Telephone Poles in the British Telecom Network—A Review

Part 1—Wood Poles

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This article, which is to be published in three parts, generally reviews the subject of the telephone pole, both the conventional wood type and the newer hollow pole. In the case of the wood pole, the cycle from the growing tree to the final demise of the decayed pole is covered. Particular stress is put on the explanation of why various materials and techniques have been adopted.

This part begins by examining the present use of telephone poles in the British Telecom network and goes on to describe general aspects of wood poles. Part 2 will describe engineering aspects of the use of wood poles, with particular attention to pole testing, and Part 3 will review the use of alternative materials for poles.

INTRODUCTION

Overhead distribution has been a feature of telecommunications since its earliest days and the pole still continues to play a major role in the network. Although the number of overhead routes in existence is much reduced, the number of poles being issued annually has remained high because of the major growth in distribution points (DPs) in residential areas. About 4·5 million poles are in use and about 100 000 new poles are issued each year, either for new work or the replacement of old poles.

The technology has been remarkably stable; the *Pinus sylvestris* tree still provides the main source of supply, with creosote as the standard preservative. The major changes over the past quarter of a century can be summarised as follows:

(*a*) The virtual disappearance of overhead open-wire trunk and junction routes has brought about the demise of the *stout* pole and the very tall poles, present-day requirements being almost entirely satisfied by *light* or *medium* poles of 15 m or less in height. The *extra light* pole is also obsolescent.

(*b*) A substantial proportion of pole erection work is now mechanised; the pole erection unit (PEU) with a two-man team suffices for about 60% of poling work.

(*c*) The introduction of the hollow pole has provided a means of complete avoidance of climbing of overhead distribution (DP) poles with the consequent improvement in safety, particularly as DP poles are those climbed most frequently.

The wood pole is unique among telecommunications equipment because it is a product used in its natural form with a very limited amount of processing. Being a natural product, its properties are also potentially very variable and the production of a safe, durable product requires a combination of subjective and objective selection and analysis. The widespread introduction of a new species of wood or a new preservation process must be approached with considerable caution, for many years are likely to elapse before a valid assessment can be made of their performance, and it can be costly to recover from an unsuccessful trial. The capital cost of the wood pole is low in comparison to the labour and transportation costs involved in getting it to site, erected and wired or cabled; this encourages a conservative approach to changes in long-established and proven materials. This reservation does not apply to the hollow pole, which, as a manufactured product, can be designed at the outset for a much more predictable performance.

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USES OF POLES IN THE NETWORK

Local Distribution

About 25% of all poles in use provide overhead DPs, commonly called *distribution poles*; about two out of every three customers are supplied with telephone service by this means. An overhead DP can have up to 20 feeds radiating from the pole head (Fig. 1(*a*) and 1(*b*)); formerly, open-wire feeds were used, but most have been replaced by dropwire cables. A single span suffices for 80% of such feeds, but, where more than one span is necessary, light poles are used for intermediate supports. According to the number of dropwires likely to be fitted to a distribution pole, a medium or light wood pole is used; alternatively, a hollow pole may be installed.

Aerial Cables

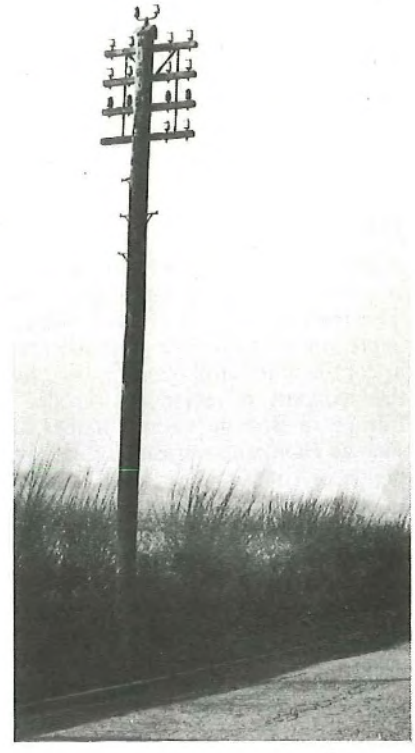
The other major application for poles is to support aerial cables (Fig. 1(*c*)). Such cables are likely to be heavy and the wind forces high, so a pole route for such cables needs to be designed with care. Medium poles are normally used, although many of the former stout type are still in use, often reduced in height compared to their original condition when they would have carried many open-wire circuits. Staying of poles on an aerial cable route is necessary where a change of direction of the route takes place or where a cable suspension wire is terminated.

Open-Wire Routes

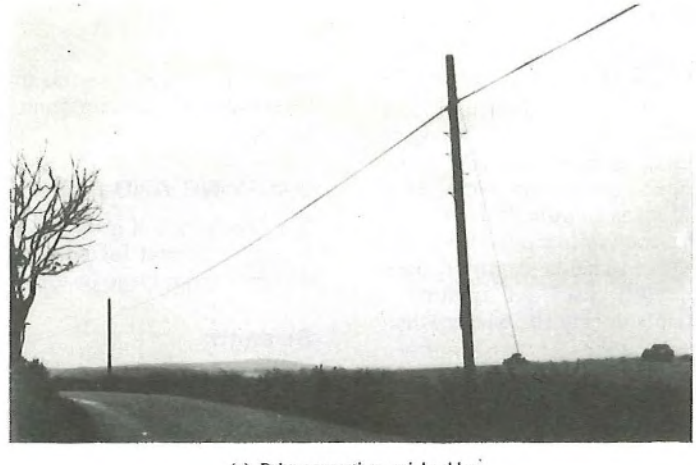
Open-wire systems were formerly the principal means of carrying telephone and telegraph circuits, but few remain, the remainder having been displaced by underground or aerial cables. The routes that still exist are found in the sparsely populated and remote areas (Fig. 1(*d*)). Ice accretion is the major hazard on such routes, and the excess mass of the ice and increased windage as a result can lead to a pole being displaced or broken. Early volumes of the *Journal*[1–3] record a number of events where very extensive damage resulted from 'ice storms'; for example, a blizzard on 27/28 March 1916 caused 6994 poles to be broken or felled, and another 26 551 deflected!

