Pine Tree to Telegraph Pole

W. W. H. Brown

Post Office Supplies Department

THE UBIQUITOUS TELEGRAPH POLE, CARRYING maybe a single line to a lonely farm or distributing telephone service in a busy suburb, is a familiar part of Britain's landscape and, like most everyday objects, is taken very much for granted by the average person. The layman little realises the care with which each pole is selected and examined, fabricated, seasoned and finally preserved to ensure that it will have a long and useful life, giving the maximum of efficiency and safety with the minimum of maintenance. This is not the simple matter of felling a suitable tree, lopping off the branches, and then brushing it with creosote that some no doubt believe it to be! There are so many points to be considered that selection and treatment are work for the expert.

Since the Post Office acquired the inland telegraph network in 1870, Scots Pine (*Pinus Sylvestris*—or European Redwood, as it is more commonly known) has been the standard species of timber, and creosote oil the standard preservative, used for the Department's poles. The choice of species becomes obvious when it is borne in mind that this conifer can normally be obtained in large quantities from Scandinavia, is straight and shapely, has a high strength-to-weight ratio and absorbs creosote well. Ninety per cent. of the poles purchased annually by the Department are of Norwegian, Finnish or Swedish origin, but every encouragement is given to home growers to supply the Post Office, and native forests do in fact contribute a useful quantity each year.

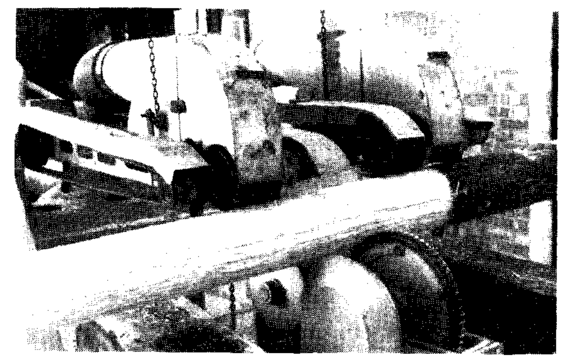
Fabrication and preservation are carried out under Supplies Department supervision at pole depots operated and staffed by contractors. Only untreated poles are therefore purchased, thus enabling the Department to ensure that they are entirely free from defects and to maintain a strict control over each stage of treatment. The specification for poles requires them to be sound, hard-grown, straight and free from large or dead knots and other defects and to have the outer and under bark completely removed. Each pole must be sawn off as close to the ground as possible, to contain the natural butt of the tree, in order to facilitate detection of heart rot and to present the maximum bearing surface against settlement after erection. Poles must be felled between November of one year and March of the next, this being the period when the sap is down and degradation from fungi is least likely to occur. There are four classes of Post Office poles, extra light, light, medium and stout, covering approximately 40 standard sizes, the shortest 16 feet and the longest 60 feet; longer poles are rarely used today.

Peeled poles of the sizes required under current contracts are delivered from Scandinavia by sea, or from home forests by road or rail, to twelve depots strategically located round the coast of Great Britain, where they are unloaded and

Sorting and stamping

individually examined by a resident Supplies Department Pole Inspector. There are sixteen major possible causes of rejection, some extremely difficult to detect. Wood being a natural product, variations in growth and quality occur which make it almost impossible to lay down hard and fast standards. The personal opinion of the experienced Inspector therefore, to some extent, influences decisions to accept or reject. As each pole is approved, the butt is marked by hammer stamps with codes which identify the inspector, the supplier and the receiving depot.

In order to obviate the risk of untreated wood becoming exposed during fabrication, all cutting and boring is completed before preservation is carried out. The poles are first passed through a



The dressing machine. Two sets of high-speed revolving cutters bear on the upper surface of the pole. The large toothed wheel, set obliquely, not only turns the pole but propels it through the machine

dressing machine, in which two sets of high-speed revolving cutters shape them symmetrically and give them their smooth finish. They are then scarfed—that is, a flat surface is planed longitudinally at the top, to provide a bearing surface for cross arms—and holes are drilled to accommodate the securing bolts for cross arms and arm braces. Roof slopes are cut, to disperse rain water, or a hole is drilled in the top to take a finial (the ornamental top fitted to some poles to comply with the wishes of wayleave grantors).

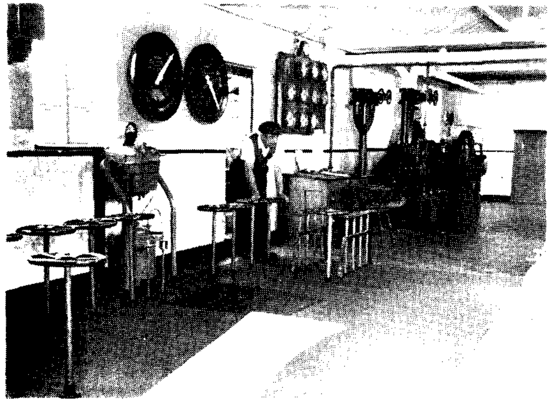
For effective preservation, it is imperative that the timber shall be thoroughly seasoned and that the moisture content at the time of treatment shall be not greater than 25 per cent. of the dry weight. The dressed poles are therefore stacked for

How the poles are stacked for seasoning. (Note the "stairway", for easy access to the upper tiers)

seasoning in open formation on dunnage of sound creosoted timber or concrete, so that the lowest tier is not less than 10 inches above the ground. The surface of the ground under the stacks is kept well drained and free from bark, shavings, grass and weeds. Depending on the class of poles, and to a very great extent on the weather, it may take from six months to perhaps two years for the timber to reach a condition suitable for treatment. Wood, being hygroscopic, tends to maintain a state of equilibrium with the surrounding air, absorbing moisture in damp weather and giving it up in dry, so that creosoting operations are normally restricted to the summer months, when it is possible to reduce the moisture content to the desired level by open-air seasoning.

Until 1913, the Bethel or full-cell process of preservation was almost invariably used for treating Post Office poles. This system, which involved impregnation under pressure until an absorption of 12 lb. of creosote per cubic foot of timber was obtained, yielded very satisfactory results and many poles so treated have given over 70 years' unblemished service. A useful life of 30 to 40 years is normally all that is now required of a pole, however, and as poles treated by the full-cell process were somewhat dirty to handle and excess creosote tended to exude during warm weather, it was decided in 1913 to adopt the more economical Rüping or empty-cell process. This process, as its name implies, is designed to coat the wood cells with preservative but to leave the cells themselves empty of superfluous creosote.

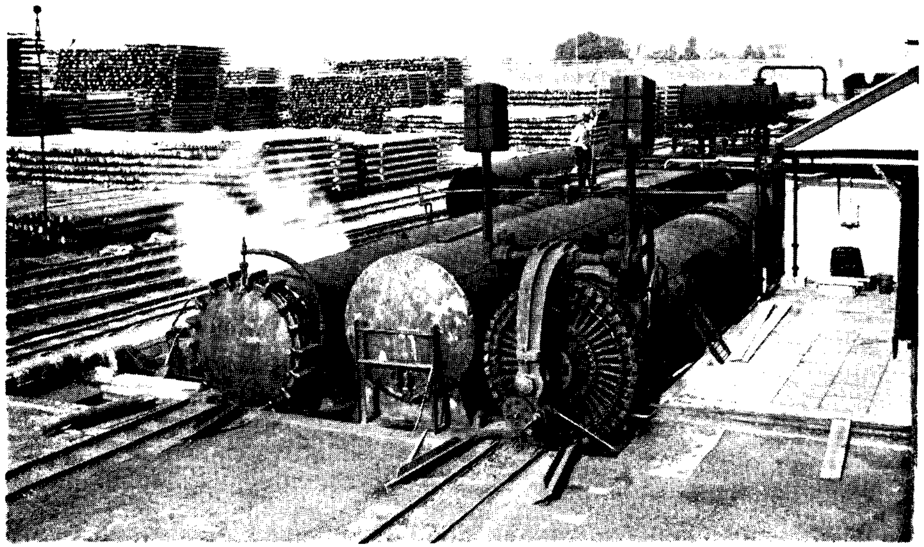
The treating process is carried out in steel cylinders, usually 7 feet in diameter and from 50 to 120 feet in length. The poles are loaded on special



Control room of creosoting plant

bogies running on rails into the cylinder, which is then hermetically sealed with doors—one at each end to ease the flow of work—somewhat resembling those of a bank vault. The air pressure in the cylinder is then raised to about 50 lb. per square inch and maintained at that level for approximately half an hour, following which creosote oil heated to over 150 F. is pumped in at a pressure of around 180 lb. per square inch. This pressure is held for about one hour, the temperature of the oil being sustained by steam heating coils in the cylinder. A high oil temperature is of great value in securing maximum penetration and reducing the tendency to "bleeding" after the process is completed, and the cylinders are therefore lagged to minimise loss of heat by conduction. The gross absorption of creosote, apart from initial absorption during the filling of the cylinder, is generally not less than 15 lb. per cubic foot. After the cylinder has been drained of creosote, a vacuum is created to remove the surplus oil; this is assisted by the compressed air in the wood cells blowing back, and a nett retention of 7-8 lb. of oil per cubic foot is achieved. The prime object of all these operations is to ensure complete impregnation of all sapwood; borings are taken after the poles have been removed from the cylinder, to confirm that this has been achieved. Finally, the creosoted poles are stacked to await distribution as required.

The creosote oil used in the treatment of Post Office poles must conform to British Standard Specification 144 and samples of oil are taken from each plant once a fortnight during the creosoting season and sent to the Government Chemist for analysis. The Supplies Department collaborates with the Construction Branch of the Engineering Department in a constant endeavour to improve the preservation process and at the same time to supply the Regions with cleaner poles, less liable to "bleed" in service, all the time bearing in mind that costs must be considered at all stages. Many desirable but not strictly essential improvements are ruled out on economic grounds alone. The co-operation of the Forest Products Research Laboratory is frequently sought and readily given



External view of creosoting plant

The outer cylinders (with doors of different types) are treating cylinders. The central tank is for oil storage

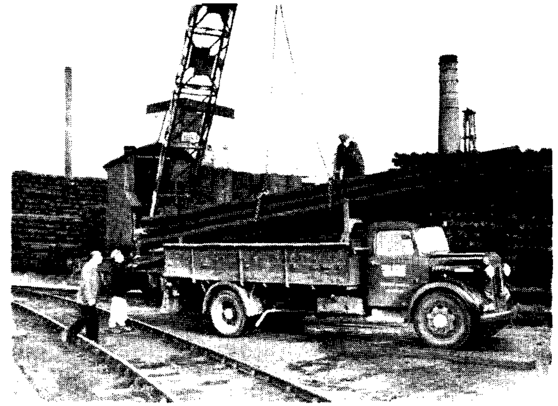
and contact is maintained with other interested organisations, such as the Association of Tar Distillers, the member firms of which supply the Department's contractors with creosote oil.

Although creosote is the standard preservative, various others, mostly of the water-soluble salt types, have been tried by the Department on occasions, and many hundreds of poles treated with such compounds are even now on trial throughout the country. The efficacy of these alternatives cannot adequately be proved until the treated poles have remained in service free from decay for the 30 to 40 years that is expected of creosoted poles. Laboratory tests serve a useful purpose by eliminating definitely unsuitable products, but it is only by extended trial under conditions of every type likely to be encountered in service that the true value of a preservative can be determined.

During World War II, the Post Office was denied access to Scandinavian poles, of course, and had to rely almost entirely on home-grown timber. During the years 1940-1945, nearly 350,000 poles were acquired from home woodlands, which were practically denuded of suitable mature trees. Scots pine not being particularly prolific in this country, alternatives such as larch, Douglas fir, Corsican pine, western red cedar and others were accepted, though all are open to objection, either because of lack of strength or resistance to impregnation, and none is of such consistently good shape as the standard species.

Limited quantities of both sheet-steel and pre-stressed concrete poles were purchased after the recent war to augment supplies of timber poles, but the initial capital cost of these types is greater than that of the wooden kind. Also, maintenance costs and life expectancy are as yet unknown quantities, and they have not proved popular with the engineering staff.

During the immediate pre-war years, some [illegible],000 poles a year were erected, but the current rate of use has not yet returned to that level, though there are at present something like 4,000,000 Post Office poles in use in the United Kingdom and it is remarkable that premature failure due to decay occurs so rarely. Safety considerations apart, timber is an expensive commodity these days and the country could ill afford repeated replacements of large numbers of poles, at ever-increasing costs of raw materials and labour, and we can no doubt be pardoned for what may seem to some to be an inordinate pride in the long life of G.P.O. creosoted wooden telegraph poles.



Poles are usually sent by rail, but they may be collected by local Post Office transport over short distances

The Supplies Department Inspectors who supervise the various processes of pole fabrication and preservation are normally recruited from within the Department. Suitable officers are selected to undergo two years' practical training in the hands of fully qualified Inspectors and to attend a short course at the Forest Products Research Laboratory at Princes Risborough, where they have an opportunity to study at first hand the lives and habits of timber-attacking insects and fungi. A considerable store of technical data and information is accumulated during training, and before being finally passed as competent each man must reach a satisfactory standard in a four-day practical and theoretical examination designed to test his knowledge of timber technology.

Enough could be written about the various aspects of pole supplies and pole preservation to fill a whole volume of this Journal, but sufficient has perhaps been said to reveal something of the inside story of a pole, and—as you may have realised—it's the inside that counts!

Acknowledgment

The photographs illustrating this article were taken at the Southampton depot of Burt, Boulton & Haywood, Ltd., by whose kind permission they are reproduced.

Underground Cables

L. F. Scantlebury

Engineer-in-Chief's Office

THE FIRST UNDERGROUND LINE WAS AN experimental one laid by Mr. (later Sir Francis) Ronalds in his private garden at Hammersmith in 1816. This consisted of a copper wire over 100 feet long, drawn into a conduit of glass tubes completely embedded in pitch, in a wooden trough sunk 4 feet in the ground. The first attempts to develop insulated wires that could be laid underground followed the introduction of the telegraph in 1837. Various insulating materials were tried in these early days, including shellac, resin, bitumen, pitch, spun glass and glass beads, but it was not until the introduction of gutta-percha in 1847 that much success was achieved. The first underground cables to be laid in this country consisted of a number of copper wires, each insulated with several layers of gutta-percha, bunched together in a serving of tarred jute and laid in wood troughing or cast-iron pipes. The original London-Manchester cable laid by the Magnetic Telegraph Company in 1853 consisted of ten copper wires insulated in this way.

Various Experiments

Gutta-percha was expensive, however, and took up a good deal of space, a 3-inch pipe affording space only for some 36 circuits. Investigations into the use of other materials, such as rubber, cotton and paraffin wax, were carried on with varying success. A lead-covered cable containing cotton-covered wires, the cotton being saturated in resin oil, was laid in 1885, in the newly opened Mersey Railway Tunnel, to connect Liverpool telephonically with Birkenhead. Extensive use was also made of the so-called bituminous cable, which was a lead-sheathed cable containing cotton-covered wires permeated with a heavy distillate of petroleum that rendered the cable solid. It gave satisfactory results but was difficult to handle. The use of a lead sheath for enclosing the insulated wires was first suggested in 1845 by Young and McNair, of Paisley, and their invention forms a notable landmark in the development of underground cables, although it was many years before full use was made of it. The particular feature of this sheath was that it was extruded, or pressed out, around the core of the cable as the latter was drawn through a press.

Telephone Cables

With the invention of the telephone in 1876 and the rapid development of the telephone service which followed, it was soon realised that overhead wires would be hopelessly inadequate and that a form of underground cable suited to telephone requirements was urgently needed. Telephone cables at first followed telegraph practice and used gutta-percha insulation. The first telephone cables, laid in Newcastle-on-Tyne because the municipal authorities objected to the unsightly overhead network in that city, consisted of 18 and 36 pairs of gutta-percha insulated wires drawn into 2-inch and 3-inch cast iron pipes.

Apart from the relatively large space occupied by gutta-percha and the other materials used for insulating purposes, the main difficulty in using such cables for telephone purposes was their high electrical capacity, which in the unbalanced condition gives rise to "crosstalk" and renders telephone messages unintelligible. The majority of subscribers' telephone circuits were unbalanced, as they worked single-wire with earth return until about 1890, when the conversion to metallic pairs began.

Conditions were improved by the introduction of the dry-core paper-insulated cable in 1890, in which the insulation of the conductors consisted of a loose wrapping of paper. The paper served to separate the wires, the insulating medium being largely dry air, which gives a lower capacity. Dry paper is an excellent insulant but is very hygroscopic; even in the comparatively dry conditions found in a cable factory, paper exposed to the air will absorb in a few hours up to 10 per cent. of its weight of moisture and under really damp conditions will absorb more than its own weight. The introduction of the paper-core cable was therefore dependent upon the availability of an absolutely water-tight sheath. Broadly, the less paper used in a cable and the more air, the lower the capacity and the cheaper the cable. If there is too little paper, however, the cable flattens badly. The insulation in most present-day cables is about 50 per cent. paper and the remainder air.

A further improvement introduced about 1890 was the use of conductors twisted in pairs or quads, which considerably decreased the "crosstalk" between circuits. The twist ensured that the average separation of each conductor of a circuit from adjacent circuits was approximately equal and that consequently the induced voltage in each of the conductors was sensibly the same, with the result that they balanced out and little or no induced current flowed in the circuit. These two improvements revolutionised underground cable practice and are still the basis of most of the telephone cables in use today.

Thinner Insulation

Since 1900, the main improvements have been a reduction in the gauge of conductors and the use of thinner and narrower insulating papers, so that a greater number of pairs can be accommodated without increasing the overall size of the cable.

It is customary in this country to refer to the gauge of conductors by weight per mile rather than by diameter or by reference to a standard wire gauge. Thus, a 10-lb. conductor weighs 10 lb. per mile; it is 0.025 inches in diameter and corresponds approximately to 23 standard wire gauge.

