WOOD POLES AND FITTINGS

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WOOD POLES

Introduction

The ideal support for overhead conductors should possess the following characteristics:-

Adequate strength

The pole should be capable of withstanding the bending stresses imposed upon it by the tension in the conductors, which will operate in the direction of the line, and by the wind pressure on the conductors and the poles, which may operate in a direction at right angles to the lines. In the case of stayed poles, the pole should also be strong enough to withstand the buckling stresses which will be imposed by the combined effect of the tension in the conductors and in the stay. Normally, a stay is fitted to a pole only to counteract the bending stresses imposed by the conductors at angles in the line and at terminal positions. In other positions the tension in the conductors on one side of the pole is balanced by the tension in the conductors on the opposite side. In deciding the strength of pole which should be used, a reasonable factor of safety, depending upon the material to be used for the pole, should be attained.

Uniform and reliable quality

This is necessary to enable the class of pole required to carry a particular load to be selected in advance, and so avoid the tedious task of calculating the strength of each individual pole.

Long Life

The pole should not be liable to early decay or corrosion. Its life should be at least equal to that of the conductors, otherwise considerable expense will be incurred in renewing it, particularly if it is carrying a heavy load.

Cheapness

The overall cost of the pole, including initial cost and maintenance charges when in position, should be as low as possible, e.g. the maintenance costs will be greater for a pole which requires frequent painting than for a pole which does not.

Reasonable weight

The weight of the pole will influence the cost of transport and handling, and should therefore be as light as possible.

Ease of erection

The pole should be capable of being satisfactorily erected without the use of special tools and appliances. The preparation of the foundation for the pole should not be unduly expensive, and it is an advantage if only the minimum size of hole to accommodate the pole need be excavated.

Satisfaction in service

When once erected, the pole should remain a stable structure with no undue swaying or vibration which would cause additional stresses in the conductors. The pole should also allow for the simple and secure attachment of any fittings that may be required on the pole during its lifetime.

Availability

The pole should be easily made and the material obtainable from several sources so that adequate supplies will always be available.

Each of the foregoing factors should be considered when deciding the type of pole to be used in given circumstances. The relative merits of each of the features will, of course, depend on the purpose for which the pole is required, e.g. if a small number of poles is required, then the fact that the pole is not readily available in large quantities is not so important as when thousands of poles are required within a short period.

In this country, most of the poles used in telecommunications are of wood, although, as a result of the post-war timber shortage, trials have been made with steel and concrete poles and some tubular steel poles are in use on overhead routes. Wood, concrete and steel poles (e.g. the lattice type) are used in this country for power transmission, although concrete poles, which have been introduced comparatively recently, are mainly used for street lighting.

Abroad, however, steel poles have been widely used for overhead telephone routes as well as for power transmission. In many countries, such as India, the use of steel instead of wood is preferred since wood poles are very liable to attack by termites, other insects, and various fungi; in this country only the latter give rise to any trouble, attacks by insects being almost unknown.

Types of timber used

Timber is classed as hard or soft. The former comes from broad-leafed decidious trees e.g. those that shed their leaves every year, and the softwoods commercially belong to the coniferous type of tree.

Timbers that are economically suitable for telegraph poles are in the softwood group; the BPO obtains two thirds of its supply from Scandinavia and the Baltic regions (chiefly Finland) and the other third is homegrown.

The softwoods can be divided into two groups those with a clearly defined heartwood and those where the heartwood is indiscernible. The cell structure of this latter group makes the penetration of preservatives, described later, more difficult but they tend to be more naturally resistant to rot.

The tree most widely used is pinus sylvestris (pinus = a tree of the pinus (pine) genus, sylvestris = of the woods) commonly known as Scots pine, and when cut as timber may be known as redwood, Scots fir, red deal, Riga fir or Baltic redwood*.

**Due to local variation in the commercial names of timbers which is sometimes confusing, it is preferable to quote the botanical name of the tree from which the timber was derived.*

Portions of cut timbers of the two groups is shown in Fig. 1.

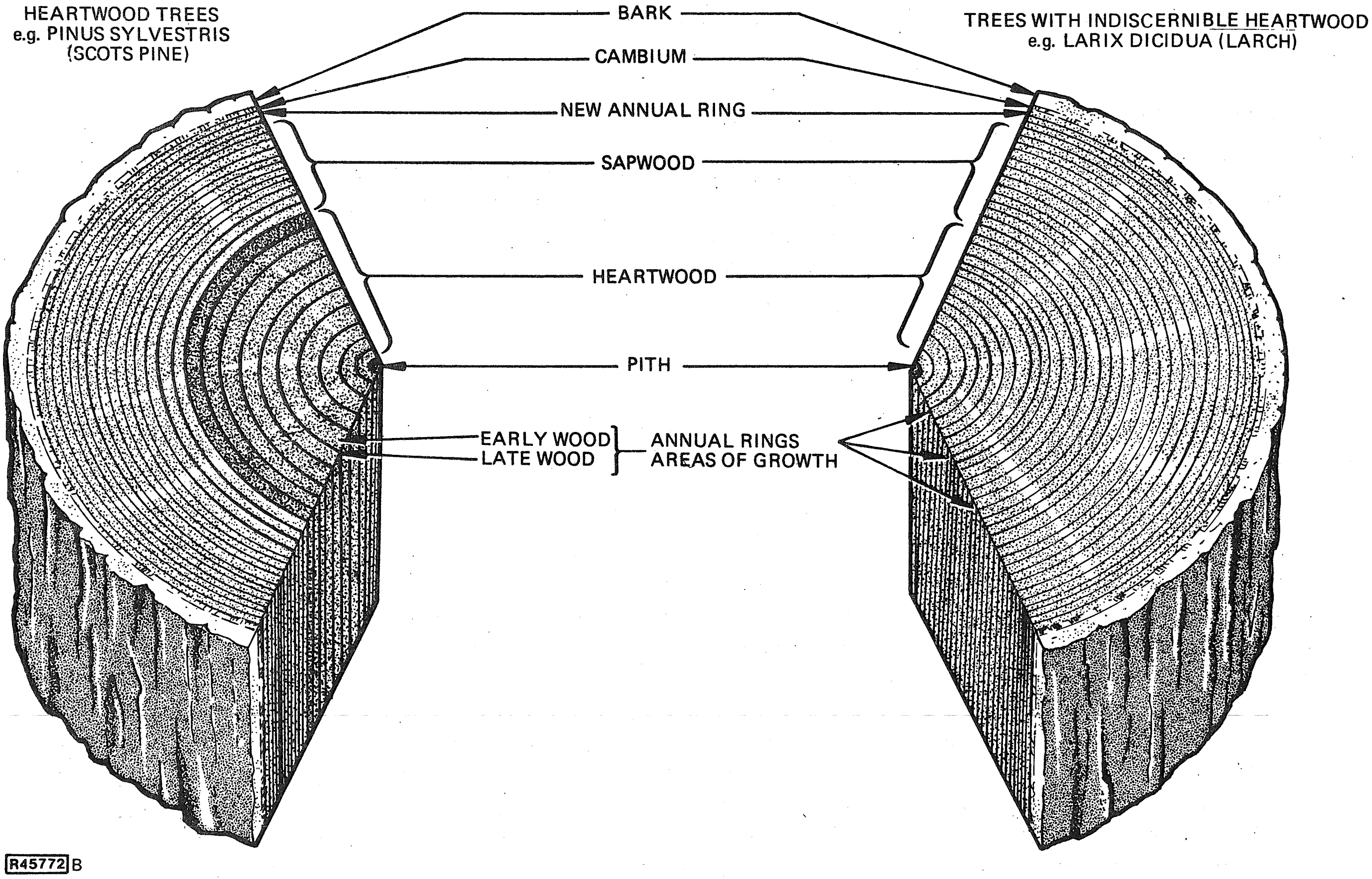


Fig. 1

Other timbers which may sometimes be used for poles are:-

The Larix group (Larch) obtained from Europe or homegrown

The Picea group (Spruce) obtained from northern Europe

Tsuga heterophylla (Western Hemlock) obtained from North America or homegrown

When a tree is growing, a watery substance, common sap, rises from the roots and travels via the cells in the sapwood to the leaves where it undergoes a change to return in the form of proper sap just below the bark (via the cambium). In doing so it deposits a sticky mass which hardens to form a new annular ring. Climatic changes affect the growth and spacing of the annular rings, the closer and more evenly spaced they are together the greater the inherent strength of the timber. In Britain, owing to the mild winters and long periods of seasonal growth the annular rings tend to be farther apart and less durable. 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 homegrown trees those grown in the north of Scotland where climatic conditions are usually more severe will produce a timber more of the required quality than that grown further south. If trees are grown in a forest close together this will produce a straight growth as lateral branches are discouraged and each tree is trying to outreach its fellows for light and air.