(*a*) A typical wood distribution pole

(*b*) A hollow distribution pole



(*d*) Open-wire route poles



(*c*) Poles supporting aerial cables

FIG. 1—Typical applications for telephone poles

Other Uses

Very tall wood poles were commonly used at Post Office radio stations to support antennae. Heights generally ranged from 15 m to 32 m. The taller examples were made up from two or three selected poles that were spliced together by scarf joints to achieve the desired height. Such poles were used as guyed masts and were only shallowly founded, the desired stability being gained by the use of staying. The use of such poles was discontinued in the 1960s and light steel masts were used instead.

THE WOOD POLE—FUNCTIONAL REQUIREMENTS

The qualities needed for a pole are:

(*a*) *Strength* It must be able to withstand the bending and compressive stresses imposed by wire and cable loading, staying, wind and ice, and staff working aloft.

(*b*) *Stiffness* Excessive deflections should not occur under load. A pole that bends noticeably under static loading is visually unacceptable. A pole that sways excessively in the wind may impose significant fluctuating loads on wires and cables, leading to their premature failure by fatigue.

(*c*) *Long Life* The timber should be naturally resistant to decay or readily impregnated with preservatives. New timber should be free from defects which could reduce its life.

(*d*) *Toughness* The pole should withstand the relatively heavy handling and transportation likely to occur at several stages from felling the tree to erecting the pole.

(*e*) *Appearance* A clean, straight, uniformly-tapering pole is more acceptable to the public, particularly in urban environments.

(*f*) *Reliable Supply* It is most desirable that the sources of supply for the material used are reliable and consistent.

(*g*) *Cost* As large numbers of poles are purchased each year, capital cost is significant; but this must be balanced by the high labour costs involved in the erection, testing and renewal of the pole in the field. The life of a pole is very long compared to most telecommunications plant.

THE TREE

About 85% of all the poles in service are of the species *Pinus sylvestris*. *Pinus sylvestris* is one of the three coniferous trees truly native to the British Isles, and is commonly called *Scots pine* or *Scotch fir*. The species also grows very widely in continental Europe and is the most important timber in the economy of northern Europe. When imported from Europe to Britain, various names are used to describe it, such as *European redwood* or as a *redwood* prefixed by the region or country of origin (for example, *Baltic redwood*). (The terminology can be confusing as *redwoods* in America and Asia are of completely different species and of sequoia or related families.) In addition to *Pinus sylvestris*, other species have been tried for poles, with varying degrees of success. Douglas fir, Corsican pine and larch have been found to be satisfactory and purchased in quantity in recent years.

All the species of tree used for poles by British Telecom (BT) are coniferous and therefore are *softwoods*. Softwoods are not distinguished from *hardwoods* by the degree of hardness of the wood (for balsa is a hardwood!), but by the form of the seed and the cell structure. Softwoods are classed as *gymnosperms* (literally, *naked seeds*) and bear cones containing naked seeds. The hardwoods are one group of the *angiosperms* (literally, *vessel seeds*) and the seed is enclosed in a seed case. Softwood leaves are typically needle-like and hardwoods are broad-leaved. The cell structure of the two classes of tree also differs. The hardwoods have three types of cell—vessels, fibres, and parenchyma—and the softwoods only two—tracheids and parenchyma. In a hardwood, the function of the fibres is to impart strength to the tree and the vessels are the conducting tissues for the flow of sap. In a softwood, the tracheids combine both functions. The parenchyma in both cases act as storage tissue and hold reserves of nutrients during the winter when sap movement is minimal.

The trunk or bole of a tree (as also branches and roots) is covered with a layer of cells called the *cambium*, which is a thin layer between the bark and the wood. In the growing season, the cells in the cambium divide to produce many new cells, those on the inside becoming wood and those on the outside becoming *bast*. The wood cells, as they grow, push the cambium and other outer layers outwards and so increase the diameter of the trunk.

When the cambium cells divide in the spring, large cells are produced on its inner layer and these constitute the *early wood* or *spring wood*. As the growing season progresses, the cells that are produced become smaller, denser and darker (known as the *late wood* or *summer wood*) until the end of the season, when they are very small. In Scots pine/redwood, these annual rings are quite distinctive because of the cell size and colour changes. In any one ring, the late wood typically occupies about one quarter to one third of the thickness of the ring. The succession of annual rings to a depth of 25–75 mm constitutes a distinctive zone called the *sapwood*. This is living tissue and is active in the storage and transport of nutrients and water from the roots to the leaves. As new rings are added, the existing sapwood progressively hardens or lignifies as the cells fill with lignin, a hard durable substance, and changes into the *heartwood*, which is, in effect, dead wood and functions solely to impart strength to the tree. As the sapwood is softer and less dense than the heartwood, it is more prone to decay, but when the tree is converted to a pole this is fortunately counteracted by the sapwood being more permeable and so takes up preservative more readily. The visible distinction between heartwood and sapwood varies between species: it is moderately well marked in Scots pine/redwood and Douglas fir, but indiscernible in others such as larch (Fig. 2). In the leaves, photosynthesis occurs and the substances required for growth of the cambium travel down the tree as sap in the bast.