At the present day, the diameter of a 1,800-pair, 4-lb. conductor cable with a plain lead sheath is about 2.6 inches, which was the diameter of a 160-pair, 40-lb. cable some 30 years ago. Until fairly recently, the smallest conductor used was 6½-lb., but a 4-lb. conductor has since been introduced for use in subscribers' cables down to 50 pairs. Improvement in the subscriber's telephone made possible an increase in the transmission limits specified for subscribers' lines and justified the use of the smaller conductor with its higher resistance. Recent investigations show that an even smaller conductor could be accepted, particularly in congested city areas, and the use of a 2½-lb. conductor is contemplated.

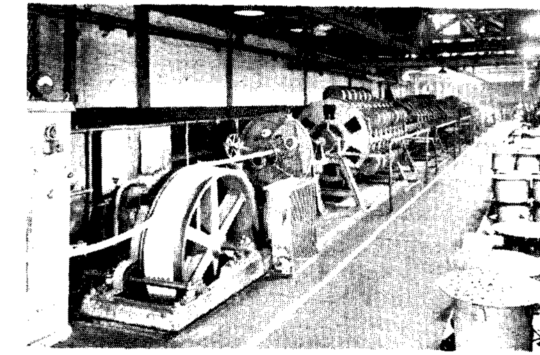
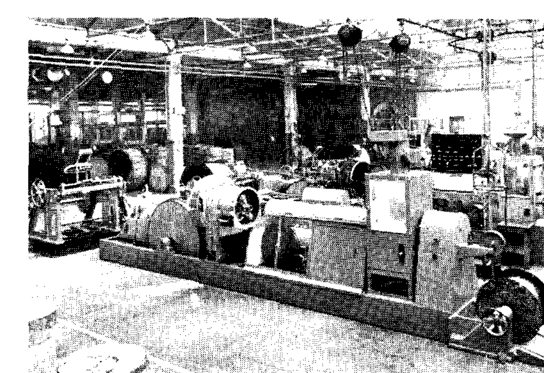


Fig. 1. Concentric layer cable in the making

In subscribers' cables, a circuit is provided for the exclusive use of each subscriber (apart from shared service and party lines) and is in use only when the subscriber is using his telephone. These circuits are short and attenuation (see below) is not a vital factor. The aim, therefore, is to keep the cost of such cables as low as possible, compressing as many pairs as possible into the cable sheath by using small-gauge conductors and thin paper insulation.

The problem is entirely different with trunk cables. Here each circuit in the cable is in use daily for a much longer period and earns considerable revenue, the ideal being to use it continuously.

Fig. 2. Manufacture of coaxial cable



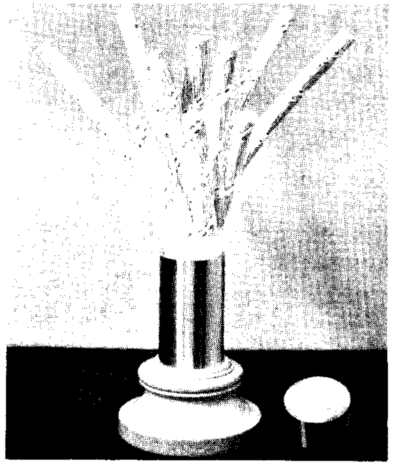


Fig. 3 Sample of 1,000-pair 6½-lb. unit-type subscribers' cable

Attenuation, or loss of speech power as the speech traverses the line, is important and has to be catered for by the insertion of repeaters at appropriate distances apart. The various couplings between circuits due to capacity and magnetic effects have to be kept as low as practicable, to avoid interference or crosstalk between circuits, as repeaters cannot discriminate between speech and interference and amplify both alike.

When trunk circuits were carried on overhead lines, attenuation and crosstalk were not such important factors. A circuit of 200-lb. copper wires would transmit speech satisfactorily over a distance of 300 miles. With a cable, however, the inductance is reduced to about a quarter and the capacity increased some eight times, with the result that when 20-lb. conductors are used the distance over which speech can be transmitted satisfactorily without the use of repeaters is only about 20 miles. Some improvement can be obtained, however, by "loading".

It was first pointed out by Heaviside in 1887 that the distortion of speech along a line could be considerably reduced by the addition of inductance to compensate for the harmful capacity, but it was not until 1899 that a practical method of achieving this was found by the insertion at certain regular intervals of inductance coils, now known as "loading coils". The effect of loading is to reduce distortion and attenuation and to make the latter more or less independent of frequency up to a certain "cut-off", above which frequencies will not be transmitted. The usual loading adopted by the Post Office for cables operated at audio frequencies is coils of 88 millihenries inductance spaced at 2,000 yard intervals, which gives a cut-off frequency of nearly 4,000 c. s.

Local or Exchange Area Cables

These cables are used for connecting subscribers to exchanges or for providing junctions between adjacent exchanges. They are paper-insulated cables in either twin or star-quad formation. With twin formation, two conductors are twisted together to form one telephone circuit, while with star-quad formation four conductors are twisted together round a string centre to form a quad, the diagonally opposite conductors forming a pair, thus giving two telephone circuits per quad. The cables can be made up of consecutive layers of pairs or quads or can be of "unit type" construction with units each consisting of layers of pairs.

With "unit type" construction, the pairs are first stranded into layers and formed into single units of 51 or 102 pairs, and a number of these units are then bunched together to form the cable. For example, a 1,020-pair cable (nominally a 1,000-pair cable) is composed of 10 separate units, each of 102 pairs, bunched together to form the complete cable (Figure 3). For identification purposes, each unit is wrapped with a numbered paper tape. This type of construction offers advantages in jointing, as groups of circuits can be separated. As all the layers in a unit are stranded in the same direction, the cable is more flexible than one made up in the conventional way, with the layers stranded in opposite directions.

Individual wires in either type of cable are identified by coloured lines printed on neutral-coloured paper. The A and B wires of a pair, or the A, B, C and D wires of a quad, are given by the number of lines, as shown in the accompanying illustration (Figure 4). Each layer is provided with a marker and reference pair or quad, which can be separately identified by the colour and number of the lines in a paired cable, and by a helical whipping of coloured cotton over the quads in a star-quad cable. Thus any pair or wire can be readily identified. To keep capacity imbalances small, the amount of ink placed upon the paper for marking purposes must be the same for all wires. Thus, a single-ring marking would be made four times as often as a four-ring marking.

In trunk audio frequency cables, the conversation is carried normally at ordinary speech frequency and the cables are usually loaded. Sometimes a single pair of wires is used for each trunk circuit, but it is more common to use a separate pair for the speech in each direction. The cables are made up in consecutive layers, either in star-quads, as in the case of local cables, or in multiple twin formation, where the conductors are first twisted into pairs and two pairs again twisted together to form a quad. Since these circuits are used over long distances, greater care is taken in manufacture to keep the capacity between wires as uniform as possible and to reduce all forms of unbalance to a minimum. Identification of pairs and wires is the same as in local cables.

The star-quad cable has a little higher pair capacity than the multiple twin cable but can accommodate more circuits in a given space. It is now standard for all trunk cables and the multiple twin formation will be found only in the older cables.

Interference between circuits is usually reduced by careful balancing. Measurements of the capacity unbalances existing within each quad are taken at selected points when trunk cables are being installed and the individual pairs are jointed in such a way that the unbalances in the lengths counteract one another, so that, over several lengths of cable, the capacities are equalised. In special circumstances, for high-grade circuits such as B.B.C. music circuits, where the frequency band used is wider than for ordinary speech circuits, screened pairs are provided to ensure complete immunity from crosstalk. These pairs are placed in the centre of the cable and electrostatically screened throughout their length by means of a closed helical wrapping of aluminium foil or of paper sprayed on one side with aluminium.

Trunk Carrier Frequency Cables

With this type of cable, two pairs of wires—one in each direction—are used to carry a number of conversations simultaneously. Each conversation is transmitted at a separate high frequency.

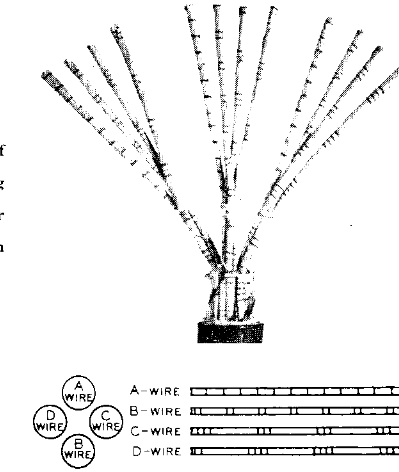


Fig. 4 Marking of insulating paper, for identification of wires

Overhearing between the channels is avoided by allocating frequencies to the channel carriers which do not interfere with each other and by the use of high-grade band-pass filters. In this country it is customary to obtain 12 or 24 telephone channels from one circuit operating at frequencies up to 60 or 108 kc. s. respectively. The cables used are paper-insulated, generally with 24 pairs of 40-lb. conductors and a maximum diameter of 1.15 in. over the lead sheath. The conductors are arranged in star-quad formation and are, of course, unloaded. The cables are specially designed to give uniform impedance and minimum crosstalk between circuits and have a little lower capacity per mile than normal trunk cables. The 24 pairs occupy the same space as 38 pairs in an ordinary quad cable.

Separate cables are provided for the "go" and "return" directions of transmission, in order to reduce crosstalk between opposite-going circuits as much as possible. Crosstalk between circuits trans-

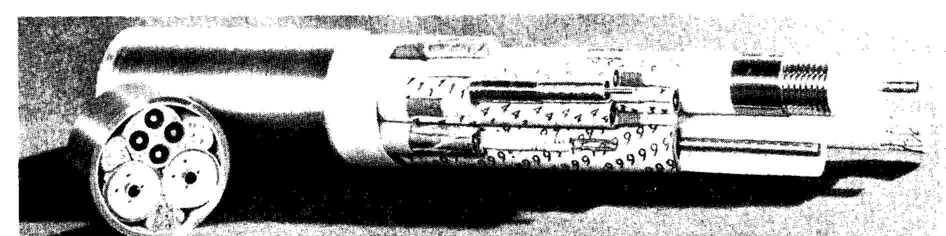


Fig. 5 Section of London-Birmingham television cable laid in 1948

mitting in the same direction (that is, in the same cable) is kept small by attention to the balance within the cable itself and by neutralising it still further with special balancing networks. Because high frequencies are used and the attenuation of these is rapid, repeater stations are required at 22-mile intervals for 12-channel working and 15 miles for 24-channel working.

Coaxial Cables

These cables, which are of an entirely different

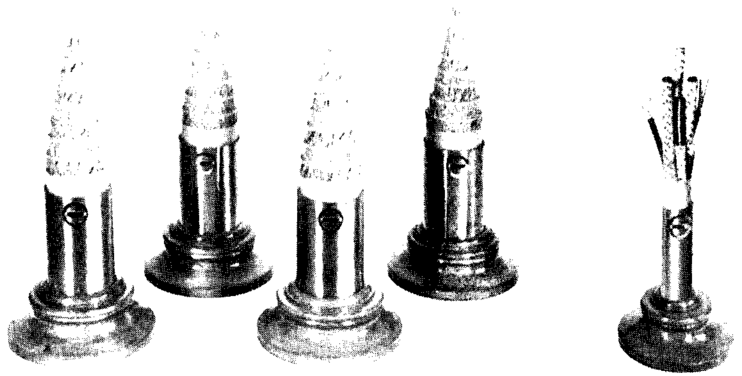


Fig. 6.
AN IMPRESSIVE COMPARISON
The *total* carrying capacity of the four large star-quad audio cables shown in this photograph would be 1,084 four-wire circuits. That of the small coaxial cable alongside, operating at carrier frequencies, would exceed 1,200

type, can be used for transmitting over long distances at radio frequency. They are therefore used for television or for carrying simultaneously a great number of separate conversations. They consist of a central copper conductor enclosed within an outer cylindrical conductor and held concentric with it by discs of polythene spaced at regular intervals. Most coaxial tubes being supplied to the Post Office at present have a central conductor of 0.104 in. diameter and an outer conductor of 0.375 in. internal diameter, formed longitudinally from a single copper tape 0.010 in. thick. To provide added mechanical strength and screening, the complete tube is bound with two mild-steel tapes, each 0.005 in. thick. Two thicknesses of insulating paper are applied over the steel tapes and the outer paper has printed on it at frequent intervals the identification number of the tube.

The cable is normally supplied in composite form, two, four or six tubes being laid up together and the whole made circular by the inclusion in the interstices of paper-insulated quads or pairs, which can be used for audio circuits. An illustration (Figure 5) shows the London-Birmingham television cable laid in 1948. The cable consists of two special television coaxial tubes of 0.975 in. diameter, outer conductors designed for an upper frequency of at least 26 Mc. s., four standard 0.375 in. coaxial tubes and eight screened pairs for the transmission of music. This cable is the first in the world to be specially designed for high-definition television. The 0.975 in. tubes are at present in use for 405-line television service only; beyond Birmingham the service is extended on 0.375 in. tubes to Holme Moss, near Manchester.

The outer conductor of a coaxial cable is a sufficiently effective screen against interference from outside sources or crosstalk between coaxial tubes at frequencies above 60 kc. s., which is the lower limit of frequency used on the tubes. Below 60 kc. s. its efficiency as a screen rapidly falls off and at voice frequencies the unbalanced nature of the circuit makes it unsuitable for telephony. The coaxial tube can be used, however, as a convenient means of transmitting a 50 c. s. power supply, and this method is adopted for the supply of power to intermediate coaxial repeater stations. A selected main repeater station normally feeds two intermediate stations on each side of it, suitable precautions being taken to ensure that the power is removed from the cable before any jointing operations are undertaken. By this means the number of external power sources to a coaxial

oute can be reduced considerably, with a consequent reduction in the possible number of power upply failures due to external causes.

The standard 0.375-in. tube has an attenuation about 8.0 decibels per mile at 4.5 Mc. s. and peater stations are normally spaced at six miles. As an illustration of the circuit capacity of axial tubes, Figure 6 shows four star-quad bles, each containing 542 20-lb. pairs, and, for mparison, a small coaxial cable with four 0.375-. tubes and four small groups of control pairs. he carrying capacity of the four large audio cables ould normally be 1,084 4-wire circuits, while that the coaxial cable operating at carrier frequencies ould exceed 1,200.

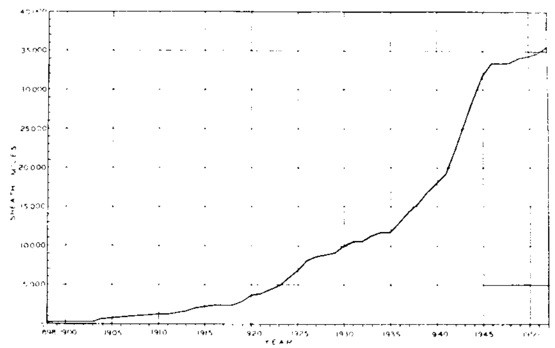


Fig. 7. Growth of main underground trunk network since 1898

xtent and Growth of the Underground Network

The capital value of the main trunk cables in the nited Kingdom, including both duct and cable, around £90,000,000, the corresponding figure r local and junction cables being £120,000,000. he annual maintenance expenditure on all classes cables is of the order of £1,000,000. The owth of the main trunk network of the country nce 1898 is illustrated in the accompanying graph igure 7). At the present time, the network comises some 1,050 cables with a combined length about 35,000 sheath miles.

The trunk cables may be divided broadly into pes: old telegraph cables, multiple twin audio bles, star-quad cables, carrier cables 12 and 24

Type	Old D.C. telegraph	M.T. audio	Star-quad audio	Carrier 24 40-lb. mainly	Coaxial
Period ...	1898–1920	1912–1929	1928 to present date	1935 to present date	1935 to present date
Sheath mileage ...	1,100	4,000	20,900	6,800	2,600

Sheath Mileage at 31st March, 1952, of Different Types of Cables in the Main Trunk Network and Period when installed

hannel, and coaxial cables. The approximate heath mileage of each of them at the present day given in the foregoing table, with the range of ears when each type was installed.

Probably the most important cable route in the ountry is that between London and Birmingham. he history of this route gives a good indication of e growth of the whole trunk network. In all, some seven cables have been laid, although only five now remain. The first cable, the L-BM 1, was laid in 1897-8 and is still in existence. It consists of 38 pairs of 150-lb. conductors, mainly in twin formation but for some miles in quad. It was used in the early days for D.C. telegraphs, but about 15 years ago was reconditioned for telephone use at audio frequencies. The L-BM 2 was laid in 1908-9 and was a composite cable containing a mixture of conductor sizes, mostly 200-lb. and 150-lb., in multiple twin formation. It also was used for D.C. telegraphs but was recovered in 1947 to make way for the L-BM 4 television cable. The L-BM 1 and 2 were laid in iron pipes, but subsequent cables were laid in earthenware ducts. The third cable, the L-BM-Liverpool, was laid in 1914-15 and was again a composite cable of 2 pairs of 300-lb., 14 pairs of 200-lb., 12 pairs of 150-lb. and 24 pairs of 100-lb. conductors, all in multiple twin formation. This was recovered in 1930 to make way for a replacing L-BM-Liverpool cable comprising four screened 40-lb. pairs and 352 pairs

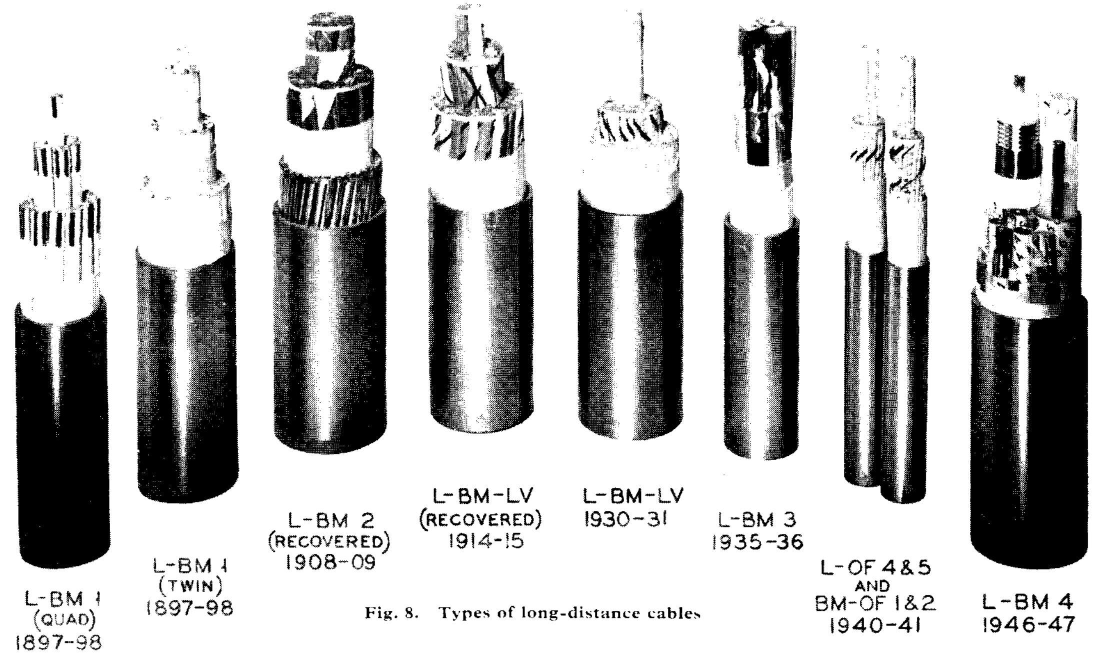


Fig. 8. Types of long-distance cables

in star-quad form of 25-lb. conductors. Both of these were audio cables. The L-BM 3, laid in 1935-36, was the first coaxial cable to be provided in this country. It contains four coaxial tubes each 0.450-in. internal diameter of outer conductor, with four 40-lb. screened and twelve 25-lb. pairs. The next cables, laid in 1940-41, were two 24-pair carrier cables via Oxford and finally in 1946-47 the television cable previously referred to was laid. Short sample ends of each of these cables are shown in Figure 8.

