FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

Interior Limbing, Bucking and Processing Study Evaluation of Hahn Tree-Length Delimber

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FOREWORD

FERIC's project on Interior Limbing, Bucking and Processing represents an on-going search for machines and methods to solve the problems of achieving high quality logs at reasonable cost. This Technical Note describes the evaluation of one such machine, the Hahn Tree-Length Delimber, which delimbs and bucks full trees. Further studies of processing machines will be made as new equipment is developed and introduced.

FERIC wishes to thank personnel from the following companies for their assistance and cooperation during this study:

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Crows Nest Industries, Elko, B.C.
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SUMMARY

The Hahn Tree-Length Delimber is a delimbing and bucking machine, which has been introduced into the Interior of B.C. There are currently 5 units working in B.C., four in the Interior and one on Vancouver Island. The machine studied was working in the central processing yard at Peachland, delimbing and bucking full trees into desired log lengths (usually 34 ft 8 in.) which were then trucked on-highway to the mill.

The machine is a self-propelled rubber-tired unit. Its chassis forms the working deck for the wrap-around knife-type delimber. Bucking and topping is done by a hydraulically operated chain saw. An electronic measuring device is used to obtain accurate bucking. Full trees are fed into the delimber by a knuckle-boom loader. After delimbing and topping, logs are ejected onto the ground at the other end of the machine. A front-end loader (Caterpillar 966C) clears the processed logs and moves debris to the disposal ditch where it is burnt. A two-man crew operated the Hahn, one on the knuckle-boom loader and one controlling the delimbing and bucking. The machine weighs about 20 200 kg and costs approximately $200,000 f.o.b. Vancouver.

This study collected both shift level information on actual performance and detailed timing data for estimating potential productivity. Bucking accuracy was also studied. Results are compared with those from a second unit in the Interior and the unit working on Vancouver Island.

During the 48 days of the study period, the Hahn processed 272 off-highway truckloads with a volume of 16 410 m^3 (= 42.5 m^3/PMH). Daily production averaged 342 m^3 (or 5.7 truckloads), which was almost one-half of the daily yard throughput. The remaining volume was delimbed by a flail and manually bucked. However, over the study period, the daily production increased slowly, and reached almost 7 loads per day at the conclusion.

Machine availability was high at 87% and utilization of 84% was also good. This latter shows that there were very few non-mechanical delays. In comparison, the other Hahn working in the Interior produced 15 260 m^3 in 65 days (= 40.7 m^3/PMH) and achieved a machine availability of 78%, with a

utilization of 67%. Some of the difference in production resulted from the smaller tree size (.3 m^3 per tree compared to .4 m^3 per tree at Peachland). Both machines were working with lodgepole pine as the major species.

Detailed timing samples showed that the processing (delimbing and bucking) activity determines the potential productivity. An average off-highway truckload of 62.4 m^3 was processed in 65.5 minutes, which equals 57.2 m^3 per productive machine hour. The Hahn actually processed only 78% of the trees in a truckload. The remaining 22% did not need processing and were transferred by its loader from the full tree piles to the processed log pile.

Potential productivity estimates for both machines in the Interior of B.C. were similar in terms of trees per PMH. Again the larger tree size at Peachland influenced volume in m^3 per PMH. The Hahn on Vancouver Island had longer cycle times because there was only one operator. Potential productivity for this machine was 85 trees per PMH. Average tree size was .71 m^3, and volume per PMH was estimated at 41.4 m^3. Here also the effect of tree size was very noticeable, and offset the longer cycle times resulting from the single operator.

This Technical Note presents some cost estimates for both favourable and unfavourable conditions. These suggest that with favourable conditions, the Hahn can process logs for a comparable price to flail limbing with manual bucking. There are also some general comments on all three machines and their operating set-ups.

All three Hahns produced cleanly limbed and accurately bucked logs. Two of them reported good machine availability and utilization. These units have demonstrated their abilities to handle Interior wood, while the unit on Vancouver Island has worked equally well with the smaller sizes of coast timber.

SOMMAIRE

L'ébrancheuse-tronçonneuse Hahn est un engin forestier qui a son apparition en Colombie-Britannique intérieure. Il y a actuellement cinq de ces machines à l'oeuvre dans la province, quatre dans la zone intérieure et une sur l'île de Vancouver. La machine étudiée, installée dans un parc central de façonnage à Peachland, ébranchait et tronçonnait des arbres entiers en grumes de la longueur voulue (généralement 34 pi 8 po), grumes qui étaient ensuite transportées par camion sur la grand'route jusqu'à l'usine.

L'engin est automoteur et monté sur des pneumatiques de caoutchouc. Son châssis forme la plate-forme où se trouve une tête d'ébranchage à couteaux enveloppants. Le tronçonnage et l'écimage sont effectués par une scie à chaîne à commande hydraulique. Un dispositif électronique de mesure des longueurs assure la précision du tronçonnage. Une flèche d'alimentation articulée amène les arbres entiers jusqu'au dispositif d'ébranchage. Après l'ébranchage et l'écimage, les billes sont éjectées au sol à l'autre extrémité de la machine. Une chargeuse frontale (Caterpillar 966 C) enlève les billes façonnées et porte les déchets jusqu'à la fosse d'élimination où ils sont brûlés. Le fonctionnement de l'ébrancheuse Hahn demande une équipe de deux hommes, un à la flèche d'alimentation articulée, et l'autre pour commander l'ébranchage et le tronçonnage. L'engin pèse environ 20 200 kg et son coût s'élève approximativement à 200 000$ f.o.b. Vancouver.

Au cours de l'étude, on recueillit des données par poste de travail sur la performance réelle, ainsi que des chronométrages détaillés permettant d'estimer le potentiel de productivité. L'étude porta aussi sur la précision du tronçonnage. On y compare les résultats obtenus avec ceux qui proviennent d'une seconde machine travaillant en Colombie intérieure et de celle qui se trouve sur l'île de Vancouver.