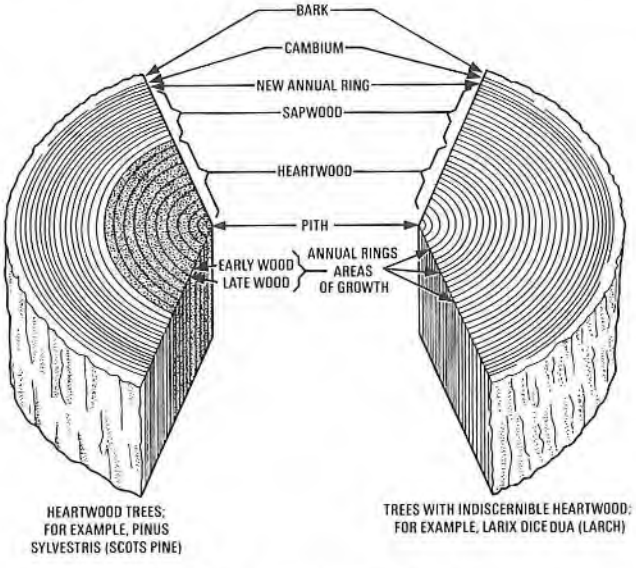


FIG. 2—Tree cross-sections

GROWING AND PROCESSING

The conditions of growth are important for producing satisfactory material for poles, which must be strong, straight, and free from large or dead knots or other defects.

Strength

Climatic changes affect the growth and spacing of the annual rings; the closer together and more evenly spaced they are the greater the inherent strength and resistance to decay of the timber. In general, as the tree gets older, the timber gets denser and stronger, and so a tree grown slowly is more likely to have a greater strength size-for-size than a tree grown at a faster rate. In Britain, owing to the mild winters and long periods of seasonal growth, the annual rings tend to be farther apart. In the colder parts of northern Europe, where summers are short and the long winters severe, the texture of the timber is more solid and the grain closer. Of home-grown trees, those grown in the north of Britain, where climatic conditions are more severe, are more likely to produce timber of the required quality for use as poles. Although a definite correlation between ring spacing and strength cannot be established, it can be stated that trees grown either very rapidly or very slowly produce weaker timber. In the case of Scots pine/redwood, timber with less than 8 rings to each 25 mm of radius is not accepted for use as poles; hardgrown imported redwood commonly exhibits 20 rings or more per 25 mm.

Ring width is only a rough guide to likely pole strength; factors such as the proportion of late to early wood, density and various defects need also to be taken into account

when the suitability of timber on grounds of strength is determined.

Straightness

If trees are grown in a forest close together, straight growth is produced as lateral branches are discouraged at lower levels and each tree competes with its neighbours for light and air. Small deviations from straightness are permitted in the specifications for poles. Crooked poles are not necessarily weaker than straight poles but they are unsightly.

Felling and Initial Processing

Trees have customarily been felled for use as poles when there is little or no movement of the sap in the colder months of the year, the argument being that the timber is then dryer. There is, however, no evidence to support this widely-held view concerning dryness. The main advantages of winter felling are firstly, the risk of fungal and insect attack is minimised and, secondly, over-rapid drying is avoided, which could cause splitting especially at the cut ends.

The tree is cut as near to the ground as possible to conserve as much of the natural butt as practical to provide a good foundation. However, with the advent of mechanised pole erection, excessive fluting at the butt is undesirable, and the natural butt may be cut back before processing to give a diameter to suit the hole drilled by an earth auger. All the top branches are lopped off before the tree is drawn out of the forest to a clearing where the outer bark is stripped off. The logs are then transported to the contractor's works, where they are examined by a BT pole inspector and, after selection, are dressed by machine to remove the inner bark, the swellings of wood around the knots and excessive sapwood on oversize poles.

Seasoning

A tree when felled is 'green', that is, its cells are still full of sap, and the moisture at this stage can be equal to or greater than the dry mass of the woody material. A pole in this condition would be especially prone to decay and could take up little preservative. It therefore has to be seasoned. The poles are stacked so that air can flow freely around each pole for six months to two years, according to pole and weather conditions. Kiln drying to accelerate the seasoning process under controlled conditions is often used for producing construction timber and is being investigated as a means of speeding up the seasoning process for poles. During seasoning, the moisture content is reduced to about 25% of the mass of an oven-dried sample of the wood, and the wood cells harden. In addition, a number of minor longitudinal splits, known as *checks*, appear in the sapwood. These checks assist in penetration of preservative, although large ones, called *shakes*, are undesirable.

Careful seasoning is an important factor in determining pole life. For example, the prevalence to decay of poles creosoted in the period 1914–28 has been noted[4]; the seasoning period was then shortened materially to cope with the demand for poles.

TIMBER DEFECTS

Because trees are very variable in their characteristics, there is a limit to the objective criteria which can be used for selecting suitable material for poles. Several features, such as dimensions, can be specified, but much depends on the experience of specialist pole inspectors employed by BT. The significance of some possibly deleterious features is indicated below. Results[5, 6] from the testing of poles in America and by BT have shown that it is difficult to quantify the effect of specific defects, but general statements can be made.

