fixed on a pole or inside or outside a building; where distribution is directly underground, a length of small cable (say 7 pair, 10 pair, or 15 pair) laid under the footway, from which the subscribers' services are tapped, would constitute the distributing point. The system of cable layout with diminishing cables is shown in Fig. 1.

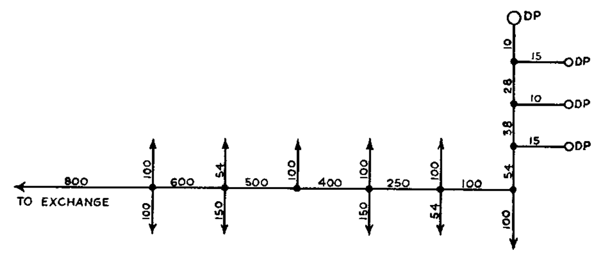

FIG. 1.—B.P.O. TYPE OF CABLE LAY-OUT. (DIMINISHING CABLES.)

(*b*) *Flexibility.*

To meet variations from the forecast and enable new subscribers to be provided quickly with telephone service, the cable plant must be designed to provide flexibility.

It has already been indicated that the smaller, or distribution, cables should be planned on an ultimate (or 20 years) basis, but that the larger, or main, cables should be laid for an 8 year period. This means that there will be considerably more pairs in the distribution cables than in the main cables and that all the distribution pairs cannot be joined through to the exchange until relief cables are provided.

By introducing a means of flexibility at the point where the planning periods change, the extra pairs in the distribution cables can be used to meet variations from the forecast growth, thus enabling the main cable to work to a greater percentage efficiency and deferring the necessity for a relief cable, or alternatively avoiding costly rearrangement of pairs in the main cable joints.

The term "flexibility" should be taken also to include adaptability of the layout to meet either normal or unexpected future requirements. Consideration should be given to this aspect in the design of development schemes. In general, the cable design is prepared in relation to the growth expected during the planning period for the main cables, but it is a distinct advantage to consider the manner in which relief will be provided when it becomes necessary. The layout should be arranged to minimise the number of rearrangements of cable pairs at the relief stage. This can be done only approximately, but its importance should be borne in mind when schemes are being designed.

(*c*) *Methods of securing Flexibility.*

In London, Cable Distribution Heads were employed for many years to provide flexibility, but they became a weakness in the system, mainly because they were not used with discretion. As cables were added, congestion of the circuits in C.D.H.s occurred, and the paper covering of the wires was disturbed and the insulation consequently impaired by frequent openings. Faults therefore became numerous. C.D.H.s have now largely been abolished and two systems for securing flexibility have since been introduced:—(i) Teeing, and (ii) Auxiliary joints.

(i) The teeing method provides for all surplus pairs in the distribution cables to be teed at the point where the planning periods change and is illustrated in Fig. **2**. The best arrangement is to connect about one half of the main cable pairs direct to the distribution points and to make each pair of the other half available at two distribution points by teeing. This method gives a measure of flexibility and enables departures from the forecast to be met within certain limits.

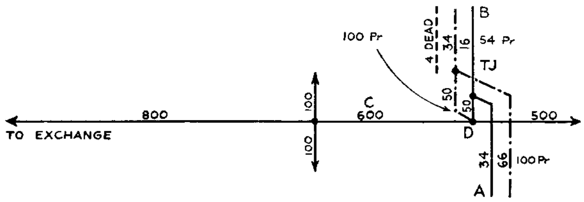

FIG. 2.—DIMINISHING CABLES WITH TEED JOINT.

(ii) The auxiliary joint method is an alternative to teeing. The joint is introduced at the same point in the layout as the teed joint as shewn in Fig. **3**. The method provides for a number of the pairs in the main and distribution cables to be brought out to a specially arranged joint, termed an auxiliary joint, the sleeve of which can be readily removed, thus facilitating rearrangement in the allotment of pairs to the several distribution points. Mechanical joints for use at the auxiliary joint are a stock item, making the removal of the sleeve an easy matter. Departures from the forecast growth at distribution points may thus be rectified to a certain extent by periodic rearrangements at the auxiliary joint. This method was fully described by Mr. Harvey Smith in a paper entitled " The Problem of Flexibility in Subscribers' Cable Distribution Plant."

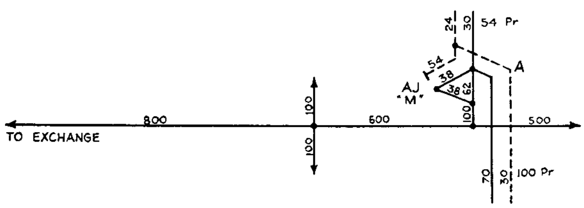

FIG. 3.—DIMINISHING CABLES WITH AUXILIARY JOINT.