The wood near to the bark is called sapwood as it contains more or less unaltered sap, and being soft is more liable to decay than the heartwood which is more compressed and so harder.

The tree selected for felling should have reached maturity, that is, be of adequate size, of uniform texture, straight, and with undecayed heartwood. It should have no large dead knots especially knots forming a complete ring, squirrel bites or other defects. Trees are felled when there is no movement of the sap between the beginning of July and the end of February for foreign trees and November to February for homegrown trees.

The tree is cut as near to the ground as possible to conserve as much of the natural butt as possible to provide a good foundation. However, with the event of mechanised pole erection excessive fluting at the butt is undesirable and the natural butt may be sawn off before processing to give an even diameter, so that when trimmed, will be in the order of 300-375 mm to suit the earth auger. All the top branches are lopped off before it is drawn out of the forest to a clearing where the bark is stripped off. They are transported to a depot by wagon or floated down a convenient river, then shipped to this country. The logs are examined by a PO representative at the contractors works, and after selection, they are dressed by a machine which trims off the outer surface by means of rotary cutters whilst being fed through by a sharp toothed wheel set at an angle. This toothed wheel causes the spiral markings often seen on a pole.

A tree when felled is green, that is its cells are still full of sap, and has to be seasoned before it is useable. This is a natural bacterialogical process which in time breaks down the sugars, starches and resins in the sap, the cells harden, and the inherent strength of the timber is increased. These substances are dissolved in water within the cells of the timber and coupled with the seasoning is a progressive reduction of the moisture content to increase the timber's natural resistance to decay. This reduction must be done gradually otherwise uneven shrinkage of the fibres will occur causing distortion and splitting. Poles are stacked for seasoning as shown in Fig. 2, which allows a free flow of air around them, and in the case of pinus sylvestris will be left from 6 months to 2 years depending on conditions. Floating the logs down river after felling can assist the seasoning process as the flowing water can start the bacterialogical action of seasoning. The timber can contain up to 100% of its own dry weight of moisture and this has to be reduced to about 25% before preservation treatment can be applied. For most wood working timbers a figure of about 17% is considered to render the timber less likely to fungicidal attack.

As the soft sap wood will absorb moisture raising its moisture content, especially near the ground line when it is buried, rendering it liable to fungicidal attack, a preservative or antiseptic treatment is applied to conserve the life of the timber.

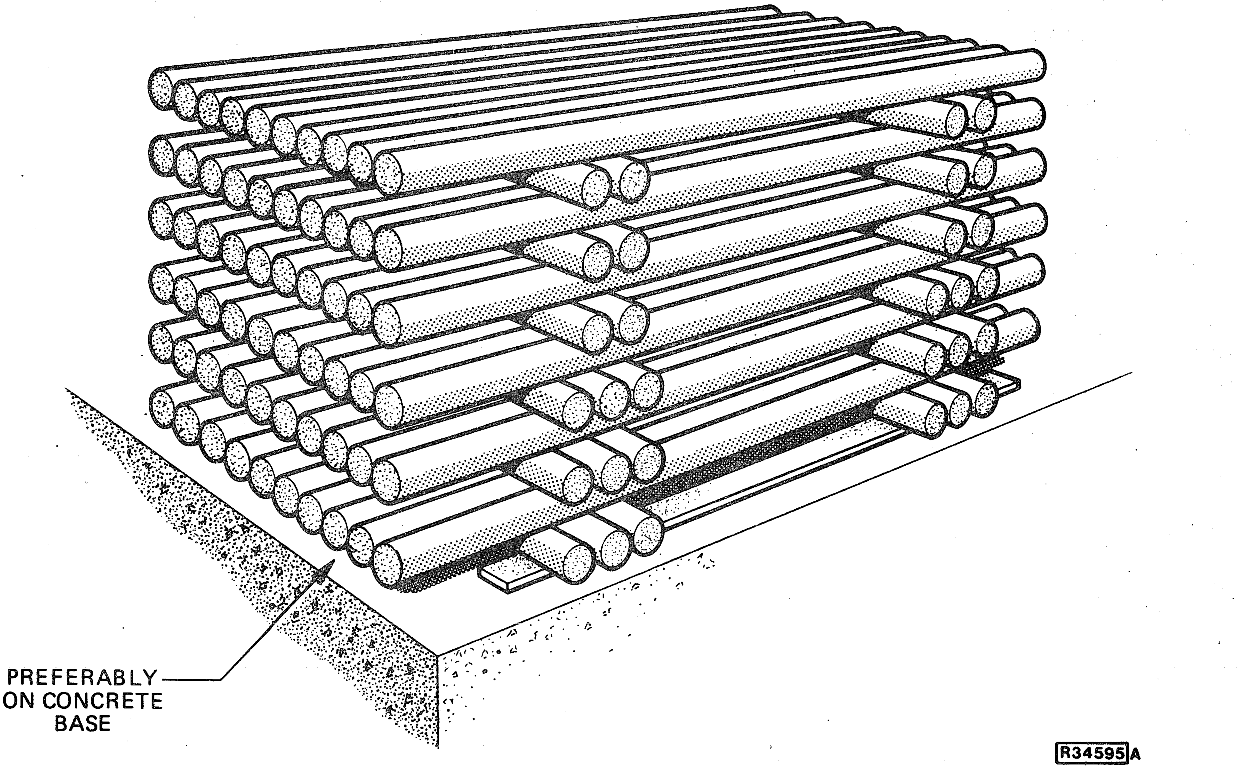


Fig. 2

Outline of causes of decay of Wood Poles

So far as is known wood suffers no physical or chemical change which would cause its deterioration as a result of age alone. It is however an organic material which can support the life of other organisms if the conditions are favourable and it is these organisms which cause its decay and ultimately its disintegration.

The principal causes of the decay of wood are,

(a) infection by wood-destroying fungi

(b) infestation by insects or marine borers

(c) weathering of the wood. This is the mechanical and chemical disintegration of the surface of the wood caused by the alternate shrinking and swelling under different weather conditions and also probably by the action of sunlight.

(d) mechanical wear including the abrasive action of dust and sand blown by the wind.

(e) chemical action. Strong acids and alkalis may decompose certain constituents of the wood causing disintegration.

There are two types of decay causing disintegration of the timber known as dry rot and wet rot. The former will occur where the moisture content of the timber is above 20% (the fungus usually responsible being merulius lacrymans) but not of such intense dampness as that which causes wet rot. Wet rot flourishes where timber is subjected to alternate wet and dry conditions. Such a condition exists at the ground line of a pole, although most cases of decay in this country are due to dry rot. The normal creosoting process preserves the pole from attack on the surface but spores of the fungus reach the unprotected sapwood via deep cracks (shakes) in the surface of the pole caused by shrinkage.

