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(Research materials)

Cable Logging Systems in Japan

By

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Summary : Historical study of the cable logging systems in Japan is made briefly, and the structural and functional features of the Japanese cable logging systems are outlined. Then the cable logging systems of many types are classified into ten large groups according to structural and functional resemblances, and reviewed from the standpoints of operating efficiency and effect on the environment. Detailed explanations of the thirty-nine typical cable logging methods, including the ones applicable for the selective logging, are given with the aid of illustrations.

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1. Introduction

In Japan, the forest land covers about 25 million ha, equivalent to 68 percent of the total land area. According to a spot-sampling survey on a nation-wide scale, flat and gentle slope forest land occupies about 30 percent of the total forested area, and the remainder is more than 15° in gradiant. And major timber stands are largely distributed in the mountainous regions.

Consequently, the cable logging systems are more frequently and successfully used for hauling logs out of the forest than any other logging methods in our country.

Recently, the public demands for the conservation of natural environment and the preservation of scenic beauty in the mountainous areas have brought about a large technical evolution in logging methods as well as in road construction methods. The cable logging systems were seriously affected by the demands of the times, too, and have been highly improved. It can be said that the common opinion asserting that "cable-hauling systems inseparably connect with clear-cutting methods" has already become unwarranted.

The purposes of this paper are to take a general view of the history of cable logging systems in Japan, to classify them according to the structural resemblances, and to find a clue to more effective cable logging systems for reducing unfavorable impacts upon the forest environment.

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2. History

A steam skidder was introduced for the first time into Kiso Imperial Household Forest in Nagano from the United States in 1920. It was the Lidgerwood steam skidder equipped with five drums and of 17.5 tons in weight. First appearance of the huge machine must have given a great surprise to the timbermen of the Kiso forest, because at the time in Japan logs were transported all by man-power, by chutes, or by water. Under the supervision of the Imperial Household Bureau, the first interlocking skidder was set up after much trouble and operated with much effort in early summer of 1920.

In 1921, after the American skidder was used in Formosan forests, the first three steam skidders called "Tsunashima skidder" were manufactured by an iron workshop in Tokyo. The Japanese-made three-drum skidders were designed by Masakichi Tsunashima who was the forest engineer of the national forest. They were put into operation in Noshiro national forest in Akita, Umaji national forest in Kochi, and Kiso forest, respectively. As for the cable logging system, the Lidgerwood interlocking system was mainly used in those days, and occasionally the highlead system was employed.

Subsequently, a Clyde gas engine equipped with four drums was imported also from America into Kiso forest together with the MacFalene slack-line system in 1928. Two years later, in 1930, modifying the Clyde gasoline skidder, Morito Works in Kawaguchi began to produce the so-called "Kiso-type gasoline skidder".

Since then, the use of the cable logging methods was extended gradually to large-scale logging sites in the national forest and the Imperial Household forest. The steam skidders

were replaced by the more efficient gasoline yarders, and the downhill North Bend system and the Tyler system developed into the typical skyline systems.

In 1930's, yarders were gradually remodeled to small-sized but high-powered ones, and carriages, blocks and miscellaneous wire-rope equipment were considerably improved.

During World War II, however, the development of cable logging techniques was retarded because of the shortage of materials. After the war, as steady progress in the forest mechanization was made, the cable logging techniques also took another step forward, and fullscale production of cable logging equipment was resumed. In 1964, Iwate-Fuji Industrial Co. began to manufacture Y-type yarders, which have become the most popular yarder in the national forest.

A new skyline system named the "Kumamoto system" shown in Fig. 13 was designed and first used in Kikuchi national forest in Kumamoto with great success in 1951[155)291)]. In the same year, the Wyssen skyline crane, which had been successfully used in European countries centered in Switzerland, was introduced to Japan[4)6)150)]. The new skyline crane was tested on a steep terrain in Kiso national forest immediately, but satisfactory results were not obtained. The reason for this was that it very difficult to transport the machine to the upper end of the yarding road, because the forest roads were usually located at the bottom of the valley.

After 1959, the light two-drum yarders which weigh 500～1,000 kg became popular, and they were used where the skidding distance was shorter than 200 m. At the same time, the slack-line system was revived, and the new cable hauling methods such as the Dunham system and the basic North Bend system were often used in several parts of the country.

The first mono-cable system was put into operation for transporting firewood in Masukawa national forest, Aomori, in 1955[122)]. From around 1965, the mono-cable system was used for yarding logs in private forests.

In the early 1960's, cable logging systems were highly improved, and the evolution in technique was largely directed towards the increase in the yarding efficiency. The total number of yarders began to increase remarkably from around that time. A little earlier, in the late 1950's, the tree-length yarding and full-tree yarding were performed in the national forest. The long-distance skylines of over 1,000 m[153)183)207)210)], the curved skylines[26)41)75)148)229)245)268)270)291)292)294)], the Y-shaped skylines as shown in Fig. 43, and the circular yarding method shown in Fig. 30 were enthusiastically tried. The wide lateral yarding up to 200 m on each side of the skyline was carried out, too.

Such remarkable development in the cable logging method resulted in enlarging the unit area of clear-cutting; however, "environmental disruption" has come to stand in the way of the timber harvesting operation, and public denunciations of clear-cutting became stronger eventually.

In the late 1960's, to cope with the serious situation, all Japanese loggers began to review the traditional cable logging methods from a silvicultural and scenic standpoint, and tried to modify them. As a result of their persistent efforts, they obtained several promising alternatives suitable for the selective logging, the small-area clear-cutting, etc. Briefly stated, the main point of these new cable logging

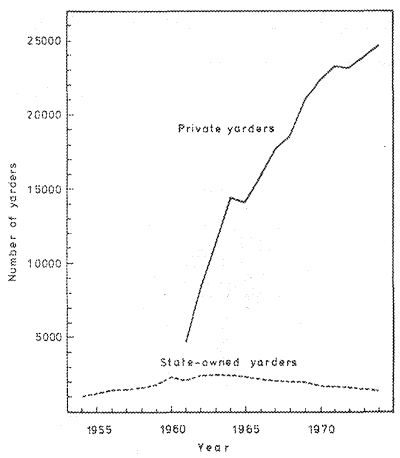

Fig. 1 Number of yarders in Japan.

systems is to restrict the passages of the operating lines, especially of the haulback line, to prevent damage to the residual stand when carrying out the selective logging.

Now in Japan, there are about 120 cable logging systems, and among them about 30 new systems are suited to selective cutting, partial cutting or thinning.

3. Cable logging equipment

Cable logging equipment may be divided into six main groups : (1) wire rope, (2) blocks, (3) carriages, (4) yarders, (5) special equipment, and (6) communication system. Skyline supports, stops and butt hooks are included in the special equipment.

3-1 Wire rope

Wire rope is multifariously used in a cable logging system as in the following :

(a) skyline* (standing line, main cable)
(b) main line (hauling line, inhaul line, haul-in line)
(c) skidding line
(d) haulback line* (receding line, outhaul line, return line, trip line)
(e) traction line
(f) endless cable
(g) lifting line* (hoisting line, lift line)
(h) hoist line
(i) carriage-drum line
(j) snubbing line
(k) pull-out line
(l) hook line
(m) tightening line
(n) control line*
(o) heel line*
(p) straw line
(q) anchor cable (anchor rope*)
(r) guy line* (guy)

Note : * Technical term applied widely in Japan.

Skyline Skylines are usually anchored to standing trees or stumps at both ends. In rare cases, skylines are anchored at one end, while the other end is tensioned by heavy weights as in the ropeways.

In the days when the cable logging system was introduced for the first time into Japanese

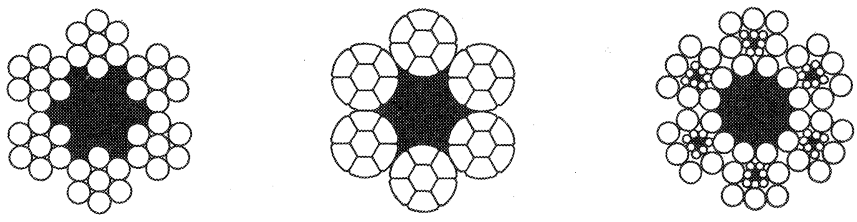

Fig. 2 Wire rope used for skyline.
(a) Round-strand wire rope; (b) Plane contact lay wire rope;
(c) Flattened-strand wire rope.

forests, the round-strand wire ropes with a main fiber core and metalic cores in strands, 6×37, ordinary lay, were used for skylines. After that time, the round-strand wire ropes 6×24 or 6×19 gradually took the place of 6×37. Since the early 1950's, however, the round-strand wire ropes, 6×7, Lang's lay, have been commonly used in our country, because they are slightly more flexible and have a better wearing surface than the ordinary lay ropes. Since around 1960, the use of new kinds of wire rope with particular cross-sections such as the plane contact lay rope and the flattened strand rope have been slowly increasing in use.

In the case of the round-strand wire rope 6×7 used for skylines, the tensile strenght of wire is usually 165 or 180 kg/mm², up to 215 kg/mm² if needed. The diameters of skyline is commonly 12～28 mm. The rope construction and diameter of anchor cable are the same as those of the skyline joined to the anchor cable.

Operating lines There are many kinds of operating lines because of the variety of the cable logging systems as above mentioned. Among them, the hoist line, the carriage-drum line, the pull-out line, the hook line, the tightening line, and the control line may be the Japanese unique operating lines. The hoist line is a line, which is wound around the carriage drum, used to lift up the turn of logs. The carriage-drum line is a wire rope used to drive the carriage drum. The pull-out line is a line, the end of which is attached to a block, used solely to pull out the fall block laterally to where the logs lie. The hook line is a line used exclusively to pull out the skidding line with butt hook laterally to where the logs to be hauled can be hooked on. The tightening line is a line used to tighten the other operating lines. The control line is a wire rope used to control the behavior of the haulback line.

For these operating lines, the round-strand wire rope with fiber main core, 6×19 or 6×Fi(25), ordinary lay, with a tensile strength of wire 165 kg/mm², is used. Its diameter is commonly 6～14 mm.

For the straw line, 8～12-mm synthetic fiber rope such as nylon rope or vynilon rope is in extensive use throughout the country.

Rope joints To connect two lengths of skylines, the so-called "long" splices are used. "Short" splices are used when two operating lines are jointed to make them into one, or when a rope is to be made an endless one. In attaching rigging to wire ropes, "eye" splice or wire-rope clips are used. Recently, clamping tubes made of aluminum alloy are often used for locking the "eye", and that develops the efficiency and safety of the cable logging operations.

3-2 Blocks

Blocks of many types are required for a cable logging system. They may be grouped in accordance with the way they are used, as follows :

(a) guide block* (snatch block)
(b) fall block
(c) skyline block (tree jack)
(d) twin block
(e) heel block*
(f) mono-cable block

Note : * Technical term applied widely in Japan.

The guide blocks may be designated as main line block, haulback block, lead block, tail block, corner block, or pull-out block, depending on their location. These blocks are all called "guide block" in our country. On almost all the skyline logging sites, the so-called "side blocking" is commonly carried out, so the guide blocks for the haulback line are arranged on the

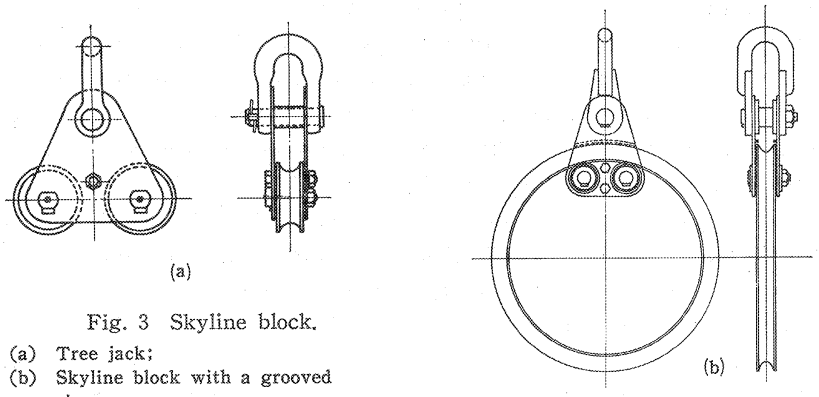

Fig. 3　Skyline block.
(a)　Tree jack;
(b)　Skyline block with a grooved ring.

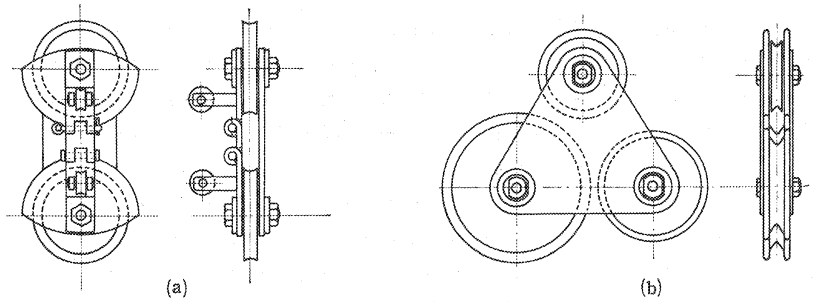

Fig. 4　Twin block.
(a) Ordinary twin block; (b) Three-sheave block.

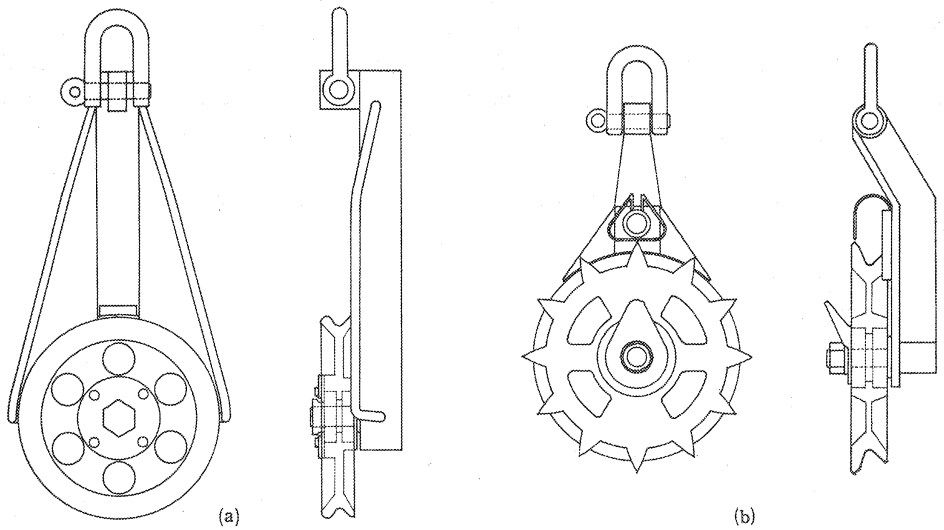

Fig. 5　Mono-cable block.
(a) Mono-cable block with an ordinary sheave; (b) Mono-cable block with a spiked sheave.

boundary of the setting to facilitate an external lateral yarding.

The fall block is called "loading block". Usually, a counterweight of 100~300 kg is attached to the bottom of the fall block, because the fall block can be lowered anywhere on the ground by gravity.

The skyline block, which is called "saddle block", has two sheaves or one large grooved ring at the bottom and a shackle on the top, and is used for skyline support at the head tree or tail tree instead of tree shoe (Fig. 3). Tree shoes are not used in our country.

The twin block consists of two part-steel shells and two sheaves. On the top of the upper shell are two small sheaves, which serve as track sheaves riding on a stationary cable as shown in Fig. 50. Recently, the three-sheave block of triangle shape has come to be more frequently used than the ordinary twin block. In the case of the three-sheave block, one of three sheaves serves as the track sheave (Fig. 4).

The heel blocks are the constituent elements of "heel tackle". Two three- or four-sheave heel blocks are used for a heel tackle to tighten the skyline.

"Mono-cable block" is a general term for the open-side blocks used in the mono-cable system. Some of them have eight to twelve spikes around the outer rim of the sheave to prevent the endless cable from running off (Fig. 5).

3-3 Carriages

The choice of carriages usually depends on the cable configuration, load and span.

The carriages used in the Tyler system, the downhill North Bend system and the Kumamoto system are equipped with two or four track sheaves in the upper part of the carriage, and one or more sheaves or blocks for operating lines at the bottom of it.

For the slack-line system, the Dunham system or the running skyline system, a rather simple carriage or a pair of blocks is preferred. In the hoist yarding system, a carriage equipped with a carriage drum holding a hoist line is employed. Hoist carriages are equipped with rather complicated hoisting or locking devices, so they weigh heavy on an average. In the aerial snubbing system, various kinds of carriages, from the simple one to the heavy one, are used. When the skyline is hung on the intermediate skyline supports, the open-side carriage is used.

To prevent collision or entwinement among the operating lines and skyline with one another, the "side-armed" carriage has been developed[20)93)101)200)206)231)238)240)276)]. This carriage has two side-arms, or cantilevers, stretched out on both sides. Both ends of the continuous traction line are attached to the end of a side-arm, and the bight of the traction line is passed through the block attached to the end of another side-arm, so that the traction line and other lines are

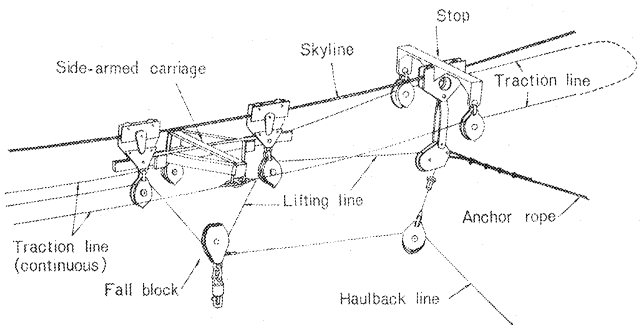

Fig. 6 Side-armed carriage and stop.

separated from one another in the air.

3-4 Yarders

At present, yarders of varied types are used in our country. The mechanical features of the yarder may be characterized with the following specifications; gasoline engine or diesel engine, output of the engine, number of drums, line pull of each drum, capacity of each drum, line speeds, brakes, clutches, total weight, and so on.

The gasoline or diesel engines mounted on the yarders range from 5 hp to 125 hp. Generally, the engine of 40 hp and downward is installed on the small-sized yarder, and the engine of 50 hp and upward is on the large-sized yarder.

The yarder has two or four drums, and, in most cases, one of them is a spool-type drum, or capstan-winding driving pulley which has no groove. The spool-type drum is commonly called "endless drum". Ordinary drum can be simply converted to spool-type drum by fitting a pair of semicircle split spools. The spool-type drum is used for driving an endless or continuous rope such as the endless cable or traction line. The spool-type drum system is so popularly adopted in our country that the expensive interlocking yarders are scarcely used.

The ordinary drum capacity is varied from 400 to 1,500 m for 10-mm wire rope, or from 300 to 1,300 m for 12-mm wire rope according to the size of the yarder.

The torque of the engine is transmitted to the drum-shafts through a single plate friction clutch, manual gear transmission, and drive shaft or drive chain. Automatic centrifugal clutches or torque converters are extensively applied to the large-sized yarders instead of single plate clutches. The torque of the drum shaft is transmitted to the drum through a drum clutch of friction block type or friction shoe type.

As regards the braking equipment, shoe-brakes or band-brakes which can be activated either by foot or by hand are used for the small-sized yarders, and oil pressure brake of internal-expanding type for the large-sized yarders.

The power plant, drums and other elements are usually mounted on a strong frame shaped like a sledge. Some large-sized yarders can be divided into two parts for convenience of transportation. Tractor mounted or truck mounted yarders are often used, too. But the profitable employment of these yarders is restricted by the forest conditions or yarding distance.

Recently, remote-control yarders have been designed and used in the national forest[56)190)]. But it is reported that the remote-control yarders are not always helpful to logging operation as yet, because of their stiff motion.

3-5 Special equipment

In cable logging systems, steel spars, skyline clamps, intermediate supports, carriage stops or butt hooks are employed, where needed.

If there is no tree suitable for the head tree or tail tree in required places, the steel spars or portable spars are used. The skyline clamp consisting of two plates 14～18 mm thick, which are connected together with ten to twelve bolts, is essential in connecting the skyline to the heel tackle or the anchor cable (Fig. 7). In curved skylines or multispan skylines, the intermediate skyline suports are employed. The stops are used for several hoist yarding systems or aerial snubbing systems. And when the selective yarding is carried out, the stop is often required as shown in Fig. 6 and 28. Butt hook is always attached to the end of the skidding line or the hoist line.

Besides, in the mono-cable system, hanging ropes and "contact" hooks are used to attach the turn to the endless cable (Fig. 8). The hanging ropes are made of strands of 10～12-mm

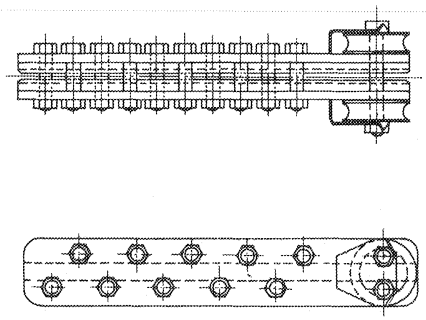

Fig. 7 Skyline clamp.

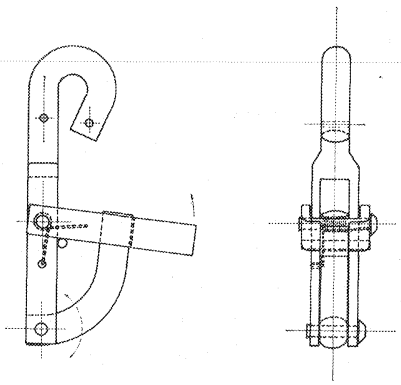

Fig. 8 Contact hook.

wire rope, 6-mm wire ropes, or 6～8-mm synthetic fiber ropes.

3-6 Communication systems

Communications and signals amoung the logging crew members, especially between yarder operator and chocker setters, are made by telephones, wood interphones, or yarder horn.

The skyline tension indicators, which give the warning when the cable tension exceeds an allowable value, were developed several years ago.

4. Cable logging systems

There are many types of cable logging systems in Japan, numbering over 120 systems. Those developed in recent years, however, are too varied and complicated to be classified according to the traditional basis. For the convenience of identification and dissemination of techniques, ten basic systems are chosen as follows according to the configuration and rigging used : the Tyler system, the North Bend system, the Kumamoto system, the hoist yarding system, the slack-line system, the aerial snubbing system, the Dunham system, the running skyline system, the mono-cable system, and the high-lead system. In accordance with the new classification criteria, almost all of more than 120 cable logging systems can be classified into ten groups systematically.

Distinguishing features of each basic system, such as component elements, cable arrangement and adaptability, are described as under.

4-1 Tyler system

The Tyler system consists of a standing skyline, a lifting line, a haulback line, a carriage equipped with two blocks at the bottom, a fall block, and a two- to four-drum yarder. In this system, the lifting line runs from the drum through a lead block on the head tree, back through the block at the front edge of the carriage, down through the fall block, then up through the block at the rear edge of the carriage, back to the tail tree and is fastened to it. The haulback line from the drum runs

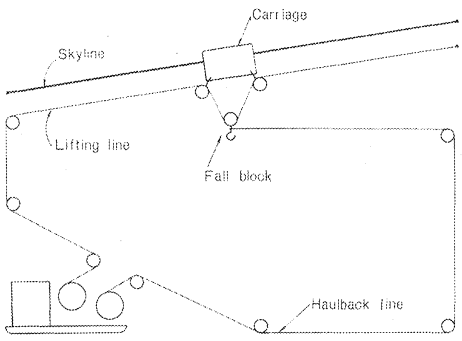

Fig. 9 Tyler system.

through a series of blocks, through the tail block attached to a stump located at where the logs lie, then up to the fall block and is secured to the back edge of the fall block. This makes it possible to carry out the lateral yarding.