(*d*) *Choice of Method.*

In the smaller towns and villages the maximum planning period (*i.e.*, 20 years) will often apply throughout. In these cases no special provision for flexibility is made.

In other areas flexibility should be provided. The Post Office Engineering Instructions state that auxiliary joints should be used in densely-developed areas, particularly where there is complete underground distribution and where frequent and sudden fluctuations in development may be experienced. They are also useful for introducing a measure of flexibility into existing cable plant. In other cases, the teeing system is the standard method of securing flexibility.

There is still a good deal of reluctance in some parts of the country to make adequate provision for flexibility in the design of development schemes, and plant proposals should be carefully examined to ensure that due attention has been given to this feature.

(*e*) *Rearrangement of Cable Pairs.*

The chief disadvantages of the Post Office system are that the flexibility obtained is inadequate to meet considerable variations from the forecast growth and that relief cables cannot usually be added without extensive rearrangements of existing plant. As a result of these two features the number of cable pairs rearranged annually is very high, involving heavy expenditure. Table 3 gives details of the total labour cost of underground work and the proportionate cost of " Wires Changed Over " during the years ending March, 1936, 1937 and 1938.

Rearrangements of paper-covered wires are always undesirable as they cause deterioration of the paper insulation and reduce the insulation resistance. This is especially the case with joints on large cables. The use of auxiliary joints reduces the rearrangement work at large joints and improves the conditions under which rearrangements are made (*i.e.*, at the smaller or auxiliary joints), but it does not appear that their use lessens the total number of wires changed over. In London, where auxiliary joints have been in use for many years on an extensive scale the proportionate expenditure on wires changed over is greater than in the provinces. Manhours spent on " Wires changed over " as a percentage of total manhours are approximately 29% for the provinces and 45% for London. The higher figure for London is no doubt partly due to the large amount of completely-underground distribution, which requires at least one pair of wires changed over for each of many new subscribers.

The automatisation programme, involving transfers of exchanges to new buildings in many parts of the country, accounts for much of the rearrangement work. This is unavoidable and would be necessary under any system of cable layout. This only accounts, however, for a part of this large expenditure and a substantial proportion must be regarded as directly due to the type of cable layout adopted. The heavy annual cost of rearranging cable pairs is a very disturbing figure both for accountants and engineers. As it remains at a high figure without appreciable variation it is equivalent to an " Annual Charge." It would be much more economical to spend the money in providing additional cable if by so doing we could reduce the rearrangement costs.

It is stated that in America the expenditure for rearrangements amounts to one-tenth of a manhour per telephone station per annum. This applies to subscribers' cable plant only and does not include rearrangements necessitated by alterations to the highways. A directly comparable figure for this country is not available, but the total average manhours per telephone station during the past three years is 1.4. This figure includes rearrangements on junction and

TABLE 3.

LABOUR COST OF "WIRES CHANGED OVER" IN RELATION TO LABOUR COST OF ALL UNDERGROUND WORK.

	1936		1937		1938	
	Manhours (effec.+ ineff.)	Direct cost £	Manhours (effec.+ ineff.)	Direct cost £	Manhours (effec.+ ineff.)	Direct cost £
All underground work.						
London . .	3,915,000	277,000	4,543,000	330,000	4,988,000	354,000
Provinces	5,186,000	357,000	6,450,000	434,000	8,588,000	564,000
Totals	9,101,000	634,000	10,993,000	764,000	13,576,000	918,000
Wires changed over.						
London ..	1,760,000	124,000	2,120,000	154,000	2,180,000	155,000
Provinces ...	1,640,000	113,000	1,880,000	127,000	2,100,000	138,000
Totals .	3,400,000	237,000	4,000,000	281,000	4,280,000	293,000
Wires changed over as percentage on all underground work						
London .	45%		47%		44%	
Provinces	32%		29%		25%	
Totals . .	37%		36%		32%	
Number of wires changed over per station.						
Number of stations	2,579,012		2,826,995		3,050,012	
Manhours per station .	1 32		1.42		1.41	

trunk cables and work necessitated by alterations to the highways, but if such work were excluded it is estimated that the rearrangements on subscribers' cable plant alone would probably amount to about ten times the American figure.

5. Distribution Cabinet Type of Cable Layout.

This system is in use in Sweden and similar systems exist to some extent in Denmark, Switzerland and other countries in Europe.

(*a*) *General description.*

A liberal use is made of distribution cabinets to secure flexibility in the cable layout. The exchange area is subdivided into sections called "cabinet areas" in each of which a distribution cabinet is located. The cable system is divided into three parts as follows:—

(i) Main cable network.
(ii) Secondary cable network.
(iii) Distribution areas.

