why a widespread system of permanent plots should not be established at once, covering the whole of New Zealand's exotic forests, and constantly extended as the work progresses. By this means, at the end of one rotation a wealth of data will be available from which we can draw conclusions of utmost value regarding the whole field of tree growth in New Zealand.

And in the case of the native bush, the writer considers the need for an extensive system of sample plots is fully as great, and even more urgent, for in this case we have no records whatever. Only until such a system of carefully measured and remeasured plots or cruise lines has been in existence for five or ten years, covering many types of bush, will we be able to decide with any basis in sound fact whether we have any increment in our native forests; whether many of our younger stands of pole rimu such as are now being ruthlessly butchered, would or would not make sufficient increment within one or two decades to justify their being withheld from milling for the present; and finally whether, providing we can establish a taxad crop of reproduction, it can be expected to reach maturity within any reasonable time.

THE ANATOMY OF NEW ZEALAND WOODS.

PART I.: LABORATORY TECHNIQUE.

(C. S. Barker.)

Introduction:

This paper represents the results of experience gained during the past year in a microscopic study of the structure of various native and exotic timbers of New Zealand.

The work commenced in a small way during 1925 in the School of Forestry as an advanced study in Wood Technology, having for its object the formation of a scheme of identification for these woods. Little time was available for the project, however, and only a very small beginning had been made by the end of the College session of last year.

At this time the State Forest Service of New Zealand made available a sum of money for work in this subject in co-operation with the School of Forestry, and under this arrangement the whole of the long vacation of 1925-6 was devoted to this work, and it has been carried on throughout the session.

The aim of the project is, as has been stated, primarily to obtain an authentic system of wood identification; but further than this it includes a study of the whole basic structure of our native woods, with a view to obtaining definite information regarding their anatomy—the types, arrangement, proportion and relative size of the component cells. These factors have a very distinct bearing on the possible use of the various woods for purposes such as wood pulp, the designing of saws, etc., and also have much to do with the ease or otherwise with which the woods may be seasoned or artificially impregnated against decay.

In presenting the results of this study it has been thought advisable to commence right from the very beginning of the project, and explain in some detail the whole of the technique which has been evolved for preparing the woods for microscopic study. The reason of this is that while microscopy has been long practiced in the sciences, comparatively little work has yet been done on woods, and the literature available dealing with the sectioning and mounting of wood specimens is exceedingly limited. Some useful data on microtomy was obtained from Cross and Cole's book, "Modern Microscopy," and Chamberlin's "Methods in Plant Histology," and some work of value in regard to the whole field of work with wood was found in Jeffrey's "Anatomy of Woody Plants," and Brown's "The Preparation and Treatment of Woods for Microscopic Study," in the Journal of the Torrey Botanical Club of April, 1926. Aside from these general guides, the whole of the technique had to be evolved as a result of experiment, and is presented here hoping that it may prove of benefit to all students on this work in New Zealand.

Preparation of Wood for Sectioning:

Before the wood is in a proper state for sectioning a considerable amount of preliminary work is involved. The wood has to be cut into suitably-sized blocks, the air removed and the tissues softened.

Wood for microscopic study must be more or less typical of the species, this being essential if only one piece from one tree is to be worked upon. It must be from a clear and even textured part of the stem, and, of course, free from knots and spiral twists. If it can be procured, green wood is preferable to dry; but if only seasoned wood can be had, it must be from the interior of largish pieces, the reason for this being that the exterior parts of seasoned wood most probably have seasoning checks, and even if these are of a minute character, it would be disastrous for good work.

Preparation of the Wood Blocks:

The blocks must be shaped in the planes in which the sections are going to be cut. It is of the greatest importance that these surfaces be truly transverse, radial and tangential, especially when a plain metal jaw holder is used. A sharp chisel was found to be the best tool to use. The blocks were studied with a hand-lens in the case of species that had narrow wood rays. With this plain jaw holder (the only holder that was used throughout the present work) the following dimensions were found to give the best results: 4 cms. longitudinally by 0.5 cms. each way on the transverse surface.