Cable Sheaths

The life of any paper-core telephone cable is dependent primarily on the ability of its sheath to form an effective barrier against water. To be satisfactory, a cable sheath must meet several requirements. For instance, it must have sufficient flexibility and strength to allow the cable to be placed on or removed from a drum of reasonable diameter several times without injury. Abrasion during drawing into a duct is reduced to some extent by lubrication, but the sheath must be able to withstand the rather severe bending and twisting necessary in running round manholes and cable chambers and in setting up for jointing. When it is installed, vibration and temperature changes tend to cause fatigue and creepage.

The sheath must also be as resistant as possible to corrosion, which tends to occur when direct (as opposed to alternating) currents leave the sheath or when the soil or water in contact with the sheath is chemically active to it.

A further requirement of the sheath is as a shield against electric and magnetic fields, to reduce inductive interference from power lines. Under certain conditions, a power line, when operating normally, can introduce noise into adjacent telephone circuits and this may upset signalling and seriously degrade speech. A fault on a power line will also cause abnormally high currents to flow, which can induce very high voltages in nearby telephone cables. Precautions must be taken against these, to safeguard the staff working on the circuits, as well as the equipment. A metal sheath considerably reduces these deleterious effects, provided the resistance of the sheath itself and its resistance to earth are low.

Lead

Since the introduction of the paper-core cable, lead has been the standard material for cable

heathing. It is easily extruded and readily lends itself to soldering, so that maintaining the continuity of the sheath at joints by means of lead leeves offers no difficulty. Pure lead is improved in resistance to fatigue by the addition of a small quantity of antimony and it is usual to employ a d alloy of about 99.9 per cent. lead and 0.1 per nt. antimony. Where there is vibration, the timony content is increased to about 1 per cent. ese sheaths give sufficient mechanical protecn for installation in most underground ducts and ovide an effective water barrier and sufficient ielding against external inductive disturbances. hey are susceptible to corrosion in damp enronments, however, particularly if stray electric irrents or corrosive soil conditions exist. It is ecessary, in certain areas, therefore, to protect the ad sheath by applying a covering, usually nsisting of two layers of hessian tape and two vers of paper, thoroughly impregnated with tumen compound.

To facilitate the installation of protected cable ducts, a graphite finish is given, to act as a bricant during drawing-in. With stray or selfnerated direct currents, corrosion occurs mainly here the current leaves the cable, and although ich currents are in practice often small, of the der of 10-20 milliamps, they flow continuously. he problem is better appreciated when it is alised that a current of 10 milliamps flowing from cable for a year will remove ¼ lb. of lead, a loss hich may not be uniformly distributed, but stricted to the small area where the current is ving the sheath.

nsulating Gaps

The condition leading to corrosion can somenes be corrected by the judicious insertion of sulating gaps in the lead sheath. A further method preventing such damage, which has been used rgely on the Continent in recent years and which being tried experimentally in this country, is the se of cathodic protection. The aim is to make the ble sheath slightly negative to earth over its ntire length, so as to prevent currents from leaving

This can be readily done in two ways, either by nnecting the cable sheath with a wire lead to an got of magnesium buried in the soil a few feet vay, or by directly applying a voltage between e cable sheath and earth by means of a suitable ctifier connected to A.C. mains. Magnesium and ad connected together constitute a simple cell, e soil forming the electrolyte, and current will flow from the magnesium through the soil to the lead sheath and back through the wire connection. In this way it is the magnesium that gradually corrodes away and the lead sheath is preserved.

Polythene

Since the war, the high price of lead and the possibility of a scarcity have indicated the importance of investigating the suitability of other materials for sheathing cables. Considerable developments were made during the war years in plastics and this is a promising field. All plastics, however, permit the passage of water vapour to some degree, but in this respect polythene seems the most suitable choice, as its rate of diffusion of water vapour is lower than that of other available plastics. Polythene is a polymer of ethylene, in which molecules of ethylene are linked together to form long chains, and is a tough, white, translucent material, which can be readily extruded at a temperature of about 140 C. It is flexible and resistant to most chemicals. It will deteriorate, however, if exposed to sunlight and to overcome this it is customary to add a small amount of carbon black.

Up till now, polythene has not been used alone for sheathing paper-core cables, as a metallic sheath has been considered necessary as a water barrier. Several trunk cables, however, have been laid in this country with an outer sheath of polythene over an inner sheath of thin lead, which has given a saving of lead of some 25 per cent. over that which would have been required had the cable been sheathed with lead of normal thickness, but the cable is slightly larger—a disadvantage where duct space is limited.

An all-polythene cable has been developed for the smaller sizes of subscribers'distribution cables from 1 pair to 50 pairs. In this cable, polythene is used for the insulation of the individual wires as well as for the sheath. It is rather larger than the corresponding lead-sheath paper-insulated cable and has a little higher capacity, but as it is intended for use mainly between pillars and distribution poles and for direct underground distribution to subscribers, these disadvantages can be tolerated. It is rather cheaper than the equivalent lead-covered paper cable and has the advantage of being flexible.

(*Photographs by courtesy of Standard Telephones and Cables, Ltd.*)

Training Traffic Staff at the Headquarters School

S. J. Marsh, Principal of the School

THE DUTIES OF THE TRAFFIC STAFF COVER A wide range of subjects, calling for some acquaintance with almost every aspect of the telephone service. They require an understanding of the general principles of the technical side and an expert knowledge of operational matters and of the processes by which exchange staffing, equipment, trunks and junctions are related to the needs of the traffic. They call for a flair for staff relations, some skill in management and the ability to write succinct letters and reports.

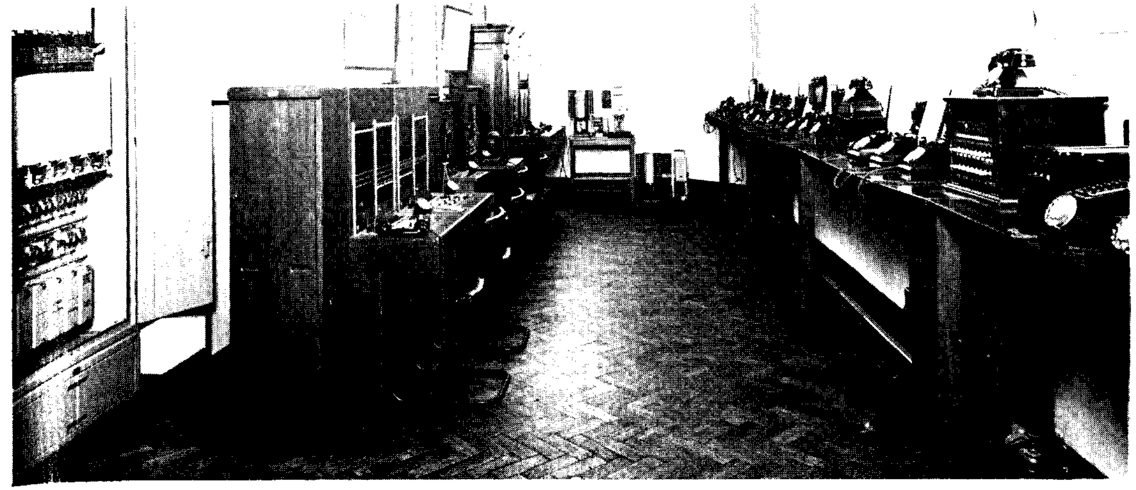
Assistant Traffic Superintendents are recruited from many branches of the Post Office by selection or limited competition, but their previous experience rarely touches on more than a small part of their new duties, while a number are recruited from outside the Post Office by open competition. It has therefore been recognised since the earliest days of the traffic staff that a recruit to this staff must be given a very thorough training if there is not to be a long period of partial ineffectiveness while he learns his job the hard way.

When taking over the telephone service in 1911, the Post Office followed the practice of the National Telephone Company in allotting a period of twelve months for training "exchange managers", who were the predecessors of the present traffic staff. After the first World War, there was a period when the need for traffic staff in the rapidly expanding service was so pressing that training went by the board for a time, but in 1925 a reserve of training posts for Assistant Traffic Superintendents was set up, the posts and training responsibility being shared between 14 Telephone District Offices. The full training period was about nine months. A quotation from the Headquarters papers on the proposed training course reads rather surprisingly today: "The training seems to cover all essential features except automatic working. It seems desirable that some mention should be made of this phase of the service".

The original training course was given entirely in the field, but it included three features that still have their counterparts in the present system. The training began with instruction in switchboard operating; it included a period at the Engineer-in-Chief's automatic school and a Traffic Superintendent was nominated in each training district to be responsible for oversight of the student's progress, but the system suffered from the disadvantage common to "training on the job", that it was apt to become a minor responsibility of those giving the instruction. Partly as a result of the second report of the Westbury Committee, which reviewed the Telecommunications Traffic organisation, and partly in the light of some centralised traffic training schemes evolved in Regions, the need for a national Traffic Training School was considered in 1940. Detailed plans were made during the war and the Headquarters Traffic Training School opened in 1945. It was housed in the Avenue Exchange building in Great Tower Street, London, and formed part of the Inland Telecommunications Department. Its first job was to provide rehabilitation courses for over 200 demobilised traffic men.

Facilities at the School

The accommodation consists of lecture rooms, offices, a common room (equipped for use as a lecture room if required) and a demonstration room. The demonstration room is a source of some pride to the School staff and is of great value for practical illustration of the working of the apparatus described in the lectures. A general view is shown in the photograph. On the left are the private manual branch exchange installations, C.B.9, 25-line, 65-line and 1A boards, on the right are examples of most of the common plan-number extensions, a cordless switchboard and a house exchange system, and at the far end is some portable equipment for use in the lecture rooms.

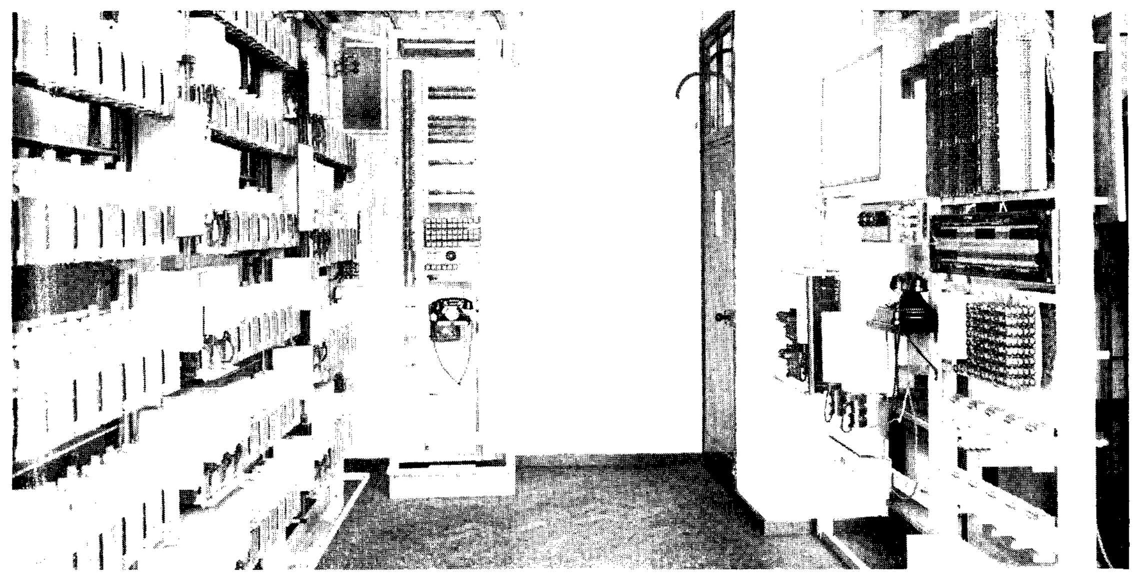


General view of demonstration room

Th[e] plan-number installations work as extensions fr[om] the P.M.B.X. boards, which have exchange lin[es] to the non-director exchange equipment re[ferr]ed to below. Battery, tone feeds and ringing cu[rre]nt are supplied from the public exchange in th[e b]uilding.

[T]he non-director equipment, part of which can be seen in the other photograph, presents the unusual spectacle of a uniselector, first selector, second selector and final selector rack all in one straight line; this arrangement, though unconventional, has great assets in presenting the elements of trunking and inter-switch connection to the tyro; it avoids the confusion inevitably resulting

Part of the training equipment



from the sheer mass of equipment in a sizeable working exchange. Connection between racks is made by way of a small trunk distribution frame located near the final selector rack. With the aid of simple grading diagrams in frames on the racks, grading arrangements—that bugbear of the newcomer to telephony—can readily be explained. An exchange line, with associated uniselector, an 'A' digit hunter, 'A' digit selector, first code switch and director, is fitted on a rack to be seen on the right in the picture; on dialling a suitable four-digit number on TOWer exchange (the School is a stone's throw from the Tower of London), the call is routed via translation '7' to a first selector on the non-director rack and thence to a working line on the non-director exchange. Multi-digit translations are also wired for demonstration purposes.

Students are encouraged to spend any spare time they may have in the demonstration room, apart from formal instructional sessions. The interchange of ideas between students is of much value, particularly when a class includes people with previous telephone engineering experience, whose knowledge is thus made available to their colleagues.

A recent addition to the equipment is a P.A.B.X. No. 1. (The automatic equipment is shown on the extreme left of the general view of the demonstration room.) This is a working installation serving the School's communication needs, while also demonstrating the facilities available to telephone renters.

A unique possession of the School is the scale model telephone exchange described in the *Post Office Telecommunications Journal* of August, 1950. This is admirably suitable for supplementing the detail of the demonstration equipment with a bird's-eye view of the layout of a modern automanual telephone exchange.

The lecture rooms are designed to cater for a standard class of twelve. This number is found to be a happy choice for the type of training given in the School: it is large enough to give a resonable variety of approach to subjects under discussion, while being sufficiently small to allow each member's individual difficulties to be appreciated. Although it is the aim to form classes from students with similar prior experience, this is difficult to achieve in practice. Classes may therefore include both Open Competition candidates and people with previous Post Office experience, and a large proportion of them contain one or more women. The variety of approach required from the instructional staff is stimulating and helps to maintain the enthusiasm so vital to effective tuition, particularly of adults.

Layout of Courses

Initial training for A.T.S.s occupies some 27 weeks; about half of this period is spent at the School, the remainder occupying three weeks at an operator training centre, early in the course, and visits to a training area in three spells dispersed through the remainder of the training time. The training is based mainly on the four principal branches of traffic work, namely the traffic design of exchanges, trunk and junction planning, regulation of exchange staffing and control of the quality of the service. All these subjects are covered in a general way in the early stages of the course at the Headquarters School and are then dealt with in more detail in the second part of the course at the School, after the trainees have spent some time in their training area. Towards the end of the School tuition, a series of visiting speakers give talks on subjects allied to traffic work, including the work of the Clerical and Sales Divisions of Telephone Managers' Offices, engineering testing and faulting and the organisation of the Post Office Engineering Department.

Methods of Instruction

The instructional methods used in the School range from lectures to mutual discussion, according to the nature of the subjects covered. An informal atmosphere is always the aim and students are encouraged to interrupt with questions on any point that they have not understood. Liberal use is made of visual aids, including charts, slides, film strips and a 16 mm. sound film projector. The classrooms are filled with modern roller-type blackboards. The preparation of personal notes is encouraged, but duplicated material and diagrams are freely distributed, including specimen exchange staffing and equipment design cases.

Among Assistant Traffic Superintendents' duties is the handling by telephone of complaints from subscribers. This is one of those jobs in which an ounce of practice is worth a ton of theory, so a practical exercise follows a short talk on the principles to be followed when dealing with such complaints. Each student in turn leaves the lecture room and is seated in an adjacent room. He receives there a telephone call from the instructor in the classroom, who acts as a complainant. The

student deals with the complaint as effectively as he can and the conversation is recorded. On return to the class he is asked whether he has any "second thoughts" and the recording is then transmitted via a loudspeaker to the assembled class. Discussion follows on the merits and failings of the student's handling of the complaint and of the course of action he proposes. This method of tuition has proved consistently successful and meets with the whole-hearted approval of the A.T.S.s in training. It should go a long way towards lessening the strain on the newly-appointed officer when he has to deal with his first genuine complaint.

