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Delimbing: Problems and prospects

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Delimbing
problems and prospects

by **MICHAEL P. FOLKEMA**

DURING THE LAST few years there has been a great deal of interest in mechanized delimbing in the Canadian forest industry. Many new ideas to mechanically delimb trees have been developed and applied to Canadian logging conditions. Some of these concepts have failed in the process of converting the idea into hardware. Other ideas have been at least partially successful, perhaps succeeding in one location but not in another.

The current interest in mechanical delimbing is not a new phenomenon. Rather, it is increased concern about an old problem, that of branch removal. It is the result of changes in harvesting equipment and systems, labor supply, and management and worker attitudes. It manifests itself in an increased willingness or desire by logging companies to introduce or extend the use of mechanical delimbers on their operations.

The status of mechanized delimbing in Eastern Canada is outlined in this report. Also discussed are the limitations of conventional delimbing using manually-applied chain saws, the trend towards full tree systems, and the problems and challenges that varied delimbing quality standards pose to both the logger and to the equipment manufacturer. The achievements and shortcomings of earlier and present day delimbing equipment are reviewed by classifying them into various categories. In the final section some features of an "ideal" delimber, suitable for many Eastern Canadian operations, are listed.

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Chain saw delimbing still predominates

During the past two decades the predominant delimbing method in Canada has been the manually-applied chain saw. Prior to that, axes were used. Today, in Eastern Canada, 70% of all trees harvested are delimbed by chain saw; the remaining 30% are mechanically delimbed. In most cases chain saw delimbing and topping is carried out at the stump, though in some cases a portion is done at roadside or at the landing.

Using chain saws permits high quality standards since the limbs can be trimmed flush to the tree. The cost ranges from 15% to 50%, but averages 30% of the direct logging costs for tree-lengths at roadside, depending on branchiness, species, tree size and other factors. For typical Eastern Canadian conditions where the average tree size is 0.2 m^3 (6 ft^3) the direct logging cost for chain saw delimbing is about \$2.10/m^3 (\$6.00/ct). For companies harvesting smaller or more branchy trees the cost of chain saw delimbing will likely be higher.

(Direct logging costs include all fixed, operating, maintenance and repair costs, but with no allowance for engineering, roads, supervision, overhead or profit).

There are many reasons why logging companies are interested in mechanized delimbing. For many the interest stems from a desire to overcome the disadvantages of chain saw delimbing. Reducing the cost is often not an important factor.

The disadvantages of chain saw delimbing are well known: Chain saw delimbing is a very labor intensive activity.

Also, many logging companies have an unstable labor supply. By mechanizing their delimbing phase, these com-

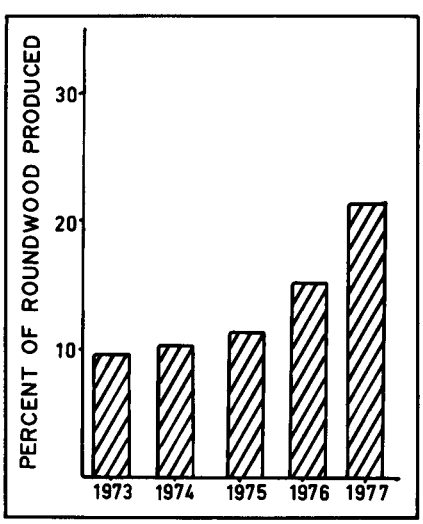


Fig. 1. Proportion logged by full tree system.

panies can increase their man-day productivity, and thereby reduce their dependence on the fluctuating labor supply. Other disadvantages of chain saw delimbing include the high incidence of chain saw related accidents, the so called "white finger" disease, plus the fact that it is often difficult, or unpreferred work.

Although the tree-length method is the predominant one used in Eastern Canada today, there is a definite trend towards the full tree system. Recent CPPA data indicate that the portion of wood harvested by the full tree system has increased from 10% in 1973 to 22% in 1977.