The Tyler system can be adapted to downhill slopes steep enough for the carriage and the turn to travel by gravity, generally more than about 15° grade. On rather gentle slopes, or even on steep slopes when steady movement of the carriage is required, the Tyler system is additionally equipped with a traction line or a main line. The traction line is usually a continuous line both ends of which are attached to the carriage, and driven by the spool-type drum of the yarder. When the main line is added, the one end of the main line is fastened to the carriage and the other end is connected with the haulback line at the yarder, and that makes two lines a continuous main-haulback line. The modified Tyler system having a continuous line is called the "endless" Tyler system, and is used very often. (See Fig. 29~41).

The Tyler system can be effectively used for yarding branched catting-strips on each side of the skyline by controlling the behavior of the haulback line as shown in Fig. 23.

4-2 North Bend system

There are two modifications of the North Bend system, namely, the modified North Bend system and the downhill North Bend system[11]. The downhill North Bend system is the most popular, and the basic North Bend and the modified North Bend system are rarely used in our country.

The downhill North Bend system is called the "Falling block" system. This system consists of a standing skyline, a main line, a haulback line, a carriage having a block at the front lower edge, a fall block, and a two- to four-drum yarder.

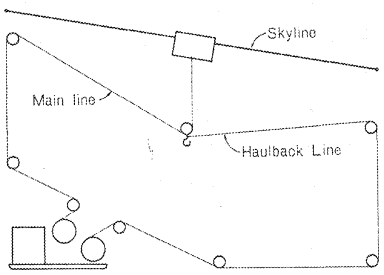

Fig. 10 North Bend system.

The main line is led from the main drum through a lead block on the head tree, back through the block under the carriage, down through the fall block, then up to the carriage, and is fastened to the back end of the carriage. The haulback line passes from the haulback drum through a series of blocks, through the tail block attached to a stump on hooking spot, then up to the fall block, and is fastened to it.

In operation, the loaded carriage travels along the skyline by reeling in the main line

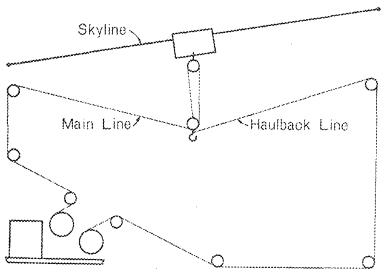

Fig. 11 Modified North Bend system.

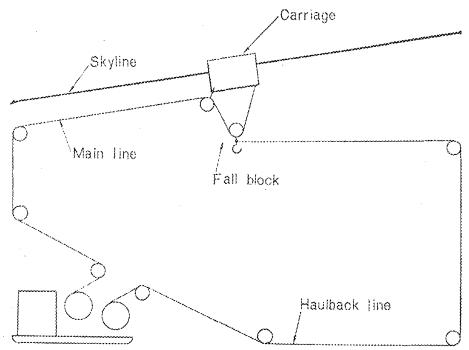

Fig. 12 Downhill North Bend system.

while the haulback line brake is released gradually. The lift on the turn of logs is provided by the main line and haulback line being pulled against each other, so that big braking power is required for the haulback drum.

The downhill North Bend system is adaptable to a wide range of conditions of topography, on moderate uphill or downhill slopes or on horizontal grounds. The average lateral yarding distance of this system, however, seems to be shorter than that of the Tyler system. Incidentally, the downhill North Bend system also can be used for yarding cutting strips by equipping with special rigging, for instance, a pull-out line or a control line. (See Fig. 42～48).

4-3 Kumamoto system

The Kumamoto system is similar to the downhill North Bend system. But there are, of course, some differences in structure and performance between these two systems. In the Kumamoto system, the main line and the haulback line are connected with each other to make one continuous line, and it is driven by a spool-type drum. In order to raise or lower the fall block, a tightening line and a twin block are used. The continuous line passes through one sheave of the twin block. The tightening line from the drum runs through the other sheave of the twin block, back to the yarder and is fastened to a stump. By winding in the tightening line, the twin block is pulled to the yarder and the continuous line is tightened, and this makes the fall block rise to the carriage.

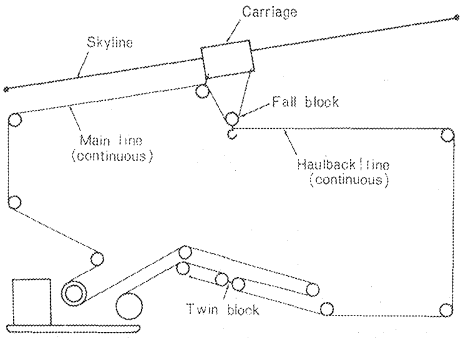

Fig. 13 Kumamoto system.

More specifically, the Kumamoto system consists of a standing skyline, a continuous main-haulback line, a carriage, a fall block, a tightening device, and a two-drum yarder. This system is characterized by its applicability to a wide range of topographic conditions and yarding distances, and its operational simplicity. However, the Kumamoto system seems to be unsuitable for the selective cutting. (See Fig. 49～51).

4-4 Hoist yarding system

The "hoist yarding system" is a general term for the skyline systems in which the hoist carriages are used.

This system in general consists of a standing skyline, one or two operating lines, a carriage equipped with a carriage drum holding a hoist line, and a two- or three-drum yarder. If needed, one or two stops are also employed.

The carriage is propelled along the skyline by the traction line, the main line or the haulback line. The carriage drum is driven by the carriage drum line or other operating lines.

Hoist carriages of various types have been developed in our country over the years, but not many of them are in successful use now. The hoist yarding system can be used for selective cutting and for clear-cutting. (See Fig. 52

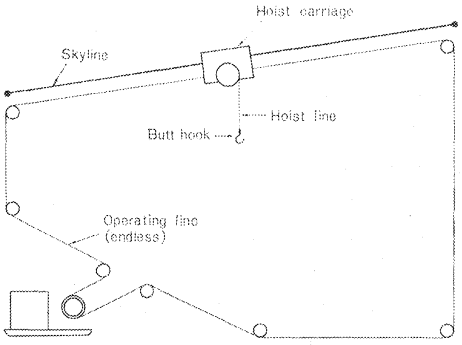

Fig. 14 Hoist yarding system.

～54).

4–5 Slack-line system

The slack-line system is used only for the short distance yarding in Japan. This system consists of a live skyline, a haulback line, a simple carriage, a two- or three-drum yarder, and a set of heel tackle. The skyline is pulled through a lead block on the head tree, threaded through the simple carriage, then pulled out to the tail tree, and threaded through a skyline block and anchored to the stumps. The end of the haulback line is fastened to the rear edge of the carriage. The skyline is raised or lowered in each turn by means of the heel tackle attached to the end of the skyline. Sometimes, a pulling machine or "tirfor" is used instead of the heel tackle. The skyline is seldom wound directly on the yarder-drum in our country.

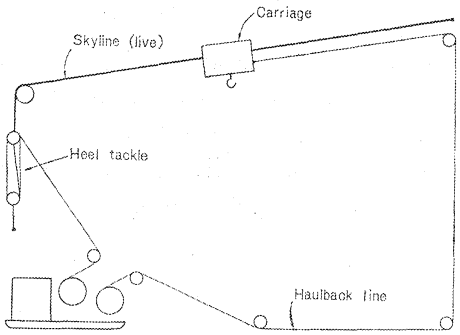

Fig. 15 Slack-line system.

In operation, the skyline is raised until turn of logs is lifted completely off the ground, then the heel-line-drum brake is set to hold the skyline up, and the carriage holding the turn of logs runs by gravity after releasing the haulback-drum brake.

If the terrain makes it neccessary, a main line is additionally rigged in this system. (See Fig. 55 and 56).

4–6 Aerial snubbing system

The aerial snubbing system consists of a standing skyline, a skidding line or main line, a carriage, one or two stops, and a one-drum yarder with heavy brake. The skidding line or main line is also called the snubbing line, which means a line used for controlling the traveling of the carriage operated by gravity. Depending on the mechanism of the carriage used, one or two stops are set up on the skyline. In the simplest case, there is no stop.

This system is adapted to yarding in rather steep terrain. The yarder is commonly installed at the upper end of the yarding road. When the carriage is hauled to the upper stop by the skidding line, locks are engaged and a butt hook attached to the end of the skidding line is lowered. After hooking, the butt hook and turn of logs are raised to the carriage, then locks are released. Downhill transportation is done by gravity.

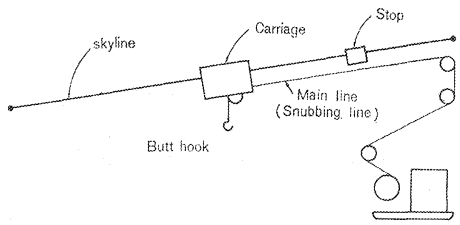

Fig. 16 Aerial snubbing system.

The butt hook can be pulled out laterally tens of meters by man power. This allows selective logging in a wide strip on each side of the skyline. (See Fig. 57).

The Wyssen system may be included in this system.

4–7 Dunham system

The Dunham system consists of a main line, a haulback line, a carriage, a fall block, and a two-drum yarder. The main line runs from the carriage forward through a lead block on the head tree, back through the upper carriage sheave, back through a tail block on the tail tree, forward through one of the two lower sheaves, down through a fall block, up through

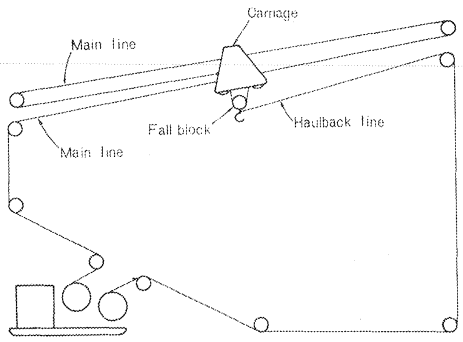

Fig. 17 Dunham system.

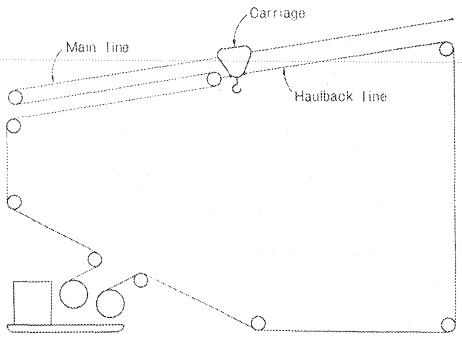

Fig. 18 *Japanese* Dunham system.

the other lower sheave, forward through another lead block on the head tree, and down to the main drum on the yarder. The main line serves as the skyline as well as the lifting line. The haulback line runs from the fall block back through a haulback block on the tail tree, forward through a series of guide blocks, then through the lead block on the head tree, and down to the haulback drum.

In our country, however, the Dunham system is a general term for all those cable systems in which the main line serves as the skyline. In many modified Dunham systems, the fall block is not equipped, and the butt hook and chokers are attached to the bottom of the carriage.

This system is not so popular, but sometimes used for the short distance yarding up to 200 m. (See Fig. 58 and 59).

4-8 Running skyline system

The running skyline system consists of a main line, a haulback line, a skidding line or lifting line, a simple carriage, and a two- to four-drum yarder.

The running skyline system also is a general term for those cable systems in which the haulback line serves as the skyline. There are many modifications of this system.

In rigging up the most popular running skyline system in Japan, the haulback line passes through a lead block on the head tree, back through the upper sheaves of the carriage, back through the haulback block on the tail tree, forward to the carriage, and is attached to the rear edge of the carriage. The main line passes through a lead block on the head tree, back to the carriage, and is fastened to the front edge of the carriage. In most cases, the main line and the haulback line are connected with each other at the yarder to make them a continuous line. The skidding line runs from the skidding drum through a lead block hung just below the main line block on the head tree, back through a block attached to the bottom of the carriage, and is hung down. A butt hook is attached to the end of the skidding line.

In any case, the *Japanese* running skyline system is slightly different from the American running skyline system which is additionally equipped with a slack-pulling line.

The running skyline system is frequently used for the selective cutting or thinning. (See

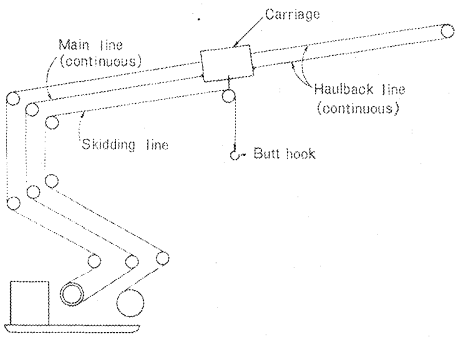

Fig. 19 *Japanese* running skyline system.

Fig. 60～63).

4-9 Mono-cable system

The mono-cable system consists of an endless cable, 20～80 mono-cable blocks, a set of tightening equipment, and a one- to three-drum yarder. The endless cable is suspended on many mono-cable blocks attached to standing trees at intervals of 10～50 m along the yarding path. Turn of logs can be attached to the endless cable with hanging ropes and contact hooks. The endless cable is driven by the spool-type drum of the yarder, and the loads are transported continuously or intermittently from the cold decks to the landing.

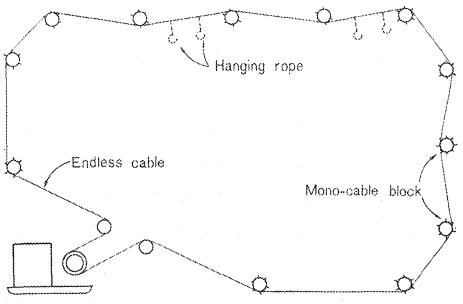

Fig. 20 Mono-cable system.

The Japanese mono-cable system differs from the European ones in that the open-side blocks are hung on the standing trees with flexible wire ropes instead of rigid equipment, and the hanging ropes are used for attaching choked logs to the endless cable.

Recently, the lateral yarding has been successfully carried out with the mono-cable system. At present, this system is thought to be the most suitable cable system for selective cutting. (See Fig. 64～66).

4-10 High-lead system

The high-lead system is not used for large-scale logging, but for short distance skidding, especially for assembling logs or making cold decks.

This system consists of a main line, a haulback line, a simple butt rigging, and a two-drum yarder. The main line and haulback line are, at times, connected with each other, and the continuous main-haulback line is driven by a spool-type drum of the yarder.

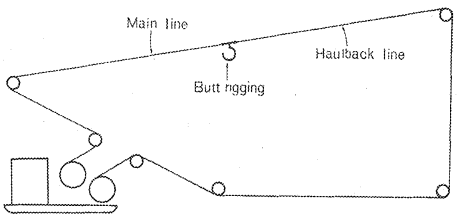

Fig. 21 High-lead system.

Recently, a modified high-lead system additionally equipped with a skidding line was developed, and it has been employed in the thinning operation. In this modified high-lead system, the main line and haulback line are connected with each other at the yarder. (See Fig. 67～68).

The cable logging systems described above can be summarized as in Table 1.

Besides, there are the double skyline system and H-shaped system for each skyline logging system. The double skyline[157)189)292)294)] is the skyline logging system in which two small-sized skylines are set up paralleling each other 0.5～1 m apart in the sky and a four-wheeled carriage rides on them as shown in Fig. 50. The advantage of the double-skyline system is the ease of setting-up operation. The H-shaped skyline system[100)146)] is similar to the Lawson skyline yarding and loading system formerly employed on the West coast of the United States[242)], but the Japanese ones are rather simple. Two tail lines, which are set up in parallel keeping adequate distance of 100～200 m between them, and a skyline, which is suspended between those two tail lines, have the shape of the letter "H".

Further, there are new combinations of two cable hauling systems as shown in Fig. 31 or

Table 1. Classification of cable logging systems

Equipment \ Cable logging system		Tyler system	North Bend system	Kumamoto system	Hoist yarding system	Slack line system	Aerial snubbing system	Dunham system	Running skyline system	Mono-cable system	High-lead system
Skyline	standing skyline	○	○	○	○		○				
	Live skyline					○					
Operating line	Main line	◌	○	○ **		◌	○	○*	○		○
	Haulback line	○	○	○ **		○		○	○*		○
	Lifting line	○									
	Skidding line								○		
	Hoist line				○						
	Endless cable									○	
	Others				○						
Carriage	Ordinary carriage	○	○	○		○		○	○		
	Hoist carriage				○						
	Snubbing carriage						○				
Fall block		○	○	○				◌			
Tightening device				○		◌				◌	

*: The line serves as skyline.
**: Both lines are connected with each other at the drum.

some cross between the two systems.

Incidentally, the grapple yarding systems popular in foreign countries have not yet been employed in Japan.

5. Cable logging operation

When setting up a skyline over a logging area, the head tree and tail tree are selected in advance of the felling of the trees to be logged. If no suitable tree is standing in the required place, the portable steel spars are used. Before the head tree and tail tree are rigged, all trees on the projected skyline road between them are felled. Then the head tree and tail tree are first limbed and rigged with a skyline block, lead blocks, and guy lines. Customarily, a "guide tree" which may be useful for setting yarder properly is selected near the head tree at almost the same level as where the yarder is placed, and rigged up in the same way as the head tree except the skyline block. The yarder is set facing the guide tree at an adequate distance from it on a cribwork of logs forming a level platform. The rear end of the yarder sled is anchored to stumps.

The operating lines such as main line and haulback line are stretched over the yarding road with help of synthetic rope or light wire rope. If the terrain or obstacles make it necessary, rope launchers or model planes are occasionally used for stretching the synthetic rope over the yarding road. Then, the skyline is extended from the head tree to the tail tree by the operating line stretched before.

A cable logging system is commonly operated by a crew of three to five men; one operator, one or two chocker setters, and one or two unhookers. In the case of tree length yarding, one or two chain saw men are added for bucking the yarded trees at the landing. Setting-up

and dismantling the cable system are, of course, managed by the same crew members.

The operating efficiency of the cable logging system depends to a great extent upon the cutting systems, the timber volume per hectare and single tree volume. Table 2 approximately shows the average daily outputs and the average turn volumes by cutting systems and cable logging systems.

Table 2. Average daily output and turn volume (m^3)

		Clear-cutting	Selective cutting	Thinning
Skyline system	Daily output	32.3 (6.6)	21.9 (5.0)	*
	Turn volume	1.14 (0.62)	0.90 (0.35)	*
Non-skyline system	Daily output	19.7 (4.0)	19.1 (2.8)	—
	Turn volume	—	—	—
Mono-cable system	Daily output	*	20.2 (2.6)	8.9 (2.6)
	Turn volume	*	0.44 (0.11)	0.13 (0.04)

(1) Figure between brackets indicates standard deviation.
(2) Skyline system includes Tyler system, North Bend system, Hoist yarding system, and Kumamoto system.
(3) Non-skyline system represents only running skyline system in this table.

To assure the safety and health of forest workers, all-round and planned countermeasures for the prevention of labor accidents are provided by laws and rules. As provided by the "Labor Safety and Sanitation Law", the enterpriser, who intends to carry out a cable logging with above 10 hp yarder, at a total skyline length above 350 m or with a maximum load of above 200 kg, shall appoint an operation head from among the persons having obtained the license, and make him direct the workers engaged in the logging operation. An operation head license of forest cable installation is granted to the person who has passed the license examination or who is in possession of the qualification as prescribed by the Ministry of Labor Ordinance.

When a cable logging system of such scales as mentioned above is desiged in a logging site, the diameter of each line, including that of skyline, should be decided on the basis of topographical data and tree size. According to the "Labor Safety and Sanitation Rule", the safety factor of each line is expressly provided as in the following :

2.7 for skyline
4.0 for all operating line, except lifting line and hoist line
6.0 for lifting line and hoist line
4.0 for guy line and tie rope

The allowable stress of each line can be evaluated by dividing the tensile stress of a given wire rope by the safety factor applicable to the line.

6. New trials for selective logging

Many unique cable logging systems suitable for the selective cutting in mountainous regions have been developed in Japan. These new methods may be classified into two large groups; namely, the improved traditional systems, and the newly developed systems. In the case of the traditional Tyler system and downhill North Bend system, the haulback line covers a wide area during the operation as shown in Fig. 22, so that the movements of the haulback line

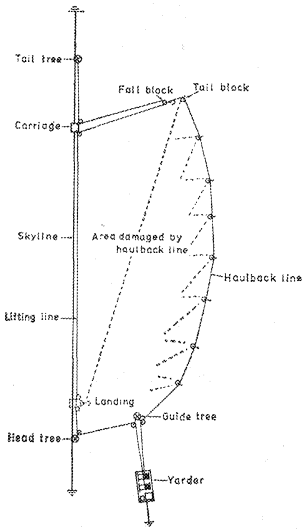

Fig. 22 Area damaged by haulback line.

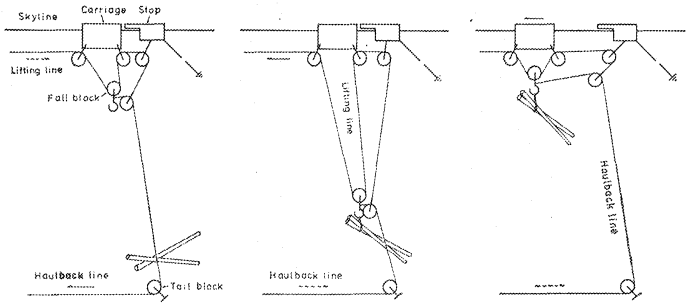

Fig. 23 Track of the haulback line is automatically regulated by the tension of the lifting line. (Tyler system)

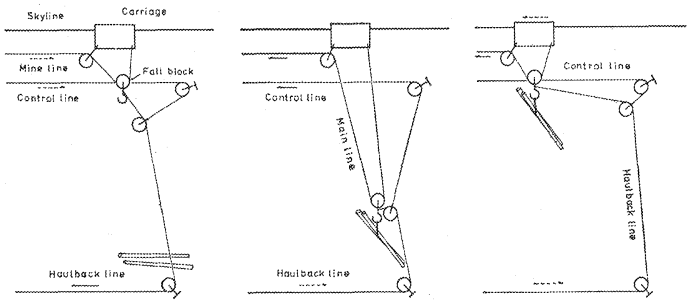

Fig. 24 Track of the haulback line is controlled by the control line. (Downhill North Bend system)

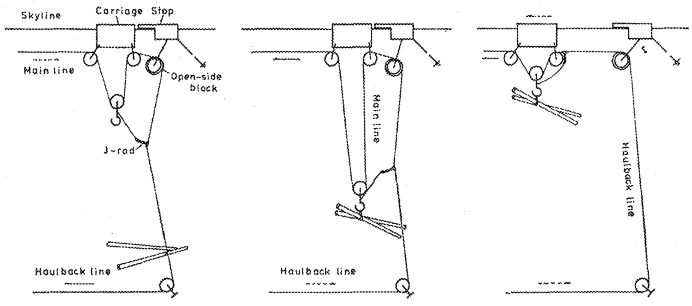

Fig. 25 Track of the haulback line is regulated by the action of special rigging; an open-side block and J-shaped rod. (Downhill North Bend system)

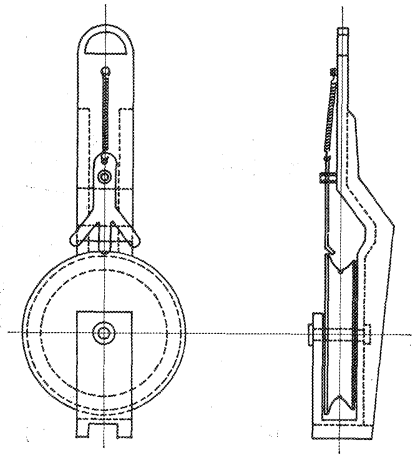

Fig. 26　Open-side block.