Each block as it was made was marked with a suitable sign. Roman numerals are the best, these being cut in one of the longitudinal faces.

Removing the Air and Softening the less Refractory Species.

After the blocks were cut they were alternately boiled in water and suddenly cooled. This process extracts the air from the cell lumina, and considerably softens the less refractory species. About 12 hours' boiling and cooling was found sufficient to soften **Pinus radiata**, Kauri, Hinau, Miro, Silver Pine and **Dacrydium Colensoi**, Kahikatea, Kawaka, Mangeao, Mahoe, Makomako, Pukatea and Rimu.

It was found to take 20 hours to remove the air from some of the harder species such as Black Maire, Southern Rata, Puriri, etc.

Softening the Harder Species:

Some woods are far too hard to section without a preliminary softening treatment. Strong hydrofluoric acid was used for this purpose, which softens the tissues by the removal of silica; other hard substances are most probably acted upon.

Hydrofluoric acid is kept in rubber bottles, the stopper being carefully coated with paraffin. This acid readily eats into glass, and optical glass is especially soft, so great care must be taken when using it. The following procedure was followed. A shallow cylindrical glass jar and glass plate were thoroughly coated with paraffin. In this jar was placed a paraffin dish with cover. Strong hydrofluoric acid was placed in this dish with the wooden blocks (after the air had been removed from them). The blocks were tested with a sharp knife from time to time; the woods were taken out when they had become soft enough to be cut like wax. This time varied greatly with different species. After the blocks had been removed from the acid they were washed in running water for ten days. The washing is rather important, because if there is a trace of acid left it will spoil the microtome knife. After washing, the blocks were placed in equal parts of 100 per cent. glycerine and 30 per cent. alcohol for at least five days. The effect of this mixture is to toughen any tissue that had become too brittle for sectioning after the sojourn in acid.

The following table shows length of time required to soften the woods experimented upon:—

Up to three weeks in hydrofluoric acid: Matai, Tanekaha, Hoheria sp., Kamahi, Rewarewa, Kohekohe, Broad-leaf **(Griselinia littoralis), Nothofagus Solandri, N. Menziesii, N. cliffortioides.**

Five weeks in hydrofluoric acid: Kowhai.

Ten weeks in hydrofluoric acid: Tawa.

Eighteen weeks in hydrofluoric acid: Southern Rata.

Twenty-four weeks in hydrofluoric acid: Taraire, Puriri, Black Maire **(Olea Cunninghamii).**

THE MICROTOME.

Description of the Instrument Used:

The instrument used was a Jung Thoma microtome manufactured by the Jung firm of Heidelberg, and having the knife moving in a horizontal plane and the object in an inclined plane. The following is a description of the instrument:—A solid base of cast-iron which rests upon the work-table on three points; a heavy central support bearing a substantial horizontal flange on one side and an inclined flange on the other. These flanges make two V grooves or tramways, one on each side of the central support. The V grooves have each three raised sliding surfaces. The object and knife carrier are made of heavy blocks of metal and slide on four insertions of ivory placed at their four corners. These, with the raised surfaces of the guides, make an absolutely free and even sliding surface. The object holder is pushed up the tramway by a slow-motion screw, which is attached to a clamp and may be fixed at any desired position on the inclined flange. The inclination of this tramway is 1 in 20, so that if the object-carrier is pushed up 1 mm. the object must be raised 0.05 mm., and the section cut will be of that thickness. It takes three revolutions of the slow-motion screw to slide the object-carrier up one mm., so that if the slow-motion screw is turned one complete revolution a section will be cut approximately 17_{μ} in thickness.