All cable pairs pass through the distribution cabinets, which are fitted in street pillars or on the outside or inside of buildings.

The arrangement is shewn diagrammatically in Fig. 4.

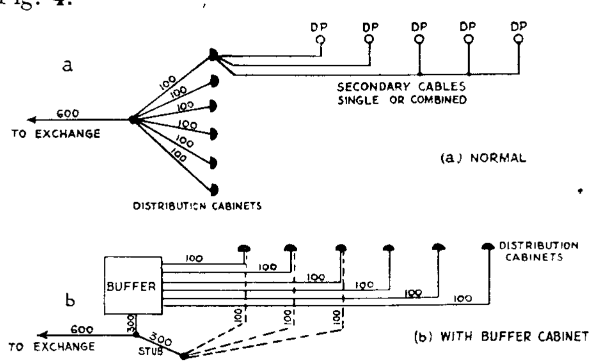

FIG. 4.—DISTRIBUTION CABINET TYPE OF CABLE LAY-OUT.

(*b*) *Main Cable Network.*

This consists of 600 pair cables from the exchange; each cable is subdivided, and cables of 100 pairs are extended to the distribution cabinets as and when required. Relief cables of the same size are added as is necessary.

(*c*) *Secondary Cable Network.*

The secondary network extends from the distribution cabinets to the distribution points, which may be on poles or in buildings. The distribution points are usually ten or twenty-pair terminals and cables of these sizes are laid back to the distribution cabinets. Where the cables can be combined, a tapered network is used, but the cables on the exchange side of the distribution cabinet are usually not more than 100 pairs. The number of cable pairs in the secondary network is considerably more than in the main cable network.

(*d*) *Distribution Area.*

The distribution area embraces the subscribers' individual lines, and the distribution point is placed so as to obtain the shortest possible and most easily erected subscribers' lines.

(*e*) *Distribution Cabinets.*

The larger cabinets, for 1400 and 700 pairs, are constructed for erection on the ground. They are usually placed in courtyards or streets, close to the walls of buildings or in niches cut into the walls.

The smaller cabinets, for 250 and 150 pairs, are designed for fixing on walls or poles, and are intended for use with aerial cables.

All working circuits are jumpered by means of rubber-insulated cotton-wound and impregnated wires in the distribution cabinets.

(f) *Flexibility.*

Considerable flexibility is secured by the use of distribution cabinets, and the main cables can be worked to a high degree of efficiency. To increase the flexibility a measure of teeing is employed in the main cables, which makes the main cable pairs available at more than one distribution cabinet. Similarly, teeing is sometimes resorted to on the secondary cables, or alternatively the distribution area is subdivided and sub-cabinets are used.

On the main cables a buffer cabinet similar in principle to the Post Office auxiliary joint is sometimes used to increase flexibility. The use of a buffer cabinet is shewn in Fig. **4**.

6. Multipling Type of Cable Layout.

This is used in by far the major part of the telephone systems of the world, including North and South America, Italy, Spain, Portugal, Rumania and Shanghai. Great flexibility and adaptability for unforeseen growth are secured by the use of non-diminishing cables combined with extensive multipling (or teeing) of cable pairs.

(a) *General description.*

The feeder cables on both main and branch routes are of uniform size either throughout their entire length or for considerable distances. A liberal system of multipling is adopted, and all main cable pairs are connected to more than one distribution point; in some cases the multipled pair may be terminated at as many as six or seven distribution points. Careful consideration is given to the arrangement of the multipled pairs in order to secure the best results.

The cables used for the final spurs to distribution points are approximately twice the size of the ultimate forecast growth. This provision, together with the non-diminishing cables and multipled pairs, secures a highly flexible and, it is claimed, an economical layout. The practice of doubling the size of the spurs is considered justifiable because they are usually of short length and the labour cost—generally the largest item in the total expenditure—is not materially increased. Large variations from the forecast at distribution points are thus readily met, and the expense of providing additional cables on the spurs or of replacing existing cables by larger ones is avoided.

A typical layout is shown in Fig. **5**(*a*) and details of the various features of the system are given in the following paragraphs:—

(b) *Uniform Sizes of Cable.*

In growing areas cables of uniform size throughout their entire length are generally used for both mains and branches on account of the flexibility they offer. If the whole, or a part, of a route is likely to be transferred to another main feed in order to conform to new exchange boundaries or for any other reason, it is desirable to have all pairs available at the further extremity and at intermediate points. Such complete flexibility is sacrificed by the introduction of diminishing cable, and it is not normally the practice to reduce the size of cable unless:—

(i) The cable size would exceed the expected growth during its estimated service life (in cases where the growth can be accurately predicted) or

(ii) There is a physical barrier such as a river, canal, or mountain preventing further extension of the plant, or

(iii) The exchange area boundary has been definitely fixed and the fundamental plan indicates there is no likelihood of the area being modified.