Durant les 48 jours que dura l'étude, l'ébrancheuse-tronçonneuse Hahn façonna 272 charges de camions de voie privée, soit un volume de 16 410 m^3 (42,5 m^3/HMP). La production journalière s'élevait en moyenne à 342 m^3 (ou 5,7 charges de camion), ce qui atteignait presque la moitié des arrivages journaliers du parc. Le volume de bois restant était ébranché par une ébrancheuse à fléaux et tronçonné à la main.

Cependant la production journalière augmenta peu à peu au cours de l'étude pour atteindre presque 7 charges par jour vers la fin.

La machine avait une disponibilité élevée de 87% et un bon taux d'utilisation de 84%. Ce dernier taux démontre qu'il y eut très peu de temps morts d'ordre non-mécanique. Comparativement, l'autre Hahn travaillant en zone intérieure produisit 15 260 m^3 en 65 jours (= 40,7 m^3/HMP), soit une disponibilité de 78% et en taux d'utilisation de 67%. Une part de la différence dans le volume produit résulte de la plus faible taille des arbres (0,3 m^3 à l'arbre par rapport à 0,4 m^3 à Peachland). Dans les deux cas, le pin lodgepole constituait l'essence principale.

Des échantillons des chronométrages montraient que l'ébranchage-tronçonnage constitue l'activité déterminante du potentiel de productivité. Une charge moyenne de camion de voie privée de 62,4 m^3 était façonnée en 65,5 minutes, ce qui donne 57,2 m^3 par heure-machine productive. L'engin ne façonnait en fait que 78% des arbres de la charge. Le reste, soit 22%, n'avait pas besoin d'être façonné et passait, à l'aide de la flèche d'alimentation, directement de la pile d'arbres entiers à la pile de grumes façonnées.

Les estimations du potentiel de productivité des deux machines utilisées en Colombie intérieure étaient semblables, quant au nombre d'arbres par HMP. Ici encore le volume plus élevé des arbres à Peachland influença le volume en m^3 par HMP. L'ébrancheuse-tronçonneuse Hahn se trouvant sur l'île de Vancouver avait des temps plus longs parce qu'elle n'avait qu'un seul opérateur. Son potentiel de productivité atteignait 85 arbres par HMP. Le volume moyen des arbres était de 0,71 m^3, et le volume par HMP était estimé à 41,4 m^3. Ici aussi l'effet de la taille des arbres était remarquable, et compensait les temps de fonctionnement plus longs dus à la présence d'un seul opérateur.

On trouvera dans la présente fiche technique quelques estimations de coût dans des conditions favorables et défavorables. Elles laissent entendre que dans des conditions favorables, l'ébrancheuse-tronçonneuse Hahn peut façonner les grumes à un coût comparable à l'ébranchage au fléau suivi d'un tronçonnage manuel. On trouvera également quelques commentaires généraux sur les trois machines et l'organisation de chaque site de façonnage.

Les trois ébrancheuses-tronçonneuses Hahn produisaient des grumes bien ébranchées et tronçonnées avec précision. Deux d'entre elles faisaient preuve d'une bonne disponibilité et d'un bon taux d'utilisation. Elles ont démontré leur aptitude à traiter les arbres de la Colombie intérieure, alors que celle qui se trouvait sur l'île de Vancouver a également donneé de bons résultats avec les arbres plus petits de la région côtière.

INTRODUCTION

This Technical Note describes the use of a Hahn tree-length delimbing and bucking machine in a central processing yard in the Interior of B.C. Productivity figures come from both shift-level and detailed time studies. Comparisons are made with two other Hahns, one working in Interior B.C. and the other in small timber on Vancouver Island.

In Interior B.C. about 75 percent of the wood harvested is manually delimbed and bucked. The use of chain flail delimbers with manual bucking accounts for another 20 percent, and the remainder is mechanically delimbed, bucked and topped. There is considerable industry interest in improving the quality of delimbing and bucking. One approach to this problem is the introduction of mechanized systems. So far, machines designed for eastern Canadian conditions are being introduced in experiments to solve the problems. Sliding boom delimbers and Hahn delimbers are handling the estimated five percent of the harvest which is processed mechanically. Sliding boom delimbers have been studied in Ontario and Quebec, and show definite potential for Interior B.C. These machines, however, only delimb and top. The Hahn includes a bucking capability as well and has aroused much interest, particularly in central processing yard applications.

TECHNICAL DESCRIPTION

The Hahn Tree-Length Delimber is a self-propelled machine. It is a 4-wheeled machine with one steering axle and one drive axle. The chassis forms the deck on which the delimbing head travels. There are four stabilizer legs which raise the wheels off the ground and provide a solid working position. The 119 kW engine is mounted off to one side between the axles. The operator's cab is mounted at the off-feed end of the unit. The knuckle-boom loader is mounted at the other end on the opposite side by the engine and fuel tanks. There is a second cab with the loader so that two operators run the machine.

The delimbing head travels the length of the machine. It is a wrap-around knife-type delimber, with 1 fixed and 4 movable knives. Two hydrostatically-driven chains move the carriage back and forth. Below the operator's cab are the holding arms which secure the tree while delimbing takes place. Also there is a kick-out arm to eject the processed log. There is a hydraulically-operated chainsaw mounted by the engine house which bucks the trees or trims off butts and defects as required.

The machine weighs 20 200 kg and the purchase price is approximately $200,000. Figures A to C show the machine and its main components. More detailed specifications are given in Appendix I.

FIGURE A. Hahn Tree-Length Delimber at Peachland Yard.

FIGURE B. Infeed of machine showing return of carriage at end of delimbing. Details of knives and limbing head are hidden by limbs. Note the two trees being processed at one time.