Possible disadvantages of full tree logging include the silvicultural implications of slash deposited at roadside, since this may mean a reduction in the amount of nutrients and in the amount of seed or cone dispersal. It is expected however that problem sites will be identified and that the use of the full tree system will continue to increase in the years ahead.

Some machines used in full tree systems include large capacity forwarders (e.g., Koehring Feller-Forwarder), clam bunk skidders, grapple skidders and new innovations such as the A-Line Swather. Many of these machines can offer lower overall logging costs if the trees can be effectively delimbed. Since chain saw delimbing of full tree piles is virtually impossible, mechanical delimbing is the only alternative. It is also interesting to note that several prototype delimbers, which will be discussed later, have been developed specifically to delimb full tree piles at roadside.

Lower standards set for delimbing quality

Although most pulpmill and sawmill managers prefer to use trees that have all the limbs trimmed flush to the stem, there is a definite trend at some mills to reduce delimbing quality requirements.

There are many factors that influence the quality of delimbing required. These factors include transportation requirements, the type of conversion plant and the product it produces, plus the type of conveying, debarking and debris disposal equipment at the mill. Sometimes, by altering one of these factors a lower quality of delimbing (done at a lower cost) can be permitted in the harvesting area.

It is necessary to point out that delimbing standards in Canada vary greatly, not only from one geographic area to another, but also from one company to another. This occasionally creates problems particularly on multi-product operations where both pulpwood and sawlogs are produced. The pulpwood may be acceptable with only "rough" delimbing. However the sawlogs must be trimmed flush with branch stubs less than 1 cm.

This variation in delimbing standards presents even greater problems to the manufacturers than to the loggers, since it is the manufacturers who must design equipment that meets the industry's minimum delimbing standards, production requirements and costs. Partly as a result of the variation in delimbing standards many new delimbers have come onto the market during the last 10 years. It is evident that no single machine will be suitable in all conditions and for all delimbing standards.

Literature review

Before going on to discuss the various types of delimbers that have been developed it is useful to review the past accomplishments in mechanized delimbing, as summarized from several earlier reports. This information, which is also summarized in Gordon's report [1] is helpful in understanding the wide variety of delimbing devices available today. J.D. Dunfield of the Forest Management Institute, in his 1971 report on delimbing [2], outlined 76 different machines and concepts. He reported that the most popular delimbing principle used (approximately half) was the stripping concept with wrap-around knives.

Another report [3] by D. Myhrman of Skogsarbeten, Sweden (1970) discussed 30 different delimbing devices. This report also concluded that the wrap-around knife (or knife-belt) was the most common delimbing tool. The report predicted that the use of rotary knife cutters, such as those used on the Sund Limbing Station (Sw) and the Arbomatic Processor (Can) would decrease, and that the use of (spiked) feed rollers for tree feeding would increase. This report also noted that:

- Maximum tree stem diameters varied from 33 cm to 76 cm with 51 cm to 64 cm being the most common.
- Feed forces with wrap-around knives or belts varied from 2000 kg to 9000 kg, the most common values being 3000 to 5000 kg.
- Maximum branch diameter capacity varied from 5 cm to 13 cm, the most common being from 7.5 cm to 10 cm.
- Feed speed varied between 1 and 3 m/s per second, usually around two metres per second.