The area, about 300 mm above and below the ground line is the danger area, usually conditions being too dry further up the pole to support the fungus, but cases do arise where decay has occurred via shakes in the top of the pole and those caused through the attachment of fittings e.g. steps.

The fungus thus requires suitable moisture conditions, temperature, air and suitable food i.e. untreated wood.

In all fungus growths reproduction is carried out by the production of "spores" from a fruiting body. The spores are produced in very large numbers and are carried about by the wind or by animals or insects or even rain. When deposited on the exposed timber where the conditions are favourable the spores germinate and grow into the wood cells to decompose the wood substance. The timber develops fine cracks and loses its strength, turning brown and splitting up into small cubical pieces. When the fungus growth is fully developed a "fruit" is formed which continues the cycle by liberating more spores into the atmosphere. To obviate the spread of infection, infected timber should be destroyed by burning, preferably on site to avoid carrying the spores further afield.

Preservative Treatments

In the untreated state, wood is subject to the natural forms of decay which, in course of time, lead to the loss of the mechanical properties upon which its value in structural work depends. In the construction of buildings, the main contributory condition, i.e. dampness, can be guarded against by care in design and it is not often that precautionary treatments are adopted, but when the timber is used externally, for example as telegraph poles, the conditions (particularly near the surface of the ground), are such that the fungoid growths can easily propagate themselves.

Different timbers resist in varying degree the forces of decay, and pinus sylvestris which in many ways is the most useful of timbers, is unfortunately one of the least resistant. In the untreated state, a life of only 4 to 5 years would be usual for pinus sylvestris poles while 7 to 10 years may be expected for larix decidua (larch) poles. Thus the advantage of preservative treatment, which will prolong the life of a pole to an average of 30 years, is obvious.

Charring and tarring of the butts of larch poles has been tried in the past but proved useless.

The preservative value of certain oils and bituments was known to the Greeks and Romans, and many other substances have been used from time to time. Copper sulphate, zinc chloride, and numerous organic antiseptics often mixed together have been marketed under various trade names. Although experiments are continually taking place to try new methods of preservation the use of coal tar creosote is at present standard in the BPO. Due to the antiseptic nature of the preservatives, the preservation process may be known as an antiseptic process.

Creosote methods

Coal tar creosote contains a number of chemical substances, so it is difficult to say which is responsible for the beneficial effects. But from various tests it seems that a large part is played by the heavy oil constituents, which are valuable antiseptics, and as the boiling points of these are high they are probably the most permanent substances introduced into the wood.

The major source of creosote supplies was from the by products of the manufacture of town gas from coal. With the changeover to natural gas this source of supply has virtually ceased; instead, the creosote is obtained from steelworks where coal is converted to coke for smelting purposes, and manufacturers of smokeless fuel.

There are a number of ways of introducing the creosote into poles, the principal one used by the BPO today is the empty cell, or Ruping process.

Bethel or full cell process was patented by John Bethel in 1838. The process consists of exhausting the container in which the wood to be preserved is enclosed, and introducing the heated preservative. The vacuum is replaced by pressure until the wood refuses to take up any more oil: at least 190 kg/m^3 was specified but in some cases as much as 320 kg/m^3 can be taken in. Until 1913 this process was standard for Post Office poles.

The Ruping or empty cell process was developed in Germany and was adopted by the Post Office for all types of poles in 1913. The advantages over the full cell process are considered to be as follows:-

(a) The poles are easier and cleaner to handle and require less weathering before erection.

(b) They are more pleasing in appearance.

(c) Contamination of water and damage to clothing becomes practically negligible.

(d) There is a direct saving in creosoting cost.

(e) The weight is reduced for handling and transport, and

(f) They can, if required, be painted more satisfactorily than full cell preserved poles.

In this process the poles are first subjected to air pressure; creosote is then forced into the wood cells under greater pressure, and finally a vacuum is applied which, assisted by the expansion of the air initially forced into the cells, removes all creosote in excess of that required to coat the cell walls. Fig. 3 is a schematic drawing of the apparatus.

The poles, of known volume and similar characteristics, are loaded upon trucks and wheeled into the heated working cylinder, the end of which is locked on. A compressor pressurises the air in the cylinder to about 3.45 bars for about 20 minutes. Without releasing the air pressure hot creosote (80°C) is transferred from the preservative tank to the working cylinder until it is full. The pressure is then increased to 12.5 bars and extra creosote pumped in from the main storage tank until t the requisite amount of creosote has been introduced. This is determined on the basis of 240 kg of creosote for each cubic metre of timber loaded into the working cylinder. The pressure is then maintained for about 2 hours in which time the sapwood is fully impregnated.

On release of the pressure the surplus creosote is drained off and a vacuum applied. This causes the compressed air in the wood cells to expand and drive out surplus creosote within them, about 115-125 kg of creosote per cubic metre being retained in the timber.

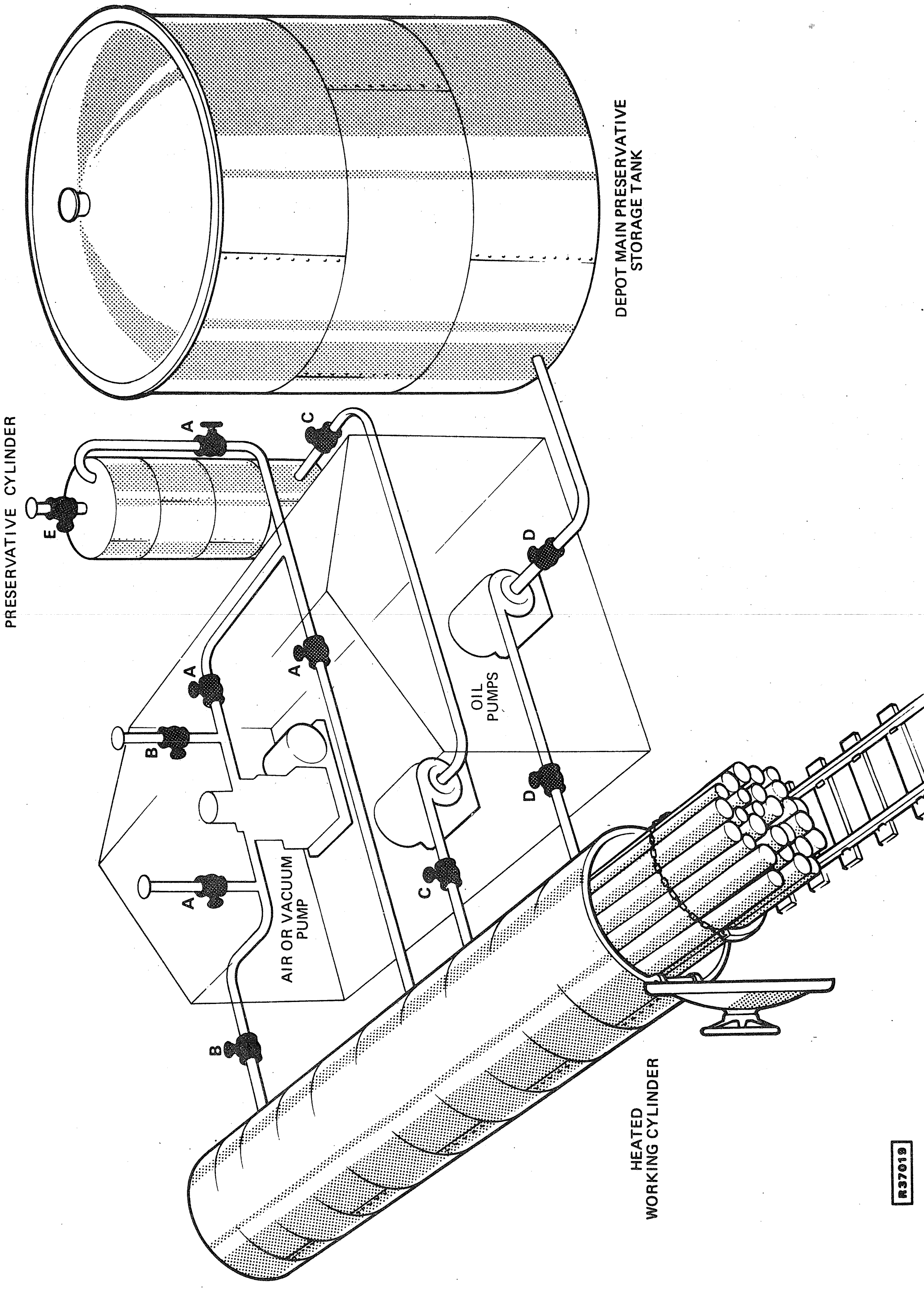

PRESERVATIVE CYLINDER
E
A
C
DEPOT MAIN PRESERVATIVE STORAGE TANK
A
A
B
D
OIL PUMPS
A
AIR OR VACUUM PUMP
C
D
B
HEATED WORKING CYLINDER
R37019