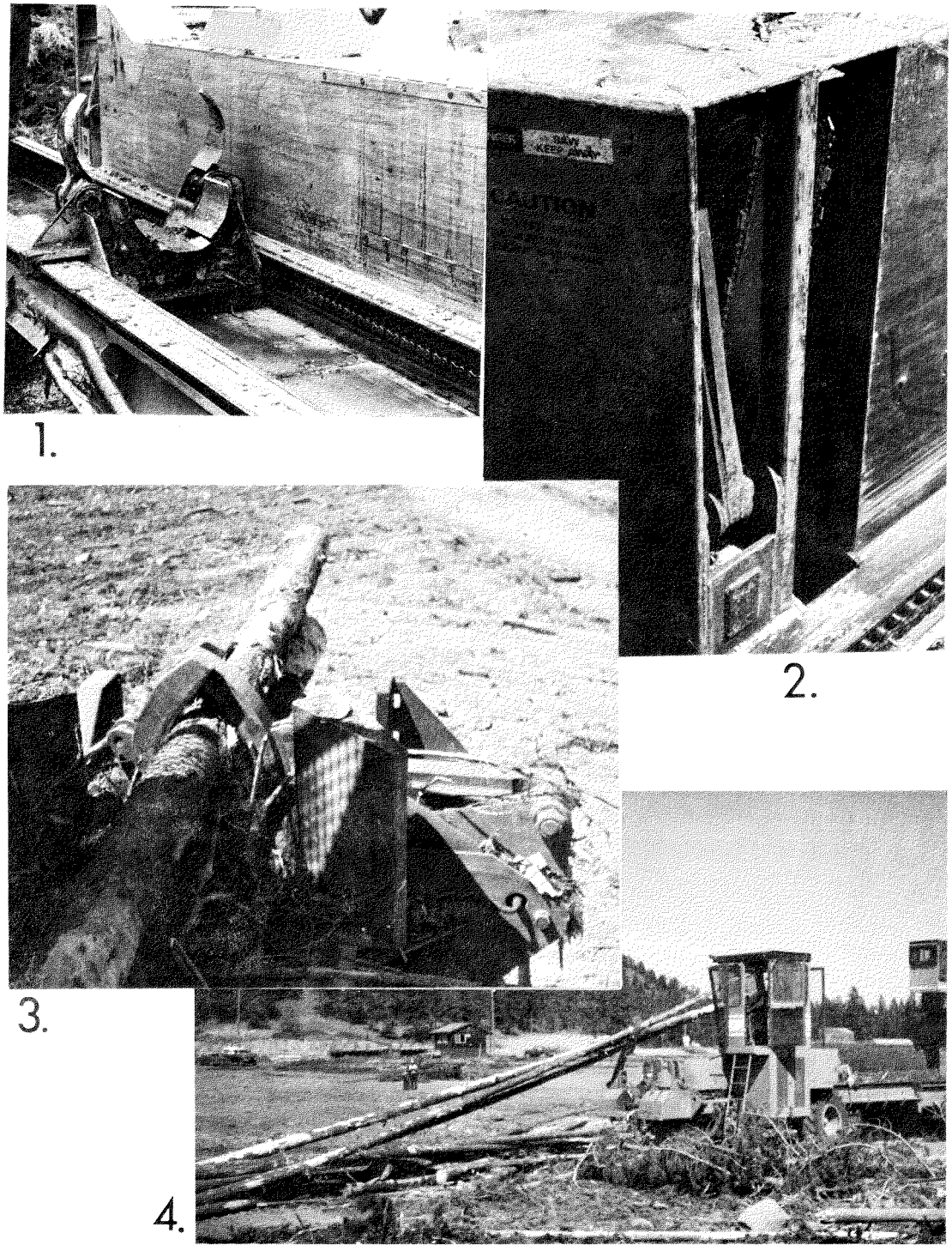

FIGURE C. Close views of machine components:
1) Limbing head 2) Cut-off saw
3) Holding arms 4) Kick-off arm

OPERATING SEQUENCE

The Hahn is positioned with the loader end close to the butts of the full-tree pile. The outriggers are extended to stabilize the machine. The loader then grapples a full tree, releasing it from the pile, and places the butt end in the delimber carriage. The limbing knives close firmly clamping the tree in the limbing carriage. This then moves to the opposite end of the machine and positions the tree on the deck. Holding arms positioned below the main operator's cab then clamp the butt of the tree. The pressure holding the limbing knives is reduced, relaxing the clamping effect but leaving the knives closed around the stem. Returning to the loader end the carriage performs the delimbing function, and carries the limbs and debris with it. Then the holding arms are released and the limbing knives reclamped, allowing the cycle to be repeated until all limbing is done. As the butt of the tree moves out beyond the holding arms, an electronic counter is tripped beginning measurement of log lengths. At the desired length, the carriage is halted (on the loader side of the cut-off saw) and bucking occurs. The bucked log is then ejected away from the machine by the kicker arm. Limbing continues until the desired top diameter is reached and the bucking saw then cuts off the top. This second log is similarly ejected onto the pile of logs. The top and limbs are carried back to the loader end and ejected onto the ground. The limber carriage then accepts the next tree and the cycle is repeated. With smaller trees which only require limbing and topping, two or three trees can be processed at the same time.

Any trees in the pile which do not need processing are removed by the loader and piled on the opposite side of the machine, alongside the pile of processed logs. These are then removed by a front-end loader and decked to await rehauling to the mill. Tops and debris are removed by the same front-end loader, and stored along the edge of the yard for subsequent disposal.

As each pile of full trees is processed, the Hahn will be repositioned several times, keeping the trees within reach of its knuckle-boom loader. At the end of processing a pile, the unit moves on to the next pile.