A third report, published by the American Pulpwood Association in

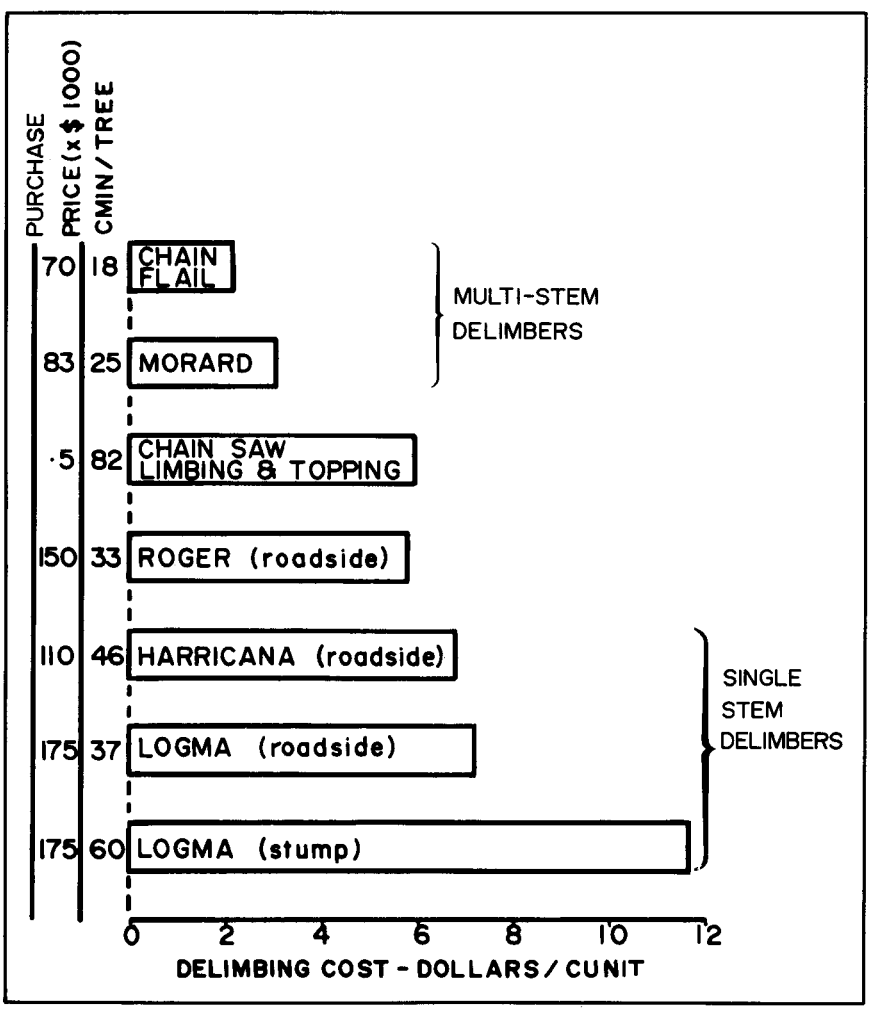
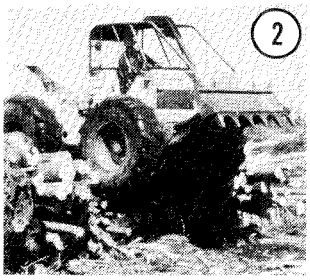
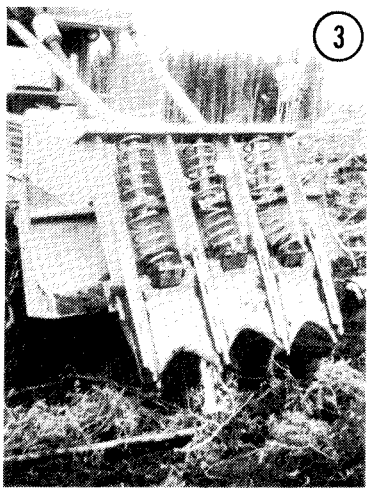
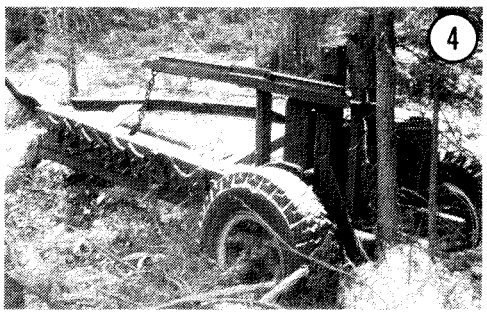


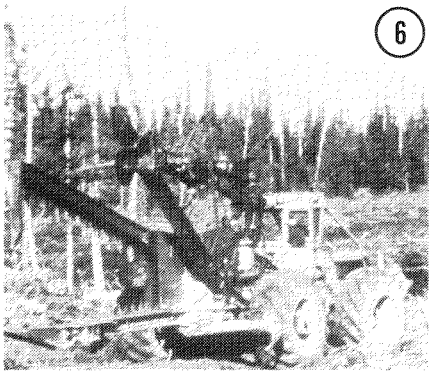
Fig. 2. Comparison of delimbing costs.