Fig. 3

The vacuum is released and the timber removed from the working cylinder taken to pole stacks, where they are allowed to weather, and are sorted ready for dispatch.

The Ruping process is successful in penetrating the sapwood of pinus sylvestris, but in the case of larix dedecua (larch) and pseudotsuga taxifolia (Douglas fir) there is difficulty in penetrating the sapwood and it is necessary to vary the above process. On wheeling the timber into the working cylinder it is filled with hot creosote (65-85°C) and a pressure of 10-11 bars applied and held for about 2 hours, or until it is found no further creosote is being taken up by the timber. Finally a vacuum is applied and held for 1 to 2 hours, or if possible overnight.

Poles subjected to the above treatments can be expected, on average, to have a life in excess of 30 years*.

The Lowrie process is popular among American creosoters, no doubt because much of the timber used has an inpenetratable sapwood. It is similar to the modified Ruping process described above, the poles are put into a tank, creosote added and pressure applied. When the pressure is reduced the air in the cells expand and expels the surplus creosote which is further recovered by reduced pressure; about 115 kg of creosote per cubic metre of pole being retained.

Boulton or "Quick" process, patented by Sir Samuel Boulton in 1879 is suitable for unseasoned or waterlogged timber. Excess moisture is removed by immersing the timber in creosote at 93°C. The moisture is drawn off as steam under vacuum for a number of hours until sufficient has been removed. Bethel or Ruping operations follow.

Brush and butt treatments are used in America where several naturally resistant timbers are available e.g. Thuja occidentalis (White cedar), Thuja plicata (Western red cedar), Castanea detata (American chestnut). Only the butts are treated. The brush treatment has proved of little use but successive immersion in hot and cold creosote has proved quite effective. Lives up to 20 years are expected as against about 12 years for the untreated timber.

When a creosoted pole is cut the exposed surface is coated with a 2 to 1 mixture of creosote and tar.

** There are instances of poles 100 years old, a characteristic being that they have been worn oval by the wind. Poles of this age being unique are in demand for investigation and research purposes. When recovered they should not be disposed of but their existence reported.*

Other methods

Wolman salts method is a pressure process, where a preservative solution of sodium fluoride, sodium dinitraphenol, sodium arsenate and sodium chromate is injected into the pole by the full-cell method: between 4 and 8 kg of dry salt per cubic metre is retained. It is claimed that this is a more economical process than creosoting and that the chromate tends to fix the mixture in the pole. The treated wood can be painted if required, when dry.

With Boucherising, the poles are laid out horizontally soon after felling and usually copper sulphate is applied under pressure to the butts. After 10-12 days the solution reaches the tip after having replaced the sap in the wood. This system is used in Finland with Wolman Salts.

Burnettising, involves the injection of a mixture of zinc chloride and other salts into the wood in pressure tanks by the full-cell process. This results in 8 to 20 kg of dry salts per cubic metre of timber being retained. Painting helps to keep the salts from leaching.

The Tanalith process (Tanalising) has been available and used by the PO in the past. It was reintroduced as a trial in 1967. It is a full cell process, the poles being placed in a tank, subjected to a vacuum, which is released at the same time flooding the tank with a solution of copper, chromium and arsenic salts. Pressure is applied and maintained for about an hour and a half when most of the sapwood is infected. About 0.02 kg/m^3 of dry salt is retained in the pole. The pole has a greenish hue when first processed, but when erected the wood weathers as its natural colour which gives it a better appearance than a creosoted pole. It is clean and dry to handle and can be painted.

The main disadvantage of all the salt injection processes is that, as they are mainly water based, there is a tendency for the material to leak out leaving the wood almost in its raw state. This leakage of preservative due to the action of water is termed "leaching".

The Cobra process involves the injection of a protective paste. A special tool consisting of a hammer having a large inoculating needle attached is used. The needle is driven into the timber for about 60 mm, and a lever operated to force the poisonous ingredients into the puncture as the needle is withdrawn. The paste is said to spread gradually throughout the sapwood but the process is very expensive and its use is limited to cases where application of the preservative at ground level only is sufficient.

The subtlest way of preserving timber is to introduce the preservative to the sap stream while the tree is still alive, in fact several methods have been patented. One method involves the introduction of a mixture of either three parts arsenic acid to one part sodium fluoride, or sodium arsenate and benzoate in equal parts. The mixture is applied to the foot of the tree via bore holes or grooves cut in the bark, when the sap is rising, until the leaves wither and die. Thus the agent is thoroughly spread throughout the sap wood and the pole can be used within a short time of treatment.

Many other processes exist, but although the actual substances used varies, the methods of preservation are similar to those mentioned already:-

(a) Surface treatment by painting or soaking.

(b) Pressure treatment - Full or Empty cell process.

(c) Diffusion processes.

Some local authorities ask for poles to be painted for the sake of appearance. One of the advantages of the Ruping process is that the pole can be painted immediately on erection, if it has been previously weathered for six months. This enables the demands of surveyors for improved appearance to be met. Ordinary paint, however, quickly discolours due to the creosote and it is usual to use aluminium paint as a sealer, first.

Size of poles

Diameter

This will be determined by the number and weight of conductors the pole is required to carry. There are five classes in use, extra light, light, medium, stout and extra stout. As it is now BPO policy to place more routes underground and aerial cable where more than two overhead circuits are to be erected there is no longer the need for the heavier poles. Apart from old stock, the metric size poles will now be used and only light and medium class of pole are used.

Length

The length of the poles will be governed by the clearance required for any fittings such as stays and the line wires. For example the clearance over most roads is 6.1 m whereas over a railway it has to be 6.7 m above the rails.

Abrupt changes of level should be avoided and it may be necessary to graduate the poles for a few spans on each side of a crossing or sudden change of ground level.

Table 1 gives an indication of the dimensions and weights of the different classes of wood poles.

Table 1

	Class of pole	Length		Diameter at top in inches				Diameter at 1.5 m from butt end		Approximate mass	
				Min.		Max.		Min.			
		m.	ft.	mm.	in.	mm.	in.	mm.	in.	kg	cwt.
Old stock	Extra light	5.485	18	100	4	125	5	125	5	40	0.9
		6.100	20	100	4	125	5	125	5	50	1.0
		6.705	22	100	4	125	5	125	5	60	1.2
	Light	6.100	20	125	5	145	5¾	150	6	75	1.5
		9.145	30	125	5	150	6	185	7¼	145	2.9
		15.240	50	135	5¼	175	7	240	9½	390	7.8
	Medium	7.315	24	140	5½	170	6¾	200	8	135	2.7
		12.190	40	150	6	190	7½	245	9¾	355	7.1
		18.290	60	175	7	220	8¾	335	13¼	780	15.9
New stock	Light metric size	6	19.7	125		150		150		55	
		7	22.9	125		150		160		65	
		8	26.2	125		150		170		100	
		9	29.5	125		150		180		145	
		10	32.8	125		160		185		155	
		11	36.0	125		160		195		175	
		13	42.7	130		170		210		360	
	Medium metric size	9	29.5	150		180		220		150	
		11	36.0	150		190		240		200	
		12	39.4	150		190		250		355	
		15	49.2	165		210		290		400	

The diameter at 1.5 m (5') from the butt end will in most cases be the diameter of the erected pole near the ground, and may be used in practice to decide to which class the pole belongs.