Knots

Knots are an inevitable feature of timber as they mark where branches existed. The knots may extend to the surface if the branches were present at felling, or they may be overgrown by later growth if, at an earlier stage of the tree's life, the branches had broken off or had been deliberately pruned to produce better quality timber. Trees grown close together tend to yield timber with smaller knots as the main branches develop higher up the tree. Branches on Scots pine/redwood develop in rings or *whorls* around the tree (Fig. 3) and, if a

FIG. 3—Branch formation on a European redwood

ring of knots is too large, the pole could be weakened; limits are placed on the size of individual knots and on the amount in the circumference occupied by knots. In the case of Douglas fir and larch, the knots are scattered irregularly.

Dead knots are those not firmly embedded in the rest of the wood. These are usually the result of the presence of a decayed branch. Such knots are likely to have a gap between them and the living wood, and this gap can act as an entry point for decay. They are also likely to weaken the pole.

Checks

Checks are small longitudinal splits of shallow depth resulting from the separation of the fibres along the axis of the pole and occur during seasoning. As stated above, these can be beneficial in facilitating the penetration of preservative during creosoting.

Shakes

Shakes are more severe in extent than checks. Large shakes can penetrate to some considerable depth and, if they open up

FIG. 4—Cross-section showing shakes penetrating to the heartwood, where decay is well advanced

more after creosoting to the extent of exposing unprotected wood, they could act as seats for decay (Fig. 4). No identifiable reduction in the strength of a pole has been noted in bending tests, although shakes must reduce the shear strength of the pole. Another form is the ring shake, where the separation of the wood tissues follows a growth ring and so is not visible unless the pole is sectioned.

Spiral Grain

Sometimes a pole grows as a straight column but the grain of the wood forms in a spiral manner. This is undesirable for trees intended for conversion to sawn timber for the construction industry but, unless severe, probably has little influence when the tree is used as a pole.

Proportions of Sapwood and Heartwood

When timber for poles is selected, a compromise is needed between the ease with which sapwood can be impregnated with preservative and the higher strength of heartwood. In the case of Scots pine/redwood, poles with sapwood extending to about one third of the radial depth are preferred.

Asymmetric Growth

With asymmetric growth the annual rings grow unevenly around the circumference of the tree and an eccentric cross-section results (Fig. 5). A pole made from such material has a varying strength and stiffness according to the direction of loading, and compression wood may also be present (see below).

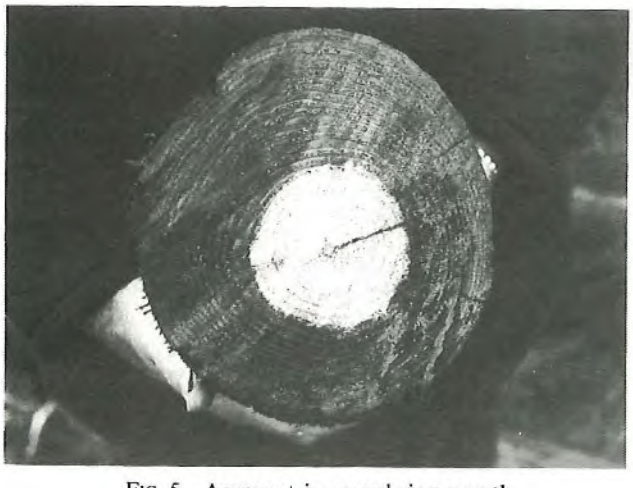


FIG. 5—Asymmetric annual ring growth

Brashness

Brashness is a term used to describe the condition when the natural toughness of the timber is appreciably reduced. Toughness is a measure of the material's resistance to the propagation of cracks during stressing, when large quantities of energy are absorbed. The typical pole fails slowly, with considerable disruption of the wood occurring over a long length (as in Fig. 6). A pole that is brash fails suddenly and

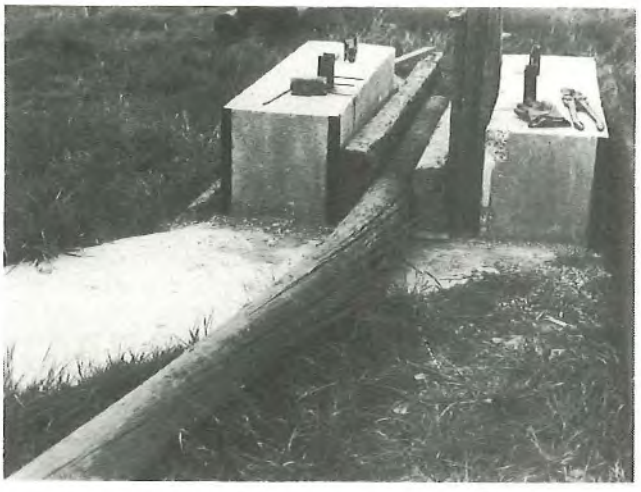


FIG. 6—Typical fracture of pole under test

FIG. 7—Failure of brash pole

breaks off quite cleanly (see Fig. 7). In normal wood, the tensile strength is usually substantially higher than the compressive strength; in brash wood, there is less difference in strengths and this factor contributes to the clean nature of the break.

Several causes have been identified as leading to brashness[7]; the most frequent cause in softwood is the presence of compression wood in the tree. As a tree grows, some wood may have tension or compression 'locked in' and this has abnormal lignin and cellulose contents.

In 1979, a large-scale investigation into the properties of a batch of poles, all of which exhibited brash fractures during test, showed that such poles were only marginally weaker than non-brash poles.

