Possibility of Naval Stores Production in Canterbury

(M. R. Skipworth)

[A special study submitted for B.For.Sc. Degree, 1930. Sections dealing with the formation of resin, and the description of the box and boring systems of tapping have been omitted, and slight condensation made throughout.]

The great activity which has taken place in New Zealand in recent years in the formation of exotic conifer stands has led to investigations into their future utilization.

These exotic conifer stands probably now occupy about 400,000 acres, and 80,000 acres approximately are being added to this area each year. Although the whole of this area may be required in the future for the production of saw timber, efforts have been made to determine the suitability of the species, mainly Pinus radiata, for the production of wood pulp. Especially has it been hoped that the thinnings could be so utilized, and thus produce some revenue before the cutting of the main crop, or at least give a sufficient return to pay for the cost of thinning.

The production of naval stores from conifer stands is a flourishing industry in several parts of the world. The commercial products derived from the crude resin of certain suitable conifers are turpentine and rosin. In the seventeenth and eighteenth centuries the crude resin was mainly converted into pitch and tar, which were largely used by sailing vessels; hence the name, naval stores. There are two separate industries for the obtaining of turpentine from coniferous trees. The wood turpentine industry obtains turpentine and pine oils from treating the wood itself, by various methods, while the naval stores industry obtains crude resin by the bleeding of various species of conifers and subsequently converting this into turpentine and resin by distillation.

The possibilities of obtaining wood turpentine from the foliage and wood of the common exotic conifers at present growing in the Dominion are at present being investigated by the Department for Scientific and Industrial Research.

Various species of the genus Pinus have been tapped in other countries for the production of resin, but of these, the only one which has been established to any extent in New Zealand is Pinus pinaster. This species has been planted in many parts of the country, usually in small plantations, and the total area is probably not more than a few thousand acres.

Several coniferous species, however, which occur only on very limited areas in their native habitats, have been extensively planted in the Dominion. Their possibilities as producers of naval stores are unknown, but it would be of great value to forestry in New Zealand if one or more species should prove suitable.

The outstanding example is Pinus radiata.

In carrying out the present local experiments, it was attempted to ascertain by tapping a few trees of P. pinaster and P. radiata if the yields were sufficient to warrant further experiments on a practical scale. It was realised that the local climatic conditions were not the most favourable obtainable in New Zealand, the minimum temperatures being lower, and the average summer humidities lower, than in many other parts of the country. If reasonable yields were obtained under such conditions, however, the prospects would be all the more encouraging where optimum climatic conditions prevail.

Methods of Turpentining.

Various trees have been tapped for resin in different countries, and in consequence the methods employed vary widely. This variation is not only due to the different natural factors involved, but also to the different ideas regarding the formation and flow of resin, and to the existing forest practice.

The systems which have been used may be classified into three main types—the box system, the cup system, and the boring system; but of these the cup system is now the only one of practical importance.

The Cup System.

This method consists of directing the flow of resin into some form of cup, attached to the tree. The cup system was introduced to the pinaster stands of France about 1860. Previous to this the resin had been collected in holes scooped in the sand at the base of the trees, but this method was very wasteful and resulted in an extremely dirty type of gum.

The cup system, with its much cleaner type of gum, rapidly replaced the old method, and is now in general use. In the Southern Pineries of the United States, cup systems were first used to any great extent in 1904, and since then have largely replaced the old and timber destroying box system.

The size of the face and shape of the streak, differ according to the practice in various countries. The resin flowing down the face is usually guided into the cups by some form of gutter or apron, inserted into the tree at the bottom of the face. In good practice, these, with the cups, are shifted up the face each season, in order, and so reduce the distance which the resin has to flow down the face. The loss through the evaporation of the more volatile portions is thus lessened.

The size and shape of the cups is also extremely variable. They are usually made of clay or galvanized iron, the flower-pot shape being the commonest. Clay cups are usually cheaper, but are heavy and bulky, and breakage loss is considerable. They do not absorb the sun's heat as much as galvanized iron, however, and there is thus less loss through evaporation. Galvanized iron cups also rust, which causes the gum to darken, with consequent loss in grade.