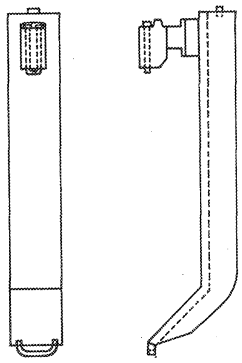

Fig. 27　J-shaped rod.

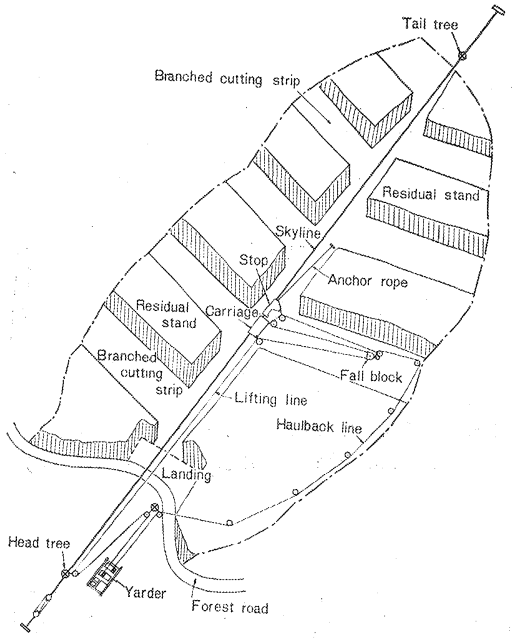

Fig. 28　Branched cutting strip yarding.

have to be restricted by some measures to prevent damage to the residual stand. Several new methods have been developed for controlling the behavior of the haulback line; that is, the one in which the movement of the haulback line is restrained by the tension of the other line such as the lifting line (Fig. 23), the one by an additional control line (Fig. 24), the one by special equipment (Fig. 25), the one by an additional pull-out line, and so on. These contrivances have made it possible to yard the branched cutting-strips crossing a skyline corridor as shown in Fig. 28.

Meanwhile, the other systems such as the hoist yarding system, the aerial snubbing system, the running skyline system, and the simplified North Bend system are, for the most part, technically applicable to the selective cutting or thinning. These allow selective logging in a strip tens of meters wide on each side of the skyline.

Above all, the mono-cable system is the developing but promising one for selective cutting in mountainous regions.

7. Usable examples

Thirty-nine usable examples of the cable logging systems, including the ones available for the selective cutting or thinning operation as well as the developing ones, are presented as follows :

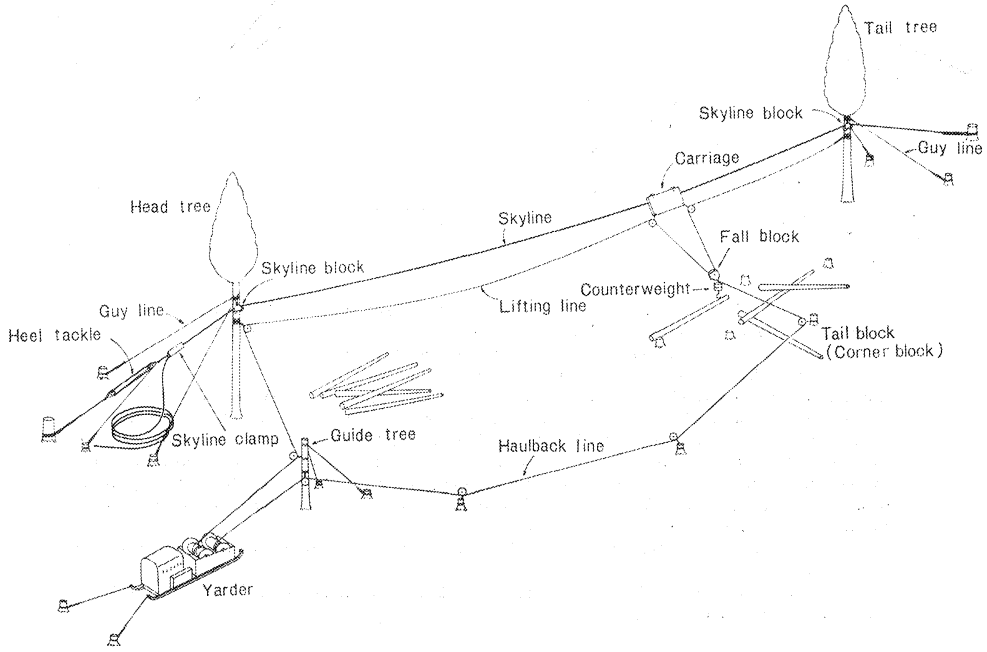

Fig. 29 This is an ordinary cable arrangement of the Tyler system which is very often preferred for its simplicity of setting up and the ease of operation. In the past this system was one of the most popular skyline methods for large area clear-cutting[94)49)147)156)183)202)224)233)].

This system is employed on comparatively steep downhill slope enough to allow the loaded carriage to travel down on the skyline by gravity. To reduce the wear on the lifting line, some self-locking carriages have been used in this system.

On gentle downhill or uphill slope, a main line or a traction line is added to this system, and a three-drum yarder is used[42)].

The modified Tyler system having a pull-out line was applied in Yanase national forest, Kochi, in 1964[112)]. A guide block through which the haulback line is passed is attached to the end of the pull-out line. The tail block is attached to the tail tree. The chief reason for the application of the pull-out line is to make it possible to carry out lateral yarding freely without changing the tail block.

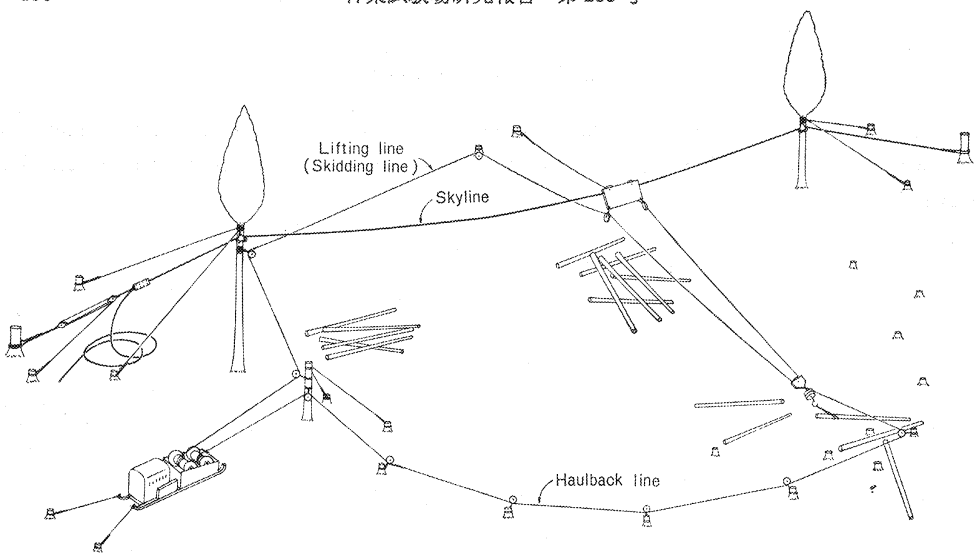

Fig. 30 In order to carry out the long distance lateral yarding, the "circular yarding" was tried for the first time in Kiso-Fukushima national forest, Nagano, in 1963[50)253)].

This method is one of the modifications of the Tyler system.

The end of the lifting line is attached to a stump on the opposite hillside, and runs from it through a block attached to the rear edge of the carriage, down through the fall block, up through a block at the front edge of the carriage, back through a guide block attached to a stump near where the end of the lifting line is secured, then through some guide blocks to the lifting line drum. The haulback block is attached to a stump at a proper distance from the skyline on the logging side. In operation, logs are hauled to the skyline laterally so as to build cold decks under the skyline, and then the logs are swung from there to the landing by the same skyline[51)254)255)283)].

On gentle slopes a continuous traction line is added to this system to control the excursion of the carriage[15)].

The longest lateral yarding distance record of 210 m was made for a 530-m span in Kiso-Fukushima national forest[254)].

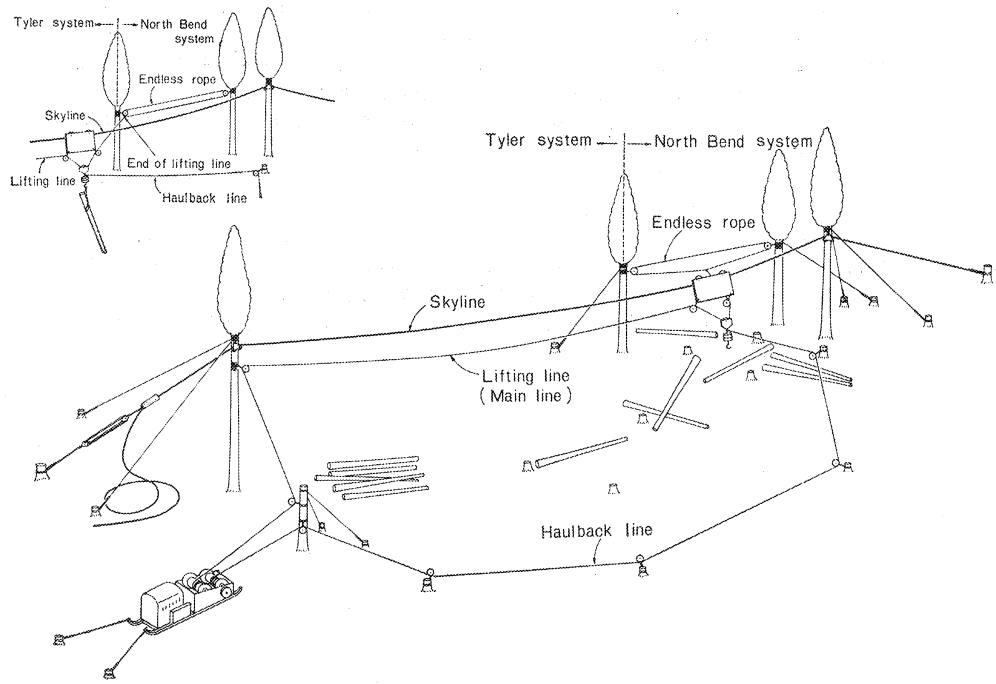

Fig. 31 This is a successful combination of the Tyler system and the downhill North Bend system.

The back end of the lifting line is secured to the bight of an endless wire rope set up between two guide blocks which are attached to the trees standing along the skyline at the outer end of the yarding road.

In operation, while the carriage is passing by the endless rope, the end of the lifting line is moved with the endless rope, so that the system works as the downhill North Bend. On the other hand, when the carriage leaves the endless-rope section, it works as the Tyler system, because the end of the lifting line is made to stop at the position of the lower endless rope block. This combination system could be applied to the convex yarding road where the slope of the road is pretty steep but the felling site near the tail tree is rather flat. To avoid an additional skyline on such a distinctive terrain, this method was developed in Nobeoka national forest, Miyazaki, in 1966[287)301)].

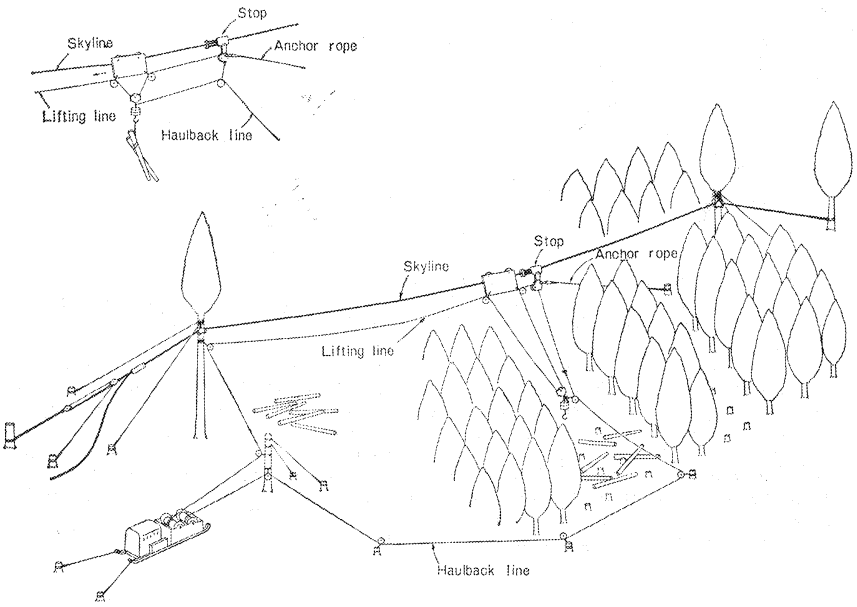

Fig. 32 This system is effective for yarding the branched cutting-strips crossing the skyline.

The lifting line runs from the carriage back through the lifting-line block attached to a stop riding on the skyline and is hung down. A guide block is attached to the end of the lifting line. The stop can be moved to any point desired on the skyline by man power and anchored backward to a stump. The haulback line runs from the fall block back through the guide block attached to the end of the lifting line, down through the tail block, then forward through several blocks to the haulback drum of the yarder.

When the empty carriage arrives at the stop, the fall block and the guide block are led to where the logs lie by reeling in the haulback line and releasing the lifting line brake. When the chokers are set, the lifting line is wound in and the haulback line is unwound at 1/3 the lifting line's speed, then the fall block and the turn of the logs are hauled to the skyline corridor laterally.

The behavior of the haulback line and fall block is controlled by the lifting line tension, so that lateral yarding in branched strips can be carried out with very little damage to the residual stand[81)88)44)138)]. The daily out-put of this new system decreases by 10～20% compared with the traditional Tyler system.

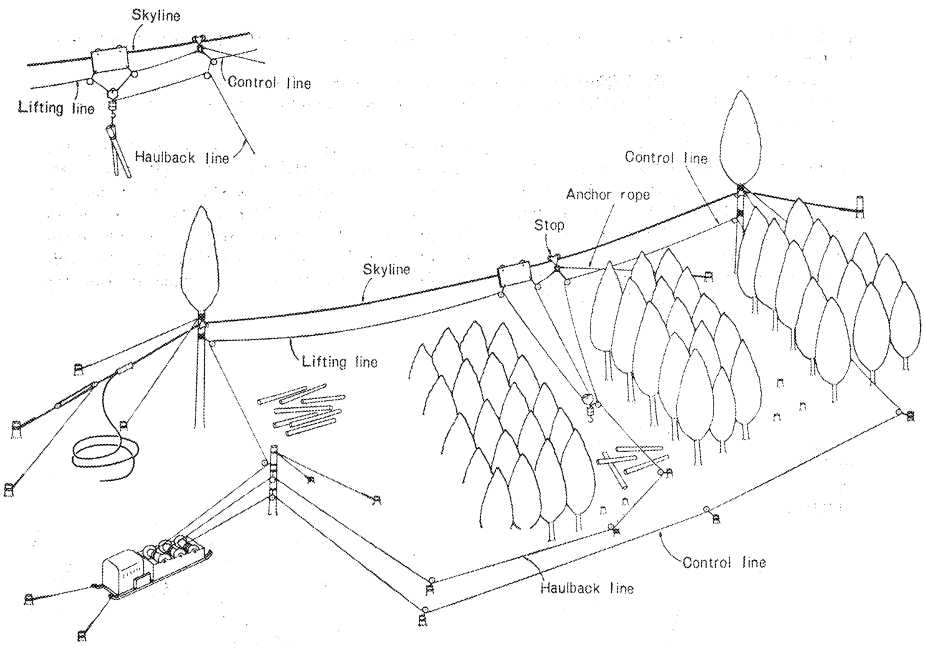

Fig. 33　This system is also suited to yarding the branched strips.

To prevent side-slipping of the haulback line caused by lateral yarding and to minimize the damage to the residual stand, a control line is added to the Tyler system as shown in the illustration.

The control line runs from the control line drum out through a series of corner blocks, and through a block attached to a stump on the opposite hillside[65] or to a stop on the skyline[30)168)]. A guide block is fasten to the end of the control line, and the haulback line is passed through it. This system can be operated with the three-drum yarder.

For lateral yarding, a great deal of skill is required in operation, because the carriage moves unsteadily along the skyline according to the tensions of three lines; the lifting line, the haulback line, and the control line. As a result, the residual trees along the yarding strips are apt to suffer damage to some extent.

This system was used for the first time in Ueda national forest, Nagano, in 1969[80)].

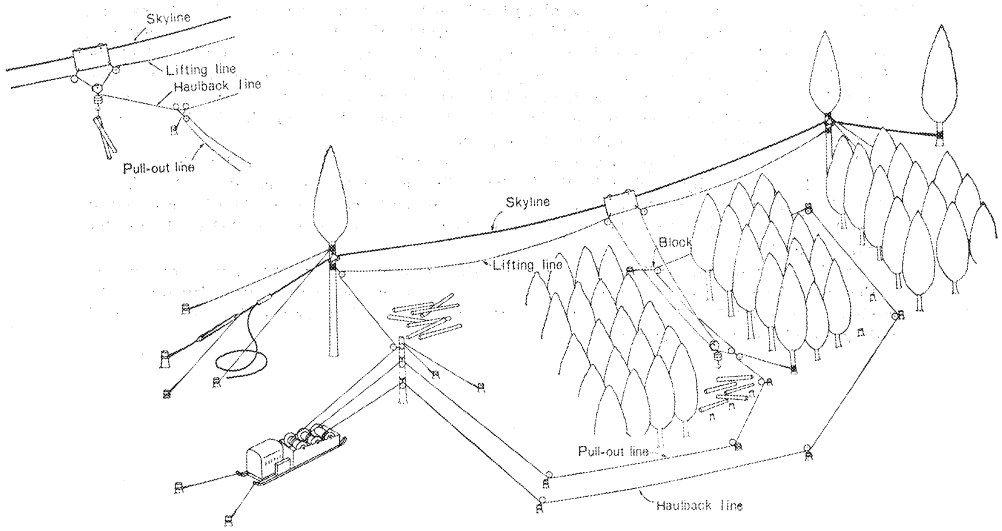

Fig. 34 This system is used for yarding the branched strips, too.

A pull-out line and two blocks which are tied with each other are added to the ordinary Tyler system. The pull-out line leading from a drum of the common three-drum yarder runs through some blocks, through a guide block attached to a stump at the far end of a branched strip, through one of the tied blocks, then to another stump near the guide block mentioned above, and is secured to the stump. The haulback line runs from the fall block through another block of the tied blocks, then through the tail block attached to a stump at the intersection of the skyline road and the branched strip, and back through the haulback block on the tail tree, and forward through some blocks to the haulback drum.

When the empty carriage arrives at the branched strip, the pull-out line is reeled in, and the lifting line and the haulback line are released at the same time to bring over the fall block to where the logs are to be hooked on. When the chokers are set, the lifting line and the haulback line are wound up, and the brake of the pull-out line drum is gradually taken off, the fall block and the turn of logs are hauled right to the carriage.

This system was operated where the average lateral yarding distance was 75 m, in Mori national forest, Hokkaido, in 1969[306].

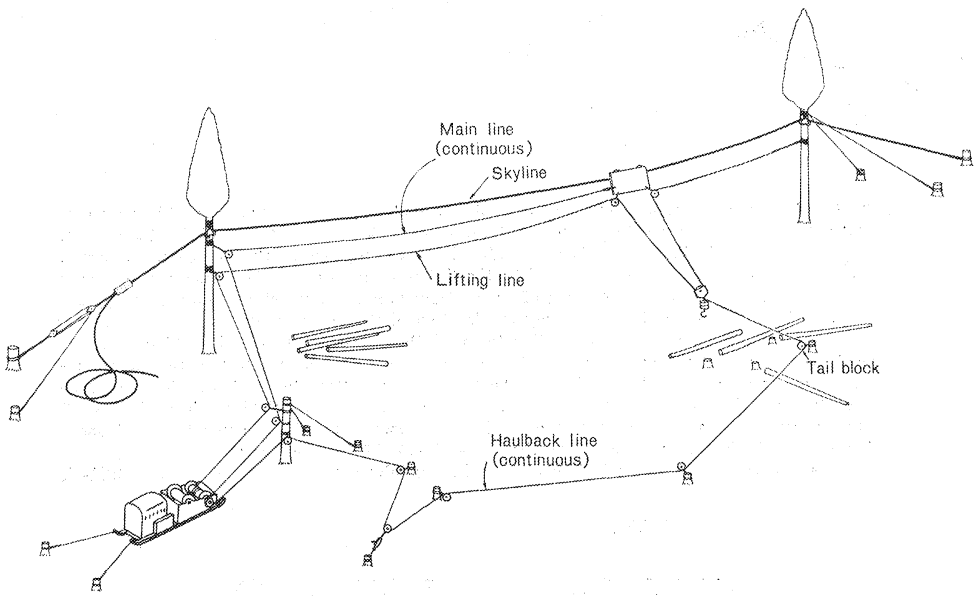

Fig. 35 This system is one of the modifications of the "endless Tyler system". It consists of a skyline, a lifting line, a continuous main-haulback line, a carriage, and a two-drum yarder. The continuous main-haulback line means a continuous wire rope made up of a main line and a haulback line. It is driven by the spool-type drum of the yarder, and its length must be adjusted by a tightening device according to the distance between the landing area and the hooking area. As shown in the illustration, the main line is attached to the front edge of the carriage and the haulback line to the fall block[54)95)185)207)].

Besides, there are some modifications of this system; for instance, the one in which both main line and haulback line are attached to the fall block[140)147)174)243)274)], the one in which they are attached to the carriage together, and so forth.

The modified Tyler system additionally having a traction line is also called the endless Tyler system. In this case, both ends of the traction line are attached to the carriage, and a three-drum yarder is required[77)115)143)164)231)258)261)].

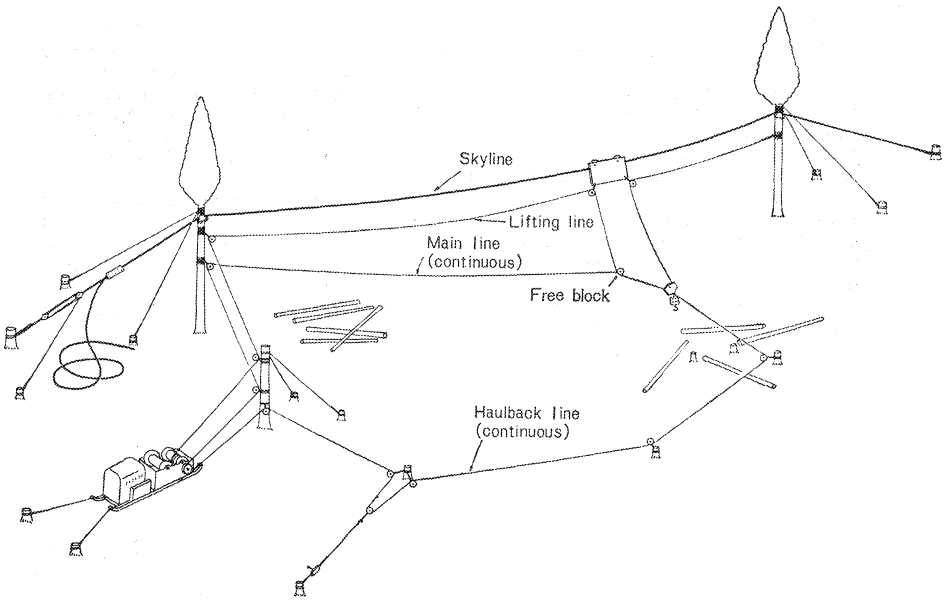

Fig. 36 The main difference between the ordinary endless Tyler system and this system is that a free block is used between the front carriage block and the fall block in this system. The end of the main line is attached to the free block through which the lifting line is passed. The end of the haulback line is secured to the fall block as usual. These line arrangements make it possible to control the tension of the continuous main-haulback line automatically, and extend a hooking area without changing the location of the tail block[22,7].