YARD LAYOUT AND OPERATING CONDITIONS

Feller buncher wood was skidded to landings and roadside by grapple skidder. Full trees were loaded onto off-highway trucks by a Barko 450 Loader and hauled to the central processing yard at Peachland. Haul distance was about 35 km. At the yard, the full trees were off-loaded by a Cat 966 wheeled front-end loader. The loads were simply pushed off. The Hahn then delimbed the full trees and bucked them into the required log lengths. The front-end loader removed the processed logs and stored them in decks or loaded them directly onto highway trucks for the haul to the mill at Kelowna. Limbs, tops and other cull material were moved by the loader to the debris ditch where it was subsequently burned.

Figure D shows the basic layout of the yard at Peachland. In addition to the Hahn, some loads of full trees were spread out, limbed using a flail, manually topped and bucked, and then decked. This ensured that the daily production of the yard achieved the required 700 m^3.

Species processed in the yard were predominately lodgepole pine, with some spruce and balsam. Tree size averaged 0.38 m^3. Branchiness* of the full trees before limbing was as follows:

class 1	82% of sample
class 2	13% of sample
class 3	5% of sample

Branchiness classes 2 and 3 were associated mostly with spruce and balsam fir trees. Most of the pine exhibited branchiness class 1.

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*Tree branchiness is defined as follows:

class 1: 0 - 33% of stem bearing live branches
class 2: 34 - 66% of stem bearing live branches
class 3: 67 - 100% of stem bearing live branches

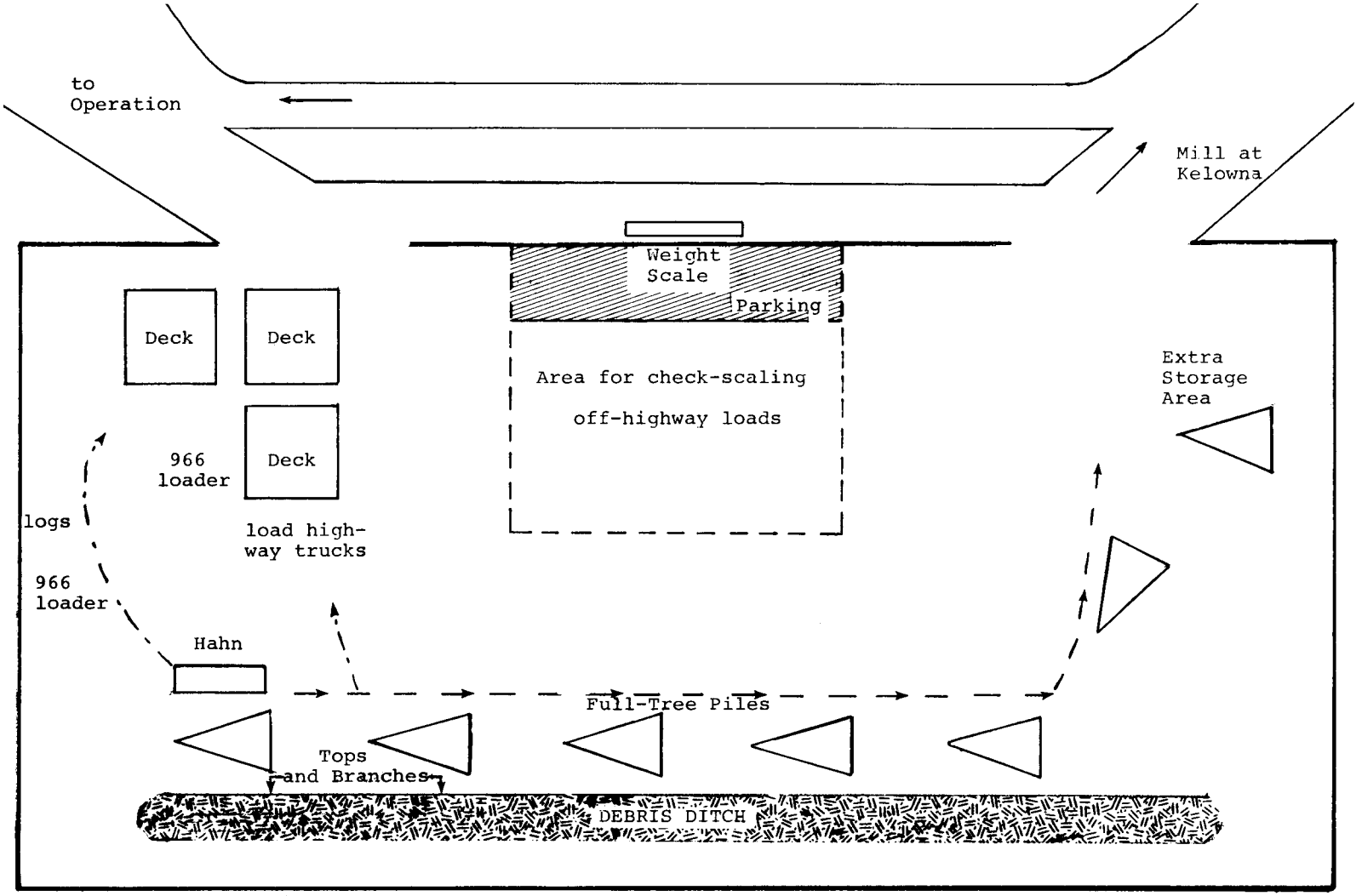

FIGURE D. Diagram of Yard Layout at Peachland.

STUDY PROCEDURES

Shift level monitoring of machine time and production occurred over a three-month period. In addition, detailed timing of the Hahn's working cycles was carried out to determine the machine's potential productivity. Log lengths were measured to determine the accuracy of bucking. More details of study procedures are available from FERIC on request.

STUDY RESULTS

Shift Level Monitoring

Table 1 presents the results of the shift level monitoring for the study period.

TABLE 1. Shift Level Monitoring Summary.