Inserted in the object carrier is the object holder. There are a number of different makes of holders, each designed for special work. The one used during the present work is in the form of a metal jaw and two clamping screws, one on each side of a central support. This holder is not of the best pattern for the sectioning of wood, as if the wood blocks to be sectioned are not cut in true radial and tangential planes, they will not be sectioned in the above planes. It is of great importance that the radial surface of a section be true, or else a very confused condition is presented under the microscope. Working with this holder (the only one available) necessitated a great deal of patience in setting up; especially if the specimen was from a tree of small diameter, as it accentuated the fact that the tangential surface is not at right angles to the radial. This necessitated very careful packing, which usually worked loose before a sufficient number of sections were cut.

E. C. Jeffrey, in his book "The Anatomy of Woody Plants," described a holder for hard objects that he designed, and which is manufactured to order by the Jung company of Heidelberg. The following is an extract from his book: "In these holders the position of the object can be varied as to obtain the proper inclination to the edge of the knife." He also describes a holder devised by Professor R. B. Thomson for the Thoma microtome. This is made in Toronto, and particulars may be obtained by writing to the Botanical Department of the University of Toronto. This holder may be used for cutting large pieces of wood which are not sufficiently softened. E. C. Jeffrey also states that "a complete Thoma microtome, with the additional holder for cutting hard objects, costs one hundred dollars free of American duty. With the Thompson device the cost is considerably greater."

If good results are desired, and much work is to be done, the above holders would easily repay their cost. Woods that are on the border-line of being too hard to cut untreated, could be sectioned with these improved types of holders. This alone would cut the time down, and would eliminate the fault of over-softening material, which will most probably lead to having to imbed in nitrocellulose. The above is clearly brought out in the case of the New Zealand **Nothofagus spp.**, which, after boiling, were too hard to cut on the present type of machine. These woods were placed in hydrofluoric acid for a time to soften; but by the time they were sufficiently softened to cut they had become very brittle. At the present time these woods are hardening in glycerine and alcohol, but it is doubtful whether they will be sufficiently strong to cut unimbedded.

The knife is held in place by a knife holder on the knife carrier. On the machine that was used the knife can be adjusted forward or backward, inward or outward. The angle in the horizontal plane with the block can also be altered. On better types of the Jung microtomes, the knife holder has an arrangement for tilting the knife.

The Knife:

(a) **Grades of Knives—**

E. C. Jeffrey recommends the C grade of knife as supplied by the Jung firm. This knife is of a true wedge shape, and would possess greater rigidity than the other grades. It was found during the present work that the C knife was of no use, the reason being that there was no suitable knife back for sharpening this grade. The knife that was used throughout was the D grade; it is 14 cms. long and 3.5 cms. wide.

(b) **Sharpening the Knife—**

Sharpening the knife to the proper angle is of the greatest importance. Knives for cutting wood must not be ground to too thin an angle. The following is an extract from Cross and Cole's book, "Modern Microscopy." "To a beginner in microtomy, the one great bugbear is the sharpening of the knives. The keenness of the knife-edge is of pre-eminent importance, and the sooner the beginner realises the fact that for the production of good work the knife-edge must be absolutely perfect, the earlier will one of his greatest troubles be over." (Page 252.)

It is essential that the knife be held at the proper angle to the stone, and this angle be kept throughout the sharpening process. This difficulty is got over by placing a false back on the knife. The back consists of two pieces of steel, which are clamped firmly to the knife by two mill-headed screws. The back must be clamped on the same way each time the knife is sharpened, and there should be a separate back for each knife used.

It is essential that good hones should be used. They should be of exceedingly fine grain, yet not too hard. It is best to have two, the one being of slightly finer texture. Belgian sandstone is the best. The hones, when not in use, should be dried and carefully put away in a box, and if good work is needed no other knives but the microtome knives should ever touch them.

A special form of strop is used for finishing off the blades, and it is most essential that this be kept free from dust when not in use. W. Walb, of Heidelberg, specialises in strops for microtome knives.

The following plan is suggested when sharpening knives:—

(1) Screw on the knife holder and remove all oil with alcohol.