The usual method of adjusting the cups beneath the apron or gutters is to support them on two nails driven into the tree at the correct position. Occasionally the cups are provided with a hole and may be hung on a nail, or they may be hung from the aprons by means of small hooks.

A new method, termed the "split face," in which a strip of bark is left between the two sides of the face, is now being tried commercially in the United States.

History.

In order to understand the modern industry, a short history and description of the methods in the important resin producing countries is given.

United States of America.

In this country the turpentine industry is confined to the southern pine region of the south-eastern States.

The southern pines are a group of yellow pines containing the following seven species:—

(1)	Longleaf Pine	..	Pinus palustris
(2)	Shortleaf Pine	..	Pinus echinata
(3)	Loblolly Pine	..	Pinus tæda
(4)	Cuban Pine	..	Pinus heterophylla
(5)	Pond Pine	..	Pinus serotina
(6)	Spruce Pine	..	Pinus glabra
(7)	Sand Pine	..	Pinus clausa

Of these, the longleaf pine is the most important, both for timber and naval stores. Its commercial distribution extends from North Carolina to Texas in a coastal belt seldom exceeding 150 miles in width.

Shortleaf pine and loblolly pine are both cut for timber, but are not important as resin producers.

Cuban pine produces good timber and an excellent yield of resin, but is comparatively sparsely distributed. It is found in a coastal belt up to 100 miles wide, from South Carolina to Louisiana, and also in Cuba, Bahamas, eastern Guatemala and Honduras.

The three remaining species are of little importance as they are of small size and are confined to the poorer sites.

The Cuban pine is regarded most favourably for future operations under organized forest management, as it yields a good timber, is a relatively fast grower, and yields a high quantity of resin which contains a larger percentage of turpentine than that of the longleaf pine.

From the earliest days of settlement in Virginia the pines were tapped, the product being converted into pitch and tar mainly. The importance of these products gradually diminished, while the demand for turpentine increased, with the result that by 1850 the manufacture of turpentine was of the most importance.

For many years these States have produced over 70 per cent. of the world's requirements of turpentine and resin.

Until recent years the majority of the trees were worked by the box system, cup systems being introduced to any extent only in 1904.

The boxing system is of minor importance under present conditions, however, the majority of the trees being cupped and the timber milled on the completion of the turpentine operations. The cup systems also yield a considerable increase of resin over the box systems.

In the usual class of cup system, two galvanized gutters are inserted in inclined gashes made by a broadaxe at the bottom of the face. The lower gutter projects two inches beyond the upper gutter, the cup being hung immediately beneath it. The gutters are two inches wide and from six to twelve inches long, depending on the size of the face, and are bent into an obtuse angle. The faces are usually from twelve to sixteen inches wide, according to the size of the tree, and each tree receives from one to four faces.

In chipping the average height of the chip is usually one half inch, and the depth varies from one half to one and a half inches. Experiments have shown, however, that lighter methods of chipping result in higher yields, besides causing less damage to the timber and allowing faces to be worked for a longer period.

A reduction in the height to 3/10ths or 4/10ths of an inch, and in the depth to 4/10ths of an inch, gives higher yields, and these methods have been adopted by many commercial operations.

One labourer looks after from 7,000 to 10,000 faces, each face being chipped once a week.

The gum is collected from the cups every four weeks usually, being emptied into buckets, which are, in turn, emptied into barrels, spaced at convenient distances throughout the woods.

At the end of the season the solidified gum remaining on the face is scraped off, but this operation is confined to the longleaf pine, as the Cuban pine yields very little "scrape."

In the autumn fires are usually run through the areas in order to improve the forage for the following spring, to reduce the damage done by accidental fire, and to remove the brush and debris and so improve access conditions.

Before burning it is necessary to rake away the resinous chips and debris from the bases of the trees to prevent the fire reaching the inflammable faces.

Yields.

The faces are chipped once a week, but the majority of the flow takes place in the first two days after chipping.

The following table shows the rate of exudation of longleaf pine, but this may vary greatly according to different factors, especially the weather:—

	Grams of Gum.	Per cent. of Total.
First day ..	113.0 ..	67.26
Second day ..	22.5 ..	13.39
Third day ..	13.5 ..	8.04
Fourth day ..	9.0 ..	5.36
Fifth day ..	..	
Sixth day ..	9.0 ..	5.36
Seventh day ..	1.0 ..	0.59

Under different chipping methods the yield per face per annum varies from 7.8lbs. tc 10.4lbs. (including scrape), the number of chippings being thirty-two.