There are, of course, several modifications of this method; the one in which two free blocks are used, and the main line and the haulback line are attached to the free blocks, respectively, and the fall block rides on the bight of the lifting line between the two free blocks[17,2]; and the one in which the main line is attached to a special block shown in Fig. 37 and the haulback line is secured to the fall block as usual, also the one in which both main line and haulback line are attached to the special block[8,9,17,1,8,10], and so on.

The first trial of these methods was made in Chichibu national forest, Saitama, in 1961[22,7].

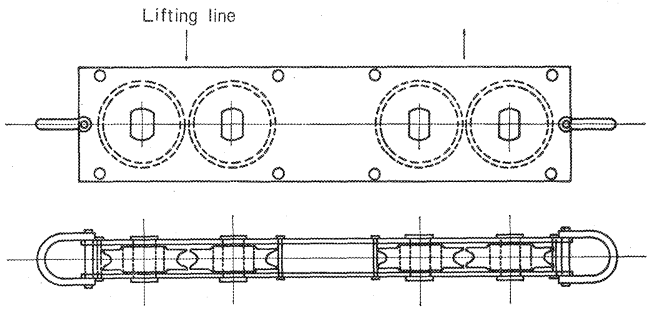

Fig. 37 Special free block.

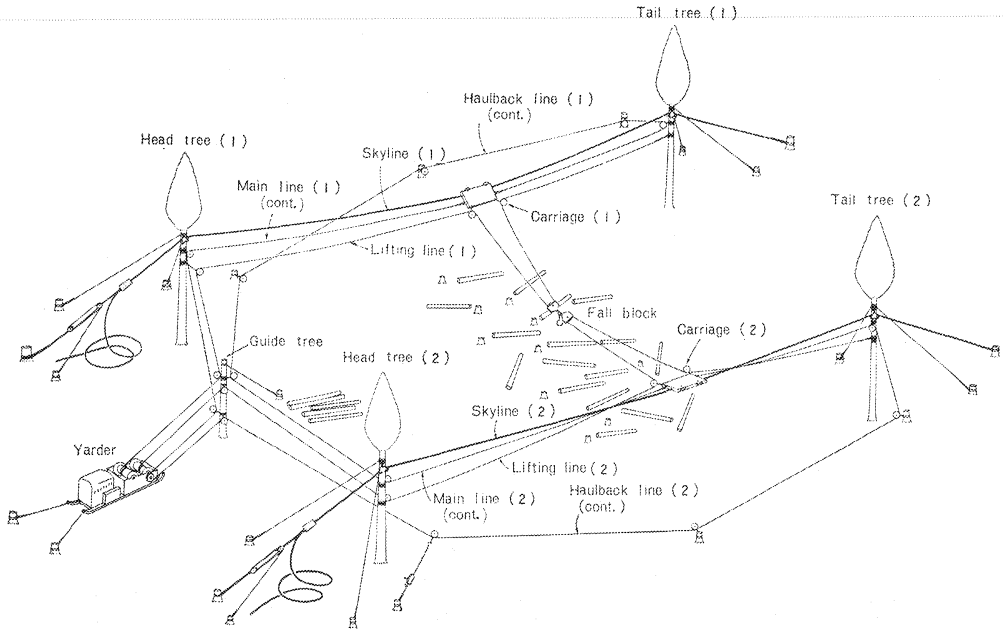

Fig. 38 For the purpose of reducing the damage to the young growth in natural forests in logging operation, the H-shaped Tyler system was first employed in Kamiashibetsu national forest, Hokkaido, in 1970[146].

It consisted of two skylines, 314 m and 324 m long, respectively, paralleling each other 75 m apart, two lifting lines, two traction lines, a fall block equipped with two lifting-line sheaves, and a three-drum yarder. The skyline was 24 mm in diameter and the operating lines were all 12 mm in diameter.

Setting up the system was done by a crew of four men in 15.5 days. The daily average output was 27.6 m^3 by a crew of four men in the test of nine days. Damage to the young growth by this system was considerably less than that by the ordinary skyline systems.

Incidentally, this H-shaped Tyler system was once tried for stacking timbers at the landing in Numata national forest, Gunma, in 1963.

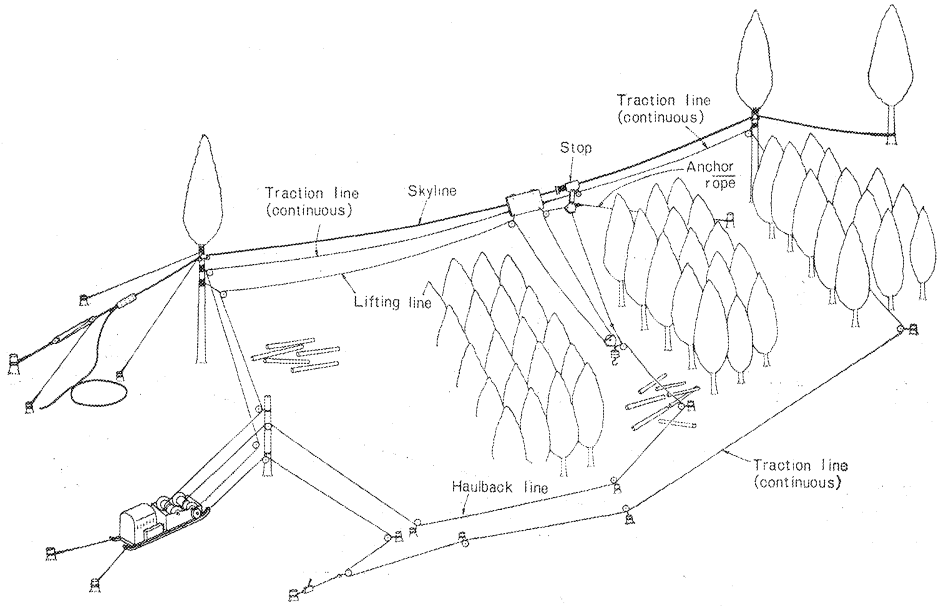

Fig. 39 This is a modified Tyler system more suitable than the one shown in Fig. 32 for yarding branched strips, because an additional traction line can regulate the movement of the carriage when lateral yarding is conducted. By means of braking the traction line, the carriage is steadily stopped at any point desired on the skyline, and, consequently, lateral yarding can be done successfully[37)43)74)93)96)97)101)138)240)246)309)].

This system is one of the most popular skyline systems for yarding branched strips, and it has been very often employed all over the country.

By this system, logs are yarded from about 100 m on each side of the skyline in the branched strips with little damage to the residual stand. This system holds the lateral yarding distance record of 220 m in Esashi national forest in Hokkaido[309)].

Compared to the ordinary endless Tyler system, however, this system shows 10~20% decrease in daily average output.

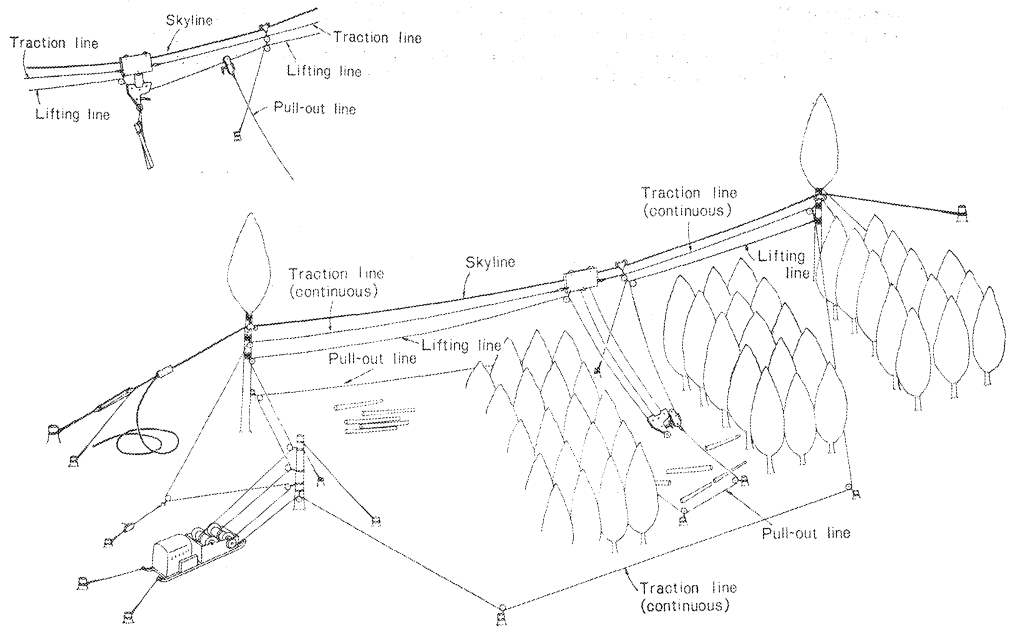

Fig. 40 A special fall block and a guide block having the locking devices are rarely used in the Tyler system to carry out the branched strip yarding. A pull-out line is attached to the locking guide block, and the lifting line is passed through it.

When the empty carriage arrives at the stop, the fall block runs into the guide block, and they are coupled with each other by the working of the locking devices. By reeling in the pull-out line and taking off the lifting line brake, the fall block joined with the guide block are led to the logs.

When the chokers are set, the lifting line is reeled in and the pull-out line is released. When the lift-up is made, the fall block hits the bottom of the carriage and the locking devices are unlocked automatically. Then the loaded carriage is made to travel to the landing by the traction line while the guide block is left at the intersection of branched strip and skyline road.

This system was operated for the first time in Otaki national forest, Nagano, in 1969[176].

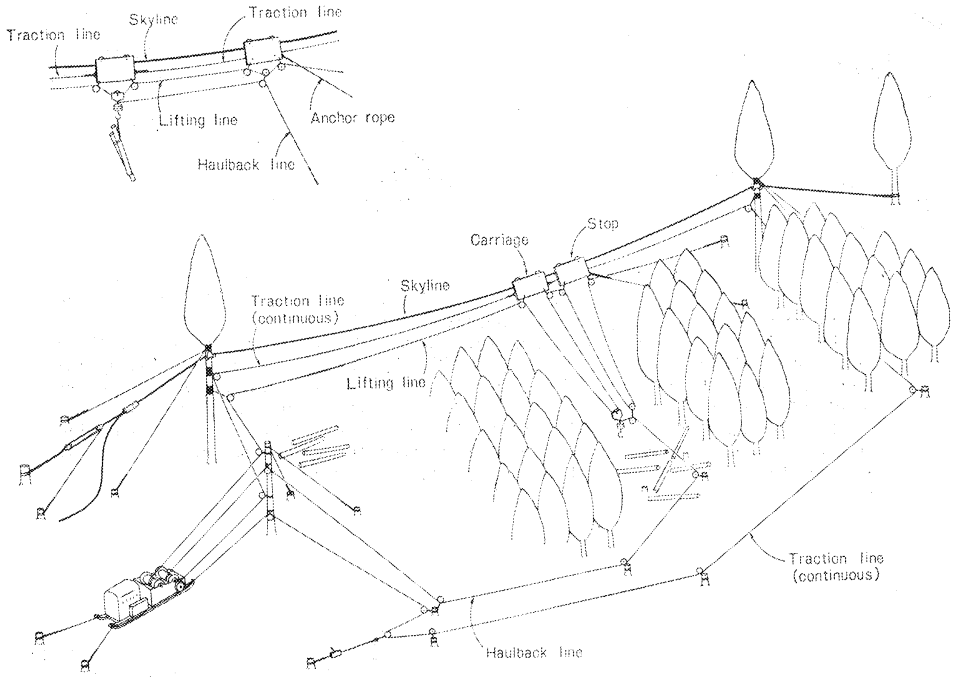

Fig. 41 This is the original skyline system for branched strip yarding, which is capable of skidding logs from the stump to the skyline and transporting the logs to the landing in one operation.

A special stop having two blocks or an extra carriage is additionally used in this system. This system is rigged by threading the lifting line through two blocks of the stop and through the upper block of the tied blocks in the same way as under the ordinary carriage, and also by threading the haulback line from the fall block through the lower block of the tied blocks. In consequence of these arrangements, the behavior of the haulback line can be controlled by the lifting line tension automatically.

When lateral yarding is carried out, the haulback line is wound up and the lifting line is released at the same time, so that the fall block is led along with the tied blocks to the tail block attached to a stump. After the logs are choked, the lifting line is wound up and the haulback line is released gradually, then the turn of logs is hauled up to the carriage in a straight line. The travel of the carriage is controlled by the continuous traction line[114)278)280)].

The selective Tyler systems, in which the behavior of haulback line is controlled automatically by the lifting line tension, have developed from this system[280)].

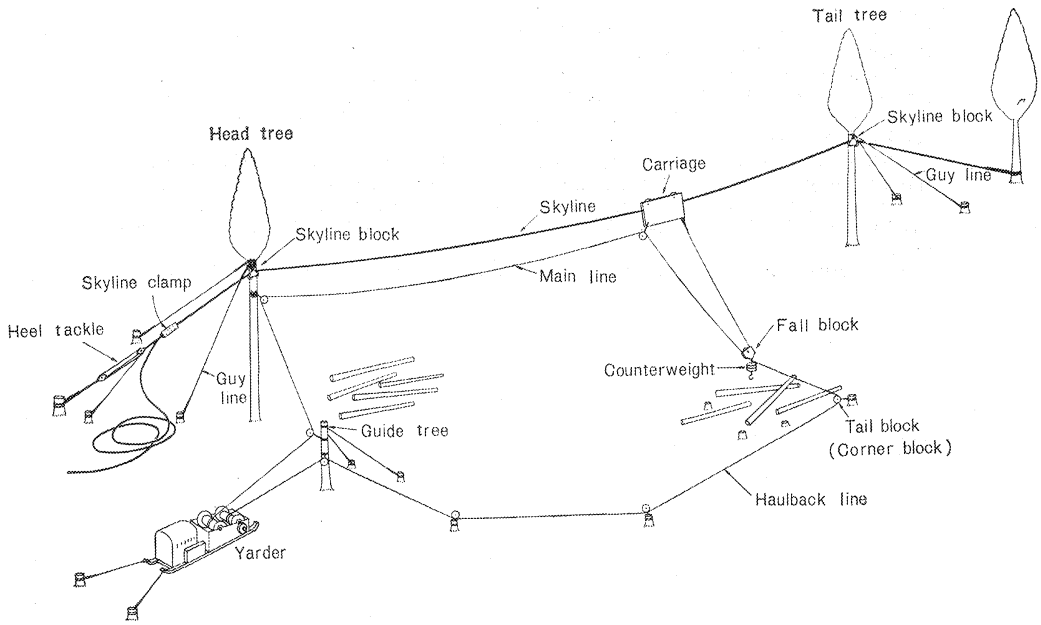

Fig. 42 The downhill North Bend system has been very often employed on flat spans or gentle downhill or uphill slopes. By this system, logs are generally yarded from 30 to 80 m on each side of the skyline in a clear-cutting area[29)135)145)211)295)300)].

Up to this time, several modifications have developed from the original downhill North Bend system; the one having a traction line additionally[275)], the one using a self-locking carriage and fall block[66)84)99)127)182)144)179)203)], the one using a locking carriage and one or two stops[54)99)203)], the one having double skylines and a two-track carriage[189)], and so forth.

The advantages of the downhill North Bend system are its flexibility and ease of rigging up, and less wear on operation lines. The disadvantage is the difficulty in operation, especially on steep slopes, unless the self locking carriage and fall block are used.

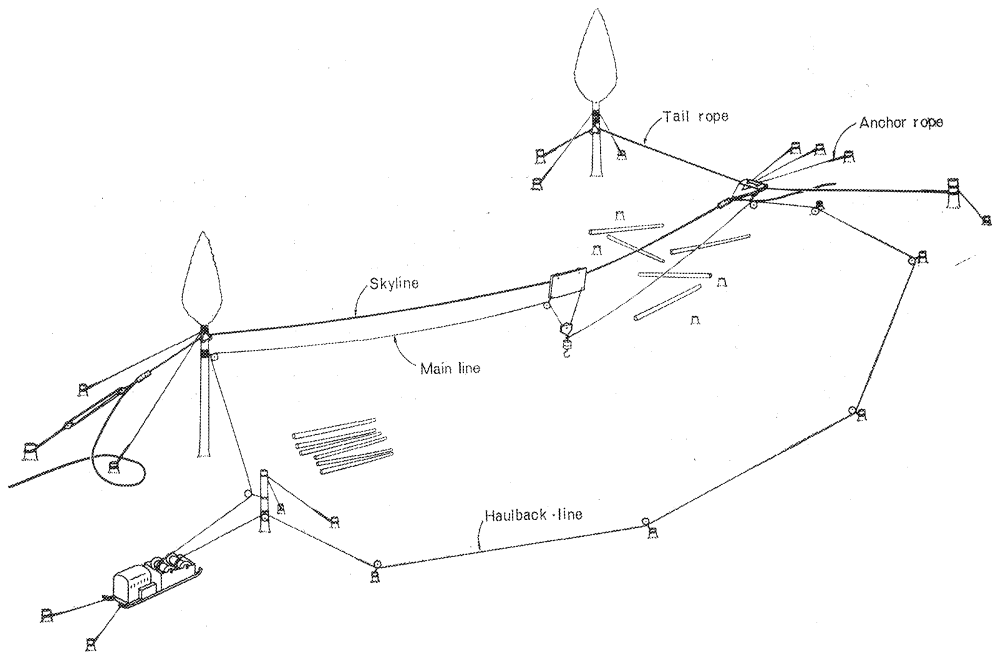

Fig. 43 In order to carry out a large area logging by one skyline, the Y-shaped skyline system is used. The expression of "Y-shaped" comes from the fact that the skyline and guide cable used in this system make the form of the letter "Y".

In this method, a guide cable, or a tail line, is set up at the outer end at right angles to the skyline and serves as a tail hold, so that the back end of the skyline is able to move along the tail line with a skyline support. Moving the back end of the skyline is done by man-power or by mechanical power.

The first trial of the Y-shaped downhill North Bend system by man-power was made in Tsubetsu national forest, Hokkaido, in 1960[290]. The back end of the skyline was secured to the skyline support riding on the tail line, and the skyline support was anchored to the stumps with the anchor ropes.

The new Y-shaped skyline system with mechanical power was tried in Hidaka national forest, Hokkaido, in 1964[119]. The skyline support was moved along the tail line by an endless rope driven by a yarder for exclusive use.

The Y-shaped skyline method has been applied to other skyline systems, for instance, to the Tyler system in Ina national forest, Nagano, in 1963[48)125)].

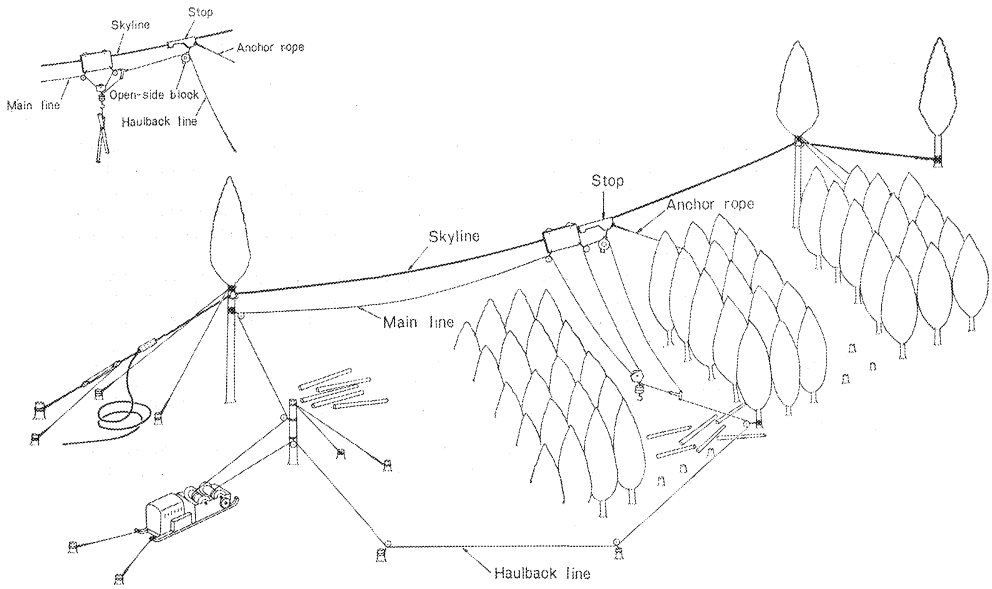

Fig. 44 This system is one of the most unique selective yarding skyline systems. It was developed for the first time in Kotanbetsu national forest, Hokkaido, in 1973[52)131)252)].

In this system, J-shaped rod and open-side block through which the J-shaped rod and wire rope pass are used as special rigging. Both ends of the main line and haulback line are attached to the head of the J-rod together, and the tail end of the J-rod and fall block are connected with each other with a 2.5-m wire rope. The open-side block is secured to the stop on the skyline.

When the empty carriage arrives at the stop, the J-rod is passed through the open-side block and pulled into the cutting strip in company with the fall block by reeling in the haulback line. When the turn of logs is skidded, the J-rod is drawn up laterally to the stop together with the fall block by reeling in the main line, and it is passed through the open-side block conversely. The loaded carriage is led to the landing by winding the main line while the brake of the haulback line is taken off gradually.

Finally, while the carriage is running there and back on the skyline, the haulback line is passing through the open-side block. And while lateral yarding is being conducted, the main line is passing through it. Yarding logs from the stumps to the skyline and transporting them to the landing, of course, are made in one operation.

There is a modification of this system, which has a traction line to change the location of the stop mechanically.

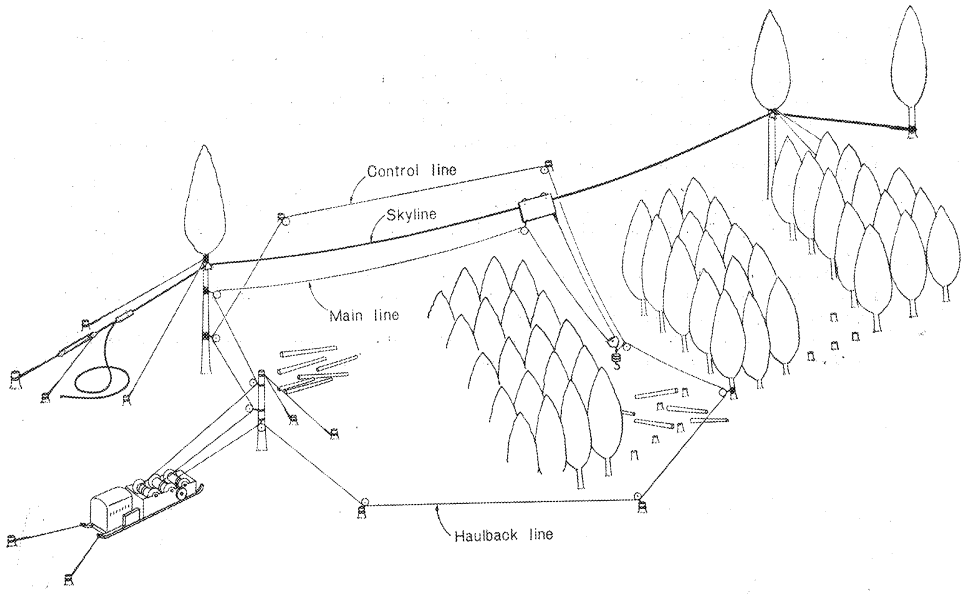

Fig. 45 This is also a modified downhill North Bend system for the purpose of selective logging. To control sideslipping of the haulback line, a control line is added to the ordinary system. The haulback line is passed through a control block attached to the end of the control line. The control line from the control block is passed through a guide block, which is located on the opposite hill side or attached to the stop on the skyline, and is led through several blocks to a drum of the yarder.

