LOGGING INDUSTRY RESEARCH ASSOCIATION

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REPORT ON STUDY TOUR TO NORTH AMERICA AND EUROPE

September, October, November, 1977.

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P.R.5 1978

N.Z. LOGGING INDUSTRY RESEARCH ASSOCIATION (INC.)

P.O. Box 147 Rotorua New Zealand

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- A C K N O W L E D G E M E N T S -

This visit was made possible by a grant to LIRA specifically for this purpose by the New Zealand Forest Owners' Association. LIRA is grateful for the opportunity thus offered at a critical stage in its development to examine logging research administration and up-date on techniques.

Without the assistance of a variety of overseas people who arranged internal itineraries and contacts, and allocated considerable time to explaining the functioning of their organisations, the tour would not have been successful. The author is indebted to many, but particularly to the personnel of Skogsarbeten and Skogshogskolan in Sweden, Metsateho in Finland, the Norwegian F.R.I., the Austrian Logging Training School, FERIC in Canada and the American Pulpwood Association, Oregon State University and various U.S.D.A. Forest Service research groups in the U.S. for their assistance in achieving his objectives.

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INTRODUCTION

This report has been prepared in four parts.

PART I. Outlines the objectives of the study tour and comments on the structure of the organisations visited. A brief summary of the factors affecting the logging industries in the countries visited is included.

PART II. Is prepared primarily for the Executive and Board of LIRA. It comments on the management of Logging Research and presents recommendations on LIRA for consideration. *(Part II is not published as part of P.R.5.)*

PART III. Presents brief notes on Logging Research project areas and the operations visited. This is primarily intended to draw to the attention of N.Z's logging industry items seen and their relevance to N.Z. Further information and reference material on most subjects covered is held by LIRA for the use of its members.

PART IV. Summary and Conclusions.

PART I

OBJECTIVES, ORGANISATIONS, AND REGIONS VISITED

1.1 THE OBJECTIVES OF THE STUDY TOUR WERE:

1. Primarily to examine harvesting research techniques and administration, and secondary to this to up-date on current logging practices and machinery in North America and Europe.
2. To examine the facilities and equipment for conducting research into harvesting in the field and the methods for encouraging industry involvement and participation. In particular, to examine steps in extension taken to ensure research findings are implemented.
3. To investigate progress and techniques in carrying out current projects and the relevance of such work to LIRA's proposed programme. Through this, to establish exchange of information on projects and seek cooperation of specific projects.
4. To establish the personal contacts necessary to facilitate exchange of information generally.

1.2 ORGANISATIONS VISITED:

The logging research organisations visited were considered to be the key institutions of North America and Scandinavia who published in English or presented English summaries of their work and with whom future exchange of information would be important and relatively simple.

All the known industry funded research organisations were visited as well as many of the Government or University institutions who carried out significant work in tree harvesting research. It was not possible to visit all the latter two groups, particularly in North America.

Some field operations, logging and manufacturing companies were also visited and are listed in Appendix I. As limited time was available for field visits, these primarily concentrated on cable logging and processing machines - priority areas for LIRA and for this reason Austria was included in the itinerary.

Brief details on the structure and objectives of the Logging research organisations visited are described. More complete information on programmes and projects is held in LIRA's library for the use of its members.

1.2.1 GROUP I - INDUSTRY FUNDED LOGGING RESEARCH ORGANISATIONS:

These included those wholly or partially funded by industry and subject to some industry direction.

(a) The American Pulpwood Association, U.S.A.

A.P.A's primary objective is to promote the best interests of the pulpwood industry in the U.S. by encouraging good forest management practices and efficient timber harvesting. It promotes research projects, collects and documents statistical data and technical reports, and cooperates with agencies in fostering improved practice, research and utilisation.

It is entirely industry funded by levies on the amount of wood consumed or handled. It has three classes of membership - consumers, suppliers, and associates, and is controlled by a Board of Directors elected from industry members in six regions.

Headquarters is Washington D.C. with three field officers in the main regions. Total staff is approximately 17.

Technical programmes are conducted by members with A.P.A. acting in a coordinating role and research is sponsored through specific projects generally funded by groups of interested members on a "special project" basis. Its "Technical Releases" aim to advise members as rapidly as possible on new developments.

A.P.A's strength lies in a practical "grass roots" approach to servicing its members through simple practical extension services offering technical, statistical and educative material and some direct assistance on development projects.

(b) L.S.U./M.S.U. Logging & Forestry Operations Centre, U.S.A.

The southern divisions of A.P.A. provide the financial support and the Louisiana and Mississippi State Universities the technical support for this centre whose objective is to provide training, education and research information to the industry.

The centre's activities are guided by an advisory committee made up of representatives from member companies from wood-using industries.

L.S.U./M.S.U. conducts short courses, workshops and seminars on both logging and forestry and promotes short term research projects with graduate students. It assists member companies in research planning and coordination.

It has a permanent staff of two located at Bay St. Louis, Mississippi.

Financing is based on annual assessment of production and consumption by member companies. Courses are in the main self-supporting by charging course participants (a differential rate exists for members).

(c) Forest Engineering Research Institute of Canada.

FERIC conducts research and development aimed at improving the efficiency of wood harvesting operations and at minimising the cost of wood used in the manufacture of forest products.

FERIC is managed by a Board of 16 Directors, 12 of whom are elected by members, members being corporations, organisations or individuals, engaged in the harvesting or transportation of wood.

The budget, initially $2.0 million dollars per annum, is provided equally by Federal Government and Industry, members being levied on total wood fibre content of their pulp and/or wood products.

Headquarters and Eastern Region Branch Office are at Pointe Claire (suburban Montreal) Quebec and a Western Region Office is in Vancouver, B.C. Strength in each division is about 20, of whom 12 are scientists.

The Eastern division's programme aims at innovative mechanical research to offset the high wood costs due to small trees, long distances to mills, and difficulties in labour procurement. High speed harvesting machines, multiple tree handling, full tree systems and transportation systems are areas currently being investigated. A joint project with the Pulp and Paper Research Institute of Canada on bark/chip segregation is nearing completion.

The Western division's programme has probably more immediate relevance to New Zealand, much of the technical work being based on operations on steeper slopes and with bigger trees. Investigations on mechanical felling and cable hauling and a comparative analysis of cable and aerial systems are being undertaken. Work on cables has indicated that more work on personnel and management influences on productivity are necessary.

(d) Skogsarbeten - Logging Research Foundation, Sweden.

Swedish industry's common body for technical and economic research and development in the field of logging, transportation and silviculture, Skogsarbeten is funded by the Forest and Agricultural Employer's Association, the Forest Owners' associations, the Forest Service, and by Government. It also has earnings from its extension services and contract research.

It is managed by a Board of 22, representing the various interested parties in relation to their financial support, who appoint 7 of their members to act as an executive committee with the Director. It has (1977) a staff of 64, 37 of whom are professional, 20 with Forestry degrees and 4 Engineering. Its Headquarters are located in Stockholm.

Skogsarbeten's research programme identifies as major project areas; Logging 26%, Silviculture 21%, Human environment 18%, Planning

14% and Transport 10% for its research project budget.

In the logging area, thinning and whole tree utilisation are currently receiving emphasis whilst work aimed at increased safety, health and job satisfaction by adaption of working techniques and equipment to meet the limitations of man in his varied working conditions is most important. They consider that the greatest unexploited resource is the human one and are doing significant work to improve the human environment at the work place.

Skogsarbeten emphasises that research results are not validated until they are applied in practice and thus much emphasis is put on extension. Publications, manuals on work methods (often supplemented by films) and presentations of results through conferences and courses form a significant part of Skogsarbeten's work.

(e) Swedish Forest Products Research Laboratory.

This Research organisation located in Stockholm is supported by Industry (57%) and Government (43%) to carry out a programme agreed between the Swedish Forest Products Research Foundation and the Swedish Board of Technical Development. Its Raw Materials Department of the Wood Products Division carries out investigations on damage to wood by various processes and, in this respect, have worked on the effect on wood quality of shearing, sawing, feeding by rollers, and delimbing, as well as assessing quality and problems in utilising root wood. They have designed equipment such as chain delimbers and disc feller-buncher heads to help reduce damage to wood.

S.T.E. draws money from the same sources as Skogsarbeten and it is considered essential that information is freely exchanged between the two organisations and others in similar research fields, such as the Royal College of Forestry, to avoid duplication of research effort.

(f) Metsateho, Finland.

Metsateho, The Forest Work Study Section of the Central Association of Forest Industries, has approximately 50 industry members from both private and state owned enterprises. It is financed by membership fees based on production and is managed by an 8-man Board of Directors appointed annually by the central association.

Initially, Metsateho investigated work measurement for wages, piece rates and contract payments for felling, extraction and transportation of timber. Now the emphasis is on research into new methods and machines and to lay the basis for development of new methods and machines. Great stress has been laid on systematic testing of new machines and controls aimed at the effective use of machines. Minimising timber harvesting costs is a prime objective.

Metsateho is located in Helsinki where it has a staff of 39 of whom 19 are professional. It places great emphasis on extension and particularly on providing manuals for training. It runs training courses for key forestry personnel and considers that for the results of research to be applied effectively in the field it must be in close contact with and give assistance to those responsible for training.

(g) Työtehoseura, Finland.

The Finnish Work Efficiency Association promotes efficiency, economy and good working conditions in many fields. It carries out research, development, training, consulting and consumer education. The Forest Section of W.E.A. has headquarters located in Helsinki and a school and research centre at Raenaki.

W.E.A's forestry membership comes primarily from the forest farmers who own 70% of the forest area of the country. The work is financed 50% by membership fees and 50% by State funds. It is responsible to a General Assembly of members through a Board of Directors.

Their research covers forest establishment, work studies on tree harvesting, economics and ergonomics. A great deal of emphasis is placed on the ergonomics and extensive studies are done on the physiology and psychology of work and work measurement. Subjective and objective analysis of the relationships of operators to machines has been used to effect improvements in operation and design. Very sophisticated investigations on machine vibration and its effect on human performance are currently being undertaken.

(h) The Norwegian Forest Research Institute (N.I.S.K.), Norway.

The Norwegian F.R.I. has seven divisions, one of which is the forest operations division, with a staff of 37. Although a Government institute, 30% of the research funds come from industry by way of a research tax on industry. This fund is controlled by a council from industry and the Forest Service who decide the amounts allocated to projects.

Currently mountain cable operations research has a grant of two million dollars and work is being done on cable cranes, radio control, planning,and line shifting systems as well as engineering testing of wire rope and rigging equipment.

In the Truck Transportation area, research is being done on road building and trailer design particularly with regard to tracking patterns and braking systems for downhill work on steep country.

Work is also being carried out on recovery of material that would otherwise be thinned to waste with a view to recovery of fuels for energy production.

1.2.2 GROUP II - GOVERNMENT, UNIVERSITY, OR PRIVATE RESEARCH ORGANISATIONS WITHOUT WIDER INDUSTRY INVOLVEMENT IN FUNDING OR DIRECTION:

As the structure and objectives of this group are of little relevance to the organisation of LIRA, comments will be limited to their current fields of research.

(a) U.S.Department of Agriculture, Forest Service, U.S.A.

There are a number of Research Stations in the various regions of the U.S. and only two were visited.

- The Equipment Development Centre at San Dimas near Los Angeles has a staff of 50 and extensive laboratories and workshops. Its work primarily centres on development of equipment for fire control and aerial operations but it is engaged in constructing tree pulling and slash assembly winches, testing heat outputs from chainsaws and re-writing the U.S.D.A. Forest Service Manual on Road Design.

- The Engineering Section of the Pacific Northwest Forest and Range Experiment Station located in Seattle are conducting mission-oriented research centred on planning and small log problems. Major current effort is in the development of a small hydraulic interlock hauler and in developing desk top computer programmes for planning road location and skyline settings. Earlier work on helicopters and balloons has been shelved because both systems are considered immature and in need of sophisticated engineering development. At present insufficient money for this purpose is available.

(b) North American Universities.

- *VIRGINIA POLYTECHNIC INSTITUTE* - and State University, Blacksburg, Virginia, U.S.A. The Department of Forestry and Forest Products at this university operates an industrial forestry operations programme wherein they run a series of extension workshops on the business of logging, improved management, road location, etc. aimed at the junior levels in the companies supporting the programme. They also conduct courses of logging equipment for loggers and cooperate with technical assistance on machinery or systems development projects.

- *OREGON STATE UNIVERSITY* - at Corvallis, Oregon, U.S.A. The strong logging engineering section (14 staff) of the Forestry School conducts a significant research programme (65% of staff effort) into log harvesting systems and effects of logging on environmental values. A high proportion of this programme is financed by a compulsory Oregon State Forest Harvest Tax, thus an Advisory Committee from industry indicates the priority requirements and small ad-hoc industry/ research staff groups are set up to identify problem areas and establish programme requirements. The Logging Engineering Section has a graduate training programme for professionals who have five to six years' field experience, and a very strong extension programme of short courses and demonstrations to ensure research results are communicated to industry. Two of the Forest Engineering faculty are full-time on this extension aspect.

The prime areas of O.S.U. investigations are centred around small wood harvesting, comparative operational efficiency of cable and aerial systems, optimisation of tactical planning, examination of forces in cable systems and examination of the extent and importance of sedimentation, slash in streams, compaction and buffer strips. Work on cable thinning is being carried out in the university's forests.

- *UNIVERSITY OF BRITISH COLUMBIA* - Vancouver, B.C., Canada. U.B.C. cooperates with FERIC on a variety of projects. Currently they are carrying out a study of shotgun and high-lead systems to compare productivity, roading requirements and overall costs.

  U.B.C., along with O.S.U. and the University of Washington, have cooperated with the U.S.D.A. Engineering Laboratory and FERIC to run a series of biennial Skyline Symposiums which have been well attended by industry. The next one is planned for December 1978 in Portland, Oregon.

(c) <u>European Research Institutions.</u>

- *THE NORDIC RESEARCH COUNCIL* - was formed when Denmark, Finland, Norway and Sweden agreed on a cooperative approach to avoid duplication of work and to budget one million dollars for a common research programme. The individual project results are published under the auspices of the particular organisation that normally is most advanced in the project area and houses the project leader, but he has cooperators in each of the other countries.

Significant work on ergonomics has been done in this way and published by the Norwegian Forest Research Institute even though work on aspects such as lighting in machinery, physical stature, statistics, influence of aerobic rates on performance etc. were done in the other countries.

- *SKOGSHOGSKOLAN* - The Royal College of Forestry, Sweden. In 1962, The Royal College of Forestry and the Forest Research Institute were merged and now 80% of the work of Skogshogskolan is research. The Department of Operational Efficiency, which is located at Garpenburg in Central Sweden, carries out research primarily in the longer term operational requirements in both silviculture and logging. There are yearly conferences to harmonize their work with Skogsarbeten - but they normally handle the long term problems where industry support is more difficult to get.

  Skogshogskolan is doing significant research into whole tree utilisation and energy harvesting and they are examining whether the cost of extraction of small wood cancels out the extra energy volumes gained. In this respect they are examining batch delimbing and the compacting of slash.

  Their ergonomics work has also indicated a close link between physiological and psychological factors and thus they are examining training systems and areas of work for partially disabled people. Economic planning for both short and long term objectives using linear programming, simulation and other computer techniques have been extensively applied to actual problems facing Sweden's forest industry.

- *MUNICH UNIVERSITY* - West Germany, combines the Forest Service, Forest Research Institute, and University faculties for research into one organisation which does 70% of the research in the logging field in Bavaria. Each state in Germany is independently responsible for their own research and there appears to be limited coordination. The fact that the Germans do not publish in English or normally have English summaries means that it is difficult to assess the value of their work.

  Although in Bavaria the percentage of cable logging is a low 11%, Munich are working on the development of an interlock hauler for a running skyline system, and the improvement of cable logging systems.

- *THE AUSTRIAN LOGGING TRAINING SCHOOL* - at Ossiach, Austria. Although the school's main function is to provide logging training for supervisors, operators and workers, it aims to develop systems particularly for cable logging and thinning on Austria's very steep terrain. It develops ideas on equipment to a stage where a system is feasible and when construction of the necessary units would be taken over by industry.

- Other European Logging Research Organisations. Although it is known that other European Countries were involved in logging research particularly France, Germany and Russia, time did not allow visits to these countries. The fact that they do not generally publish results in English or have English summaries means that it is particularly difficult to assess the relevance of their work to New Zealand and to establish the personal contact desirable for a free exchange of ideas.

1.3 FACTORS AFFECTING LOGGING DEVELOPMENT IN THE COUNTRIES VISITED:

New Zealand has a constant requirement to import new technology, but the reasons behind specific developments in distinct home environments must be understood to be able to assess the viability of overseas importations on the N.Z. scene.

Development of the systems and machines used overseas is influenced by economic considerations prevailing in the particular area e.g. labour availability, taxation, basic machinery cost, environmental requirements, legislation, etc. As a result, many developments are limited in application elsewhere because they occurred to meet specific economic requirements, e.g. particular machines may be developed to meet environmental constraints on operations or through manufacturing advantages that only exist in the originating country. In an area as remote as New Zealand, constant intelligence is necessary to be able to assess the application of new technology in our environment. It is thus important to regularly review overseas wood cost trends, labour costs and availability, machinery costs and other factors.

