FORESTRY COMMISSION

BULLETIN No. 27

UTILISATION OF HAZEL COPPICE

LONDON: HER MAJESTY'S STATIONERY OFFICE

TEN SHILLINGS NET

UTILISATION OF HAZEL COPPICE

This paper was made by the Manchester College of Technology from a mixture of 15 lb. hazel pulp and 15 lb. softwood sulphite pulp. The hazel was prepared by digestion with caustic soda for 4½ hours at 158° C, and bleached with sodium hypochlorite, using a two stage process.

40 lb. of hazel chips, including the bark, at 17% moisture content, were used to obtain 15 lb. of pulp, a yield of 46.3%. The weight of this sample is approximately 90 grams per square metre.

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1956

FOREWORD

This bulletin presents the results of studies carried out on the rate of growth and yield of coppices of the common hazel, and on the utilisation of hazel poles both by traditional means and by modern technical processes. As hazel occupies over 160,000 acres of woodlands in Great Britain, its proper utilisation, where this is economically feasible, is a matter of concern to owners of woodlands. Under other circumstances, the use of the land it occupies for some alternative form of forestry, may have to be considered.

The preparation of this bulletin and the studies on distribution and yields of hazel coppice, were carried out at the request of the Forestry Commission's Advisory Committee on the Utilisation of Home Grown Timber. The Forestry Commission wish to thank those private woodland owners and underwood craftsmen who assisted in the investigations described in this report and to acknowledge the valuable help given by the Rural Community Councils, the British Paper and Board Industry Research Association, The Bowater United Kingdom Pulp and Paper Mills, Ltd., the Manchester College of Technology and Mr. C. Bruce Durham.

The Rural Industries Bureau has helped throughout in the planning and execution of the work and in the preparation of the report. Particular thanks are due to Mr. W. G. Trust, the Bureau's Underwood Officer.

The Commission's share in this investigation was entrusted to Mr. E. G. Richards, B.Sc., its Utilisation Development Officer.

FORESTRY COMMISSION,
25 Savile Row,
London, W.1.
March, 1956

CONTENTS

THE PHOTOGRAPHS

Photographs numbered 1 to 27 inclusive have been supplied by the Rural Industries Bureau, and the Forestry Commission wishes to record its thanks to that Bureau for its assistance.

Photograph numbered 28 is by Mr. C. F. Walker, and the remaining illustrations are drawn from the Forestry Commission's own collection.

INTRODUCTION

The hazel (*Corylus avellana L.*) has long been known to man as a valuable shrub of the temperate regions, yielding an edible nut of fine flavour and providing strong and supple twigs used for a wide variety of purposes. Thus the large areas of natural hazel found in pre-Roman Britain provided a source of raw material which could be won and manufactured with the primitive tools of the day. For example, the comparatively small diameter attained by hazel, its suppleness and the ease with which it can be woven by hand, provided man with a building material which it was within his powers to utilise. Again because of its small diameter, it provided a source of firewood which could be easily felled, transported and cut into lengths without the necessity of splitting it. Hazel nuts also undoubtedly provided a source of food both for man and his domestic animals. Even when man learnt to fashion the tools with which he could fell and shape the larger trees of the forest, hazel continued to play an important part in his economy. In later medieval times, as the use and cultivation of land became more ordered, hazel was planted as a crop, and harvested on a regular rotation.

There are, today, some 167,000 acres of hazel coppice or scrub growing in the country. By far the greater part is privately owned, and almost three-quarters of the total area occurs in the south of England in the counties of Wiltshire, Dorset, Hampshire, Sussex, Surrey, Berkshire and Kent. The remainder is scattered over England and Wales, with a little scrub in Scotland.

Although no precise figures have been available, it has been apparent for some years that only a part of the total area of hazel has been cut on a regular rotation in the traditional manner, and that the utilisation of the remainder has presented considerable difficulties to woodland owners. In considering the problem of expanding the existing markets for hazel or finding new uses for it, the Commission's Advisory Committee on the Utilisation of Home Grown Timber felt that it was necessary to find out the area of hazel required to meet the demands of the existing hazel underwood industry, and to have some indication of the probable yield of hazel coppice. Only when these facts had been ascertained could the problem of finding new uses for unworked hazel coppice be seen in its true perspective. Accordingly, the Rural Industries Bureau, which is represented on the Committee, agreed to undertake a census of all established hazel underwood craftsmen in England and Wales, and to find out their raw material requirements. The field work was carried out on a County basis by the Rural Community Councils from 1951 to 1953, under the general direction of the Bureau. The yield of hazel coppice was investigated by the Research Branch of the Forestry Commission. The results of these investigations are given in this bulletin.

The current utilisation of hazel is discussed by Mr. C. Bruce Durham who has devoted considerable attention to the study of hazel as a commercial crop. A chapter is also devoted to work undertaken for the Committee by the British Paper and Board Industry Research Association on the production of paper from whole unbarked shoots of hazel, and by the Bowater United Kingdom Pulp & Paper Mills Ltd. on the production of fibre building boards from hazel, while the Manchester College of Technology has contributed the results of a small scale paper-making trial and provided sample sheets of hazel paper.

Chapter 1

DISTRIBUTION AND EXTENT OF HAZEL IN BRITISH WOODLANDS

The following account is based on two surveys of the woodlands of Great Britain carried out by the Forestry Commission between 1947 and 1952. The first of these, the Census of Woodlands 1947–49, covered all the larger individual woods, of five acres or more in extent. The second, the Census of Hedgerow and Park Timber and Woods under Five Acres, in 1951, covered the smaller areas. The full data has been published in the Commission's five *Reports on Census of Woodlands*, which are obtainable from Her Majesty's Stationery Office.

Woods of Five Acres and Over :

Hazel Coppice

Two types of coppice were recognised in the 1947–49 Census of Woodlands, viz., coppice-with-standards (Plates 6 and 7) and simple coppice (Plates 1 to 4). Coppice-with-standards was defined as coppice growth with an over storey of not less than six standards per acre; normally these standards were of seedling origin and had survived more than one rotation of coppice. Where coppice occurred either without standards or with fewer than six standards per acre it was recorded as "simple coppice", unless the standards were very large. Coppice-with-standards was classified both according to species of coppice and species of standard. The data given here deal only with the classification by species of coppice. In simple coppice, where several species occur in mixture on the same piece of ground, one species frequently predominates. Where the predominant species was hazel the coppice was recorded as "mixed mainly hazel". Simple coppice was recorded as "pure hazel" only where 90 per cent of the crop or more consisted of hazel.

The total area of woodland of all types (of 5 acres and over) recorded in the Census amounted to some 3·4 million acres, of which some 350,000 acres comprised coppice and coppice-with-standards. The area of hazel coppice with standards, simple coppice and mixed coppices "mainly hazel" is given in Table 1 below.

AREA OF HAZEL COPPICE IN GREAT BRITAIN
As at September, 1947

TABLE 1 *Woods of 5 acres and over*

Country	*Grand Total*	*Private & Commission Woodlands*			
		Coppice with Standards	*Simple Coppice*		
			Pure	*Mixed Mainly Hazel*	*Total*
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
England	115,300	87,168	9,249	18,883	28,132
Wales ..	2,042	1,028	164	850	1,014
Scotland	—	—	—	—	—
Totals ..	117,342	88,196	9,413	19,733	29,146

Distribution by Counties

(a) *England.* The three counties of Hampshire, Sussex and Dorset together contain just over 50 per cent of the total hazel coppice in the country.

	Acres
Hampshire (including Isle of Wight) ..	33,771
Sussex	15,375
Dorset	10,144
	59,290

A further 27 per cent of the total area of hazel coppice is contained in five counties each having between 5,000 and 10,000 acres of hazel.

	Acres
Wiltshire ..	7,866
Surrey ..	7,758
Kent ..	5,468
Berkshire ..	5,092
Suffolk ..	5,018
	31,202

The remaining 23 per cent of the total area of hazel is spread over 28 counties. Twelve counties each contain between 1,000 and 5,000 acres of hazel, ten counties each contain between 100 and 1,000 acres of hazel, and six counties have less than 100 acres of hazel each. On the whole, the bulk of the hazel coppice occurs in the southern and midland counties of England.

Details of the area of hazel coppice occurring in counties where the hazel underwood industry is active, are given in Table 2, Chapter 3, page 11.

(b) *Wales.* In Wales about 70 per cent of the hazel is contained in two counties, viz.,

	Acres
Monmouth	690
Brecknock	674
	1,364

Hazel Scrub

The same Census recorded that the total area of hazel scrub in Great Britain amounted to 35,519 acres. Scrub was defined for the purpose of the census as inferior growth which was unlikely to develop into a utilisable crop of coppice, poles or timber. Thus hazel coppice was recorded as scrub where it had been abandoned, or was exhausted or suffering from undue exposure or adverse soil conditions.

Area of Hazel Scrub in Great Britain (as at September, 1947) Woods of five acres and over

Country	*Hazel Scrub*
	Acres
England	27,019
Wales ..	5,318
Scotland	3,182
	35,519

Woods of One to Five acres in extent

Hazel, either in the form of scrub or coppice, was recorded as occupying six per cent of the total "Small Wood" area (omitting the 17,300 acres classed as "felled"), i.e. about 9,700 out of 161,000 acres. In addition, there are approximately 4,500 acres of coppice-with-standards, in most of which hazel is the predominant coppice species. Hazel areas thus total 14,200 acres and represent about 40 per cent of the 34,000 acres of small woods of all species which have been classed as coppice, coppice-with-standards and scrub.

Summary of Position

The position may be summarised thus:

Area of hazel coppice with standards:	*Acres*	
Woods of Five acres and over	88,196	
Woods of One to Five acres	4,500	
		92,696
Area of simple hazel coppice:		
Woods of Five acres and over	29,146	
Woods of One to Five acres (Includes some scrub)	9,700	
		38,846
Area of hazel scrub:		
Woods of Five acres and over		35,519
Total for all descriptions of hazel coppice and scrub		167,061

The total area of woodlands included in these census surveys was 3,626,662 acres, and hazel therefore accounted for 4·7 per cent of all woodland examined in Great Britain. If England alone is considered, then hazel occupies approximately 154,800 acres out of 1,978,000, or 7·7 per cent of all woodland examined in that country.

Chapter 2

MANAGEMENT AND UTILISATION OF HAZEL COPPICE

BY C. BRUCE DURHAM, F.L.A.S.

Hazel grows profusely in the form of coppice, producing large numbers of shoots from the "stool" or rootstock (see Plates 1–4). One of our native shrubs, there are few areas in Britain where it will not grow. Although it may be found growing almost equally happily on heavy clays or light loams with a chalky sub-soil, it is possible that growth is somewhat stronger on the heavier soils. Certainly where quick grown rods are required by the underwood industry, hazel grown on heavy soils is said to be more readily marketable than that grown on lighter soils. If hazel has any preference, it is for a well drained soil, since it will not thrive in swampy or boggy conditions. It has little regard for aspect, is a moderate shade bearer and is virtually unaffected by frost, wind, diseases or pests. Almost its only enemy is the rabbit, which can kill out a rootstock by continually biting off the tips of the young shoots which emerge from the freshly coppiced stools.

Established hazel coppice should be cut down with a clean cut close to the rootstock on a rotation varying from six to ten years, according to the use to which the rods are to be put. Cutting should take place from September to March, and summer cutting should be discouraged, as it will weaken the coppice habit. Where stools have died out and need replacement, this can be effected by layering. Lack of cutting will cause a gradual deterioration in the strength of the rootstock, and if it is desired to revive an area of old hazel (say over twenty years of age), it is helpful if, after the initial cutting, the shoots are again trimmed off at the end of the first growing season.

In Britain, hazel has been managed on a simple coppice system since very early times and under the coppice-with-standards system (Plates 6 and 7) since the Middle Ages. The simple coppice system gives the best growth of hazel; on the other hand the demand for branchy oak timber for the construction of wooden ships could readily be met from trees grown in mixture with coppice which in turn yielded firewood, fencing material and similar assortments of timber on a very short rotation. More modern demands are for clean boles which can only be produced from standards grown reasonably closely together, and if this practice is followed the hazel coppice or underwood becomes stunted and twisted. The coppice with standards system has therefore become outmoded so far as its original concept is concerned. Nevertheless there is still a large legacy of coppice-with-standards woodlands in the country, and in the 1947 Census of Woodlands some 88,000 acres of hazel coppice-with-standards were recorded against only 29,000 acres of simple hazel coppice. (Table 1, Chapter 1, page 2.)

For the last three centuries at least, the main demands for hazel have been for the manufacture of wattles for "wattle and daub" plaster work, sheep hurdles, sheep cages, barrel hoops, crate rods, garden fencing, pea sticks, bean rods, faggots, thatching spars, hedge stakes and heathers, firing for brick kilns and baking ovens, and fascines for laying under roads on boggy land. The most important demands today are for crate rods, sheep and garden screen hurdles, pea sticks, bean rods, thatching spars, liggers and sways, and, to a lesser degree, sheep cages, hedge stakes and heathers. (See Plates 8, 10, 15, 18, 22, 23, 24 to 28.) It is unfortunate that the old demand for "bunts" or "bavins" or bundles of faggots made of hazel twigs, which for so many years provided the firing for brick kilns and bakeries, has virtually ceased. Indeed, except in localities where the skilled underwood-cutter and the man who can "work up" bundles of crate rods or make hurdles still exists, there is little or no demand for hazel coppice.

Crate Rods

The production of crate rods used in the manufacture of pottery packing crates is still a regular industry in certain southern counties of England, particularly in Hampshire. The cutting, sorting, tying or bundling of the rods, is a highly skilled craft which has been handed down from generation to generation. Simply described, the process is as follows:

Having selected an area of coppice considered ripe for cutting, the age of which may vary from six to nine years, the craftsman usually cuts a small area and lays the staff in "drifts" about six yards apart, with all butts facing one way, ready to hand when working up commences. A skilled man cuts close to the ground to encourage the new shoots to spring in profusion from the "stool" itself, rather than from the tops of the cut over shoots (Plate 9). The craftsman then proceeds to "work up" the wood.

The various sizes of the rods which are needed by the cratemakers are known as 20's, 40's, 75's and 100's and can be more exactly described as follows:

- 20's — 20 rods bound together in a bundle, each rod being approximately 1½ in.–2 in. in diameter at butt, and of a length exceeding 10 ft.
- 40's — 40 rods bound together in a bundle, each rod being approximately 1 in.–1½ in. in diameter at butt, and of a length exceeding 12 ft.
- 75's — 75 rods bound together in a bundle, each rod being approximately ½ in.–1 in. in diameter at butt, and of a length from 10–12 ft.
- 100's — 100 rods bound together in a bundle, each rod being approximately ½ in. or less in diameter at butt, and of a length from 7–9 ft.

A "load" or 100 bundles of crate rods should weigh approximately 4 tons and is normally composed of 30 bundles each of 20's and 40's and 40 bundles of 75's, or perhaps a few 100's will be worked in. Crateheads are generally cleft or sawn from material of 3 to 6 inches butt diameter; usually from hardwoods other than hazel. Ash is not normally used because its import is prohibited in many countries, e.g., U.S.A., owing to the risk of introducing insect pests.

As the craftsman trims up the rods with his billhook he will lay them in several piles, according to their sizes, segregating suitable tops for pea sticks and odd sized poles for bean rods or "crateheads" (also called crate headings). Thatching material, hedging stakes or fruit props may also be selected depending on the demand. Each of the selected sizes will then be bundled and tied at each end and in the centre, with a twisted hazel rod or "withe", perhaps the most skilled operation of the whole process. The pea sticks will be tied into bundles varying in size according to the district. It then only remains to carry or cart the bundles to the road-side ready for the lorry to collect.

The amount of saleable products that can be produced from one acre of wood will depend on the quality or density of the growth and more particularly upon the skill of the craftsman. A good piece of hazel coppice will, on an average, produce the following per acre: 2½ loads or 250 bundles of crate rods, 400–500 bundles of pea sticks, 20–30 bundles of bean rods and 100 crate heads. Hazel is seldom found absolutely pure and crate heads, stakes and fruit props may often be obtained from other species of coppice found growing amongst the hazel.

The whole operation is usually paid for on a piecework basis although there are many "underwood dealers" who do their own cutting and sorting, etc.; the following are the average 1952–53 prices for the various jobs: cutting down, £6 to £8 per acre; sorting and tying rods, 2s. per bundle; bundling pea sticks 8d. per bundle; bundling bean rods, 1s. 4d. per bundle.

The following list gives the average prices that may be realised in relation to the piecework rates quoted above. One load of rods, from £20 to £25, at the roadside, the cratemakers paying all carriage; crate heads, £2 per bundle; pea sticks, £5 per 100 bundles –varying according to district and size of bundles; bean rods, 2s. per bundle. A skilled worker will, on the average, cut down one acre of hazel in one week and work up one acre in three to six weeks, depending on the quality of the hazel (i.e. density of growth).

The industry of cratemaking or round stick joinering, as it is sometimes called, is an old and highly skilled craft calling for a considerable amount of strength and manual dexterity on the part of the worker and is one upon which the pottery trade is still mainly dependent for the safe package and transport of its delicate products to all parts of the world. To make crates the hazel rods after being dressed, heated, bent and twisted, are interlaced in such a way as to give maximum strength and flexibility. The stronger structure or main framework of the crate is made from the "crate heads", which may be stout hazel, or else oak, birch, or alder, round or sawn.

The larger crates will carry up to a ton of china, and the unique shock-absorbing qualities which the resilience of hazel rods imparts to the crate, ensures a minimum of breakage in transit. The decline in demand for hazel for this purpose, which began before the 1939–45 war, is due to foreign importers' preference for relatively small cardboard cartons which are easy to handle and need only to be re-labelled for re-consignment from the ports to their final destination, thereby obviating the time and labour involved in repacking crated pottery. Considerable numbers of hazel crates are still used, but since the customer's requirements are bound to be given every consideration, it is reasonable to suppose that cardboard cartons may eventually completely replace crates for the package of exports.

Wattle Hurdles

Wattle hurdles for sheep folding and protective garden fencing, are the other important products of hazel coppice, requiring today a greater quantity of hazel coppice than the crate rod industry. These are usually made in the following sizes: sheep hurdles 6 ft. × 3 ft.; garden hurdles 6 ft. × 3 ft., 6 ft. × 4 ft., 6 ft. × 5 ft. and 6 ft. × 6 ft. The Rural Industries Bureau estimate that some 13,000 dozen wattle hurdle garden screens are made annually. The quality of hazel need not be so high for hurdle rods as for crate rods nor is the wood required to be as young, nine or ten years normally being appropriate. (See Plates 11 to 17, 20 and 24 to 27.)