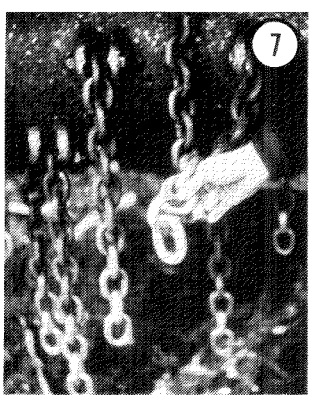
Multi-stem delimbers

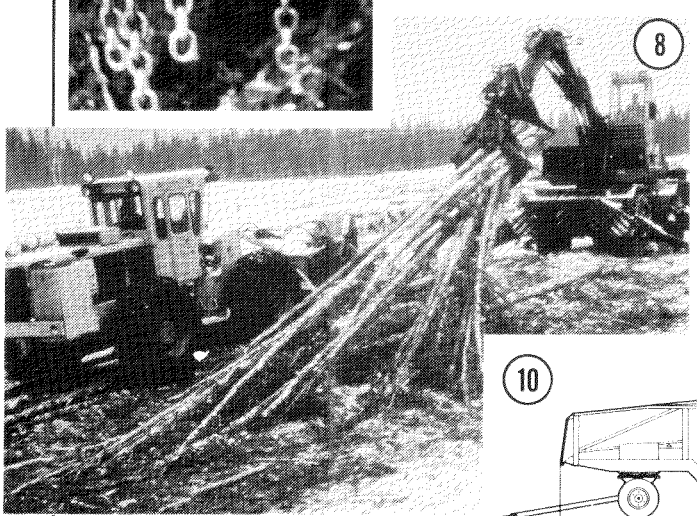


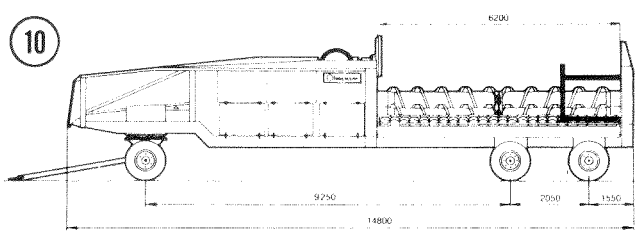


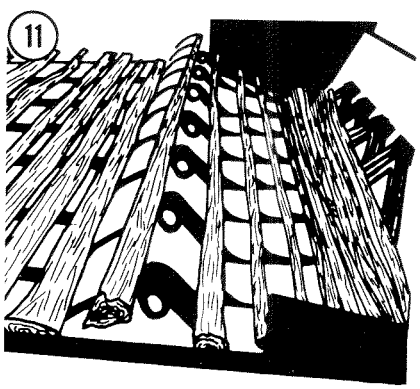












1. Skidder blade
2. Grooved skidder blade
3. Laberge delimbing attachment
4. Matakainen delimber
5. Whale delimber
6. Morard delimber
7. Chain flail
8. Hydro-Ax 500 – Tanguay 14030 delimbing system
9. Nesco-GLFP boom-mounted flail
10. Scruven delimber
11. Bear pit delimber

1973 [4] categorized over 100 delimbing devices for the period 1960-1973 and discussed specifically the following aspects of machine delimbing:

- Where delimbing occurs
- Tree and tool relationship
- Tool's action on tree
- Tree position during delimbing
- Single or multi-stage delimbing
- Single stem or multi-stem
- Product length
- Direction of the delimbing on the tree stem.