Marking of wood poles

Poles are stamped on their butts with their length in feet, or in metres if a metric size, and one or more crowns to indicate the class of pole. Thus:-

One crown signifies	Extra Light or Light
Two crowns signify	Medium

Poles supplied after 1909/10 contracts are stamped at a point 10 feet (3.04 m) from the butt with the letters 'GPO', length in feet and class of pole, and the last two figures of the year of preservation treatment. At this point the class is indicated by the letters XL, L, M or S, standing respectively for extra light, light, medium and stout. A list of marks with their position is shown in Table 2.

Table 2

Mark	Position	Detail
One Crown	On Butt	Extra-Light or Light poles (Para 2)
Two Crowns	On Butt	Medium pole
Three Crowns	On Butt	Stout pole
Two Code Letters	On Butt	Shipper and Creosoting Depot
Initials (Two Letters)	On Butt	Inspecting Officer
Length (Figures)	On Butt	Stock length
PO (previously GPO)	3 m from Butt	Ownership
Length (Figures) together with classification letters (XL, L, M, S as appropriate)	3 m from Butt	Stock length and Class of pole
Date (Figures)	3 m from Butt	Last two figures of year of applying preservative treatment (Table 3)
One or more Letters (Table 3)	3 m from Butt	Species and/or preservative treatment

Table 3 gives a list of marks for the species and preservation process. It s of interest that there have been a variety of species and treatments used by e BPO apart from the standard.

Table 3

Mark	Details
A	Russian Red Fir (Archangel)
AL	American and Canadian Larch
B	Preserved with Wolman salts (Triolith 1930) (Tanalith 1944 and 1947/8)
BX	Preserved with Wolman salts and Fuel oil (1930)
BB	Preserved by "Quick" Process
C	Preserved with Celcure
CP	Corsican Pine
CDF	Canadian Douglas Fir
CS	Canadian Spruce
D	Creosoted by "Full cell" Process and supplied by LMS
DF	Douglas Fir (Home-grown) incised and creosoted by "Full-cell" Process (1935)
E	Larch (Summer-felled)
EF	Wallaba
F	Polish poles of second quality
GNS	German, Norway Spruce
H	Silver Spruce (Summer-felled)
IC	Iron Bark (Queensland) Eucalyptus: Crebra
IP	Iron Bark (Queensland) Eucalyptus Paniculata
JP	Jack Pine
K	Creosoted by "Rueping" Process (mark discontinued 1931)
L	Larch (Home-grown)
LP	Lodge Pole Pine (Canadian)
M	Western Red Cedar (Canadian)
N	Creosoted by "China" Process
NS	Norway Spruce (Home-grown)
O	Oversize Light Poles
P	Preserved with Pentachlorophenol
PC	Lodge Pole Pine (Scotland)
PP	Ponderosa Pine
Q	Creosoted by "Quick" Process
R	Russian Red Fir (Riga)
RP	Red Pine (Canadian)
S	Poles acquired by PO from Electric Power Companies or other sources
SF	Red Fir (Summer-felled)
SS	Sitka Spruce (Home-grown)
T	Larch seasoned with bark on
TC	Preserved with Tanalith "C"
V	Creosoted by "Pre-vac" Process
W	Weymouth Pine (Home-grown)
WC	Eastern White Cedar (Canadian)
X	Redressed Pole
Y	Western Red Cedar (Home-grown)
4	Pre-creosoted Swedish Poles

In the absence of any such letters, it should be assumed that the timber is pinus sylvestris creosoted by the Ruping process.

Plastic numbers and letters which are nailed on to poles at a point 2.5 m (8 ft) above the ground level refer to the series numbering in a route for identification purposes.

Testing the condition of poles in situ

There are three tests used to detect decay in wood poles, these are the hammer test, the prodding test and the boring test.

In the hammer test the pole is tapped with a light hammer, the sound obtained indicates the condition of the pole at the point struck. A hollow note indicates extensive internal decay whilst a dull or dead note indicates slight internal decay or surface decay. The sound obtained at one point may not be particularly distinctive but a change in tone will be noticed as the hammer taps pass from the good to the decayed wood.

The prodding test consists of prodding the pole with a sharp pointed tool. If the timber is in good condition it will resist penetration and grip the point. Decayed wood will offer little or no resistance to penetration and will not grip the point.

The boring test is used in exceptional cases where the hammer test raises doubts regarding the internal condition of the pole.

When it is suspected that a pole has internal decay, it is permissible to bore one hole into the pole at the doubtful spot. Fig. 4 shows the section of a pole with a boring made with a special boring bit for this purpose. The shank of the bit is thinner than the threaded head to prevent binding and it carries 12 mm ($\frac{1}{2}$") markings to allow it to be used as a depth gauge.

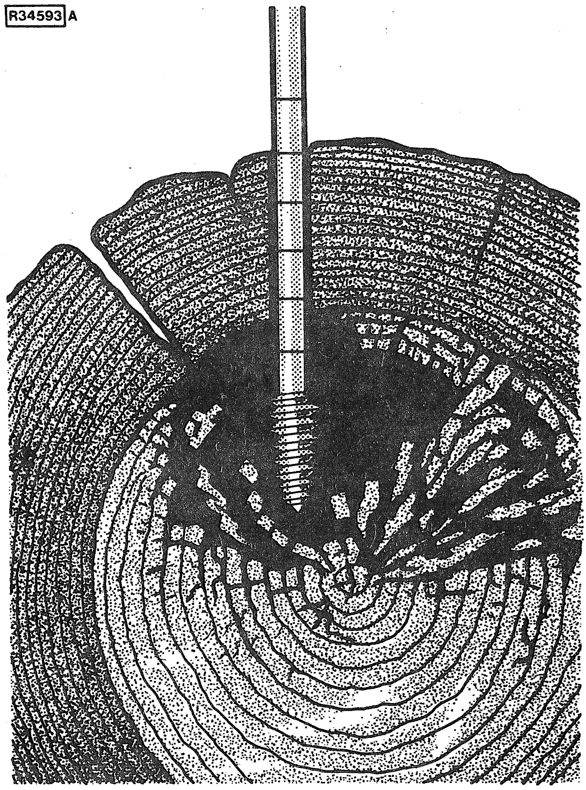


Fig. 4

The resistance felt when the bit is screwed into the pole in a carpenters brace gives an indication of the condition of the timber. If decay is met there will be a marked reduction in resistance to turning the brace, whilst if a cavity is reached the tool can be pushed in and out and the depth of decay and thickness of good wood deduced from the markings on the shank. An allowance of 20 mm ($\frac{3}{4}$") is made for the length of the threaded head. The bit is screwed out and the hole sealed with a creosoted wood plug.

Looking at the cross section of the pole shown in Fig. 4 it will be seen that the creosote had penetrated approximately 35 mm ($1\frac{1}{2}$"), as measured by the graduations on the boring bit (darker shade). To the left of the bit is a radial crack which extends right through the creosote layer to the untreated sapwood; these are the sort of cracks that give access to fungus spores to the untreated sapwood. The actual decay shown extends from the inner edge of the creosoted area right into the heartwood.