The coppice is first cut and piled into drifts (Plate 5), but it is essential that too large an area is not cut over at one time and that cutting should alternate with working up. If the rods are left lying too long on the ground they dry out, lose their suppleness and do not cleave readily, and thereby lose the properties which both aid the craftsman in his work and enable him to turn out a good quality hurdle. Once the coppice is cut the rods are trimmed out and those suitable for hurdle making placed in separate heaps. No attempt is made at this stage to further prepare or sort the hurdle rods, as final shaping and selection is carried out during the actual process of hurdle making. Where the rods are to be transported before being made into hurdles they are commonly tied in bundles of fifty unsorted hurdle rods. In cutting out his rods the craftsman will also select material unsuitable for hurdle making for pea sticks, bean rods and thatching material; shoots between two and four inches in diameter will be cut into the posts or "shores" which are supplied to hold the hurdle in position.

The hurdles or screens may be made up in the wood or at some central yard or workshop according to the preference of the individual craftsman, but the methods of construction are the same in each case. The general procedure is described below, but it should be pointed out that, as the ability of the skilled craftsman to turn out a uniform product from a varied raw material depends not only on his manual dexterity, but on his judgment in selecting the right shape and size of rod for each individual member of the hurdle, no written description can do real justice to the intricacies of hurdle making.

Uprights are first inserted into holes drilled in a curved piece of wood called a mould or break. Ten uprights are used for a sheep hurdle, nine for a garden screen, the end uprights being normally round, the intermediates cleft i.e. half-round. Once the uprights are firmly fixed in the mould, which is itself securely pegged to the ground the horizontal rods are woven between the uprights. Where the rods pass round the end uprights they are twisted to lock them in position. From two to six round rods may be used at the bottom, centre, and top, of the hurdle; the remainder are cleft. Round rods vary between ½ inch and ¾ inch butt diameter. Cleft rods are obtained by splitting, in two or four, material of from ¾ inch to 2 inches butt diameter. When weaving is completed the ends of the horizontal, and tops of the uprights, are neatly trimmed with a billhook, and the finished hurdle is lifted bodily from the mould. Continuous garden screens are made *in situ* by weaving rods through uprights driven into the ground. The plates show this type of work.

An acre of good hazel coppice may produce, on average, 10,000 rods which, at 50 to the bundle, will equal 200 bundles. (See also Table 9, page 18.) A good hurdle maker will make a load or 10 dozen sheep hurdles from 80 bundles so that an acre of ground may produce 25 dozen sheep hurdles. In addition there may be 200–300 bundles of pea sticks and 10 bundles of bean rods, besides thatching wood, stakes of various specifications, and shores. The number of pea sticks and bean rods per bundle will vary from place to place. In Hampshire 25 pea sticks per bundle is the usual number; elsewhere a bundle may comprise 36 sticks. Similarly bean rods will vary from 20 to 25 per bundle.

This work is also frequently paid for on a piecework basis. The following are average prices for 1952–53: cutting down, £6 to £8 per acre; working up and tying into bundles of 50, 1s. per bundle; bundling up pea sticks, 8d. per bundle; bundling up bean rods 1s. 4d. per bundle; bundling up hurdle shores (20 to a bundle), 1s. 6d. a bundle; making hurdles, 30s. to 40s. per dozen.

The following prices which, in general, applied in 1952–53, will give some indication of a reasonable average return from one acre; 25 dozen sheep hurdles, 6 ft. × 3 ft., at £6 per dozen; 200 to 300 bundles of pea sticks at £5 per 100 bundles; 10 bundles of bean rods at 2s. per bundle.

Garden screen hurdles are sold at the following approximate prices: 6 ft. × 6 ft. at 25s. each; 6 ft. × 5 ft. at 20s. each; 6 ft. × 4 ft. at 15s. each.

As with cratewood a skilled worker will, on average, cut down one acre of hazel in one week; work up rods, pea sticks, bean rods, and shores in three to five weeks. Up to five dozen sheep hurdles may be made in one week.

Thatching

There is a steady demand for hazel rods by the 800 thatchers at work throughout the country. Broches or spars (see Plates 8, 21 to 23), which are inserted vertically to secure the thatch to the rafters or straw below, often with the aid of ledgers, take the greater quantity of rods used. These may be round or cleft, the round ones being used straight for rick work, whilst the cleft spar, of which far greater numbers are used, is employed for both house and rick thatching. When used they are twisted at the centre and doubled to form a staple. Hazel rods for this purpose are cut into lengths which vary from 24 to 36 inches according to local custom. The pieces are dealt with according to their diameter and suitability for cleaving or use as round spars or spitts. Round spars are pointed with a billhook at one end only, whilst material for cleft spars is halved or quartered, each quarter being halved again if the size of the material permits. They are trimmed and pointed at both ends with a billhook, and tied in bundles of 100. Generally, the butt diameter of the hazel used ranges from ¾ inch to 2 inches. The number of spars which may be cleft from each piece depends on the skill of the craftsman, and the quality of the material.

Cleft lengths of hazel three to five feet long, called liggers or rods (see Plates 8, 21 and 28), are used on the surface of the thatch in conjunction with broches to secure the ridges, eaves and verges.

Round or cleft lengths of hazel five to eight feet long, called sways or ledgers, are used horizontally to secure each course of thatch. (See Plate 18).

The hazel rods used for these purposes should be comparatively straight and clean, particularly if they are to be used for cleft spars, sways or ledgers, but the straightness of the rods is not so important as is the case with, for example, crate rods. Straight long pieces can be selected for sways and liggers, and when cutting rods into short lengths for spars any crooked sections can be discarded.

Hazel for thatching is supplied in two forms. In the Eastern counties the majority of thatchers prefer their material in the round and of random lengths up to two inch butt diameter from which they prepare spars, sways and liggers as required, whilst in the majority of southern counties the thatchers purchase these ready for use from underwood craftsmen.

Sheep Cages, Hedge Stakes and Heathers

Sheep cribs or cages (Plate 10), hedge stakes and heathers comprise three of the principal uses of hazel which assume varying degrees of local importance but which do not greatly affect the total demand for hazel in the country as a whole. Sheep cages are woven from cleft hazel rods using much the same techniques as that adopted for making wattle hurdles. They are used to hold fodder when hand feeding has to be resorted to. A type of openwork sheep feeding crib designed to keep hay clear of the ground, may also be made, at least partially of hazel. Hazel stakes are used in hedging to help hold in position the shoots after they have been partially severed and laid and to make gaps stock-proof until they are filled in by new growth. The "heathers" or "ethering rods" which consist of long rods of hazel up to twelve feet in length by 1½ inches butt diameter, are woven horizontally between the stakes, serving to bind them together and to help prevent the laid shoots from springing upright. The stakes and heathers also serve to make the hedge stock-proof until it is reinforced naturally by the new growth that follows on trimming and layering.

Minor Uses

For slack cooperage, that is for barrels designed to store or transport dry or solid goods, hoops of hazel were used extensively in the past and a limited demand still exists today, but it is for the most part for small sized hoops (see Plate 19). The size range of rods used is three to fifteen feet with a butt diameter range of from one to three inches. Good quality straight rods are required as these are cleft and bent into a circle before being driven on to the barrel. The conical Severn salmon traps, or putchers, consist of a framework of hazel held together by willow; hazel is used in the making of lobster and crab pots, fenders for boats, and was formerly used in the construction of coracles. Large rafts, called "mattresses", which may be made of hazel fascines, are sometimes used in the construction of defences against river and sea erosion and in the repair of gaps caused by flooding. The "mattresses" are floated out and are then sunk in the desired position by filling them with stones.

In basketry hazel is frequently used with other timbers. Thus hazel rims are commonly found in the cleft oak baskets (spelks or spale baskets) of Lancashire. The hazel rods used to make the rims or "bools" are from 1 to 1½ inches butt diameter, with a minimum length of 6½ feet. The rods are split, shaved flat on one side, steamed and bent into an ellipse. The nail used to join the scarfed ends of the bool is the only one used in the whole basket.

Gates, rose pergolas, and more ambitious forms of rustic work such as summer houses are still made from hazel woven on a wooden frame. As with garden screens the demand for these products is probably greatly in excess of the supply, supply being limited in most cases not by a lack of suitable hazel but by a shortage of underwood craftsmen. There are instances, however, where a supply of suitable hazel is not locally available and craftsmen have been obliged to bring in material from counties other than their own.

Chapter 3

THE HAZEL UNDERWOOD INDUSTRY

BY W. G. TRUST
Rural Industries Bureau

The simple coppice system (which is the oldest known system of forest management) was originally employed to provide such items as fuel wood, the wattle for wattle and daub building, and stock fencing. In many districts there were few other materials capable of being so easily won and worked by primitive tools, and the considerable demand for small poles resulted in the cultivation of a large acreage of simple coppice, and later coppice-with-standards, throughout the country. Later, the advent of coal and improved tools, changes in agricultural methods and rural economy, greatly reduced the demand for this class of material. Changes in the social life of the countryman, too, have played their part in reducing the quantity of coppice which has been worked systematically in the present century. History indicates that the status of the craftsman in rural communities had reached its peak in the Middle Ages. During that period communities, isolated as they were, were entirely dependent on the skill of the craftsmen for the provision of buildings, domestic and agricultural implements and primitive forms of transport. The decline in the status of craftsmen through the ages was coincident with the decline of agriculture, which was gradually replaced in order of importance by urban industry. The disruptive effects of revolutionary changes therefore, undoubtedly contributed to the decline in the numbers of coppice craftsmen, but in the main the decline can be attributed to the lack of policy for agriculture and forestry prior to, and during, the early part of the present century. Before the 1914 war, impoverished agriculture obliged craftsmen to work long hours for returns which enabled them to provide little more than a bare living for their dependents. The war involved the younger generation of craftsmen, and many of those who survived, returned to seek a living in the industrial towns rather than the rural community, where lack of opportunity had engendered apathy and barred the way to a better standard of living.

When the 1947–49 Census of Woodlands had been completed it was at once obvious that, in spite of the decline in the demand for coppice-wood, large areas of woodland were still under coppice or coppice-with-standards. In many of these woodlands the coppice had not been worked for a considerable number of years; in others there was every sign that the coppice was being systematically worked on a regular rotation, and the Rural Industries Bureau were also in a position to confirm the existence of a small but healthy "underwood industry". Moreover, for certain types of underwood produce, the decline in demand, which had continued throughout the centuries, seemed at last to have been arrested. In some cases demand even exceeded supply. The information at the Bureau's disposal was however of a qualitative rather than quantitative nature and in order to assist the Advisory Committee on the Utilisation of Home Grown Timber and to complete their own records, the Bureau undertook to promote a detailed survey of the underwood industry. The survey was started in June 1951 and the field work was completed by March 1953. A form designed to show details of numbers employed, articles produced, species and category of raw material used, and the location of the woodlands involved, was circulated to the county organisations, whose Rural Industries Organisers possess a wealth of local information and a detailed knowledge of the craftsmen in their area. In designing this form, it was borne in mind that rural craftsmen dislike supplying information for form filling, and the number of questions which would have to be put to them was reduced to an essential minimum.

The five Area Officers of the Rural Industries Bureau acted as links between county organisations and the Bureau technical staff, to ensure that any advice and assistance required would be made available. The field work of the survey involved visits to all known and many hitherto unknown craftsmen, and on completion the Underwood Officer of the Bureau was responsible for revising, classifying and summarising the data collected. The summary reveals that more than 2,000 workers are fully employed in the industry, which uses hazel, chestnut and other coppice species, small hardwood forest thinnings, and in some cases, varying quantities of small softwood thinnings. This publication is, however, only concerned with that section of the industry which uses hazel coppice.

There are now approximately 300 full-time workers engaged in the hazel coppice industry, which is spread in the main through the southern and eastern counties of England, with the greater concentration south of a line from London to Gloucester. It is estimated that the area of hazel coppice required to maintain the established hazel underwood industry at its present level amounts to 12,200 acres assuming a rotation of six to ten years. There are many part-time workers who divide their time between seasonal agricultural work and coppice cutting and conversion; so that in arriving at this figure an additional allowance of 10 per cent on the area required by full time craftsmen has been made to cover the acreage cut by casual workers. These figures make no allowance for hazel cut on private estates, where the work is carried out by estate employees, producing for example, crate rods and material for fencing and the maintenance of hedges.

In the past, independent hazel coppice craftsmen produced sheep hurdles, stakes, and laths for local farms and building, and in addition many were employed by estates on similar work. Today the mastermen generally employ from one to six full-time workers, and their products find a much wider market in town and country. Small numbers are still employed by private estates, but the majority prefer to work for themselves or to be employed by the master craftsmen.

The craftsmen generally do not own coppice woods, but purchase hazel as a standing crop at local auction sales. In districts where there are too few craftsmen to render an auction practicable, they frequently arrange with local estate owners to purchase on a year-to-year basis sufficient suitable coppice for their needs. Alternatively a whole wood containing sufficient coppice for several years' work may be leased.

Size of Hazel Used

Table 2 gives the size of rods used by the hazel underwood industry as ranging from ½ inch to 4 inches butt diameter; it is, however, quite certain that the bulk of hazel products are made from rods of 1 inch to 2 inches butt diameter, and that the use of rods of smaller or larger butt diameter is very much a question of local conditions.

Rods of small diameter are always found no matter what the age of the hazel may be, since apart from any other consideration, several fresh new shoots are sent up each year, even when no cutting has taken place. The economic use of small rods is therefore an important matter for the underwood craftsman who, generally speaking, uses as many small rods as his markets will allow. Small diameter rods are commonly used as withes for tying produce into bundles.

The rods at the top end of the diameter range, i.e. from 2 to 4 inches, are used principally for shores and stakes. Rods of this size occur in stands where the coppice is uneven-aged and on woodland boundaries where the unrestricted light may produce very fast growth. In recent years much of the largest material used (4 inch butt diameter) has been derived from the rehabilitation of coppice neglected during the war.

Rotation

The table shows a considerable variation in the rotation adopted for hazel both within counties and from county to county. These variations are caused by the interaction of a number of factors, some of a permanent, others of a more temporary nature. The soil and climatic conditions on any one site have a constant effect on the rate of growth. These factors will, however, vary from locality to locality, and therefore the time taken for a crop to reach any desired size will vary with its location. The effects of unchecked overhead canopy development of standards and weed species may produce heavy shade and overcrowded conditions which progressively retard the rate of growth of the hazel, reducing the effective number of stools per acre and the number of shoots per stool. These conditions, it is true, may influence no more than a single rotation, but there are many instances where such conditions have been allowed to persist over long periods, unnecessarily lengthening the rotation for the hazel. The quality of the crop also suffers considerably under these conditions. (See Plates 1 to 7.)

Rise and fall in demand may result in a single rotation being shortened or lengthened. A change in the kind of end product which represents the bulk of demand may eventually result in a permanent change in the length of rotation. This does not become evident for some time, but nevertheless accounts to some extent for the variation which the table discloses. The steady increase in demand for garden screen type wattle hurdles since the war has resulted in the use of coppice which had grown out of rotation through lack of demand and a consequent period of neglect. The disruptive effects of war have been the cause of unusually long rotations in some counties, and the age of coppice cut has in many cases been the result of circumstances rather than choice.

The silviculture and utilisation problems which the interaction of these factors pose can all be resolved by good management, and provided that there is a good demand for the end products the adoption of a general purpose rotation has much to recommend it. For hazel grown on favourable sites, a nine-year rotation may be regarded as sufficiently long for most purposes, without in any way unduly limiting the diversity of end-products which may be obtained.

The greatest demand for hazel coppice is for the garden screen type wattle hurdle (Plates 15, 24 to 27), and although these can be made from hazel grown on rotations of from six to twelve years a rotation midway between these may be regarded as the best general-purpose rotation. From coppice of this age, wattle hurdles of both types, crate rods, stakes, bean rods, pea sticks, and thatch spars, can be produced. The butt diameter of nine-year old hazel will range from ½ inch to 2 inches with an average height growth of fifteen feet.

The sheep-folding type of wattle hurdles (Plate 14) is traditionally made from rods of a more limited size range than that now generally used for the screen type hurdle, but the demand for the latter is considerably greater, and it may be assumed that from coppice grown on a nine-year rotation there will be sufficient rods of the required sizes to meet demand for both types.

A six-year rotation is favoured and may be the best, where crate rods are the principal product, demand being heaviest for small rods of ½ to 1½ inches butt diameter with a length of from ten to fourteen feet, but illogically this short rotation is still adhered to in some counties, where the demand for crate rods has fallen.

Acreage cut Annually by Individual Craftsmen

The table indicates that the area cut, on average, by one man in one year varies considerably as between counties. Such variations are due to the variations in yield and types of end-product, but in the Bureau's experience the felling and conversion of four to five acres of hazel coppice employs one man for one year. In cases where less than this area is cut the craftsman concerned may also be engaged in the cutting and conversion of species other than hazel.

On the basis of the average for the country as a whole the individual hazel underwood craftsman requires forty acres of hazel coppice to keep him in full employment, the average rotation being eight years and the average annual cut five acres.

Tools

The coppice craftsman's tools are few in number but various in design. With the exception of the hurdle mould they are all hand-operated edge tools. The most used and important is the billhook, which varies in shape and weight from county to county, some bearing a county name, such as the Monmouth bill. Generally, coppice cutters producing crate rods, pea boughs and bean sticks, and all kind of stakes, require only two tools, a billhook which they use for laying the crop and trimming the rods, and a five-to-six pound felling axe for laying the heavier rods which occur in crops managed on a long rotation. The hurdle maker commonly uses three billhooks, a heavy one for laying the crop, a lighter one with a curved cutting edge for cleaving, and a lighter one with a straight cutting edge for trimming or finishing the hurdles (see Fig. 7). Alternatively, a small adze may be used for cleaving. This tool is still preferred by some of the older craftsmen.

A hurdle mould or break (Plate 16) which is curved and drilled, often with two sets of holes which take the upright stakes of both types of hurdle, and leather kneepads or knaps, which fasten above and below the knee for protection, complete his equipment.

Mechanisation

There are few existing forms of mechanisation which can readily be adapted for the industry because of the irregularity and small size of the material involved. Some mechanical means of laying the crop is possible, but there are many difficulties which will need to be resolved before this form of mechanisation can be generally adapted for coppice management. A machine capable of cutting and laying the crop in orderly fashion, which would not at the same time damage the stools and reduce their life to a fraction of that possible with hand harvesting, is required. Several machines have been tried but so far none has been found suitable.

Discussion

The survey carried out by the Bureau indicates that the hazel underwood industry at present utilises less than ten per cent of the total area of hazel coppice, including hazel in woods of one to five acres in extent. The decline in the use of hazel may be attributed primarily to the decline in the demand for the traditional products made from hazel; but it would be wrong to assume that this is the sole explanation for the existence of such a large area of unworked hazel coppice. Indeed the current demand for hazel garden screens is considerably greater than the supply. A shortage of skilled underwood workers is a factor of some material importance in deciding the present size of the industry. As the older men retire their places are frequently left unfilled by the younger generation, in spite of the fact that the financial rewards are good. The problem of attracting new recruits to the industry is accentuated by virtue of the fact that the making of hazel garden screens, the product for which there is the best demand, calls for a considerable amount of skill.