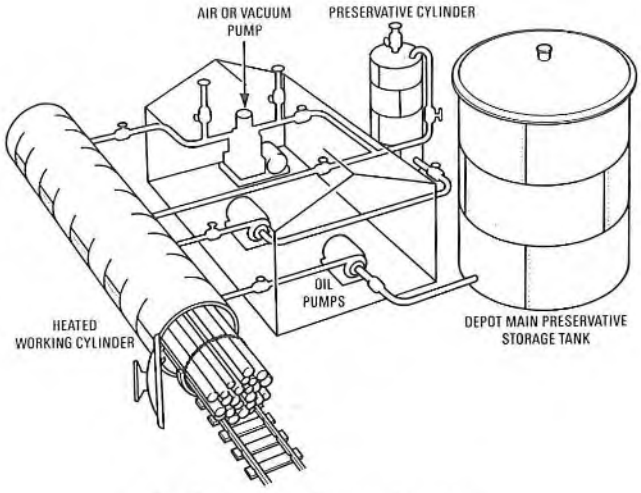


FIG. 8—Layout of creosoting plant

Decay

Wood decay is caused by the growth of fungi, the spores of which feed on the wood and cause it to disintegrate. Fungal growth generally needs warm, damp and oxygenated conditions to sustain it, and so exterior timbers are especially vulnerable, particularly when in contact with the ground. Softwood has only moderate resistance to decay, and a Scots pine pole could be expected to last only about five years, unless treated with preservative. Fungal decay can attack the timber in the growing tree, after felling, during seasoning, and finally in the standing pole. Several fungi cause rot but one is of especial relevance in the present context for, even when treated with creosote, softwood does not acquire an indefinite life. The fungus which accounts for most of the decay of such wood is *Lentinus lepideus*, and it is remarkably resistant to creosote, albeit in low concentrations[8]. It is economically the most important fungus causing decay of poles, railway sleepers and softwood fencing. *Lentinus lepideus* can attack wood that has up to about 15 kg/m^3 creosote content. Although poles are initially impregnated with about eight times this amount, the concentration declines over a long period of time and the wood becomes vulnerable to decay. As the creosote concentration further reduces, other fungi are able to attack the wood, notably microfungi which lead to soft rot. Deterioration of a pole can be accelerated if fungal spores can gain access to the interior of the pole, as in the case of cracks in the wood opening up after preservation, the heartwood is likely to be attacked, particularly as it does not take up creosote as readily as sapwood. The exterior of the pole may then look sound, yet the interior may be severely decayed.

POLE PRESERVATION

Some form of preservative process is essential to achieve an acceptable life for a pole. A number of different types of preservative have been tried, but creosote has proved to be the most acceptable. Creosote not only inhibits fungal decay, but also deters attacks from boring insects, although insect attack is only a minor problem in the UK.

With the advent of coal-gas production on a large scale and the distillation and use of the by-products, it soon became evident that in coal-tar creosote a most efficient preservative had been found, and it was used extensively as the standard preservative for wood poles used by the Post Office from the early 1900s onwards. Creosote is a complex mixture of distilled tar oils, and its constituency varies according to the nature of the coal tar and control over the distillation process. The creosote used for preserving poles is described in the appropriate British Standard[9] as consisting 'wholly of a blend of distillates of coal tar and shall be free from any admixture of petroleum oils or oil not derived from coal tar'. It is specified in broad terms in the form of the maximum and minimum percentage volumes of distillate at four discrete temperatures, its phenol content and insoluble matter.

With the introduction of North Sea gas and the consequent decline in the production of coal-gas, together with its associated by-products, a new source of supply for creosote had to be found; this resulted in the bulk of the creosote now used originating as a by-product of the carbonisation of coal to produce smokeless fuel.

Creosoting is carried out by the Rüping (often anglicised to *Rueping*) pressure process, which was first used for poles in 1913 (Fig. 8 is a schematic drawing of a creosoting plant). In this process, fully-seasoned poles are loaded on trucks and wheeled into the heated working cylinder, which is then sealed. The sequence of operations for treatment of Scots pine/redwood is as follows:

Stage 1 The air in the cylinder is pressurised to about 3·45 bar to compress the air in the wood cells.

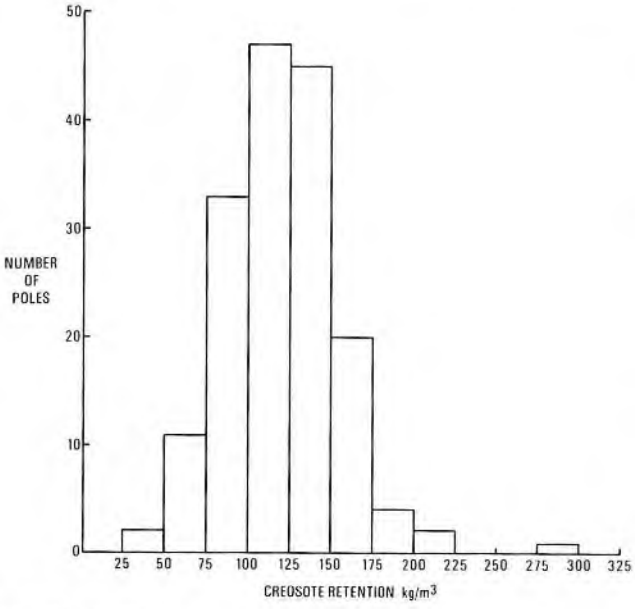
Stage 2 Without the air pressure being released, hot creosote at 80°C is transferred from the preservative tank to the working cylinder until it is full. The pressure is then increased to 12·5 bar and extra creosote is pumped in from the main storage tank until the requisite amount of creosote has been absorbed. This is determined on the basis of an injection of 240 kg of creosote for each cubic metre of timber loaded into the working cylinder.