When the fall block is pulled into or out of the cutting strip laterally, three lines, namely the main line, the haulback line and the control line, should be handled at the same time. Consequently, the three-drum yarder is required for this system, and its operation is rather hard.

The method in which the guide block for the control line is attached to the stop was first developed in Suwa national forest, Nagano, in 1968[88]. And another method in which the guide block is attached to the stump on the opposite hill-side has been used in Mukawa national forest, Hokkaido, since 1969[85)109)136)170)].

As the result of performance of the latter method for several years, it was realized that the daily output decreases by about 20% as compared with the ordinary downhill North Bend system.

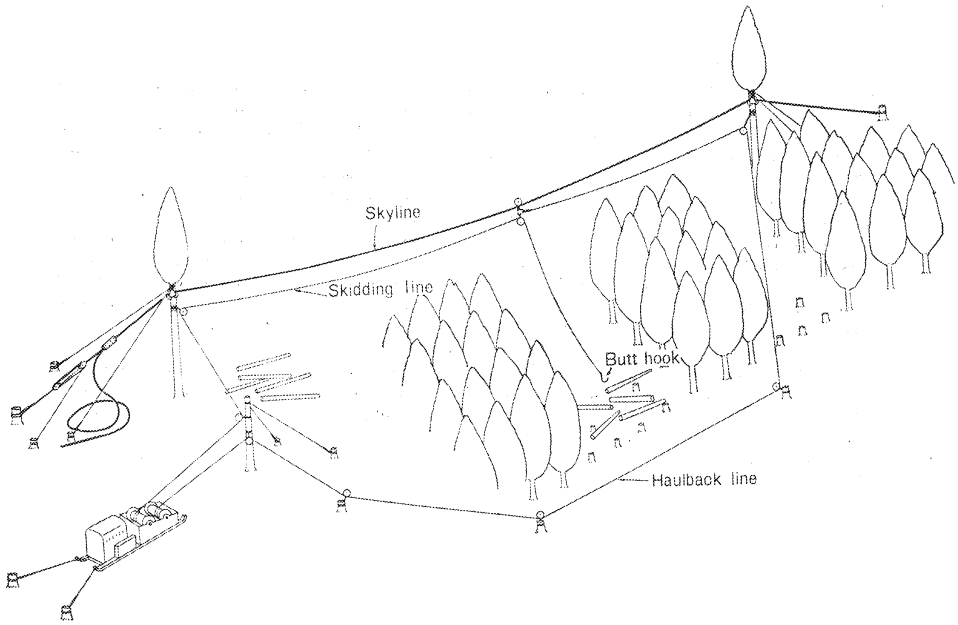

Fig. 46 This system is regarded as the simplest form of the Lidgerwood skidder system. But it can also be considered that this is one of modifications of downhill North Bend system, because it has the same dynamical principle as the downhill North Bend in the way that the operating lines work on the load. That is, the turn of logs can be lifted up and held in the air with the result that the skidding line and the haulback line are pulled against each other.

In this system, a simple carriage equipped with two track sheaves and a skidding line sheave or two guide blocks shackled with each other is used. The skidding line from the drum is passed through the skidding line sheave and hung down. A butt hook is attached to the end of the skidding line. The haulback line is attached to the rear edge of the carriage.

This system is often used as a selective yarding system over short distances of 50 to 300 m.

It was used for the first time for selective cutting in Jozankei national forest, Hokkaido, in 1970[286]. In this case, a truck crane equipped with two drums was used as the yarder, and the skyline was 14 mm in diameter.

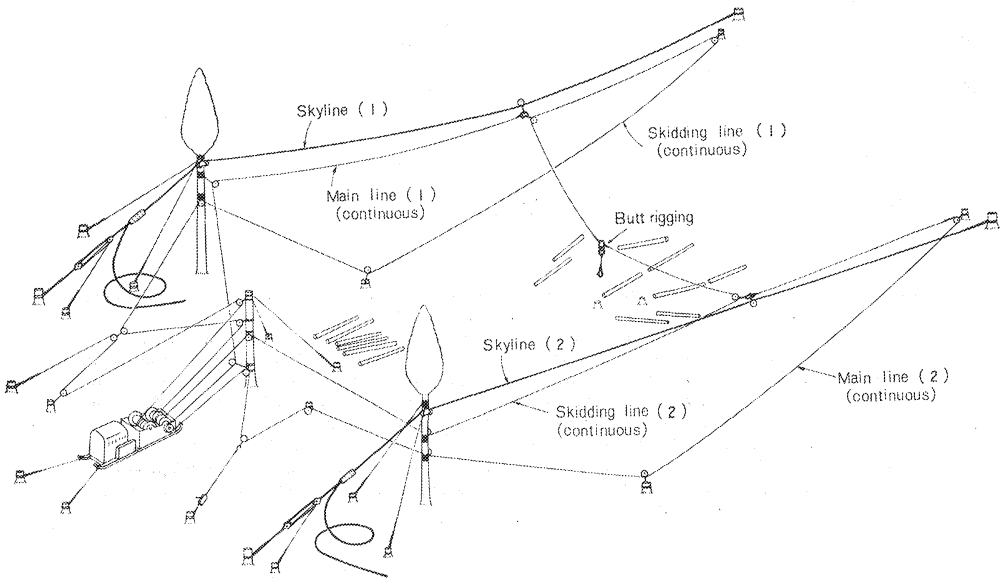

Fig. 47 This is the H-shaped North Bend system, or a combination of two simplified North Bend systems shown in Fig. 46.

Two skidding lines are connected with each other with a butt hook in between, and the other end of them are also connected with each other, and that makes a continuous rope. Each haulback line is attached to the simple carriage respectively, but the other ends of the haulback lines are connected with each other, and that makes another continuous rope. Each line is driven by the spool-type drum of the yarder.

For the purpose of raising and lowering the butt hook, a tightening line is used.

When the skidding line and the haulback line are driven in opposite direction at the same speed, both carriages and butt hook are moved lengthways all together. If there is, however, some difference between the speeds of two moving lines, the butt hook is moved crosswise regardless of the movement of the two carriages.

This system was first tried in Nahari national forest, Kochi, for yarding strips along contour lines in 1973[100].

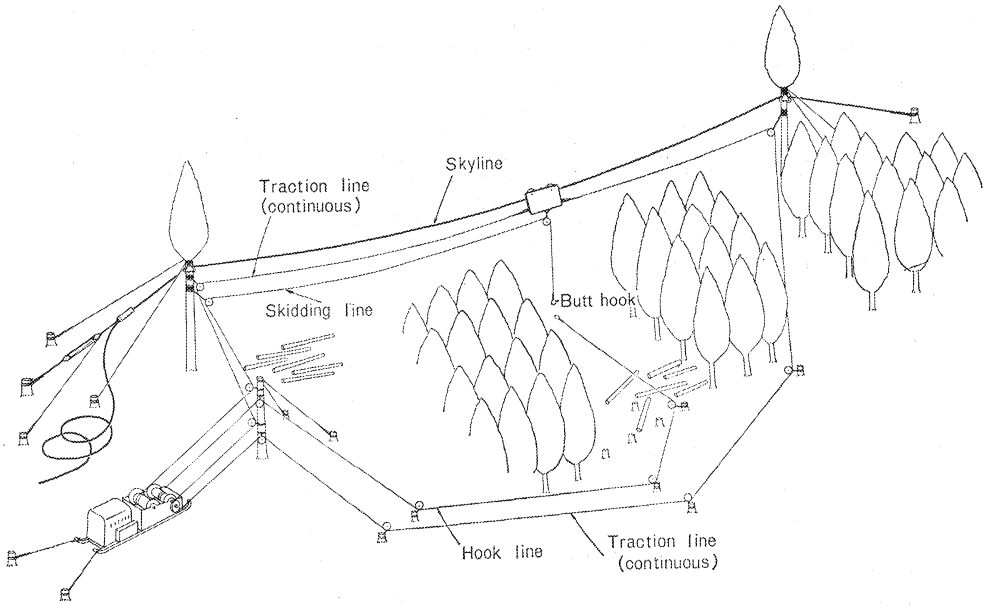

Fig. 48 This system is composed of a skyline, a skidding line, a traction line, a hook line, a carriage, a butt hook, and a three-drum yarder.

The continuous traction line is driven by the spool-type drum. The butt hook is attached to the end of the skidding line which is passed through the lower sheave of the carriage and hung down. The hook line is used for pulling the skidding line with butt hook laterally to where the logs to be hauled lie. The hook line is hooked to the butt hook by one of the crew members every time, and it is taken off from the butt hook by him, too.

As a modification of this system, there is the one having no hook line. In this modified system, pulling the skidding line laterally is done by man-power. This one was adapted to a selective cutting site in Usuda national forest, Nagano, in 1972. It had a span of 320 m, and the skyline was 24 mm in diameter.

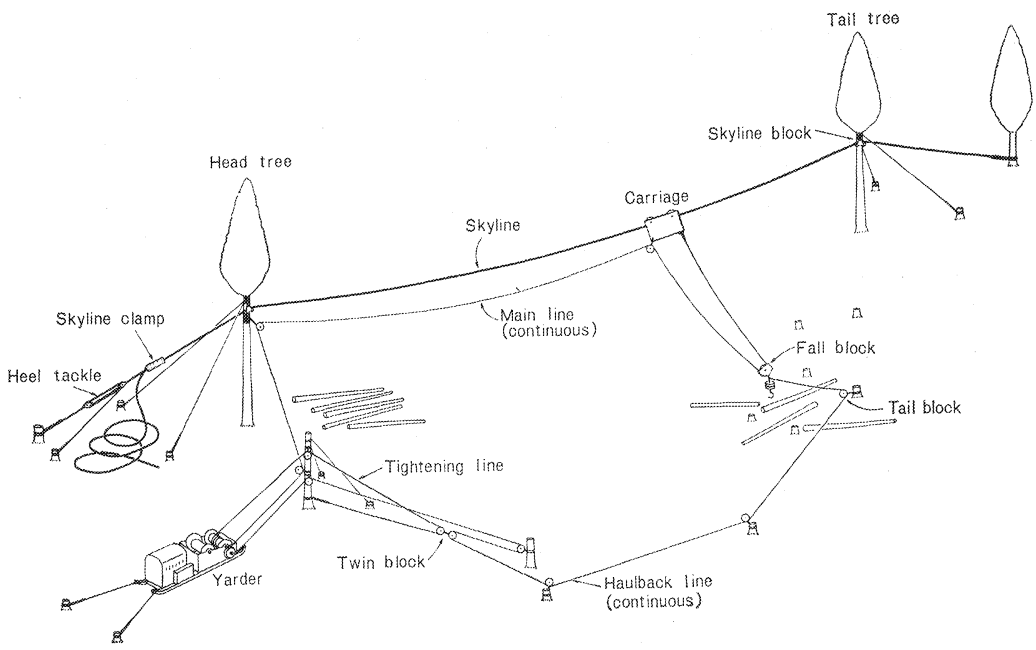

Fig. 49 If the main line and the haulback line in the downhill North Bend system are connected with each other at the yarder, and a tightening line for controlling the continuous line tension is added for raising or lowering the fall block, the downhill North Bend system becomes the Kumamoto system[155)184)198)210)].

The advantages of the Kumamoto system compared with other skyline systems are its simplicity of operation, adaptability to a wide range of gradients from gentle slope to medium slope, and use of the small capacity yarder equipped with an ordinary drum and a spool-type drum. The disadvantages are difficulty of long distance lateral yarding, hardness on rigging up, and severe wear on the continuous main-haulback line.

This system is not suitable for selective logging, because of the arrangement of operating lines.

There are many modified Kumamoto systems; the one in which a self-locking carriage and fall block are used[47)144)], the one in which a locking fall block and guide block as shown in Fig. 40 are used, the one in which a pull-out line is added[214)], and so on.

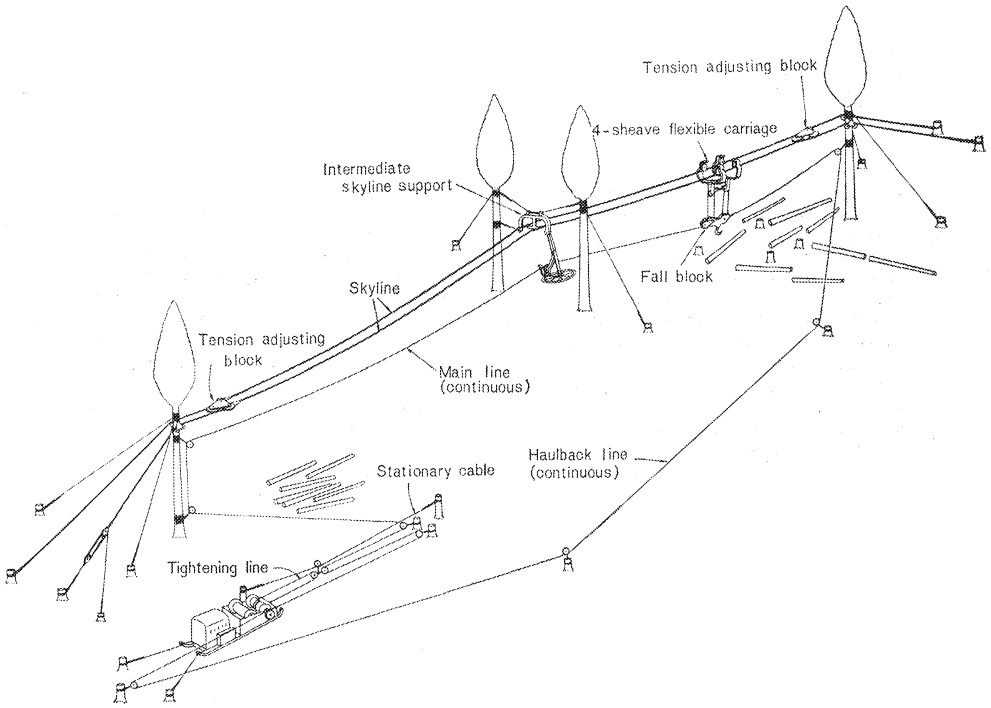

Fig. 50 The modified Kumamoto system having two small skylines instead of a single heavy cable was developed so as to make its setting up and changing roads easier and to make it possible to yard logs along a curved road[292)294)].

As special rigging for this system, two tension adjusting blocks, mono-carriages connected with each other by connecting rods, and an intermediate support are used. A fall block is used for large logs, but a butt hook for small logs. The tension adjusting blocks each of which has an isosceles-triangular frame and three sheaves are used at both ends of the double skylines and anchored respectively with anchor cables. One of the principal features of the intermediate support is its operating-line support like a long arm of a gibbon which makes it possible to yard the curved road.

This system was first tried in Kikuchi national forest, Kumamoto, in 1954[292)]. S-curved road yarding was also carried out with great success in 1957[294)].

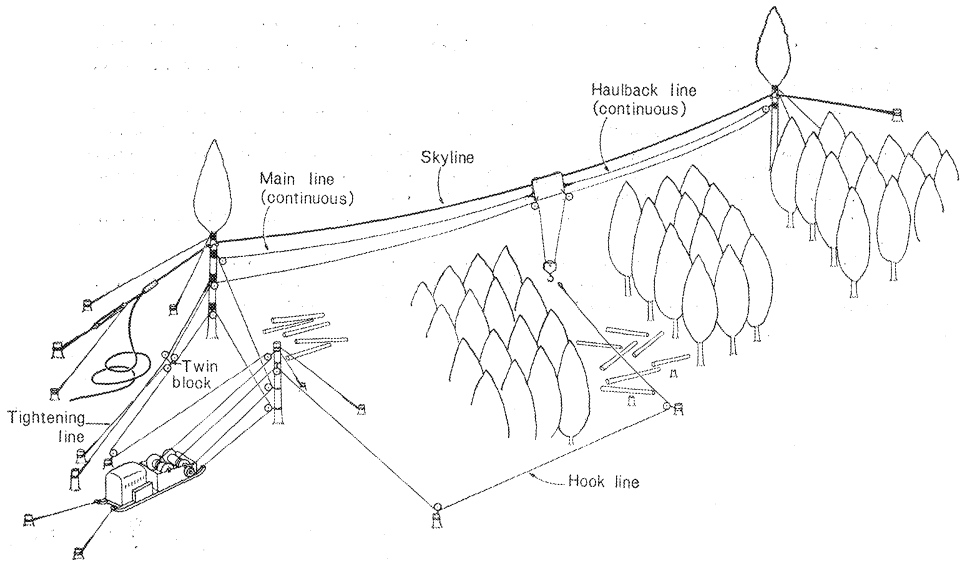

Fig. 51 This system is operated in the same way as the Kumamoto system, in that the turn is lifted or lowered by means of tightening or slackening a continuous main-haulback line, and the carriage is traveled by the same continuous line.

The haulback line from the rear edge of the carriage runs back through the haulback block on the tail tree, forward through the lower blocks under the carriage into the fall block, through a lead block on the head tree, then to the spool-type drum on the yarder. The main line fastened to the front edge of the carriage runs forward through another lead block to the spool-type drum and is spliced with the haulback line, so that the main line and the haulback line are made a continuous line. The tightening line from the tightening drum runs through the twin block in the same way as the Kumamoto system. An additional hook line serves for pulling out the fall block to where the turn is to be hooked on. The hook line is attached to or taken off the fall block by hand.

This system was first used for selective cutting in Usuda national forest, Nagano, in 1971[43)97)].

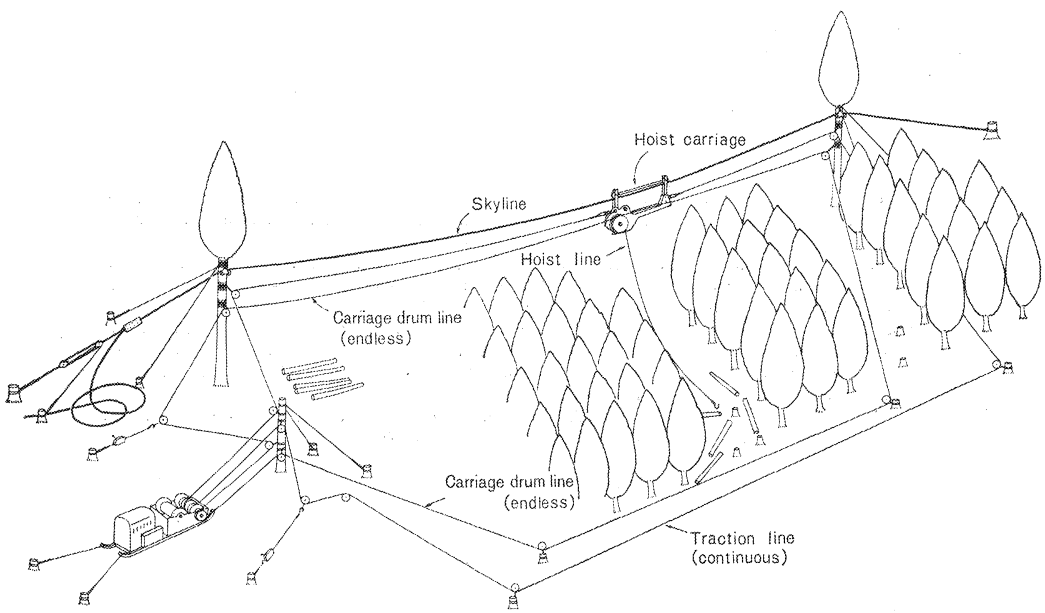

Fig. 52 This is the most popular hoist-yarding system in Japan.

It consists of a skyline, a hoist carriage which has a carriage drum holding a hoist line, a continuous traction line, both ends of which are fastened to the front and rear edges of the hoist carriage respectively, an endless carriage drum line, and a two drum yarder.

When the traction line and the carriage drum line are driven at the same speed, the hoist carriage travels keeping a certain distance between the carriage and the butt hook attached to the bottom end of the hoist line. When there is difference between two line-speeds including the case that one of them is at a stop, the hoist line drum is driven so that the butt hook is raised or lowered[6)7)13)94)190)259)278)282)299)305)].

This system was developed in Yabuhara national forest, Nagano, in 1957[282)299)]. After that, various improvements were made with the result that this system has been put to widespread practical use. The span of this system is usually 200~600 m, and the daily output is 20~30 m³ by a crew of three or four men.

As a unique application of this system, the Y-shaped hoist carriage system which is called the "standing tree yarding method" was tried in Daigo national forest, Ibaragi, in 1962[80)81)82)]. In this trial, each of the mature trees were cut and yarded as they stood to prevent the young trees planted in the forest before cutting from damage. The trial in Daigo national forest proved successful because the skyline could be held high up over the stand.

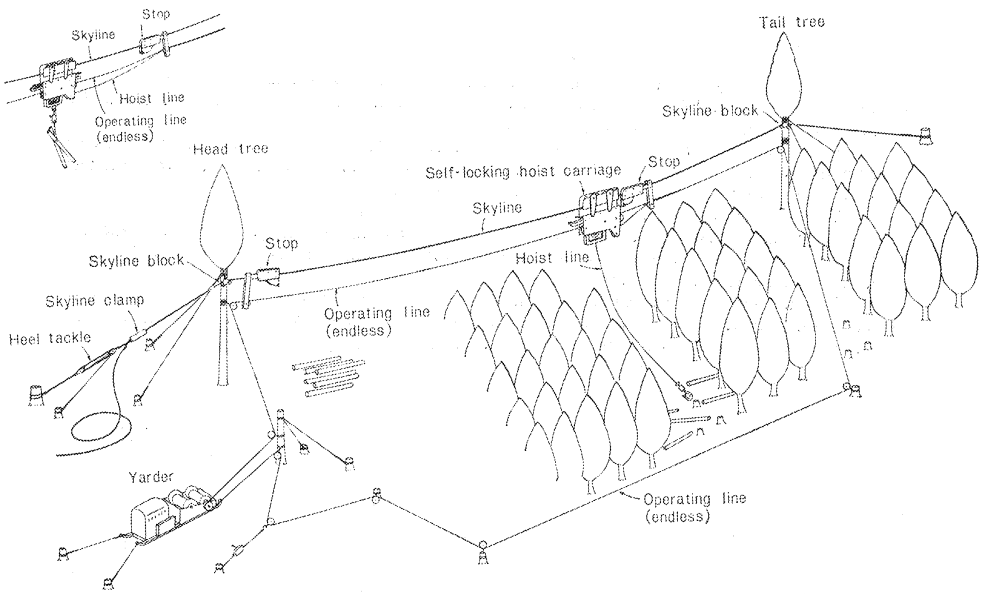

Fig. 53 This system consists of a skyline, an endless operating line, a hoist carriage equipped with a self-locking device and a carriage drum, two stops, the upper one and the lower one, and a one-drum yarder.

Since the self-locking device of the carriage ordinarily tightly grasps the operating line, the carriage is traveled by the operating line. When the carriage runs into a stop, the self-locking device instantly releases the operating line and grasps the skyline instead. As a result, the carriage drum is operated by the operating line and a hoist line is lowered to the ground. On the contrary, when the hoist line is reeled in and the butt hook thrusts up the bottom of the carriage, the self-locking device releases the skyline and grasps the operating line again. The operation of this system is easy, but the self-locking device is complicated and because of that it does not always work satisfactorily[46)187)186)187)188)228)228)229)].

A hoist carriage named "Akimoku carriage" was developed in Odate national forest, Akita, in 1954[228)229)]. The "Maruken carriage"[45)] developed in 1953 is similar to the Akimoku carriage in mechanical principle.