DEMAND FOR HAZEL COPPICE BY THE HAZEL UNDERWOOD INDUSTRY IN ENGLAND AND WALES IN 1952–53

TABLE 2

Uses	*Butt diameters Inches*	*Rotation Years*	*Number of Establish-ments*	*Number of Men Employed*	*Area of Hazel Coppice in Acres*		
					Total	*Worked*	*Unworked*
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
HAMPSHIRE—Wattle hurdles, crate rods, rustic gates, pea sticks, bean rods, thatching spars	½–4	6–9	44	77	32,372	3,800	28,572
SUSSEX—Wattle hurdles, thatching spars, broom handles, charcoal, pea sticks, bean rods, stakes, barrel hoops ..	½–4	8–10	19	48	15,375	2,250	13,125
DORSET—Wattle hurdles, crate rods, sheep cribs, thatching spars, fencing piles, stakes, barrel hoops	½–3	6–9	22	52	10,144	1,850	8,294
SURREY—Wattle hurdles, faggots, charcoal, barrel hoops, stakes	½–3	9	4	20	7,758	1,250	6,508
WILTSHIRE—Wattle hurdles, thatching spars, pea sticks, bean rods	½–4	6–9	10	16	7,866	700	7,166
SUFFOLK—Wattle hurdles, gate hurdles, hay rakes, thatching spars, hop poles, crab pots, bean rods, pea sticks	½–4	9–7	6	18	5,018	650	4,368
WARWICK AND NORTHAMPTONSHIRE—Pea sticks, bean rods, wattle hurdles, thatching spars, horticultural stakes	½–3	9	9	12	2,571	400	2,171
KENT—Wattle hurdles, bean rods, pea sticks	½–3	10	3	11	5,468	350	5,118
LINCOLNSHIRE—Thatching spars, stakes, sheep trays ..	1–4	10	3	13	1,230	250	980
OXFORD, BUCKINGHAM AND BERKSHIRE—Wattle hurdles, thatching spars, stakes ..	½–3	9	2	4	8,795	250	8,545
CAMBRIDGE AND HUNTINGDON—Gate hurdles, thatching spars, stakes	1–3	9	3	5	917	200	717
NORFOLK—Thatching spars, willow wattle hurdles, gate hurdles, baskets, rustic work, stakes	½–3	7–9	11	23	1,737	150	1,587
LEICESTER AND RUTLAND — Fencing, thatching spars, 4-poles (pea drying), bean rods, pea sticks	½–4	9	1	1	337	50	287
OTHER COUNTIES	—	—	—	—	17,754	50	17,704
TOTALS	½–4 (range)	6–10 (range)	137	300	117,342	12,200	105,142

Notes: Col. (v) Established full-time craftsmen.

Col. (vi) Coppice and Coppice-with-Standards occurring in Woodlands of 5 acres and over, as recorded in the 1947 Census of Woodlands.

Col. (vii) Includes estimated area worked on a regular rotation by part-time underwood craftsmen but excludes cutting by private estates for their own use. Formula used for calculation, $(a \times \text{rotation}) + 1/10\ (a \times \text{rotation})$ = total area worked, (rounded up to nearest 50 acres), where a = annual cut in acres, by full time craftsmen.

Chapter 4

THE YIELD OF HAZEL COPPICE

BY J. N. R. JEFFERS
Forestry Commission

(i) Description of Investigation

The yield of hazel coppice is judged by the underwood craftsman in terms of out-turn of utilisable produce rather than in terms of volume or weight of timber, and so long as hazel could be sold for its traditional uses no other method of measuring its yield was called for. But with large areas of hazel finding no outlet whatsoever, a different approach to the problem of yield was indicated, and it seemed desirable to know the probable yield in the conventional units of measurement (i.e. volume or weight) used outside the underwood industry. The practical difficulties of measuring accurately the volume of large numbers of small sized shoots are at once obvious. Weighing seemed a much more likely method but weight in itself has little meaning when applied to timber unless other factors such as moisture content and specific gravity or density are also known in relation to the weight quoted. It was decided, therefore, to use the fresh-felled weight of hazel coppice as the basic unit of measurement and to obtain the average moisture content at the time of weighing, so that the yield for different localities could be calculated and presented as:

(a) *Weight per acre on an oven-dry basis,* i.e. free from all moisture.

(b) *Weight per acre at the average moisture content of fresh-felled hazel* (average moisture content as determined during the investigation).

The data in (a) and (b) would be in such a form that valid comparisons of yield as between one locality and another could be made without the complicating factor of possible differences in moisture contents having to be taken into account. Moreover it was considered that if any new uses for hazel coppice were developed, say, in the field of pulp manufacture, the data would be available in a form (oven-dry weight) suitable for consideration by those interested in this possibility.

It was also decided to obtain the average specific gravity of hazel so that weights per acre could be converted to volumes per acre, thus enabling some comparison, however general, to be made with yields from other forest crops.

Measurements were made in sample plots, each of 1/10th acre, located in different parts of the country. Four sets of plots were chosen in the south of England where the bulk of the hazel coppice is situated. Two sets of plots were selected in East England in order to obtain data outside the main hazel producing area. The sets of plots were "paired" so that in each locality in which measurements were made one set of plots fell in an area of coppice currently managed on a coppice rotation, and the other set fell in unworked hazel coppice on a similar site. The sets of plots were located and paired as follows:

Locality	*Unworked Coppice*	*Worked Coppice*
Hampshire	Micheldever	Kings Somborne (two age groups)
Sussex	Rewell Wood	Poling Copse
East England	Tunman Wood Notts.	Bury St. Edmunds, Suffolk

Details of the methods used and of the data obtained are given in Appendix I, page 22. A brief note of the conditions at each site is given in Appendix II, page 31.

(ii) Results

The following tables give yields from hazel coppice for favourable sites; on poorer sites, or where coppice has been damaged or worked out, yields may be only half those given in the tables. The recorded yields for Bury St. Edmunds and Tunman Wood are examples of these low yields.

Height Growth

The average height of hazel coppice—defined as the average of the lengths for the dominant shoot on each stool—varies from site to site, but on any one site does not increase very much after about seventeen years. From Figure 1 it may be seen that average height of the coppice is not a good measure of the quality of the site—at Bury St. Edmunds and Tunman Wood, the yields were low, but the average height of the coppice at these two sites is only a little less than at the more favourable sites. For this reason yield has been related to age, and not to height, in the tables which follow.

AVERAGE HEIGHT OF HAZEL COPPICE AT VARIOUS AGES

TABLE 3

Age in Years	*Average height in feet*
5	11
10	17
15	21
20	23
25	24

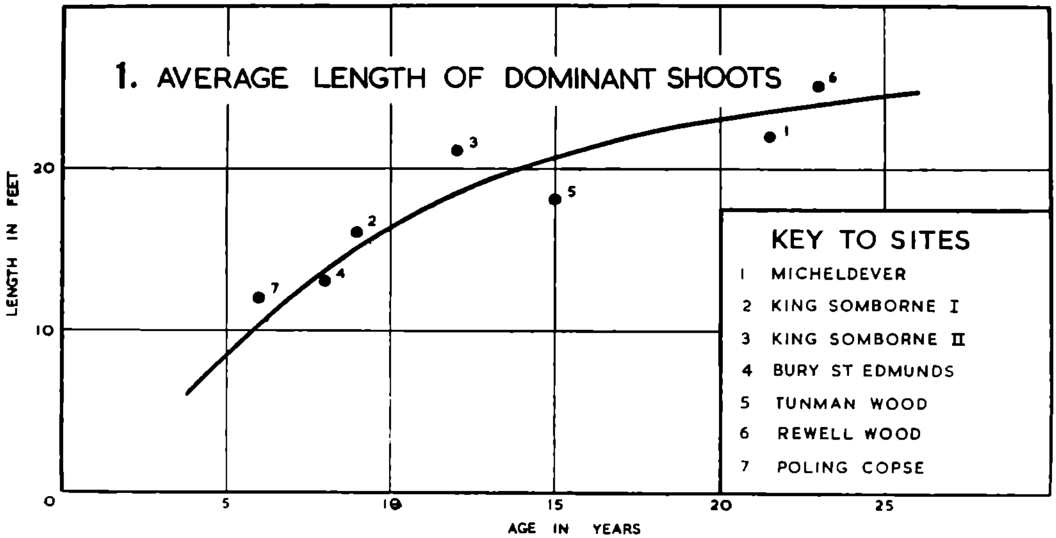

Fig. 1. Average length of dominant shoots, in relation to age.

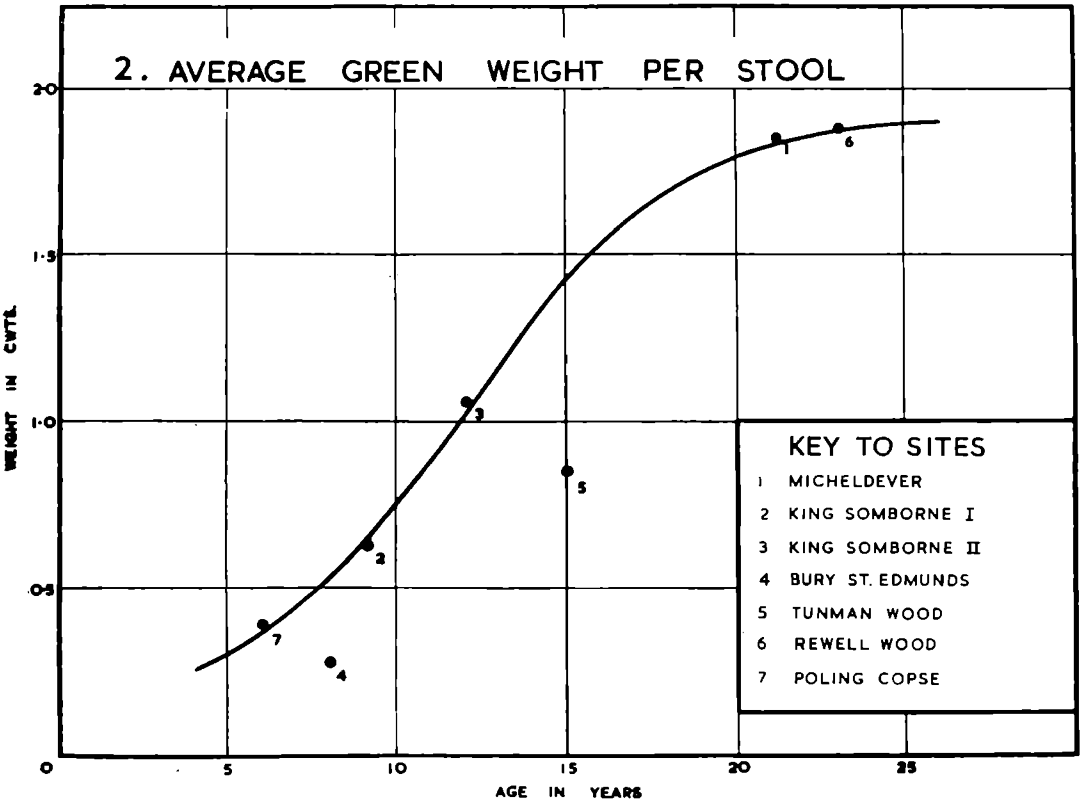

Fig. 2. Average weight of fresh-felled coppice per stool, in relation to age.

TABLE 4

TOTAL WEIGHT OF FRESH-FELLED HAZEL COPPICE

Age (Years)	*Weight per stool (cwts.)*	*Moisture Content of Fresh Felled Material*	*Number of stools per acre*						
			100	200	300	400	500	600	700
		%			*Weight in tons per acre*				
5	·3	92	1·5	3·0	4·5	6·0	7·5	9·0	10·5
10	·75	87	3·8	7·5	11·3	15·0	18·8	22·5	26·3
15	1·45	84	7·3	14·5	21·8	29·0	36·3	43·5	50·8
20	1·80	80	9·0	18·0	27·0	36·0	45·0	54·0	63·0
25	1·90	80	9·5	19·0	28·5	38·0	47·5	57·0	66·5

Total Weight of Fresh Felled Coppice

For each site, the average weight per stool of fresh felled coppice is plotted in Figure 2. The points, except those for Bury St. Edmunds and Tunman Wood, lie on a smooth curve. This curve has been taken to represent the yield per stool on favourable sites. Table 4 is derived from this figure and gives the average weight of fresh felled hazel coppice per stool at intervals of five years, and also the total weights per acre for varying numbers of stools per acre.

The yields in this table suggest that the increase in total volume is unimportant after about twenty years, and that increment begins to fall off after about fifteen years, or possibly a few years earlier. For well-stocked coppice (500–600 stools per acre), the total yield of fresh felled coppice is two to two and a half tons per acre per annum, for rotations of between ten and twenty years, but, on poorer sites as at Bury St. Edmunds and Tunman Wood, total volume production may be only half that shown in the table.

It is possible that competition between stools would reduce the yield at ages of twenty and twenty-five years for densities of 600 to 700 stools per acre. This investigation gave no information on this point,

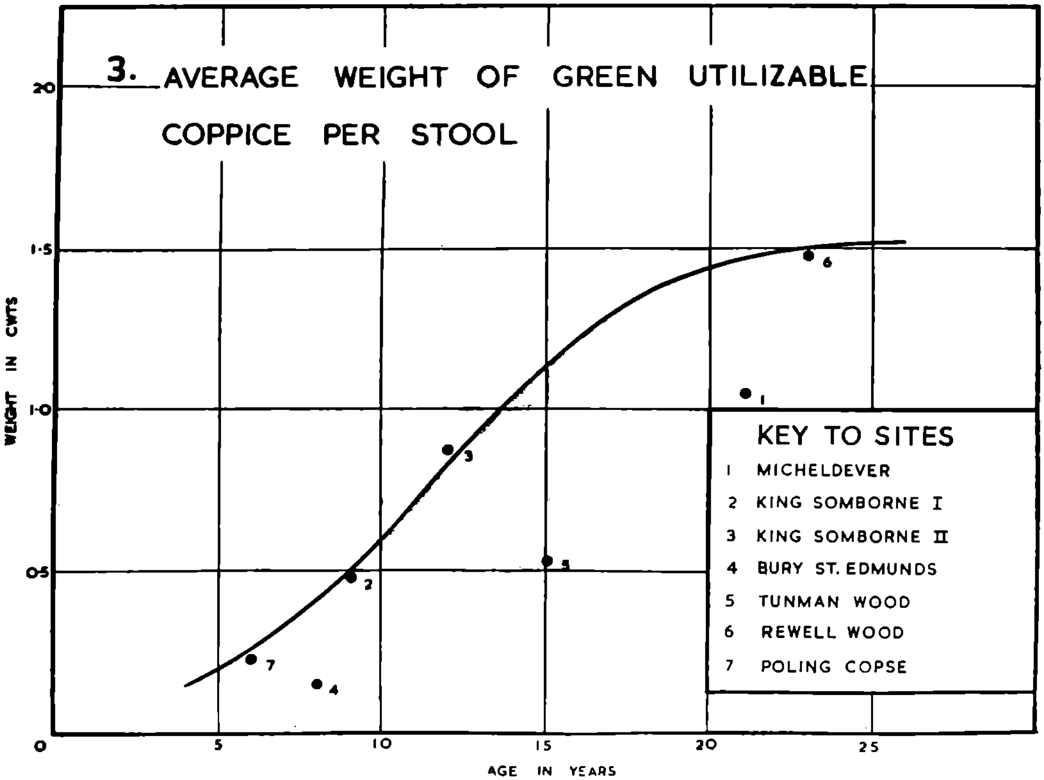

Fig. 3. Average weight of fresh-felled utilizable coppice per stool, in relation to age.

Plate 1. One year's growth of vigorous hazel coppice, from a cut-over stool

Plate 2. Well-tended hazel coppice, seven years old, ready for cutting

Plate 3. Neglected hazel coppice, aged about 20 years; too old, thick and brittle for hurdle making

Plate 4. Neglected, over-aged hazel coppice, with an odd stem of ash; too thick for utilisation

Plate 5. Well-grown hazel coppice, recently cut, laid in "drifts" for sorting

Plate 6. Coppice-with-standards. The hazel coppice has just been cut; the standard trees are oak and ash

Plate 7. Coppice-with-standards. Hazel coppice about three years old, springing up amid oak standard trees

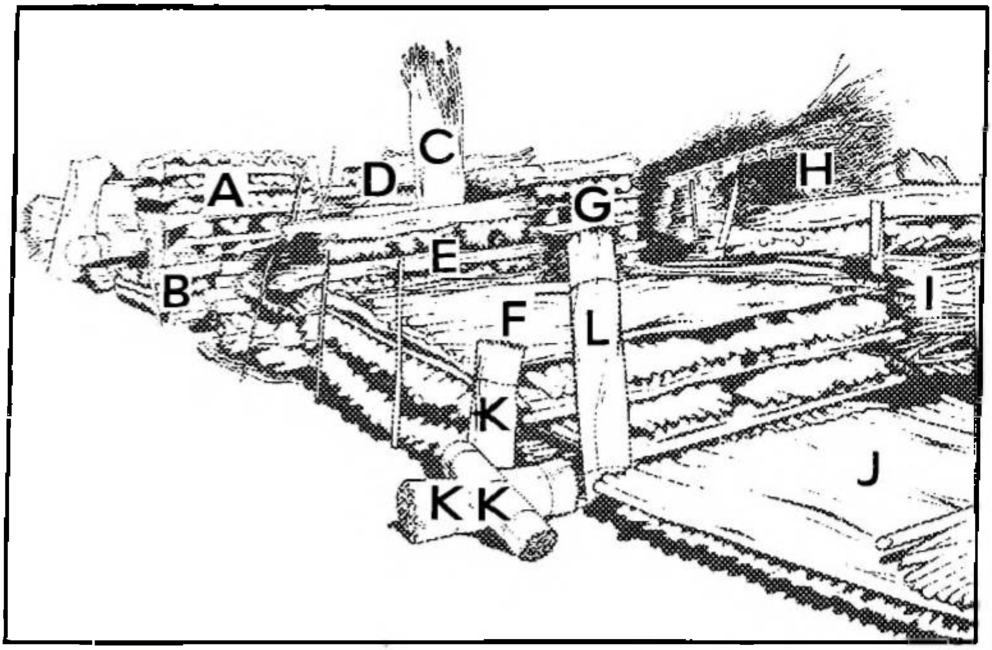

Plate 8 and Key Drawing. Produce sorted out from newly-cut hazel

A, E.	Beansticks.	B.	Tomato Sticks.
C.	Clothes Props.	D.	Packing Rods.
F, J.	Tree Stakes.	G.	Dahlia Stakes.
H.	Peasticks.	I.	Packing Sticks.
K.	Thatching Spars.	L.	Liggers for Thatching.