No. of shifts reported	49	
No. of shifts worked	48	
		hr/shift
Scheduled Machine Hours (SMH)	458.0	9.35
Productive Machine Hours (PMH)	386.25	7.90
Mechanical delay time - repair hours	61.50	1.25
- service hours	-	-
Non-mechanical delay time (hours)	10.25	0.20
CPPA Machine Availability	86.6%	
CPPA Machine Utilization	84.3%	
No. of off-highway truck loads processed	272	
Volume processed (based on average truck volume of 60.3 m^3)	16 410 m^3	
Average piece size, m^3	.38	
Average daily production	342 m^3	
Average number of truck loads processed	5.7	

Results show a 9.35 hr shift length which is explained by the fact that this is a contractor operation, not a company crew. No service time was recorded separately during the study. Servicing of the machine was often performed during the lunch period or during repair time, which explains the zero hours reported.

Productive time (PMH) includes the time spent limbing and bucking the full trees, and time spent moving, both while processing each pile and travelling from one pile to the next. It also includes minor delay times, such as waiting for loaders to clear debris and clear processed logs. These delays are normally expected to interrupt processing, but only for short intervals of time.

Shift level monitoring shows an average time for limbing and bucking each off-highway truck load at 1.39 hours (or 83 minutes). Average productivity based on these figures equals 43.3 m^3 per PMH.

Table 2 shows a breakdown of the repair hours by machine assembly, and gives number of repairs. Average time per repair was 1.8 hours, and average time between repairs equalled 13.5 scheduled hours or 11.4 productive machine hours.

Non-mechanical delays averaged only 12 minutes per shift.

TABLE 2. Summary of Repair Time.

Machine Assembly	Repair Time		Number of Repairs	Average Repair Time, hr
	hours	%		
Limbing head	14.45	23	8	1.8
Cable for limber head	14.05	23	7	2.0
Kick-off arm	11.70	19	3	3.9
Cut-off saw	5.00	8	4	1.2
Loader	2.25	4	4	0.6
Undercarriage	10.65	17	5	2.1
Hydraulics	3.40	6	3	1.1
	61.50	100	34	1.8

Detailed Timing Results

To determine the potential productivity of the Hahn, a sample of 12 off-highway loads was timed. Since the machine is operated by 2 men, one feeding full trees into the limber head, and the other controlling the processing, both activities were timed individually. From the timing, we can see which function determines the machine's output.

Table 3 gives the results of timing the feeding activity.

TABLE 3. Summary of Feeding Activity.

Activity	Time Per Truck Load		Time Per Tree
	minutes	%	minutes
Feeding	24.36	38.4	0.19
Assisting feed into limber	0.32	0.5	<0.01
Wait for limbing carriage	22.23	35.0	0.17
Move	1.58	2.5	0.01
Delays	14.97	23.6	0.12
Total loading time	63.46	100%	0.50

Assisting feed into limber occurred very infrequently. It is the time spent when the loader holds a tree while the limber carriage begins its processing cycle. It occurred when a tree was jammed in the pile and the loader had been unable to completely free it, and also for an occasional crooked tree which did not fit properly into the limber head. Delays include some mechanical downtime, but for the most part comprises the time spent transferring trees and logs which did not need processing from the full-tree piles to the opposite side of the machine. From here the loader would reclaim them for decking with the processed logs.

Table 4 summarises the times for the processing activities.

TABLE 4. Summary of Processing Activity.

Activity	Time Per Truck Load		Time Per Tree
	minutes	%	minutes
Delimbing and bucking	51.61	78.8	0.40
Waiting for trees	4.98	7.6	0.04
Delays (including moving, clearing debris, etc.)	8.91	13.6	0.07
Total processing time	65.50	100%	0.51

From Tables 3 and 4, we see that the loader spent much more time waiting to put trees into the limbing carriage than the limbing carriage spent waiting for trees. Therefore, the processing activity, i.e. delimbing and bucking, determines the production of the machine.

Average off-highway load volume was 62.4 m^3 (22 cunits). Using this volume and the average processing time per truck load from Table 4, potential productivity equals 57.2 m^3 per productive machine hour (PMH) (or 20 cunits per PMH). Assuming the same level of machine utilization from Table 1, potential productivity per 8-hr shift equals 386 m^3. To meet the required daily output (700 m^3) for the Peachland yard, the Hahn would have to operate for 12.25 productive machine hours each day. This would require 14.5 scheduled hours or 2 working shifts.

Using the average total time per tree from Table 4 gives a processing rate of 118 trees per PMH. From the potential productivity of 57.2 m^3 per PMH a rate of 150 trees per PMH is calculated. The apparent difference in rates (32 trees per PMH) is explained by the trees which do not need processing. These logs are transferred by the Hahn's loader from the full tree piles directly to the processed log piles. For the study period, 22% of the trees arriving at the yard required no further processing.

Comparing the potential productivity with the actual from the shift level monitoring, the Hahn is achieving almost 76% of its potential.

Bucking Quality

Crown Zellerbach's bucking requirements for the yard at Peachland are a 34 ft 8 in. log when possible, with top diameter not less than 3.5 inches. If trees are less than 52 feet (i.e. small pine), then the log is topped at 3½ inches. Quality control also required long butting to remove rot, root flare and damaged butts. Forked trees were normally topped at the fork, except where the fork was low enough to allow an extra log above it.

A sample of 90 logs was measured to determine the accuracy of the bucking. Only those trees bucked to produce two logs were used; those topped to remove forks were usually of random lengths and were excluded. Table 5 shows the results.

TABLE 5. Summary of Bucked Log Lengths.

Length	Tolerance	Number of Logs	% of Sample
34 ft 2 in.	-6 in.	0	-
34 ft 5 in.	-3 in.	1	1
34 ft 8 in.	0 in.	5	6
34 ft 11 in.	+3 in.	3	3
35 ft 2 in.	+6 in.	22	24
over 35 ft 2 in.	>+6 in.	59	66
		90	100%

A tolerance limit of ±6 inches was used to compare bucking accuracy with the company's allowance. None of the sample logs was more than 3 inches short of the desired length. Ten percent were within a tolerance of ±3 inches, and 34 percent were within a ±6 inch tolerance. The remaining 66 percent exceeded the +6 inch tolerance. The longest log measured 37 ft 8 in., or 36 inches longer than the desired length.