In cases where cables are diminished, the general practice is to reduce the number of pairs by about 50% at each diminishing point.

(c) *Cable Stubbing.*

Cable stubs are usually provided at all points along the main feeder cable where branch cables will be connected. A stub consists of a short length of cable connecting the main joint with an additional joint, called a stub joint, in the same manhole. A group of main cable pairs is brought out of the stub joint, where some of the pairs are joined to the branch cables, the remainder being left insulated in the joint and therefore available for unforeseen development.

The object of a stub is to provide a means whereby new branch cables may be added, existing branches replaced or removed and cable pair numbers rearranged, without opening the main joint. The use of a stub obviates complicated main joints and avoids the risks, which arise when main joints are opened, of lowering the insulation resistance and damaging the paper covering. Stubs are provided when the main cable is installed, even though the branch cables may not be required until later. Stubs on any one cable are generally placed in successive manholes along the route, and normally they are not provided on more than one cable in each manhole.

It is found in practice that the number of pairs per stub should be such that the following conditions are fulfilled:—

(i) The stub should usually contain three times as many pairs as the total branch pairs estimated to be connected to the cable at that point.

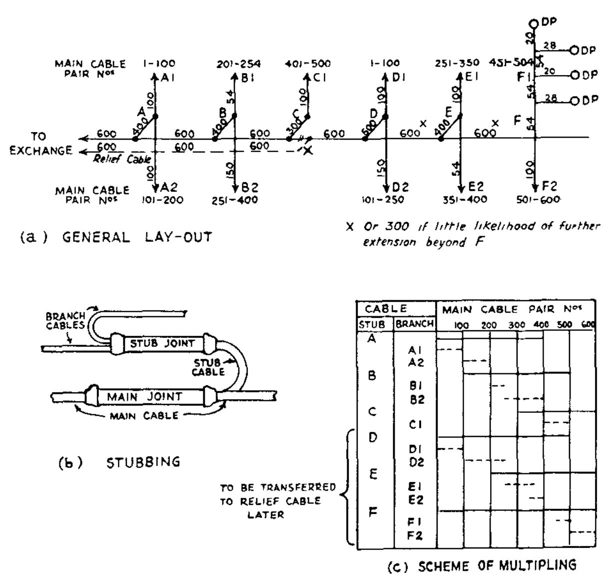

FIG. 5.—MULTIPLING TYPE OF CABLE LAY-OUT. (NON-DIMINISHING CABLES.)

(ii) The stub should not be smaller in size than 200 pairs for 200, 250, 300 and 400 pair cables, and 400 pairs for 600, 800 and 1000 pair cables.

Fig. **5**(*b*) shows the stub cable method as applied in practice.

(*d*) *Cable Pair Multipling.*

Multipling is a term used in telephone work for the repeated availability of a circuit. The principle applies in the multiple of an exchange switchboard. Similarly, in cable work, multipling refers to the repeated availability of the same cable pairs at several distribution points.

The objects of cable pair multipling are as follow:

(i) To terminate all cable pairs or make them available for termination where they will be most needed.

(ii) To distribute ultimate loads throughout the cable as evenly as possible.

(iii) To provide for variations in location or amount of growth — or both — with a minimum number of rearrangements.

(iv) To make the same cable pair available at a sufficient number of points so that the best possible use can be made of the circuits.

(v) To conform to relief plans by terminating all cable pairs or by planning for their future termination within the ultimate area to be served by a section of cable—*i.e.*, between points of relief.

Multipling of cable pairs may be carried out at three places situated between the exchange and the distribution points:—

(i) At the junction of the main and branch cables.

(ii) At the junction of the branch and distribution cables.

(iii) At the junction of the distribution cable and the spur cables to the distribution points.

The first arrangement secures flexibility of cable pairs over a large area, the second over a number of distribution cables, and the third over a group of distribution points.

In the case of (i) the multipling is effected in the stub joints described in paragraph (*c*). The method is illustrated in Fig. **5**(*a*) where the first stub A is connected to pairs 1—400 and the fourth stub D to pairs 1—500. Pairs 101—200 are joined to branch cable A2 and pairs 101—250 to branch cable D2, so that pairs 101—200 appear in both branch cables and at the terminals connected thereto. In Fig. **5**(*c*) the horizontal lines indicate the main cable pair numbers which are jointed to the various stubs and branch cables.

In the case of (ii) the multipling is carried out at the points where the distribution cables leave the branch cables.