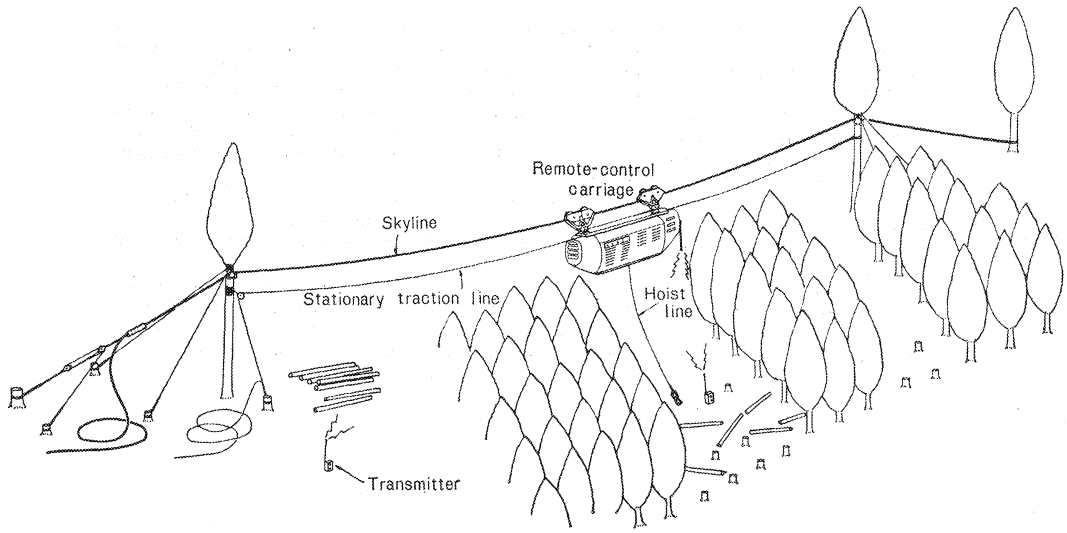

Fig. 54 The test run of the first self-propelled hoist carriage was made in Takanosu national forest, Akita, in 1964[197]. The carriage had a 60-hp gasoline engine, a wireless control device and a hoist drum inside, and weighed 750 kg.

It traveled over a 26-mm skyline approximately 300 m long by pulling in a stationary 12-mm wire rope. Driving the carriage and raising or lowering the hoist line were handled by a choker setter and an unhooker through transmitters.

The daily output was about 14 m^3 by a crew of four men.

After that, a new self-propelled hoist carriage, which had a 55-hp gasoline engine and was 980 kg in weight, was used in Numata national forest, Gunma, in 1968[191]. The daily output of this system was about 16 m^3.

To summarize the disadvantages of this system; ① it needs another yarder for setting up the system, ② the mechanism of the carriage does not always work smoothly, and ③ the carriage itself was too heavy to lift an additional heavy load.

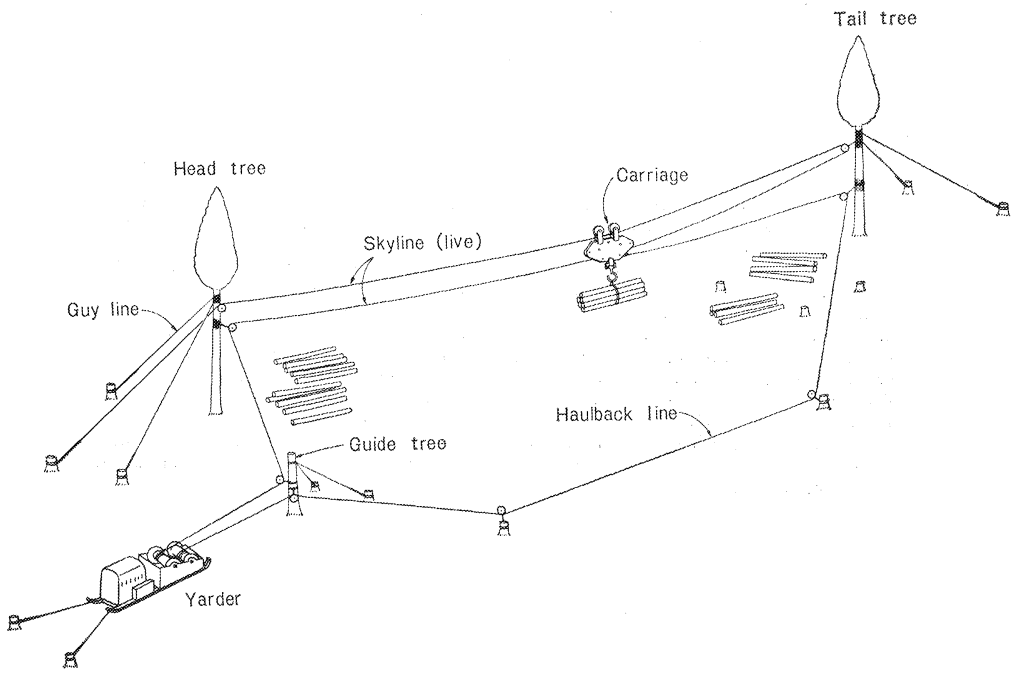

Fig. 55 This system is a combination of the double slack-line system and the gravity slack-line system. The skyline anchored to a stump or a tree near the head tree runs back through the skyline block hung on the head tree, through two carriage sheaves, through the skyline block on the tail tree, then forward through two other carriage sheaves, and through another skyline block on the head tree to the skyline drum of the yarder.

The end of the haulback line is fastened to the rear edge of the carriage, and the haulback line is led through the haulback block on the tail tree, forward through a series of blocks, and to the second drum of the yarder. A butt hook is attached to the bottom of the carriage[218)219)249)].

This system was used in Ichinohashi national forest, Hokkaido, from 1961 to 1965[218)]. The skyline was 12 mm in diameter and the haulback line 10 mm in diameter. The daily output was about 19 m³ by a crew of five men at 100-m yarding distance.

Since a small-diameter skyline is used, it is easy to set up this system. However, this system is unsuitable for selective logging.

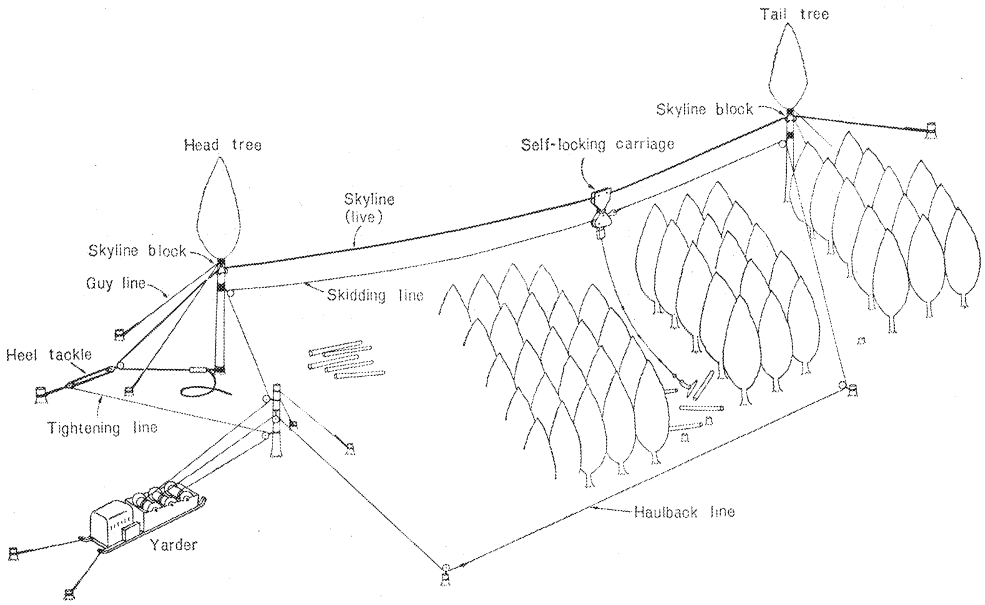

Fig. 56 This is a modified slack-line system provided with a locking carriage. The carriage is equipped with a locking device for holding the skidding line. The skidding line is passed through the lower sheave and the locking device of the carriage, and hung down under the carriage. A butt hook is attached to the end of the skidding line. There are several stopper fittings, which are made of wire rope, on the skidding line every 2 m from the butt hook.

By holding one of the stopper fittings on the skidding line by the locking device of the carriage, the butt hook is hung down keeping enough distance from the carriage to be caught by a choker setter on the ground. The end of the haulback line is attached to the back edge of the carriage. The butt hook is pulled to the side by man-power. If the terrain makes it necessary, the skyline is raised or lowered by the heel tackle.

This system was used for the first time in Maruseppu national forest, Hokkaido, in 1968[67)285)]. The system commonly operates over yarding distances of 200～300 m, and it can be used for selective logging[67)152)221)285)].

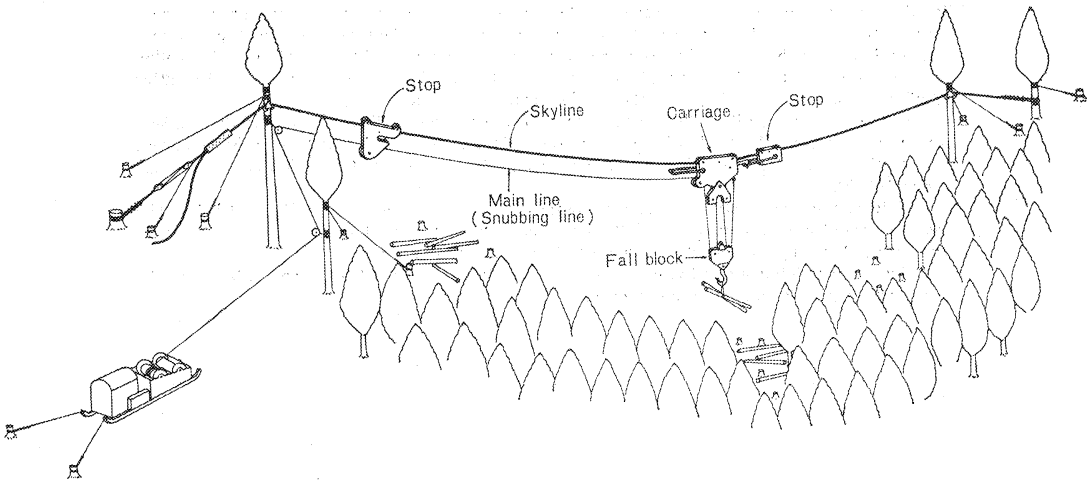

Fig. 57 This aerial snubbing system consists of a skyline, a skidding line, or snubbing line, a snubbing carriage, a locking fall block, two stops, and a one- or two-drum yarder. Since the two stops, the upper one and the lower one, are installed and the fall block can be lowered to any position desired at the stop, this system is not restricted by topography.

In operation, the fall block is released from the carriage and lowered, when the carriage collides with the stop and couples to it. On the contrary, when the fall block thrusts up the device, the fall block is locked in the locking device at the bottom of the carriage, and the carriage is released from the stop.

This system was used for the first time in a private forest in Kochi Prefecture in 1956, five years after the introduction of the Wyssen skyline crane[25)26)27)].

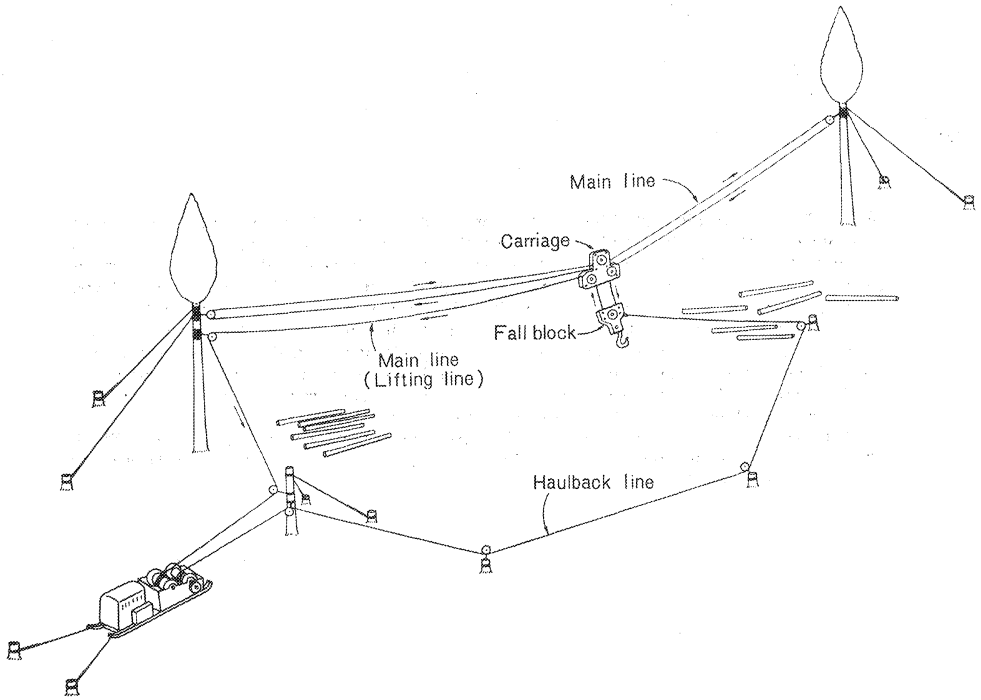

Fig. 58 The Dunham system consists of a main line, a haulback line, a three-sheave carriage, a fall block, and a two-drum yarder.

The main line runs from the main line drum on the yarder through a lead block on the head tree, back through one of the two lower carriage sheaves, down through the fall block, up through the other lower sheave, back through a tail block on the tail tree, forward through the upper carriage sheave, then through another lead block on the head tree, back to the carriage, and is attached to the front edge of the carriage. The haulback line runs from the haulback drum through a series of blocks, then through a tail block, and is attached to the fall block.

The rigging is so complicated and line wear on the main line is so severe that this system has been rarely used so far. A new Dunham carriage shown above was designed in Kogawa national forest, Kochi, in 1960[68].

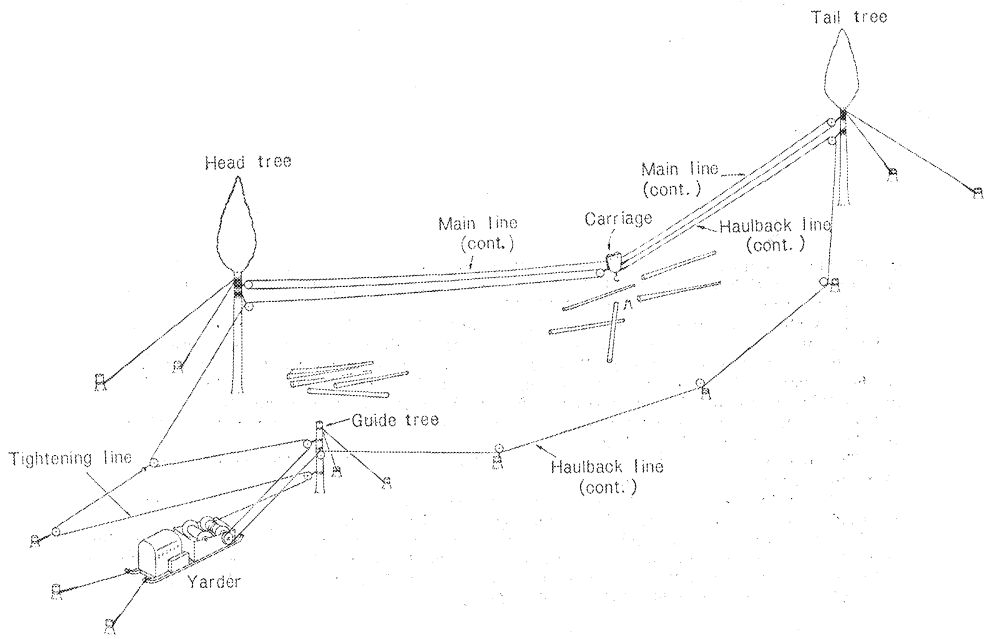

Fig. 59 This modified Dunham system consists of a main line, a haulback line, a tightening line, a carriage, and a yarder equipped with one drum and one spool-type drum. The main line and the haulback line are connected with each other at the spool-type drum to make a continuous line. Fall block is not used, and a butt hook is attached to the bottom of the carriage. The carriage rides on the main line, so the main line serves as the skyline.

Raising or lowering the carriage is managed by the tightening line working on the continuous main-haulback line. The operation of this system is easier than the ordinary Dunham system, because the main line which serves as the skyline is kept at almost constant deflection by setting the brake on the tightening line. Since it difficult to pull out the carriage to the side laterally, this system is commonly used only in a short distance swinging operation[195].

Besides, there is another modified Dunham system additionally rigged with a skidding line[71]. In this new system, the continuous main-haulback line is set up in the sky, and lifting up or lowering the turn of logs is done by the skidding line.

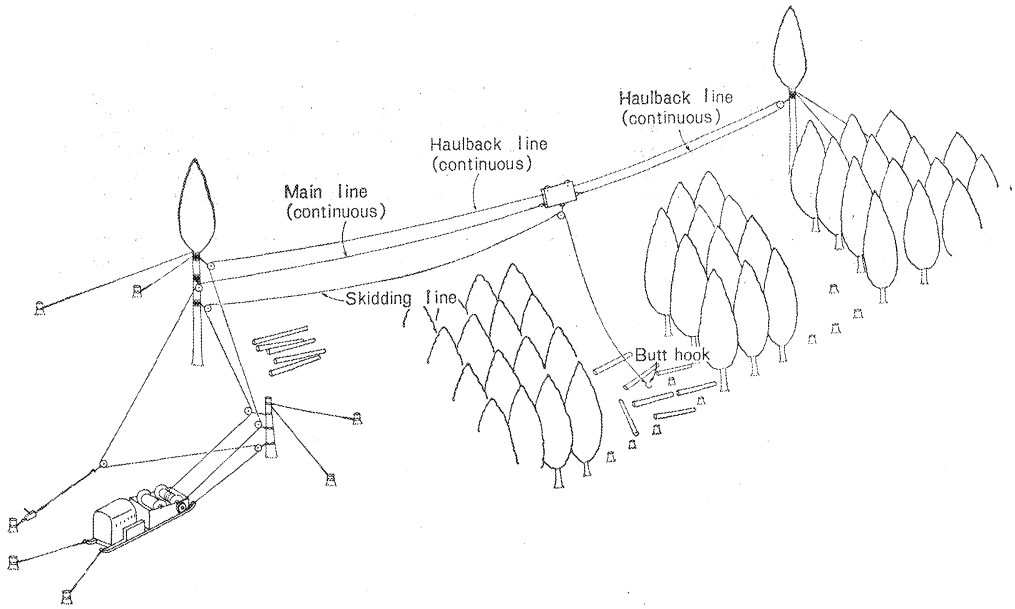

Fig. 60 This system is generally called the "Obihiro system," and it was developed in Nemuro national forest, Hokkaido, in 1961[244)247)]. It is one of the most popular simple yarding systems for the selective cutting[1)2)12)16)39)65)71)129)178)181)234)307)].

The system consists of a continuous main-haulback line driven by a spool-type drum, a skidding line with a butt hook, and a simple carriage equipped with two upper track sheaves and a lower skidding line sheave. Both ends of the continuous main-haulback line are fastened to the carriage. The diameters of the continuous main-haulback line and the skidding line are 10~12 mm in general. The carriage rides on the haulback line serving also as the skyline. When the empty carriage arrives at the desired point, a choker setter pulls the skidding line to where the turn is to be hooked on.

The span of this system is comparatively short as 100~300 m. The daily output is 15~23 m^3 by a crew of three or four men.

If the skyline is too high to be held by the choker setter, a tow line or a counterweight is attached to the end of the skidding line together with the butt hook.

Recently, two or three modifications have been introduced; the one in which a tightening line is used for raising or lowering the continuous main-haulback line[166)220)304)], another in which a hook line is added for pulling the skidding line to the side[6)19)], and one in which a tightening line and a hook line are added[43)92)96)], and so forth.

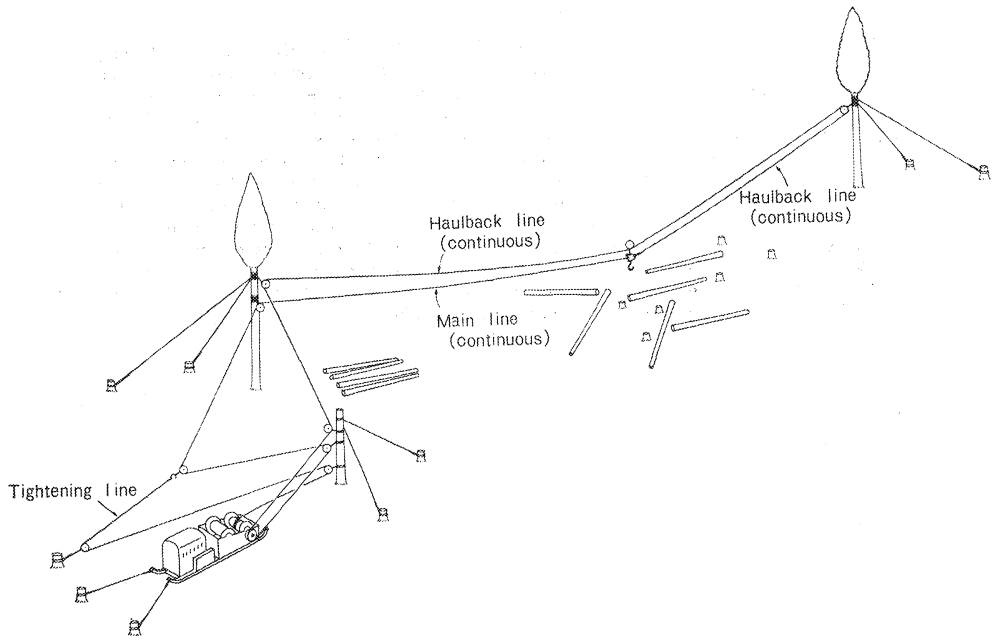

Fig. 61 It can be considered that this system is the simplest of all the running skyline systems.

The haulback line runs from a drum through a lead block on the head tree, back through the carriage sheave, through a block on the tail tree or stump, then forward to the carriage, and is fastened to the back edge of the carriage. The main line runs from another drum through a lead block on the head tree hung just below the haulback lead block, and is fastened to the front edge of the carriage. Since the carriage rides on the haulback line, the line serves as skyline simultaneously. A butt hook and chokers are attached to the bottom of the carriage[98)139)209)].

The advantage of this system is that it can yard the logs more smoothly than the high-lead system for the reason that the turn of logs is always hauled with its front end lifted over the obstacles. This is because the vertical component of the forces in the main line and haulback line is greater than that of the high-lead system of the same scale.

This system was employed for the first time in Maruseppu national forest, Hokkaido[139)], and Odate national forest, Akita, in 1959[209)].

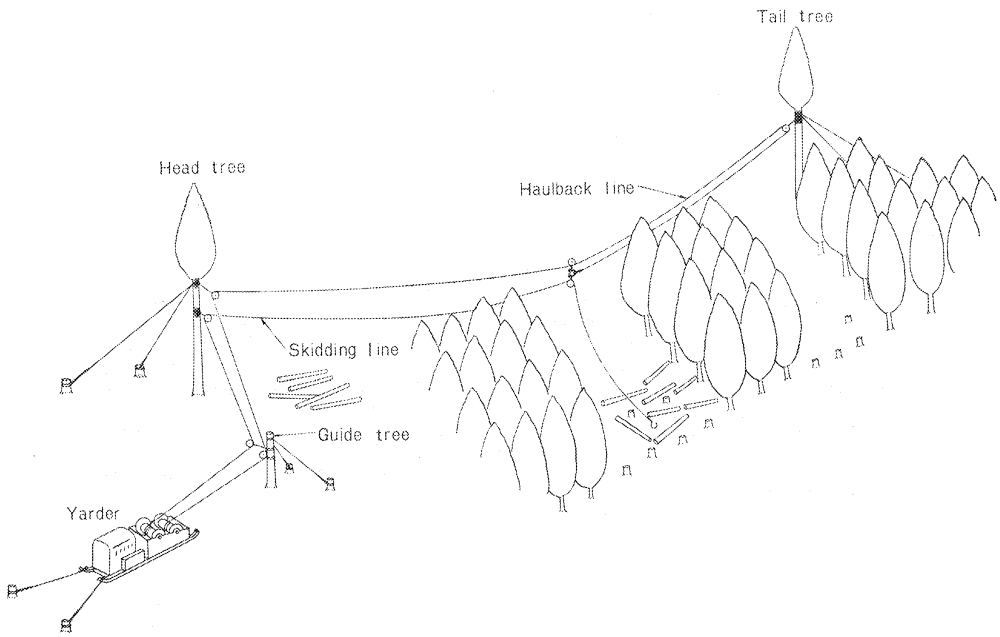

Fig. 62 It may be considered that this system is a cross between the running skyline system shown in Fig. 61 and the simplified North Bend system shown in Fig. 46.