Plate 9. Stool of newly-cut coppice, showing good, clean, sloping cuts made with the bill-hook

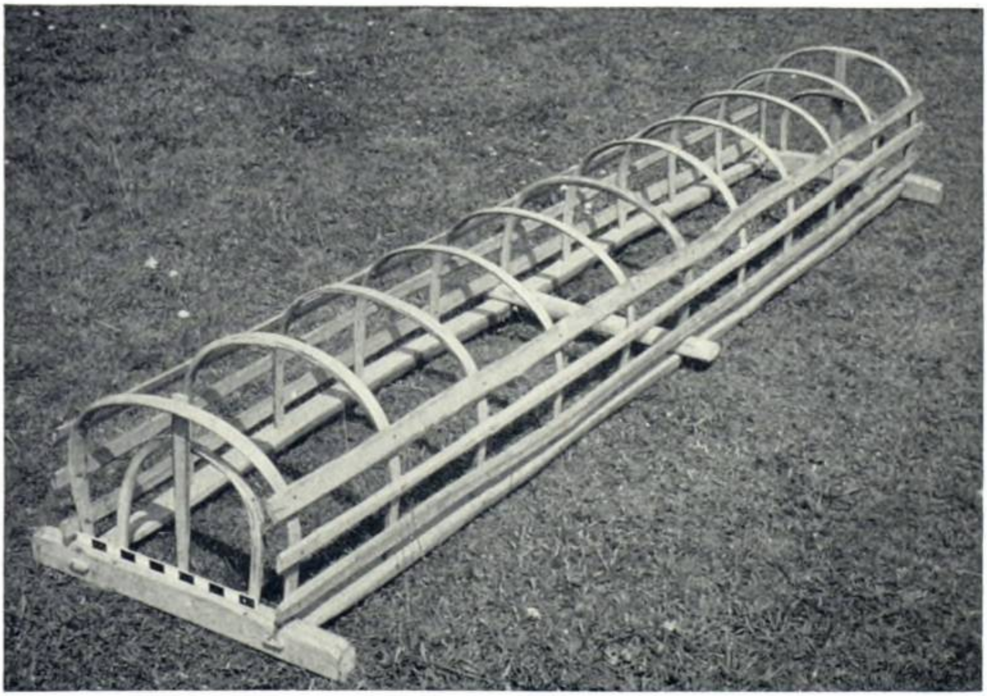

Plate 10. Sheep-feeding crib, made of ash, with hazel hoops

Plate 11. Hurdle-making. Cleaving rods with the bill-hook. Note, on left, uprights set ready in the "break"; on right, selected round rods and cleft rods laid out on the "horse"

Plate 12. Hurdle-making. Weaving in a cleft rod. Note round rods used for the lower courses.

Plate 13. Hurdle-making. Turning a cleft rod round an end post, and interweaving it.
Note, below, how the round rods are interlocked at their ends with cleft rods higher up, to hold the hurdle together

Plate 14. Hurdle-making. Trimming up the finished hurdle

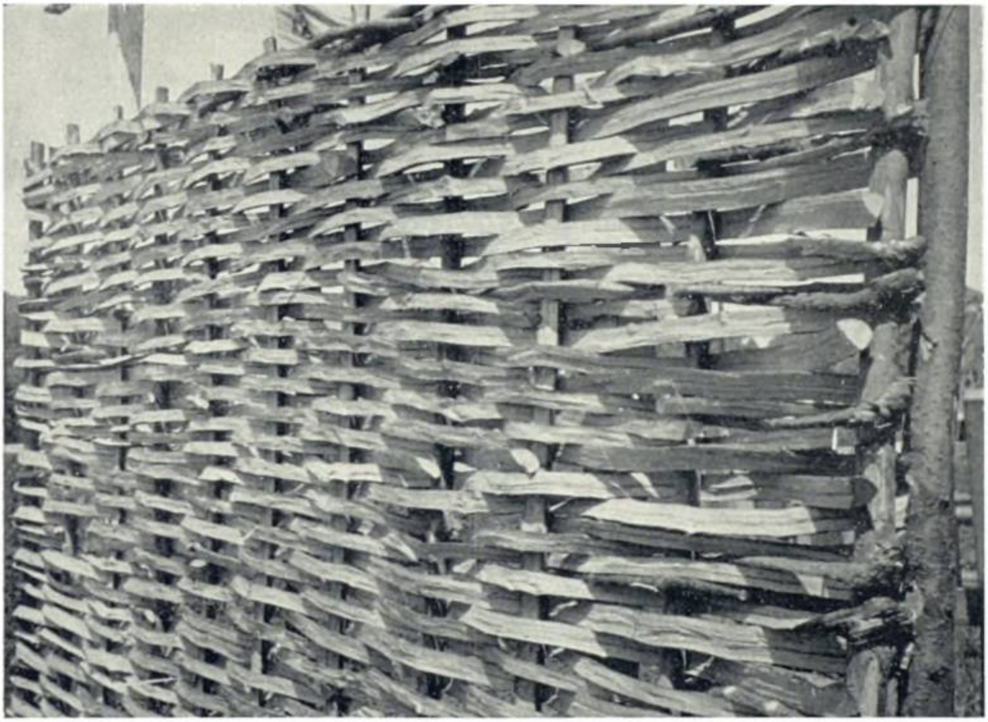

Plate 15. Detail of a cleft-rod garden screen

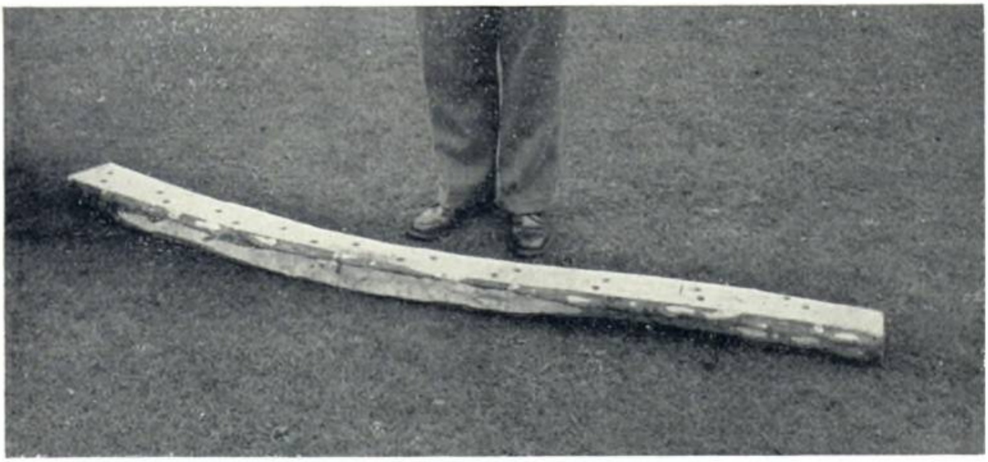

Plate 16. Typical " break " for hurdle making. Note curved outline, and double series of holes for uprights to allow variation in spacing

Plate 17. Hurdle-making. Turning a cleft-rod round an end upright

Plate 18. Cleft sways for thatching

Plate 19. Shaving hoops of cleft hazel with a draw knife on a special " break "; a varied assortment of coppice produce lies stacked in the background

Plate 20. Hurdle-making. Turning a round rod at the top of a hurdle; its end will be interwoven with the cleft rods below

Plate 21. Thatching a rick. Using a broche to secure a ligger

Plate 22. Cleft spars of hazel, for use in thatching, as bent broches, or in the straight length

Plate 23. Two methods of twisting spars to form broches

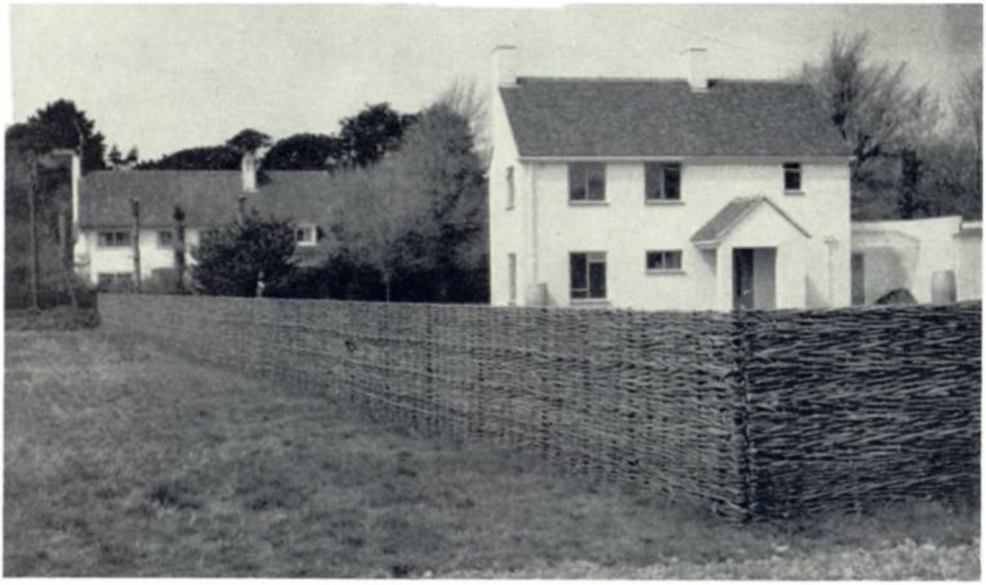

Plate 24. Continuous wattling with round rods, forming a garden screen

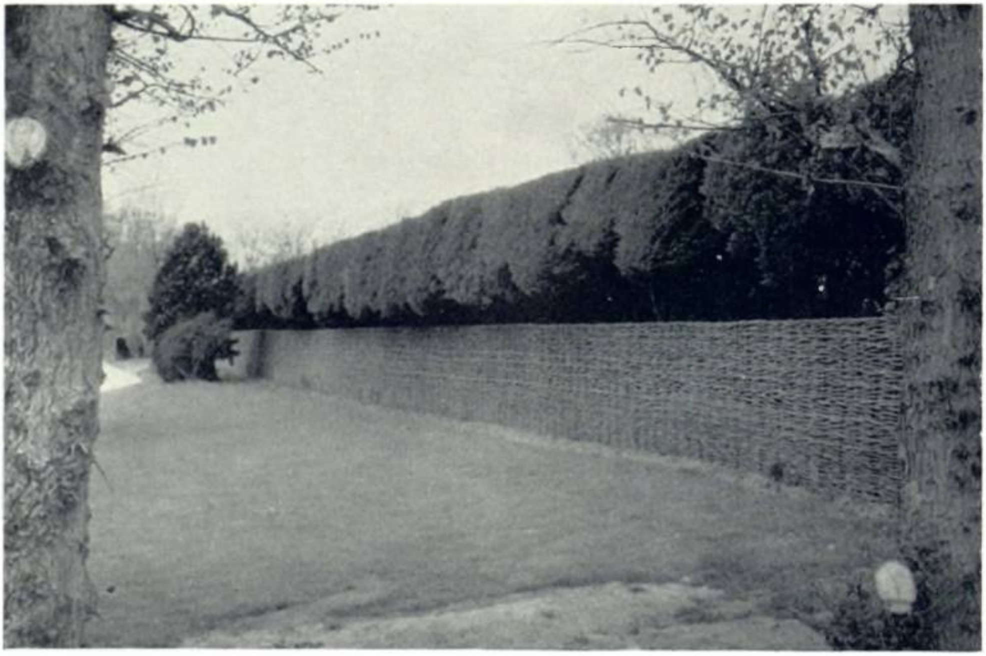

Plate 25. A continuous round-rod screen used to fill a gap below a tall hedge

Plate 26. Detail of continuous round-rod wattling

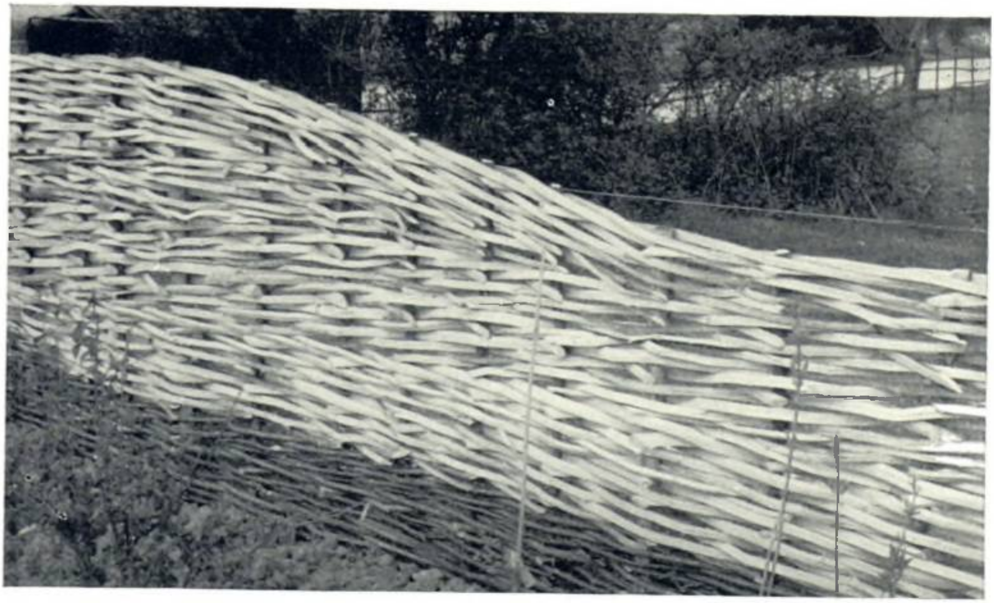

Plate 27. Composite continuous screen; cleft rods above, round rods below

Plate 28. Newly thatched cottages at Swan Green, near Lyndhurst, New Forest. Note the pattern produced by the liggers

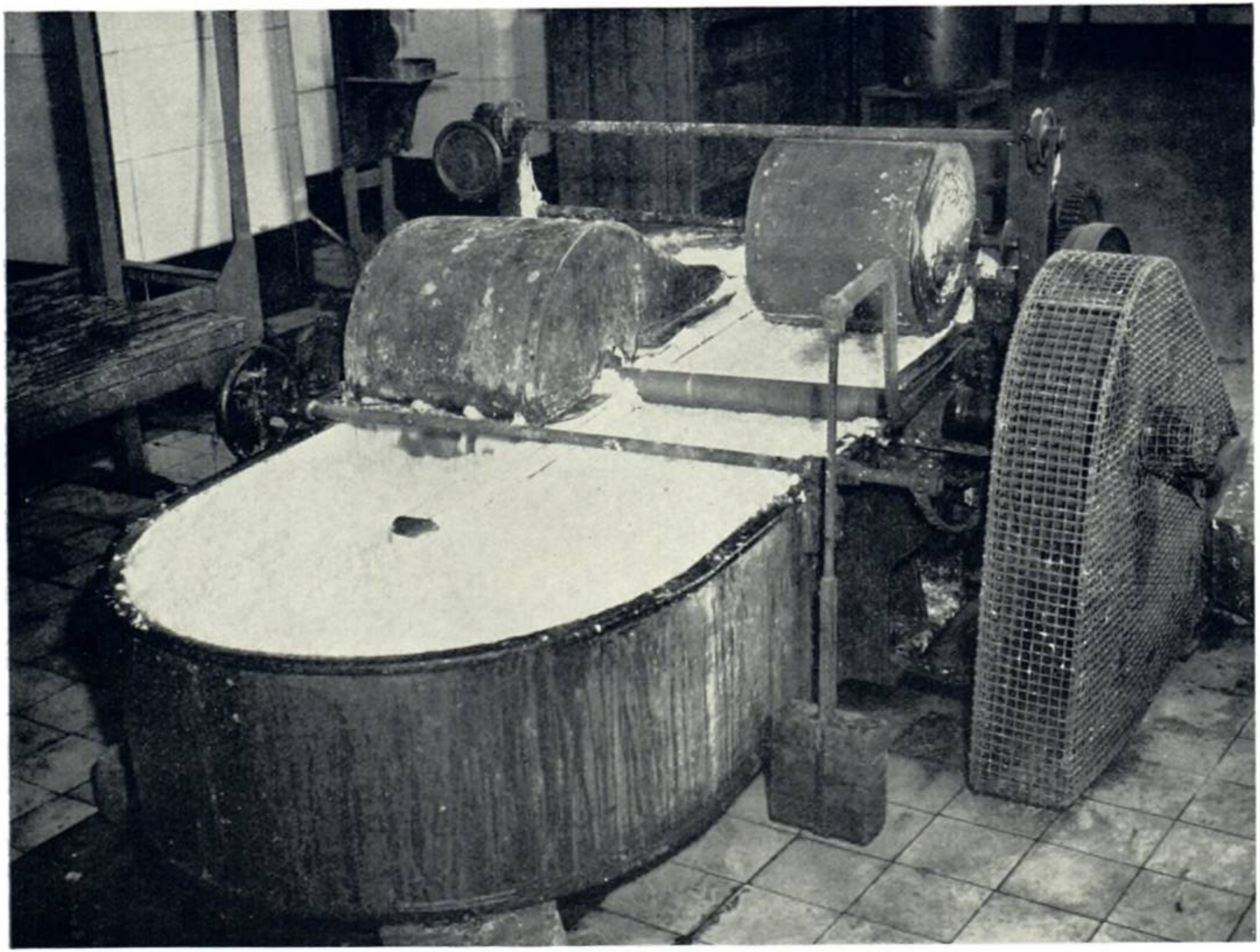

Plate 29. Making paper from hazel on an experimental scale. Beating the wood pulp