Taking the average width of face as 14 inches, the yield per inch per chipping varies from .017lbs. to .025lbs. Scrape may form up to 20 per cent. of the total yield, but it gives only a low grade of resin with 11 per cent. of turpentine, as compared with 19 per cent. from the dipped gum.

France.

In France turpentine operations are carried out in the maritime pine stands of the Landes region. The revenue obtained from resin is of more importance than that obtained from saw timber, and the stands are managed with the main object of resin production.

On the final clear felling of the maritime pine stands, at ages varying from 55 to 75 years, dense natural reproduction usually occurs. This young growth is cleaned and thinned every five years, the stand being rapidly opened out in order to stimulate crown growth.

Between 20 and 25 years the average stand contains about 200 trees per acre. At each cleaning the trees are marked for thinning, but if of sufficient size are not removed immediately but are tapped exhaustively until death occurs.

The commencement of this thinning tapping is usually between the ages of 15 and 25 years. No tree which is to form part of the final crop is tapped until it has reached 13 or 14 inches in diameter.

Before tapping commences the rough outside bark is removed with an axe from the area which is to be tapped during the ensuing season. The face varies in width from 3 to 3.5 inches wide, and is usually 0.4 inches deep or less. As the face is carried up the tree it narrows in width, in the fourth year varying from 2.3 to 2.75 inches. The rate at which the face ascends the tree increases each year, varying from about two feet in the first year to over three feet in the fourth year. The height of the face increases about .6 to .7 inches for each chipping, and if a face is worked for the fifth year it is necessary to use ladders.

A tree to be tapped to death may receive four or five faces, but a tree treated under "gemmage a vie" usually receives only one face.

Chipping commences early in March and finishes towards the end of October, the total number of chippings usually varying between 35 and 40. The chippings may be done once a week or every five days, and other methods are also employed, including the practice of increasing the rate of chipping during the hottest part of the season.

Special tools are used for all the operations, the faces being kept remarkably smooth.

The labour is skilled, efficient and cheap, the workman's wages often consisting of half the proceeds from the sale of the resin collected by him.

A zinc gutter is placed at the base of the face, a gash of a depth of .2 inches being found sufficient to hold the gutter in place.

Conical glazed earthenware pots of a capacity of one quart are most frequently used and rest on a nail, the upper part being held in place by the projecting gutter.

Elaborate regulations and tapping cycles are in vogue.

Yields.

Yields naturally vary considerably, highest yields being obtained from open stands near the sea, especially during the second and third years.

The usual yield of resin per inch width of face per chipping varies from .023 to .029 lbs.

LOCAL EXPERIMENTS.

Location.

In locating a suitable area, it was necessary that the area contain both Pinus radiata and P. pinaster of suitable size, that the area be unfrequented but within easy cycling distance of the city, and finally, of course, the owner's consent was necessary.

An area was finally obtained in the Bottle Lake district, on Section 2431, Christchurch S.D. The area is situated about two miles from the sea, the trees being planted on what was probably a naturally fixed dune area. Some two or three acres were planted about 40 years ago, mainly with radiata, laricio and pinaster. A few Douglas fir, Pinus tuberculata and P. sylvestris are also present, but are not in a very healthy condition. The radiata and pinaster have grown into very fine trees, but the pinaster are separated from the radiata, both species growing amongst the laricio and tuberculata.

A younger stand would probably have been more suitable, as the 40-year-old trees have probably passed their greatest vigour.

The radiata and several of the pinaster are situated on the open eastern side of the plantation.

Operations.

Permission was obtained from the owner to turpentine twenty trees, fifteen pinaster and five radiata being selected.

Within the narrow limit of these numbers it was attempted to obtain as wide a selection of crown classes as possible. As the stand was even aged, no range of age classes could be obtained, however.

The measurements of the trees were:—

(1 = small crown; 2 = medium crown; 3 = large crown.)