All wood poles over seven years old should be inspected at six year intervals. The routine inspection is carried out in a particular sequence. When the test at any one point shows the pole to be extensively decayed, the remaining parts should not be tested. The prodding test should be restricted to those parts of the pole where decay is visible or where the hammer test indicates that the pole may be decayed. The routine test is carried out in the following manner:-

(a) The hammer test is made as near the ground as possible at approximately 25 mm intervals all round the pole and, at intervals of 100 mm, to other parts of the pole within reach from the ground.

(b) The ground is excavated to expose 300 mm of the pole below the ground line, the pole cleared, and the hammer test applied at close spacings to the parts exposed.

(c) Creosote and tar mixture is applied to the exposed portion to a height of approximately 300 mm above ground level.

(d) The earth is then replaced and thoroughly consolidated around the pole.

(e) The hammer test is applied all round the pole at approximately 300 mm intervals, commencing from the point previously tested within reach of the ground.

Poles which have considerable areas of decay are declared 'dangerous' or 'suspect' according to the extent of the decay.

Poles are declared dangerous when:-

(a) internal decay extends more than half-way round the pole,

(b) the average depth of external decay is from $\frac{1}{8}$ to $\frac{1}{4}$ of the pole's diameter and extends half-way round the pole,

(c) the average depth of external decay is more than a quarter of the pole's diameter and extends a quarter-way or more round the pole.

Poles are declared suspect when:-

(a) internal decay exists but not to a sufficient extent to cause the pole to be declared dangerous,

(b) the average depth of external decay is up to $\frac{1}{8}$ of the pole's diameter for a considerable proportion of the pole's circumference, isolated pockets of 25 mm or so in width being ignored,

(c) the average depth of external decay is from $\frac{1}{8}$ to $\frac{1}{4}$ of the pole's diameter and extends up to half-way round the pole.

(d) the average depth of external decay is more than $\frac{1}{4}$ of the pole's diameter and extends up to a quarter-way round the pole.

Poles which are classified as dangerous are recovered as soon as possible. They should not be climbed, access to the top being made by an elevated platform, unless the pole is adequately secured by stout ladders or scaffolding lashed to them. On suspect poles the decayed patches are removed and the exposed wood is treated with creosote and tar. Such poles may still be climbed in the ordinary way.

A letter D in red paint is used to mark a dangerous pole 2.15 m (7 ft.) above the ground in a position clearly visible to anyone approaching the pole. A letter S is used for suspect poles. Red plastic labels may also be fitted.

Preservative methods of maintenance

It is generally accepted that new poles, suitably creosoted, are safeguarded from attack by fungus for several years; possibly from five to ten. Although some poles may remain free from rot for more than twenty years it is suggested that additional protection, provided in the early life of the pole, say after five to ten years, will greatly reduce the possibility of attack by fungus disease.

When it is considered that the PO have some 4¼ million poles in use and renew 36 000 poles per year at a cost of approximately £10 per pole, it is obvious that a preservative method of maintenance which extends the life of a pole is attractive, provided that it is not too expensive.

There are several different methods claimed to extend the life of poles in situ, and the BPO have in the past had some of them on field trial to test their relative advantages and costs. However, with the reduction in pole usage and increased cost of maintenance, it is not BPO policy to apply any preservative methods of maintenance but with the rising price of timber to ensure more than ever that the initial preservation is effieiently carried out.

POLE FITTINGS

In the past, overhead lines consisted exclusively of open wires, but the continued increase in the number of circuits the routes had to carry has led, where they have not been put underground, to their replacement by aerial cables. Whilst there are still many open wire routes in the field, it is now practice to provide aerial cable for more than two circuits, and for new work it is not usual to fit a pole with more than two arms. This has led in turn to a reduction in the variety of overhead line fittings.

Arms

The standard pole arm is designed to carry four insulator spindles (4 way arms). It consists of a 65 mm (2½") square, 1.065 m (42") long piece of suitable hardwood e.g. oak, with chamfered corners, bored to take the 15 mm (⅝") spindle. Bolt holes for the accommodation of braces are bored locally.

The arms are thoroughly seasoned, straight in grain and free from sapwood, splits, shakes, large knots and other defects. They are impregnated with preservative by the Ruping or open tank process. The open tank process consists of immersing the arms in heated oil-based or water-based preservative for several hours and then allowing them to cool whilst still immersed.

Slotting Method of Arming Poles

This method of arming poles is no longer used in the P.O. but examples of slotted poles still exist in the field. The pole was drilled and a slot cut to accommodate the arm. As this cutting was done prior to erecting the pole, unprotected parts of the pole were exposed, which could give rise to decay. It is better to deal with large numbers of poles at a central depot than to prepare each one on site, because of the economy in labour and greater uniformity that mass production provides.

Pre-cut Method of Arming Poles

This was a method used for arming poles where all cutting and marking was carried out at the pole depot before creosoting and subsequent issue. This ensured an unbroken layer of creosote over the whole surface of the pole, thus preventing the germination of spores and subsequent decay.

A flat surface was provided from the top of the pole for a sufficient distance to accommodate the arms, which were secured in position by arm braces. A roof was also cut on the top of the pole as a means of shedding water from the top of the pole.

Arming Poles

It is not now considered that the pole roof has much effect on the life of a pole so that new poles are plain with square ends, with just two holes bored for the arm retaining bolts. The arms are bolted on with a galvanised mild steel seating between the arm and the pole giving the arm lateral stability in the absence of a flat face.

Fig. 5 shows a pole with this method of fitting the arms.