A comprehensive analysis of the factors influencing the development of tree harvesting systems in each country or region is not possible in this report, but the following observations may be helpful in interpreting the relevance of information from the countries visited.

1.3.1 SOUTHERN STATES OF THE U.S.A:

The forest products industry in this region of the U.S. possibly has the cheapest wood costs. This is primarily based on the contract or piece work activities of thousands of small independent operators with cheap equipment and low overheads who often procure their own stumpage and sell logs to a dealer. Labour is generally not unionised and the industry wood users do not want to employ people directly because of incurred social costs and potential union problems.

The forests are on generally easy, but often wet, terrain and where mechanisation has been introduced it aims at increasing the productivity of locally hard-to-get and more expensive wage labour and to integrate mechanisation of harvesting and establishment phases of Forestry or Company lands. Some companies are thinking in terms of increased value utilisation and to do this long wood processing has significant advantages. Thus with one large company operation, foliage is left on and they attempt to bring whole trees to a mill area for processing. For effective logging this requires multi-stem handling and special systems for whole trees. The terrain and tree crops lend themselves to a high degree of mechanisation but the overall industry aim is to maintain low wood prices by continuing the small contractor system.

1.3.2 NORWAY:

Industrial workers and contractors are expensive labour in Norway and thus much logging equipment development is aimed at small forest owners (farmers) who might typically own 10 ha. of farm and 60 ha. of forests and produce wood cheaper than any other labour. Wood costs are 50% machinery, 50% labour and the aim is for flexibility in operations with light machinery that can be used by owners on a variety of terrain. Much research and development in logging is based on applications of or extension to agricultural or industrial tractors.

A main objective is to improve mountain logging as they are only cutting two-thirds of the increment of their forests. Most of the unexploited resource is on mountain land and thus much research emphasis is on light cable logging equipment.

1.3.3 SWEDEN:

The situation in Sweden differs markedly from the north to the south. Generally in the north, smaller piece sizes, larger land ownerships, bigger companies and highly mechanised logging. In the south, faster growth, bigger trees, majority of farm forests,and smaller operations exist. Maximum growth per annum in the south is

15 m^3 per ha. and it goes down to almost zero in the north. Forest land is considered productive if it has more than 1 m^3 per ha. per year of increment.

Currently annual cut equals growth at about 80,000,000 m^3. There is a deficit period from 1985 to the year 2010 in which the Swedes would need to import wood. They are attempting to fill the gap by planting *P.contorta* and by improved whole tree utilisation. Sweden is also currently importing chips from the southern United States.

Thinning contributes 30% of the cut, with clear-felling 70%. The ownership pattern is 50% in private hands, 20% Forest Service, 25% company owned and 5% others.

Topography is generally easy but surface conditions are rugged, with large boulders from the glacial moraines which cover most of Scandinavia posing constant problems. The basic forwarder chassis, which is the carrier for much Swedish logging machinery, has obviously been designed to cope with the problems presented by this terrain.

Wood costs are very high with machinery/manpower probably 80%:20% of cost. High labour and very high social costs are reflected in the pricing of Swedish equipment which is highly sophisticated and well designed to meet ergonomic principles and maximum comfort of operators.

1.3.4 FINLAND:

Eighty percent of Finnish forest products production goes to export markets primarily in England, France and Germany. The annual cut (approximately 25 million m^3) is currently less than increment (50-60 million m^3) but the Finns import five million m^3 from Russia.

Private forest owners, primarily farmers, own 66% of forest land in Finland (mostly the highest volume forests), the State owns 23%, companies own 7% and communes, local bodies etc. own 4%. The State forests are primarily in the north (Lapland) and the company forests in the middle and eastern section. Neither of these owners have significant holdings in the south which is the domain of farm forests.

Geographically, the Baltic coast is very flat, being raised from the sea bed. The rest is not steep by our standards, in fact it is only the surface conditions that present any difficulty being of similar glacial origins to those in Sweden.

Machinery design centres round the forwarder type chassis. Multiple-function machines are favoured to reduce the costs of moving a number of machines frequently between small ownerships. The Finns predict a rapid increase in this type of machine to meet their requirements.

Significant research effort is directed into providing a better working environment for both machinery operators and woods labour. Ergonomics and research into the physiology and psychology of work are highly developed.

1.3.5 AUSTRIA:

Considering the mountainous nature of the Alpine region of central Europe: Bavaria, Austria and Switzerland, the percentage of cable logging is surprisingly low, probably less than 10%.

Of the forests of Austria, 15% are State forests, 30% belong to farmers (primarily small forests) and 40% are company forests. The rest are held by churches, villages, etc. Management plans are compiled on a 10-year basis and have to be approved by the Regional State Forestry Office. No clear-felling of more than 0.25 ha. is allowed without the approval of the District Forester. A deposit of money has to be lodged prior to approval to fell and is retained until the area is re-forested. All forest owners - the State, the private companies and the farmers - do most of their own logging. Transport in the main is by companies. 10,000,000 m^3 per year is the total logged from Austria. Only 6% of this is by cable. The value of the wood is high - 1 m^3 of sawlog on ride being $85-125 (NZ) and 1 m^3 of pulpwood from $41-46 (NZ).

Although the percentage of cable hauling was low, the operations seen indicated the Austrians had developed some new approaches to the art of logging steep terrain. They had developed uphill cross-hill felling to aid extraction and reduce damage and had introduced truck-mounted steel spar haulers that operated off narrow contour roads with effective self-locking skyline carriages.

1.3.6 EASTERN CANADA:

Eastern Canadian logging developments are based on their particular forest environment: small trees, low and irregular stockings, long distances to mills and low labour availability (none in many logging areas). On the Canadian Shield which spreads across most of the eastern provinces, the average tree size is 0.14 m^3 per tree, average diameter is less than 16 cm. Currently power saw felling and delimbing, plus extraction by rubber-tyred skidders account for approximately 80% of log production, but harsh working conditions and seasonal unemployment resulting in difficulties in recruiting labour is forcing adoption of increasing levels of mechanisation. Currently wood costs are the highest in the world when quality is taken into account, i.e. their output of value is much lower than Sweden. Therefore, they must have a degree of improvement in systems and they are looking for revolutionary areas where they might improve productivity 25-50% not in the evolutionary 1-5% area where most development takes place.

Given these circumstances, they therefore aim to develop extremely high-speed systems concentrating large quantities of wood at a centralised landing. The systems are based on the principles of:

(a) High-speed harvesting
(b) High-speed forwarding
(c) High-speed processing at concentrated landings.

1.3.7 BRITISH COLUMBIA:

This Canadian province probably has the highest logging labour costs in the world and costs of logging have doubled on that prevailing five years ago. The development emphasis has shifted from the large timber on the "Coast" logged by large companies to the interior where more operations are carried out by independent contractors. Mechanisation of felling and limbing is widely used in interior B.C. and much development in shears, feller-bunchers and delimbers has occurred there. Now in this region loggers are attempting to develop methods and machinery for cable logging in smaller timber than that existing in the coastal region and progress in this work could be relevant to N.Z.

1.3.8 PACIFIC NORTH-WEST OF U.S:

In the States of Washington, Oregon and Northern California, a highly competitive situation exists between companies, and an 'adversary' situation between Government and industry, thus it is difficult to get detailed information direct from industry particularly with regards to costs of operations. There is thus limited exchange of information between industry organisations.

There are also grave problems with the public and conservationists. Extreme conservation attitudes have influenced Federal timber sales to the extent that aerial operations (balloon or helicopter) are prescribed for some sales. All studies show these methods to be extremely expensive and in need of major improvement, particularly costwise, before they could be considered viable in normal situations. Many environmental requirements are imposed on logging operations by Government Agencies bending to the pressures of preservation groups.

Logging cost movements have been significant and costs have recently risen annually in U.S. logging in the following fashion:

Labour	15%
New equipment	12%
Parts	16%
Diesel	20%
Stumpage	16%

An analysis of labour costs showed the following:

U.S.South	$ 5.48 per hour
U.S.North-west	$10.58 " "
Sweden	$11.50 " "
British Columbia	$13.60 " "
Norway	$ 9.80 " "
Germany	$10.00 " "
Austria	$ 9.00 " "

A big variation in the labour costs is due to social costs.

In comparing machinery capital costs between countries, one U.S. source indicated rough analysis of equipment costs showed North American equipment to cost $2.50 per lb of gross machine weight against Swedish equipment at $4.60 per lb. A similar analysis could be done on the basis of hp or a more complete analysis on the basis of components.

PART III

LOGGING RESEARCH
PROJECT AREAS AND LOGGING OPERATIONS

INTRODUCTION

This part of the report deals only with project work seen or discussed and the operations actually visited. The study tour concentrated on the primary objective of examining the work of research organisations, thus only limited time was left for field visits and no attempt was made to cover the whole range of operations in any one area. Hence important aspects of logging field operations are not covered herein.

A logical approach to discussion of the various aspects is taken, thus this part of the report starts with the first step - planning, then discusses systems concepts and principles of mechanisation before dealing with the detail of tree harvesting, extraction and transportation and concluding with reference to the human area.

The use of trade names or firm names in this section is primarily for convenience of discussion and illustration. It does not imply endorsement of a particular product or firm. The comments are copyright and cannot be reproduced or used in advertising.

3.1 PLANNING.

3.1.1 PLANNING TECHNIQUES:

Competent planning is the first requirement for an effective operation. Advanced techniques are being used for long term logging planning (the interface between Logging and Forest Management), problem solving in crisis situations (such as windthrow), and tactical planning (e.g. for skyline settings or roads). Additionally, modelling and simulation techniques have been introduced for comparative evaluation of logging systems and to identify criteria for machinery development.

Skogshogskolan have used computer planning to solve immediate problems imposed on wood handling systems by such unpredictable factors as heavy insect damage or windthrow. The approaches used could be useful to N.Z. in the crisis planning required for extensive wind or fire damage or for analysing the options possible with the reduced tree sizes predictable in the 1980s and beyond. In the Swedish situation linear programming techniques allowed an examination of the costs and effects of alternative systems of movement of logs from the stump to the mill and the effects of stockpiling at various points. In the exercise carried out, when the Swedish Government ruled that no unbarked logs could remain at Forest roadside because of extreme susceptability to insect attack, the solutions arrived at enabled satisfactory quality to be maintained in mill imput and that logs produced by the three main logging sectors - Farmers, Companies and the State - were uplifted before being rendered unmerchantable[1].

Tactical planning problems in road location, cable logging and environmental planning are being simplified by computer programs developed for both hand-held and desk top computers by the U.S.D.A. Forest Engineering Laboratory in Seattle. These programs enable the Logging Manager or Planner to examine alternatives for road, landing or skyline layout with accuracy and speed.

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1 "Examples of the Availability of Wood Within Forestry with Road Side Delivery" by S.Nilsson,1977. Royal College of Forestry, Dept. of Operational Efficiency, Res.Note 109.

Optional locations are plotted on topographic maps and selected measurements from these are fed into the computer by means of a hand-manipulated 'digitiser'. The computer in turn prints out road or skyline profiles, road cross sections, calculated cut and fill balances, skyline deflections and survey data that can be used in located fieldworks[1]. In environmental planning oblique views of future "cut settings" can be plotted to indicate their visual impact from selected vantage points[2].

Analysis of the options available in the planning of logging layout or the selection of logging equipment and systems have in the past been primarily solved by applying experience and possibly some intuition. Mathematical and simulation techniques using computers have been developed and are beginning to be applied in some of the larger North American operations. The "Log Plan" program developed by the Canadian Forest Management Institute optimises the scheduling of operations and enables Logging Managers to calculate what happens to productivity and costs when they, for example, replace skidder crews with forwarders or short wood harvesters, or hold back more stockpiles at landings or do any of a number of operational manipulations feasible in their logging system. "Log Plan" is an effective way of calculating easily the affect of simulating changes in a large complex logging operation but is not so valid for the smaller organisation[3].

An extensive range of computers and programmable calculators are available, particularly in the U.S., and the price of much of this type of equipment is reducing rapidly making it feasible for use by the smaller organisations. For example, FERIC uses one small desk top computer capable of 960 programmable steps and costing only $600 (US).

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1 "New Tools Allow Examination of Skyline Alternatives Speedily" by D.Burke, 1975. Forest Industries, June, 1975.

2 "Preview: Computer Assistance for Visual Management of Forested Landscapes" by E.Myklestad and J.A.Wagar, 1976. U.S.D.A.Forest Service Research Paper N.E.-365. 1976.

3 "Simulation Techniques and Their Possible Application to Forest Harvesting in Canada" by R.M.Newnham, 1973. Reprint from Symposium on Planning and Decisionmaking as Applied to Forest Harvesting, For.Res.Lab., Oregon State University.

3.1.2 COMPARATIVE PLANNING AND EVALUATION OF SYSTEMS:

Comparative studies, particularly of skyline and aerial systems, are being carried out by FERIC's Western Division, O.S.U. and U.B.C.

FERIC has completed studies on B.C. coastal logging systems, simulating planning for each system over 36,000 acres and using actual experience, cost and production figures, to compare the costs of hauling and roading for the traditional high lead system against those for running skylines, other skylines and balloon systems. They concluded that all these systems, with the exception of balloons, were actually cheaper than high lead if roading costs, which are rising more rapidly than hauling costs, were properly accounted for. The balloons required very high investment and, as a system, were still immature needing significant expenditure on balloon and winch design.

The options of using small tractors on steeper terrain are being studied as are the application of F.M.C. and Bombardier track-laying skidders.

O.S.U. has also carried out comparative studies on aerial logging systems with detailed studies over two summers supplementing information from shift-level operation records where the effect of downtime and machine availability on production were kept[1].

U.B.C. is currently doing an in-depth study of cable logging systems to compare gravity return or "shotgun systems" against conventional high lead. They aim to analyse all the variables that affect each type of operation.

The techniques used in these studies could be applied in N.Z. and some of the results are valid here providing the differing environments are properly understood.

The U.S. industry has experienced the effect of environmental pressures for a longer time than N.Z. and as a result studies to compare the effect of

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1 "The Pansy Basin Study - Comparing Yarding Rates and Costs for Helicopter, Balloon and Cable Systems" by D.P.Dykstra, 1974. Reprint from Pacific Logging Congress "Loggers Handbook" Vol.XXXIV, 1974.

various logging practices on soil, water and other values are more advanced[1,2]. O.S.U. in particular has done significant work on debris in streams and buffer strips, the results of which counter many earlier arguments advanced by environmental groups and give a better understanding of the processes involved.

3.2 SYSTEMS CONCEPTS.

3.2.1 FULL TREE UTILISATION AND ENERGY HARVESTING:

The Scandinavians have done extensive work on whole tree utilisation with separate investigations in a number of countries coordinated by the Nordic Council. Most of the possible work areas have been partially covered and progress reported on at a recent European Symposium in Holland. At present industry has limited interest in the whole tree concept because of a current business downturn, and this feeling extends to North America.

The whole tree utilisation programme is basically divided into three areas - stumps, other forest residues and short rotation forests. The following is a summary of some of the essentials.

(a) *STUMPS.*

Scandinavian industry is more interested in stumps which have generally better quality wood and greater wood volume than other residues. Skogsarbeten calculate potential production of 4 m^3 per ha of stump wood down to 5 cm using an excavator type stumping machine.

The problems with stumps centre around the method of removal - achieving high production, and removal of dirt - particularly stones, which vary between 20%

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[1] "Costs of Stream Protection During Timber Harvest" by D.P.Dykstra and H.A. Froehlich, 1976. Reprint from Journal of Forestry, Vol.74 No.10, 1976.

[2] "Natural and Man-Caused Slash in Headwater Streams" by H.A.Froehlich, 1973. Reprint from Pacific Logging Congress "Loggers Handbook" Vol.XXXIII, 1973.

and 50% of total weight. Extra problems occur with hidden stones and fibres at right angles to each other.

Stump harvesting machines under development include a Pallari stump harvester with a draw knife mounted on a boom with 60 ton pull[1]; an Osa stump remover based on splitting the stump into four pieces first thus loosening the stump and reducing lift requirements up to ten times; an Osa forwarder that combines forwarding and dirt cleaning in similar fashion to a concrete mixer, and a hammer type unit for cleaning at the landing.

(b) *SMALL WOOD RESIDUES*.

Although there has been considerable research into methods and machinery for recovering tops and branchwood, the fact remains that unsegregated whole tree chips are of too poor quality for most mills and separation of wood from other elements remains difficult. An important factor to calculate is whether the cost of extraction and energy used in doing it cancels out the extra volume gained. The Swedes have concluded that minimum size is about 5 to 6 cm diameter in their case.

Although some equipment has been tried for assembling small wood elements in the field in Finland, and an agricultural baler has been used for bundling green slash in the U.S., the most general conclusion is that one must knock off a high percentage of the green material in the woods where it is useful on the forest floor and transport whole trees to the mill. Weyerhaeuser Co. in the U.S. *(Figs. 1 & 2)* and Skogsarbeten have had good results from debarking such stems in drums but there are waste disposal problems. One field chipper, the Morbark Chiparvester *(Fig. 3)*, now has a separator device which casts aside most of the dirt, needles and wood slivers in the woods operation.