In 1976, L.W. Johnson of FERIC reported that the chain flail delimber [5] met three basic Canadian requirements:

- Multi-stem delimbing
- High production capacity
- Low capital investment.

Further work reported by Skogsarbeten [6] in 1976 was aimed at identifying the most effective delimbing components for mounting on logging machines currently under development. It concluded that (for Sweden) the most economical limbing solution is fixed knives with roller feeding.

Review of delimber types

In this section of the report, mechanical delimbers are placed into broad categories and are discussed in regard to their achievements and shortcomings. Since the categories are arbitrary in nature there may be some delimbers that do not fit neatly into one of the categories listed. The delimbers are divided into two large groups, multi-stem and single-stem, each of which is divided into a number of sub-groups.

For this paper, single-stem delimbers are defined as "delimbers that normally delimb only one medium size tree at one time." It is acknowledged that some single-stem delimbers can occasionally delimb two or more trees at once. However, this is usually only possible in smaller trees with similar size and length characteristics, which allow joint topping.

The review which follows is primarily limited to a comparison of machine function. To provide a means of comparing the production and direct logging costs of these delimbers, several examples are presented in Fig. 2.

The comparison is based on the method used in Boyd and Novak's earlier report on comparing machine systems [7]. It uses "Industry Average Performance" production as a means for comparison and is based on an average tree size of 0.2 m^3 and an operator wage-fringe benefit package of $12.00 per scheduled machine hour. It should be recognized that the use of the chain flail and Morard delimber may result in "rough" delimbing. The cost of additional trimming with chain saws is not included. Also not included are the costs of logistics delays to other phases of the operation, for example delays in skidding or extra travelling distance for skidders.

Multi-stem delimbers

(a) Rake type

Rake type delimbers use a scraping action to break off the limbs. They normally perform "rough" delimbing where some branches or branch stubs remain. These remaining branches are often removed with a chain saw. Most rake-type delimbers also require chain saw topping. If several or more skidder crews are serviced by one rake delimber, delays due to waiting and increased travelling distance for the skidders can be a problem.

There are two main types of rake delimbers. The first consists of some type of blade device, usually mounted on a skidder, to scrape off the limbs. The simplest and most common example is the ordinary skidder blade. On many operations, particularly in winter, skidder operators perform "rough" delimbing by running the blade along the length of the trees.

An obvious improvement is to equip the blade with grooves, to allow it to conform to the shape of the tree stems and to delimb some of the side branches. A further improvement is incorporated into the Laberge delimber. This delimber is actually an attachment that mounts onto the skidder blade. It has moveable spring-loaded limbing blades which permit them to conform to the shape of trees. This is an advantage, particularly if there is variation in tree size within each bunch of trees. Some touch-up work with a chain saw is usually required when delimbing with the Laberge unit.

The second type of rake delimber requires two machines: a skidder and a delimber. Usually the skidder pulls or winches the trees between two raker arms. The raker arms break or cut off the branches as the tree bunch is pulled through the delimber.

An example is the prototype Matakainen delimber developed near Chapleau, Ont. This unit features rotating delimbing discs to spread the trees for better delimbing. The Whale, another prototype rake delimber, developed near Timmins, Ont, uses the forward motion of the trees, a sprocket drive, and a clutching mechanism to force down the upper limbing arm for delimbing. A third, and more costly unit, is the Morard Limber, a production machine developed in north central Ontario in the early 1970s. The delimber jaws and a track-mounted, circular topping saw are mounted on a rubber-tired carrier.

Another concept, popular in the U.S. south (but not in Canada), is the Gate delimber, which consists simply of a rectangular steel frame 4 m wide and 1½ m high, with criss-crossed lengths welded within the frame. The skidder operator simply backs the skidder load through the frame, thereby breaking off the limbs.