Tree. No.	Species.	Diameter.	Height.	Crown Class.
1	Pinaster	34 in.	96 ft.	2
2	,,	26 in.	80 ft.	2
3	,,	25 in.	80 ft.	2
4	,,	16 in.	72 ft.	2
5	,,	22 in.	85 ft.	2
6	,,	16 in.	68 ft.	2
7	,,	15 in.	66 ft.	1
8	,,	16 in.	66 ft.	1
9	,,	17 in.	70 ft.	2
10	,,	33 in.	88 ft.	3
11	,,	28 in.	88 ft.	2
12	,,	15 in.	72 ft.	1
13	,,	26 in.	78 ft.	2
14	,,	21 in.	70 ft.	2
15	,,	17 in.	68 ft.	1
16	Radiata	32 in.	98 ft.	2
17	,,	38 in.	115 ft.	2
18	,,	25 in.	95 ft.	1
19	,,	30 in.	100 ft.	1
20	,,	32 in.	105 ft.	2

As it was necessary to prevent the trees being damaged or disfigured to any great extent, the width of the faces was kept very narrow, varying from two inches to five inches.

System of Tapping.

The preliminary blaze was made about four or five inches high, according to the shape of the tree and the difficulty of fixing the gutters. It was attempted to make them of a uniform depth,, one half inch deep from the inner bark, but the amount frequently erred on the deep side.

All faces were made on the north side of the tree and as close to the base of the tree as possible. The effect of the sun's rays on the face is supposed to have a beneficial effect on resin production, and as the majority of the rain storms come from the south or south-west, it was thought that the cups would collect least rain-water in this position. The blazes were made with an axe, a chisel being used to smooth the faces off. Zinc foil gutters were inserted into cuts made in the faces with chisel and mallet. Cylindrical glazed earthenware cups, of one pint capacity, were supported by nails driven into the tree. The faces were made on August 14th, 1929, the first chipping being on September 11th. An interval between the facing and the first chipping is said to allow of the collecting of resin at that point, so that higher yields will be obtained from the first few chippings. The first chipping could probably have been made at least one week earlier with satisfactory results, as the season was well forward.

Chipping.

The faces were chipped at weekly intervals commencing on September 11th. The eighth chipping was on October 30th, and from this date until March 7th no chippings were carried out, owing to the examinations and vacation work. Four more chippings were made from March 7th to March 28th, 1930. After this date weather conditions were so unfavourable for resin flow that further chipping produced but very poor yields. The end of March seemed to indicate a very definite change in the vigour of resin production. The chippings were made with the aid of a sharp chisel, it being attempted to carry the face up at the rate of one quarter of an inch at each chipping.

Yields.

The resin was collected every four weeks from the cups, but owing to the frequent occurrence of days with low humidities—e.g., nor'wester days—a fair amount of turpentine was, no doubt, lost through evaporation.

This seemed to be especially so for radiata resin, as it appeared to be much less viscous than that of pinaster. Pinaster resin quickly formed a dried looking surface skin, thus retarding the further evaporation of the volatile constituents.

The yield of resin per inch of face per chipping, for pinaster, was from .0051lbs. to .0236lbs., the average being .0098lbs., and for radiata from .0050lbs. to .0107lbs.

These figures may be compared with the yields obtained in other countries:—

		Per Inch of Face per Chipping.
Local	Radiata	.0073 lbs.
,,	Pinaster	.0098 lbs.
United States	Southern Yellow Pine	.0170 to .0270 lbs.
France	Pinaster	.0230 to .0290 lbs.
India	Pinus longifoloa	.0260 lbs.

These very poor yields are not due to a number of trees with very low yields pulling down the general average, as the results are fairly uniform. Only one tree, tree No. 12, reaches the general French averages. A number of reasons are apparent why the yields are so low, but even with the rectification of a number of faults, the yields would still be very much below the French or American averages.

The number of trees tapped was insufficient to give a reliable average, and there was no range of age classes, the trees probably being past their most vigorous stages.

Makeshift apparatus being employed in the tapping, a certain amount of resin was naturally lost through dripping over the edges of the gutters and the like.

With the necessary skill and apparatus, the faces would, no doubt, have been cut and chipped in a more efficient manner, and thus the yield increased.