In North America, both A.P.A. and FERIC have supported projects on bark/chip separation.

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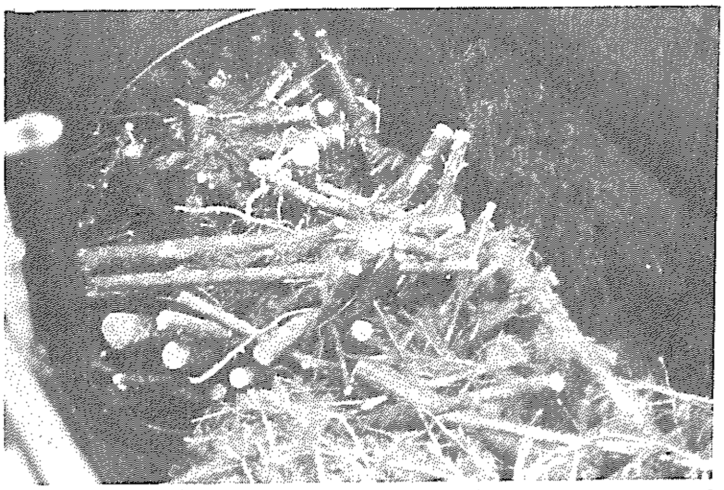
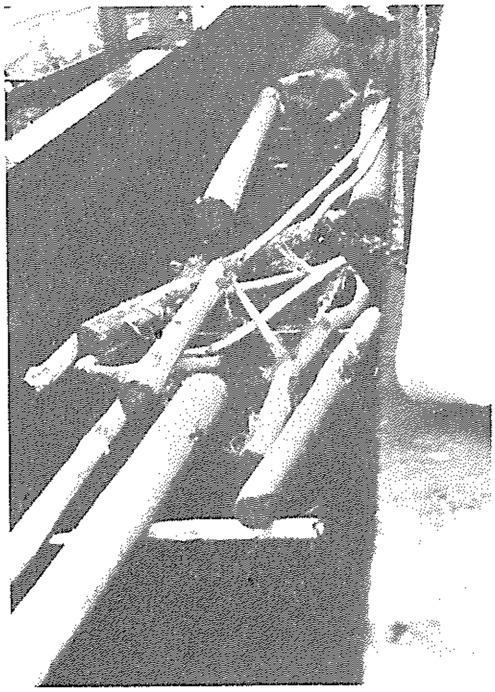
1 "The Pallari Stump Harvester" by M.Nylinder and R.Akerman, 1976. Skogsarbeten Teknik No.3 1976.



(Weyerhaeuser photo)

FIG.1 Slashed whole trees entering drum debarkers at the mill. U.S. South.



(Weyerhaeuser photo)

FIG.2 Debarked whole tree pulp logs, Weyerhaeuser Co., Oklahoma, U.S.A.

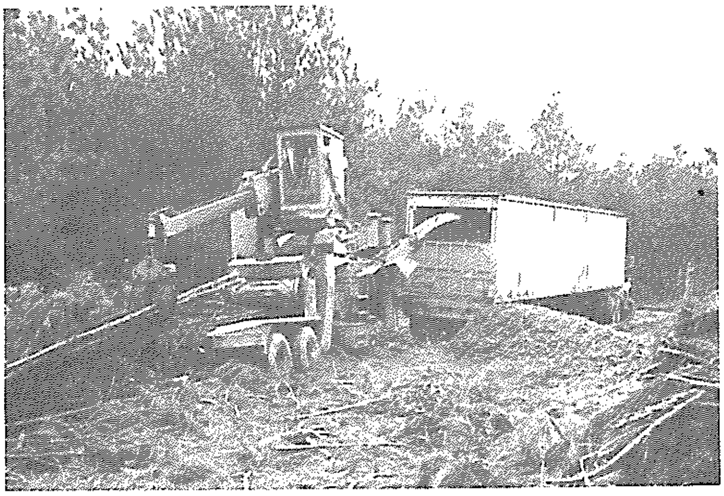


FIG.3 Morebark Chiparvester Model 22 with separator segregates out 70% of the dirt, 50% of needles, knots, and slivers. Bodecaw Co., Pineville, L.A., U.S.A.

There are two parts to the problem - separation and segregation. For separation; tumbling, screening, use of rubber compression ribbed rollers, softening and agitation in water have all been tried. For segregation; air streams, rebounding processes, flotation methods, food industry processing techniques, and pulping have been investigated. Apparently best results are obtained by a three-stage mill process involving conditioning in piles to soften the bark, agitation in water, and washing. By such processes, an average of 20% bark can be reduced to 3% approximately. At present a great deal of secrecy is maintained on the details of specific processes.

A quite different approach is a process being developed in Canada for using whole tree chip material to make particle board without using adhesives.

(c) *SHORT ROTATION (ENERGY) FORESTS.*

The world energy crisis has sparked off a flurry of research in this field. The Americans have discovered that the energy potential of green material is very high and consider agricultural harvesting techniques would be valid for very small wood. A.P.A. have coordinated a Silvicultural Energy Project wherein the possibilities of harvesting and transporting slash material has been examined. F.M.I. in Canada are currently experimenting with coppice harvesting of mini-rotations of poplars and have developed a harvester incorporating a small saw, a V-shaped receiver and belt assembly and drawn by an agricultural tractor to handle material 3" to 5" diameter. Thinning to waste material from more traditional rotations are being extracted experimentally by the Norwegians using assembling winches and mobile chipper forwarders designed as accessories to agricultural tractors *(Figs. 4, 5 & 6)*.

The Energy budgets and costs of all these systems indicate they currently have limited economic viability. However one large southern U.S. Company have launched an energy recovery programme for logging slash within 25 miles of their Louisiana mill.

Experimental Extraction of Small Thinnings for Energy Production. Norwegian Forest Research Institute, Hurdal, Norway.

FIG.4 Pine thinnings extracted by tractor winch to access truck.

FIG.5 P.T.O. winch and A-frame on agricultural tractor.

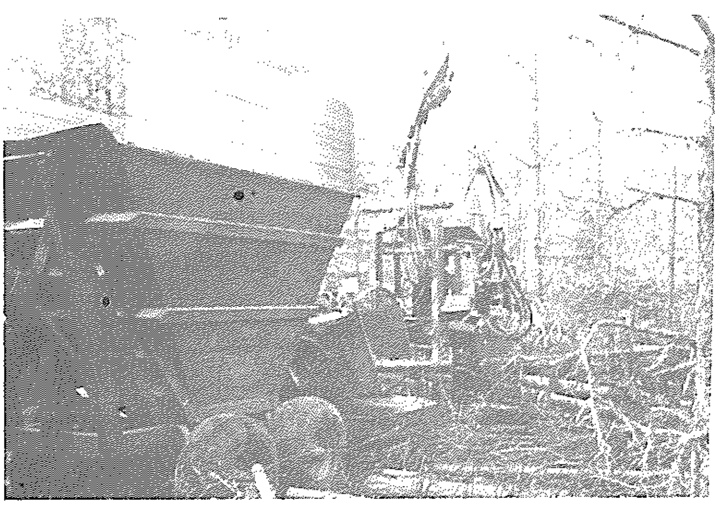


FIG.6 Agricultural tractor with knuckleboom crane and chipper and chip bin trailer.

3.2.2 MULTIPLE STEM HARVESTING:

A number of individual researchers consider that revolutionary and dramatic progress can only come from rapid handling of multiple stems. As tree sizes for potential harvests decrease the interest in this concept increases. The logic is based on stem volume as a function of diameter squared. As most harvesting equipment handles single stems and the time to handle each stem is the same regardless of size, you can expect cost increases to escalate as size decreases. Speeding up single stem handling has less possibility than handling multiple stems e.g. each of the functions of a feller-buncher: speed, swing, handling time, cutting speed, etc., has a limited possibility for improvement - thus equipment, for example, for bundle bunching, offers possibilities for marked improvement. Currently these concepts are in the early stage of development.

In the U.S., shears for multiple stems are being developed by Allen-Jarck, Hydro-Axe, and Rome. The latter is building a stem combine to handle whole skidder bundles of small trees. The Finns have developed the Makkeri bundle buncher for whole tree utilisation systems.

The most revolutionary development is a prototype high-speed cutting machine - a "Swather" - under trial in Canada. It consists of 4ft diameter circular saw mounted on a boom projecting in front of a tractor to mow stems into a retainer basket as it moves forward at about 7 km.p.h. It can cut a 30 cm tree in one-fifth of a second and a 76 cm tree without pausing. The prototype cuts 12 to 15 trees per minute in stands where the mean tree is less than 16 cm diameter. Current potential is 113 m^3 per hour just cutting and 50 m^3 per hour delivered at roadside.

Multiple stem debarking by flails, screws and drums also show potential for revolutionary improvements. A combination of rough woods delimbing to get rid of most of the unsaleable material followed by tumble delimb/debarking at the mill, can give good quality at low costs in smaller pulpwood.

3.2.3 THINNING SYSTEMS:

The decision to thin is made for a variety of management reasons but the higher wood cost associated with thinning has spurred development of a wide range of extraction methods in Scandinavia but little full mechanisation due to the likelihood of stand damage.

The spacing of and methods of operating from strip roads has been examined in Sweden in conjunction with the development of radio controlled single and double drum winches to haul logs to these strip roads. Long reach feller-bunchers and processors to operate from strip roads in thinnings are also under development.

In the Pacific North-west, high wood costs resulted in a virtual cessation of thinning but now Weyerhaeuser and O.S.U. are taking a renewed interest in light cable hauling machines, multiple span systems, and locking carriages.

3.2.4 ANALYSIS OF SYSTEMS:

Skogsarbeten have developed an approach for analysis of future options for logging systems or machine design which is based on known performance data for part of the system or machine plus estimates of optimistic, pessimistic or median performance of the unknown machines or components. Computors have made possible the rapid calculation of a wide range of options and thus it is possible to estimate the probability of a proposed system or machine being successful.

This type of analysis has convinced the Swedes and Finns of the viability of multiple-function machines based on proven forwarder-type carriers particularly where they may be working distinct small stands in different ownerships.

3.3 MECHANISATION:

Increased mechanisation in logging is normally

introduced to -
(a) reduce costs by increased productivity
(b) reduce labour requirements
(c) reduce accidents.

However it is not axiomatic that increased mechanisation results in meeting these objectives, particularly the first one. The concentration of activity at fewer cost centres requires a clear understanding of the interrelationship of elements in the logging system. Efficient operational and maintenance management is essential for success.

In Sweden, 30% of felling is mechanical and 60% of delimbing, but this is influenced mostly by shortage of woods labour, particularly in the north. Labour costs in Sweden are also very high but this is reflected in the cost of their machinery too - so gains are probably limited.

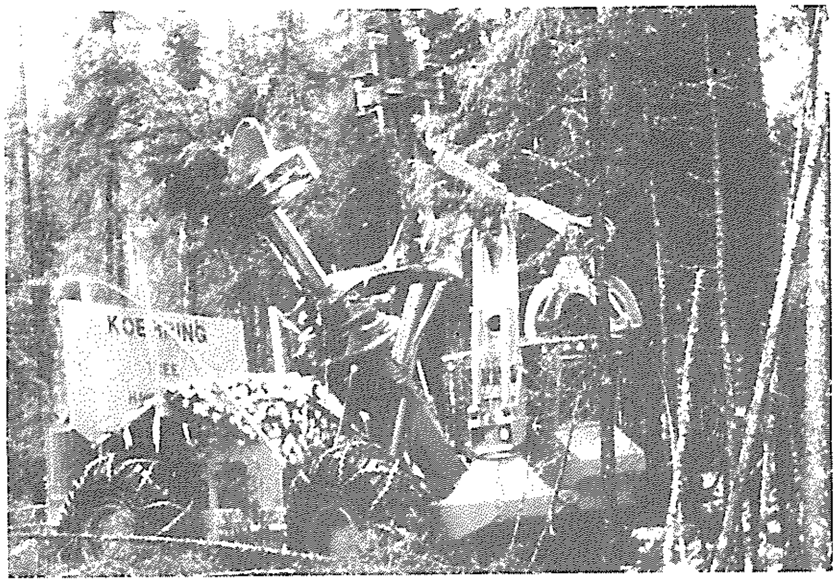
In Finland, Metsateho have investigated machinery development costs compared with manual costs for a wide range of possibilities and have examined future manpower requirement against predicted population movement and wage legislation and concluded that higher levels of mechanisation are essential in Finland.

Mechanised harvesting in Eastern Canada has to date not been a great success. It has cost both the producer firms and the machinery designers a lot of money and has not resulted in reduced costs. In general, the more conservative firms that did not introduce mechanisation a few years ago have been able to maintain costs lower than those who did.

It is evident that the introduction of such systems require effective management of both production and servicing. It is reported that for example in Eastern Canada different firms using the Koehring shortwood harvester *(Fig. 7)* (167 units in operation) have managed to achieve among both the lowest and the highest wood costs in Canada. *Fig. 8* shows the variation experienced with typical systems in Eastern Canada 1975-76. It should be noted that the variation within systems is much greater than the variation between systems.

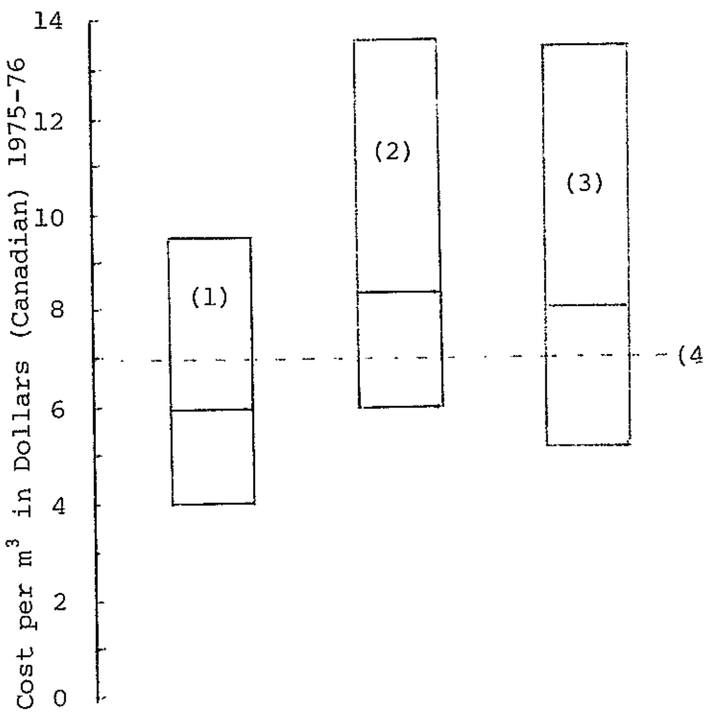
The following relationships need to be examined and understood, particularly by firms considering increased levels of mechanisation:

FIG.7 Koehring Shortwood harvester - fells, delimbs, cuts to length and forwards to roadside.



(Photo courtesy D.Neilson, K.L.C.)

FIG.8 RANGE OF WOOD COSTS EXPERIENCED WITH THREE TYPES OF MECHANISED SYSTEMS. CANADA 1975-76.



Top of bar indicates inefficient operating level (does not include complete disaster)

Median of bar indicates average industry performance for each syste

Dotted line indicates average conventional tree length system

Bottom of bar indicates achievable industry performance (i.e. best 10% have achieved this)

Systems to produce shortwood

(1) Feller-buncher/grapple-skidder/flail/slasher.
(2) Feller-buncher/single-stem-delimber/grapple-skidder/slash
(3) Short-wood harvester.
(4) Chainsaw-fell-limb-top/choker-skidder/slasher

(a) the availability and cost of labour
(b) the cost of operating machines compared to likely productivity gains
(c) the probable level of breakdown which will affect productivity of the whole system required to keep the downtime percentage to a minimum.

3.3.1 MACHINERY DEVELOPMENT:

Some general points on development trends and general aspects of mechanisation are probably valid.

In Scandinavia both forwarders and knuckle-boom loaders have been developed to a high stage of effectiveness and reliability and thus a high percentage of mechanisation development for logging and forestry is based on travel on a forwarder chassis and lifting and placement by knuckle-boom. However it should be understood that development of these units has reached the stage it has because of the necessity to overcome the twin Scandinavian problems of very rough ground conditions and numerous small (and light) wood pieces. These conditions do not necessarily apply in other countries.

Size of markets certainly influences machinery costs and marketing. In 1969, 6800 skidders were sold throughout the world, by 1971 the number had come down to 4200 and all overhead costs had to be absorbed by fewer numbers. The price increases to compensate for this were significant worldwide from 1972 on. High sales rates are important to marketing; one Finnish firm considered they could not afford to service a market as remote as N.Z. with sales less than 30 units per year. Many specialised new markets have limits, e.g. the predicted shortwood harvester market in Eastern Canada was 150 units and this has possibly now been filled except for replacements.

Design, engineering and factory set up costs for new units are high and they mostly require specialised follow up and field servicing, thus these costs must be offset by reasonable output in numbers to achieve reasonable unit costs. It is notable here that a country such as India - with grave needs for employment opportunity - does not consider it viable to manufacture relatively simple machines like hydraulic skyline carriages, even though it is within their technological capacity. They apparently adopt, as a guideline, a minimum of 200 units for local use before they would consider manufacture.