Stage 3 The pressure is released, the surplus creosote drained off and a vacuum applied for at least one hour. This drives out the surplus creosote within the wood cells while leaving a coating on the cell walls; about 115–128 kg of creosote per cubic metre is retained in the timber.

Stage 4 The vacuum is released and the timber removed from the working cylinder, at which stage the poles appear dry. They are then taken to pole stacks and allowed to weather prior to issue.

The Rüping process is successful in forcing creosote to penetrate the sapwood of Scots pine/redwood; but, in the case of larch and Douglas fir, there is a greater difficulty in impregnating the sapwood and it is necessary to vary the above process. The initial air pressure stage is omitted and the creosote pressurisation and subsequent vacuum processes are modified. This method is known as the *Lowry process*. Timbers that do not take up creosote readily may be incised by making cuts parallel to the fibres to facilitate impregnation.

In the Rüping process, the minimum creosote retention specified up to 1951 was 75 kg/m³; since 1951, the requirement has been increased to 115 kg/m³. A statistical survey in the late-1940s indicated that 5% of poles aged 28 years could be expected to be decayed; increasing the creosote retention was designed to substantially extend pole life. It should be noted that the retention values cited represent the minimum uptake per cubic metre of creosote for the batch of poles in the working cylinder. Within the batch, individual poles may retain appreciably more or less than the average for the batch, as illustrated in Fig. 9. However, poles with a low uptake are not necessarily more prone to decay as they are likely to be denser and more resistant.



Size of batch: 165 poles
Average creosote retention per batch: 119 kg/m³
Standard deviation: ±32 kg/m³

FIG. 9—Variation of creosote retention within a batch of poles

The Rüping method is known as the *empty cell* method, as the surplus creosote is removed from the wood cells. Prior to 1913, the Bethel *full cell* process had been used. In this method, the poles were placed in a vessel, initially subjected to a vacuum to remove air from the cells and the vacuum was then replaced by hot creosote under pressure. As the poles were not subjected to a further vacuum, the creosote was left in the cells—hence the name of *full cell*. The minimum absorption of creosote was specified as 192 kg/m³, although up to 320 kg/m³ could be taken up. The Rüping method was adopted as it was more economical in the use of creosote, the preserved poles were of lower mass and a cleaner and more socially acceptable pole resulted, with much less creosote bleeding through to the surface. The relative long-term efficiency of the two methods does not appear to have been explored.

After the pole is creosoted, it is most desirable to preserve the creosoted layer over the whole surface of the pole. At one time, poles were slotted to take arms and bored for the arm bolts at the roadside. Such activities exposed less-effectively preserved wood, and it has been shown[10] that decay was almost as prevalent near the top of the pole as it was at the ground-line. In the mid-1930s, a change was made so that the poles were pre-drilled and pre-cut before creosoting to provide a flat surface of sufficient length to accommodate the arms and arm bolts. As few poles are fitted nowadays with arms, poles are no longer pre-cut, although bolt holes are still provided. Where it is necessary to fit an arm, a specially-shaped steel arm-seat is used to enable the arm to sit on a flat surface without the need to cut the pole.

Creosote is not completely stable in the pole and with time a slow reduction of the degree of protection results[11,12]. The more volatile fractions of creosote are gradually lost by evaporation, and changes occur as a result of oxidisation and polymerisation. Perhaps most importantly there is a downward flow of creosote in the pole and some is lost from the buried section into the surrounding soil. This leakage is beneficial and helps to sterilise the surrounding soil. However, if that soil is disturbed or the pole re-used in a new position, this protection is lost. It has been found that otherwise sound poles have decayed rapidly when moved to a new site, and this may have been the cause. It has also been noted that the amount of creosote retained in a pole falls off rapidly above ground level, and so planting a pole in a deeper hole or raising the ground level around an existing pole is likely to lead to an acceleration of decay. Pole testing parties are required to apply creosote liberally around the exposed base of the pole and in the backfill material after checking the condition of the pole below the ground-line to avoid such decay acceleration.

Many other methods of preservation have been examined and some subjected to extensive trials but none has yet superseded creosote. There have been two main classes of alternative preservatives, namely water-borne salts and organic solvents. The general requirements of a preservative for pole applications are that it must

(*a*) provide long-term protection to the pole; that is, it must be chemically stable and not easily leached out of the wood;
(*b*) penetrate the wood readily;
(*c*) be economic, so that any extra costs incurred in improving preservation are balanced by savings accruing from a longer pole life;
(*d*) have high toxicity to fungi and insects but low toxicity in other respects, endangering neither BT staff, the public or animals;
(*e*) not cause accelerated corrosion of pole fittings; and
(*f*) give a clean and pleasing finish to the pole.