Similarly the multipling for (iii) is effected where the spur cable to the distribution point leaves the distribution cable. Fig. **6** gives examples and shows also the arrangement of the cable pair numbers at each distribution point. Three methods, known as single lap, double lap and unequal lap, are indicated, and the choice among them depends upon considerations of the class of service, location of subscribers and growth, and the multipling arrangement of main cables. The single lap method, being a simple arrangement, is commonly used but the double lap method provides better flexibility, is more readily multipled in the main cables, and provides a point of future relief should a change in the character of development or class of service require it. Either of these methods is suitable where the growth is more

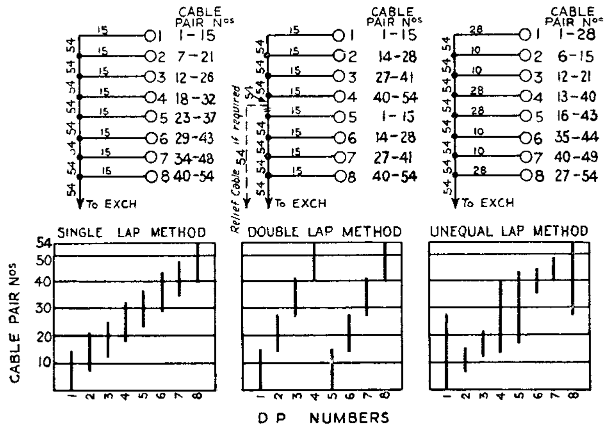

Fig. **6**.—Cable Pair Multipling—Distribution and Terminal Cables.

or less uniform, as in the case of a residential area where the houses are similar in type. It will be observed that the distribution points are of similar circuit capacity with the single and double lap methods.

The unequal lap method provides still greater flexibility and is suitable for areas where it is anticipated that the growth will not be uniformly distributed.

(*e*) *Methods of Relief.*

As the spare capacity in cables becomes exhausted, relief is afforded by:—(i) Reinforcement, or occasionally by (ii) Replacement, or (iii) Rearrangement.

(i) Reinforcement consists of laying an additional cable either along the same or an alternative route to a suitable point on the existing cable. The existing cable is cut at this point and one portion connected to the new cable, the other portion remaining untouched. The result is two cables in service, each of which provides for some of the existing subscribers and for growth. Fig. **5** shows how the relief is provided.

The points of relief are definitely determined when the original scheme is prepared, and multipling is arranged so that no alteration is needed when the relief cable is provided. Fig. **5** illustrates the arrangement of the multipling.

(ii) Replacement consists of laying a larger cable and recovering the one existing, but the layout is so designed that this procedure is not often necessary.

(iii) Rearrangement involves a redistribution of cable pairs in the stubs, but this method is a temporary expedient and is not frequently used. A well designed layout reduces such redistribution to the minimum.

(*f*) *Distribution Plant.*

In countries using the non-diminishing cable system the methods of distribution differ from those followed in this country in those localities where overhead services from poles are not practicable. Instead of the British method of direct underground distribution a branch cable is brought from a manhole situated on the main route to the nearest point of a nearby block of buildings and the cable is then carried along the buildings on the outside walls, terminal blocks being fixed at convenient points as shewn in Fig. **7**. Where

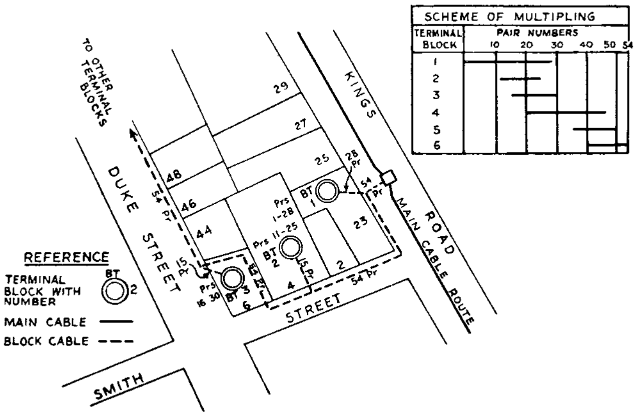

FIG. **7**.—DISTRIBUTION PLANT—BLOCK CABLING.

suitable facilities exist, the cable may be installed inside the buildings. The principles applicable to non-diminishing cables on main routes are also followed on branch routes.

This method of block wiring is used in Great Britain only to a limited extent, but it might be adopted more widely with advantage. It is much cheaper than underground distribution, and the difficulties connected with wayleaves, or building alterations do not seem to present any serious obstacle abroad.

(*g*) *Records.*

A typical record form is shewn in Fig. **8**.

NAME OF TOWN . ...
NAME OF EXCHANGE....... .. . .