Because of limited markets for specialised machines, machinery companies cannot spend a lot of money on developing such equipment. Most companies prefer to develop attachments for proven base machines which have applications in other markets. Thus, for example, a good front-end loader is a suitable base for such items as shears, feller-bunchers, and tree processors. An accessory designed to match a standard basic machine generally proves much cheaper than a specialised machine.

Machinery development based on simulation of the log harvesting requirements is used in Sweden by Skogsarbeten, working closely with the machinery industry. F.M.I. have developed similar computerised techniques for use in Canada. Simulations of typical forest stand types, based on data on size, characteristics, and spatial distribution of trees, are matched with studies of logging systems and probable machine design limitations in such things as speed of travel, reach, sweep, and functional limitations of components. Application of such techniques takes a lot of the expensive "guesswork" out of machinery development.

3.3.2 MACHINERY EVALUATIONS AND TESTING:

A number of research organisations carry out machinery evaluations. The North Americans' main objective is to inform their members of new developments with some guidance on possible application. The Scandinavians coordinate evaluation with design and liaise closely with the manufacturers. They carry out analyses of proposed new units or studies on prototypes with a view to recommending design changes at an early stage.

Some comparative evaluations are done by Skogsarbeten; e.g. on hydraulic cranes *(Teknik NR4 of 1976)*. They have set up computer programs to compare effectiveness, identify design requirements and work out operating cycle times.

Some principles in evaluation used overseas that are applicable to LIRA, F.R.I., and the N.Z. industry firms carrying out evaluations are probably relevant.

(a) Prompt reporting of new ideas is required by Industry. Thus, a concept evaluation of the specification and application of new machines with an indication of their performance and potential (as in the A.P.A. Technical Releases) is desirable to give industry a preview of development. Modification of the new machine or method commonly occurs in the first year or so, thus such studies should be brief and indicative rather than detailed in this period.

(b) Once a number of units are in action or after a development period is over, more detailed cycle times plus the use of Tachograph recorders is important in indicating productivity variables, downtime, and availability. Identification of component problems should be allied to this as it often indicates where management changes are needed. (Metsateho's identification of the dominance of hydraulic problems in harvesters influenced change in operator training to give emphasis to field replacement thus reducing downtime significantly.)

(c) Although examination of reported failures is necessary to develop new machines or modifications it is considered that autopsies on the failure of machines have limited value; to quote one prominent research engineer, "You would need a pyschologist rather than a mechanical analyst to find out why a machine failed."

Sophisticated testing facilities existed at some of the organisations visited but it was evident that utilisation of much of this equipment was low and therefore, except where there were very special and essential requirements that could not be duplicated elsewhere, it was preferable to have testing done under contract where facilities already existed.

The Norwegian Forest Research Institute have a wide range of engineering testing equipment particularly for their cable logging programme. They test power and torque outputs, breaking strains of wire rope and blocks, and the stresses induced in the various operating lines and guys under various rigging systems.

Testing of chainsaw kickback has been done by Skogsarbeten, S.T.E., and Omark Industries, and this is still obviously a complex subject where the best answers to reduction of kickback injuries may lie in the training field.

In Sweden, standardisation of machinery components (such as hydraulic fittings, and layout of machine controls) is under action by industry committees set up by Skogsarbeten. They feel that action to influence standardisation of components is a very important approach to reduce downtime delays and facilitate servicing and training.

In the U.S., The Equipment Development Centre at San Dimas carried out exhaust testing of chainsaws and other equipment aimed at defining standards for mufflers and spark arrestors in forest machinery. This work has influenced design changes in these machines.

3.4 TREE HARVESTING AND PROCESSING.

3.4.1 FELLING:

Chainsaw felling world wide remains the most common system, but many loggers are investigating better methods of using them particularly for directional felling to assist extraction, and improve thinning operations, better wood utilisation, and environmental protection.

The simplest and most effective device seen for smaller trees is the Swedish 'Nordfeller', an air-cushion that can be placed into the back-cut, fitted easily to a connection on the power saw, and blown up whilst cutting. There are two models, the largest gives seven tons of lifting pressure for directional felling *(Fig. 9)*.

The Americans in the Pacific Northwest, and the Austrians, commonly felled uphill or cross slope,

FELLING TECHNIQUES

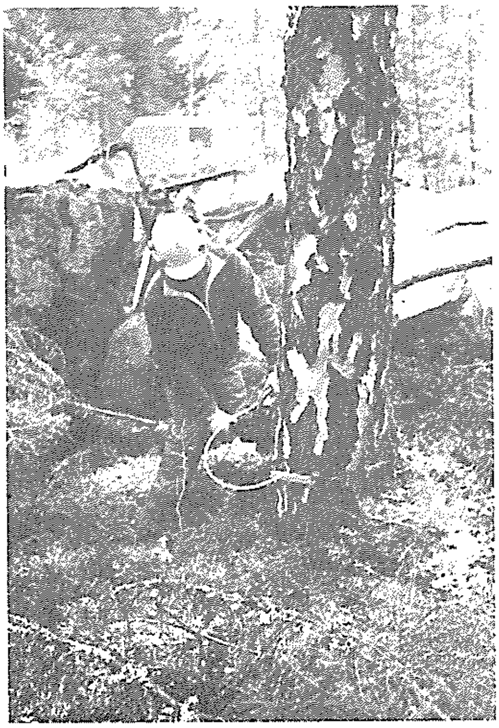


FIG.9 Nordfeller in use for directional felling in Sweden.

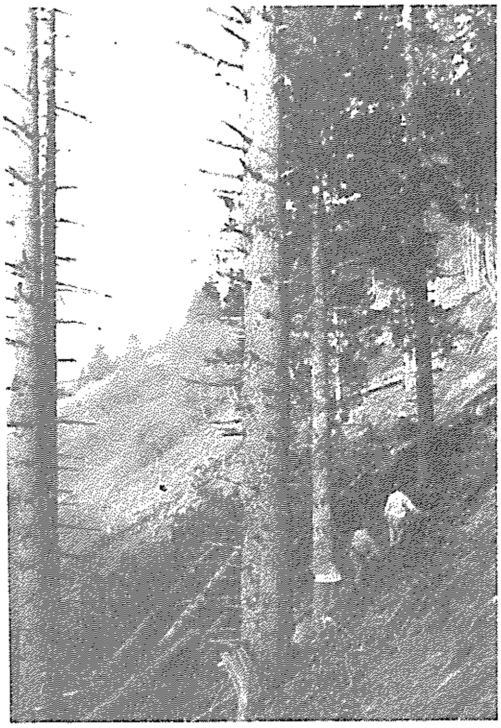


FIG.10 Cross-hill falling to suit cable extraction, Austria.

Photo courtesy M.Groben,
Coos Bay Timber Co.

FIG.11 Hydraulic jacks being used for uphill falling to avoid breakage. U.S.A.

on steeper terrain than is logged in N.Z., to reduce damage to valuable logs and improve cable extraction in many situations *(Figs. 10 & 11)*. They also cut to length at the stump. Safe techniques, good training, and extra incentives, made such operations feasible and no less dangerous than ordinary felling.

Analysis of the effect of tree shape and centre of gravity on requirements for felling have been made by O.S.U.[1] FERIC is currently working on the forces initiated when the tree starts to fall so that account can be taken of kickback and other forces that would affect the design of felling heads and their supporting carriers.

A variety of feller-bunchers are now commonly used throughout North America and Scandinavia. The latest variations of interest are:

(a) A felling head incorporating a rim saw with riveted chain. This unit, being developed by S.T.E., aims to improve utilisation by avoiding splitting and by cutting deeper into the stump. Any damaged teeth can be re-riveted in *(Fig. 12)*.

(b) Sweden has developed a long reach crane with a free rotating felling head for thinning up to 15 metres from a strip road *(Fig. 13)*.

(c) The Canadians have fitted a similar OSA felling head, and a Cranab knuckleboom crane on a F.M.C. skidder, the objective being to fell trees on steeper slopes. It is currently being studies by FERIC. In this system the stump gives support to the felling head thus taking strain and impact shock off the boom and carrier.

(d) Accumulating felling heads are being tested for use on small trees *(Fig. 14)*. Hydro-axe and Rome companies are two companies involved; the latter are also developing a continuous accumulating shear to fit a JD 544 skidder.

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[1] "Force Analysis of Directional Felling" by J. Robert McRae. An O.S.U. Thesis (Unpublished).

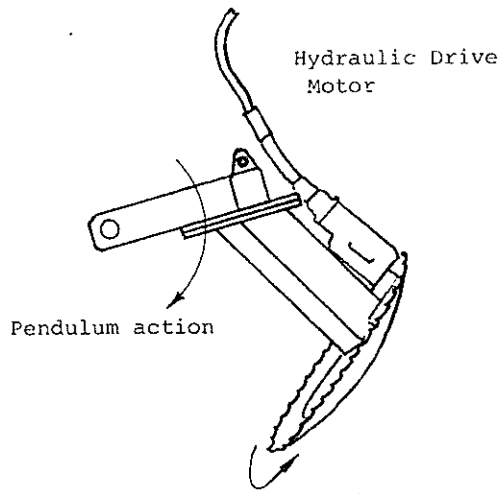
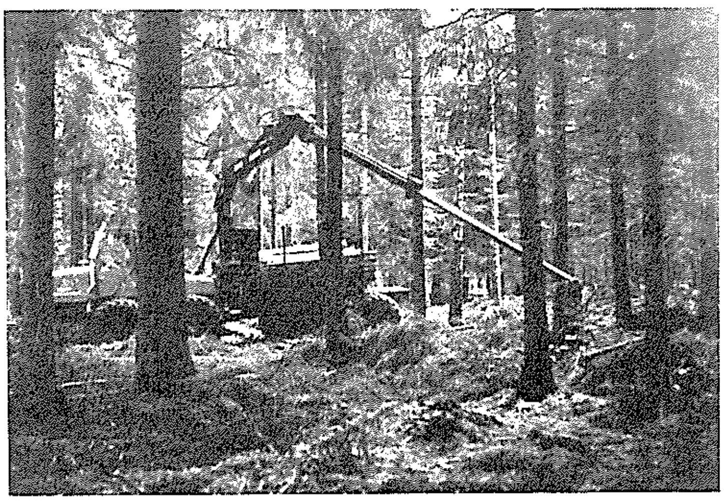


FIG.12 Diagram of Pendulum-type Rim saw, a Felling head under development at the Swedish Forest Products Research Laboratory.



(Skogsarbeten Photo)

FIG.13 Long Reach Crane and Felling head under development for thinning operations, Sweden.

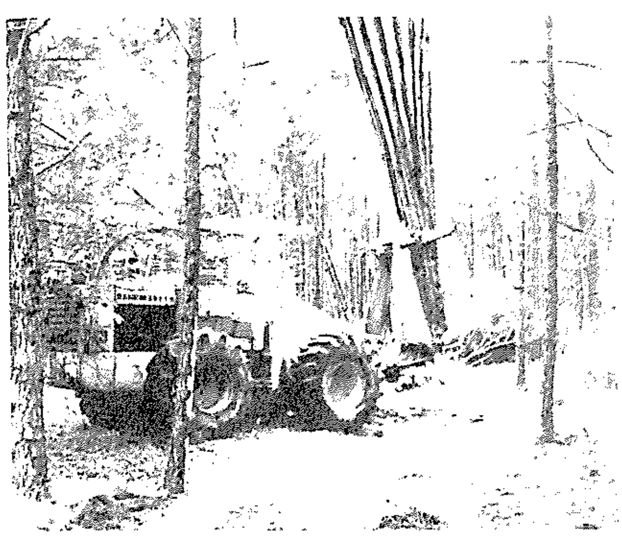


FIG.14 Rome accumulator shear on John Deere loader row thinning small pine stems, Southern U.S.A.

3.4.2 DELIMBING:

Probably one of the most widely used and successful stripper-type delimbers that can be used at the felling face or landing is the Kockums Logma *(Fig. 15)*. It, in common with many other Scandinavian machines, is on a modified forwarder carrier. One Logma seen worked effectively in heavily limbed spruce with branch diameters up to 6 cm diameter and occasionally up to 12 cm. This delimber worked from the head and many branches were broken out rather than cut and quite a lot of bark was also stripped. They are considered very reliable; apparently of the 300 of these machines produced only three are not working.

Many research and development personnel are aware of the limits to development possible with single stem delimbing and thus there is considerable interest and development centred around various applications of "batch" delimbing. In most cases it is recognised that you may have to forego a measure of limbing quality in the interests of productivity.

(a) The simplest (and cheapest) are variations of the gate delimber principle whereby a turn of logs is either pulled or pushed through a grid of bars to partially delimb from 3-10 trees simultaneously *(Fig. 16)*.

(b) Chain flails, because of the simplicity of design, mobility, and relative cheapness, are attractive even if problems continue with chain wear and delimbing quality. In Sweden, Skogsarbeten, A.B.Construction Co., and Nordfor, have been working on mounting flails on forwarders to avoid the dirt problem and reduce chain wear. Horizontal and vertical flails, some of which can be moved over logs as they are loaded onto a forwarder, are being experimented with *(Fig. 17)*. S.T.E. are working on small-diameter chain delimbing, aiming at removing small material (leaves, twigs and small limbs) prior to conversion to whole tree chips.

    Canadian flails have been primarily located at the landing because of the difficulty of getting stability with the flailing machine in the woods due to pockety muskeg and peat soils. However, as they consider skidder machine productivity drops off up to 30% with untrimmed wood, the Canadians are currently experimenting with boom mounted flails on more stable carriers.

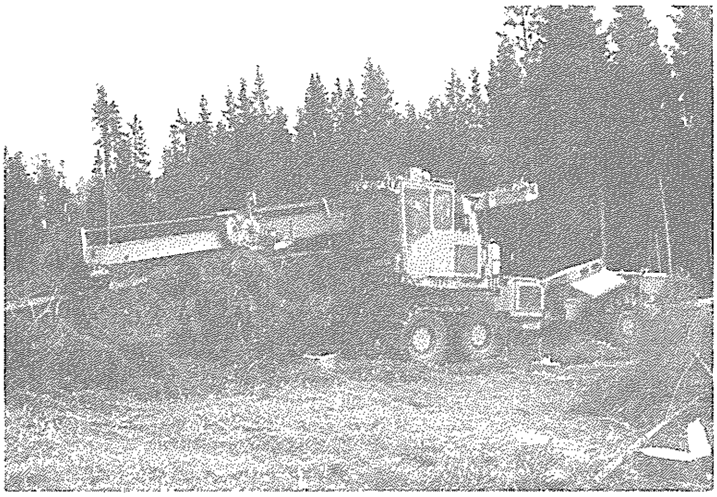


FIG.15 Logma Delimber, Sweden.

FIG.16 A simple "Gate" delimber, Southern U.S.A.

(Skogsarbeten Photo)

FIG.17 Experimental Forwarder-mounted Flail delimber in thinnings, Sweden.

(c) Batch delimbing was effective with spiral blade "Bear pit" delimbers in the north of Sweden but the system was dropped because of the problems of reduced load capacity of the full tree forwarding or skidding. Currently the Swedes are studying devices for compacting tops and branches to reduce this effect. Weyerhaeuser in the southern U.S. consider multiple-stem delimbing in a mill drum debarker *(Figs.1 & 2)* was successful in giving cleaner chips and a side benefit was a massive increment in hog fuel. They are overcoming the in-woods problem by designing trucks especially for transport of whole tree material where otherwise conventional truck loads were reduced 25%.

3.4.3 PROCESSORS AND HARVESTERS:

The Swedes and the Finns both predict a swing to harvesters and other multi-function machines which currently process only about 10% of the cut. Their logic is based on the fact that only one chassis is required and thus the total capital requirement is much less. In their environment such single unit systems are more suited to contractors who have to frequently log small farm-forest settings. The Finns consider that by 1984 machines like the Pika and Valmet harvesters will handle 60% of the cut. They expect 60% mechanical availability with such multi-function machines compared to about 70% with single purpose units.

The following are samples of units seen in operation:

- The Norwegian Stange processor designed by NISK is mounted on a Massey Ferguson 70 hp tractor *(Fig. 18)*. Its boom reach and clamp enabled it to pick up trees extracted to the roadside, feed these rapidly through belt delimbing knives and cut to pre-selected short lengths by saw. In small material it could process multiple logs and processed 16-18 m^3 per day in smaller logs.

- The Allen-Jarck harvester in the Southern U.S. fells, delimbs, cuts to length and bunches

HARVESTING MACHINES

FIG.18 Norwegian Roadside Processor designed as accessory to an agricultural tractor.