The Hahn was originally equipped with a roller device for measuring log lengths. At Peachland, this had been replaced with an electronic measuring device. Log lengths were more accurate, but it is desirable to improve the accuracy further to reduce the amount of extra trim and improve load volumes on the highway trucks. Assuming an average on-highway load of 100 trees, improving the bucking accuracy to the desired length would give about 2% more usable volume per truck load.

LIMBING QUALITY

Using the limbing quality standard described in Appendix II, the Hahn processed logs to class 1 standard. Figures C3 and C4 show the limbing quality achieved, which was considered excellent.

COMPARISON WITH OTHER HAHN TREE-LENGTH DELIMBERS IN B.C.

At the time of writing this report, there were 4 other Hahn Tree-Length Delimbers working in B.C. Two of these have been studied, one by the operating company and the other by FERIC briefly as part of a different project. Results from these 2 studies are compared with those for the machine at Peachland and the comparisons are presented below.

The first machine has been operating since 1978 in the southeast region of B.C., and for the most part in small pine stands, heavily infested with mountain pine beetle. It operated on landings with trees brought by skidders to the machine. This Hahn was run by two operators, and there was a front-end loader removing logs and debris. The user company conducted a shift level study* and carried out detailed timing to determine the machine's actual and potential performance. Results from this study are presented below.

Table 6 shows results from the shift level study with corresponding results for the Hahn at Peachland, taken from Table 1. Both machines had operated for similar lengths of time up to the dates of each study, which means that the comparison is not between an older and a more recent model of the Hahn.

The comparison shows that both machines are producing at almost equal rates. Both had similar total productive machine hours in the period of the studies. At Peachland, tree size was larger by one-third, but volumes produced do

*Murphy, D.G., 1979. Evaluation of a 'Hahn Harvester Full Tree De-Limb' in the Flathead Valley of Southeastern British Columbia. Unpublished Thesis, School of Forestry, Lakehead University, Thunder Bay, Ontario.

TABLE 6. Comparison of Shift-Level Results.

	Southeastern B.C.	Peachland
Days reported	65	49
Scheduled Machine Hours	559	458
Productive Machine Hours	375	386.25
Repair hours	99	61.5
Service hours	8	-
Non-mechanical delay hours	76	10.25
CPPA Machine availability	78%	87%
CPPA Machine utilization	67%	84%
Volume produced, m^3	15 260	16 410
Productivity, m^3/PMH	40.7	42.5
Volume per tree, m^3	0.3	0.4

not reflect the same difference. The Hahn at Peachland was processing fewer trees to achieve the volume, and obviously had slower cycle times per tree. A major difference between the 2 machines is shown by the repair hours and non-mechanical delay times, and therefore reflected in the different machine availabilities and utilizations.

The second machine used in these comparisons was working on Vancouver Island in small-sized old growth timber. The main species were balsam fir and hemlock, with some yellow cypress. The Hahn was operating in a sortyard, with full trees coming off-highway to the yard. Full trees were unloaded onto skid logs adjacent to the Hahn by a D-8 push Cat. Up to 4 off-highway loads could be placed on the skid logs to supply the Hahn. The push Cat would have to move the logs closer to the Hahn as processing continued (see Figure E). This Hahn was run by one operator, who controlled both the loader and the delimber from the main cab. Figure F shows this Hahn working at roadside on an earlier logging show.

Three days of detailed timing of the processing activities were made by FERIC in June 1981. The results are compared with results from the other two machines and are presented below in Table 7.

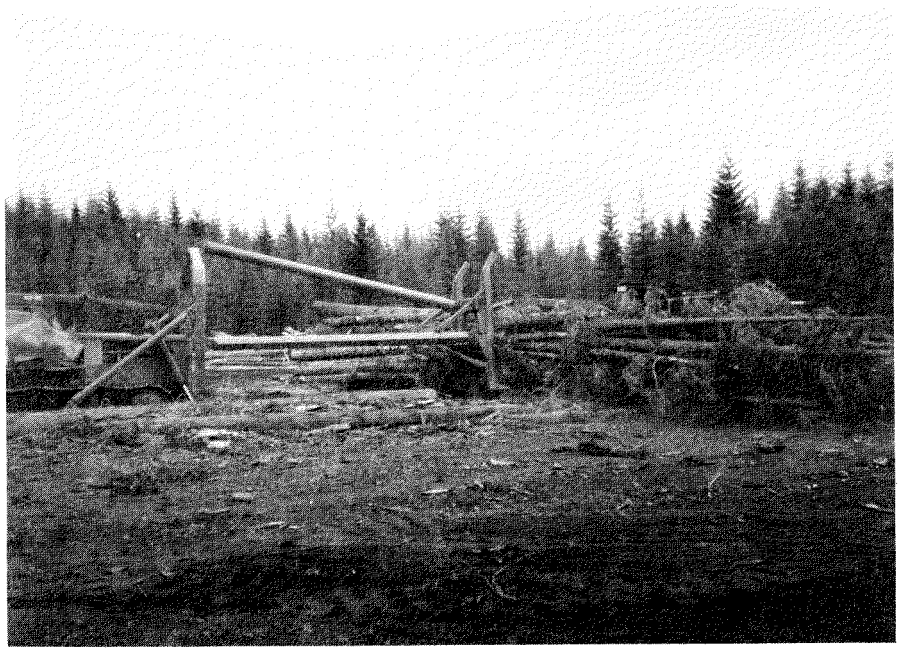

FIGURE E. Push Cat moving full trees on skid logs to the Hahn.