Written tests are set at intervals during the School training; the students' papers are annotated by the lecturing staff and, when desirable, a session is devoted to collective instruction in the correct approach to the problems. As a variant, a form of oral test is used, which is found a useful expedient for revision of earlier work. Each student in turn is presented with a question relating to work previously covered in instructional sessions and is invited to present his answer orally to the class, taking on the temporary status of instructor for the purpose. He is invited to draw upon the knowledge of his class (and, if unavoidable, of the School staff). In the process of elucidating the required answers, a large amount of revision is made in a manner which impresses it upon the minds of both the temporary lecturers and of their fellow students. With this type of test and with the verbal complaint training, the maintenance of an informal atmosphere helps materially to lessen the strain on self-conscious trainees.

Traffic Officer Training

In October, 1950, the responsibilities of the Headquarters Traffic Training School were extended to include the training of recruits to the basic traffic grade, Traffic Officers. Initial training follows in style that for A.T.S.s but is, of course, shorter and not so wide in scope. The classes have been housed in three classrooms in Ibex House in the Minories—just by the Tower of London—and students have used the demonstration room and recording facilities at the main School. The accommodation at the main School is now being extended to take over Traffic Officer training.

Traffic Training in Telephone Areas

Since a large part of the training takes place in Area offices, close co-ordination of the students' activities in the School and in the Areas is essential. To this end, a Traffic Superintendent in each of the training Areas is nominated to take responsibility for traffic training. He is advised of the detailed programme of School training of each of his charges and arranges the curriculum in the Area to correspond with the student's needs. Periodical conferences are held between the School staff and the Area Traffic Training Officers to ensure that the School and Area programmes are well dovetailed together and to give the Area men an opportunity to exchange ideas and experience regarding traffic training.

The training Area has the responsibility of reporting at the end of the training period whether or not the student is adjudged suitable for confirmation of appointment; the School staff do, of course, give their opinions if invited, but it is considered that since the new recruit will usually take up duty as part of an Area Traffic Division staff, an opinion about his aptitude for the job comes better from an area than from the Training School—performance in a classroom is not always a measure of ability on the job.

Specialist and other Training Courses

The School has an important role in providing specialist training on specific aspects of the work for more senior traffic personnel and though initial training is the major continuing commitment, series of courses on Lines work and Equipment Design have been conducted and further courses of similar character are in prospect. Among other types of instruction provided may be mentioned talks to Sales staff on traffic aspects of their work, courses for Army Signals Officers and for selected Accountant-General's Department staff, and "junior traffic" courses for officers-in-charge of the larger telephone exchanges. Visits are paid to the Engineering Department Central Training School at Stone, to talk to engineers about working relationships between traffic and engineering staffs in the Areas.

No doubt the present centralised training scheme for traffic staff falls short of the ideal in many respects. For instance, it would be most desirable to have residential facilities, so that full advantage could be taken of the interchange of ideas between students in their off-duty periods. Nevertheless, the present scheme is a great improvement on prewar arrangements and at least the foundations of adequate training of traffic staff have been well and truly laid.

Choosing a Site for a Telephone Exchange

R. A. Giles

Telecommunications Branch, South-Western Region

PRACTICALLY THE ONLY FEATURE OF A building that cannot be altered is its location. It is not surprising, therefore, that quite a lot of thought goes into the choice of site. If you were going to build a house, for example, you would consider whether a particular site was in a suitable district, whether there were shopping facilities reasonably near at hand and whether it was on or near a bus route. Should you want to set up a business, you would have to consider other factors, such as the existence of a good market for your wares and the degree of competition to be expected. Few establishments can rival a telephone exchange in the exacting nature of its site requirements. Here is an outline of the problems involved and how the Post Office tackles them.

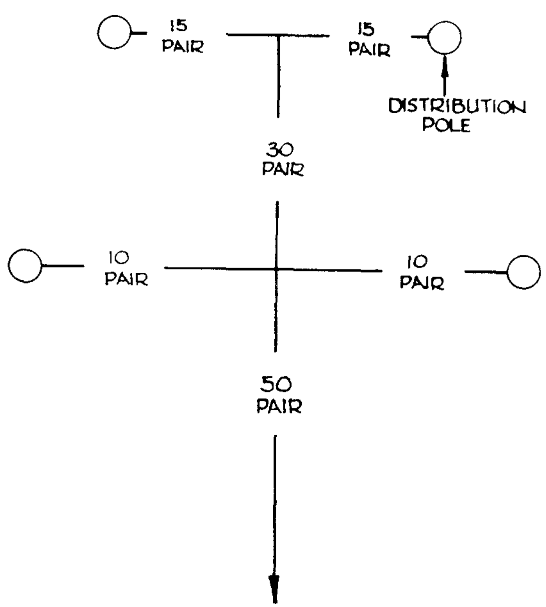
The method of defining the area to be served by one telephone exchange is beyond the scope of this article, but it is relevant to say that the numbers of subscribers' lines connected to various exchanges vary from a dozen or so to upwards of 10,000. In spite of this wide variation in the size of exchanges, however, the basic requirements remain the same.

To appreciate the difficulty of getting a telephone exchange in the right place, it is necessary to have some idea of how subscribers' lines are connected to it. There must be an individual pair of wires from each telephone (or pair of telephones sharing service) to the exchange, and these are carried in multiple-pair cables which get progressively larger as they approach the exchange (Figure 1). Cables are among the most expensive items of telephone equipment and it is of prime importance, therefore, to adopt the most economical layout. It is possible to calculate mathematically a theoretical point from which all subscribers in the area could be served with the minimum amount of cable. Take two simple examples (Figure 2):—

Example 1.—Let us suppose that all the subscribers to be served are disposed at equal intervals round a circle. It requires no mathematical analysis to show that the ideal site for the exchange is at the centre of the circle.

Example 2.—Now suppose there are two systems as in Example 1, of similar size and adjacent to one another. It is fairly obvious that the ideal site would be at the mid-point of the line joining the centres of the circles.

Fig. 1. Local distribution cabling



In practice, an infinite number of variations of these examples occur and each exchange area is considered individually.

So far, we have considered the problem as though we were going to install a completely new system and lay our cables in ideal positions. However, the ideal site (or "theoretical centre", as it is called) may not be practical. For example, it might be in an impossible place—the middle of a lake, perhaps. Also, nowadays, when we want a new exchange, most of the cables are already laid. Further, the practical considerations of laying new cables must be taken into account. The necessary adjustments will give us a "practical centre", where we should, if possible, build our exchange.

Unfortunately, the chances of being able to find an available site right on the practical centre are rather remote, except perhaps in a scattered, rural district, and the next step is to decide how far from it we can build effectively. In other words, we define an "area of search". If we place our exchange anywhere but on the practical centre we incur "out-of-centre" line-plant costs and, obviously, the further we go from the practical centre the higher these costs will be. The rate at which the costs increase with distance is not the same in all directions, however. Geographical features and the distribution of potential subscribers throughout the area affect the issue. Again, we have to consider existing cables. We are denied, therefore, such simple definitions as, for example, "within [illegible]00 yards of the practical centre". Acceptable "out-of-centre" line-plant costs for the exchange are calculated according to the size of the exchange and a map is marked to show the area in which the exchange should be built to ensure that these costs are not exceeded. A typical "Area of Search" map is illustrated in Figure 3.

So far, we have considered only the location aspect of a telephone exchange site. The most obvious of the other qualifying factors is that it should be large enough. The telephone needs of areas where it is expected that not more than 800 lines will be required within fifteen years are met by the provision of unit automatic exchanges. These are housed in standard buildings, for each type of which there is a standard size of site.

For example, if the expected 15-year development were 750 lines, a U.A.X. No. 14 would be appropriate; this would probably be accommodated in an F type standard building, which would need a site 75 ft. × 120 ft. behind the building line (Figure 4). For larger exchanges, the accommodation required at the 20-year date is worked out in detail and from this information the Ministry of Works Architect determines the size of site that will be needed. Present policy with regard to the size of sites is, broadly, to acquire one large enough (*a*) to accommodate a proposed U.A.X. plus a replacing U.A.X. of the next larger size, or (*b*) for individually designed exchanges, to provide for an *initial* building that will suffice for 20 years, with site space for 100-150 per cent. extension.

The location and size of the site having been decided, the search for a suitable plot of land begins. The Ministry of Works undertakes this job, as agent for the Post Office, frequently enlisting the aid of local authorities, who are themselves interested from the point of view of town and country planning.

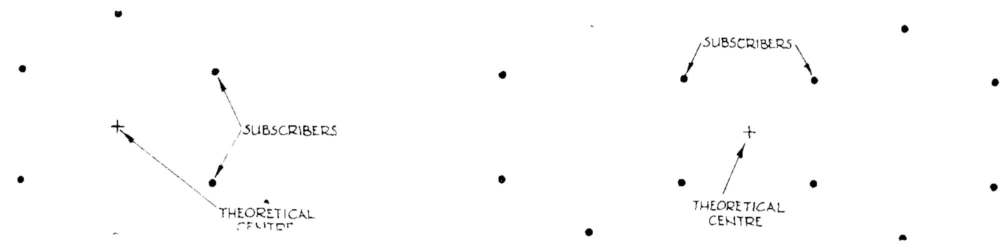


Fig. 2. Simple examples, showing the theoretically ideal site for an exchange

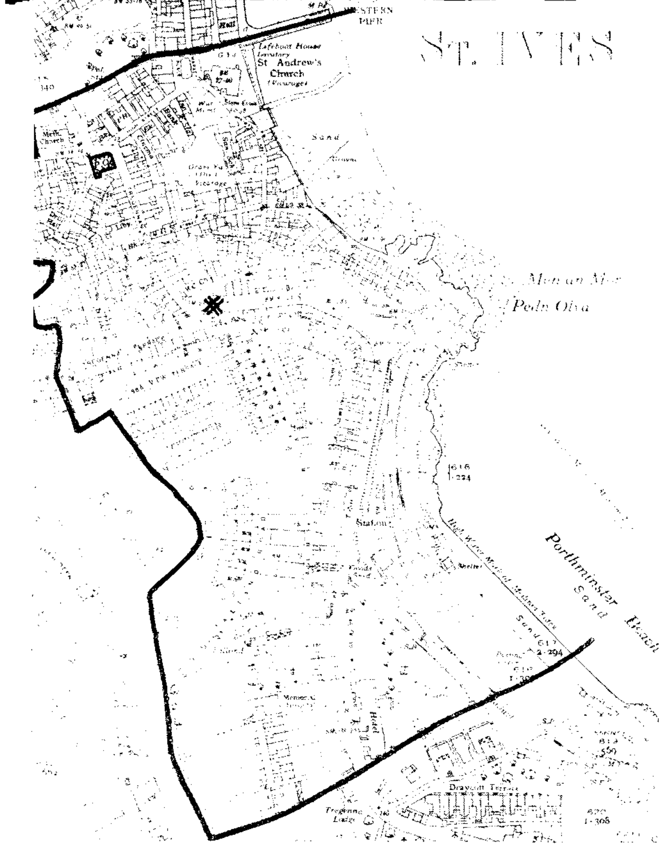


Fig. 3. A typical area of search

In many cases, more than one site which satisfies the primary qualifications of location and size come to notice, and the comparative merits of each are then assessed. The factors considered at this stage include the following:

(*a*) Can the cables be led on to the site conveniently?

(*b*) Is there suitable access for vehicles and staff?

Fig. 4 U.A.X. 14 in F type building

(*c*) Is the price reasonable and can the site be developed architecturally at reasonable cost?
(*d*) Is there any risk of flooding?
(*e*) Are there industrial undertakings nearby that might give rise to pollution of the atmosphere or excessive humidity? (These effects are injurious to telephone exchange equipment.)
(*f*) Are main electricity, gas, water and sewage services available?
(*g*) Are security considerations, if any, satisfied?
(*h*) If operating staff will be employed, is the neighbourhood suitable and are reasonable transport facilities available?

If, as sometimes happens in built-up areas, an exhaustive search fails to reveal any suitable sites within the area of search, an extended "Area of Search" map is prepared on a similar basis to the original, but allowing for higher "out-of-centre" line-plant costs. In extremely difficult places, this process may have to be repeated.

When a site is decided upon as that which best meets the many conditions we have discussed, as well as any others that may arise in specific cases, the concurrence of the local authority's Planning Officer is needed. Assuming this is obtained, negotiations with the owner of the land may begin.

The difficulties that can arise from this stage to the final settlement of the purchase would fill a book, but they have no place in this article. Sufficient has perhaps been said, however, to make one wonder how the Post Office manages to obtain any suitable sites at all! In finding a telephone exchange site, the percentage of the work that proves to be abortive is high and the disappointments are many, so the next time you see or hear of a new exchange being opened, spare a thought for the Post Office and Ministry of Works staff who were "in on the ground floor", and to whom so much credit is due.

L.T.R.'s Last Magneto Exchange

On the 6th October, Southfleet, the last magneto telephone exchange in the London Telecommunications Region, was converted to automatic working. Serving less than 200 subscribers in a rural area near Gravesend, Southfleet is now an unattended automatic exchange.

Maintaining 56,000 Miles of Submarine Cable

Design and Work of C. S. *Stanley Angwin*

J. A. Smale, B.Sc., M.I.E.E.

Engineer-in-Chief, Cable and Wireless, Ltd.

CABLE AND WIRELESS, LTD., OWNS SOME 155,000 miles of cable spanning the North and South Atlantic, the Mediterranean and th. Indian and Pacific Oceans.

.o maintain these cables, the Company owns a.. operates a fleet of eight cable ships, based at s...egic points throughout the world, so that there w.. be the minimum delay in restoring an i..rupted cable. Two of the fleet are Admiralty c..e ships bought and converted after the war to r...ace losses during the decade 1935-45. Cable s.. *Edward Wilshaw*, built in 1948, was the latest a..ition until C.S. *Stanley Angwin*, her sister ship, w.. launched on February 11th, 1952.

.he launching was at Newcastle and was perf..med by Lady Angwin, who named the vessel a..r her husband, Sir Stanley, Chairman of the C..mmonwealth Telecommunications Board, f..merly Chairman of Cable and Wireless, Ltd., a.. previously Engineer-in-Chief of the General P..t Office from 1939 to 1946.

.his vessel is the twenty-second cable-ship to b. built by Swan, Hunter and Wigham Richardson, L.d., at their Neptune Yard. Her principal dimens..ns are:—

Length overall	...	315 feet
Beam ...	...	41 feet
Load draught	...	19 feet
Gross tonnage	...	2,530 tons
Range ...	...	10,000 miles
Service speed	...	10¾ knots.

A clipper stem carries three "V" shaped cable-s.eaves and the anchors are housed in pockets to a.oid obstruction when paying out the cable.

Two independent cable gears, which work at f.ll boiler pressure, are fitted abreast on the main d.ck forward. The windlass engine is fitted in a s.parate compartment on the main deck, having cable lifters on the upper deck worked by vertical s.afting from the engine below. A capstan head is f.ted on the centre line on the upper deck forward and a warping capstan port and starboard at the after end.

Electric power is supplied by two steam-driven generators and one Diesel-driven set, each having an output of 40 kW. at 220 volts D.C.

The main propelling machinery, which is aft, consists of two triple-expansion engines designed to develop 1,450 i.h.p. collectively at about 104 r.p.m. on trial. Steam is supplied by two oil-fired Scotch marine boilers generating saturated steam at 220 lb. per sq. in. under forced-draught conditions.

She is provided with three cable tanks capable of storing some 400 miles of deep-sea cable. Her complement of officers and crew is 114.

Accommodation is provided on the bridge deck for the Captain and senior officers, while cabins for the ship's officers and engineers are on the upper deck.

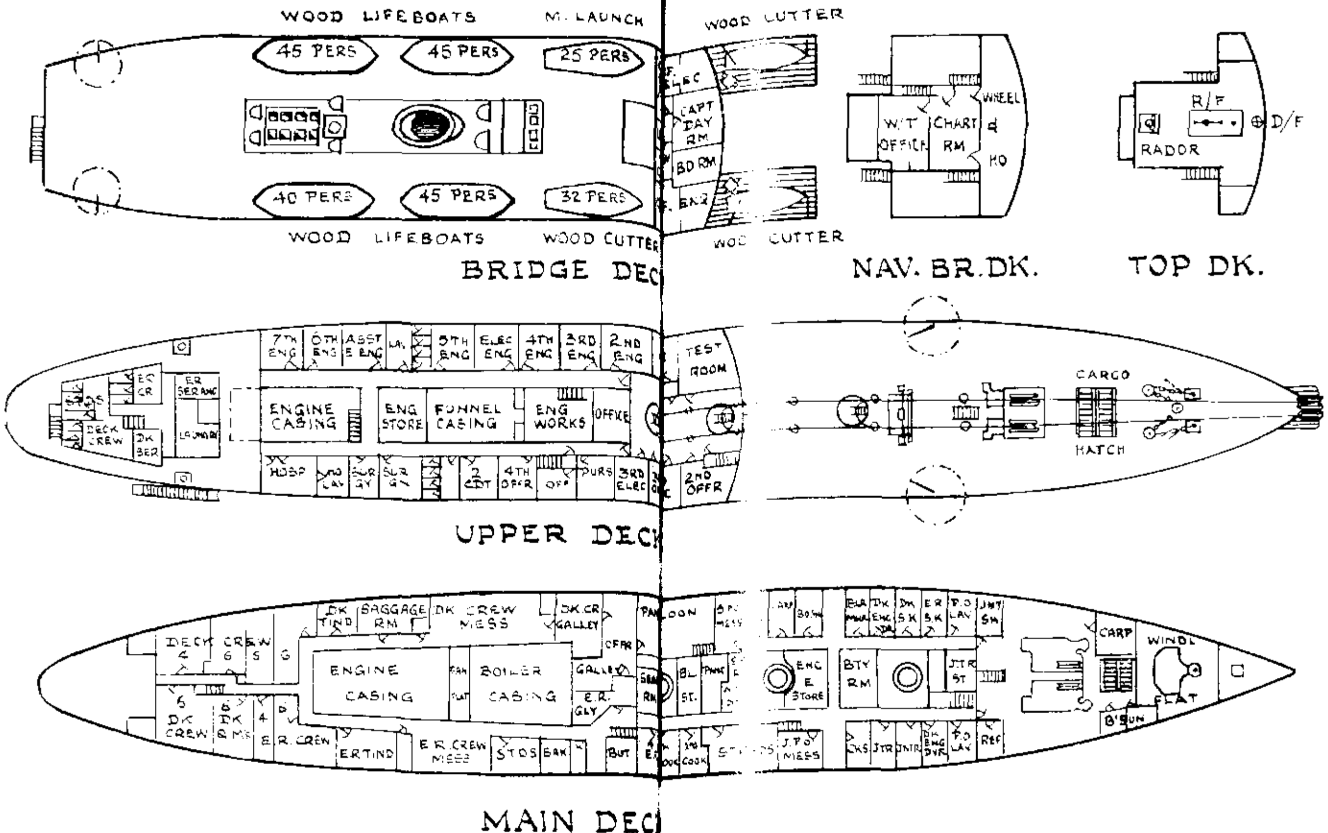
A dining saloon and separate lounge and an engineers' duty mess are provided. The Petty Officers and crew, with their respective messes, are berthed on the main deck and upper deck aft. Hot water showers are available to officers and crew.