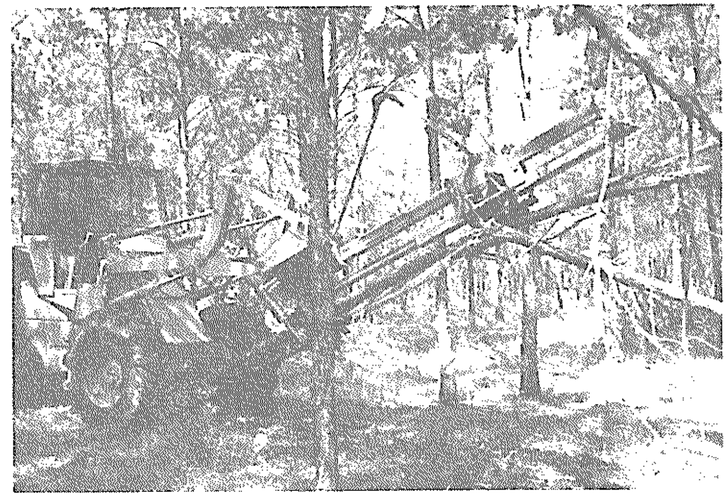


FIG.19 Allen-Jarck Harvester mounted on Case W 14 loader. Southern U.S.A.

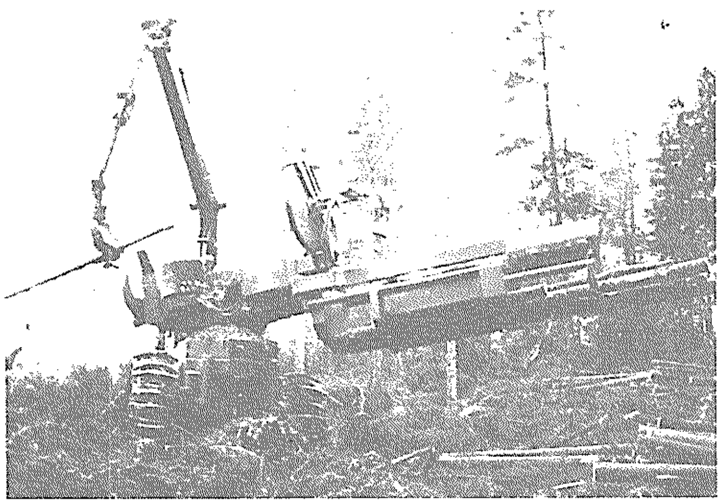


FIG.20 Valmet 448 Processor segregating sawlogs and pulplogs, Central Finland.

FIG.21 Franz Meinhof Co. in-line processor operating on a narrow contour road, Leoben, Austria.

small trees up to 32 cm diameter. It is a fast lightweight machine with good limbing quality mounted on a Case W14 front-end loader that bunches 5 ft pulpwood for forwarding *(Fig. 19)*.

- The Valmet 448 Processor was operating on medium size trees on very rough terrain near Tampere, Finland *(Fig. 20)*. The machine, on a standard forwarder chassis, uses a standard Cranab knuckleboom to feed logs to the processing unit. The machine delimbs, cuts to length, and segregates pulpwood and sawlogs automatically to a programme set by the operator, who is occupied mainly with the knuckleboom feeding function. The pulpwood bundles and sawlogs are later forwarded to the roadside separately. The control cab of this unit resembled a jet aircraft's and the layout was organised for maximum comfort and simplicity of operation by the operator. (At a later stage a Finnish Lokomo 961S harvester was seen under construction; the massive wiring and hydraulic reticulation systems confirmed the jet aircraft impression.)

- Most processors operate across the chassis, a procedure not suitable for operating on steep contour roads. Austria's Franz Meinhof Company has developed a roadside in-line processor for operation on steep terrain *(Fig.21)*. The unit seen had two operators, one for delimbing, the other for cutting to length and it processed material butt-first giving good delimbing quality and easy prime sawlog selection cuts. Logs dumped on the contour road in front of it were processed into piles behind it for loading by self-load truck and pup-trailer units.

Two harvesters not seen, but studied and considered to be among the best by the Canadians, were:

- The John Deere 743 which is one of the more reliable of the tree-length harvesters. Fifteen to twenty are working and they are reasonably simple to maintain and train operators. Main disadvantage is a lack of bunching ability. They are capable of felling and delimbing about 80 trees per hour.

- The Koehring short-wood harvester. This actually performs better and produces wood cheaper than anything else in the area, but there is a great variation in productivity between companies using them depending on the efficiency of their management.

3.4.4 DAMAGE INCURRED IN MECHANICAL HANDLING OF WOOD:

In Sweden, S.T.E. have done extensive work on forces required and damage involved in shearing and in force feeding of logs. They are active in development of machinery to avoid or lessen such damage. They have investigated vertical side shearing of stumps, disc-type shears, saws in felling heads and rim-saw discs.

S.T.E.'s work on power and knife shape requirements for delimbing have identified the importance of knife angle and the fact that in shearing from the top more force is required and that the knife often acts as a wedge to break out limbs.

Damage from delimber feed rollers has some importance to sawlog and peeler recovery - more significant than actual physical damage though is the introduction of blue stain into the wounds. They are currently experimenting with ribbed and rubber-lined feed rollers to reduce this damage.

3.4.5 OPTIMISATION OF WOOD HANDLING:

One large U.S. Company's Raw Materials research group have analysed all aspects of log handling and have come to the conclusion that most profit improvement can be made by improved control of log cutting and quality selection. A comparison of actual measured field bucking to length with the theoretical best merchandising possible from the measured specification of these logs have convinced them that if bucking and selection decisions are made in a cleaner environment, closer to the mill quality control than in the woods, a very significant improvement in profits is possible. Technical equipment to automatically measure length, diameter, and sweep is available. Thus if defects can be made visible to an operator in control of a computerised bank of slash saws, dramatic improvements are possible. This company is working on the development of such a "merchandiser".

3.5 EXTRACTION AND TRANSPORTATION.

3.5.1 FORWARDERS:

Forwarder development in Scandinavia possibly parallels skidder development in North America and both systems are now at a mature stage of development i.e. nearly all of the mechanical design problems solved and the systems working effectively in their respective environments. One can only speculate why the two regions differ in this primary log extraction phase.

Possibly the main reasons behind forwarder development in Scandinavia are partially because traditionally short-wood logging systems have dominated and, probably more importantly, the very rough boulder-strewn surface of the terrain has made assembling and skidding of long logs difficult and caused much breakage. The high proportion of farm-forests has meant that a forwarder contractor in Finland with one machine could extract and load or stack on-ride logs felled and prepared by a forest farmer. In North America, the region where forwarders have developed most is in the small pulpwood operations of the South where they have replaced a traditional short wood system - the bob-tailed truck - to some extent *(Fig. 22)*.

The basic forwarder unit of Scandinavia is now considered a very rugged and reliable unit and it can certainly negotiate very difficult ground conditions. A high level of skill in their use has been developed through operator training in courses run by the employing organisations, but also because the manufacturers normally give one to two weeks of intensified training on operation and maintenance to operators particularly from the smaller organisations. As forwarder operators normally in isolation from other forest workers it is notable that the forwarders have very comfortable, well-designed cabs, often equipped with cassette-radios, and that the operators are trained to do a high percentage of the maintenance themselves, in particular replacement of hydraulic fittings which could otherwise cause excessive downtime. On most operating cycles, forwarders spend 50% of the time either loading or unloading so that efficient crane operation is essential for effectiveness.

Forwarders would appear to have limited application to the tree length systems normal to clear-felling in N.Z. However, providing that proper training was given and that they were fitted into a short length system that integrated extraction and loading by forwarder with a trucking system based on short wood trucks and pre-load trailers *(Fig. 23)*, they might have some application in thinning where tree damage by long length extraction causes concern.

The available Scandinavian machines were compared in a Skogsarbeten publication[1].

Clam Bunk Skidders

A more recent development that would have application on high production jobs in N.Z. has been the clam bunk skidder. These articulated 4 or 6 wheel drive machines are fitted with a pedestal mounted knuckleboom crane and a grapple bunk. They have a large payload capacity for full tree or tree length skidding and providing trees are pre-bunched so that loading time is reduced, their productivity is very high. The low chassis height and forward placing of the clam bunk makes a much better weight distribution than is possible with wheeled skidders and thus they are reported to have better performance on slopes and soft ground than skidders. *(Fig. 24)*

3.5.2 CABLE SYSTEMS:

Cable logging systems present a wide variety of technical options for extraction of logs from difficult, particularly steep terrain and for reducing damage to soil and vegetation. As logs produced by cable systems have been generally more expensive and a higher level of operation and supervision skill has been necessary, most management to date have opted for skidders, tractors or forwarders wherever they could be used. Currently however throughout the world, there is recognition of the need to develop better cable systems because of the necessity

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1 "Forwarders - A Review" Skogsarbeten Teknik 2E, 1976.

FIG.22 Pulpwood Forwarder, Southern U.S.A.

FIG.23 Pulpwood Trailer for Forwarder System.

FIG.24 Valmet 882K Clam-bunk Skidder.

for working on steeper terrain than before and because of the environmental concerns over damage to soil, water, and scenic values. The opportunity was taken to inspect some recent developments.

(a) High Lead Systems.

Easiest to rig, and most commonly used system to date in the Pacific Northwest, high lead has lost favour in some quarters because of the close road network required. Road construction is the major source of soil damage in the Northwest and roading costs are rising more rapidly than hauling costs. Recent studies by FERIC have indicated that if all costs are taken into account it may be the most expensive way to log in the B.C. coastal areas.

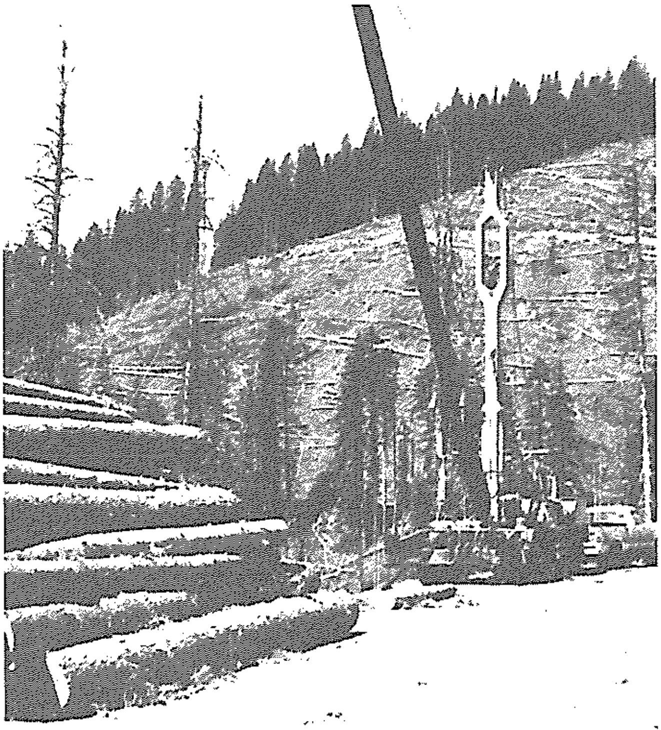
A traditional high lead machine in the interior of the Western States where smaller trees have been the rule is the Idaho Jammer *(Fig. 25)*. The basic drum sets, manufacturered by American Machine Co. of Spokane, Washington, are mounted on a variety of trucks on which individual contractors have constructed a supported swinging spar. The units are relatively cheap and effective for short distance yarding and decking of logs on contour roads. The close spacing of roads, at about 125 m. apart, has brought the system into disrepute in some areas. Because of their lower cost, jammer systems would have some application in N.Z. where roading is relatively easy and production requirements are not high.

(b) Gravity System.

Cable-crane gravity extraction systems have traditionally been used in the Central Montane area of Europe. They are mostly steep (more than 20° of slope), long distance, tightly tensioned fixed skylines. Loads are yarded to a carriage which locks on the skyline *(Fig. 26)* and is then lowered by gravity under control of a single-drum winch with a fan brake. The system has not been favoured in North America or New Zealand because of the high proportion of skilled rigging time and generally low productivity.

FIG.25 "Idaho Jammer" an inexpensive high lead machine for short distance hauling off contour roads.

(Photo courtesy P. O'Sullivan.)



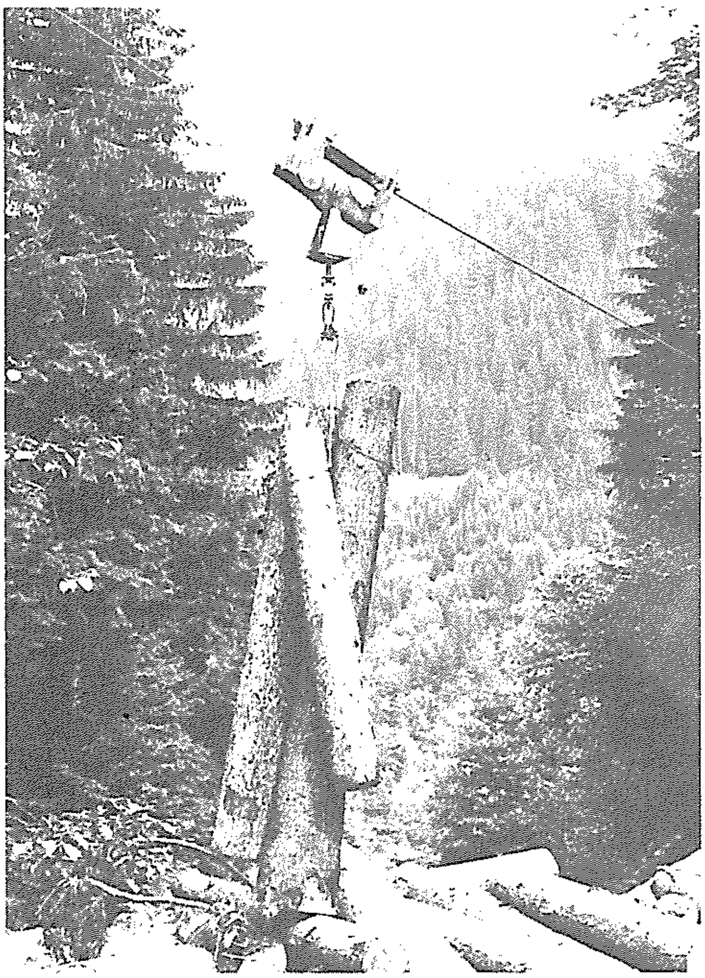


FIG.26 Koller locking carriage being used with a gravity skyline system.

Gravity return or "Shotgun" uphill live-skyline logging systems whereby only two operating drums are required and the carriage is returned by gravity are being increasingly used in both the Pacific Northwest and Austria. They are of two types. In the first, a simple carriage heavy enough to return the butt-rigging at speed has the chokers attached to it. With the second, which has considerably more flexibility and application for selection logging and thinning, a self-locking carriage is used which enables the hauling rope to be pulled some distance to the side *(Fig. 27)*.

Comparative studies of gravity systems and high lead using the same types of haulers have indicated that higher production can be achieved on steep uphill hauls by the former providing that there is sufficient clearance to allow the carriage to return unimpeded to the back spar or stump. Some care has to be exercised that the system in not overloaded as more tension on the spar and back-guys can be applied with this system.

Gravity return systems with the correct type of carriage have potential in N.Z. particularly for indigenous selection logging and exotic thinning. A wide range of basically high lead haulers can be used for the system. In the Pacific Northwest of the U.S.A. a range of haulers from converted Bantam Cranes to large Madills are used. In Austria Urus, Koller and other makes of mobile steel spar yarders were used with both locking and simple carriages. - *A pre-requisite for the application of such systems in New Zealand would be reduced landing size and changed methods of log-handling at the landing.* -

(c) <u>Running Skylines with Interlock Haulers</u>.