No tapping was done from November to early March, the midsummer period, when the yields would be expected to be the highest, owing to the much more favourable temperatures.

In September, 1929, the average temperature was 2.4 degrees below the normal, and this was caused, not through the absence of high temperatures, but on account of the large number of nights on which abnormally low temperatures were recorded. This naturally caused a diminution in resin flow, especially when such temperatures were recorded on the night following chipping.

In March, also, the average temperature was 1.4 degrees below normal. Such fluctuations from the normal temperatures would result in extremely variable annual yields, and consequent inconvenience to a resin industry.

Composition of Yields.

Investigation into the compositions of the turpentines from radiata and pinaster shows that both are quite as suitable as the overseas products for all purposes.

The percentages of turpentine obtained are as follows:—

Americal—average	19%
Pinaster—local	22.2%
Radiata—local	21.7%
Pinaster—S.F.S. Auckland	20.6%
Radiata—S.F.S. Auckland	22.4%

The New Zealand State Forest Service recently decided to investigate the resin yields of radiata and pinaster, and one hundred trees of each species were tapped during 1929-30 summer at Riverhead, Auckland. (See Annual Report S.F.S., 1930, and Press report of 1930 Forest Service Conference.) The encouraging results obtained at Riverhead draw attention to the fact that the climatic conditions of Auckland are much more suitable for turpentine operations.

Comparing the average mean minimum temperatures for each month for Auckland and Christchurch, it is found that the Auckland temperatures are from 7 degrees to 12 degrees above the Christchurch temperatures. The fact that the temperature does not fall to a low figure each night means that the restraining effect on resin flow is reduced proportionately. The monthly maximum and mean temperatures also show considerable differences.

No comparison can be made of the local results with the Riverhead results, as no figures on the width of the faces used there have yet been published.

The great importance of the climatic conditions is demonstrated by an American experiment where an average increase in temperature of 15 degrees F. doubled the yield of resin. No temperature curves of America or French tapping areas are available locally, however, with which to compare the New Zealand temperature curves.

Costs and Markets.

If some of the exotic conifers prove to be capable of yielding payable quantities, a New Zealand industry would have several advantages.

The artifically established plantations are easily accessible and contain a higher number of trees per acre than the natural stands of India and America.

The thinnings, at present, usually have no value, and the rights to tap these would probably be obtained at small cost.

Some disadvantages are the high cost of labour and the limited local market for the product of the industry.

In America one labourer attends to 7,000 to 10,000 faces, the cost for each crop averaging £145 per annum for labour and £30 for supervision. The leasing of the timber costs from £50 to £80 per crop per annum, and the raking of the debris from the bases of the trees before burning for grazing purposes costs £5 to £7 per annum.

These two costs would be saved to the forest owner in New Zealand.

Allowing that a New Zealand labourer could work one fifth extra the number of faces that an American labourer works, owing to the greater ease of working the local areas, and that the burning and leasing costs were saved, the comparative costs would be:—

	America	New Zealand
Leases	£70	—
Burning	6	—
Labour	145	200
Supervision	30	25
	£251	£225
Ratio of Resin Produced	220	100
Cost per Unit	1.14	2.25

This is based on the local yields, but with the same size faces as in the States. A higher turpentine yield locally (22 per cent. as compared with 19 per cent.) would reduce the ratio to 1.14 : 1.88, considering turpentine only.

New Zealand imports about £20,000 of naval stores per annum and Australia about three to four times the amount. Here, the turpentine is mainly used by the painting trade, the wholesale price varying from 5/- to 5/6 per gallon. The rosin is mainly used in the manufacture of soap, and the price is about 2d. per lb.

If the local yields were up to foreign standards for a six-months' season, the acreage required to supply New Zealand would probably be between 20,000 and 30,000 acres of normal forest. This would include the yields from thinnings and provide for the forest being worked on a conservative basis.

Summary.

The experiments indicate that there is little chance of any commercial development of resin-tapping in the cold and variable climate of Canterbury.

Future work should be confined to areas possessing a warmer and more equable climate.

Experiments in the northern parts of the Dominion should show more encouraging results, but further work in Canterbury would not seem justified.