MAIN CABLE PAIR Nos	NATURE OF SERVICE	SUBSCRIBERS NUMBERS	DISTRIBUTION POINTS, ADDRESS & NUMBER: 64 Queen St DP 231		72 Lime St DP 447		7, Park Rd DP 448		21 Grange Rd DP 450		
1		1642									
2		0247									
3											
4		7291									
5		6145									
6		1423									
7											
8		5411									
9		7241									
10											
11	P B X	6112									
12		2433									
13		4001									
14											
15		3112									
16		3921									
17		1312									
18		1409									
19											
20											

FIG. **8**.—TYPICAL RECORD USED WITH MULTIPLING SYSTEM.

7. Comparisons of Various Types of Cable Layout.

(*a*) *Distribution cabinets* are not favoured for general use in this country. Distribution frames are employed to a limited extent by the Post Office in the large cities, but a more extensive use is not recommended.

The cabinet system offers a considerable degree of flexibility, but it has the following disadvantages:—

(i) Large distribution cabinets are expensive.

(ii) Every cable pair passes through one or more distribution cabinets, involving jumpering and some increase in fault liability.

(iii) The prevalence of fog and dampness in our atmosphere during the winter months might cause difficulties in maintaining the insulation resistance.

(iv) Difficulty is anticipated in securing accommodation for the distribution cabinets.

(*b*) *The Multipling System.*

(i) *Advantages.*

Multipling has a number of important advantages. It affords great flexibility of cable pairs over the whole of a main cable area without any rearrangement of cable pairs, thus enabling wide variations from forecast to be met. Relief cables can be easily and quickly provided and a more economical use made of ducts, while draw-overs are reduced to the minimum.

The number of cable sizes is reduced considerably, facilitating every stage of the work and offering economy in manufacture as well as in construction.

Joints are seldom disturbed or rearranged except those between the cable stubs and the branch cables. High insulation resistance can therefore be maintained and maintenance costs reduced.

The chief attractions of multipling are its great flexibility and the ease with which relief cables may be provided. Considerable departures from forecast growth can thus be met and telephone service given in any part of the system without delay.

(ii) *Cost.*

An attempt has been made to compare the costs of the multipling system with the Post Office system over a 20 year period and Table 4 shows the result.

The costs in each instance are in favour of the Post Office system, but in examining these figures it must be borne in mind that the cable layouts are based approximately on the forecast growth.

The extra cost of the multipling system is more than offset by the value of the additional flexibility secured and it seems likely that if the cost of providing for departures from the forecast growth could be brought into the calculations the net result would be in favour of the multipling system.

(iii) *Fault liability.*

An objection raised to the system is the additional fault liability and the increased

TABLE 4.

COMPARATIVE COSTS OVER A TWENTY-YEAR PERIOD OF THE B P.O. AND AMERICAN SYSTEMS.

	B.P.O. system.		American system.		Balance in favour of B P.O system	
	Capital cost. £	P.V. of A.C. £	Capital cost £	P.V. of A C £	Capital cost. £	P.V. of A.C. £
London.						
Orpington	19,417	21,508	19,853	21,862	486	354
Mansion House	1,853	1,776	2,027	2,066	174	290
Sanderstead	7,867	8,962	8,531	9,891	664	929
Hurstway	5,043	6,006	5,164	6,184	121	178
S. Wales District.						
Dursley	6,931	7,523	6,939	7,602	8	79
S. East District.						
Lewes .	5,128	5,476	5,510	5,684	382	208
Gross Totals	46,239	51,251	48,024	53,289	1,785	2,038

difficulty of locating faults. In countries where the system is in use, however, it is contended that there is no noticeable increase in each case. In fact, the use of cable stubs and the avoidance of rearrangements, especially on the main cable joints, tend to reduce faults caused by working parties.

The repeated appearance of the same cable pair at several terminal blocks may increase such trouble as face plate leakage but, in practice, these sources of trouble can be kept so low in well-maintained plant as to be barely perceptible.

(iv) *Records.*

The records used for the multipling system are simple and, as rearrangement of cable pairs is less frequent, it seems likely that the records can be maintained with greater accuracy than under other systems.

TABLE 5.

TABLE OF EXCESS COSTS PER HOUSE OF DIRECT UNDERGROUND DISTRIBUTION AS COMPARED WITH NORMAL DISTRIBUTION FOR HOUSES AT VARIOUS FREEHOLD SELLING PRICES.