FIGURE F. Hahn Tree-Length Delimber working at roadside on Vancouver Island.

TABLE 7. Comparison of Detailed Timing Results for Processing Activities.

	Peachland Yard (2 operators)		Vancouver Island Yard (1 operator)		Southeastern B.C. Landing (2 operators)	
	min/tree	%	min/tree	%	min/tree	%
Processing	.40	79	.42	58	.31	65
Wait for tree	.04	7	.17	24	.06	14
Delays (incl. move)	.07	14	.12	18	.10	21
Total Time	.51	100	.71	100	.47	100
No. of trees timed	1,511		258		1,228	
Average tree size, m^3	.38		.49 (estimated)		.28	
Potential Productivity						
trees/PMH	118		85		128	
m^3/PMH	44.7		41.4		35.7	

These results show that the two machines working in the Interior of B.C. are similar in potential productivity based on trees per PMH. The effect of tree size is clearly shown. For the Hahn on Vancouver Island the effect of having only one operator is shown by the high wait-for-tree time. This represents the time spent operating the loader to grapple and load a tree before processing can commence. The disadvantage of having only one man is more than offset by the larger tree size. Tree size was estimated using an average butt diameter for the sample of 32 cm and a tree height of 15.2 m. (No loads into the Vancouver Island yard were scaled by weight or volume, as were the loads in the Interior.)

Using a second operator on the Hahn's loader increases potential productivity in trees per PMH by over 40% more than that for only one operator.

COST ESTIMATES

The machine costs presented below show a realistic range of costs that may be expected with the Hahn Tree-Length Delimber, in view of the uncertainties entering into some of the estimated values.

The total cost in dollars per m^3 for the Hahn is calculated by the equation used in previous FERIC reports on machine evaluations. Known cost values include:

Purchase price	: $200,000 f.o.b. Vancouver
Fuel & lubricants	: $10.00/PMH (incl. hydraulic fluid)
Operator's wage	: $15.00/SMH (incl. fringe benefits) per man
Depreciation period	: 4 years
Interest & insurance factor	: 0.20

Estimated values (based on western Canadian conditions) include:

	Favourable	Unfavourable
Residual value, $	20,000	20,000
Economic life of machine, SMH	16,000	12,000
Utilization, %	80%	60%
Maintenance cost (100% and 150% of fixed costs) $/SMH	17.88	35.74
Productivity (based on tree volumes of .5 m^3 and .3 m^3) - m^3/PMH	58.6	35.2
- cunits/PMH	20.7	12.4

Using the above values in the cost equation gives the following results:

	Favourable	Unfavourable
Total cost, $/PMH	92.20	159.28
Total cost, $/$m^3$	1.57	4.53
$/cunit	4.45	12.85

The calculations show that the Hahn can achieve acceptable processing costs when it operates at a high level of utilization with favourable tree sizes.

Compared to manual delimbing and bucking or flail delimbing with manual bucking, the Hahn provides safer working conditions, improved limbing quality and more accurate log lengths (with their effect on hauling costs and mill recovery). Under favourable conditions, expected costs are comparable to those for manual and flail delimbing--estimated to be in the range of $3.50 to $5.00.

Calculating an expected favourable cost for a Hahn with only one operator, and the 40 percent reduction in productivity as mentioned earlier, gives a total cost of $1.75 per m^3 ($4.96 per cunit). This is again comparable to manual or

flail costs, and only slightly more expensive than for a 2-man crew. In this set-up, the need for favourable operation is very important.

DISCUSSION

The main objective behind introducing the Hahn Tree-Length Delimber into the central processing yard at Peachland was a reduction in loader time. FERIC's earlier study* of central processing yard versus conventional logging reported that in winter 2 Cat 966C front-end loaders handled a daily volume of 820 m^3, but in summer there were 3 loaders handling 575 m^3 through the yard. At that time, delimbing was done by chain flails, with manual bucking and topping. The report states:

> "The portion of the loader activity attributed to processing in the C.P.Y. System increased from 48% in the winter to 59% in the summer. The per-volume cost was double in the summer, however, because the total number of hours was greater. This increase was due to a reduced volume throughput and increased debris handling."

Loader costs were given as $1.36 per m^3 in winter and $2.16 per m^3 in summer, and around 50% of these costs related to the processing activities of the loaders.

By modifying the processing method to a mechanized system, this phase of loader activity would be greatly reduced. During the study of the Hahn, there were 2 front-end loaders working in the yard. These 2 machines performed all the necessary functions to maintain the daily volume processed in the yard. As the Hahn was not processing the total volume of 700 m^3, flail delimbing and manual bucking still occurred. One of the loaders spent time spreading loads for this and decking the processed logs, in addition to the unloading of off-highway trucks and loading of highway trucks.

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*Hedin, I.B., 1980. Comparison of Two Logging Systems in Interior British Columbia: Central Processing Yard vs Conventional. Forest Engineering Research Institute of Canada (FERIC) Technical Report No. TR-45.

To date, the company feels that it has succeeded in reducing loader time by introducing a Hahn. In changing from flail delimbing, they feel that the quality of chips produced from trim material at the mill has improved. The quality of log entering the mill has improved through better delimbing quality and more accurate log lengths. They also feel that it is now a safer operation, with the workers in the machine cabs.

Since the study, the logging contractor has purchased a second Hahn Tree-Length Delimber. It commenced work in June. The 2 units are able to process the required daily volume. The crew on the second machine is still gaining experience and production should increase to the same level as the first unit.