The haulback line runs on the same route as the simplest running skyline system. The haulback line serves naturally as the skyline. The skidding line runs from the skidding drum through a lead block on the head tree, through the lower sheave of the carriage, and hangs down under the carriage. A butt hook is attached to the end of the skidding line. The skidding line and the haulback line are usually 10~12 mm in diameter[91)164)].

This system was first applied in Maruseppu national forest in Hokkaido, where the selective cutting was carried out, in 1964[164)]. It had a span of approximately 200 m.

As a modification of this system, one using a locking carriage similar to the one shown in Fig. 56 was tried in Ikutawara national forest, Hokkaido, in 1972[3)]. It had a span of 167 m and the daily output was about 21 m^3 by a crew of three men.

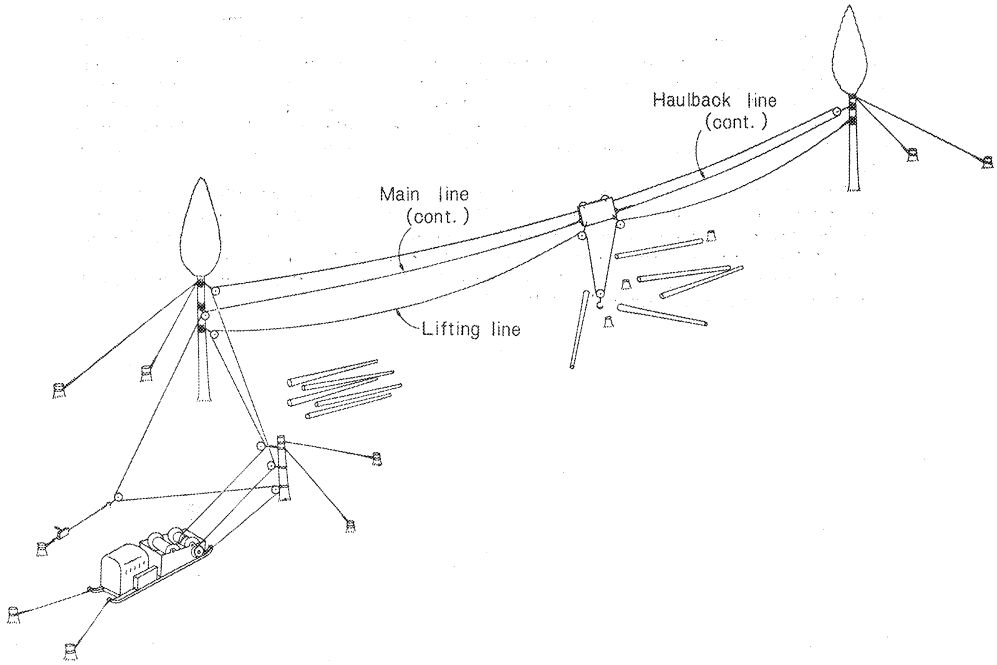

Fig. 63 This system is a modified running skyline system provided with a lifting line and a fall block instead of a skidding line and a butt hook. Having the lifting line like the Tyler system, this system can transport a heavier load than the ordinary running skyline system. However, since the haulback line is not fastened to the fall block but to the carriage, it is very difficult to pull out the fall block to the side. Accordingly, this system is especially suited to swinging the logs from a cold deck to the landing[24)134)243)].

This system was employed for the first time for a small area clear cutting in Hatano private forest, Kanagawa, in 1969[134)]. Generally, the span of this system is less than 150 m and the daily output is 10～15 m³ by a crew of three or four men. The wire rope used in this system is 8～10 mm in diameter.

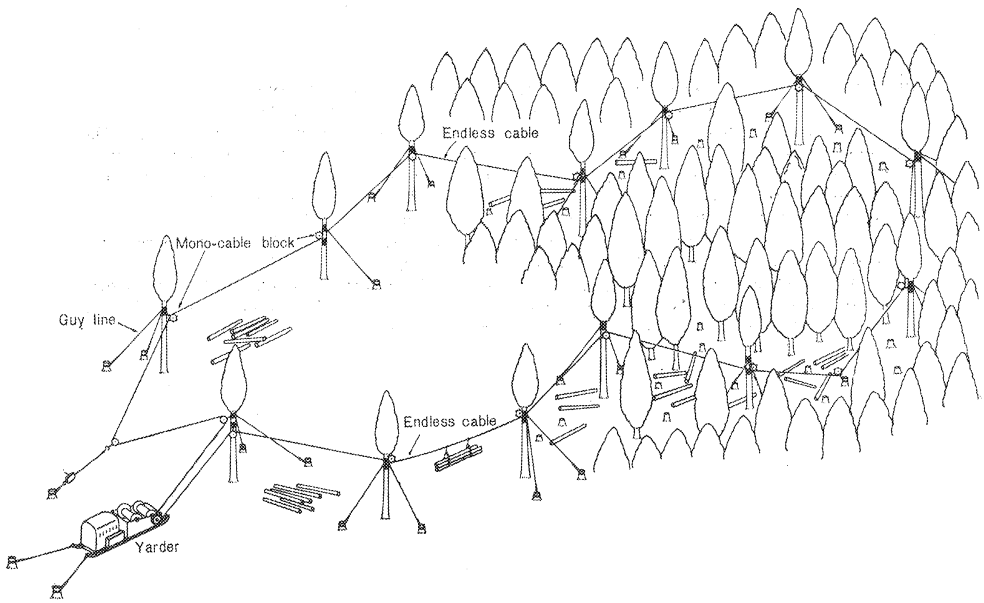

Fig. 64 This mono-cable system consists of an 8～14 mm endless cable, more than twenty open-side mono-cable blocks, and a yarder equipped with one spool-type drum and one ordinary drum. The turn of logs is attached to the endless cable with chokers and hanging ropes. To drop the turn instantly at the landing area, the contact hooks are set between chokers and hanging ropes as required. Generally, the weight of a turn is 100～400 kg, and two or more turns are transported at regular intervals. The daily output is 10～20 m^3 regardless of the yarding distance. The total length of the endless cable sometimes reaches over 1,500 m.

There are two different operation methods, one for the continuous operation and the other for the intermittent operation.

In the continuous operation, the endless cable is always driven at a uniform speed and never stopped except in time of danger. The endless cable is held down close to the ground by a guide block at the hooking area so as to make it easy for the choker setter to attach the turn to the endless rope. The turn of logs is generally choked at one point with a choker[187)264)265)266)].

In the intermittent operation, the endless cable is made to stop every time picking up or dropping the turn is done. When the turn is attached to the stopped endless cable, the cable is lowered by hand directly or with heel tackle. The turn of logs is usually choked at two points[60)76)86)122)232)248)263)264)296)].

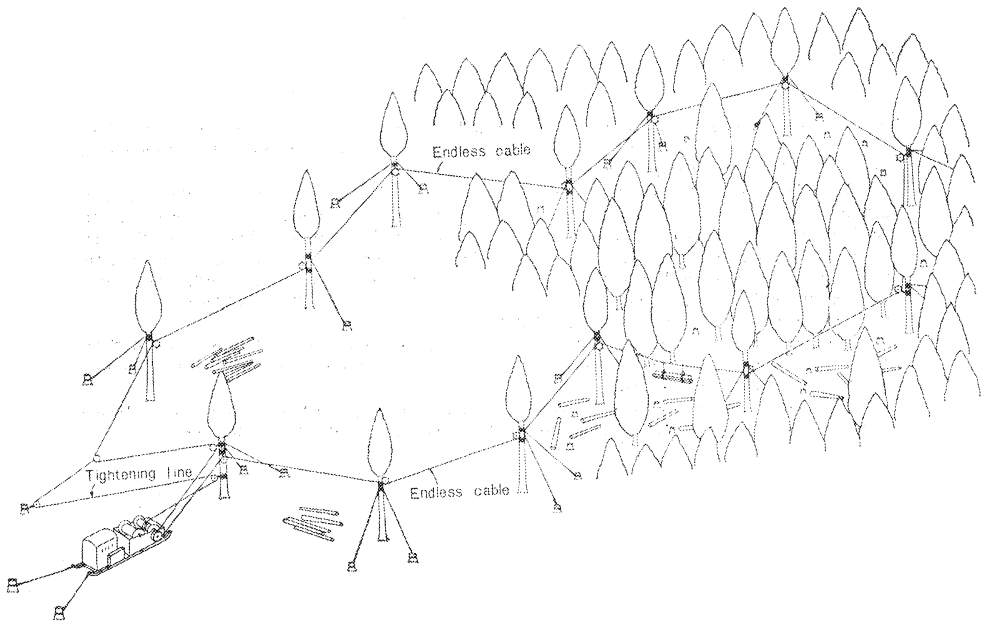

Fig. 65 This system is a modified mono-cable system additionally equipped with the endless rope control devices which are composed of a tightening line and a twin block or guide block. The endless cable is passed through the twin block or the guide block, so that the endless cable can be raised or lowered by the tightening line.

For the safety of operation, when the turn of logs is hooked at a cold deck or unhooked at the landing, the endless cable is always stopped and slackened down.

As the endless cable is frequently stopped, the daily output is less than that of the ordinary mono-cable system[23)46)241)262)306)].

This system was used for the first time in Akita prefectural forest in 1966[262)].

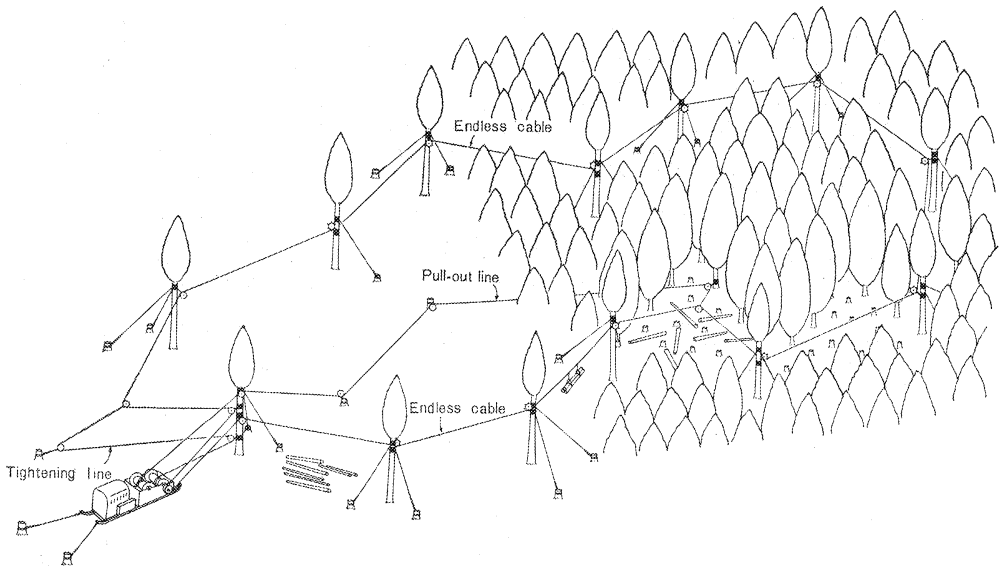

Fig. 66 This new mono-cable system is additionally equipped with a pull-out line. The logs on each side of the endless cable can be hauled laterally to the yarding path and swung to the landing in one continuous operation.

A guide block is attached to the end of the pull-out line, and the endless cable is passed through the block in the section where the lateral yarding is conducted. With every lateral yarding, the endless cable is slackened down by means of the tightening line. After the turn of logs is attached to the endless cable, the cable is tightened slowly and carefully, and the turn is hauled to the yarding path. When the turn arrives at the yarding path, the endless cable is driven by the spool-type drum. There is no necessity to build a cold beck. Generally, the continuous transportation is not carried out.

This mono-cable system was developed in Oma national forest, Aomori, in 1972[32)27)]. Twelve-mm endless wire rope is used for a turn of 0.4～1.0 m³ logs. The daily output is about 20 m³ for a distance of 200～300 m.

This new mono-cable system is one of the most effective yarding systems for selective cutting, because selective yarding can be carried out almost perfectly by this system.

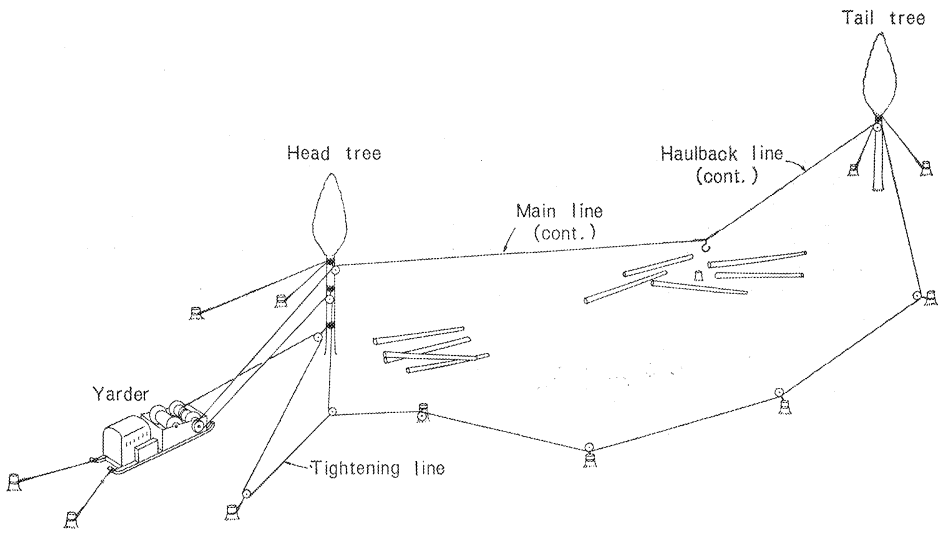

Fig. 67 This system is one of the modified high-lead systems. The main line and the haulback line are connected with each other to make a continuous line. The continuous main-haulback line can be raised or lowered by the tightening line. The yarder equipped with one drum for the tightening line and one spool-type drum for the continuous line is required for this system. The reason for making two lines into a continuous line is to make the high-lead system adaptable to almost any topographic conditions, especially to steep downhill slopes.

This system was used in Matsuyama national forest, Ehime, in 1960[117], and in Esashi national forest, Hokkaido, in 1961[58].

The continuous main-haulback line and the tightening line are 10～12 mm in diameter. Yarding distance extends to a maximum of about 250 m.

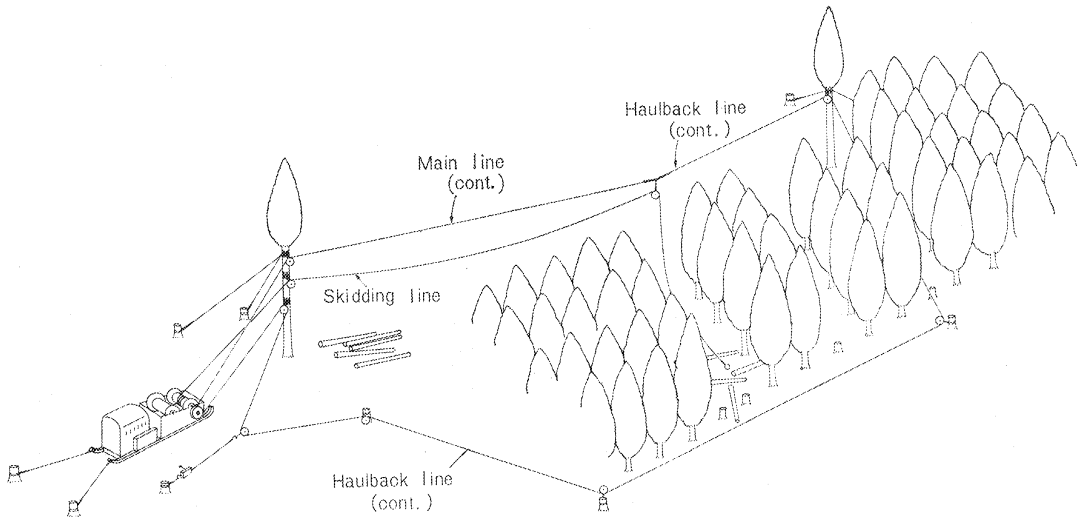

Fig. 68 This system is slightly different from the ordinary high-lead system. The system is additionally equipped with a skidding line which is passed through a guide block attached to the butt rigging and is hung down under the butt rigging. A butt hook is attached to the end of the skidding line.

The skidding line is pulled out laterally to where the logs lie by the choker setter. When the chokers are set, the turn of logs can be hauled to the yarding path by reeling in the skidding line while the brake is held on the continuous main-haulback line.

This new high-lead was used for the first time in Shinshiro national forest, Aichi, in 1971[87)110)288)]. The system is useful for thinning. Since the continuous line is usually set up in a triangular shape, it is called the "Sankaku (triangle) yarding system" in our country. The principal feature of this system is that the yarding operations can be conducted on any direction of the triangle.

The yarding distance is 40～80 m. Eight-mm continuous main-haulback line and 6-mm skidding line are used. The yarder having one ordinary drum and one spool-type drum is required.

Advantages of this new high-lead are the simplicity of rigging up and changing road, and its adaptability to the thinning operation.

Literature cited

Almost all literatures concerning the cable logging systems in Japan are written in Japanese. Those, however, are cited for indicating the sources of information.

1) 阿部英雄：低位利用材の簡易搬出法，山林，1048，33～39，(1971)
2) ――――：帯広エンドレス方式による低位利用材の簡易搬出法に関する試験，新潟県林試研報，16，71～92，(1973)
3) 安部川浩二・佐野健一：簡易架線用ストッパー付きブロックの改良について，北見局業務研究発表集録（47年度），18，88～91，(1973)
4) 味戸長寿：ウイッセン集材機の作業調査の一端，林機情，19，26～36，(1952)
5) ――――：ウイッセン集材機の作業調査の一端，長野局直営生産事業研究報告集（23～26年度），1，211～221，(1953)
6) 有賀　宏：間伐材，低位材の搬出るおけるダブルエンドレス式集材，機械化林業，234，57～70；235，48～70，(1973)
7) ――――：アベックキャリヤによるカラマツ間伐材の搬出，機械化林業，238，47～65，(1973)
8) 麻田保弘・勝　武光・渡辺昭雄・江尻義則：簡易索張りによる集材について，札幌局業務研究発表集録（1968），14，314～321，(1970)
9) 朝鳥昌次：移動式鞍形集材について，札幌局製品生産事業研究発表会報告集，7，188～196，(1964)
10) Berger, K.: Skyline logging methods. Timberman, **27**, 10, 152～158, (1926)
11) Brown, N. C.: Logging. John Wiley & Sons, New York; Chapman & Hall, London, 418 pp., (1949)
12) 千葉治夫：帯広式索張り用リフチングストッパーの開発について，帯広局業務研究発表論文集（事業部門）（43年度），12，183～188，(1969)
13) 千葉信雄・武藤要明：搬器の改良と架線方式について，北見局製品生産事業研究発表集（事業部）（41年度），13，94～102，(1967)
14) 越中貞蔵：小型集材機使用「フォーリングブロックシステム」に依る曲線路集材法に就て，日林講（昭13年春季），550～558，(1939)
15) ――――：集材機索張り図集，林業機械シリーズ，12，林業機械化協会，95 pp.，(1960)
16) 江尻義則：帯広式エンドレスの実験について（予報），札幌局製品生産事業研究発表会報告集，11，81～85，(1968)
17) FAO: Symposium on forest operations in mountainous regions. FAO Techn. Rep., 90 pp., (1973)
18) 藤　迪夫・中森釩郎：Z・B（ジグザグブロック）による間伐木の搬出について，東京局業務研究発表集，4，168～176，(1972)
19) 藤川銀治・八谷定義：択伐作業における先山機械集材の横取り架線方式について，旭川局製品生産事業業務研究発表集（36～40年度），56～67，(1966)
20) 藤原金太郎：サイドアームキャレージの改良について，青森局林業技術研究集録，(1969)，148～150，(1970)
21) 藤原敏雄：集材機のハイリード方式による全幹集材について，青森局林業技術研究集録（1964），137～141，(1965)
22) 福田弘之：集材機用簡易索張りによる搬出について，山林，1048，40～47，(1971)
23) ――――：変形ダンハムエンドレス式による間伐材の搬出（1），（2），機械化林業，234，18～29；235，5～11，(1973)
24) 福田　功：農家林業の機械化について，山林，1048，51～55，(1971)

25) 福田次部・右城克世：簡易集材機用搬器の改良に関する研究（第3報），右城式T2号A型自動搬器について，67回日林講，323～326，(1957)
26) ――――・――――：簡易集材機用搬器の改良に関する研究（第4報），T2号自動搬器による曲線集材について，68回日林講，327～329，(1958)
27) ――――：集材機用自動繋留搬器としての右城式T2型搬器について，林機情，61，9～29，(1958)
28) ――――：集材機用搬器の新考案，林機情，85，8～20，(1960)
29) 福田豊吉・森谷金雄：集材機による全木集材作業について，帯広局業務研究発表論文集（事業部門）(42年度)，11，64～71，(1968)
30) 古幡　明：漸用作業における直角集材方式の考案について，長野局業務研究発表集（44年度），1，35～40，(1970)
31) ――――：自動ストッパーの考案について，長野局業務研究発表集(45年度)，2，170～175，(1971)
32) 古川昌彦・浅見俊次：ジグザグエンドレス集材法の開発，青森局林業技術研究集録（1972），133～137，(1973)
33) 古川精次：亜高山地帯（金木戸国有林）の施業について，2製品生産関係，名古屋局業務研究発表論文集（45年度），97～107，(1971)
34) 古里政治・平松百三：先柱附近におけるタイラー式全幹集材法，名古屋局業務研究発表論文集（41年度），1～4，(1967)
35) Gibbons, W. H.: Logging in the Douglas fir region, U.S.D.A. Bull. 711, 256 pp., (1918)
36) 後藤久英・月橋敏雄：F型架線集材の実行とその効果について，前橋局林業技術研究発表集（事業部門），10，156～166，(1969)
37) 後藤　晋・佐藤栄司：新しい森林施業に対応した集材方法に取組んで，東京局業務研究発表集，5，141～146，(1973)
38) 巾崎栄和・宮尾益雄：コントロールライン使用によに集材方式について，長野局業務研究発表集，5，86～88，(1974)
39) 半田　勉：天下I類施業における機械作業実行結果について，寒帯林，114，134～143，(1965)
40) 原田憲顕・古畑富省：漸伐集材作業法，山林，1092，40～47，(1975)
41) 橋詰　勝・大地宮一・三石文彦：二胴集材機によるツー・キャレージ曲線集材方式について，長野局事業部だより，108，2～4，(1972)
42) 畠山　宏：オペレーチングラインハンガーの考案，林業技術，295，27～28，(1966)
43) 服部孝文・関口昌男・小林　清：亜高山帯針葉樹林の施業法，国有林技術研究発表集（47年度），128～141，(1973)
44) 林　　寛・松井勝巳：花崗岩地帯における総合防災施業，国有林技術研究発表（45年度），111～122，(1971)
45) 林　　正・森川公七・伊藤吉郎：エンドレス万能集材機及び同自動キャレジ取扱について，名古屋局直営生産事業研究発表論文集（28年度），26～36，(1954)
46) 樋口義男：機械化を前提とした間伐法の開発，青森局技術開発報告書(46年度)，150～165，(1972)
47) 平野一郎：早口式自動繋留搬器，林機情，94，64～67，(1961)
48) 平田利夫：扇形集材方式，機械化林業，123，1～16，(1964)
49) ――――：集材機作業における横取り（引込み）法，機械化林業，126，36～52，(1964)
50) ――――・高倉　章：新しい円型集材方式，機械化林業，128，25～35，(1964)
51) ――――：円型集材その後，機械化林業，138，59～75，(1965)
52) 広野一弘・高橋哲夫・高浜重義：旭川式フオーリング・コレクターの開発について，国有林技術研究発表集（48年度），9～17，(1974)
53) 久松滝蔵：機械木寄，架線方式について，銀葉，81，25～27，(1962)
54) 市川雅康：TY式自動係留搬器使用結果について，山林作業の研究，十条製紙山林部，8，79～86，