Freehold selling prices of houses.	Cash equivalent per house of contribution by the estate owner.					
	1 service pipe per 2 houses.			1 service pipe per house.		
	Service pipe.	Charge in addition to provision of service pipe.	Total.	Service pipe.	Charge in addition to provision of service pipe.	Total.
£	£	£	£	£	£	£
700	.42	.87	1.29	.84	1.03	1.87
725	.435	.65	1.085	.87	.82	1.69
750	.45	.46	.91	.90	.61	1 51
775	.465	.28	.745	.93	.41	1.34
800	.48	.12	60	.96	.23	1.19
825	.495	.03	.525	.99	.07	1.06
850	.51	—	51	1.02	—	1 02
875	.525	—	.525	1.05	—	1 05
900	54	—	.54	1.08	—	1.08
925	.555	—	.555	1 11	—	1 11
950	.57	—	.57	1 14	—	1 14
975	.585	—	585	1.17	—	1 17
1000	.60	—	.60	1 20	—	1 20
1025	.615	—	615	1.23	—	1 23
1050	.63	—	63	1.26	—	1.26
1075	.645	—	.645	1.29	—	1.29
1100	.66	—	.66	1.32	—	1 32
1125	.675	—	.675	1 35	—	1.35
1150	.69	—	.69	1.38	—	1 38
1175	.705	—	.705	1.41	—	1.41
1200	.72	—	.72	1 44	—	1 44

NOTE.—Intermediate figures for Cash equivalents should be obtained by interpolation, *e.g.*, £810 houses—1 service pipe per 2 houses.

Cash equivalent per house for service pipes $= .48 + \frac{10}{25}(.495 - .48) = .48 + .006 = £.486$

,, ,, ,, ,, charge in addition to provision of service pipe $= .12 - \frac{10}{25}(.12 - 03) = 12 - .036 = £.084$

,, ,, per house Total $= 60 - \frac{10}{25}(60 - 525) = .60 - .03 = £\ 570$

8. Experiments with Multipling Type of Cable Layout.

In view of the favourable aspects of this system it was decided last year to lay down experimental schemes to provide practical experience. Five such schemes are in hand, three in London, one in S.E. District, and one in the S. Wales District.

9. New Estates—Revised Method of Treatment.

(a) General.

Owing to increasing objections from estate owners to the erection of poles in roads, mainly because of amenities, the Post Office has experienced considerable difficulty in providing telephone service on new estates. When consent for poles is refused it has been the custom to offer the estate owner the alternative of contributing the difference between the present values of annual charges over 20 years for overhead and underground construction. The contribution may be a cash payment, or its equivalent in the form of free trenching and re-instatement, or the provision of service pipes, or a combination of any of these alternatives.

(b) Present procedure.

The procedure for dealing with such cases is cumbersome and slow as it involves:—

(i) Obtaining a development forecast from the Sales Branch.

(ii) Preparing alternative plant layouts and financial comparisons.

(iii) Submitting the case to Headquarters for decision.

In some instances many months elapse before a decision can be reached, and in the meantime, considerable building progress may be made on the estate, permanent pavings may be laid, and requests for telephone service become outstanding.

(c) Revised procedure.

Consideration has been given to all the known methods of serving subscribers by a direct underground distribution. Where the roads and footways are not already paved, the most economical one where the anticipated telephone penetration is fairly high proves to be the provision at the outset of a pair of wires from each house to a terminal pillar similar in design to the pillar used extensively in Australia. Cable pairs from the exchange and from the houses are all terminated on connection strips in the pillar and connection is made by jumpering at the pillar when required. Any main cable pair at the pillar can be connected to any house, and ceased lines can be disconnected at this point. Fig. **9** shows a typical layout.

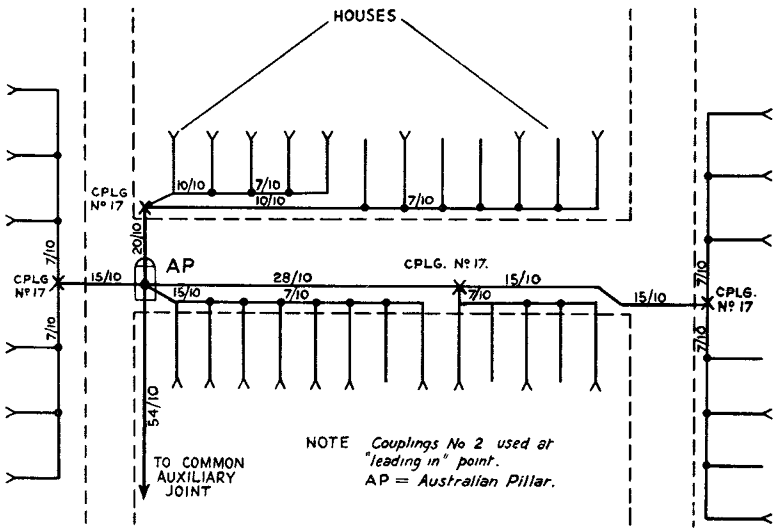

Fig. **9**.—Typical Lay-out for New Housing Estate.