Forced ventilation, steam heated when necessary, is arranged throughout all accommodation.

Among the amenities for the officers and crew is a sound reproducing system comprising a broadcast receiver and a gramophone unit with five loudspeakers, with an aerial-splitter equipment, which enables individual private wireless receivers on board to share one common aerial system.

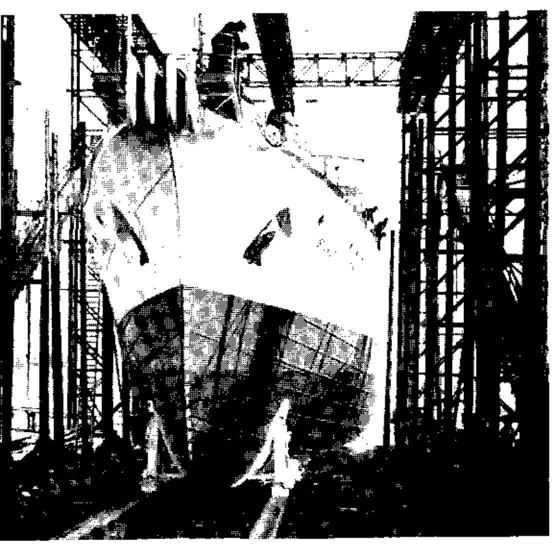
A spacious testing-room is provided with all the necessary electrical apparatus for testing cables. High-precision instruments are provided for locating faults and breaks in cables and for indicating whether the insulation of the cables is up to standard. Telegraphic sending and receiving instruments are also provided, so that communication can be carried on between ship and shore through

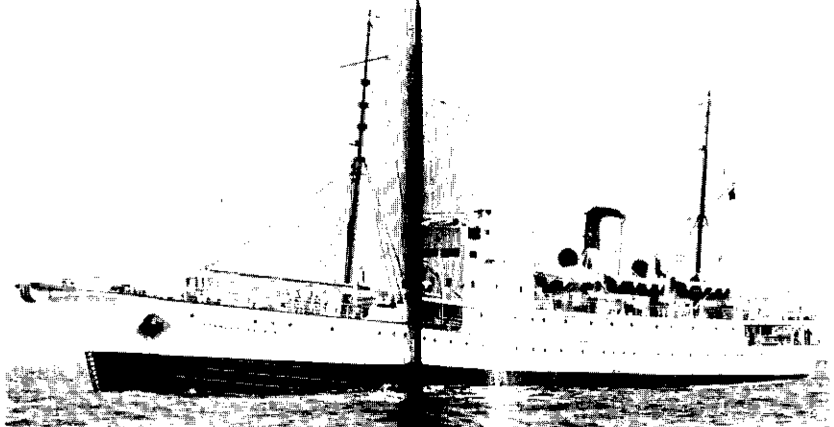
ong Jeng in the officers' galley



Chief Engineer D. E. McGuinness in the engine-room

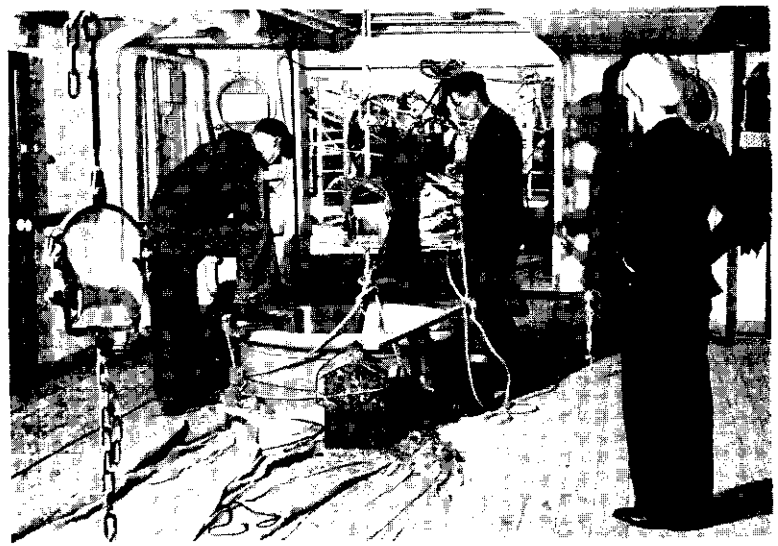
ps: showing the bow sheaves





CABLE SHIP nley Ingwin

Cable passing below into tank



Coiling down

a cable under repair, when the end of the cable is on board. All these instruments are very delicate and it is essential that they should be kept dry and as free as possible from vibration. Precautions have been taken to ensure these conditions as far as practicable in the Testing Room.

Ample cupboard and filing space is also provided in the Testing Room, to accommodate the necessary records of the cables to be repaired in the area covered by this vessel. Some 50 cables are involved, varying in length from a few miles to over 3,500 miles, with a total mileage of over 56,000.

Full details are kept, not only of the original laying of each cable, but of every repair undertaken. These records give mechanical and electrical details of every length of cable laid and a comprehensive report of every repair carried out. A simplified arrangement of filing has been provided, so that these records are readily available for reference purposes and for correction following every repair.

Some 250 cable-charts are supplied, showing the position of every cable and each repair that has been carried out.

The latest navigational aids are supplied, including gyro-compass, Chernikeeff distance and speed log, radar, deep-sea and shallow-water echo-sounding apparatus and a comprehensive radio installation.

Stanley Angwin, after loading cable in London, will leave this country for the Far East, where she will replace the Company's old C.S. *Recorder*, which, after fifty years of service, has now returned to this country and has been sold for breaking up.

The new vessel will be stationed at Singapore, where she will be responsible for maintaining the vital Australian cable routes both across the Pacific and via Singapore and Cocos. Her area of operations will cover from the East Coast of Africa to Singapore, Australia and across the Pacific to Vancouver and in the China sea to Hong Kong and Manila.

Only a vessel with an extensive steaming range such as *Stanley Angwin* can undertake these long passages without refuelling.

In addition to ordinary cable repairs, *Stanley Angwin* will assist in the Company's programme of renewals and the modernisation of some of the older cables. For this programme, a total of some 1,500 miles of cable are required annually for ordinary repairs and a further 1,500 miles for renewals. The majority of cable required for this purpose is manufactured in London and supplies are periodically freighted from London to the Company's various cable depots throughout the world. At Singapore, however, the Company owns a small cable-factory, now being rebuilt and modernised. It is hoped that this new factory will be in full production by the end of 1952, when *Stanley Angwin* will receive all her necessary supplies of cable from that source.

She has started cable work early in her career, for, on passage out to Singapore, she has carried out repairs in the Red Sea. A heavy programme of operations is ahead, with the prospect of visiting many strange lands and little-frequented waters. She will continue, as her many predecessors, to maintain the highest degree of efficiency, which has been the Company's motto for so many generations.

(Deck plan by courtesy of the Editor of "Zodiac")

From left to right: H. H. SADLER, Chief Clerk; T. S. SKEET, Area Engineer (Maintenance and Installation); B. KNOWLDEN, O.B.E., Telephone Manager; E. … POOLEY, A.M.I.E.E., Area Engineer (Planning and Construction); S. R. H…MAN, Chief Traffic Superintendent; J. McQUIRE, Secretary; C. A. T…RMAN-NEWELL, Senior Sales Superintendent.

NOTTINGHAM TELEPHONE AREA

The Nottingham Telephone Area, which comprises some 1,200 square miles, includes the County Boroughs of Nottingham and Derby, the Shire of Nottingham and some 500 square miles of Derbyshire, with its beautiful hills and dales.

The industries are varied, ranging from the manufacture of lace and artificial silk to the heavy industries of iron works, coal mining, production of locomotives, aero engines and motor-car engines.

Agricultural interests are centred in Derbyshire and the northern part of Nottinghamshire.

The Area contains 97 exchanges, of which 71 are automatic, serving over 66,500 exchange connections and 107,000 stations — an increase of 32,000 lines and 54,000 stations since September, 1939.

The total area staff, including engineering grades, is 1,318, while the supervising and operating force numbers 984 in addition.

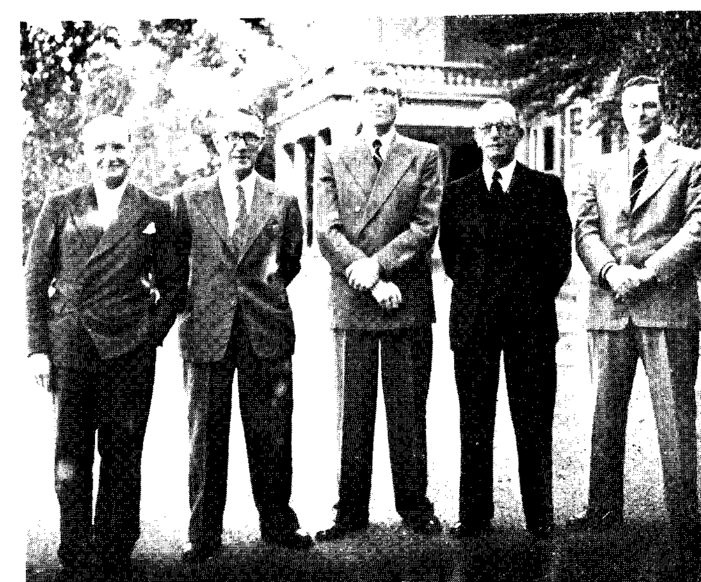
GUILDFORD TELEPHONE AREA

The earliest line of communication left in this country is the Old Road. Along it travelled pre-Roman Britons seeking new settlements. Much later the Road was called the Pilgrim's Way, because of its use by Chaucer's pilgrims, travelling to Canterbury "the holy blissful martyr for to seek". The Old Road can still be traced along the North Downs—the principal geographical feature in a telephone Area of 750 square miles.

The Area is mainly residential, community life being centred on Guildford, Aldershot, Basingstoke, Camberley, Dorking, Farnham, Godalming, Haslemere and Woking. Light industry has lately been attracted to most towns, notably Basingstoke and Woking. Aldershot and Camberley are well-known in military history. There is everywhere a lively farming industry.

As modern successors of those who made the Old Road, we now provide telephone communications through 69 exchanges, serving 66,300 telephones. The Staff (excluding operators) numbers [illegible]35 and the annual revenue approaches £1,000,000.

From left to right: W. CAMPBELL, Senior Sales Superintendent; J. W. COLLARD, Chief Traffic Superintendent; E. A. MAYNE, B.Sc.(Eng.), A.M.I.E.E., Telephone Manager; E. C. MATTHEWS, Chief Clerk; H. M. WELLS, A.M.I.E.E., Area Engineer.



Submarine Cables: Location of Faults

P. R. Bray, M.Sc.(Eng.), A.M.I.E.E., and A. T. Storold,

Cable Test Section, P.O.E.D.

SUBMARINE CABLES HAVE ALWAYS REPRESENTED a heavy capital investment, which has been justified by the heavy rate of usage with a reasonable charge per call or message.

In spite of the fact that radio links now carry part of the load, development, both in cables and associated apparatus, is continuously directed to making each individual cable link do more and more work in a given time. Thus the Anglo-Dutch No. 6 telephone cable at present is handling, in peak traffic conditions, up to 84 simultaneous calls, and telegraph submarine cables commonly work in both directions simultaneously at 200 words a minute.

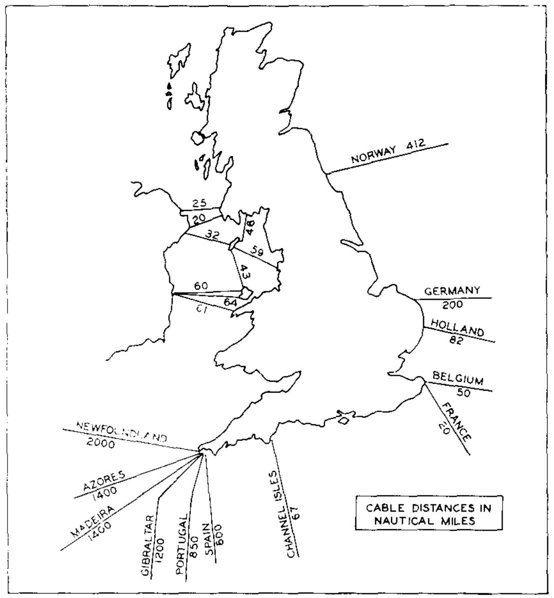


Fig. 1. Diagrammatic map of main submarine cable routes (telegraph and telephone) from the British Isles

It follows that the breakdown of a submarine cable can have a serious effect on traffic and revenue, even though temporary re-routing is nearly always possible, and a repair must be effected as soon as possible. The first need is to determine the position of the fault, so that if a cable-ship is required, it may be sent to grapple and raise the cable close to the fault position. Although a submarine cable fault on a given system is fortunately not quite an every-day affair, in the aggregate it is by no means a rare occurrence. In 1951, for instance, there were 66 faults in telephone cables, and an average of one fault per day in the 150,000 nauts (170,000 land miles) of British-owned telegraph cables throughout the world. These figures refer to cables in G.P.O. and Cable and Wireless maintenance. The main routes from the British Isles are illustrated in a general manner in Figure 1. On each route there are usually several cables.

Types of Cables

Before discussing fault location, it might be interesting to have a look at some types of submarine cables and to consider the purposes for which they were designed.

All submarine cables for communication purposes, at the present time, consist of one or more insulated conductors armoured overall by steel wires. They differ one from another, however, in conductor, insulating material (dielectric) and amount of armouring, depending on the job they have to do. In the examples shown in Figure 2, we have cross-sections of:

(a) A deep-sea telegraph cable, of medium-size core, with gutta-percha dielectric. Here the armouring has to provide the necessary strength to enable the cable to be laid in and lifted from great depths, which may be as much as 3,000 fathoms (3½ statute miles).

(b) A telegraph cable for intermediate depths. The core is the same size as in (a), but the armouring is heavier, to protect the core against damage which is more likely in shallow waters. For example, off the European coast is a "shelf" which has a maximum depth of a few hundred fathoms only, and the edge of the shelf is a favoured fishing ground for trawlers. Even heavier armouring is employed in very shallow waters and at landing points.

(c) A multi-pair telephone cable, the Anglo-French 1939, designed for 12-circuit carrier working, consisting of two groups (7 quads and 16 pairs) separated by a concentric screen. Each of the 14 pairs of the inner group, in conjunction with the corresponding pairs in the outer group, can carry twelve simultaneous conversations in each direction. Each conductor is comparatively light in weight (47 lb. per nautical mile) and insulated by a lapping of paper in such a way that the medium immediately around the conductor is mainly air. The complete core is enclosed by a rubber-covered lead sheath. The heavy armouring wire is typical for English Channel and North Sea cables, where they are very liable to be hooked by ships' anchors. In a cable having this type of core, delay in effecting a repair when the covering and sheath are broken means that a greater length of cable becomes unusable owing to water penetration.

(d) A solid-dielectric coaxial cable, which might perhaps be regarded as a standard for the British Post Office. It is not unlike a telegraph cable in construction, but the insulating material is either Paragutta or, more recently, Telcothene. This is a trade name for a type of polythene*. Both these materials, and in particular the latter, have a much smaller electrical loss at higher frequencies than natural gutta-percha. Over the dielectric, this cable has a coaxial return conductor, which plays an essential part in a system designed to operate at frequencies much higher than the 60 kc. s. limit of 12-circuit carrier telephony. It is into this type of cable that submerged repeaters have been inserted, to increase still further its traffic-handling capacity.

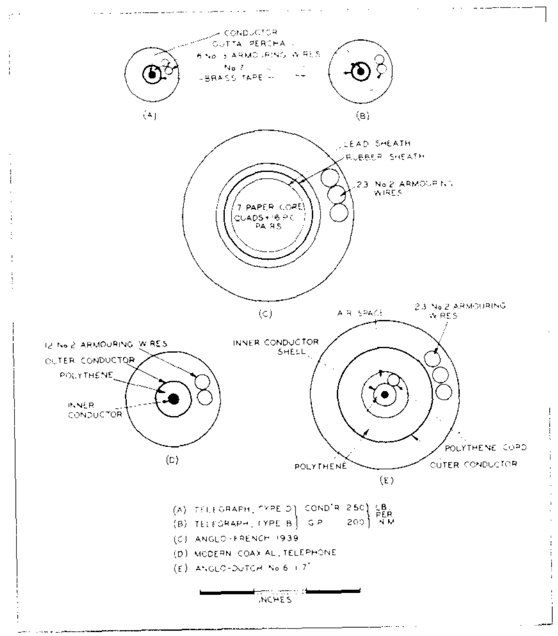


Fig. 2. Cross-sections of typical submarine cables, telegraph and telephone types

(e) An air-spaced coaxial cable; the electrical loss introduced by this type is even less than that of the cable described in (d), partly by virtue of the air space around the inner tubular conductor and partly by the increase in the cross-sectional dimensions of the inner and outer copper tubes. The solid centre conductor is not a part of the main transmission path. When armoured, the diameter overall is 2.75 inches and this (as in example (c)) is approaching the upper limit of size which cable ships can be expected to handle, at

* *A tough, flexible white plastic, developed in recent years. Ethylene gas is subjected to very high pressure to promote the formation of long-chain molecules of polythene.*

least for cables with an air space. This type of cable has been laid to Holland and Belgium.