Running skyline systems, whereby the tail-rope acts as both skyline and haulback, present opportunities for more efficient cable hauling over extended distances and a wide variety of terrain. Three-drum haulers incorporating interlock systems harmonize the inhaul and outhaul rope speeds and maintain tension, and thus lift,

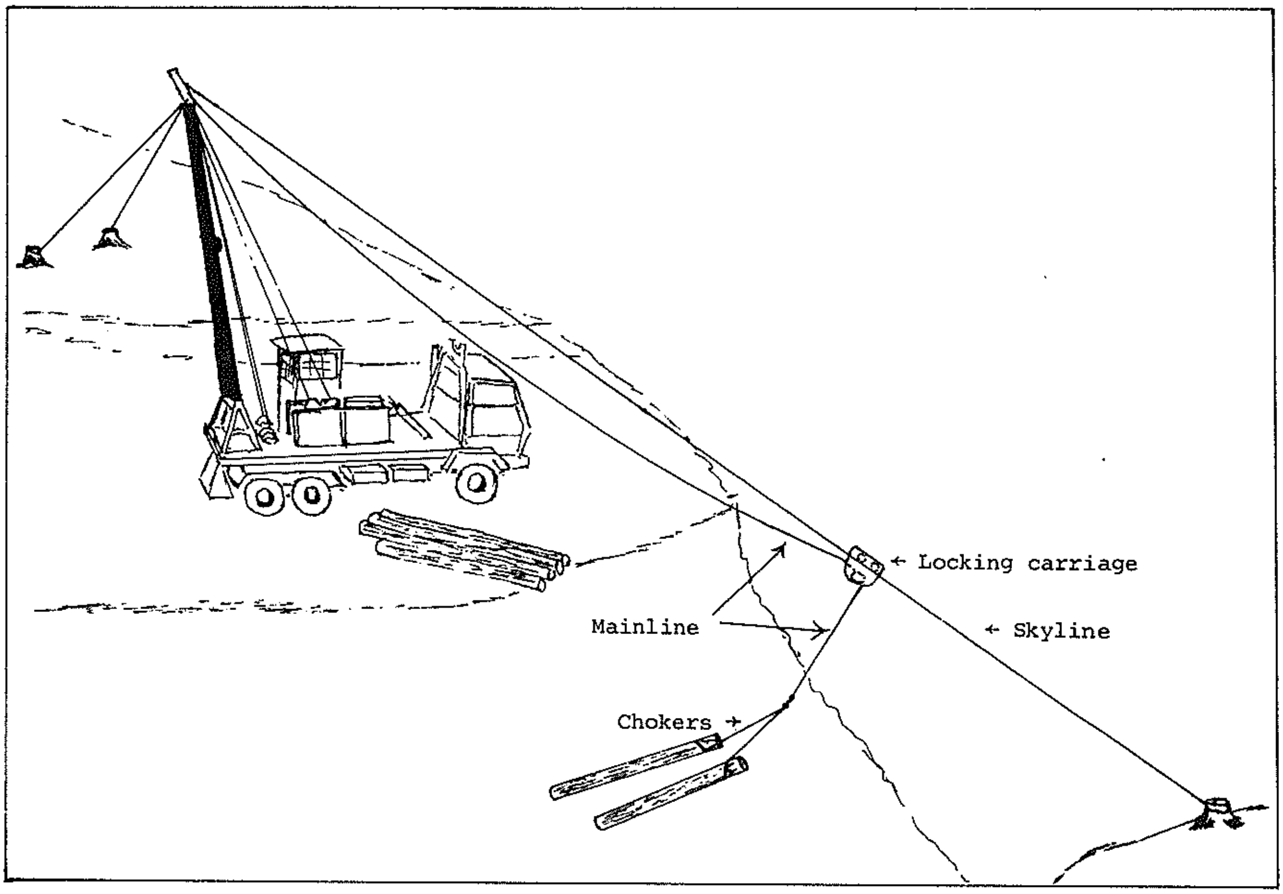


FIG.27 Live Skyline - Gravity return (Shotgun) system.

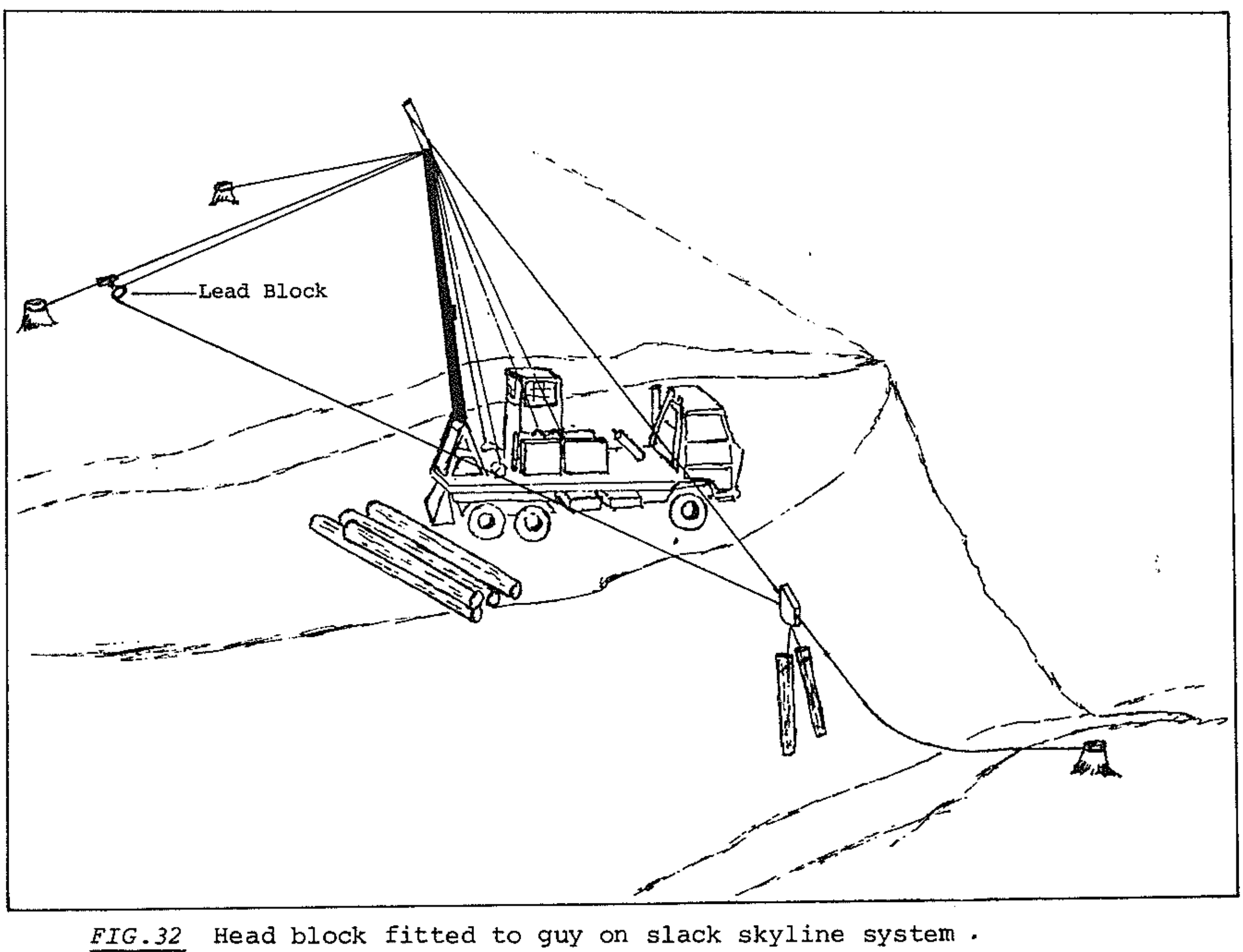
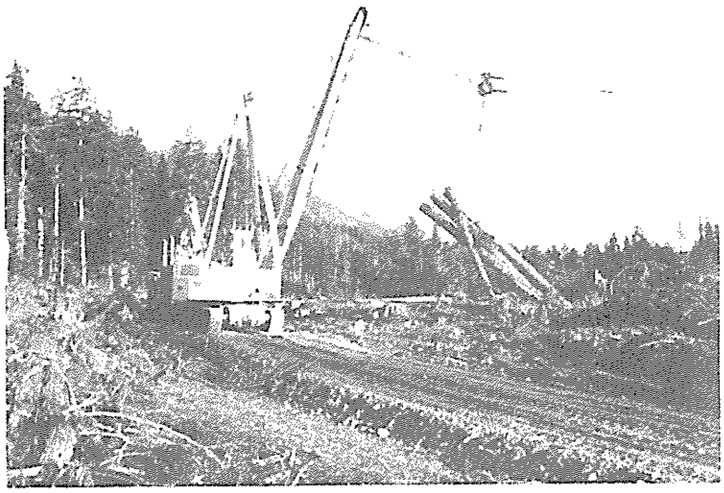


FIG.32 Head block fitted to guy on slack skyline system . allows logs to be stacked on road.

on the running rigging and enable a great efficiency of operation with running skyline systems. About 10 years ago running skylines were introduced with grapple yarding to the Pacific Northwest and this system has proved very efficient given well planned settings and trained crews. Night operations are possible. More recently the use of slack-pulling carriages has increased the system's flexibility particularly when carrying out partial cuts and very high productivity has been recorded. (One contractor operating an interlock yarder is regularly producing 500-700 logs per day in clear-cutting - *Fig. 28*.) Pre-rigged tail-spars, bunching hooks, and pre-set chokers are the key to his productivity which of course is necessary to offset the $450,000 capital cost of the hauler.

Such heavy, high-powered, expensive equipment is primarily restricted to situations mainly in the larger timber with constant high production requirements. The problem has been to design a cheap interlock hauler for logging smaller low value logs. Some of the current developments are:

- In Germany, H.P.C. Company in Augsburg, a small factory not previously involved in logging, with assistance from Munich University Forest Engineering staff, are developing an interlock yarder and spar designed for mounting on a skidder or agricultural tractor of 85 hp. This "KMH Seilkran" incorporates a hydraulically operated interlock system manufacturer from standard hydraulic and mechanical components and thus is expected to cost about 120,000 Deutchmarks *(NZ$54,300)*. It is primarily designed for thinning with a maximum 300 m. haul distance and 4½ tonne lift. The prototype will be tested this year.
- The U.S.D.A. Forest Engineering Section in Seattle have already conducted trials with their new "Pee Wee" yarder. This machine is an interlock running skyline mounted on and powered by a 110 hp John Deere JD640 skidder *(Fig. 29)*. A cleanly designed 3-drum unit with no clutches,



(Photo - U.S.D.A.Seattle)

FIG.28 Herman Bros. Contractors - Washington Skylock 118 Yarder operating in clear-felling Olympic Peninsula 500-700 pieces per day.

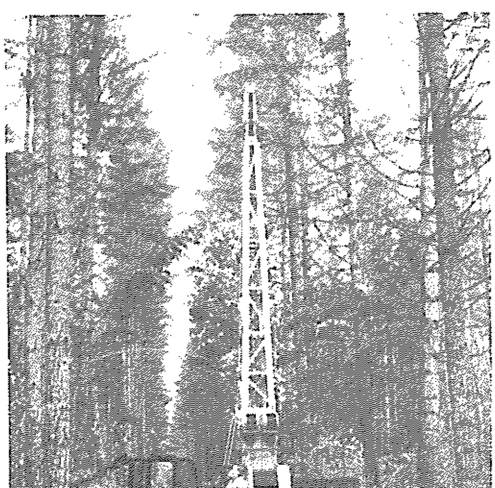


FIG.29 "Pee Wee" hydraulic mobile yarder undergoing trials - U.S.D.A., Seattle.

brakes or air controls, it is operated by standard hydraulic motors driving each of the three drums and a planetary system that allows speed changes in each drum. The two level controls are simple and positive; one moves the carriage in or out, the other moves the drop line in or out and decreases or increases tension. The unit is designed for 360 m. hauls and was expected to cost U.S.$100,000 but it may be difficult to maintain this price.

(d) Multiple Span Systems.

Rigging of downhill multi-span systems for gravity skylines such as the Wyssen, which has been used in N.Z., necessitated high hangers to give clearance over the whole length of skyline and thus has usually required short log extraction. Rigging time for such systems can take from two to four days and wood cost has been consequently high. This experience, plus difficulties anticipated in the rigging of hangers, and a lack of carriages that can pass them easily has prevented wide use of multiple-span systems except in Europe and Japan. Lack of "clearance" for conventional systems has meant that cable hauling possibilities in convex terrain have been avoided. To get "clearance" over the edge of landings, high spars and more expensive haulers have been used, and in the case of thinnings and small wood logging, this has contributed to the high costs of such operations.

O.S.U. have experimented with uphill intermediate support systems in Douglas fir thinnings over the past two years and proved that support trees rigged at about 40 ft give sufficient clearance to haul tree-length logs and that hanger rigging can be simple taking about 10 minutes on prepared trees. Light haulers such as the Igland Alp can be used with such systems and if hangers are rigged at the approach to a landing *(Fig. 30)*, high spars are not necessary to adequately deck logs on the landing. Open-sided skyline carriages can pass successfully over the hanger at a wide range of vertical angles. Use of such

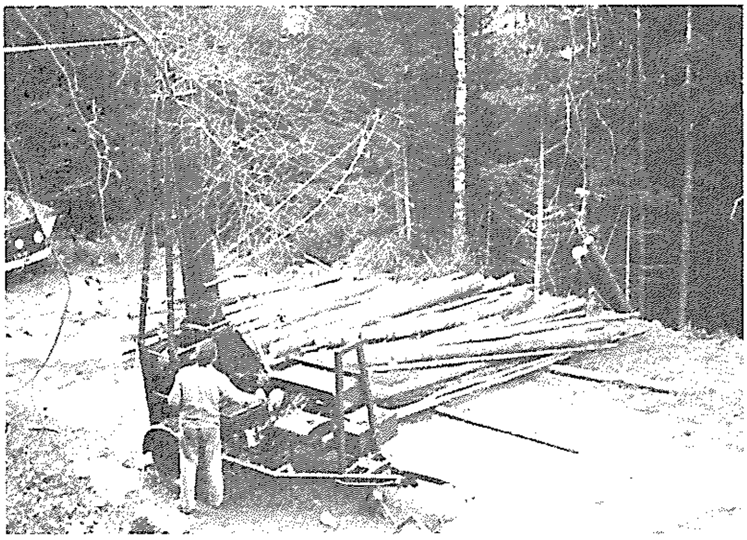


FIG.30 Mini-Urus Trailer mounted hauler with hanger rigged at landing lip to give lift. Austria.

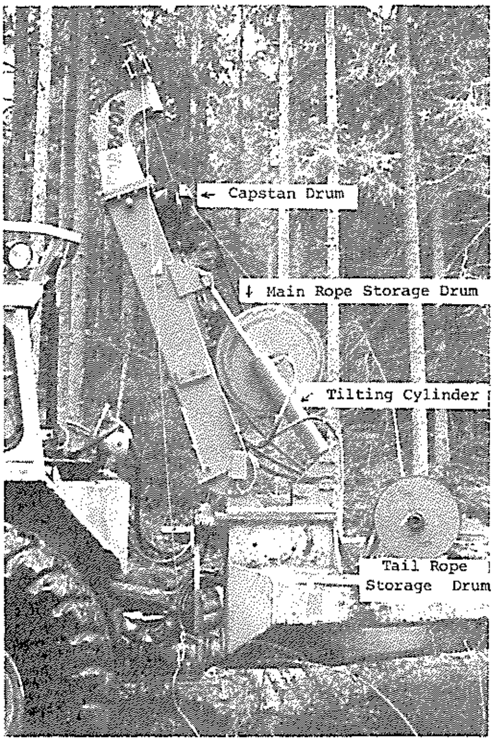


FIG.31 Nordfor "Tilt Winch" with hydraulic capstan drum and storage drums. Thinning small logs. Sweden.

multi-spars would have applications for cable systems in N.Z. and allow less powerful haulers and greater flexibility in skyline planning particularly in thinning.

(e) Pre-Haulers.

Small single-drum portable winches for assembling small wood to a roadside or track are reasonably common in Scandinavia particularly in farm-forests. They are frequently radio-controlled but the single drum means that the operator has to come to the roadside each time to retrieve the operating line.

Nordfor are developing a double-drum "Tilt" winch to overcome this problem *(Fig. 31)*. This winch can be mounted on any carrier with hydraulic power take off capacity. The laterial tilt capacity of the spar means that even with limited lift, logs can be piled at the roadside without fouling the back of the existing stack. The operator's radio control of this function enables him to avoid hangups to some extent on the inhaul. The unit is unique in that a hydraulically driven capstan drum of small dimension, on which the rope is wrapped five times, is the line pulling drum and rope is simply stored on the main drum without the usual rope fleeting problems associated with small spars.

(f) Austrian Haulers.

Austrian cable logging was characterised by small clear cut settings on very steep country. It had traditionally been done by cable cranes but over recent years mobile truck-mounted units with self-raising steel spars have been developed for operating off narrow contour roads. The Austrians have developed new approaches to the problems associated with such systems and equipment.

(1) The hauler is situated on the narrow contour roads, no landings are used. Thus logs are landed, and appear to stick, on the very steep slope dropping away from the road. No large

accumulation of logs is possible and they are removed by skidder to a process landing. Another option for handling logs at the roadside by fitting a lead block on a guy as shown in the diagram *(Fig. 32 Page 52)* advantage is that the generally short spars can get clearance to the back of the haul line and use of better carriages to assemble logs to the skyline is possible.

(2) All units seen were using two operating drums and a gravity-return tight skyline system.

(3) As this system set up greater stresses on the skyline than other two-drum systems (e.g. high lead), provision was made to clamp the skyline to the spar (mostly hydraulically) *(Fig. 33)* thus transferring the stress to the back guys rather than the drum.

(4) Final tightening of the skyline is often by using a split drum and shifting the rope to the small diameter section of the drum for tightening *(Fig. 34)*.

(5) In one machine, synchronisation of inhaul and outhaul rope speeds was achieved by using subsidiary grooved twin capstan drums of the same diameter on both main rope and tail rope drum sets, the primary drums being for rope storage, not for exerting pull. An automatically adjusted hydraulic device enabled them to be slipped to accommodate the varying speed requirements *(Fig. 35)*.

(6) Hauler construction was as far as possible based on readily available standard hydraulic and mechanical components.

(g) Skyline Carriages.

The carriage used is often the key to versatility and application of the skyline system and a wide variety of these exist throughout the world. Three types of relatively simple carriages that would have application in N.Z. are briefly described here.