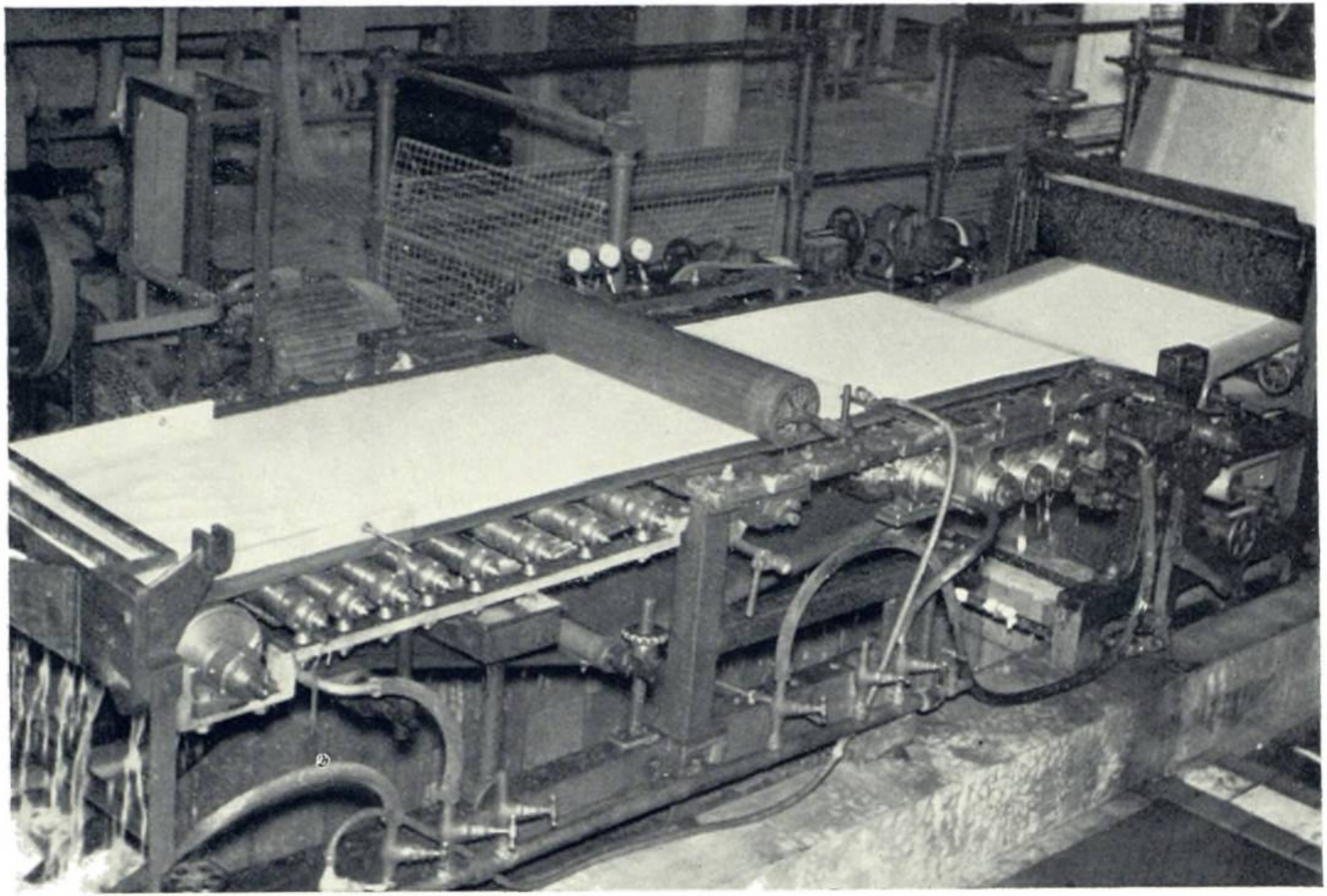

Plate 30. Paper making. The paper is formed from the pulp on a moving band of felt, through which the surplus water drains away

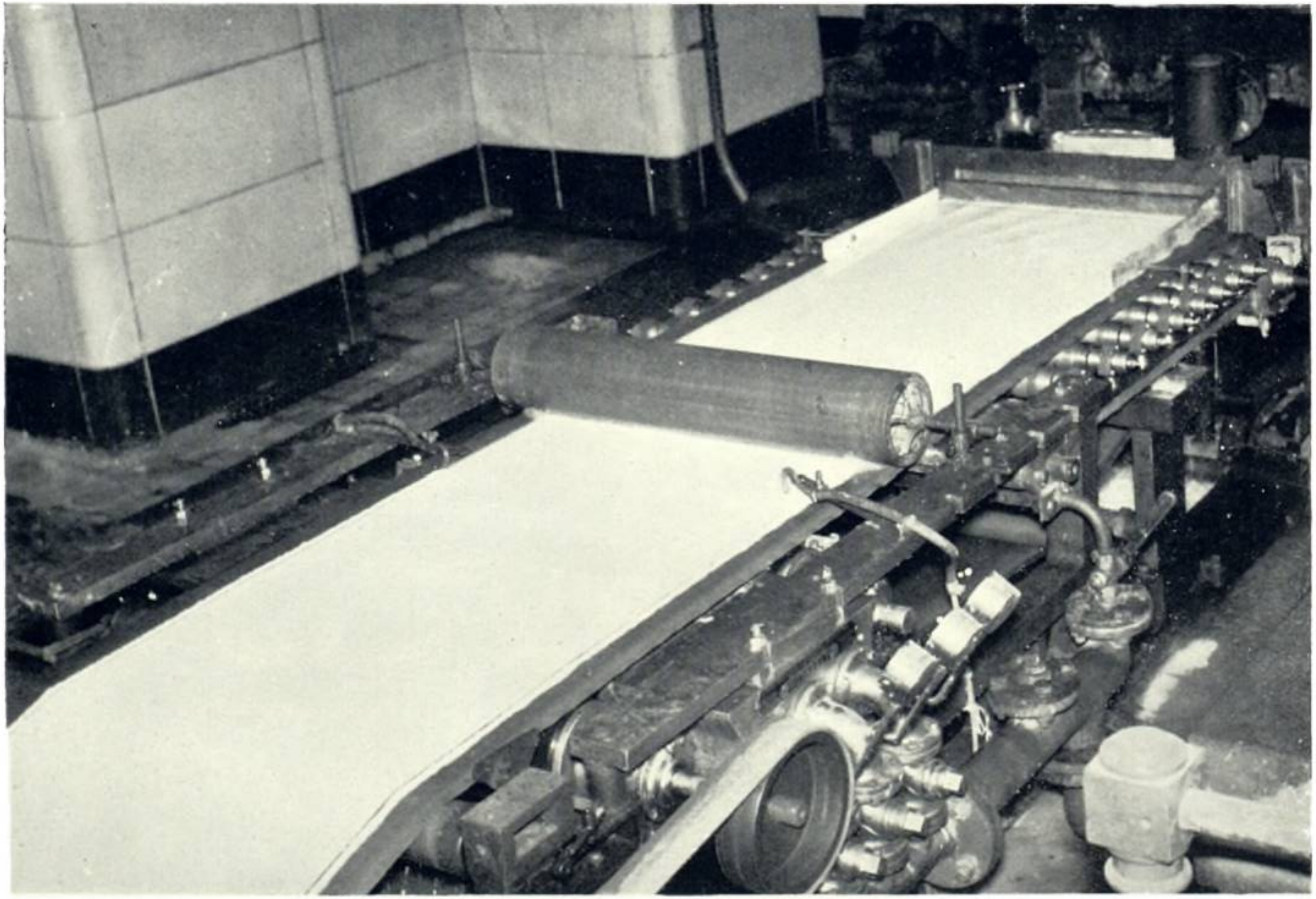

Plate 31. Paper making. Edging the roll of paper with water jets (centre of picture)

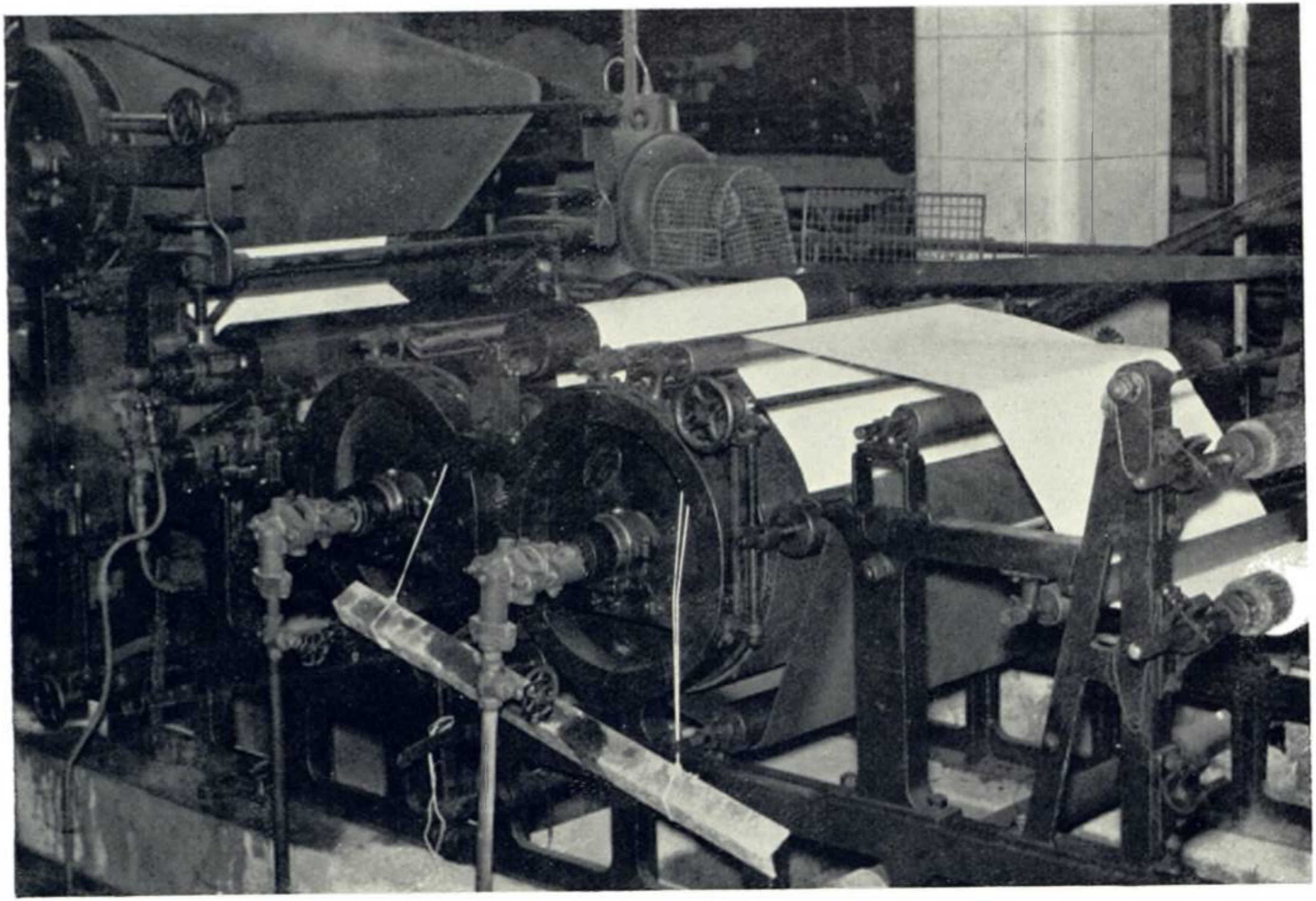

Plate 32. Paper making. The paper, having left the felt, passes over the drying rolls

WEIGHT OF FRESH-FELLED TRIMMED COPPICE

TABLE 5

Age (Years)	Weight per stool (Cwts.)	Weight per stool: As % of Total Weight	Moisture Content of Fresh Felled Material %	Number of stools per acre: 100	200	300	400	500	600	700
				Weight in tons per acre						
5	·20	67	92	1·0	2·0	3·0	4·0	5·0	6·0	7·0
10	·60	80	87	3·0	6·0	9·0	12·0	15·0	18·0	21·0
15	1·16	80	84	5·8	11·6	17·4	23·2	29·0	34·8	40·6
20	1·44	80	80	7·2	14·4	21·6	28·8	36·0	43·2	50·4
25	1·52	80	80	7·6	15·2	22·8	30·4	38·0	45·6	53·2

and no allowance has been made for such an effect in Table II or in any of the tables which follow.

Weight of Fresh Felled Trimmed Coppice

The average weight of fresh felled trimmed coppice per stool for each site is plotted in Figure 3. A smooth curve, similar to the one in Figure 2, has been drawn through the points for Kings Somborne, Rewell Wood and Poling Copse. The yields for Bury St. Edmunds and Tunman Wood were again low, and they have not been taken into account in drawing the curve. The yield for Micheldever was also low, and this point has also not been taken into account because it is known that at Micheldever the coppice material was trimmed to a larger top diameter than at the other sites. Table 5 is derived from the smoothed curve in Figure 3, and gives the average weights of fresh felled trimmed coppice per stool at intervals of five years, the percentage of the total fresh-felled weight that these net weights represent, and the yields per acre of trimmed coppice, for varying numbers of stools per acre.

The figures in this table suggest that the proportion of "utilisable" hazel coppice, i.e., trimmed shoots, increases rapidly in the early years, reaching about 80 per cent of the total weight in ten years. At twenty-five years it is still 80 per cent of the total weight. In well stocked coppice, the yield of trimmed coppice is approximately two tons (fresh-felled weight) per acre per annum for rotations of between ten and twenty years.

In the data obtained by this experiment, there was no evidence of any correlation between the proportion of "utilisable" coppice (to total weight) and the average number of shoots per stool.

Moisture Content Percentages

The average moisture content of fresh-felled hazel coppice for each site is plotted in Figure 4 as a percentage of the oven-dry weight. The moisture content at first decreases with age, through about 90 per cent at five years to a constant proportion of about 80 per cent at ages of fifteen years and over. The moisture content of the coppice at Micheldever was lower than those recorded at the other sites, but at Micheldever, there was a delay of a few days between cutting the coppice and testing samples for moisture content.

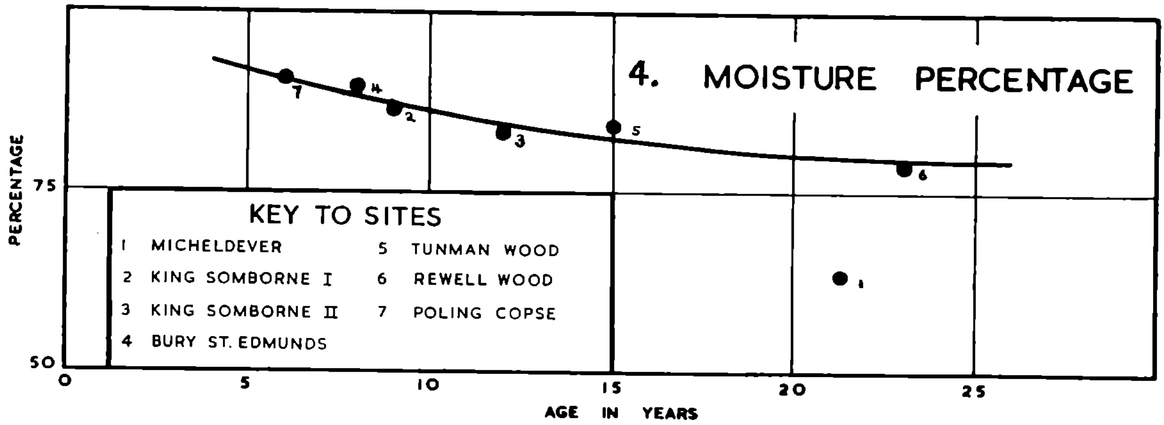

Fig. 4. Moisture content of fresh-felled coppice expressed as a percentage of oven-dry weight, in relation to age.

WEIGHT OF OVEN-DRY TRIMMED COPPICE

TABLE 6

Age (Years)	Weight per stool (cwts.)	Number of stools per acre.						
		100	200	300	400	500	600	700
		(Weight in tons per acre)						
5	·10	0·5	1·0	1·5	2·0	2·5	3·0	3·5
10	·32	1·6	3·2	4·8	6·4	8·0	9·6	11·2
15	·63	3·2	6·3	9·4	12·6	15·8	18·9	22·0
20	·80	4·0	8·0	12·0	16·0	20·0	24·0	28·0
25	·85	4·2	8·5	12·8	17·0	21·2	25·5	29·8

Weight of Oven-dry Trimmed Coppice

The average moisture content percentages, read from the curve in Figure 4, were applied to the average weights of fresh felled, trimmed coppice per stool given in Table 5 to obtain average weights of oven dry trimmed coppice per stool. The average moisture content percentages, and the average weights of oven-dry trimmed coppice per stool are given in Table 6, and Figure 5, together with the yields of oven-dry trimmed coppice per acre for different numbers of stools per acre.

Thus, for well stocked hazel coppice, the yield of oven-dry trimmed coppice is about one ton per acre per annum for rotations of between ten and twenty years, i.e., a little more than half of the equivalent fresh felled weight.

Volume of Trimmed Hazel Coppice

The average volume of trimmed hazel coppice for each site is plotted in Fig. 6. A smooth curve was drawn through the points for Kings Somborne, Rewell Wood and Poling Copse. Using the volumes read from this curve, and the oven-dry weights from Table 4, average specific gravities are obtained and are plotted in Fig. 7. Specific gravity is shown as increasing rapidly through 0·65 at five years, to 0·71 at ten years, and remaining at approximately that figure.

Table 7 gives average volumes of utilisable hazel coppice per stool and average specific gravities for intervals of five years, and also the volumes per acre of hazel coppice for varying numbers of stools per acre.

These data suggest that for well-stocked hazel coppice, the volume production of "utilisable" coppice, i.e., trimmed coppice shoots, is about fifty hoppus feet per acre per annum. For comparison, the volume production of a coniferous plantation with a moderate rate of growth (Scots pine of Quality Class II) is in the region of 100 hoppus feet per acre per annum.

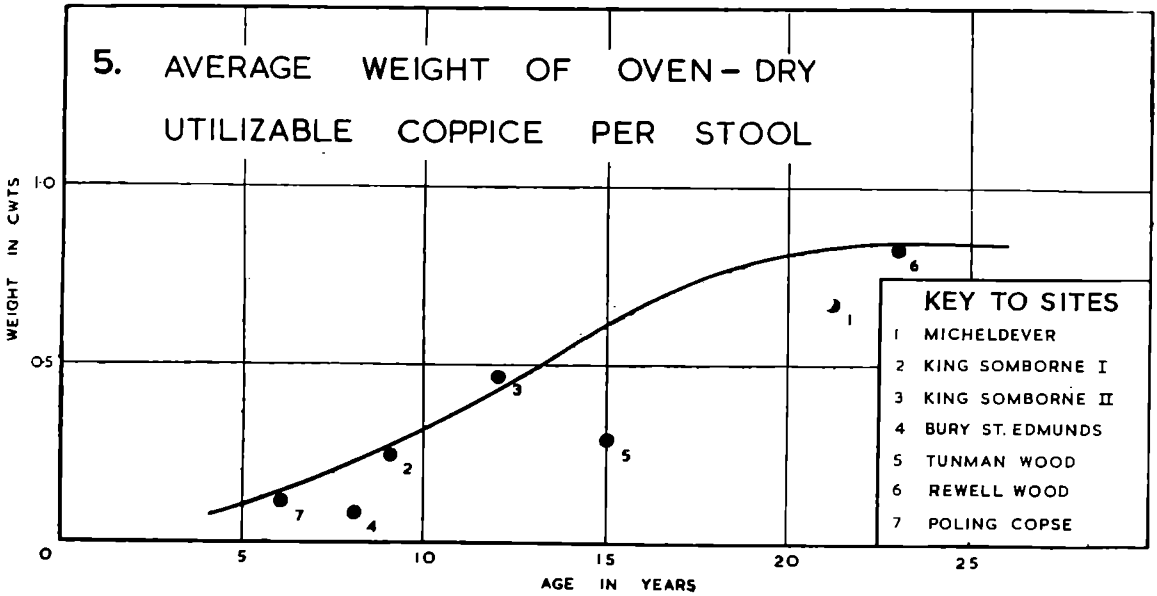

Fig. 5. Average weight of oven-dry utilizable coppice per stool, in relation to age.