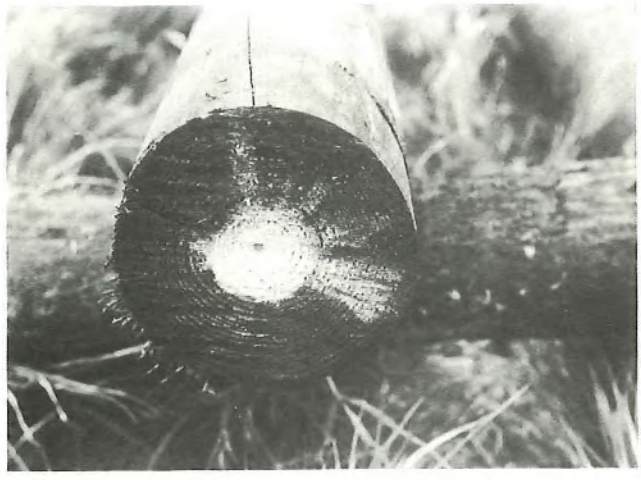
LIFE OF A POLE

The life of a pole is dependant on factors such as

(*a*) tree species;
(*b*) growing conditions;
(*c*) method and effectiveness of preservation (compare depth of penetration in Figs. 10(*a*) and 10(*b*));
(*d*) environmental conditions at pole location—soil type, air and ground temperature, air humidity, pollutants in atmosphere or ground water, etc;
(*e*) effectiveness of routine maintenance when the pole around ground level is re-cresoted during the pole examination procedures; and
(*f*) physical damage by hedge-cutters, vehicle impact, lightning strokes, woodpecker activity etc.

The environment clearly plays a part in determining pole life; there are indications, for example, that the mild climate of South-West England facilitates more rapid fungal attack than the cooler conditions in Scotland. Another factor which may be significant in northern Britain is the continuous wetting with acidic ground water, common in moorlands, inhibiting decay. The determination of the average physical life of a pole, that is, the life taken to the point where the pole is no longer safe to retain in use, is a difficult task. The main statistical sources for such calculations are the records of pole purchases for the whole of this century, and the returns which result from the monitoring of the routine pole-testing programme. It is necessary to obtain a realistic estimation of pole life to provide data for economic purposes

(*a*) Hardgrown timber with restricted creosote penetration



(*b*) Deep creosote penetration

FIG. 10—Creosote penetration

as well as for design and safety considerations. The calculation is complicated by such factors as the following:

(*a*) The service life may be substantially shorter than the pole's physical life, and the pole may be scrapped although it is still sound.

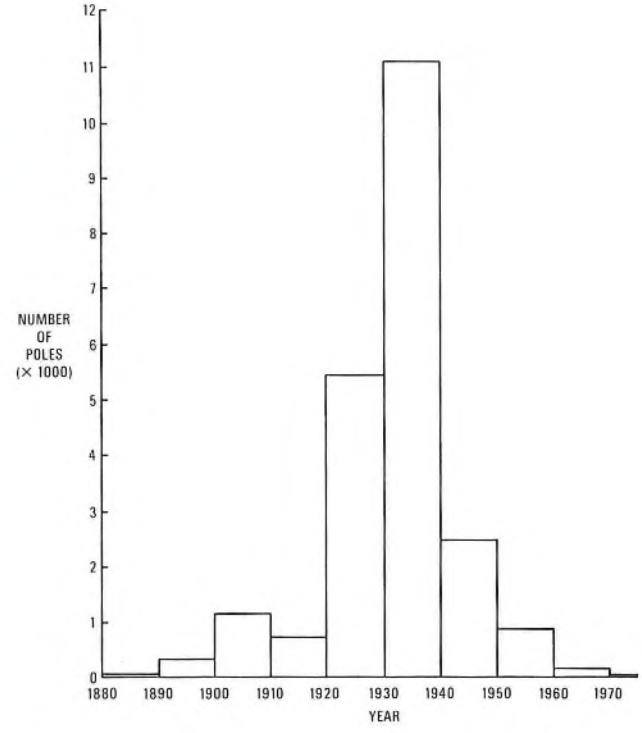
(*b*) Standards for poles and their preservation have changed with time.

(*c*) Many poles are reissued after recovery, and at one time re-creosoting was also adopted.

(*d*) Sample surveys indicate that, because pole testers tend to err on the safe side, some 10% of poles classed as decayed are in fact sound.

(*e*) Poles can be classed as defective for reasons other than decay.

Two recent independent studies have arrived at average lives of 42 years in one case and 44 years in the other. One of these studies also concluded that the average service life was 33 years and the average life in one location 29 years. It is to be expected that, as the post-1950 poles with the higher creosote retention constitute an increasing proportion of the poles in service, the average life of the population of poles will increase substantially.



Results of a nationwide survey of the date marks on all poles made 'D' during the period Sept. 1975–Sept. 1976. 26 437 'D' poles were found, but of these 4224 poles had no date mark and so are omitted from the histogram

FIG. 11—Histogram of the age of poles classified 'D'

Fig. 11 shows the result of a national survey to determine the age of all poles classified as 'D' (defective) for whatever reason over a one-year period. The peak value at year 1936 should not be taken as directly indicating the average life of a pole, as that year also corresponds to the period when pole issues nationally were twice the average (Fig. 12), and