(2) Place the knife under the low power of the microscope and examine thoroughly. If the knife needs grinding there will appear to be shiny and roughened places on the blade besides small notches. An idea of the proper condition of the knife under the microscope can be only gained by practical experience.

(3) If the notches in the blade are deep use the coarser hone. Flood the hone with water, some microtomists recommend soap to be used with the water. Always have the same end of the hone pointing to the right. It is best to mark the right-hand side of the hone. Lay the knife down diagonally upon

the left-hand side of the hone. Let the knife rest evenly upon the hone; there will be a tendency to place more weight on the heel of the knife. Draw the edge forwards and from the heel to the point along the hone and to the right-hand side. Do not draw the knife along the hone in such a manner that its point inscribes an arc, but so that it inscribes a straight line. Turn the knife over on its back and repeat the work. As the hone is narrower than the knife, and this process is followed for long, the centre will get more grinding than the point; so the heel and point must be given some extra grinding. The time taken in honing varies greatly, sometimes the blade only wants a comparatively few strokes.

Note.—The above is a description of honing a true wedge-shaped knife. The procedure for a knife with a concave side is to lay the concave side down and grind this side continuously, and afterwards grind the other until a good edge is formed.

(4) Take the back off and place the knife under the microscope (seeing that the stage is free from dust and grit).

(5) If the larger notches have become considerably smaller, use the finer hone and repeat (3) and (4).

(6) If the knife has been sufficiently ground the edge should appear even; but there will be a slightly serrated edge. There should be no suspicion of a notch. The knife should be now in a state for stropping.

(7) Place the blade on the knife again and strop. Carrying out the motions given in (3), but with the following important difference—the knife must be moved backwards and not forwards, as in honing. The edge should now appear quite even and straight, and without the slightest trace of a serrated edge under the low power.

The knife should now be sufficiently sharp not only to split hairs, but be too sharp to do this, for with the slightest movement it should run straight through. The hairs on the back of one's hand should be removed with the greatest of ease, the blade not touching the skin, and the hairs flying off with a metallic sound.

If the blade is not going to be used immediately, it should be oiled and put away in its box.

The Cutting of Sections with the Microtome:

The following procedure is suggested when cutting sections. This process would be necessarily altered with other types of holders and microtomes.

(1) See that the microtome is well oiled on all moving parts. Any good light oil will do; but it must not be of a sticky nature.

(2) Remove oil from the knife with 90 per cent. alcohol.

(3) Place the knife in the knife holder in such a position that the point of the knife will be used first. Screw down the knife tightly in position. In the holder use the angle of the knife to the cutting plane is 14°, this angle being a fixture.

(4) Unscrew the thumb-screw of the knife holder and adjust the horizontal angle of the knife to the cutting plane to about 58°, and clamp firmly. It was found by experiment that a cutting angle of 58° gave the best results.

(5) Take a block to be sectioned. Examine thoroughly and decide upon which surfaces to use. It was found best to cut one of the longitudinal surfaces first, preferably the radial, as this gives the most trouble in packing.

(6) Cut two V incisions on the radial surface of the block, one about 0.5 cms. from one end and the other 0.5 cms. from the first. Then cut the rest of the radial surface away to the depth of the second cut, leaving two raised portions with **sloping** cutting edges. These are the parts from which the sections will be cut.

(7) Place the block between the jaws of the object holder and clamp in firmly, using wooden wedges for packing. It will be found that a great deal of time will be lost before the block lies securely in such a position, as to cut true radial section.

(8) Draw the object carrier and knife carrier gently towards one another, until the wooden block almost touches the knife.

(9) Draw up the carrier of the slow-motion screw until the screw point touches the object carried and clamp.

(10) See that all screws are screwed down tightly. If any vibrations are set up from loose parts, the knife at once jumps off the section.

(11) Flood the knife with 70 per cent alcohol.