TABLE 7

VOLUME OF UTILISABLE COPPICE TRIMMED SHOOTS

Age (Years)	*Volume Over-bark per Stool (Hoppus feet)*	*Specific Gravity*	*Number of stools per acre.*						
			100	200	300	400	500	600	700
			(Volume (Over-bark) Hoppus ft. per acre)						
5	·25	·65	25	50	75	100	125	150	175
10	·75	·70	75	150	225	300	375	450	525
15	1·45	·71	145	290	435	580	725	870	1,015
20	1·84	·71	185	370	550	735	920	1,105	1,290
25	1·96	·71	195	390	590	785	980	1,175	1,370

Other Species of Coppice

The yields in weight and volume of the coppice of other species, growing amongst the hazel, were also examined, but no clear relationships were observed between yield and age. Yields, in the early stages, were similar to those for hazel, but for species like oak, ash and lime, increment was still increasing at twenty years, and volumes and weights per stool were somewhat higher than for hazel. Here, the species would seem to be the important factor, but the experiment gave no reliable data on the growth of species other than hazel. The experiment also did not show whether the coppice of other species either retarded or encouraged the growth of the adjacent hazel coppice.

Comparison of results with those obtained by other workers

Worked Hazel Coppice

Bruce Durham (Chapter 2, page 3) gives an estimate

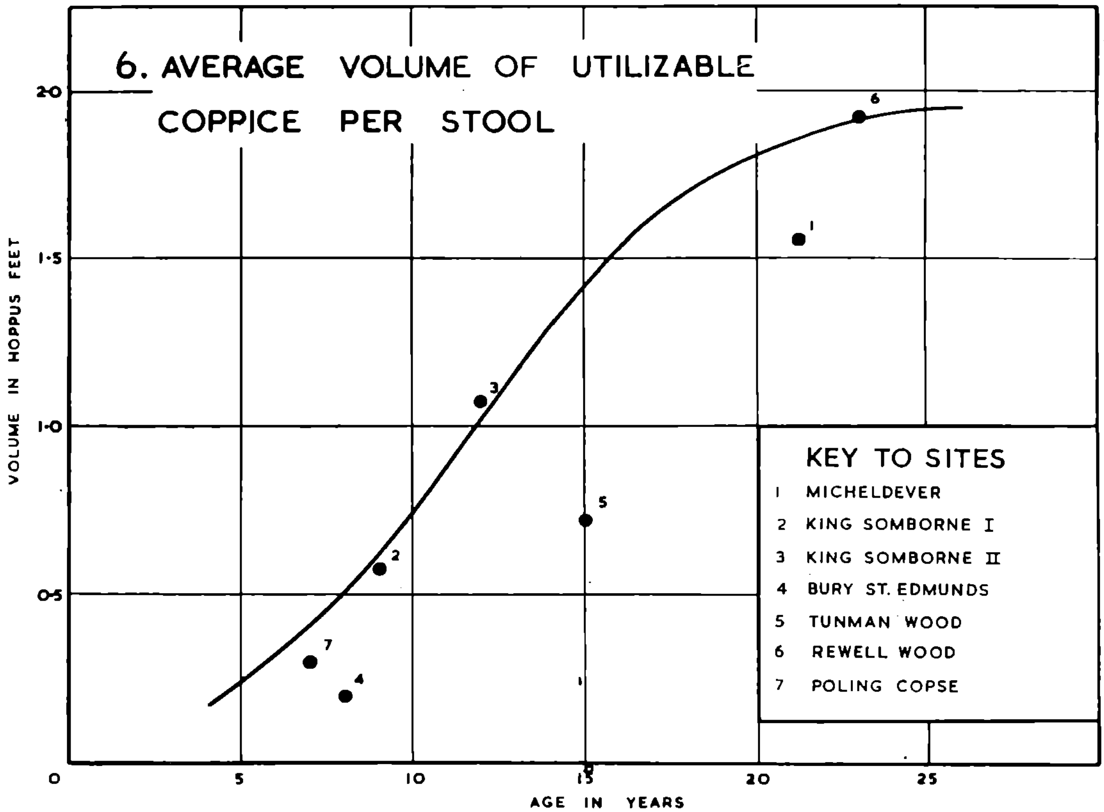

Fig. 6. Average volume of trimmed hazel coppice per stool, in relation to age.

of the average amount of produce which is obtained from one acre of good quality hazel coppice. He points out that the age at which hazel coppice is cut depends on the growth and the purpose for which it is to be used. Yields of utilisable produce will vary according to the quality of the hazel and the skill of the underwood craftsman. Hazel intended for hurdle making is cut normally when it is between nine and ten years of age, and one acre will produce some 10,000 hurdle rods; in addition between 200 and 300 bundles of pea sticks and 10 bundles of bean rods,can be obtained. For the production of crate rods, hazel may be large enough to cut any time between six and nine years of age, according to its rate of growth on any particular site. The average yield per acre of hazel cut for crate rods is 2½ loads or 250 bundles. Table 8 has been built up to show the average yield per acre of hazel cut for crate rods.

HAZEL CUT FOR CRATE RODS

TABLE 8

Type of Bundle	*Contents of One Bundle Per acre*			*Number of Bundles*	*Total No. of Rods*
	No. Rods	*Butt diam. Inches*	*Length Feet*		
20's	20	1½—2	Over 10	75	1,500
40's	40	1—1½	Over 10	75	3,000
75's	75	½—1	10—12	100	7,500
				250	12,000
			Crate heads ..		100
			Grand Total rods ..		12,100

Average Yield per Acre

Bruce Durham points out that a few bundles of 100's may be included in place of 20's, 40's or 75's. A bundle of 100's consists of 100 rods each 7 to 9 feet in length and with a butt diameter of ½ inch or less.

The trimmings will give material for 400–500 bundles of pea sticks and 20–30 bundles of bean rods.

The figures given by Bruce Durham in Table 9 for number of rods per acre are in general agreement with those obtained in the present investigation, except in the case of Bury St. Edmunds where the stocking of hazel was poor.

COMPARISON OF YIELDS

TABLE 9

Bruce Durham's Figures		*Forestry Commission Figs.*	
Age Years	*Number of hazel rods per acre*	*Age Years*	*Number of hazel shoots per acre*
6—9	12,100	6	12,800
		8	6,600
		9	12,700
9—10	10,000	9	12,700
		12	12,100

Unworked Hazel Coppice

At Micheldever, after the required measurements had been obtained, the felled coppice was worked over in order to meet a local demand for firewood. The shoots of all species were cut at the 2 inch diameter point and the material over 2 inches was piled into cords. In all some 13¾ cords of firewood were produced from the 9 one-tenth acre plots, equivalent to about 15 cords per acre. Whilst it would be wrong to attach too much importance to this figure, it is interesting to note that similar yields of firewood were obtained from hazel coppice of a similar age, in an independent series of experiments conduced at Gardiner Forest in Wiltshire.

Chapter 5

NEW USES FOR HAZEL COPPICE

(i) General

As the survey carried out by the Rural Industries Bureau was completed and the data on the yield of hazel coppice became available, the magnitude of the problem of finding new uses for hazel became evident. More than 100,000 acres of hazel coppice with a potential annual yield of 100,000 tons of oven-dry fibre (trimmed shoots) were not being utilised. It was decided that one of the few industries which might be able to make use of such large quantities of such small-sized material was the paper and board industry. The three reports which follow indicate that technically hazel is suitable for paper or fibre-board manufacture, and it is also known that it would not be unsuitable for the manufacture of certain types of cardboard.

However from discussions with interested firms it is apparent that hazel has no special properties which would compensate for the extra expense involved in handling large numbers of small-sized hazel shoots. Hazel coppice shoots would probably therefore fetch a price considerably below the prices ruling for other species of pulpwood which occur in larger diameters, unless it could be supplied in diameters greater than 1½ inches in some cases, or 3 to 4 inches in others, depending on the pulpmill concerned. Even in old coppice woods the proportion by weight of hazel over 1½ inches diameter is not great in relation to the total quantity on the ground; the proportion of material over 3 to 4 inches in diameter is much less. It does not therefore seem that it would be financially profitable to fell hazel solely for the purpose of producing pulpwood; the fact that owners who wish to replace hazel coppice with other species have at present little or no outlet for the hazel, which they must in many cases fell, puts the matter in a very different light and under those conditions the existence of a market for hazel pulpwood might well prove a boon to woodland owners.

These remarks are based on general observations and discussions with interested parties: a certain amount of information is available on the cost of cutting and trimming well-managed coppice of about ten years of age. The information is incomplete in that it does not cover the question of extraction and delivering to the mill but it may nevertheless be worth repeating here. The yield per acre for coppice of this age is of the order of two tons (fresh felled weight) per acre per annum. In ten-year-old hazel one man can fell one acre in one week. Trimming the shoots, sorting them into sizes, burning the trimmings and working up minor produce may take a further three to six weeks, working to the precision required when crate or hurdle rods are the main products; but if no minor produce were prepared it is unlikely that a skilled man would require longer than two weeks for a pulpwood specification which only required the shoots to be neatly trimmed out without sorting them into size classes. Thus in ten-year-old hazel some twenty tons of trimmed coppice shoots could be prepared in three man-weeks, but it might be safer to assume a rate of one ton (fresh felled weight) per man-day. In older coppice, say up to fifteen to twenty years of age, the daily rate tends to increase, but no precise information is available on this point.

The question of utilising the present surplus of hazel for paper or fibre-board manufacture is not likely to be solved by the establishment of paper-pulp or fibre-board mills based entirely or mainly on hazel. Quantitatively the supplies are there, but the costs of winning the hazel in relation to its potential value as pulpwood are likely to rule out the possibility of its being worked on a regular rotation for the supply of pulpwood.

(ii) Hardboard

BY DONOVAN JOHN ROACH

The Bowater United Kingdom Pulp and Paper Mills, Ltd., Kemsley, Kent

Introduction

Building board manufacturers are often asked to consider the use, in their industry, of many types of raw materials which they have never formerly used, or of waste products for which there are no established outlets. Every attempt is usually made to view these requests sympathetically, especially if there is a prospect of improving the product, but the practical difficulties involved in running a satisfactory mill trial, are by no means few. Laboratory tests can furnish a certain amount of information which broadly outlines the material's properties, but from a laboratory trial alone no firm decision can be made.

A building board of some type or quality can be made from almost any fibrous material of vegetable origin. However, practical considerations limit the field and many materials including certain hardwood timbers have to be rejected.

Perhaps the three most important factors are hardness, moisture content and fibre length. A very hard timber over-taxes the chipping machine, giving poor quality chips; similarly, a very dry wood may produce the same results. Chips turn out uneven, brittle and splintered, with excessive dust and tend to give a poor quality pulp after defibrator treatment. Very dry wood may even burn in the defibrator causing blockage between blades and hold-up in production. Most of the denser, close-grained hardwoods give what the pulpmaker calls a short-fibred pulp. Shortness of fibre, in this instance, however, bears no relation to the original length of fibre in the wood. Defibrator treatment reduces the wood chips to bundles of torn fibres and unsuitable material may yield short stumpy bundles with weak felting power.

Ideally, timber supplied to the board mill should be of medium softness, high in moisture and carry little bark; the sticks or poles should be straight and free from branch stumps.

Mill Trials

In 1952 a trial run was made at Bowater's building board mill at Kemsley, near Sittingbourne, Kent, using hazel coppice supplied by the Forestry Commission. This consignment consisted of hazel rods of 1½ to 3 inches diameter, with a preponderance of the smaller sizes. Its specific gravity was high at 0·52, but the moisture content, averaging about 43 per cent, was satisfactory.

Although it behaved quite well in the chipping machine, giving chips of reasonably uniform quality, a satisfactory feeding rate was difficult to maintain as, being in the main material of extremely small diameter, the number of sticks required to give the normal volume of feed could not be handled quickly enough. From these chips a fairly smooth, well defibrated pulp stock was produced, but at once, it was apparent that fibre length was short—as was to be expected from such a close-grained wood.

Standard test boards were made in the laboratory from the hazel pulp, and also, for comparison, from the normal mill stock. On this occasion, the hazel pulp made a hardboard of good appearance but of a strength appreciably lower than the generally acceptable standard, nor did it respond to beating treatment to the same degree as the usual run of mill stock.

For the full scale manufacture of board, it was impossible to run the mill on hazel alone. The pulp produced from hazel during these trials was furnished to the board machine in admixture with the normal mill stock. No specific effect was observed as a result, but it must be noted that hazel pulp formed only a very small percentage of the total. However, no adverse effects were noted in the board produced.

This part of the experiment was repeated whenever convenient, for several weeks afterwards; very small amounts of hazel stock were fed to the board mill and the results proved not unsatisfactory.

Conclusions

From the laboratory tests carried out on pulp from hazel coppice, and by comparison with pulps produced from several other species, its short fibre length and general properties suggest that it should be used only in very small amounts in a mixture of pulps obtained from more suitable woods.

Some hardwoods, as they dry out, tend to harden more rapidly and to a greater extent, than others, and it is possible for a timber to behave extremely well when green, yet become the source of serious difficulties after being stored for some time. This aspect of hazel coppice has not been studied in much detail, but simple experiments carried out on small specimens seem to indicate that this species may be too hard for board-making when the moisture content falls below 25 to 30 per cent.

A further drawback is the small diameter of hazel coppice which ranges mainly from ½ inch to 3 inches with only a small proportion above the latter diameter. This feature alone tends to make it unpopular in the mill, for, in addition to lowering the quality of chips, smaller diameters demand more handling time in the preparatory stages.

The results of these short trials can then be fairly summarised as follows: hazel coppice, under certain circumstances, can be manufactured into a hardboard of reasonable general appearance, but considerably lower in most strength categories than the usually accepted standard. For the manufacture of insulating board, it may be considered as most unsuitable. In some respects, however, hazel is likely to be preferred to certain of the very hard woods for hardboard manufacture provided that it is available in a suitable state. The only practicable way in which it can be utilized is as a very small percentage of a mixture of the softer woods.

While other species are readily available hazel coppice presents little attraction, but it might, perhaps, be more attractive to the mills if obtainable in sticks of larger diameter—a minimum of 4 inches—and with a moisture content not lower than 40 per cent, *but*, as yet, there is no justification for substituting hazel in place of any of the woods normally used for the manufacture of hardboard.

Note.—All moisture percentages referred to in this section are expressed according to the following formula:

$$\frac{(A-B)\times 100}{A}$$

where A = Weight of wood as received.
B = Weight of wood oven-dry.

(iii) Paper

BY DR. R. S. JOBIN

British Paper and Board Industry Research Association

Introduction

The possibility of utilising hazel coppice wood for the production of pulp and paper was discussed with the Forestry Commission. In view of the fact that larger-scale trials might be carried out at a British paper mill if the laboratory results appeared promising, the pulping and bleaching procedures employed in the laboratory trials were limited to those which

RESULTS OF PULPING TRIALS WITH HAZEL COPPICE

TABLE 10

Cook No.	*% Na OH based on moisture-free wood*	*Maximum digestion temp.*	*Time at maximum temp.*	*Unscreened pulp yield*	*Screened pulp yield*	*Shives retained on screen*	*Fines lost during concentration*
1	30%	170° C.	2 hr.	41·3%	37·5%	0·1%	3·8%
2	23·5%	170° C.	2 hr.	49·3%	40·3%	3·7%	5·3%
3	30%	147° C.	4 hr.	50·2%	38·4%	5·5%	6·3%

could be conveniently carried out at a paper mill. The hazel wood was pulped, therefore, by the caustic soda process and the pulp was bleached with calcium hypochlorite solution.

The sample of hazel wood supplied for the investigations consisted of a bundle of unbarked coppice shoots about 8 feet to 12 feet long, varying in diameter from ½ inch up to 2 inches, and representative of hazel coppice cut on a nine year rotation. In normal pulp production the pulpwood usually exceeds 4 inches in diameter and is barked prior to chemical processing. Recent work carried out in Canada, however, has established that high quality pulp can be prepared from orchard prunings and other types of lop and top up to 3 inches in diameter without removing the bark, although botanical age rather than diameter was the determinant. It was, in fact, found beneficial to include the bark during pulping, since long bast fibres were obtained from the bark which enhanced the paper making qualities of the pulp.

Pulping Trials with Hazel Coppice Shoots

The hazel coppice shoots were cut into 4 inch lengths and representative samples were taken for each of the three pulping trials carried out. Prior to pulping the wood was crushed to facilitate penetration of the cooking liquor. The moisture content of the wood sample as received was 48 per cent*, whilst that of the crushed pieces employed for the pulping trials average 40 per cent.

In the pulping trials about 3 lb. of crushed wood (moisture-free basis) was filled into a 4 gallon capacity autoclave and covered with a solution containing a definite quantity of caustic soda which is expressed in Table 10 as a percentage of the dry wood weight.

In all trials the ratio of weight of liquor to weight of dry wood was 4 : 1. The autoclave was gas-heated and contained a vomit pipe which allowed liquor circulation during the pulping process. At the end of the digestion period the autoclave was allowed to cool down, the spent digestion liquor drained away, and the residue in the autoclave was washed with hot water. The digested material still retained its crushed wood form at this stage, but it was considerably softened and subsequent treatment in a high speed mixer disintegrated the material into a pulp consisting of individual wood and bark fibres. The pulp was washed by concentration on a 100 mesh sieve and the yield of pulp determined. In all pulping processes it is usual to find that a small proportion of the raw material has not been broken down completely to individual fibres and the practice is to pass the pulp suspension through a screen to remove such fibres aggregates or contraries (usually referred to as *shives*). In the laboratory the pulp suspension, at about 0·2 per cent fibre concentration, was passed through a vibrating screen plate containing slots of 0·008 inch width and the screened pulp was concentrated on a 100 mesh wire sieve. In Table 10 figures are given for the screened pulp yield, shives retained on the screen plate and the loss of short fibres and cells during concentration of the screened pulp in the wire-mesh sieve.

Sample sheets were prepared to show the appearance of the screened pulps prior to bleaching. The sheets contained fibre bundles which were sufficiently fine to pass through the selected screen, but these would be easily disintegrated during the beating process if unbleached paper was being manufactured.

Bleaching of Hazel Wood Pulps

The three hazel wood pulps were bleached at 5 per cent fibre concentration with calcium hypochlorite bleach liquor, the amount of bleach added being given in Table 11 as percentage of available chlorine on moisture-free pulp. The pulps did not bleach easily to a good white colour in a single stage bleaching treatment unless excessive quantities of bleaching solution were added. Under these conditions we prefer to carry out the bleaching process in two stages, with adequate washing after each stage. The amount of available chlorine added in the second bleaching stage is shown in Table 11. It is sometimes possible to obtain a whiter pulp with the large-scale process

*Moisture Content Percentage =

$$\frac{100 \times (\text{Wet Weight} - \text{Oven-Dry Weight})}{\text{Wet Weight}}$$

BLEACHING OF HAZEL PULP

TABLE 11

Cook No.	*Available chlorine added in first stage*	*Chlorine consumed in first stage*	*Available chlorine added in second stage*	*Chlorine consumed in second stage*	*Pulp whiteness*	*Bleached yield (based on moisture-free wood)*
1	10%	9·1%	2%	0·8%	78%	35·6%
2	12%	10·9%	2%	1·0%	69%	37·4%
3	12%	12·0%	4%	2·4%	75%	34·6%

employed in the mill than with the laboratory-scale process using the same proportion of bleach liquor, so that if a mill-scale trial was carried out it might be possible to obtain a pulp with a sufficient degree of whiteness by a single stage bleaching process.