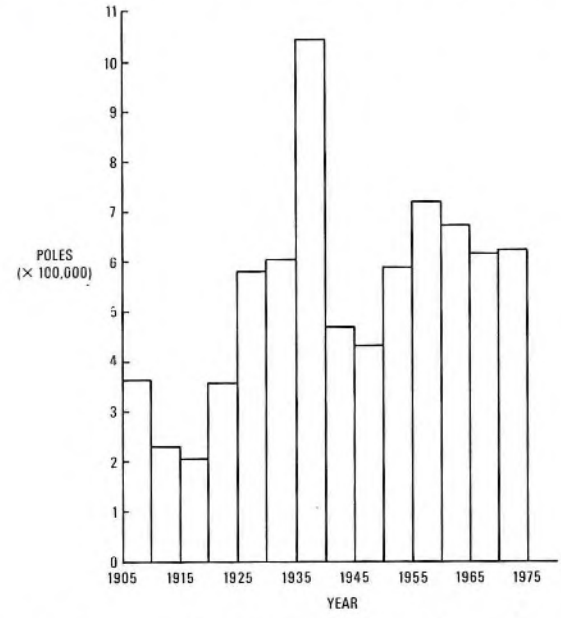
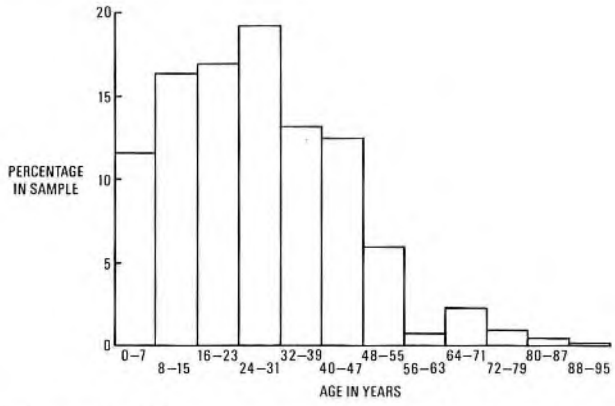


FIG. 12—Histogram of national pole issues during the period 1905–1974

so a 'bulge' in 'D' poles at that age would be expected simply because proportionately there are likely to be more in the field. Applying corrections to account for variations in annual pole issues has the effect of showing an increase in the mean life.



Random sample of 3351 poles, representing all those visited by pole testing parties in the South West Region in one week in March 1976

FIG. 13—Typical age distribution of poles

A typical age distribution of poles in service (Fig. 13) shows that many poles survive for over half a century. It is most unusual for any pole to require replacement because of decay in less than 20 years, although replacements are sometimes necessary in less than 20 years as the poles may be regarded as unsafe to climb for a variety of other reasons—unsafe location, physical damage, inadequate depth due to ground level alterations subsequent to erection, or located such that they cannot be examined for decay. Many older poles are scrapped not because of a 'D' classification, but as a result of technical change; for example, a recovered stout pole, even if sound, would not now be reissued.

TYPES AND MARKINGS

Four classes of wood pole exist: medium (M), light (L), extra-light (XL) and stout (S). Classes XL and S are obsolete, but some still remain in service. The stout pole, last issued in 1966, was extensively used on major open-wire routes and is now likely to be found only in a reduced-height form supporting aerial cables. Extra-light poles were purchased from 1935 onwards to assist in reducing the costs of rural work in circumstances where the loading was very light with no more than four wires on the pole. However, issues of XL poles ceased in the early-1970s, although many such poles remain in service. Light poles are available in standard lengths from 6–13 m and medium poles from 9–15 m; Table 1 lists the current metric range of sizes.

TABLE 1
Current Range of Pole Sizes

Length (m)	Minimum Diameter at Top (mm)	Maximum Diameter at Top (mm)	Minimum Diameter 1·5 m from Butt-End (mm)
LIGHT POLES			
6	125	150	150
7	125	150	160
8	125	150	170
8·5	125	150	180
9	125	150	180
10	125	160	185
11	125	160	195
13	130	170	210
MEDIUM POLES			
9	150	180	220
11	150	190	240
12	150	190	250
13	160	200	260
15	165	210	290

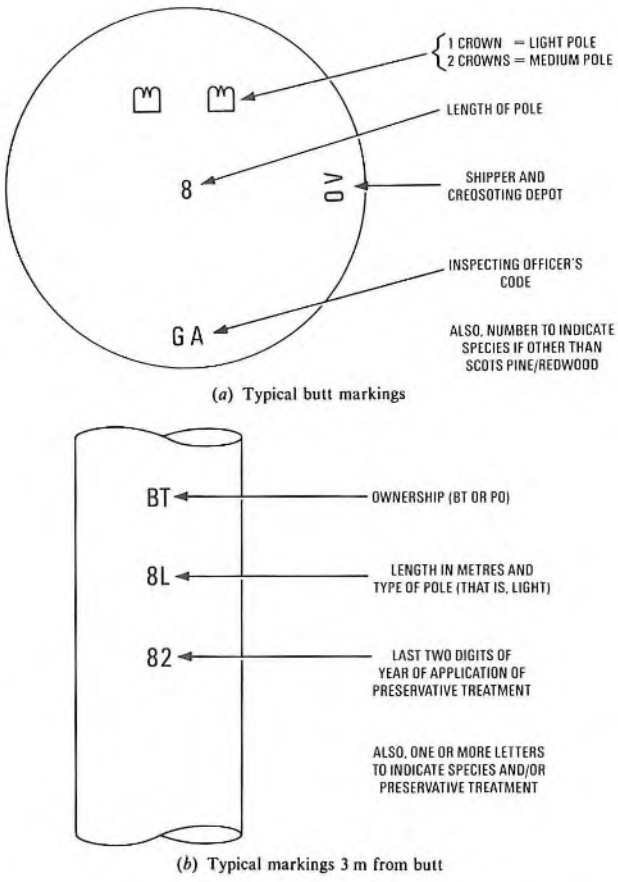


FIG. 14—Pole markings

Poles are stamped or gouged in two places, as shown in Fig. 14, to enable details of the pole to be determined readily.

In the case of poles dated 1931 or later, if there are no letters indicating species or preservative treatment, the pole can be assumed to be Scots pine/redwood and preserved by the Rüping process. If a pole has been shortened at the tip and re-issued, a fourth line indicating its new length will have beeen added to the 3 m mark. The 3 m markings also function as a simple means of checking the depth of the pole in the ground.

(To be continued)

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