(12) The microtome is now set up for cutting sections. Raise the object by means of the slow-motion screw. Draw

the blade across the object. The first few sections will be of no use. Remove all sections from the knife with a camel-hair brush. Always keep the blade well flooded with alcohol.

(13) After these preliminary sections have been cut, turn the slow-motion screw a definite amount and note, say, 1 1-3 revolutions. Draw the blade slowly but firmly forward with a **downward** pressure on the carrier. If the section starts to curl while being cut, flatten it out immediately with the brush.

(14) Remove the section from the knife and examine it under the microscope. If this section is too thick or thin, alter the thickness of the following sections accordingly. Now will be seen whether or not the knife has been properly sharpened.

(15) For tangential sections the same process is followed. A new part of the blade is used for each "set up." (After the knife has been used over once it will have to be re-sharpened.

(16) For transverse sections the block may be clamped into the jaws without any packing.

As each batch of sections was cut it was found best to place them in small tubes in 70 per cent. alcohol, each with its appropriate label inside. Elder pith makes excellent stroppers, and the tubes were stored in a large jar of 70 per cent. alcohol.

The following main points are as well to remember when cutting sections. Treat the microtome with care; all movements should be gently carried out. If at any time when cutting sections a new part of the blade is tried, run the object carrier back and proceed as set out in (8) and (9). Keep a constant watch on the quality and the thickness of the sections by examining under the microscope. If the elements of the section appear to be torn, the knife wants sharpening.

The width of the sections cut vary greatly with the species, and for what purposes they are being cut. Transverse and radial sections were cut 16-25μ in thickness, while tangential were cut to about 15μ.

Staining and Mounting of the Wood Sections:

The following directions explain the method which gave the best results:—

(1) Stain in a 2 per cent. solution of fuchsin in 70 per cent. alcohol for at least 2½ hours.

(2) Wash excess stain from sections in two or three changes of 70 per cent. alcohol. To remove stains from cell lumina leave the sections in 70 per cent. for at least three hours.

(3) Dehydrate in 90 per cent. and two changes of 100 per cent. alcohol—15-20 minutes in each.

(4) Clear in olive oil, 15-20 minutes.

(5) Transfer to xylol, 10 minutes.

(6) Mount in Canada balsam.

Preparation of Woods by Maceration:

To become well acquainted with the shape, length and diameter of tracheids, fibres and vessels, some method of teasing apart must be resorted to. This is done by placing suitable sized chips of wood in nitric acid and adding a little potassium chlorate; by this the dissolution of the middle lamella takes place and the cells fall apart.

A modified procedure of that set out by B. H. Brown (Bulletin of Torrey Botanical Club, p. 137, April, 1919) was carried out. The following is a description:

(1) Chips were cut to expose a radial length of 2 cms., a longitudinal length of 1 cm., and a tangential thickness of 2mm. Each chip was marked with a suitable sign. It was found that even after boiling lead pencil marks were easily seen.

(2) The chips were placed in a beaker and kept at a boiling temperature in water for about one hour. The boiling water was replaced with cold and then reboiled. This was continued for at least five changes.

(3) Each chip was then placed in a numbered test tube (numerals printed upon paper and sealed in a small glass tube made excellent means of reference). The chips were covered with 50 per cent. nitric acid and a small amount of potassium chlorate (as much as could be taken upon a small knife blade). The tubes were then placed in a beaker full of boiling water, until the chips had become whitened and commenced to fray or fall to pieces. Cold water was then poured on, causing the action to cease.

(4) The acid was removed by boiling in three or four changes of water.

(5) The macerated material was transferred to a watch glass and the water replaced by 90 per cent. alcohol until all air had been removed from the cell lumina.

(6) The alcohol was replaced by a 2 per cent. solution of Bismark brown in 70 per cent. alcohol, in which the material was allowed to stand for 12-24 hours.

(7) Excess stain was removed by washing quickly in 70 per cent. alcohol and

transferred to glycerine, which was changed if it was greatly coloured by the stain.