The whiteness of the pulps was determined employing a General Electric Reflectance Meter. The G.E. whiteness figures given in Table 11 express the amount of standard blue light diffusely reflected from the surface of the paper as a percentage of that reflected from a standard magnesium oxide surface. A good quality bleached wood pulp would have a G.E. figure of about 83 per cent, whilst bleached esparto and straw pulps produced in Great Britain would have G.E. figures varying between 65 and 78 per cent according to the grade of paper being made.

Preparation and Testing of Laboratory Sheets from Hazel Wood Pulp

In order to prepare cellulose pulp for paper production the pulp fibres are given mechanical treatment in beaters or refiners, the degree of treatment varying according to whether, for example, it is desired to produce a blotting paper or a transparent tracing paper. In the laboratory the paper-making properties of the pulp are evaluated by treating the pulp in a standard beater and abstracting samples at different time intervals for the preparation and physical testing of sheets.

The hazel wood pulps were beaten in a Valley Niagara Beater at 2 per cent fibre concentration with an applied load of 2 kg. At intervals pulp samples were abstracted from the beater and sheets were prepared employing the standard British Paper and Board Makers Association Pulp Evaluation apparatus. The sheets were prepared with a basis weight of 60 gram/sq. metre (on a moisture-free basis) and tests were then carried out on the sheets to determine the thickness, bulk, bursting strength, tensile strength and resistance to tear. In order to compare the properties of different papers it is customary to calculate the following factors from the test data:

Burst Factor

$$\frac{\text{Average bursting strength in gram/sq. cm.}}{\text{Basis weight}}$$

Tear Factor

$$\frac{\text{Force in grams to tear a single sheet} \times 100}{\text{Basis weight}}$$

Breaking Length (metres)

$$\frac{\text{Average tensile strength of 15mm strip in Kg.} \times 66{,}700}{\text{Basis weight}}$$

Bulk

$$\frac{\text{Average thickness of a single sheet in microns}}{\text{Basis weight}}$$

These factors for the hazel wood pulps are given in Tables 12, 13 and 14. Sheets were also prepared from mixtures of hazel wood pulp and unbeaten and beaten commercial bleached sulphite softwood pulp and data for these mixed pulp sheets are given in the tables along with data for sheets prepared from 100 per cent bleached softwood pulp. The figures given in the tables for "Canadian Freeness" are indicative of the rate at which water will drain from the pulp suspension and are of importance in paper manufacture. The higher figures correspond to higher drainage rates.

Discussion of Results

Of the three pressure cooks carried out with hazel wood only Cook No. 1 (30 per cent caustic soda at 170° C.) gave a product which was softened sufficiently to be broken down with ease in a high speed mixer to produce a well-defibred pulp practically free from shives. The digested material produced from Cooks Nos. 2 and 3 was distinctly harder and although it could be disintegrated fairly readily in a high speed mixer the pulps produced had a fairly high shive content. The yield of unscreened pulp from Cooks Nos. 2 and 3 was considerably higher than that obtained from Cook No. 1 as a result of the milder cooking conditions employed, but the yields of screened pulp were of about the same order because of the high screen rejects with the milder cooked pulps. It would be possible to obtain higher yields of screened pulps from Cooks Nos. 2 and 3 by treating

TABLE 12

TESTS ON SHEETS PREPARED FROM HAZEL WOOD PULP (COOK NO. 1)

Sheet No.	*Description*	*Canadian Freeness*	*Bulk*	*Burst Factor*	*Tear Factor*	*Breaking Length*
1	Unbleached, unbeaten pulp..	502	1·80	34·3	94	6080
2	Bleached, unbeaten pulp	450	1·61	38·1	49	7090
3	Bleached pulp beaten 5 minutes	388	1·61	42·3	48	7500
4	Bleached pulp beaten 15 minutes	252	1·44	44·0	40	7810
5	Bleached pulp beaten 23 minutes	160	1·40	44·0	37	7740

TABLE 13

TESTS ON SHEETS PREPARED FROM HAZEL WOOD PULP (COOK NO. 2), BEATEN BLEACHED SOFTWOOD PULP, AND MIXTURES OF THE TWO PULPS

Sheet No.	*Description*	*Canadian Freeness*	*Bulk*	*Burst Factor*	*Tear Factor*	*Breaking Length*
6	Unbleached, unbeaten hazel pulp	475	1·77	42·7	105	7630
7	Bleached, unbeaten hazel pulp	440	1·63	54·7	70	9050
8	Bleached hazel pulp beaten 10 minutes ..	400	1·60	60·0	66	9600
9	Bleached hazel pulp beaten 15 mins. (A) ..	340	1·52	60·0	63	9200
10	Bleached, beaten softwood pulp (B) ..	360	1·42	50·2	83	7260
11	66% pulp (A)+34% (B)	320	1·43	56·8	70	8650
12	80% pulp (A)+20% pulp (B)	320	1·46	59·0	68	8760

TABLE 14

TESTS ON SHEETS PREPARED FROM HAZEL WOOD PULP (COOK NO. 3), UNBEATEN BLEACHED SOFTWOOD PULP, AND MIXTURES OF THE TWO PULPS

Sheet No.	*Description*	*Canadian Freeness*	*Bulk*	*Burst Factor*	*Tear Factor*	*Breaking Length*
13	Unbleached, unbeaten hazel pulp	638	1·92	26·7	90	5200
14	Bleached hazel pulp beaten 15 mins. (X) ..	414	1·35	66·0	80	9550
15	Unbeaten softwood sulphite pulp (Y) ..	674	1·69	23·0	145	3140
16	75% pulp (X)+25% pulp (Y)	442	1·42	54·8	93	8030

the unscreened pulp in a beater or refiner prior to screening to break down the shives. This would probably be carried out in practice if the bleached pulp was not required to have a high degree of whiteness.

The pulp from Cook No. 1 bleached more readily to a good white colour than the pulps from Cooks Nos. 2 and 3 when treated with calcium hypochlorite bleach liquor, but the strength properties of this bleached pulp were considerably lower than those of the bleached pulps obtained from Cooks Nos. 2 and 3, indicating that some degradation had occurred during the cooking and bleaching process. Cook No. 3, which produced the greatest amount of shive due to having the mildest cooking conditions, produced the strongest bleached pulp. In America or Scandinavia unbleached pulp of the type produced by Cook No. 3 would be bleached to a high degree of whiteness with minimum loss of strength by adopting a multi-stage bleaching process involving aqueous chlorination, caustic extraction and calcium hypochlorite bleaching. This type of bleaching process is not normally used in Great Britain, however, and it is fairly certain that if a mill-scale trial is carried out with hazel twigs the bleaching will be carried out solely with calcium chlorite.

The data given in Tables 12, 13 and 14 indicate that the strength properties of hazel wood pulp are influenced to a considerable extent by the cooking and bleaching procedures. Bleached pulp from Cook No. 1 produced sheets with poor strength properties and this pulp would not run very satisfactorily on the paper machine. Strength properties were better with bleached pulp from Cook No. 2, chiefly because a smaller quantity of caustic soda was employed in the cooking process. This pulp did not bleach easily, however. The best strength properties were obtained with pulp from Cook No. 3, which can be attributed to the use of a lower cooking temperature (147° C.

instead of 170° C.). The strength properties of beaten bleached pulp from Cook No. 3 were as good as those obtained with beaten bleached sulphite softwood pulp and beaten bleached wheat straw pulp and the formation and opacity of the hazel wood sheets were superior. A good printing paper could be produced from such a pulp, providing no difficulties were experienced at the Fourdrinier paper machine due to breaks between the couch and first press. Between the couch and the first press the wet web of paper (20 per cent fibre, 80 per cent water) is unsupported and breaks can easily occur if the wet web has poor strength properties. At this stage fibre bonds have not been formed and the strength of the wet web depends largely on fibre length. The average fibre length of hazel wood pulp was found to be 0·85 mm., which is a little shorter than esparto pulp but only one-third of the fibre length of softwood pulps. If breaks occur on running 100 per cent hazel pulp on the paper machine, the difficulty may be overcome by adding about 25 per cent of softwood pulp to the paper furnish. Sheets were prepared from mixtures of hazel pulp and bleached sulphite softwood pulp. The addition of the softwood pulp improved the resistance to tear, whiteness and softness of the sheets. Tear resistance was increased most by adding unbeaten softwood pulp to the hazel pulp and although this decreased the burst and tensile strengths of the resultant sheets these strength values were sufficient for most purposes.

Fibre Dimensions

Work carried out in Canada on the pulping of orchard prunings (Crossley, T. L., *Pulp and Paper Mag. Canada*, **53,** No. 7, 126) and other waste woods of less than three inches in diameter had shown that valuable long bast fibres were often obtained from the bark, the amount increasing as the diameter of the wood decreased. The presence of these long bast fibres, together with the short deciduous wood tracheid fibres, gave a pulp which could be run satisfactorily on the paper machine without the addition of long-fibred softwood pulp. It was obviously of interest to determine whether long bast fibres were contributed by the hazel wood bark.

A representative sample of hazel wood shoots was boiled in water and the bark stripped away by hand. The weight of bark was found to be 15 per cent of the total wood weight. The bark and stripped wood were then reduced to fibrous pulps separately and the pulps examined under the microscope. The bark pulp fibres were quite short, varying in length from 1·0 mm. up to 1·6 mm. and the fibre walls were thicker than those of the wood tracheids. The wood tracheid fibres varied in length from 0·3 mm. up to 0·9 mm. and had fibre diameters varying from 0·008 mm. up to 0·024 mm. It will be observed, therefore, that whilst it has been established that hazel wood shoots can be pulped satisfactorily without prior removal of bark, very little additional value is gained by the inclusion of the bark from the point of view of supply of long bast fibres.

General Remarks

As indicated in the introduction, the object of the work which has been reported was to assess, from a few preliminary trials, the possibility of producing useful pulp and paper from hazel coppice. From the work which has been carried out so far we have reached the following conclusions:

(a) Hazel coppice can be pulped satisfactorily with caustic soda solutions without removal of bark.

(b) Bleached pulp with a reasonably good degree of whiteness can be produced by treatment with calcium hypochlorite solution.

(c) The bast fibres from the bark are fairly short and do not contribute any outstandingly valuable characteristics to the pulp.

(d) Laboratory sheets prepared from Cook No. 3 pulp have good strength properties, good formation and good opacity. On the mill-scale such a pulp could be converted into a useful printing paper. Long-fibred softwood pulp may be a necessary addition to reduce breaks on the paper machine.

(iv) Practical Test of Paper-Making

Following on the preliminary trials described in the previous section, a practical test of paper making using hazel coppice material, was made at the Manchester College of Technology. Stages in the process, which was carried out on a small-scale plant, are illustrated in Plates 29 to 32.

A sample of actual paper prepared from hazel in this way, is inserted in this bulletin.

The report of the tests runs as follows:

Report on Production Test of Paper from Hazelwood Chips

Submitted by The Forestry Commission.
Test No. 12271–53 25th January, 1955
The net weight of the sample, after deducting the weight of two bags and sample for moisture content (17 per cent), was 32·4 lbs.

Digestion

This was carried out in a rotating spherical digester under the following conditions:

% NaOH on oven-dry wood	*Temperature ° C.*	*Time at maximum temp.*	*Liquid ratio*	*Unbleached Yield dry/dry*
25	158	4·5 hrs.	3·1	46·3%

The amount of screenings was negligible. The black liquor was drained off and the chips were washed.

Bleaching

This was done in the hollander-beater after disintegrating the chips and washing out the black liquor residues with the aid of a washing drum. Sodium hypochlorite was added, equivalent to 9.5 per cent chlorine (calculated on the oven dry pulp), in the first stage. This was all consumed at ordinary temperature and after an intermediate wash, the equivalent of 1·5 per cent Cl. was added and most of this was consumed.

The pulp was then beaten to 210° C.S.F. and the following ingredients were added during beating.

15 lb. bleached sulphite pulp 3 per cent rosin (on oven-dry fibre), as size
4 per cent alum
3·5 per cent titanium oxide

The paper had quite a yellow shade despite the use of bleached pulp and titanium oxide. (In a subsequent test, using a multi-stage bleach, a satisfactory white paper was obtained from pure hazel chips.)

It will probably give a satisfactory result if used for printing.

Sheets 19½ in. × 15 in. were cut.

470 were obtained from this trial.

It is thought probable that a semi-chemical pulp of higher yield could be produced from hazel wood by the monosulphite process.

This would give a pulp suitable for making boards. It would, however, require the use of equipment capable of breaking down the chips after digestion e.g. rodmills.

The product could then be used without bleaching.

Tests carried out by
Papermaking Section of the
Textile Chemistry Department,
Manchester College of Technology

Chapter 6

DISCUSSION AND CONCLUSIONS

Hazel in the form of simple coppice, coppice-with-standards and scrub covers a total area of some 167,000 acres; the area required to maintain the hazel underwood industry at its present size is some 12,000 acres, and with one major exception—that of garden screens—the industry is able to meet existing demands. The inability of the industry to meet the demand for hazel garden screens is caused by a shortage of manpower but attempts to expand this section of the industry by training more men in the art of weaving hazel garden hurdles or screens are meeting with some success. However even if the number of men in the industry were doubled, the industry could only utilise a small portion of the present area of unworked hazel coppice.

The indications are that it is unlikely, for economic reasons, that paper-pulp or fibre-board mills will be based solely or mainly on hazel as a raw material. This seems to rule out the possibility that hazel will be cut on a regular coppice rotation solely for the production of pulpwood; there is no reason, however, why a proportion of the hazel which has to be cleared for other purposes should not find an outlet for certain pulping processes, provided it meets the appropriate pulpwood specification as regards size and straightness. *Except in those localities where it forms the basis of a healthy and prosperous underwood industry*, there seems to be no justification for the maintenance of hazel as a forest crop. The yield is considerable but it arises in a form which makes its utilisation difficult except under special conditions. Indeed the lack of demand for hazel has caused a number of private owners to make a start in replacing their hazel coppice with high forest. Where forest land purchased by the Forestry Commission contains hazel for which there is no continuing local demand it is also normal practice to convert to high forest. The cost of establishing another species in place of hazel coppice is generally high; on the other hand hazel is usually found growing on soils which, by forestry standards, have a high productive capacity. It is in the interests of the individual owner and the country as a whole that full advantage be taken of that productive capacity.

Appendix I

YIELD OF HAZEL: METHODS USED

In the spring of 1952, seven sets of plots of hazel coppice in three different regions, namely Hampshire, Eastern England, and Sussex, were selected for investigation. The choice was made in such a way that each region had one "pair" of sets, so as to include a set in coppice that had long been *worked* on a regular rotation, and a set in *unworked* coppice. In the Hampshire region, the worked set at King's Lamborne was subdivided into two age groups, aged respectively nine and twelve years.

In each plot in each locality the following procedure was adopted. The material from each stool was kept separate throughout the experiment.

1. The number of coppice stools of each species and the total number of shoots on each stool was counted.
2. The height of the tallest shoot on each stool was measured.
3. The coppice was felled and trimmed iu accordance with normal underwood practice.
4. The trimmed shoots and the trimmings themselves were weighed separately to obtain the fresh felled weights of each of these two classes of material.
5. Samples, each about 6 inches long, were then immediately cut from near the butt and near the tip of one shoot per stool and weighed.
6. The samples were dried at 105° C. until there was no further loss in weight, and re-weighed.
7. The moisture content of the samples was then obtained from the formula:
   Moisture content per cent=
   $$\frac{\text{Initial Weight} - \text{Oven-Dry Weight}}{\text{Oven-Dry Weight}} \times 100$$
8. The specific gravity of the oven dry samples was then determined (oven dry weight, oven dry volume).
9. The fresh-felled weights of trimmed shoots and trimmings (item 4 above) were then reduced to oven-dry weights using the formula:
   $$\text{Oven-dry weight} = \frac{\text{Fresh-felled weight}}{1 + \frac{\text{M.C.}}{100}}$$
   the moisture contents used being the average fresh-felled moisture contents for each plot as determined from the samples (items 5–7 above).
10. From the oven-dry weights (item 9) and the oven-dry specific gravities (item 8) oven-dry volumes were calculated. These oven-dry volumes were then increased by an arbitrary figure of 16 per cent to give fresh-felled volumes (i.e. volumes above fibre saturation point).

The tables and graphs on which the discussion on the yield of hazel is based were constructed from these data which are reproduced in Tables 15 to 21.

Other Broadleaved Species of Coppice

For species other than hazel the same procedure was adopted except that neither moisture content nor specific gravity determinations were carried out. The volume weight ratio of other species was estimated, on the basis of the data obtained for hazel, to be about 25 hoppus feet per ton for fresh-felled material. In bringing the actual fresh-felled weights of other species to a given moisture content the figures applicable to the hazel in that locality were used.

Once experience had been gained no difficulties of any practical consequence were encountered during the investigation but the determination of the age of unworked hazel coppice gave rise to considerably more work than had been expected, and although the points made may appear to be elementary, it has been thought worthwhile to include a short note on this subject.

Age of Unworked Coppice

In coppice areas which are currently managed on a coppice rotation there is seldom any difficulty in establishing the exact boundaries and ages of the various small stands or cants, which together make up the total area of a woodland. When, however, for one reason or another, the coppice is no longer managed as such, these boundaries tend to disappear so that even if records exist, showing when the various cants were last cut over, it becomes increasingly difficult with the passage of time to locate the cant boundaries on the ground. The situation may be further confused by virtue of the fact that since the last major cuts were recorded, unrecorded minor cuts may have been made from time to time in order to meet some local demand. These minor cuts were doubtless made in the most convenient and suitable places without necessarily having regard to the original cant boundaries.

It follows from what has been said above that it was not possible to determine in advance that in unworked hazel coppice all plots in one locality fell in exactly the same age of coppice; nor that all the coppice in any one plot would be of the same age. In each locality the plots were located in areas uniform as regards age so far as could be assessed visually and from local knowledge. The actual age of the dominant shoot on each stool was then ascertained from a count of the annual rings. The ages so obtained were then subjected to a statistical analysis and in all cases the results were found to be in general agreement with the local assessment of age.