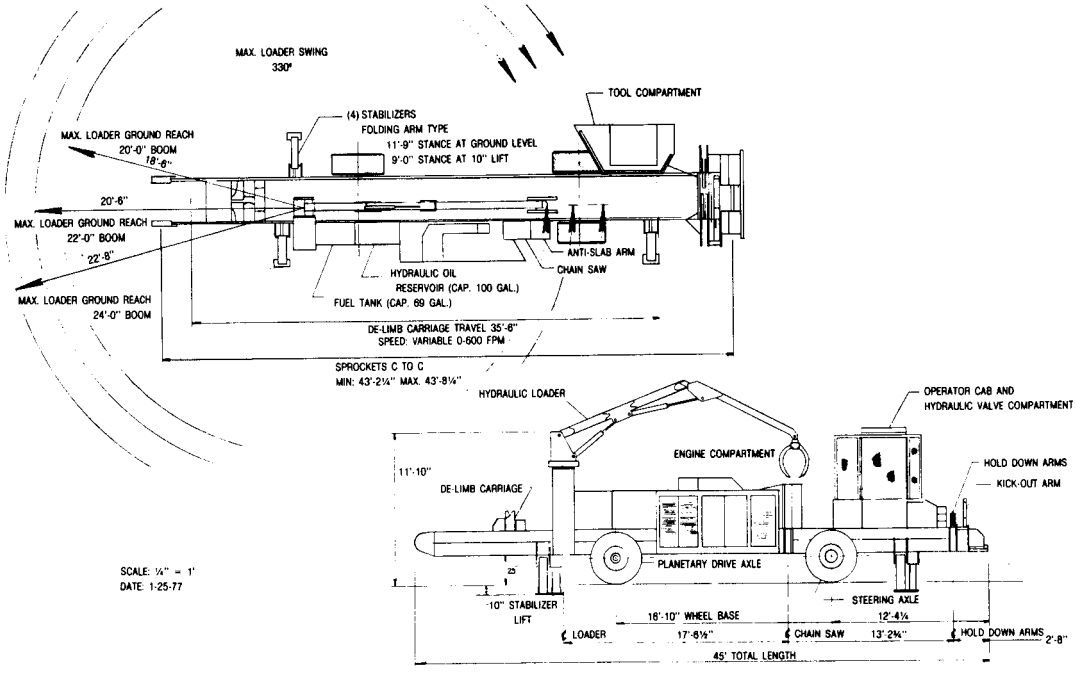
The machine studied showed an acceptable level of availability and utilization. Its production increased over the period of shift-level monitoring showing an increase in operator proficiency as experience increased. The level reached at the end of monitoring represented a very acceptable volume under the prevailing conditions. The ability to process more than one tree at a time for the smaller tree sizes was demonstrated. The machine does show the normal sensitivity to tree size. For effective delimbing and bucking of small trees, development of a multi-stem processor is needed.

CONCLUSIONS

Introducing a Hahn Tree-Length Delimber into its central processing yard at Peachland allowed the user company to achieve its objective of reduced loader time, and therefore a reduction in loader costs. The machine displayed a high level of machine availability (87%) and utilization (84%). Production averaged 5.7 off-highway truck loads per day (342 m^3), and showed an increase throughout the study up to 7 loads per day (420 m^3). During the study, 22% of the trees arriving at the yard did not require limbing and bucking by the Hahn. In order to process the yard's daily volume, either a second shift was necessary or the addition of a second unit. The latter has occurred and the daily volume is now mechanically processed. Secondary benefits of improved log quality and worker safety have also been realized.

The number of Hahn Tree-Length Delimbers in use in B.C. has grown, and its ability to handle small size coastal timber as well as Interior wood has been demonstrated.

APPENDIX I: MANUFACTURER'S SPECIFICATIONS



SPECIFICATIONS

BASIC MACHINE
Weight: 44,500 lbs. Width: 10'-0"
Height: 12'-5" Length: 45'-0"

ENGINE
GM 4-71 Diesel, 160 hp at 2,100 rpm

AXLES
Drive: Franklin, no-spin planetary, hydraulically propelled
Steering: Hydraulically actuated

LOADER
Hahn 793. external gear turn-table bearing, hydraulic motor swing.
Lift capacity: 15,200 lbs. @ 5 feet,
3,300 lbs. @ 20 feet.
Electro-Hydraulic joy stick controls.
Continuous rotate grapple.

DELIMB
17,000 lbs. force @ 600 feet per minute

CARRIAGE DRIVE
Hydro Static

BRAKES
Drive line mounted hydraulic disc caliper with brake lock for park.
Power assist disc brakes on drive wheels.

TIRES
17.5 x 25 Traction Tread

OPERATOR CAB
Fully insulated with heater/defroster

STANDARD ACCESSORIES
Hydraulic operated chain saw
Light package group
Fixed heel on loader
Low oil level warning system
Anti-slab arm

OPTIONS
Additional control station for loader operator
Electronic log length measuring system

The Hahn patented delimb carriage ensures positive delimbing down to four-inch diameter.

In keeping with Hahn Machinery's policy of continuous product improvement, all specifications are subject to change without prior notice.

Manufactured by
HAHN MACHINERY, INC.

APPENDIX II

LIMBING QUALITY GUIDE

In order to assess the quality of delimbing full trees mechanically or manually, some standards are needed. A visual assessment of quality offers the best potential for fast effective examination. Some differentiation by classes is necessary, in order for effective comparisons between machines and methods. The four classes given below are derived from an earlier PAPRICAN study* which evaluated a delimbing machine which processed a whole skidder turn at one pass. Their use in appraising the quality of delimbing is recommended by FERIC, and will be used in future studies of delimbers.

Description of Quality of Limbing Classes 1 to 4

Quality of Limbing Class	Description
1	No branches and branch stubs left on trees or logs.
2	A few branches and branch stubs left on trees or logs but no additional manual limbing is necessary.
3	About 50% of the trees or logs have some branches remaining. Additional manual limbing may be necessary.
4	Nearly all the trees or logs have some branches remaining. Bushy appearance. Additional manual limbing definitely necessary.

*Heidersdorf, E., 1973. Evaluation of New Logging Machines: Morard Delimber. Pulp & Paper Research Institute of Canada, Logging Research Report LRR 52.