Types of Faults

Damage to either the dielectric or the conductor can result in the transmission being so adversely affected that the cable becomes faulty. When a cable is completely broken, it is usual to find that the inner conductor (or conductors) is earthing to some degree. Occasionally, the conductor breaks while the dielectric remains whole under tension, so that in solid-dielectric cables, on finally breaking, the conductor end may be sealed from the water. A similar type of fault arises, from the electrical point of view, when a conductor joint parts without the cable being broken. For a multi-pair cable, in the latter case, there will almost certainly be some good wires still jointed through at the fault point.

If the dielectric be damaged and the cable not broken, a conductor may have quite a high resistance fault to earth. Even in the case of single-core cables, this does not stop transmission completely, but it has an unfortunate effect on the speed of working of telegraph cables. Battery conditions have to be specially arranged to keep the fault resistance high, and often duplex (two-way) working is not possible.

Conductors may develop high-resistance connections at joints. This fault is more likely to occur in telephone cables having many lightweight conductors, but it happens on occasions in telegraph cables. In the former case, it can lead to a noisy circuit and to interference between circuits. Interference can also occur in multi-pair cables, due to incorrect jointing during a repair, and great care has to be taken to ensure that cable wires are connected correctly and in suitable groups. Yet another fault peculiar to such cables is a wire-to-wire or a wire-to-screen contact. (These cables often contain a screen or screens to separate circuits in different groups.)

Cables may be damaged by heavy seas close inshore, chafing on rocks, wrecks, moving sandbanks, earth tremors, ships' anchors and trawls. Even in depths where most of these are extremely unlikely, if the armouring wires are weakened by corrosion, the core may be unable to withstand tensions that normally the cable could carry with ease.

Sometimes a cable may be kinked during laying or repair operations in deep water, particularly when a final splice is slipped. The teeth of fish have been found in the dielectric, having literally found a chink in the armour, and the brass tape sometimes wrapped round the core of a telegraph cable is placed there not specifically as a return conductor, but to protect the gutta-percha against the depredations of the teredo, a burrowing mollusc.

Direct-Current Methods of Fault Location

From the early days of submarine telegraphy, especially at the time of the first Atlantic cables, it was realised that means must be found for estimating the position of a fault. It was then that the basic principles of the majority of direct-current tests were laid down, and subsequent work was largely a matter of modification and improvement in detail. Wheatstone's bridge was already known, of course, but the problem of measuring resistance and capacitance independently on long cables, in the presence of various disturbing factors, was found to be one that was not too easily solved.

Suppose a single-core cable be broken and the conductor earthing. It would seem to be reasonably simple to measure the resistance to the break and divide by the resistance per unit length to give the distance from the measuring end, but in fact the result can be seriously affected by several things. For instance, there is usually a difference of electrical potential between the earth connection on the measuring set and the earth at the fault, due to the sea acting as a moving conductor in the earth's magnetic field, to magnetic disturbances or to man-made interference from electric traction or transmission systems. For working purposes, the effect is largely overcome by having a twin or triple core cable for the first few miles out to sea and using the extra cores as connections to special earthing arrangements at their ends, but when making measurements it is always necessary to employ a test which eliminates the effect of the potential difference, even on occasions when the "sea earth" can be utilised. This test entails balancing the Wheatstone bridge to a false or electrical zero; that is, the required condition of balance is that the deflection of the indicating instrument, usually a mirror galvanometer, should be unaltered by the application of the testing battery. The galvanometer must be provided with

a specially wide range of torsion control, to enable the turning effect of the unwanted potential difference to be opposed to a reasonable degree, in order that the full sensitivity of the galvanometer can be employed. Care has to be taken that any charge effect due to switching the battery circuit shall not damage the galvanometer and that sufficient time be given for the charge (or discharge) current to decrease to such a low value that is does not affect the deflection. It has to be assumed that the earth potential difference remains constant during each false-zero balance.

Another trouble arises from the behaviour of the fault itself. The combination of copper conductor, sea water and steel armouring forms an electric cell having internal resistance. Chemical changes known as polarisation take place in this cell when current passes through it, and these manifest themselves as a change in the resistance. The fault resistance will appear as a direct error in the estimate of distance, unless its value can be determined and subtracted from the apparent line resistance. This can be done provided that the resistance of the fault varies with the value of the testing current and that the law of variation can be determined. Quite a number of tests have been introduced, some of which assume a law of some type or other, and it is a matter of experience which test best applies in given circumstances.

Any test conditions that might cause a sudden change in the fault resistance (such as a reversal of current) are usually best avoided. In the majority of cases, the fault behaves better with the negative pole of the testing battery connected to line.

For insulated conductor breaks, the location test consists in measuring the capacitance of the cable. For lengths up to 50 miles or so, a direct deflection method may be used, in which galvanometer readings obtained on charging the cable and charging a standard capacitor are compared. On longer cables this method becomes increasingly inaccurate, owing to the time constant of the circuit, and the more elaborate Kelvin or Gott methods are used.

For faults where the line is partly earthing but still continuous, an "overlap" test is used. Each terminal station balances alternately with the same value of current, the end closer to the fault having extra resistance inserted in the line. It is essential that the fault be affected by the testing current only, and therefore signalling, except by observations of this current, is avoided. The aim of the test is to work up to a value of added resistance which, considered in conjunction with the resistance of the line, places the fault in a symmetrical position relative to the similar bridges at each end. This test, which may well be carried out with the

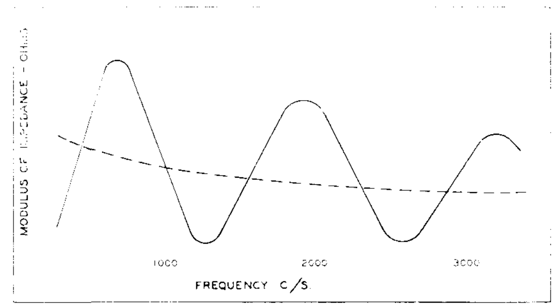


Fig. 3. Typical impedance-frequency curve, showing normal and fault conditions

co-operating engineers over 1,000 miles apart, has an artistic as well as a technical merit. It has points of similarity with the Varley test, which requires a further connecting link between the testing points, and the Varley is sometimes used to locate contact or earth faults on unbroken multi-pair cables.

When carrying out any of the direct-current tests just described on board ship, it is necessary to use galvanometers specially balanced mechanically, in order that false deflections will not be obtained when the ship rolls or pitches.

There is yet another method of fault location, which is sometimes employed at cable stations on the long telegraph routes and may be used for such troubles as high-resistance joints. When a telegraph cable is being worked duplex—that is, simultaneous transmission in both directions—it is normally necessary to have at each end a network of capacitors and resistors which simulate the cable. At the low frequencies represented by telegraph signals, this artificial line has in fact to be made up of a large number of units, each representing a few miles of cable, and its purpose is to balance a bridge to prevent the weak received signals from being affected by the strong outgoing ones. If a change takes place in the cable owing to a fault, the artificial line no longer truly represents the cable, and interference between the signals results. The nature of the fault being known, a similar fault is introduced in turn at various points in the artificial line, until the balance is restored, thus determining the position of the actual fault. This has some features in common with the impedance-frequency method, now to be described.

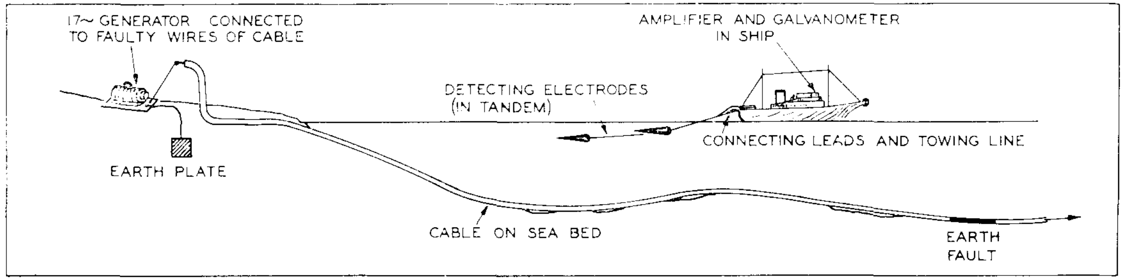


Fig. 4. Detecting the cable by the use of trailing electrodes

Impedance-Frequency Method

It will be appreciated from the previous paragraphs on D.C. methods that the correct answer depends to a large extent on the operator's experience of the behaviour of the fault resistance. Although the location is usually accurate to within a mile, under some fault conditions (such as when broken cable ends are sticking into ooze) the change in this resistance value is erratic and challenges the testing officer's skill in interpreting its behaviour.

The impedance-frequency method, when cable conditions allow it to be used, has a decided advantage, in that the value of the fault resistance does not appear directly in the test results obtained. In the hands of an experienced officer, the location can be made speedily and confidently and this is important when a cable ship is already on the cable ground waiting for an answer. The essence of the method lies in the study of the change in cable circuit impedance at different frequencies.

To measure circuit impedance, a form of the familiar Wheatstone bridge is used, in which capacitance and resistance elements can be adjusted in value until the combined effect of these elements equals the impedance of the cable circuit at a selected testing frequency.

If a series of these balances is obtained at different frequencies and the impedance values are plotted, the result for a circuit in good condition would be something like the dotted line of Figure 3. When a fault such as a cable break occurs, a remeasurement of a circuit in the cable, from the same station, will show that the dotted line of Figure 3 has been disturbed, and now it may look like the full line shown. Since it is the disturbance of the normal circuit condition at the fault point that is responsible for this state of affairs, it is usually attributed to "reflection at the fault". Looking at the rippling curve of Figure 3, we observe that the peaks and troughs occur at regular intervals along the frequency scale and also that the "swing" of these ripples decreases as the frequency increases. The frequency interval depends on two things—one, the velocity of the test signals sent along the circuit, and two, the distance of the fault from the measuring station. If we deliberately introduce into a good circuit a faulty condition at a known distance (such as the far-end station), we can observe the frequency interval and so obtain the velocity value for the particular circuit being measured. This velocity value can then be used to locate future faults in that cable. Such values have been computed, of course, from measurements made on the majority of cables in British Post Office maintenance or may be determined from measurements made after manufacture.

The decrease in the "swing" of the ripples

(Figure 3) as the test frequency is increased is due to the increased power loss in the cable circuit at the higher frequencies, and this limits the value of useful test frequency, since the method depends on accurate determination of the changes from the normal circuit impedance. However, this is not very serious in the majority of cases, because the farther away the fault point is from the testing end, the smaller is the frequency interval of the ripple between successive peaks or successive troughs, and so a lower frequency will give sufficient information.

Normally for the submarine cable links to near continental countries (France, Belgium, Holland and Germany), which are up to 200 miles in length, the lowest test frequency sufficient in practice is about 300 cycles per second, but application of the principle of this method, using test frequencies as low as a few cycles per second, are being investigated, for this would enable faults on the longer telegraph routes to be "seen" at much greater distances, because of the lower cable loss per mile at such frequencies.

The reliability of the impedance-frequency method is extremely useful for check measurements from a cable ship. When the ship has cut and lifted cable ends—especially in deep sea work, where this is a lengthy operation—the Commander will wish to know how near the fault is now, so that he can decide whether to continue to pick up cable or grapple at some other point. This decision can mean saving of both time and cable.

In the cases of cables fitted with submerged repeaters, the impedance-frequency method is still applicable with only a little extra complication in the manner of extracting information from the test results. These submerged repeaters, which at present are inserted in the cable at about 16-mile intervals, affect the frequency interval between the peaks or troughs on the fault curve in the same way as would the insertion of about 12 miles of similar type cable at that point, although the power loss introduced is very small in comparison. An added difficulty is that a small amount of reflection from each junction of cable and repeater is also created, and so the normal impedance-frequency plot from either end of the system is irregular.

With the question of future fault location in mind, then, the circuit impedance is measured in the first place, as each repeater is inserted into the cable (this has necessarily to be done from the commencing end of the route) and, for a four-repeater cable for instance, four master curves are obtained. For a later fault condition, the appropriate master curve would be used, depending on the repeater section of cable in which the fault had occurred. The impedance-frequency values would be obtained for the faulty cable condition from the end to which the master curves referred, and frequency by frequency each fault impedance value would be subtracted algebraically from the corresponding master-curve value. When these differences are plotted, a regular ripple, such as in Figure 3, would be produced, and, allowing for the known effect of each repeater up to the fault position, the location can be made. In the November, 1951, issue of this journal, it was explained how the use of a pulse method could determine the repeater section that contained a fault. Since this will probably raise the question of why the position of a cable fault could not be precisely determined by pulse methods, it is pointed out that the efficacy of that method depends on the use of the successive repeater amplifications to return the harmonic pulse to the receiver. The use of a pulse method on a non-repeatered cable is limited by the relatively high cable loss. The impedance-frequency method, using a frequency range according to its needs, is not limited to the same degree.

Electrode Search Methods

An entirely different aspect of fault location is the use of towed electrodes, which actually enable the towing craft to search for the cable position, as distinct from navigation to a point decided by electrical measurements from either end of the route. This method, described as far back as 1923, consists of connecting a 17 cycles per second supply (a standard ringing machine would do) between cable conductor or conductors and earth at end A of the cable. For the purpose of the test, the same conductors are connected to earth at the remote end, B, when the cable is "good", or are usually so connected via the sea water when the cable is broken. The path taken by the 17-cycle current in returning from B to A is mainly via the sea water, and the fall of potential along this path is utilised to detect the presence of the cable. A pair of brass electrodes spaced some distance apart are secured to lengths of line sufficient to clear the disturbing effect of the ship's hull and

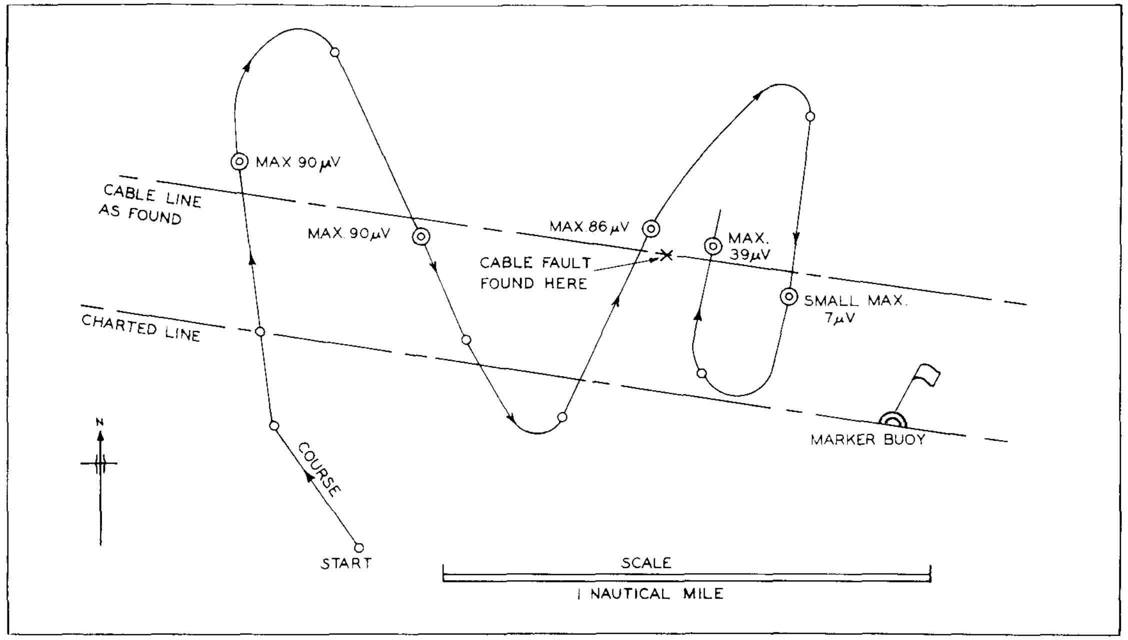


Fig. 5. Ship's manoeuvre to establish the position of a fault on the Bacton-Borkum No. 2 cable

are swept across the area of search. Insulated wire connections from the electrodes are brought inboard and connected to the input terminals of a valve amplifier designed for high sensitivity to 17-cycle signals. The amplified output is then rectified and indicated by a galvanometer deflection. The operation is depicted in Figure 4 (in which relative sizes have been accommodated to the need for clarity). The maximum deflection of the galvanometer needle is obtained when the electrodes are directly over the cable line, so that by proceeding in a criss-cross fashion (Figure 5) and plotting the points of maximum deflection, the line of the cable is charted. In the case of a fault, the maximum deflections are very much smaller when the fault has been overshot. The use of the electrode method is invaluable in charting the inshore section of submarine cables, where routes converge to enter the cable house. The question of fashioning the most effective form of electrode and the production of a recording unit, which would enable the towing vessel to proceed along the line of the cable and have direct indication when it deviated from this line, has had a preliminary investigation in recent years.

It may be mentioned as a point of interest that successful results have also been obtained in tracking telegraph cables by towing two lengths of Paragutta coaxial cable with the ends stripped for about a fathom, using the exposed conductor in each case as an electrode.

Finally, it will be realised that much of the benefit arising from accurate testing is wasted unless cable records are accurately maintained. For telegraph cables, in particular, many different types and sizes of cables are inserted, owing to repairs over the years, and their lengths and electrical constants must be recorded and kept up-to-date. This is not always easy, since on occasions an unknown length of cable is abandoned after parting on the repair ship's grapnel, and this length then has to be estimated from the ship's position and subsequent electrical tests.

Acknowledgment

The help given by members of the staff of Cable and Wireless and the Post Office in the preparation of this article is gratefully acknowledged.