AUSTRIAN TRUCK-MOUNTED MOBILE HAULER

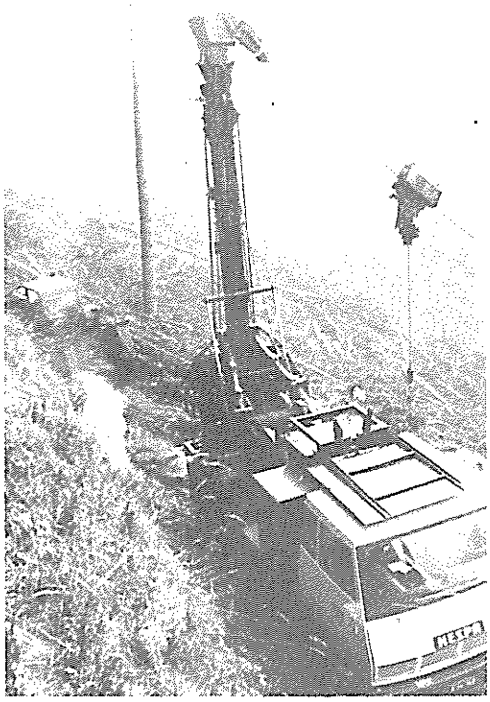


FIG.33 Urus Mobile Spar with hydraulic skyline clamp.

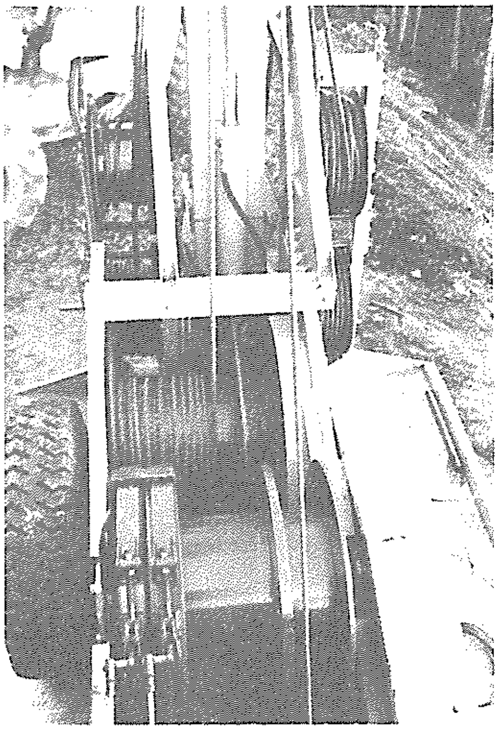


FIG.34 Split Skyline drum on Koller Mobile Spar.

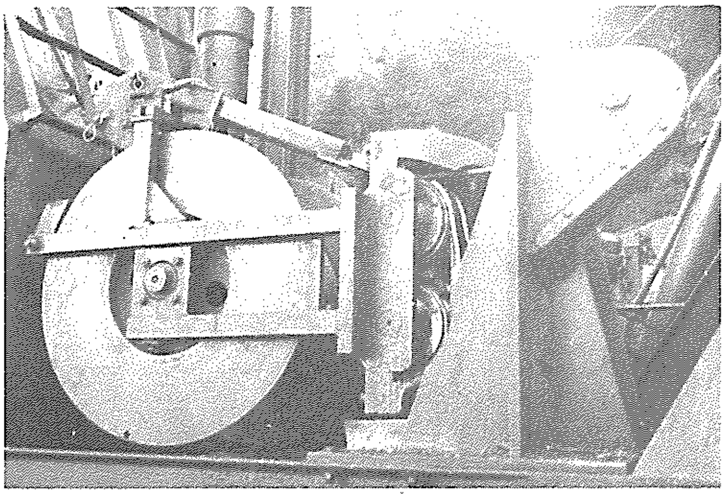


FIG.35 Grooved capstan drums and mainline storage drum on Franz-Meinhof hauler.

Increased effectiveness of gravity return skyline systems are possible if carriages which lock on the skyline and allow slack to be pulled out are used. U.S.A. carriages such as the Maki and Christie *(Fig. 36)* are activated by easily removable stops clamped on the skyline and would be particularly suitable for thinning or selection logging where control of breaking out to the skyline is essential to avoid damage.

Many carriages controlled remotely by either radio or hydraulic means are in operation, some of them are very heavy and expensive and thus of limited application. A carriage that meets criteria of versatility, lighter weight, and relatively simple operation, is the Austrian Koller carriage *(Fig. 37)* which can be used for gravity systems and uphill or downhill skylining. It has the ability to pass over intermediate supports (thus hauling on convex slopes is possible), is self-locking on the skyline (activated by reversing the haul rope), and has the ability to pay out slack on the drop line. It could have advantages in thinning on difficult terrain.

Running skyline systems used on yarders with interlock ability can be used in the widest range of conditions with relatively simple slack pulling carriages. The "West Coast" carriage has three drums on the one shaft. The centre drum spooling the drop line being operated by the relative movement of the two haul lines, one underwound and one overwound on the outside drums *(Fig. 38)*. Another simple carriage uses a separate sheave for a drop line which is attached to one of the haul lines *(Fig. 39)*.

It was notable that many Pacific Northwest loggers had more than one carriage readily available and they changed carriage to suit the different conditions imposed by terrain in each setting if necessary.

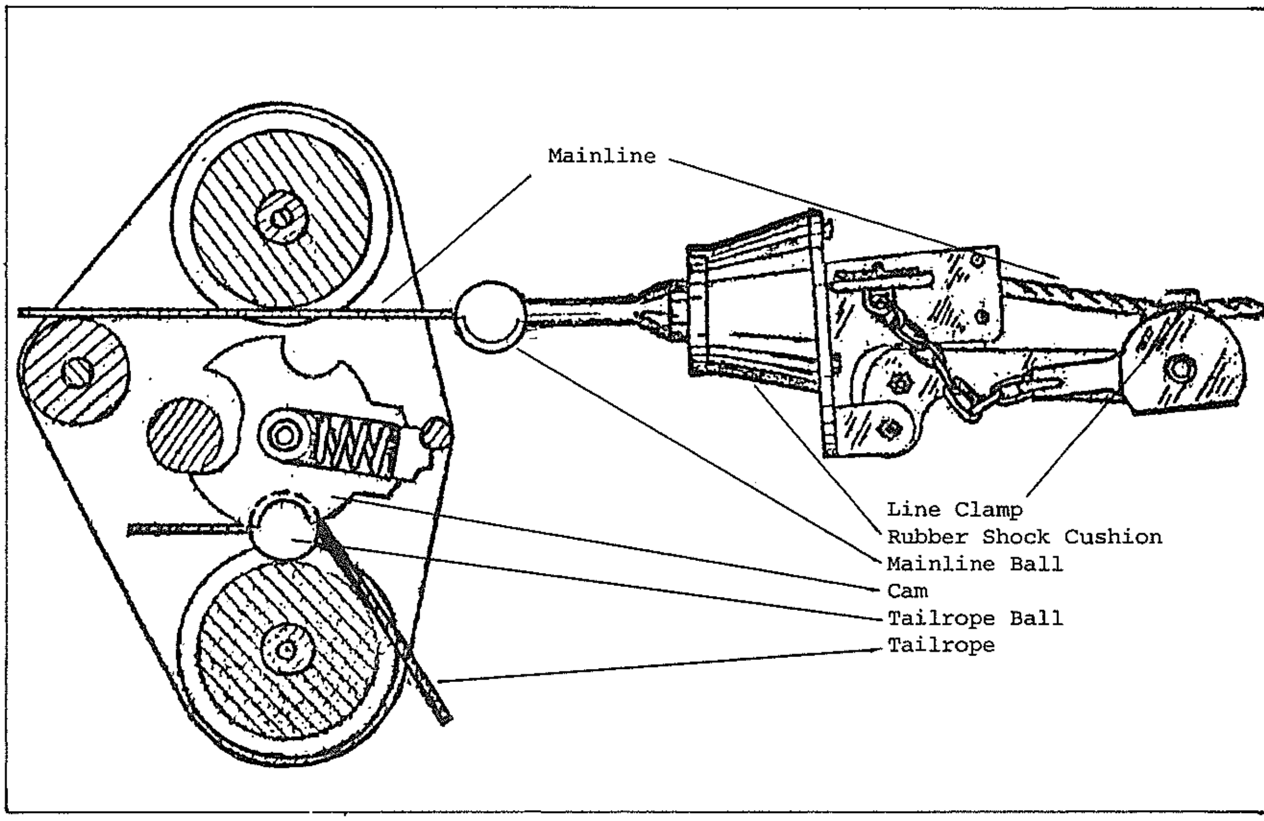


FIG.36 Christie Carriage

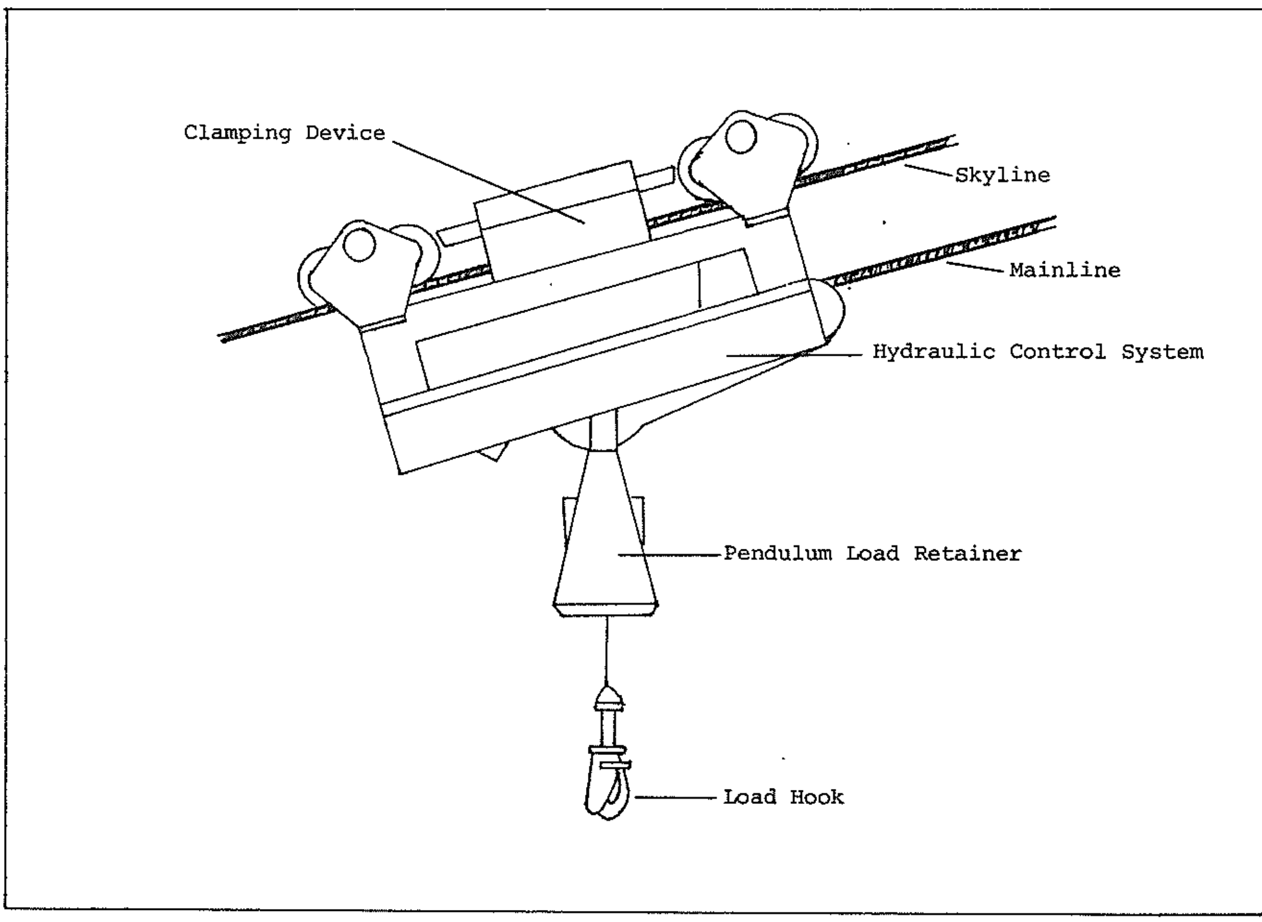


FIG.37 Koller Carriage

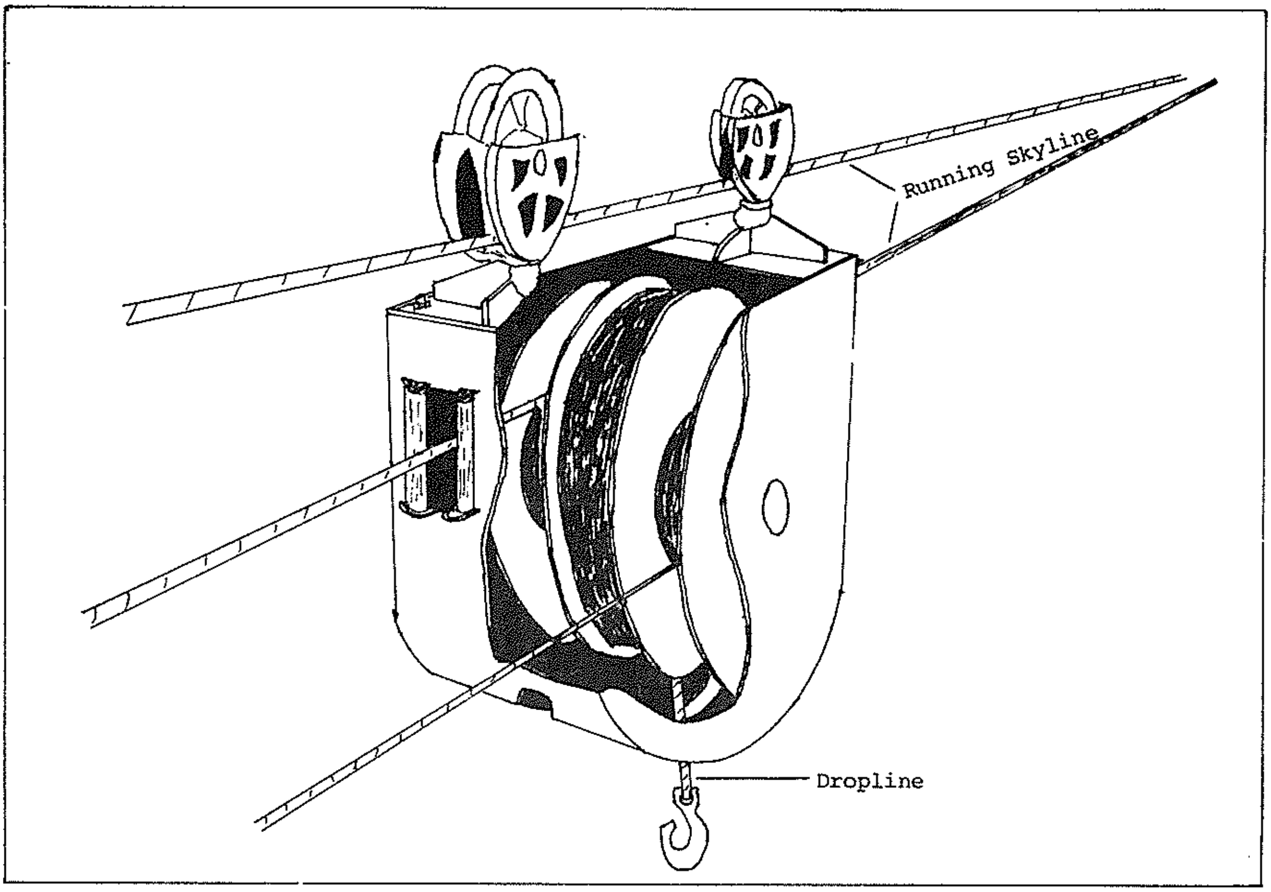


FIG.38 West Coast Carriage

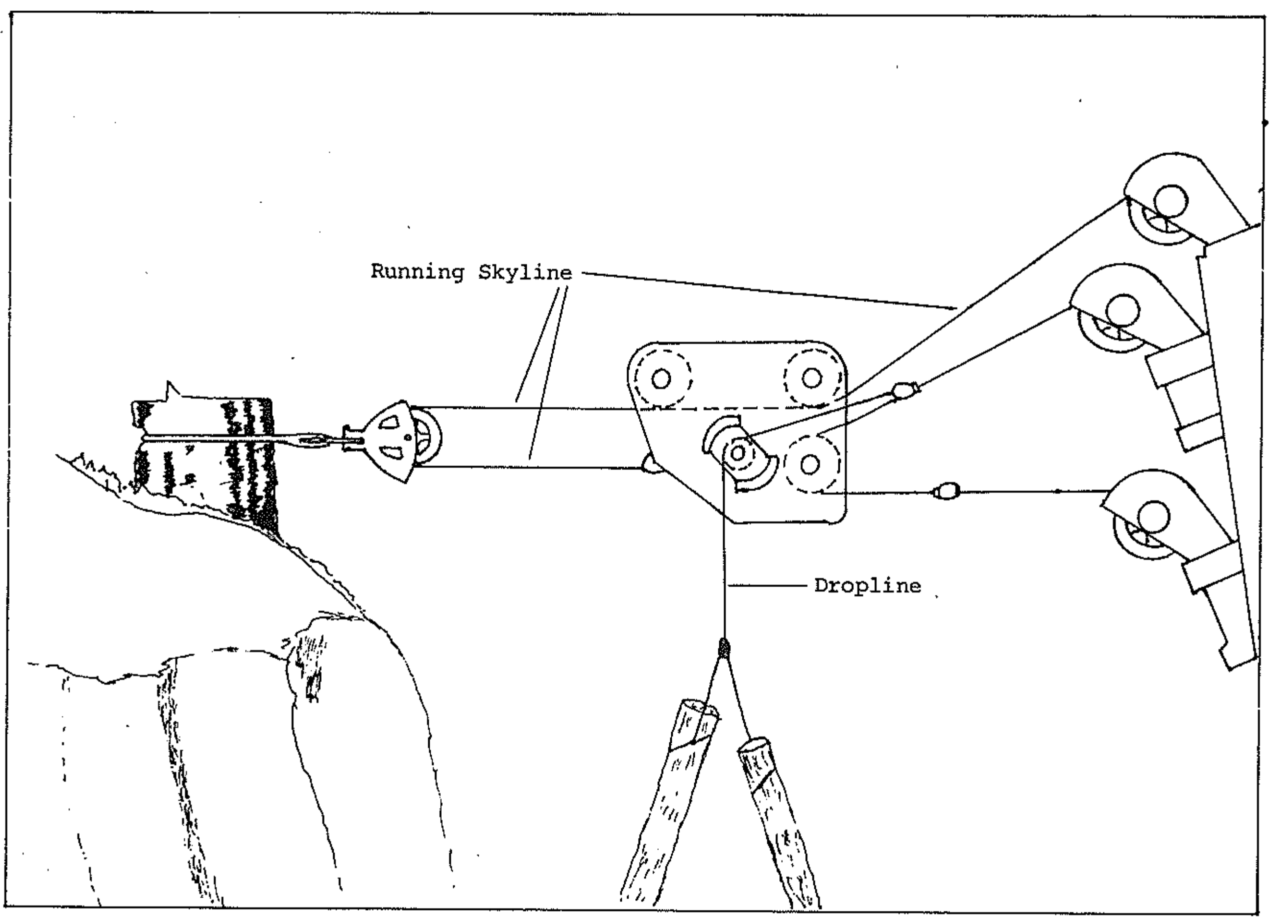


FIG.39 Slack throwing carriage

(h) Cable Hauling Studies and Research.