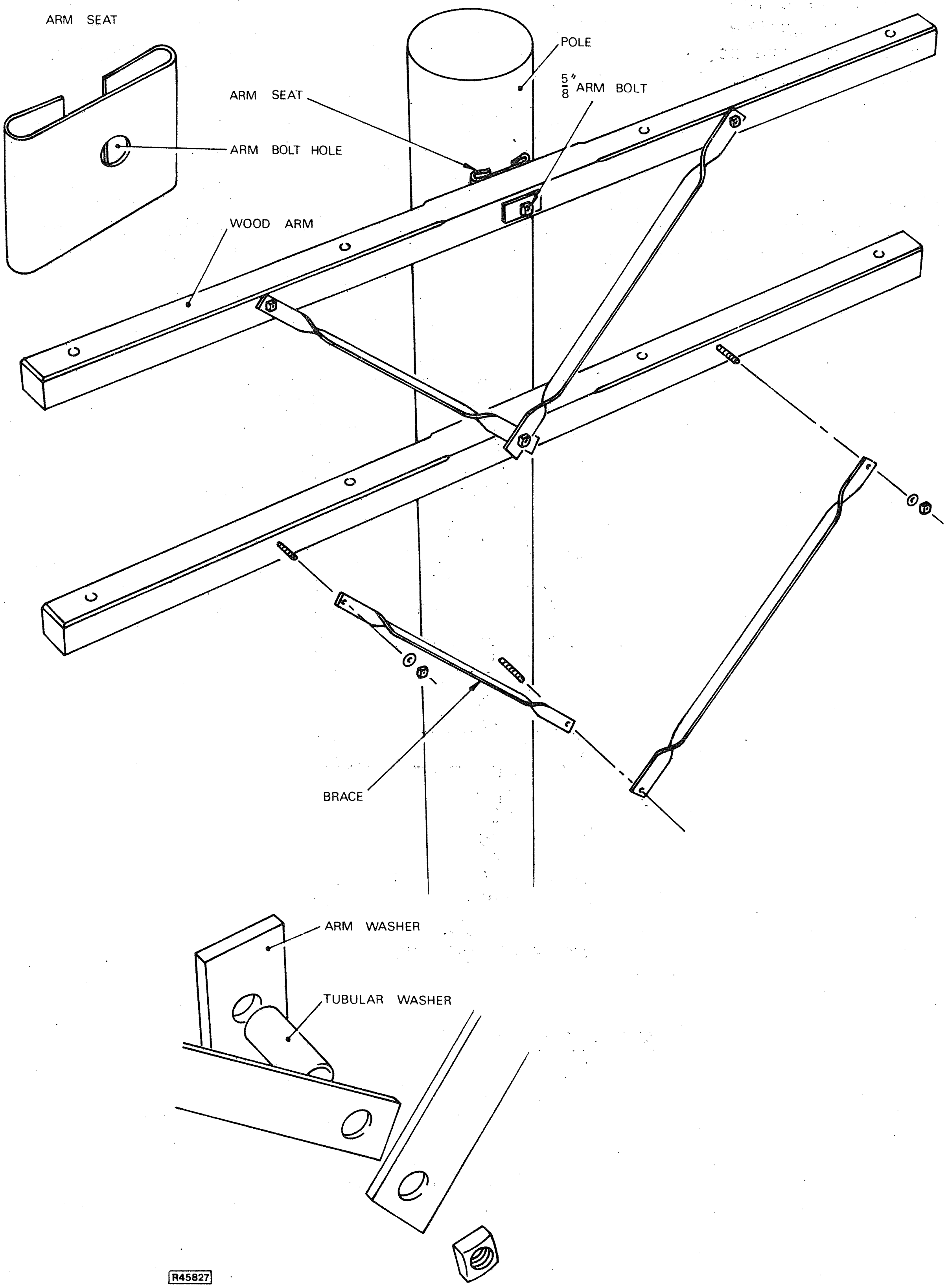

ARM SEAT
ARM SEAT
ARM BOLT HOLE
POLE
5/8" ARM BOLT
WOOD ARM
BRACE
ARM WASHER
TUBULAR WASHER
R45827

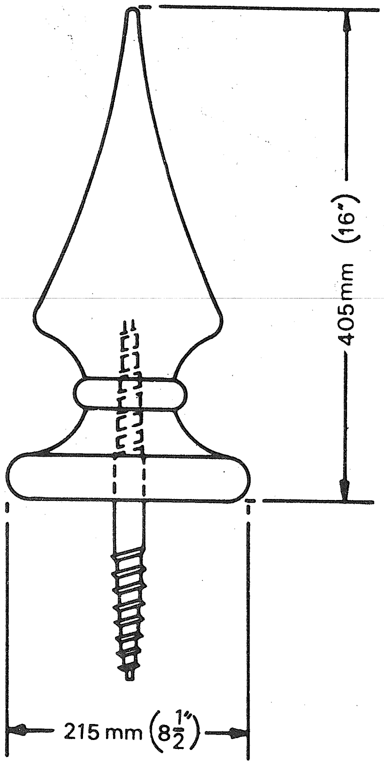
Fig. 5

Arm Braces

These are made from a strip of 6 mm (¼") galvanized mild-steel with a twist in the centre section for additional strength and a fixing hole at each end. The method of fitting the braces is illustrated in Fig. 1. It will be seen that the braces for arms are bolted to the front of the arms. Braces for the lower arm are bolted to the pole with a tubular washer to take up the thickness of the arm.

Finials

These are screwed into the top of a pole to give it a more ornamental appearance, but are only provided where they are demanded by wayleave grantors. The standard finial, in painted hard wood, is illustrated in Fig. 6.

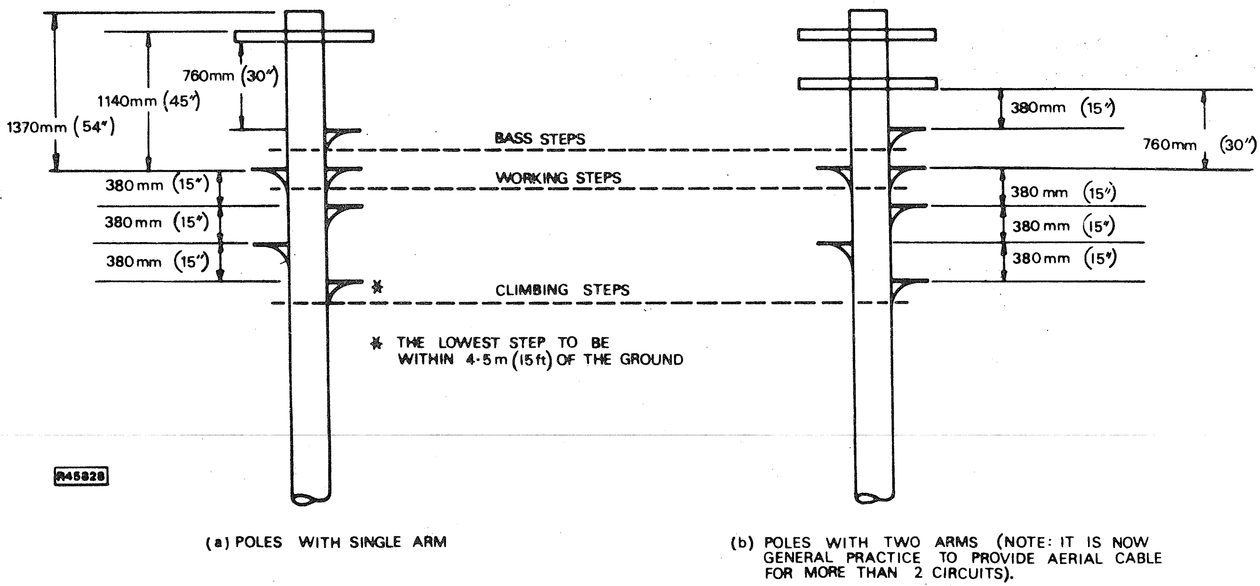


R36074A

Fig. 6

Pole Steps

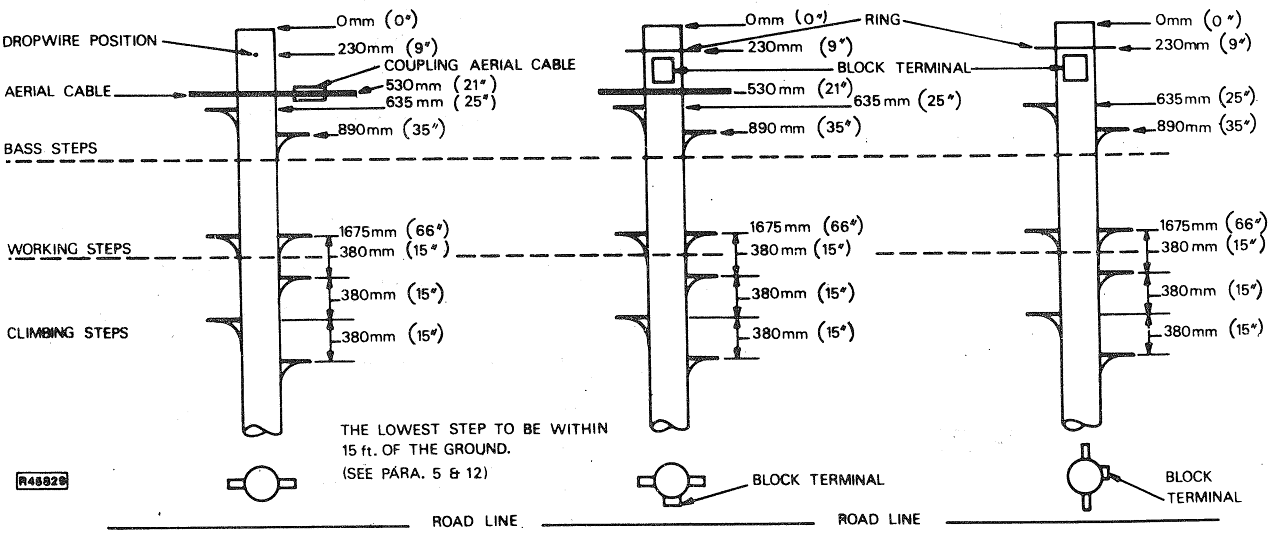
Galvanised steel steps are fitted with three coach screws on alternate sides of poles at a vertical distance of 380 mm apart to facilitate climbing. A pair are fitted opposite each other as working steps 1.37 mm from the top in the case of armed poles, and 1.98 m for aerial cable and distribution poles. The lowest step should not be lower than 4.75 m from the ground. A further step is provided to hang a tool bag (bass), called a bass step. Fig. 7 shows how a pole with arms is stepped, and Fig. 8 shows how a pole for aerial cable and a distribution pole is stepped.