Partial Call Queueing

The Canterbury Experiment

F. Cox. Inland Telecommunications Department

THE PROBLEM OF THE UNFORTUNATE CALL (the call that is kept waiting while later calls are being answered) has existed since the days of the first introduction of large telephone switchboards, as it is impossible for an operator to determine, reliably and consistently, when a number of calls are awaiting attention, which of them has been calling the longest. The greater the number of waiting calls, the more difficult the operator's problem becomes, and the more serious the repercussions on the quality of service given to the subscriber. To a certain extent, the unfortunate call problem exists at manual exchanges (where each calling signal appears only once on the switchboard) when positions are unstaffed. It assumes a much greater degree of importance at auto-manual exchanges, however, where the fact that calling signals are repeated at regular intervals, usually every 6 or 2 panels, throughout the answering multiple of the switchboard results in a greater number of waiting signals appearing before an operator.

Records at Headquarters show that attention was given to the problem of the unfortunate call as early as 1932. Since then, a considerable amount of thought has been brought to bear on means of overcoming it. Many schemes have been examined and some of them tried over a number of years, particularly at auto-manual exchanges, with varying but not very encouraging results. It is of course technically possible to design new types of exchange equipment that will store all calls and present them to the operators in the order in which they are made, and the cordless board has been designed on this principle. The immediate problem, however, is to devise a system of call queueing that can be applied to existing switchboards without involving considerable modification to the switchboard equipment.

The most promising scheme that has been proposed to date is known as " partial call queueing combined with call suppression". It is hoped that this scheme, which is at present undergoing trial, will minimise considerably the problem of the unfortunate call. A word of warning, however, at the outset, so that the reader can get the description that follows "into focus". It has not been claimed that this scheme will do any more than minimise the problem of the unfortunate call. It will not solve the problem, nor will it, by itself, improve average time-to-answer figures, but it should go a long way to reducing the risk of calls waiting a long time before being answered.

The principle of the partial call queueing scheme is that only a portion of the potential calling signals appear on the switchboard, the later arrivals being temporarily stored in the apparatus until the earlier calls have been answered. The calls are displayed on the switchboard in batches and at no time will the total number of glowing calling signals exceed the pre-determined size of the batch. The answering of calling signals in any batch is not controlled and, consequently, the scheme does not provide for calls to be answered in strict order of arrival, but it does set a limit on the maximum time it is possible for a call to wait before being answered.

The apparatus (Figure 1 shows the front of the apparatus rack) has been developed as a unit catering for a maximum of 400 switchboard working calling equipments and employs 16-bank motor-driven uniselectors (Figure 2) as queue linefinders. Facilities are provided for up to 25 calls (including those displayed) to be queued in the order in which they arrive at the exchange. It has been assumed, in the design of the equipment, that there should be no more than 25 calls awaiting answer at any one time in an exchange consisting of 400 or less calling equipments. (A pen recorder was associated with the equipment at Canterbury—where the first unit was installed—for the first

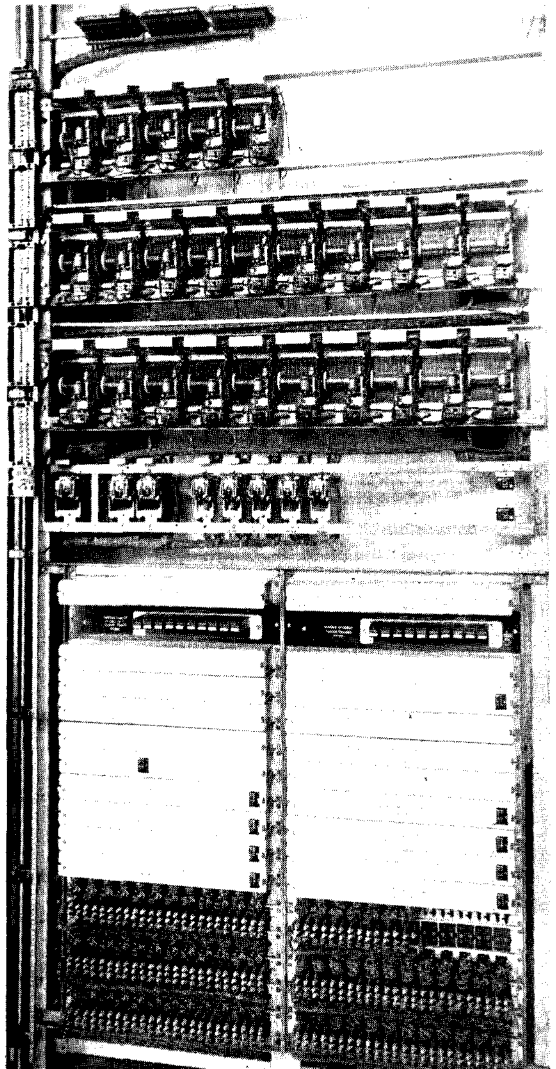


Fig. 1. The apparatus rack. (For close-up of meters, see Fig. 5.)

few weeks of the trial and this proved that 25 queue places were more than adequate at that exchange.) If, however, there are more than 25 calls at any one time, the excess calls are retained in a common pool outside the queue and are selected, although not necessarily in order of arrival, to fill any queue places that become free; the design of the equipment is such that there is no possibility of a call becoming truly "unfortunate" and remaining in the pool. Ringing tone is returned on all calls waiting in the pool. With the exception of a supervisor's control panel, all apparatus associated with the scheme is installed in the apparatus room.

One of the main attractions of the scheme is that no modifications to the switchboard are required, as the calls cause their normal calling signal to glow when they appear on the switchboard, and the only difference from an operator's viewpoint is that there are fewer calling signals at a time, and also that they may appear in batches rather than individually. For the purpose of the field trial, the size of the batch displayed can be varied from 3 to 11 simultaneous calls by the operation of a switching device on the control panel.

No other signals are displayed until the call that has waited the longest has been answered. At this stage, other calls that have been retained in the queue will be displayed on the switchboard up to the pre-determined size of the batch to be displayed. If the batch of calls is answered in reverse order of arrival in the exchange, no further calls will be displayed on the switchboard until the last signal has been answered. The procedure can best be illustrated by the following examples, assuming the size of the display has been pre-set at 6, and there is a total of 11 calls awaiting answer. The calling signals of the first batch of 6 calls displayed are indicated by "o", and the remaining 5 calls stored (but waiting in the queue) by "X". The earliest displayed calling signal still unanswered is called the Head of the Queue (HOQ) call.

1	2	3	4	5	6	:	7	8	9	10	11
o	o	o	o	o	o	:	X	X	X	X	X

(*a*) Calling signals answered in chronological order. If call No. 1 is answered, call 7 appears as a calling signal, and No. 2 call becomes the HOQ call, thus:

1	2	3	4	5	6	7	:	8	9	10	11
o	o	o	o	o	o	o	:	X	X	X	X

If call No. 2 is now answered, call No. 8 appears as a calling signal and call No. 3 then becomes the HOQ call, thus:

1	2	3	4	5	6	7	8	:	9	10	11
o	o	o	o	o	o	o	o	:	X	X	X

and so on, if the calls are answered in strict order of arrival.

(*b*) If, however, the calling signals are answered in reverse order of arrival (6, 5, 4, 3, 2), the calls waiting in the queue do not appear as calling signals until the HOQ call (now the "unfortunate call") has been answered. The following illustrates the position before the last remaining calling signal (i.e. the HOQ call) of the original batch has been answered:

1	2	3	4	5	6	:	7	8	9	10	11
o	o	o	o	o	o	:	X	X	X	X	X

(*c*) It is more probable in actual practice, however, that the batch of displayed calls is answered neither in chronological order, nor in reverse order of arrival, but in random order. The following illustrates such a case. If, as before, 11 calls are awaiting answer and 6 are displayed on the switchboard when, say, calls Nos. 3, 4 and 5 are answered, the position is thus:

1	2	3	4	5	6	:	7	8	9	10	11
o	o	o	o	o	o	:	X	X	X	X	X

The display is now only 3 calls with No. 1 still as HOQ. If the HOQ call is answered next, No. 2 call becomes the new HOQ and No. 7 will be displayed, thus:

1	2	3	4	5	6	7	:	8	9	10	11
o	o	o	o	o	o	o	:	X	X	X	X

If No. 2 call is answered next, No. 6 now becomes HOQ call and Nos. 8, 9, 10 and 11 will be displayed, thus:

1	2	3	4	5	6	7	8	9	10	11
o	o	o	o	o	o	o	o	o	o	o

The worst condition that can arise in these circumstances is that calls Nos. 7—11 are answered before call No. 6, which thus becomes the eleventh call to be answered; but, as already explained, it is not possible for any additional calls to be displayed until call No. 6 has been answered.

The scheme, therefore, does not eliminate the unfortunate call, but by suppressing subsequent calling signals until an earlier one has been answered, it does set a limit to the time that the unfortunate call can remain unanswered, and this should prove of material benefit.

The Control Panel (Figure 3) contains the following three facilities:

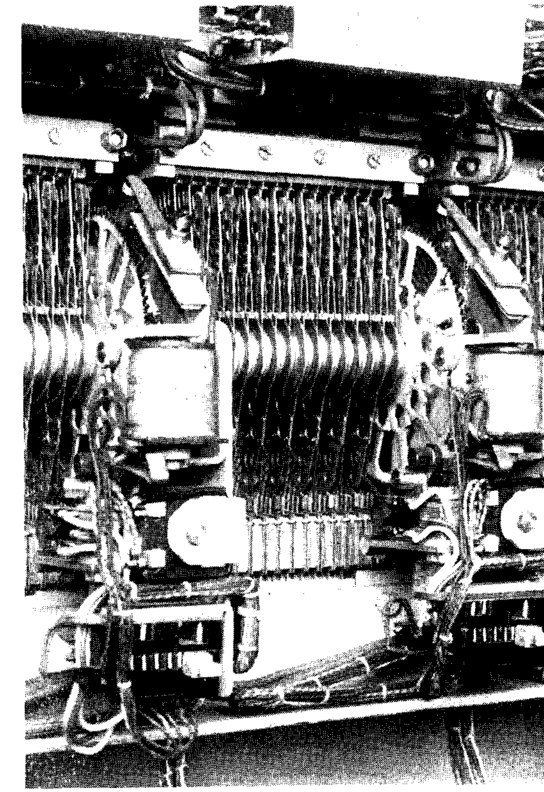


Fig. 2. Motor-driven 16-bank uniselectors used as queue linefinders

(*a*) "*Size of Display*" Control. The size of the batch of displayed calls can be pre-set at any figure from 3 to 11 by the operation of a switching device. Originally, the maximum size of the batch was 12, but as the conditions at Canterbury were such that a batch size of 12 would never be used, the last key position was utilised to enable the "calls in queue" indicator to be switched off when not required. A maximum batch size of 11 calls is being maintained on units to be installed at other exchanges. A key is provided to cut out the partial queueing and call suppression facility and restore to normal working.

(*b*) "*Calls in Queue*" *Indicator*. This consists of 25 lamps (labelled 0—24) located vertically behind a pre-cut stencil, the latter being covered by a translucent plastic screen. Tests are made automatically at 6-second intervals and the appropriate

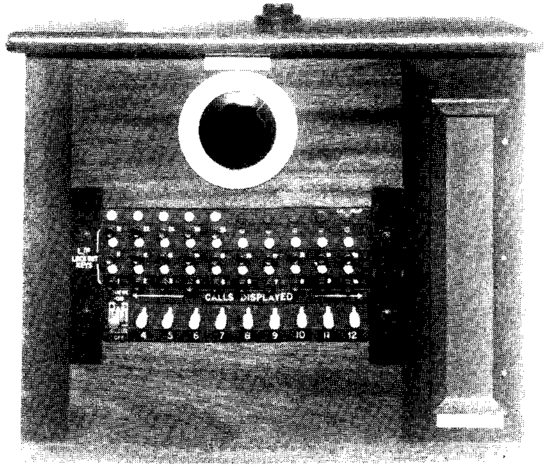


Fig. 3. The control panel used in the Canterbury experiment

lamp glows to indicate the number of calls waiting in the queue (including those displayed) at that particular instant; this number remains illuminated until the next test is made. Originally, the testing interval was 30 seconds, but practical experience proved that this was too long and it was changed to 6 seconds. The additional units referred to in (*a*) above include a "waiting calls" meter in place of this indicator, as experience has shown that it is preferable to give an instantaneous display of the number of calls waiting, rather than present information that may be up to 6 seconds "out of date".

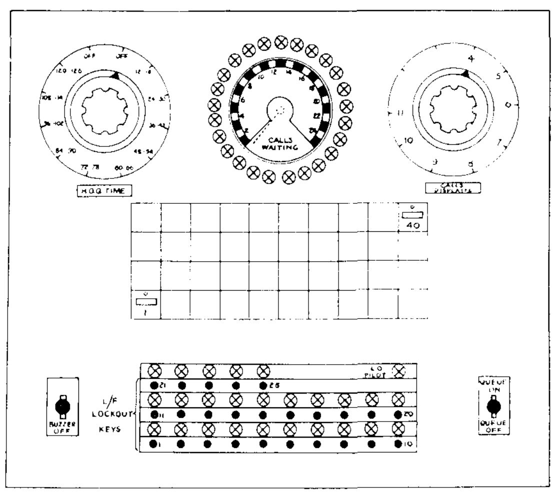
(*c*) "*Head of the Queue*" *Control Facility*. This facility consists of a switch that can be turned to a number of different time settings. The selected setting determines the length of time a call can remain unanswered at the head of the queue before an alarm is operated. The facility has been provided primarily to cater for a possible lamp relay failure resulting in no calling signal being displayed, and in these circumstances the alarm will operate after the call concerned has been at the head of the queue for the specified time. A lamp on the control panel indicates to the supervisor which of the 25 linefinders is associated with the offending call; she can then lock out the linefinder concerned by depressing the appropriate plunger key, thus allowing subsequent calls to appear on the switchboard.

An additional display of lamps has been provided to give a "picture" of the conditions existing in the queue. This display consists of a circle of 25 lamps corresponding to the 25 linefinders. When a linefinder is handling a call (irrespective of whether the call is displayed on the switchboard) the corresponding lamp glows. When the call is answered, the lamp is extinguished. As the 25 linefinders are allotted in consecutive order, the effect of the display is an arc of glowing lamps moving around the circle. This arc may be broken, of course, as the calls displayed on the switchboard are not necessarily answered in order of arrival. From a traffic point of view, this display gives a very good indication of conditions in the queue and the rate of flow of traffic through the exchange.

Associated with the apparatus rack at Canterbury are two sets of ten meters each (see Figure 5). These sets of meters provide details of the number of queue places engaged and the waiting time of a call in a queue place, respectively. The first set operates in conjunction with the supervisor's display of the number of calls waiting in the queue, and counts, at 6-second intervals, the number of queue places engaged. The other set of ten meters, which is connected to one queue place, records the length of time every 25th call waits in the queue before being answered.

The additional units will include a total of 40

Fig. 4. The control panel used in the London and Middlesbrough trials. This panel accommodates 40 meters for recording statistical data



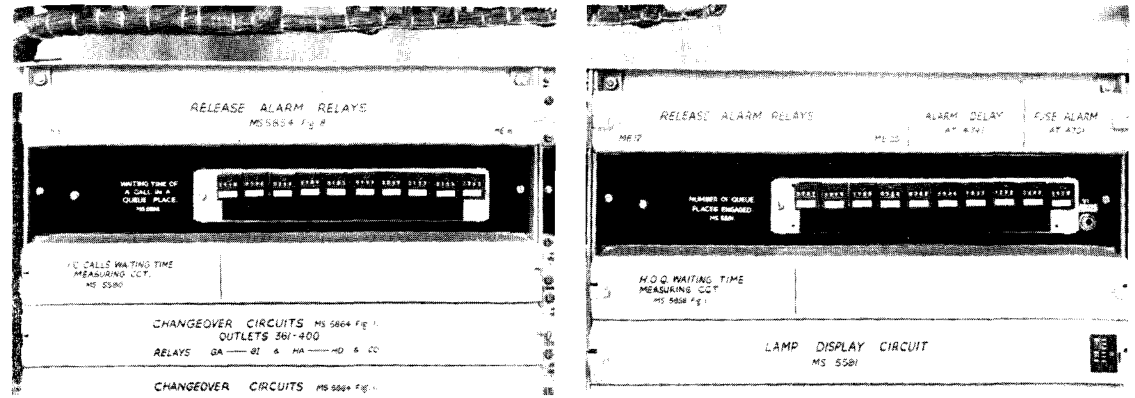


Fig. 5. Meters giving details of waiting time in a queue (left) and number of queue places engaged (right)

meters, fitted on the control panel. (Figure 4 is a drawing of the control panel used in the further trials referred to below.) These meters will record data pertaining to the waiting time of 4 calls in 25, the total number of calls handled by the equipment, the number of occasions when the queue is full and various other statistics.

No final results of the trial at Canterbury are yet available, but the scheme is regarded as sufficiently promising to justify further trial and two additional trial units will be in operation by the time this article appears. One of these will be installed in a trunk control centre in London (where the traffic is all of high value) and the other at Middlesbrough, a provincial group centre with two suites of positions; at the latter exchange, the traffic on one suite will be fed via the queueing equipment, whereas that on the other suite will be left to call "at random". By this means, a close comparison of the service under "queueing" and "random answering" conditions will be obtained.

In conclusion, I should like to express my appreciation of the assistance so willingly given by colleagues in the Inland Telecommunications and Engineering Departments in the preparation of this article.

Stockholm Conference. 1952

The world radio conference in Atlantic City in 1947 (described by L. V. Lewis in the first issue of this Journal) allocated three bands of very high frequencies for broadcasting in Europe—41-48 Mc. s. (band I), 87.5—100 Mc. s. (band II) and 174-216 Mc. s. (band III). A conference at Stockholm earlier this year, attended by representatives of 31 countries, produced an agreement with which are associated three plans for the assignment of frequencies to European broadcasting stations, one for each of these three bands. The agreement comes into force on July 1, 1953, and will be reviewed not later than July 1, 1957. It was signed on behalf of the administrations of 21 of the countries represented at the Conference, the non-signatories being Portugal, the U.S.S.R. and eight other Eastern European countries.