(b) Chain flail type

The chain flail delimber is basically a drum to which are attached lengths of chain. The drum is rotated at approximately 400 rpm, and when moved over fallen trees the chains beat the limbs off the stems. Chain flails have the potential to maintain a high level of productivity since they can process several trees simultaneously.

The main problem with the chain flail on many operations is the low quality of delimbing which results, particularly during the summer operating season. On some operations chain saws can be used for additional trimming, but on others this practice may not be practical or economical. Other problems with chain flails include logistics and supervisory problems, particularly if the flail is servicing a series of landings. The life of a set of chain is usually 15 to 45 operating hours with a cost of $300 to $400 per set. However, on some operations a much longer chain life is reported.

The most common method of using the chain flail is to have it work on one, or several adjacent roadside landings. The full trees are spread out in a single layer, with a front-end loader being used to pile the trees or load them into waiting trucks. Several new methods are also being used. In Quebec, FERIC is monitoring the trial of a delimbing system which uses a Tanguay 14030 loader and a Hydro Ax 500 flail to delimb roadside piles of full trees deposited by the Koehring Feller-Forwarder.

FERIC is also involved in the development and evaluation of the Great Lakes Forest Products/Nesco boom-mounted chain flail.

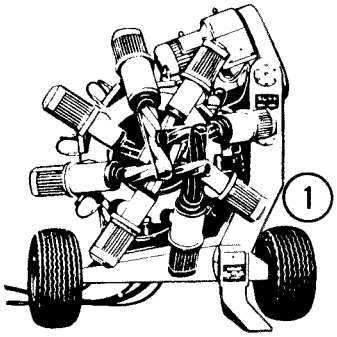
(c) Others

Several other bunch delimbers not generally known in Canada can be included in this category. These include the Swedish machine "Scruven," a production machine of which 10 units were built; the Russian "Bear Pit" type of delimbers: and the Swedish prototype delimbers "Drum" [8] and "Cradle" [8] (1972). Most of these delimbers are considered to be stationary units.

Single-stem delimbers

Single-stem delimbers can be divided into two broad categories; those having "indirect" drive and those with "direct" drive. "Indirect" drive is a