(a) POLES WITH SINGLE ARM

(b) POLES WITH TWO ARMS (NOTE: IT IS NOW GENERAL PRACTICE TO PROVIDE AERIAL CABLE FOR MORE THAN 2 CIRCUITS).

Fig. 7



(a) AERIAL CABLE AND / OR WITH DROPWIRE

(b) AERIAL CABLE AND RING TYPE D.P.

(c) RING TYPE D.P.

Fig. 8

Earth Wiring of Poles

An earth wire is fitted to a pole if it is a distribution pole carrying (or likely to carry later) pole top protectors, or to a pole where a signalling earth may be required e.g. a distribution pole where a three wire dropwire cable will be used. It consists of a 1.6 mm diameter cadmium copper wire stapled with brass staples to the pole, where it is wound into a helix and stapled to the base of the pole. If it should be found that this earth is too high a resistance, or an earth has to be provided at an existing pole, an earth spike is driven in the ground at the foot of the pole and the earth wire connected to it.

Insulators

Insulators (Fig. 9) are used to support open wires on poles, and are affixed to spindles which bolt through the pole arm.

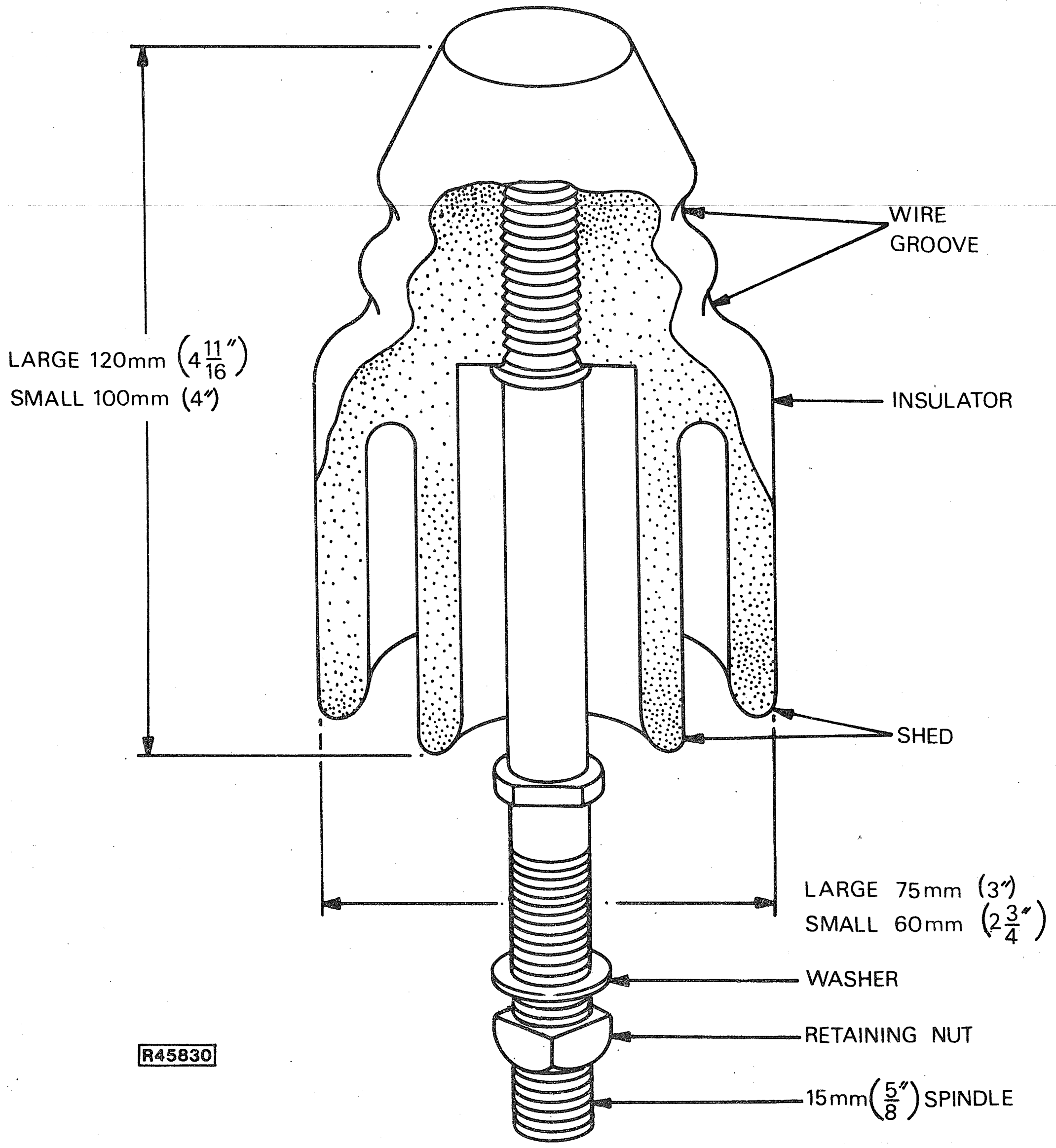


Fig. 9

The characteristics of the material used for insulators are:-

(1) High specific resistance
(2) Homogeneity
(3) Non-porosity
(4) Ability to take a high polish
(5) Freedom from rapid deterioration
(6) As slight an affinity for moisture as possible
(7) High tensile and compressive strength
(8) Toughness

Insulators are made of white porcelain or stoneware.

Electrical porcelain is made from four ingredients, ball or potter's clay, china clay, silica and felspar. The first material is obtained from Dorset, the second from Cornwall, whilst silica and felspar normally come from Norway.

These ingredients are thoroughly mixed with water and the mixture is placed into a press which forces out the surplus moisture. After preliminary shaping on a potter's wheel the insulator is finally shaped on a lathe which also forms the thread. The insulators are next exposed to hot dry air for several days and then dipped into a glazing fluid and fired.

The glaze is not put on to render the insulator waterproof; its chief function is to give a surface from which rain will readily clean off any soot and dirt. As the surface resistance may be a lot less than the resistance through the material from the spindle to the groove, this aspect is naturally an important one.

The greater part of any current due to a low insulation resistance between the wire and the spindle will travel across the surface of the insulator. This should be so designed that the current will have to travel a long way over a clean and dry surface, and thus be kept to a low value. The length of this path is increased by tubular extensions at the bottom of the insulators, known as "sheds". These are clearly shown in Fig. 9, where the insulator is said to be double shedded. For the same reason the insulator has two grooves, the line being placed in the top one. A large and a small insulator of this standard type is available.

Insulator Spindles

The spindle used to support the insulator is made from a 15 mm ($\frac{5}{8}$") mild steel rod. This has a shoulder which beds to the pole arm when the securing nut is tightened. The top has a $\frac{5}{8}$" thread to provide a satisfactory joint between the spindle and the ceramic insulator.

The spindles are hot dip galvanised and the threads cut afterwards. It is shown with an insulator in Fig. 9.

Other Pole Fittings

Apart from the fittings just described, others will be found in associated Educational Pamphlets.

EP LINES 1/1	Provision and Maintenance of Overhead Wires
EP LINES 1/4	Construction of Overhead Routes
EP LINES 1/7	Aerial Cabling
EP LINES 1/8	Subscribers Distribution

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