The plans for bands I and III provided 568 assignments for European television stations and the plan for band III provides nearly 2,000 for sound broadcasting stations. The plan for band I also includes 151 assignments for sound broadcasting stations in Eastern Europe.

An interesting feature of the agreement is a clause which allows countries to modify the technical characteristics of their stations after obtaining the consent of other countries likely to be affected by the change and defines, by means of a table of powers and distances, the countries whose consent must be obtained.

The Post Office Telephone and Telegraph Society of London

A Forum for Discussion

C. R. Clayton, Hon. Secretary

THE POST OFFICE TELEPHONE AND TELEGRAPH Society of London was started as "The London Telephone Society" and by 1906, though young in years, it was in a flourishing condition. Members were keen and it was not uncommon for two papers to be read and discussed in one evening. The Society must have suffered from "gate-crashers", for the minutes record that "at each meeting a man in uniform shall be at the door and insist on seeing each member's card of membership". Three prizes of a guinea each were awarded annually for the best-written papers from the junior members of the Society. An inducement to women to join in the Society's activities was the introduction of a half-rate subscription of 9d. instead of the usual 1s. 6d. It was also discreetly conveyed that smoking was not prohibited at meetings. Alas! The minutes do not state whether permission to smoke was an inducement or a warning!

Two papers read in the 1906-7 session carried the titles "Transmission Measurements" and "Sales Development": the same titles today could conjure forth some highly interesting papers. Mention is made of the cordial relations that existed between the Society and similar bodies both in London and in a number of provincial towns. The agenda for each meeting was brief in substance but lengthy in time. Demonstrations were given from 6 o'clock in the evening to 7 o'clock and papers were read and discussed until 9 o'clock.

The London Telephone Society changed its title in 1909 to "The Telephone Society of London". The minutes do not say why the change was made. The title that the Society bears today was adopted in 1913 when the Government took over the various telephone companies that existed at that time. Then, as now, the Committee was drawn from the various departments in London, with the difference that, in 1913, the Committee was elected by the membership, whereas now each department concerned with telecommunications nominates one, and sometimes two, members to serve. Meetings were held, and are still held, in the lecture hall of the Institution of Electrical Engineers. The cost of printing papers was a problem then as it is today, but support came from the Treasury and a grant made by "My Lords" enabled each member to be supplied with a copy of each paper. Nowadays the Society has perforce to forgo this luxury.

As 40 years ago, so today emphasis is placed on the discussion that follows the reading of a paper. No author expects, nor has he the right to expect, that all his statements will go unchallenged. His paper represents his own opinions, which may not necessarily be shared by the Post Office, and he is prepared to defend those opinions. The discussion provides his audience with the opportunity to accept his challenge and the gauntlet is vigorously taken up. Younger members are as keen as the older ones to take part in the discussion. Many meetings are attended by pensioners, who add their contribution to the evening's proceedings. Membership costs only 6d. more than it did in 1906, and it is open to all Post Office staff and to Cable and Wireless staff in the United Kingdom. Visitors are always welcome.

FORTHCOMING TALKS

December 1st.—Review of the Telephone System of the United States (Wm. H. J. McIntyre, United States Embassy).

January 5th.—Railway Signalling (J. H. Fraser, Railway Executive).

February 9th.—Some Problems Affecting London Station, Cable and Wireless Services (Col. H. J. Wellingham, M.C., T.D., M.I.Mech.E., M.I.E.E., A.M.I.E.E., Telegraph Manager).

March 4th.—My Experiences of International Conferences (Col. A. H. Read, C.B., O.B.E., T.D.).

NOTES AND NEWS

P.A.B.X. for British Association—Radio Show—Telegraph Rates Olympic Games—Achievement by "Monarch"—Repair work by P.O. Factories—"How the Telephone Works"—Television Outside Broadcasts—MINcing Lane—Opening of Wenvoe

P.A.B.X. for the British Association.—The Senate of Queen's University, Belfast, decided some time ago to replace their P.M.B.X. by an automatic system and an order for a P.A.B.X. No. 3 was placed with Standard Telephones and Cables, with a request that the work should be completed, if at all possible, before the opening of the British Association's meetings in September. As a result of special efforts by the company and the Telephone Manager's staff, who had to provide and install power plant, underground cables and the wiring and instruments for 100 extensions, the exchange was completed in three weeks and was tested and handed over for service two days before the inaugural meeting on September 3.

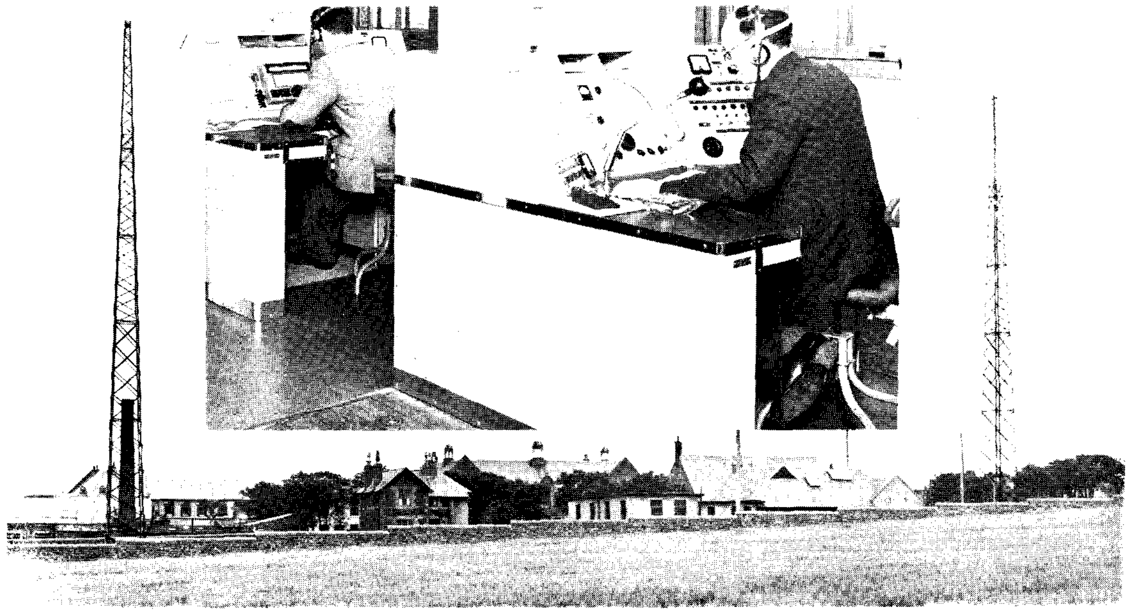
This is the first P.A.B.X. No. 3 to be installed in Northern Ireland, but three others had previously been completed in Great Britain.

Members of the British Association visited Telephone House and were shown over the apparatus rooms and switchroom and entertained to afternoon tea.

* * *

Radio Show.—In collaboration with the Central Office of Information, the Post Office installed an exhibit at the National Radio Show, Earls Court, London, in August, to impress on the public the need to purchase licences before installing and operating television receivers.

A television detector van, of the type used by the Post Office to locate working television receivers, was the main feature. Above the van, an animated panel enabled the demonstrator to show how, by means of the special radio receiver with its three



The reconstructed Post Office Radio Station at Wick, North Scotland, opened by the Assistant Postmaster-General in September. Inset: part of the operating room horizontal loop aerials fixed to the van roof, the approximate position of a television receiver in relation to the van could be determined.

One of the audience was then invited to use the small portable detector apparatus to find the actual position of the television receiver, which was kept hidden from view until it was discovered.

An enquiry bureau was provided, at which visitors were invited to discuss any difficulties experienced, owing to interference.

* * *

Telegraph Rates—It has been obvious for some time that substantial increases in oversea telegraph rates would soon be necessary ; apart from minor increases in charges to European countries when services were restored after the war, the rates were still at their pre-war level—indeed, no general increase had been made for about a quarter of a century. A new tariff, embodying general increases, was therefore introduced on September 1.

The main reasons for the changes are similar to those given for the increases in telephone charges earlier in the year—rising costs of buildings and equipment and increases in salaries and wages.

The increases are the minimum necessary to guarantee the payment of the standard dividend to the Exchequer on the shareholding in the overseas company and to provide some margin in hand to meet possible further rises in costs or a decrease in revenue due to a fall in traffic during the next few years.

In comparison with the rise in prices of other services and commodities, however, the increases are moderate.

* * *

News of the Olympiad.—In anticipation of a considerable increase, during the Olympic Games, in the number of overseas telegrams sent from Finland, the Great Northern Telegraph Company, which carries a very considerable portion of the Finnish oversea telegraph traffic, made many special arrangements in both Finland and their connecting offices oversea. In London, a special high-speed Morse circuit was installed between the company's office and the Post Office Cable and Wireless station in Electra House, in order to keep to a minimum the time taken in transferring traffic from Great Northern to Imperial.

Throughout the period of the Games, there was a heavy flow of Press messages through Electra House, both transit traffic and pictures and news that had been collected by the news agencies in London and edited and handed in for onward transmission overseas. During the period July 12-August 3, the Post Office Cable and Wireless circuits handled approximately 660,000 words of Press traffic and 335 phototelegrams about the Olympiad, with a total value of £17,000.

One feature was the exceptionally heavy demand from all parts of the world for broadcast reports on the various events. To meet this demand, a network of high-quality trunk circuits linking Finland with the principal cities of Europe was established for continuous use for the duration of the Games. More than 120 separate transmissions, involving a total circuit time of some 150 hours, were relayed to the United Kingdom alone. Many of the reports obtained from Helsinki in this manner were retransmitted from European radio-telephone terminals to overseas countries. In all, 74 transmissions were relayed from London to Australia, South Africa and other parts of the Commonwealth.

* * *

Achievement by "Monarch".—H.M.T.S. *Monarch* has recently completed for Cable and Wireless, Ltd., the renewal of some 800 miles of the cable connecting Porthcurno, Cornwall, with Harbour Grace, Newfoundland, and the diversion to deeper water and renewal of the cable from Harbour Grace to Halifax, Nova Scotia.

* * *

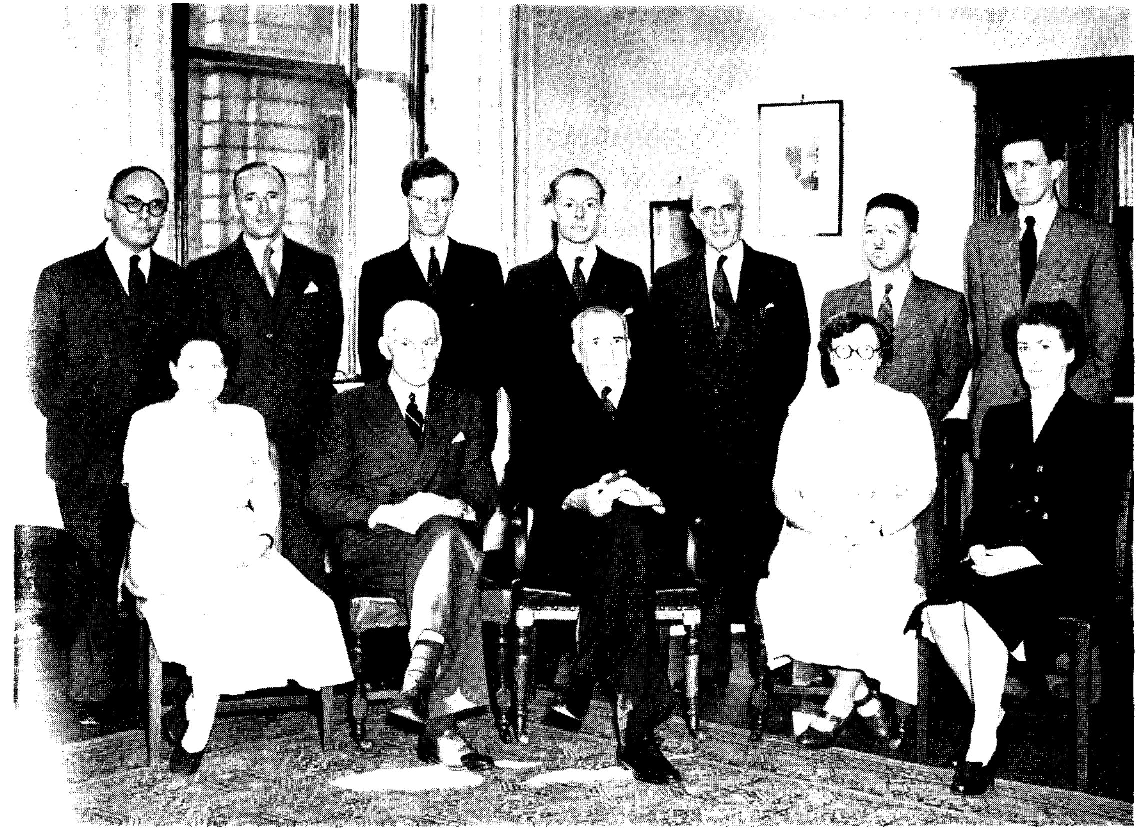
Repair Work by Post Office Factories.—Post Office factories in London, Birmingham and Edinburgh deal mainly with the repair of apparatus, an important element in the general economy of the Post Office. Repair work comprises more than 70 per cent. of the total output of the factories and the replacement value of apparatus repaired exceeds £3,000,000 annually.

The total number of types of apparatus and equipment repaired in a year is approximately 2,000. Items dealt with include fire protection equipment, clocks, stop watches, moving coil and radio equipment, measuring and testing instruments and unit assemblies of many kinds. There is also a regular monthly output of components such as jacks, indicators, relays and coils, to enable such articles to be replaced on the site.

These repairs include modernising. The progressive improvement of the telephone service is thus achieved without the need to write off large sums of money annually to scrap.

* * *

"How the Telephone Works".—One of the last films to be made by the G.P.O. Film Unit before it was disbanded was entitled "How the Telephone Works". It proved to be one of the most popular and successful films produced by the unit. The number of showings, both inside and outside the Department, was such that the numerous copies eventually wore out and, as the demand continued, it became necessary to remake the film. A new version has been completed recently. The film is now available for use in training courses.



United Kingdom delegation to I.T.U. Plenipotentiary Conference in Buenos Aires

Left to right (*standing*) H. G. LILLICRAP, O.T.D. ; C. CARPENTER, C. & W., Ltd. ; I. M. SINCLAIR and R. M. SANER, O.B.E., Foreign Office ; M. CAWS, A.G.D. ; R. V. HATTON, O.T.D. ; G. R. BRANDON, O.T.D. ; (*seated*) Miss S. E. SHORT, P. A. to Deputy Leader ; Col. A. H. READ, C.B., O.B.E., T.D. Deputy Leader ; Sir BERTRAND JERRAM, K.C.M.G., Leader ; Miss E. M. PERRY, O.T.D. ; Miss J. I. B. ALFORD, P.A. to Leader. Miss P. T. METCALFE, Foreign Office, and Miss K. M. DAVIS (clerical duties) could not be included in the photograph.

B.B.C. Television Outside Broadcasts.—The B.B.C. intends to provide three mobile television control rooms for use in handling broadcasts from outside London. One will be based in Scotland, one in the Midlands and the other in South Wales. The Post Office will set up three regional engineering teams to deal with the provision and lining up of Post Office circuits used in connection with the broadcasts.

* * *

"MINcing Lane"—after the famous tea traders' street in the City of London—is the name of a new exchange opened to relieve pressure on the Mansion House Exchange.

In the West End of London, the Welbeck exchange is also to be relieved. Public opinion is being sounded about the acceptability of "Tyburn" as the name for the new exchange. The Tyburn or Tybourne formerly flowed near an ancient site of public executions, and to some people the name is more readily associated with Tyburn Tree than with the bourne itself.

* * *

About 80 per cent. (or 40,000,000) of the United Kingdom population can now have television in their homes, said the Postmaster-General, opening the new Wenvoe (South Wales) transmitter in August. This compares with about 50 per cent. of the population in the United States of America.

Correction.—In our August issue, the photograph on page 151 was captioned "By courtesy, West Sussex Fire Brigade". This should have read : "Hampshire Fire Brigade".

Book Review

WIRELESS FUNDAMENTALS. By E. Armitage ; first edition, demy 8vo., 378 pp., well illustrated ; published at 18/- by Sir Isaac Pitman & Sons, Ltd.

Most persons concerned with teaching radio know how difficult it is to find a really adequate elementary text-book in this field; many elementary books attempt too much and thereby confuse the beginner or, at the other extreme, present him with a scrappy and possibly inaccurate foundation on which to build his future knowledge.

Wireless Fundamentals avoids these pitfalls very successfully, since the author has wisely limited the scope of his book to the more important aspects of the subject and deals adequately with these. This is a feature to be recommended, because of the clarity in ideas that it ensures. On the other hand, the derivations of the formulæ used are given separately in appendices, a procedure which avoids obscuring the physical phenomena under discussion by too much mathematical detail. Well-selected experiments are suggested in footnotes to the main text.

Adverse criticisms of the book are few and are partly concerned with terminology. For example, the term "mutual characteristic" on pp. 22 and 245 is surely less self-explanatory than the straightforward " anode-current grid-voltage characteristic". Again, on pp. 323 and 352, "electron mixer" is less expressive than "multiplicative mixer". On p. 285 it is said that "an aerial that is suitable for transmission will also be suitable for reception"; this is not always true, since a short aerial away from a noise field may be more effective for reception than a long aerial in it, while for transmission the long aerial may be the better.

This book can be confidently recommended to beginners and students taking, for example, Grades I and II of the City and Guilds of London Institute examinations in Radio.

Beam Jubilee.—On September 5, the Government of India Overseas Communications Service celebrated the silver jubilee of India's radio beam telegraph services; it was on September 5, 1927, that the beam service was opened between London and Bombay, through stations at Grimsby and Kirkee.

Publication and Price. This Journal is published in November, February, May and August. Price 1/6. The annual postal subscription rate is 6/6 post free to any address at home or overseas.

Contributions. The Editorial Board will be glad to consider articles of general interest within the telecommunication field. No guarantee of publication can be given. The ideal length of such articles would be 750, 1,500 or 2,000 words. The views of contributors are not necessarily those of the Board or of the Department.

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