Single-stem delimbers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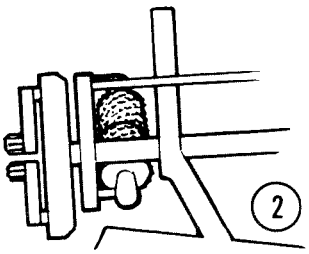
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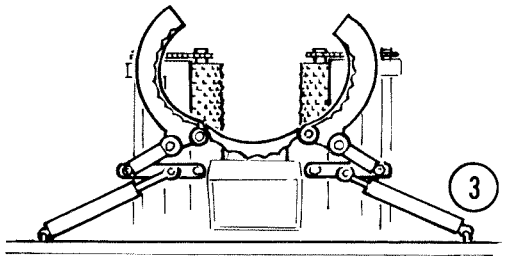
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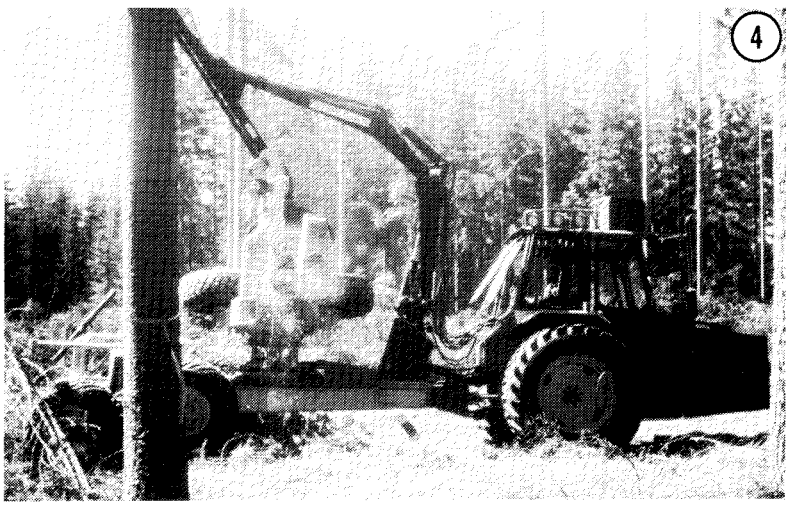
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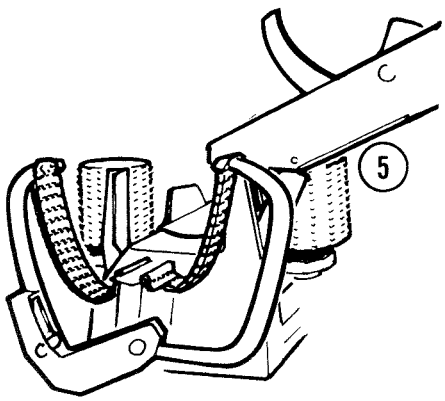
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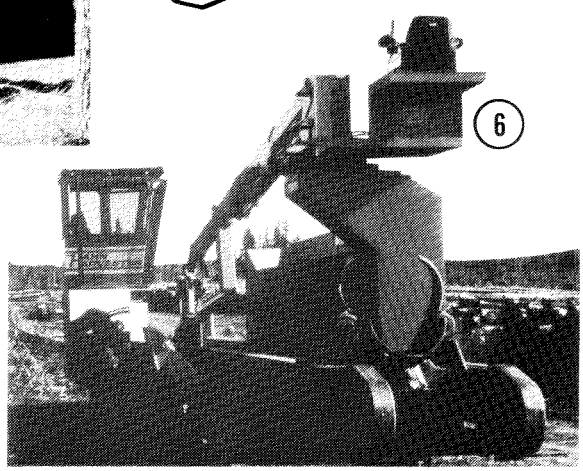
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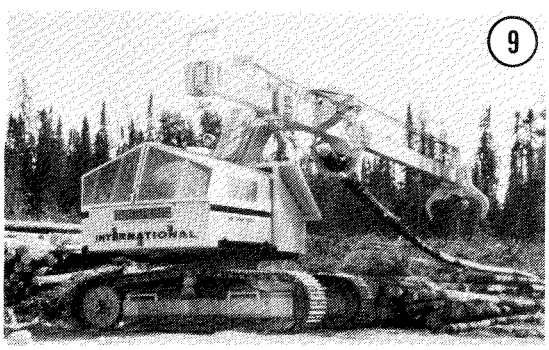
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1. Sund limbing station
2. LRA Arbomatic processor
3. Wrap-around knives — roller feeding
4. Tire-type feed rolls — Rottne processor
5. Wrap-around knife belt — roller feeding
6. Hahn harvester
7. Logma T-310
8. Roger delimber
9. Harricana delimber

word used to describe delimbers that use some type of feed roller to drive the tree through the delimbing unit (which is usually stationary). In contrast, "direct" drive delimbers are those units which (normally) hold the tree in a stationary position while the delimbing knives travel along the length of the stem. Categories (a), (b) and (c) have "indirect" drive devices while category (d) has "direct" drive devices.

(a) Rotary knives or cutters — roller feeding

Rotary knives or cutters can be used for delimbing, and can be found on some older machines. This method is seldom used today due to high maintenance costs and low productivity. Examples are the Sund Limbing Station (1965) and the LRA Arbomatic Processor (1968).

(b) Wrap-around knives — roller feeding

The feed rollers, which are usually hydraulically driven, pull the tree through a set of delimbing knives. The delimber knives are usually comprised of one fixed and two moveable knives.

This type of delimber is very common, particularly on multi-function machines. Although popular, problems can arise with this type of delimber when removing large branches or heavy whorls of branches. The rollers may stop due to insufficient power, but more commonly the rollers may "spin-out" due to insufficient grip on the tree stem. "Spin-out" usually causes wood damage as well as processing delays.