(8) A clean microscopic glass slide was taken and a drop of glycerine was placed on the centre. In this drop was placed a small portion of the macerated wood. The slide was then placed under a dissection microscope, and the wood gently teased apart by tapping with dissecting needle.

(9) A No. 1 cover-slip was placed on and cemented with gold size. A No. 1 cover-slip is essential if measurements are going to be taken under high powers.

Editorial Note—Further articles by Mr. Barker dealing with the anatomy of New Zealand woods will appear in future numbers of this journal.

CANTERBURY'S NATIVE BUSH.

(Arthur F. Clark.)

From about the year 1800 the establishing of small trading posts or depots at various points along the coast of New Zealand was of fairly common occurrence, particularly in the North Island. At these visiting vessels would call and exchange their trade goods (of which the musket rapidly became the most sought after) for Maori produce. The Pakeha-Maori, a white man, in some cases with an exceedingly doubtful history, was often retained by the tribes, and upon the calling in of a vessel at one of these depots his function was to act as interpreter and bargain-maker between the Maori and the trader. The success which attended his efforts in carrying out this delicate task often prevented his conversion into an article of diet. Thus the white man was already known in many parts of New Zealand before definite attempts at settlement were commenced.

Already Nelson and Taranaki were occupied by small but determined bands of colonists, when, in 1847, a movement was set on foot in London which led to the formation of the Canterbury Association, the object of which was to found a colony in New Zealand to be known as Canterbury. The moving spirit in the Association was John Robert Godley, a man of great energy and singular strength of character. Throughout the difficult years before the scheme had definitely matured, when the attitude of the Imperial Parliament towards colonising efforts was by no means encouraging, it was due, undoubtedly, to his untiring efforts that the spirit of the movement was kept alive. Unlike previous efforts at colonisation the plans of the would-be colonists were most carefully prepared in advance. Captain Thomas preceded the expedition by some two years with authority to act fully in most matters for the Association. The plains of the Wairarapa had first been brought to the notice of the Association, but Thomas encountered difficulties in connection with this site, and as the Canterbury block had already been favourably reported upon, it was upon it that he recommended the foundation of the new settlement. The preliminary mapping of the Port Cooper district and the site of the city of Christchurch was carried out by Edward Jollie, one of the earliest surveyors, with the assistance of Thomas. Arrangements for food were made, and a number of buildings were erected. The plans of the Association were well carried out, and when, in December, 1850, the first four ships arrived at Port Cooper, the foresight and ability of the organisers was well rewarded by the startlingly rapid manner in which the colony proceeded to establish itself. Such, indeed, was the energy and grit of the new colonists, that when Mr. Godley returned to England in the December of 1852, the object of the Association was an accomplished fact; the success of the settlement was assured.

Prior to the advent of the Association, however, Canterbury had attracted several families from Australia, while Banks Peninsula had been the home of a small band of French colonists since 1840. These, too, were well established and thriving. While still in England the settlers of the Association had decided to make Port Cooper, which they now named Lyttelton, the capital of the settlement. On arrival, however, the idea was quickly abandoned, owing, mainly, to the hilly nature of the country, and while some expressed doubt as to the wisdom of the move, the vast majority were in favour of the development of Christchurch as the leading town. From Lyttelton round the beach road, through Sumner, the first settlers came, and upon the broad flat stretch of plains country the new settlement was founded.

The circumstances which influenced Captain Thomas, and, through him, the Association, to choose the Canterbury block were the absence of hostile Maoris and the large amount of open country which was available immediately for grazing and agriculture. This vast stretch of practically useless country must, indeed, have afforded a striking contrast to the densely wooded districts of Nelson and Taranaki. That the first settlers found a considerable area of country in bush, however, is well known. The first recorded estimate of the amount of bush in the Province was in 1830, and the area 300,000 acres. Torlesse later submitted a report to J. R. Godley, then Agent of