To simplify the procedure in dealing with such cases and to avoid the slow process of cost comparisons, Table 5 has been prepared. This table is based on penetration factors appropriate to the various freehold selling prices of houses. The table enables the excess costs to be quoted to the estate owner in respect of houses ranging in freehold selling prices from £700 to £1200 provided:

(*a*) the frontages do not exceed 60 feet and

(*b*) the estate is not already partly served by normal distribution which would need replacement.

The table shows the excess cost per house subdivided into the equivalent cost per service pipe and costs beyond the value of a service pipe which would be required from the estate owner. In other cases an investigation of costs should be made.

The use of this table would enable questions relating to the method of serving new estates to be dealt with promptly. After ascertaining the price of the houses to be erected, the local engineers could negotiate at once with the estate owner as to the terms on which complete underground distribution could be provided.

Pending a complete settlement of procedure, and in order to provide for unforeseen contingencies, it has

Fig. 10.

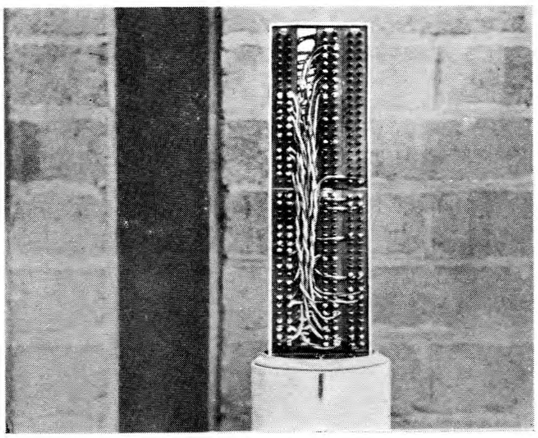

Fig. 11.

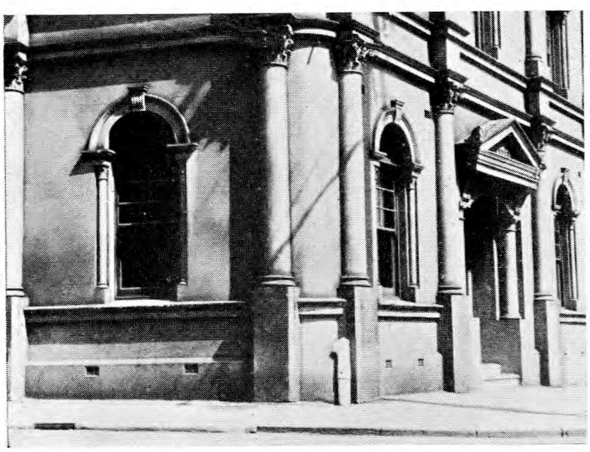

Fig. 12.

been arranged that, where objection is raised to poles on new estates, an offer shall be made to provide underground distribution on all new building estates with houses having an average freehold value of £850 or more with average frontage of not more than 60 feet and where no overhead distribution already exists if a free service pipe or its equivalent is contributed by the estate owner.

(*d*) *Australian pillar*.

The pillar is of asbestos cement and stands about 3 feet above ground level. It is illustrated in Figs. **10-12**. The cables are led up the pillar from an adjacent joint box and sealed into the pillar. They are terminated on soldering tags which are extended to screw terminals from which jumpers are run as required. The cross-connecting field is covered by a metal canister fitted with a rubber ring and secured by pressure on the ring through a helical spring from the cover of the pillar, which is held down by a bolt passing through the body of the pillar. Terminals for 120 pairs would normally be provided.

10. Conclusion.

The large amount of capital invested in local line plant networks emphasizes the necessity for ensuring that all plant provided is used to its maximum efficiency.

Forecasts of telephone growth indicate that the present number of exchange lines will be roughly doubled during the next twenty years which means that an average yearly capital expenditure of about three million pounds will be required for the subscribers' line network alone. This huge expenditure demands an early decision as to whether there is a case for adopting the multipling type of layout as a future standard.

Notes on the Discussion.

It was generally agreed in the discussion that the paper had described very clearly the different systems of subscribers' line plant provision in use in various countries, and that the paper formed a very valuable contribution.

The speakers agreed that the multipling type of layout offered definite advantages in the way of flexibility with its consequent high percentage utilization of plant, simplicity of layout, and ease with which main cables could be added to the system. The adoption of a non-tapering layout also permitted a reduction in the number of cable sizes. Cable rearrangements, although necessary to some extent, appeared to be far less than with other systems. Some doubt existed regarding the probability of more difficult maintenance and possible impairment of transmission with the multipling type of layout, but the trial schemes referred to in the paper, and which are being carried out, should provide valuable information on these points.

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