A wide range of studies comparing the effectiveness of skyline systems, high lead and aerial systems are being carried out in the Northwest particularly by FERIC and O.S.U. and to a lesser extent by U.B.C. and U.S.D.A. in Seattle. More basic studies on the tensions set up in the different systems during the hauling process have been done by Peters (O.S.U.), Jorgenson (Weyerhaeuser) and Daniel (FERIC). They are working on tower failures, geometry or skylines over intermediate supports, tensions in static lines, sheave sizes and the relationship of load, span, deflection and tension to stresses in running rigging. Much work is aimed at providing industry with simple means of calculating the effects of varying these factors and ensuring that the practice used is safe.

3.5.3 TRUCK TRANSPORTATION:

Although everybody recognises the importance of this phase of logging particularly in cost terms, it is considered to be at a mature stage in development and there is a paucity of new developments or research work.

The Norwegians are looking at trailer design for long length logging in steep country to improve tracking patterns and braking systems. This is aimed at convincing the highways department that loading is safe, control is better and techniques are safe. The type of self-loading trailer used *(Fig. 40)* means that pick-a-back trailer loading is not restricted by loader capacity.

Both N.I.S.K. and Weyerhaeuser are developing trailers with shapes designed to use with full tree logging if energy harvesting or full tree chipping at mills becomes possible.

Surprisingly Scandinavia, and especially Finland where the multi-lift system was developed, has given little attention to exploiting the possibilities of palletising or

FIG.40 Norwegian Self-loading truck and trailer unit equipped with knuckleboom and grapple.

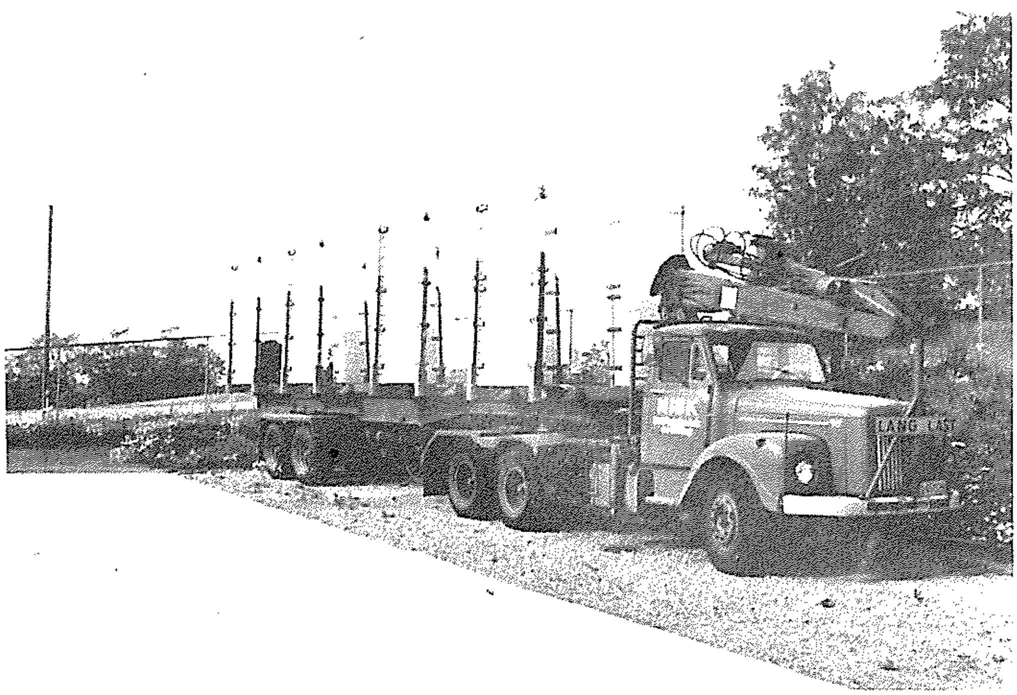


FIG.41 Trailer designed for cartage of whole trees, Norway.

pre-loading. Trucks in Scandinavia are mostly privately owned by small operators and many are leased by the companies at rates negotiated with the truckers' association. Contrary to expectations most are loaded by separate loaders and only the privately owned trucks operating over short distances are equipped with knuckleboom loaders. These mostly pick up their own wood at privately owned woodlots.

FERIC was the only organisation doing significant research and investigation in trucking. They consider that many short term improvements are possible in the maintenance and servicing area. They are also comparing truck costs with different types of trucks and have developed a methodology that would be applicable to LIRA.[1]

3.6 MAN AND WORK.

There is a dramatic difference in the status of research work in this area between the Scandinavians and the North Americans. The former considered that the human resource was the greatest unexploited resource and concentrated a high percentage of research effort on making work more effective and pleasant. Apart from manpower surveys and in-company training and safety schemes, the North Americans did little. The industry financiers of industrial research in particular seemed antagonistic to the principle of doing investigations that could place tools in the hands of their adversaries in the prevalent labour-management confrontation situation.

3.6.1 ERGONOMICS - THE PHYSIOLOGY AND PSYCHOLOGY OF WORK:

The Scandinavians aim to make people, labour and management, more effective in logging and

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1 "Logging Trucks - Comparison of Productivity and Costs" by D.G.Smith and P.P.Tse. FERIC Technical Report TR-18, 1977.

furthermore to develop the will to make a contribution to the organisation. They are therefore not only doing significant work in ergonomics but are deeply involved in the inter-related fields of physiology, psychology, payment for and organisation of work in the following areas:

- Psychological analysis of labour attitudes and motivations through questionnaire techniques have indicated areas for improvement in:

  1. Better machine design.
  2. Job rotation through broader training.
  3. Involvement in local decision making - tree selection, planning of strip roads, control plots, etc.
  4. Incorporating servicing with operating particularly on shift work.
  5. Using training systems to develop a team approach, interchangeability, basically equal payments, and mental as well as financial incentives.

- An ergonomic approach to design of machines and systems has resulted in:

  1. Identifying problems and potential breakdown areas early.
  2. Using an ergonomic check list where feasible as an aid to correction of design mistakes.
  3. Analysing near accidents particularly with new machines which enables corrective action with regard to guards, non-skid surfaces, etc., to be applied early.

- Physiological research and testing has improved productivity by:

  1. Examining capacity of workers by testing and identifying work areas for the partially disabled people (bad backs, hearing, age, etc.)
  2. Examining physiological and psychological stresses inherent in various work systems and developing suitable clothing and equipment for the work environment. This has been particularly emphasised in Finland.

3.6.2 SAFETY IN WORK ENVIRONMENT:

"Near accident" reporting is a technique that can be used to identify accident causes and take action on prevention at an early stage. The workers themselves are involved in this evaluation of sudden incidents that might have been an accident and provided they are properly briefed and only kept on it for short periods it is an effective tool for increasing awareness and revising poor methods.

W.E.A. in conjunction with the School of Technology in Helsinki are carrying out very sophisticated evaluations and testing of vibration in logging machines, particularly processors, where low frequency vibration badly affects human performance and concentration. They tape-record the vibrations on machines operating in the forest, then repeat the pattern in a mock-up cab in the laboratory where the operator's heart cardiograph, adrenalin level, blood pressure, urine content and head joggle can be monitored whilst his accuracy in operating the machine is measured. The results of this work will be used in improving machine design for operator comfort and concentration.

Comparative chainsaw kickback testing has been done by Skogshogskolan and S.T.E. in Sweden both of whom built rigs for this purpose. Results in the former generally indicated low profile chains were better. Omark Industries in U.S.A. do continuous testing of chains for quality control, fatigue, cutting effectiveness, life, and kickback characteristics. Their work, which indicated wide radius bars have more kickback violence than narrow profile bars which wear faster, has lead them into the development of uneven profile bars which have the best compromise of characteristics.

3.6.3 METHOD STUDIES AND PRODUCTION ANALYSIS:

Data collection, work measurement, method study and operational analysis are basic to research and development.

Skogsarbeten collects and coordinates this information at three levels and their principles are adopted in some other logging research institutions.

1. Secondary data on a broad scale collected by industry at source such as labour or machine inputs into various operations is coordinated and compiled by organisations such as Skogsarbeten and A.P.A. This type of information is necessary to check overall performance against the potential performance as indicated by studies.
2. Standardised plot data from a variety of typical stands is compiled so that performance of new machines and systems can be simulated using this data, and later field tested by production studies.
3. Detailed time study information measures everything for a period of two or three days particularly on the newest machines. This is normally kept confidential for a period to enable the manufacturer to make modifications. At its conclusion, the manufacturer, producer company, and research unit, examine the results and assess the implications of the developing machines and systems.

A universal aim of logging research should be to standardise systems of collection of data and thus develop studies on a uniform basis. Care has to be taken in use of averages in forestry work and to ensure the spread of stand data is used. Productivity tends to be linked to tree diameter in logging and a common 'rule of thumb' is that the productivity in cubic metres increases in proportion to increases in diameter squared.

Identification of the effect of measurable variables is often difficult in logging. FERIC for example considered detailed studies not overly useful in cable systems as nett cycle times could only account for 39% of the variation. Problems also exist in trying to get true replications of experimental studies in logging and thus intelligence analysis by experienced practitioners is often more valuable than detailed studies where major variables cannot be quantified.

PART IV

SUMMARY AND CONCLUSIONS

This report has outlined the structure and objectives of the Logging Research organisations of North America and Scandinavia indicating the main areas of research into tree harvesting. The social, geographic and economic factors that influence operations and research in these areas are also briefly indicated as it is necessary to have an appreciation of these factors in assessing whether local technologies can be imported to New Zealand.

Concepts of planning, systems and mechanisation are discussed and techniques useful in interpreting these concepts are described, the main conclusions being:-

1. That there are new techniques for tactical planning, option analysis, scheduling and simulation that have application in New Zealand primarily for the bigger industrial organisations.
2. Significant research and some trials of full tree utilisation and energy harvesting have been initiated in both Continents and the results of this work should be closely monitored.
3. The past decade's developments into full mechanisation have indicated limited gains with highly mechanised systems. Their

> introduction to this country must be carefully planned and they will not be successful unless the working environment is suitable and the operational management very efficient.

Some potential developments were seen that could have possibilities in New Zealand - although time was insufficient to properly assess them. They were:-

1. The use of directional felling to reduce damage, improve recovery and facilitate extraction. A felling bag to assist this in smaller trees appeared to have potential.
2. Multiple stem processing of smaller wood was considered necessary to keep costs of this element of mill supply down. Flail type developments in the forest and/or drum delimbing/debarking at the mill appeared to have most potential.
3. Investigations into optimisation of tree length cutting indicate that there is potential here for dramatic improvements where value differentials between log types is great and production is high. The technology exists for automated measurement of log form and computerised cutting at central log yards.
4. Improvements in extraction by cable logging could be effected by:
   a. Gravity return systems using locking carriages.
   b. Employing multiple span systems in conjunction with smaller haulers in thinning particularly on convex topography.

c. The use of running skylines with smaller interlock haulers.

Work on the human factors and the relationship of man to machines in Scandinavia indicated there was significant potential for improvement in logging operational efficiency by giving attention to human aspects.

It is emphasised that the report is by no means a complete coverage of the logging scene in the countries visited nor was there enough time to investigate any of the ideas suggested above thoroughly.

Major gains to LIRA and to the logging industry were:-

(a) The wide range of reference material collected and the future continuing access to much more of this material.

(b) The invaluable contacts made with the research organisations and their personnel who have a detailed knowledge of operations within their countries.

(c) An appreciation of the limitations of development within New Zealand and the value of constant intelligence gathering on overseas developments.

Copies of the Project Report are available to LIRA members as is access to the reference material collected. Extension of the knowledge gained to industry will be effected by:-

1. Publication of the report which indicates the scope of the study tour.
2. Presentation of illustrated talks at local

meetings of industry members throughout New Zealand.

3. Follow up research and development work in the priority areas suggested.

APPENDIX I

LIST OF ORGANISATIONS VISITED

(In order of visit sequence.)

U.S.D.A. Forest Service, Equipment Development Centre, San Dimas, California, U.S.A. (E.D.C.)	1 day
American Pulpwood Association, Southern Logging Operations, U.S.A. (A.P.A.)	2 days
L.S.U./M.S.U. Logging & Forestry Operations Centre, Bay St. Louis, Louisiana, U.S.A. (LSU/MSU)	1 day
American Pulpwood Association, Jackson, Mississippi, U.S.A. (A.P.A.)	1 day
Virginia Polytechnic Institute, Blacksburg, Virginia, U.S.A. (V.P.I.)	1 day
American Pulpwood Association, HQ, Washington, U.S.A. (A.P.A.)	1 day
U.S.D.A. Forest Service, Engineering Section, Washington, U.S.A. (U.S.F.S.)	1 day
Norwegian F.R.I. Experimental Operations, Hurdal, Norway. (N.I.S.K.)	2 days
Norwegian Forest Research Institute, Ås, Norway. (N.I.S.K.)	1 day
Skogsarbeten (Logging Research Foundation), Stockholm, Sweden. (Skogs)	2½ days
Skogshogskolan (Royal College of Forestry), Garpenburg, Sweden. (R.C.F.)	1 day
Swedish Forest Service Technical Section, Falun, Sweden. (S.F.S.)	1 day
Nordfor Company, Sater, Sweden	1 day
Swedish Forest Products Research Laboratory, Stockholm, Sweden. (S.T.E.)	1 day
Metsateho (Forest Work Study Section of the Central Association of Finnish Forest Industries), Helsinki, Finland. (Mets)	1½ days
Finnish Work Efficiency Association, Helsinki, Finland. (W.E.A.)	½ day
Valmet and Lokomo Machinery Companies, Tampere, Finland.	1 day

H.P.C. Company, Augsburg and Munich University, West Germany	1 day
Austrian Cable Logging with Koller Co., Kufstein, Austria.	2 days
Austrian Training Centre and Urus Operations, Ossiach, Austria (A.T.C.)	1 day
Franz Meinhof Company, Leoben, Austria.	1 day
Forest Engineering Research Institute of Canada, East, Montreal, P.Q., Canada. (FERIC)	2 days
Forest Management Institute of Canada, Ottawa, Canada. (F.M.I.)	1 day
Forest Engineering Research Institute of Canada, West, Vancouver, B.C. (FERIC)	1½ days
McMillan & Bloedel Operations, Squamish, British Columbia.	1 day
University of British Columbia, Vancouver, B.C. (U.B.C.)	1 day
U.S.D.A. Forest Engineering Laboratory, Seattle, U.S.A. (F.E.L.)	1 day
Peewee Yarder trials, Pack Forest, Washington, U.S.A.	1 day
Weyerhaeuser Company, Raw Materials Research Division, Tacoma, U.S.A. (Wey.)	1 day
Oregon State University, Corvallis, Oregon, U.S.A. (O.S.U.)	2 days
Omark Industries, Portland, Oregon, U.S.A.	1 day
Pacific Logging Congress, Vancouver, British Columbia. (P.L.C.)	2½ days.

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NOTE:

This list is only a selection of the most relevant reading from the many references collected during the study tour and now in the LIRA Library.

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