SUMMARY OF SITE DATA

TABLE 15

	Locality	*Age* *Years*	*Height* *Feet*	*Species*	*Fresh felled weight of Coppice after trimming out: tons per acre*	*Volume of Coppice after trimming out: hoppus feet per acre*	*Volume of standards: hoppus feet per acre*
Hampshire	Micheldever .. .. (Unworked)	21	22	Hazel ..	15·5	460	240
				Other Bl...	6·5	180	
				Total ..	22·0	640	
	Kings Somborne .. (Worked)	12	21	Hazel ..	21·0	520	340
				Other Bl...	1·5	30	
				Total ..	22·5	550	
		9	16	Hazel ..	15·0	370	430
				Other Bl...	0·5	10	
				Total ..	15·5	380	
East England	Tunman Wood .. (Unworked)	15	18	Hazel ..	11·5	300	5
				Other Bl...	4·5	120	
				Total ..	16·0	420	
	Bury St. Edmunds .. (Worked)	8	13	Hazel ..	4·0	100	20
				Other Bl...	4·0	100	
				Total ..	8·0	200	
Sussex	Rewell Wood.. .. (Unworked)	23	25	Hazel ..	25·5	670	410
				Other Bl...	1·5	40	
				Total ..	27·0	710	
	Poling Copse .. .. (Worked)	6	12	Hazel ..	7·5	190	100
				Other Bl...	0·5	20	
				Total ..	8·0	210	

Note: All weights and volumes include bark.
Weights have been rounded off to the nearest ½ ton.
Volumes have been rounded off to the nearest 10 hoppus feet.

TABLE 16

NUMBER OF STOOLS AND COPPICE SHOOTS PER ACRE

	Locality	*Age* *Years*	*Height* *Feet*	*Species*	*Number of Shoots per Stool: mean of Plot Averages*	*Number of Stools per Acre: mean of Plot Averages*	*Number of Shoots per Acre to nearest* 100(1)
Hampshire	Micheldever .. .. (Unworked)	21	22	Hazel ..	10·8	294	3,200
				Other Bl...	5·1	77	400
				Total ..	—	371	3,600
	Kings Somborne .. (Worked)	12	21	Hazel ..	24·8	490	12,100
				Other Bl...	7·7	77	600
				Total ..	—	567	12,700
		9	16	Hazel ..	20·3	627	12,700
				Other Bl...	10·9	47	500
				Total ..	—	674	13,200
East England	Tunman Wood .. (Unworked)	15	18	Hazel ..	12·1	424	5,100
				Other Bl...	5·8	182	1,100
				Total ..	—	606	6,200
	Bury St. Edmunds .. (Worked)	8	13	Hazel ..	13·0	507	6,600
				Other Bl...	11·7	255	3,000
				Total ..	—	762	9,600
Sussex	Rewell Wood .. (Unworked)	23	25	Hazel ..	11·0	350	3,900
				Other Bl...	2·5	28	100
				Total ..	—	378	4,000
	Poling Copse .. .. (Worked)	6	12	Hazel ..	19·7	650	12,800
				Other Bl...	6·5	78	500
				Total ..	—	728	13,300

(1) $\frac{\text{(Number of shoots per stool)}}{\text{(Mean of plot averages)}} \times \frac{\text{(Number of stools per acre)}}{\text{(Mean of plot averages)}}$

TABLE 17

HEIGHT OF HAZEL COPPICE IN FEET

Based on the length of the tallest shoot in each stool

	Locality	*Age Years*	*Mean of plot averages*	*Range of plot averages*
Hampshire	Micheldever .. (Unworked)	21	22	17·0–24·5
	Kings Somborne ..	12	21	18·7–22·3
	(Worked)	9	16	13·9–19·2
East England	Tunman Wood .. (Unworked)	15	18	15·6–21·2
	Bury St. Edmunds.. (Worked)	8	13	10·3–14·3
Sussex	Rewell Wood .. (Unworked)	23	25	23·1–26·6
	Poling Copse .. (Worked)	6	12	10·3–13·8

WEIGHT OF COPPICE

TABLE 18

	Locality	Age Years	Height Feet	Fresh felled Moisture Content % (i)	Species	Fresh-felled weight: Tons per acre			Oven-dry weight: Tons per acre		
						Trimmed shoots	Trimmings	Total	Trimmed shoots	Trimmings	Total
Hampshire	Micheldever .. (Unworked)	21	22	63·3	Hazel .. Other Bl.	15·48 6·35	11·81 3·19	27·29 9·54	9·99 3·86	7·31 1·93	17·30 5·79
					Total ..	21·83	15·00	36·83	13·85	9·24	23·09
	Kings Somborne (Worked)	12	21	83·1	Hazel .. Other Bl.	21·23 1·36	4·93 0·7	26·16 2·06	11·61 0·74	2·70 0·38	14·31 1·12
					Total ..	22·59	5·63	28·22	12·35	3·08	15·43
		9	16	88·3	Hazel .. Other Bl.	14·97 0·56	4·66 0·39	19·63 0·95	7·94 0·29	2·46 0·20	10·40 0·49
					Total ..	15·53	5·05	20·58	8·23	2·66	10·89
East England	Tunman Wood .. (Unworked)	15	18	83·5	Hazel .. Other Bl.	11·28 4·58	6·87 3·03	18·15 7·61	6·09 2·55	3·73 1·68	9·82 4·23
					Total ..	15·86	9·90	25·76	8·64	5·41	14·05
	Bury St. Edmunds (Worked)	8	13	89·9	Hazel .. Other Bl.	3·86 4·0	3·25 3·37	7·11 7·37	2·03 2·11	1·71 1·78	3·74 3·89
					Total ..	7·86	6·62	14·48	4·14	3·49	7·63
Sussex	Rewell Wood .. (Unworked)	23	25	79·4	Hazel .. Other Bl.	25·74 1·44	7·09 0·36	32·83 1·80	14·44 0·82	3·97 0·21	18·41 1·03
	..				Total ..	27·18	7·45	34·63	15·26	4·18	19·44
	Poling Copse .. (Worked)	6	12	90·3	Hazel .. Other Bl.	7·47 0·75	5·37 0·45	12·84 1·20	3·91 0·39	2·81 0·24	6·72 0·63
					Total ..	8·22	5·82	14·04	4·30	3·05	7·35

(i) Mean of plot averages.

MOISTURE CONTENT AND SPECIFIC GRAVITY

TABLE 19

	Locality	Age Years	Height Feet	Moisture content of fresh felled hazel coppice: Average of all plots %	Range %	Specific gravity of oven dry hazel coppice
Hampshire	Micheldever .. (Unworked)	21	22	63·3	48·1–87·6	0·7124
	Kings Somborne (Worked)	12	21	83·1	81·1–84·3	0·7311
		9	16	88·3	78·9–100·1	0·7067
East England	Tunman Wood .. (Unworked)	15	18	83·5	69·3–94·0	0·6547
	Bury St. Edmunds (Worked)	8	13	89·9	81·9–98·2	0·6381
Sussex	Rewell Wood .. (Unworked)	23	25	79·4	60·3–90·9	0·6979
	Poling Copse .. (Worked)	6	12	90·3	76·0–97·6	0·6540

OVERBARK VOLUME OF TRIMMED SHOOTS

TABLE 20

	Locality	Age Years	Height Feet	Overbark volume: Hoppus feet per acre		
				Hazel	Other Bl.	Total
Hampshire	Micheldever .. (Unworked)	21	22	459	178	637
	Kings Somborne (Worked)	12	21	519	34	553
		9	16	368	13	381
East England	Tunman Wood .. (Unworked)	15	18	304	118	422
	Bury St. Edmunds (Worked)	8	13	104	97	201
Sussex	Rewell Woods .. (Unworked)	23	25	676	38	714
	Poling Copse .. (Worked)	6	12	195	18	213

Notes: *Overbark volume of trimmed hazel shoots.* Calculated from oven dry weights and oven dry specific gravities. Volumes so obtained were increased by 16% to allow for the expansion from oven-dry conditions to Fibre Saturation Point.

Overbark volume of other broadleaved species. Calculated on the basis of 25 Hoppus feet per ton at 85% Moisture Content.

OVERBARK VOLUME OF STANDARD TREES OVER 3 INCHES BREAST HEIGHT QUARTER GIRTH OVER BARK OCCURRING IN HAZEL COPPICE

TABLE 21

	Locality	Age of coppice	Principal species standard trees % by volume	Total volume per acre hoppus feet	Number of standard trees per acre	Average volume per tree Hoppus feet
Hampshire	Micheldever .. (Unworked)	21	Oak .. 54 Birch .. 43 Sycamore .. 2 Ash .. 1	240	67	3·59
	Kings Somborne (Worked)	12	Oak .. 100	344	17	20·24
		9	Oak .. 80 Ash .. 20	430	16	26·88
East England	Tunman Wood .. (Unworked)	15	Birch .. 100	5	1	5·0
	Bury St. Edmunds (Worked)	8	Oak .. 46 Ash .. 26 Maple .. 14 Willow .. 14	24	7	3·39
Sussex	Rewell Wood .. (Unworked) ..	23	Ash .. 80 Oak .. 13 Birch .. 7	408	74	5·51
	Poling Copse .. (Worked)	6	Ash .. 59 Oak .. 35 Holly .. 6	104	17	6·09

Appendix II

SITE DESCRIPTIONS

Hazel Coppice Material

Micheldever (Unworked)

The nine plots at Micheldever Forest were laid out in Black Wood, some 12 miles south west of Basingstoke in Hampshire. Black Wood lies on a gentle slope, facing south to south-west, the plots being at elevations between 450 and 500 feet. Although open to prevailing south-west winds, no signs of undue exposure were noted. The soil showed little variation, being in general, a clay loam merging into chalk at depths around 18 inches.

The hazel was formerly worked on a regular rotation, but in general the last large-scale coppice cutting was carried out between 1926 and 1930. The area is characterised by a comparatively large number (67) of small standards per acre, mainly oak and birch.

Kings Somborne (Worked : Two groups)

Nine plots were selected on a private estate near Kings Somborne in Hampshire, in a 30 acre woodland, consisting of hazel coppice with a few standard oak and a few ash standards numbering on the average 17 to the acre. Two groups of plots were distinguished here, one with an average age of nine years, and one with an average age of twelve years.

The elevation ranges from 200 to 300 feet, the general aspect being westerly with gentle slopes, and only a moderate degree of exposure. The soil is similar to that at Micheldever—a clay-loam on chalk, freely drained.

The area is representative of hazel coppice that has long been worked on a regular rotation, normally of nine years on this estate. The incidence of twelve-year-old cants to-day is due to the fact that during the war it was not possible to get sufficient underwood workers to carry out the full planned programme of cutting, and once the sequence of operations has been disturbed on an area it takes some time to get things back to normal.

The underwood industry based on Kings Somborne regard the manufacture of wattle hurdles and garden screens as their main industry, although they do sell pottery crate rods and various assortments of minor produce.

Bury St. Edmunds (Worked)

The hazel coppice area selected on a private estate near Bury St. Edmunds in Suffolk is situated on a plateau lying at an elevation of some 300 feet above sea level; the aspect is general and there are no signs of undue exposure. The soil over the whole area comprises a dark to medium brown clay-loam overlying boulder clay. There are signs of impeded drainage locally. The coppice is cut on an eight-year rotation, the bulk of the production being converted into wattle hurdles and garden screens.

This area was paired with Tunman Wood, the two being treated as representing hazel coppice grown outside the south of England. Although worked on a regular rotation approximately every third stool encountered in the nine plots was of some species other than hazel. From local knowledge it appears that most of the original oak standards were felled some twenty years ago and only a very few standards, mainly oak and ash but including a few cherry, now remain.

Tunman Wood (Unworked)

Tunman Wood, which is situated about seven miles south-west of Lincoln, in Wigsley Forest, Nottinghamshire, lies at an elevation of some 50 feet above sea level and occupies a total area of approximately 250 acres. That part of the wood at present covered with hazel coppice is flat and suffers only a moderate exposure: the soil is clay-loam to loam, over-lying the limestones and shales of the Lower Lias which characterise the area.

The hazel coppice has not been worked for some time and is now about 15 years of age. As in the case of Bury St. Edmunds, approximately every third stool in the nine plots measured consisted of some species other than hazel. An occasional standard birch tree was encountered in the area measured.

Rewell Wood (Unworked)

Nine plots were located in Rewell Wood, Slindon Forest, about a mile north-west of Arundel, in Sussex, on a moderate slope facing east and at an average elevation of 300 feet. There are no signs of undue exposure, the area sampled being to some extent sheltered by adjacent stands of beech and larch. The soil is clay on chalk.

There is a comparatively large number of small standards, mainly ash.

Poling Copse (Worked)

Six plots were situated in Poling Copse on a private estate two miles east of Arundel, Sussex. The area is flat, and lies at a general elevation of 50 feet above sea level. The soil is a heavy clay, dark to medium brown for the first six inches, changing to a mottled grey/light brown clay to a depth of a foot. The parent material is London Clay. The whole area has been intensively drained in the past, and is managed on a regular coppice rotation with an average of 17 standards per acre.

GLOSSARY

ADZE	Axe-like tool used for squaring or shaping timber.
BAVIN	Bundle of twigs used for firing in brick kilns or bakers ovens.
BOOL	Rim of a spale basket.
BROCHE OR BROOCH	Twisted piece of hazel in the form of a hairpin, used for securing thatch. May be round or cleft.
BUNT	(*See* Bavin).
CRATE HEADS OR CRATE HEADINGS	The stronger components of china-ware containers, made from stouter lengths of hazel or other species such as oak, birch and alder.
CRATE RODS	Lengths of hazel used in the manufacture of china-ware containers.
DRIFTS	Strips or lanes of cut-over coppice.
ETHERS	Small rods of hazel for binding together the hedge stakes.
FAGGOTS	Bundles of twigs (*See also* Bavins).
FASCINES	Bundles of hazel rods used in river control or revetment work.
FRUIT PROPS	Stout pieces of hazel used to support heavily laden branches of fruit trees.
HEDGE STAKES	Upright stakes used in hedging to secure shoots after the hedge has been laid.
HURDLE, GARDEN	Woven hazel used in gardens.
HURDLE MOULD OR BREAK	Curved piece of wood with drilled holes to contain the uprights of hazel during the manufacture of sheep and garden hurdles.
HURDLE, SHEEP	Sections of woven hazel used for penning sheep.
LAYERING	A method of vegetative propagation by striking live branches in the soil to encourage adventitious rooting of the branches.
LEDGERS, OR SWAYS	Round or cleft hazel 5 to 8 feet long used in conjunction with broches to secure each course of thatch.
LIGGERS	Cleft hazel 3 to 5 feet long used with broches to secure ridges, eaves or verges (*See* ledgers).
ROUND STICK JOINERING	The craft of making crate rods into containers.
SHORES	Supports for hurdles.
SHEEP CRIB	Open box or cage for holding fodder.
SLACK COOPERAGE	The manufacture of barrels for holding dry or solid goods.
SPALE BASKET SPEK, OR SPELK	Basket made from cleft oak strips.
SPARS	*See* broche.
SPITTS	*See* broche. Round as opposed to cleft spars.
SWAYS	*See* ledgers.

Note: Whilst the definitions shown above have been followed throughout the text, it is realised that local variations in the use of these terms probably occur.

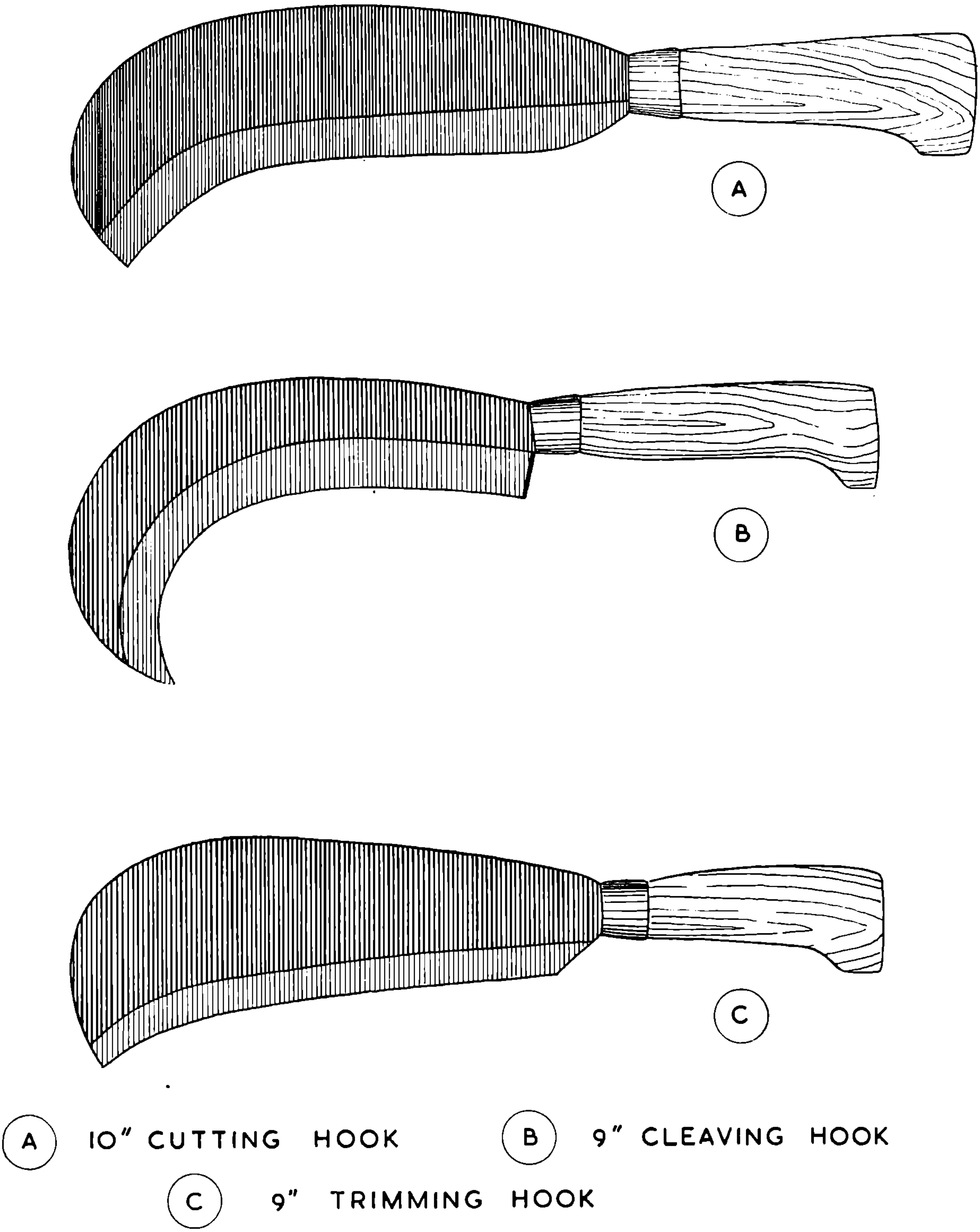

Fig. 7. Three types of billhook used by the same worker for preparing hurdle rods.

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