Examples of wrap-around knives with roller feeding on multifunction machines are the Timmins-Fel-Del harvester and the John Deere 743 tree harvester. Sometimes wrap-around knives with roller feeding are also used on single function machines. An example is the Timmins roadside delimber.

In Scandinavia, concern about spike damage and blue stain damage in lumber has prompted the development of rubber tire-type drive rolls. Several machines such as the Rottne processor and the Lokomo 961 harvester are now available with the new drive rolls.

(c) Wrap-around knife belt — roller feeding

Flexible wrap-around knife belts with roller feeding are used on some logging machines. Some problems with knife belts are similar to those listed for (b) "Wrap-around knives". Also, wrap-around knife belts have problems in removing large limbs, due in part to the friction caused by the wrap-around action of the belts. An example of this type is the OSA 705 processor.

(d) Direct-drive delimbers

Direct-drive delimbers usually hold the tree in a stationary position while the delimbing knives travel along the length of the tree stem. Normally they employ a grapple device along with a winch cable or sprocket drive.

Direct-drive feed mechanisms are potentially suitable for the most difficult delimbing conditions since the tree stem can be firmly gripped with none of the slippage or "spin-out" that characterizes spiked feed roll drive mechanisms. A second reason for good performance in large limbs can often be attributed to the "axe effect". The weight of the sliding boom or carriage is often much higher than that of the tree being delimbed. Thus, the inertia element of the delimbing force can be much higher than that for feed roller-type delimbers. Direct drive feed mechanisms are particularly useful on processing machines which utilize a stop-start delimbing action to produce shortwood.

Examples of direct-drive delimbers using a winch cable on multi-function machines include the Beloit harvester and the Timberjack RW-30. An example of a winch cable drive on a single-function machine is the Hahn Tree-length Harvester. Another example is the Logma T-310 which uses a telescopic boom action, produced by steel cables and a hydraulic winch, to delimb.

The recently developed Roger and Harricana delimbers are examples of direct-drive delimbers which utilize a hydraulic motor with a sprocket drive to extend the boom for delimbing.

An "ideal" delimber?

FERIC's involvement in delimbing has permitted discussions with operating personnel about desirable features that could possibly be incorporated into an "ideal" delimber. It is recognized that it is unlikely that a delimber could be built to include all the features listed below, particularly since tree characteristics, mill acceptance standards and other factors vary widely. So in one way this title may seem somewhat pretentious. However, the list may serve as a starting point for discussions on the merits of both existing and future delimbing machines.

The features include:

1. multi-stem delimbing — is preferred — due to high productivity. (However, it may be difficult to include this feature with other features listed below.)
2. the delimber should produce minimal interference with other phases of the logging operation; *i.e.,* felling, skidding, loading onto trucks.
3. it should be simple in design, so that the average bush mechanic can carry out all necessary repairs.
4. it should be an attachment. The base machine should be readily convertible to perform other jobs, if required. This requirement is particularly important on contractor operations.
5. it should be designed to handle stems primarily in the 0.12 to 0.3 m^3 tree size, since delimbing costs are highest for small trees.
6. it should remove large branches and branch clusters cleanly and without difficulty.
7. the delimber should have a low capital cost.

The job of designing delimbers that will incorporate some or all of the features listed above belongs to the equipment manufacturers. In spite of the difficulties involved I am sure that substantial progress will yet be made. Within the logging industry there exists a great deal of ingenuity. Putting that ingenuity to work to solve our delimbing problems should prove to be an interesting challenge.

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Résumé. Notre rapport examine la situation actuelle de l'ébranchage mécanique des arbres dans l'Est du Canada. Après avoir abordé les facteurs qui déterminent la nécessité d'ébrancheuses mécaniques et leur utilisation, nous parlerons des succès et des échecs du matérial d'ébranchage jusqu'à aujourd'hui et mentionnerons quelques caractéristiques d'une ébrancheuse "idéale", convenant à de nombreuses situations dans l'Est canadien.

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