(1961)
55) 市岡多賀男・谷村義治：リードロープ式集材法，名古屋局業務研究発表論文集（43年度），347～349，(1969)
56) ――――・清水可行・栃本金次郎：リモートコントロール集材機の使用結果報告について，名古屋局業務研究発表論文集（45年度），383～393，(1971)
57) ――――：自走式集材機（バロネスウインチエース）による間伐材集材の実行結果について，名古屋局業務研究発表論文集（47年度），182～195，(1973)
58) 一山邦夫・田中保雄：小型巻上機による機械木寄，札幌局業務研究発表集録（1969），301～307，(1970)
59) 五十嵐清之助：フリーブロックの試作，秋田局研究発表論文集（43年度），128～129，(1969)
60) 井川忠夫：主索循環式索道による間伐作業について，熊本局林業技術研究発表集録（46年度），3，200～207，(1972)
61) 池沢芳雄：屈曲間伐集材について，機械化林業，244，1～4，(1974)
62) 今井正已：奥南川事業所における多支間集材について，高知林友，401，15～17，(1960)
63) 石田　操：集材機，北見林友，**6**，7，41～44，(1957)
64) 石井　宣：集材機に就て（其の3），林機情，3，17～24，(1950)
65) 石川寿郎：択伐作業区における先山機械集材作業について，旭川局製品生産事業業務研究発表集（36～40年度），179～181，(1966)
66) 石岡千良：集材機用自動繋留器の紹介，機械化林業，180，1～9，(1968)
67) 石山善次郎：変型スラックライン方式とその張り替え方法について，北見局業務研究発表集（製品生産・土木）（43年度），15，51～60，(1969)
68) 伊藤政光：機械木寄における搬器と索張りの考察について，高知林友，408，1～2，(1960)
69) 伊藤暢夫：Y-211型集材機及びＢＣＡ型自動搬器の改良について，林機情，44，21～27，(1956)
70) 伊藤資郎・中村重敏：Y字型索張りについて，東京局製品生産事業研究発表集（41年度），9，11～13，(1967)
71) 伊藤　司：機械集材索張りについて2，3の考案，林機情，98，41～48，(1962)
72) 岩原健一・奥原菊太郎・花岡寿生：広範囲集材の一考察について，長野局業務研究発表集（46年度），3，111～114，(1972)
73) 岩手富士産業株式会社：新しい林業機械Y-27Ａ型集材機，林機情，77，77～91，(1960)
74) 掛川営林署：変形コレクタ（仮称）集材，機械化林業，248，38～40，(1974)
75) 鎌田憲一：曲線集材について，日林東北支部会誌，8，48～50，(1957)
76) 金沢啓三：低位利用材の簡易搬出法に関する試験，三重県林業技術普及センター業務報告書，8，118～127，(1971)
77) 金子一美・川上久男：三胴集材機によるエンドレスタイラー方式の集材成果について，名古屋局事業部関係研究発表論文集（37年度），70～77，(1963)
78) 蟹田営林署：集運材作業法の検討，青森局技術開発報告書（モデル営林署実験報告）(1972)，17～35，(1973)
79) 唐渡　稔：新しい集材索張り法・ＥＦＫ式，機械化林業，172，20～29；173，13～25，(1968)
80) 片岡秀夫：じぜん植栽法とたちき集材法，林業技術，255，12～16，(1963)
81) ――――：「たちき集材」と「じぜん植栽」，山林，967，16～20，(1964)
82) ――――：たち木集材法に関する研究（Ⅰ）（Ⅱ）（Ⅲ），日林誌，**47**，11，406～410；**48**，4，180～182；**48**，10，372～375；(1965～1966)
83) Kato, S.: Popular skyline cable systems used in the mountain forests of Japan. Miscel. Inf., 14, Tokyo Univ. For., 53～62, (1962)
84) 桂川　登：自動キャッチキャレーデについて，名古屋局直営生産事業研究発表論文集，(30年度)，

10～24，(1956)
85) 川越教男・東　隆男・福島久雄：天然林施業における架線集材・直角集材（ライトアングル方式）の実践，札幌局業務研究発表集録（1969），316～329，(1970)
86) 川越孝之：林内特殊架線による集運材，林機情，80，65～74；81，68～79，(1960)
87) 桐山甚栄・増井重太郎：変型ダンハムによる簡易集材について，名古屋局事業部関係研究発表論文集（37年度），99～103，(1963)
88) 北林富久雄：機械集材作業における架線方式の応用について，熊本局製品生産事業研究発表集（40年度），7，73～77，(1966)
89) 北川宗熊：エンドレス式集材について，暖帯林，4，3，21～22，(1949)
90) ――――：エンドレス式集材作業，暖帯林，4，7，53～60，(1949)
91) 北村靖方：マツセイファーガソン集材用トラクタの実用試験，沼田林業機械化技術指導所試験報告（43～44年度），1～18，(1970)
92) 木次　寛・古幡　明：「漸用集材作業における」八ケ岳式架線方法考案について，長野局業務研究発表集（45年度），2，162～169，(1971)
93) 清藤　孝・鈴木澄夫：保残木施業地における集材方法の実験結果，国有林技術研究発表集（47年度），9～20，(1973)
94) 小林君雄：ＴＥ59型小型集材機の使用実績，銀葉，81，15～20，(1962)
95) ――――：ウエル・エンドレス式索張り方式について，銀葉（林業技術研究論文集），64～68，(1965)
96) 小林　清：漸用作業のための架線方式と自動ストッパーの考案，スリーエムマガジン，128，22～24，(1971)
97) ――――：漸伐作業・その後の中間報告，スリーエムマガジン，140，12～15，(1972)
98) 小林重雄：小型集材機の架線方式について，前橋局製品生産事業研究発表集（36年度），3，5～11，(1962)
99) 高知営林局作業課：高知営林局管内に使用する搬器の種類とその得失について，林機情，32，59～70，(1954)
100) ――――：Ｈ型索張りによる全幹空中集材作業について，高知局技術だより，5，6～9，(1973)
101) 小池今男・山下　洋：保残木施業地における集材方法の実験結果について，旭川局業務研究発表集録，18，2～7，(1972)
102) 小板橋英雄：短距離機械集材作業の索張り「くも糸式」の考案について，スリーエムマガジン，32，15～17，(1963)
103) ――――・松岡鶴治：択伐作業林における機械集材作業の一考察，函館局業務研究論文集（44年度），15，70～81，(1970)
104) ――――・菅原　正・門間辰太郎：トラクタ集材作業の一考察，函館局業務研究論文集（47年度），18，83～86，(1973)
105) 小松伸哉：リフチングラインによるリード集材について，高知林友，463，26～28，(1965)
106) 小沼順一：林業機械，林業技術史，4，219～307，(1974)
107) 高野営林署事業課：Ｙ211型集材機使用について，林機情，38，84～90，(1955)
108) 小山豊勝：小型集材機についての一考案，沼田林業機械化技術指導所試験報告，150～163，(1969)
109) 窪田木三・小塚芳一・西本達男：ライトアングル集材方式の考案，国有林技術研究発表集（45年度），42～53，(1971)
110) 窪田正一・岡崎　勇：自走式小型ウインチによる間伐木の簡易架線集材法の開発，国有林技術研究発表集（46年度），113～121，(1972)
111) 久保田善信：スラックラインによに低位利用材の搬出試験，愛媛県林試業務報告（44年度），174～

189，(1970)
112) 甲藤　清・西野有義・別府恒一：三胴集材機による横取集材について，高知林友，460，48～51，(1965)
113) 久慈勝己・間山　茂・泉田重次：択伐作業用搬器の改良と使用結果について，青森局林業技術研究集録(1971)，25，127～130，(1973)
114) 熊本営林局機械指導係：機械集材用器具の紹介，熊本局生産だより，117，1～5，(1973)
115) 熊本営林局作業課：全幹集材実地試験報告(抜萃)，機械化林業，114，34～49，(1963)
116) 公文久富：面河団地の施業方法と面河式搬器について，高知林友，423，2～9，(1962)
117) 公文一自：間伐材の特殊集材について，高知局国有林野事業に関する研究考察事項発表会講演集(35年度)，23～28，(1961)
118) 黒木精蔵：交走エンドレス(単線)集材の一考察について，熊本局製品生産関係研究発表集，116～120，(1963)
119) 久留島秀雄：択伐林における横取(Y型)集材について，札幌局製品生産事業研究発表会報告集，7，65～77，(1964)
120) 桑原　暁：低位利用材の簡易搬出法に関する試験(Ⅰ)，鳥取県林試試験研究報告，13，58～63，(1970)
121) ――――：低位利用材の簡易搬出法に関てる試験(Ⅱ)，鳥取県林試試験研究報告，14，32～39，(1971)
122) 巻田源久：可撓吊持鉄索運搬装置F，林機情，46，48～55，(1956)
123) ――――：F型軽架線の進歩と実績，日林講，70回，404～408；71回，342～345；72回，392～393；74回，408～410；75回，523～526；76回，467～469；77回，422～423，(1960～1966)
124) ――――：間伐材搬出の12Fの実績，80回日林講，358～360，(1969)
125) 牧田辰三・山寺　博：小黒川製品事業所における扇形集材の考察，長野局製品生産事業研究報告集(38年度)，12，16～36，(1964)
126) ――――・――――：全幹扇型集材について，長野局製品生産事業研究報告集(39年度)，13，75～84，(1966)
127) 丸口達雄：丸口式自動けい留器について，長野局製品生産事業研究報告集(38年度)，12，1～5，(1964)
128) ――――：漸伐作業集材における自動横取器の考案について，林業技術，330，20～22，(1969)
129) 丸岡正雄：択伐作業における集材法，札幌局業務研究発表集録(1969)，15～19，(1970)
130) 丸山耕一：トラクターによるエンドレス集材について，旭川局製品生産事業研究発表並びに調査報告集，9～13，(1968)
131) ――――：旭川式フォーリングコレクターの開発について，旭川局生産だより，91，2～4，(1973)
132) 丸山正和・米田幸武・上田　実：荷上索操作式繋留器の比較試験，70回日林講，411～414，(1960)
133) 益田　信：ファルコンウインチによる木寄集材および巻立作業について，68回日林講，324～327，(1958)
134) 間杉鶴男：簡易集材装置の功程調査研究，神奈川県林試業務報告，1，144～162，(1969)
135) 増子広美：全幹機械集材について，前橋局製品生産事業研究発表集(37年度)，4，127～135，(1963)
136) 松賢四郎・小寺幸雄：集材機による直角集材作業の開発について，函館局業務研究論文集(47年度)，18，73～78，(1973)
137) 松井栄幸：低位利用材の簡易搬出法に関する研究，富山県林試業務報告(46年度)，7，231～239，(1972)
138) 松隈　茂・飯塚正明：コレクターによる集材機作業の効果，前橋局林業技術研究発表集(事業部門)(45年度)，12，47～53，(1971)
139) 松本忠行：Y-27小型集材機作業に関する一考察，北見局技術研究(直営生産)，8，146～159，

(1961)
140) 松野隆吉：エンドレス式架線の試用について，長野局直営生産事業研究報告集（23～26年度），1，158～160，(1953)
141) 松尾武治：馬路式集材滑車機に就いて，日林誌，**26**，2，1～8，(1944)
142) 松岡鶴治：短距離機械集材作業「くも糸式」の一考察，銀葉（林業技術研究論文集），9～12，(1965)
143) 松下和男：天然林の全木集材を実行して，東京局製品生産事業研究発表集（39年度），8，20～27，(1964)
144) 皆川勝治：鈴木式自動繋留搬器について，林機情，65，26～36，(1959)
145) 光永　基：ハイリード方式による保残木作業について，札幌局製品生産事業研究発表会報告集，11，18～31，(1968)
146) 宮川重友・中尾克二：ダブルスカイライン方式集材の実験について，札幌局業務研究発表集録（1970），16，325～345，(1972)
147) 都鳥軍二：ジープに登載した小型材機とその作業方法について，樹氷，**10**，11，26～34，(1960)
148) 水口　薫：曲線吊金具使用による集材装置の一考察，寒帯林，111，160～155，(1964)
149) 水間清八郎：集材機による全幹集材について，旭川局製品生産事業業務研究発表集（36～40年度），93～98，(1966)
150) 水野遵一：集材機，主としてウイッセン集材機の考え方と性能について（その3），林機情，13，16～23，(1951)
151) 森岡澄義：人力木寄せ・せり出し作業工程の機械化について，大阪局業務研究発表会記録，2，73～82，(1962)
152) 森谷治三郎：自動繋留搬器を応用した変形スラックライン式による択伐林の集材，山林，1093，36～39，(1975)
153) 宗石幸吉：長距離集材について，林機情，32，34～43，(1954)
154) 村上誠一・尾崎一三・三石昭一：連けい作業の実行成果，国有林技術研究発表集（44年度），121～136，(1970)
155) 武藤和也：エンドレス式架空線集材に関する研究，林機情，12，108～116，(1951)
156) ――――：Y型集材機による長距離集材の実験，熊本局直営生産関係研究発表集（29年度），79～90，(1955)
157) 妙見　薫：複線式集材の実行結果から，スリーエムマガジン，36，8～11，(1964)
158) 長野初太郎：F型架線による間伐材搬出結果を検討する，スリーエムマガジン，98，14～17，(1969)
159) ――――：間伐の促進に応えて，F型架線による間伐の搬出の実験，東京林友，**22**，2，82～94，(1969)
160) 長尾　弘：集材用Y型架線の支点移動用搬器，機械化林業，134，35～40，(1965)
161) 中村英碩：集材機とその考え方，林業機械シリーズ，32，林業機械化協会，東京，312 pp.，(1965)
162) ――――：ジグザグシステム（1），（2），（3），（4），機械化林業，213，10～21；214，30～35；215，31～40；216，21～26，(1971)
163) ――――：ジグザグ作業システムと間伐材の搬出，山林，1068，46～54，(1973)
164) 中村正義：天下I類による機械集材作業の結果について，北見局製品生産事業研究発表集（39年度），11，70～75，(1965)
165) ――――：特殊キャレージの考案について，北見局製品生産事業研究発表集（事業部）（40年度），12，27～33，(1966)
166) 中尾昭三・吉岡繁雄：簡易索張（帯広式）と使用器具の改良について，札幌局業務研究発表集録（1971），309～313，(1973)
167) 奈良岡　宏：秋木式自動搬器について，青森局林業技術研究発表会記録（34年度），154～160，

(1960)
168) 仁井田幸雄：急峻地におけるコントロール集材の実行結果について，札幌局業務研究発表集録(1970)，317～324，(1972)
169) 新山節雄：面河式搬器（KOC-2E3型）の使用について，長野局製品生産事業研究報告集（39年度)，13，89～98，(1966)
170) 西本達男・東　隆男・福島久雄：ライトアングル集材方式の考察，札幌局業務研究発表集録(1970)，296～316，(1972)
171) 西村　勲・中越栄喜・高木　太：引き上げ集材用索張り方式の考案について，長野局業務研究発表集（44年度)，1，240～249，(1970)
172) 新田　勉：変形エンドレス集材について，旭川局製品生産事業業務研究発表集（36～40年度)，197～200，(1966)
173) 野沢　斌：変形集材について，前橋局林業技術研究発表集(事業部門)(41年度)，8，44～46，(1967)
174) 大林正樹・伊藤寿夫・前沢　稔：ダブルコントロール方式による線下作業排除の一方法，スリーエムマガジン，112，18～20，(1970)
175) 大淵　実・山田信逸：リモートコントロール集材機の実用化試験，秋田局研究発表会論文集（42年度)，114～118，(1968)
176) 小川晴男・三浦雪雄・安江昭雄：スカイダー（YT式自動横取り装置）の使用結果について，長野局業務研究発表集（44年度)，1，251～265，(1970)
177) 大菊　等：面河式搬器(KOC2E-3型)遊動滑車の改良について，高知林友，475，16～19，(1966)
178) 小栗裕介・松沢哲夫：ヒノキ人工林間伐林の集材と有利採材に関する実験的実行の一例，国有林技術研究発表集（46年度)，105～112，(1972)
179) 大石　豊：大石式搬器について，林機情，32，70～75，(1954)
180) 岡野　宏：集材機の架線方法に就て，御料林，100，109～125，(1936)
181) Okawara, S.：Eine neue Methode des Holzrückens mit leichter Kurzstreckenseilförderanlage (Iwate-Universität-System＝Iw. U. S.)（I)，(II)，(III)，(IV)，(V)，J. Jap. For. Soc.，**53**，4，93～97；7，199～209；8，252～255；9，271～278，(1971)
182) 岡山喜八郎・原田隆雄・川上久男：主索移動集材について，名古屋局業務研究発表論文集（41年度)，269～275，(1967)
183) 岡崎　勇・清水可行：長スパン集材の実行結果について，名古屋局業務研究発表論文集（41年度)，63～70，(1967)
184) 尾坂靖二：大畑営林署における機械集材の一例，Y-25型集材機を利用したロープシステムの考察，青森林友，8，33～44，(1954)
185) ――――：Y25型集材機を利用したエンドレスシステムの考案について，大畑営林署の場合，林機情，36，26～38，(1955)
186) 小山内文雄：秋木式自動搬器について，青森局林業技術研究集録（1961)，159～162，(1962)
187) ――――：秋木式自動搬器使用結果について，青森局林業技術研究集録（1962)，168～172，(1963)
188) ――――：秋木式自動搬器使用結果の総まとめ，青森局林業技術研究集録（1964)，116～122，(1965)
189) ――――・玉熊　勉：小面積皆伐区における簡易索張り集材について，青森局林業技術研究集録(1972)，26，151～154，(1973)
190) 小山田孝二：南星式リモートコントロール集材機の実用化試験，沼田林業機械化技術指導所試験報告（43～44年度)，199～220，(1970)
191) ――――：無線操縦搬送機の実用化試験，沼田林業機械化技術指導所試験報告（43～44年度)，72～99，(1970)

192) 小山田孝二：ヒンテレッガーD-2型キャレッジの適応試験，沼田林業機械化技術指導所試験報告（43～44年度），19～29，(1970)
193) 大関長春・高信宗次：変型フォーリングブロック集材，機械化林業，214，19～25，(1971)
194) Pacific Northwest Forest and Range Exp. Sta., U. S. D. A. : Glossary of cable logging terms. Portland, 7 pp., (1969)
195) 林業機械化協会：新編，集材機索張り図集，林業機械シリーズ，45，材業機械化協会，東京，151 pp.，(1970)
196) 林野庁監修：林業統計要覧，1961～1975，林野弘済会，(1961～1975)
197) 三枝勝治：無線操縦集材機を開発，蒼林，182，56～62，(1965)
198) 西条憲視：エンドレス方式における作業功程について，帯広局業務研究発表論文集（事業部）(39年度)，8，61～68，(1965)
199) 斉藤栄吉：釣上式集材法（High lead yarding）の採用を提案する，木寄集材に代るものとして，林機情，33，6～11，(1954)
200) 斉藤富士雄：サイドアームキャレジの使用結果について，秋田局研究発表会論文集（47年度），35～37，(1973)
201) 斉藤勝也：ハイリード索張方式による全幹集材について，青森局林業技術研究集録（1965），164～168，(1966)
202) 斉藤正二郎：タイラー型エンドレス式V状複線架線集材運材法，北見局技術研究（直営生産），5，62～66，(1958)
203) 斉藤敏彦：係留搬器図説，機械化林業，142，1～24，(1965)
204) 斉藤吉治：索張方法の改良による素材の早期生産について，林業技術，342，p. 24，(1970)
205) ――――：索張方法の改良による素材の早期生産について，北方林業，**23**，9，20～25，(1971)
206) 坂本毎生：変形サイドアーム方式キャレージによる索張り方法を採用して，東京局業務研究発表集，3，209～214，(1971)
207) 坂本史郎：長スパン集材における功程調査，秋田局研究発表会論文集（42年度），169～171，(1968)
208) 坂田文雄：集材機による引上作業について，東京局製品生産事業研究発表集（35年度），7，13～21，(1960)
209) 笹島　武・滝川宗晴：ダンハム方式による集材実績報告，秋田局製品生産事業研究発表論文集，6，33～36，(1960)
210) 佐々木　稔：長大スパンの集材作業結果，青森局林業技術研究集録（1964），134～137，(1965)
211) 佐々木重雄：広葉樹全幹集材実行にあたっての問題点，青森局林業技術研究集録（1966），145～153，(1967)
212) 笹村定良：平方集材の実験調査，秋田局研究発表会論文集（42年度），165～169，(1968)
213) 佐藤　一：小型集材機に依る集材作業の一考察，札幌局製品生産事業研究発表会報告集，4，64～77，(1962)
214) 佐藤賢祐：三胴型エンドレス式の横取り作業の問題点について，青森局林業技術研究集録（1969），141～142，(1970)
215) 佐藤巳美：横取兼用木寄集材機械並びに架線方式の考案，林機情，90，28～37，(1961)
216) 佐藤　憭：集材機による広葉樹全幹集材と架線設計，青森局林業技術研究集録（1962），158～160，(1963)
217) Schenck, C. A. : Logging and lumbering or forest utilization, A text book for forest schools. L. C. Wittich, Darmstadt, 189 pp., (1913)
218) 制野周定・山本貞吉：製品生産事業における作業仕組，機械の各種比較について，旭川製品生産事業業務研究発表集（36～40年度），32～39，(1966)
219) 関谷三郎・染谷定能：集材方法の改善について，東京局業務研究発表集，5，174～180，(1973)

220) 柴田順一・上田　実・斉藤敏彦・富永　貢：集材機の索張力について，帯広式エンドレス方式の場合，81回日林講，321～322，(1970)
221) ――・――・――・――：集材機の索張力について，変形スラックライン方式の場合，81回日林講，322～324，(1970)
222) 柴田信夫：自動ストッパー付搬器の設計について，長野局直営生産事業研究報告集（33年度），8，65～69，(1959)
223) ――：間伐集材用キャレジの考案について，長野局業務研究発表集（45年度），2，185～197，(1971)
224) 渋谷金治郎：機械集材作業の功程算出について，秋田局直営生産事業研究発表論文集，2，134～144，(1955)
225) 渋谷正三：Y211型集材機使用経過について，銀葉，22，74～103，(1954)
226) 椎野寛一：巻田式運搬装置による間伐材搬出について，東京局直営生産事業研究発表集，3，101～108，(1955)
227) 鹿内勝治：横取り集材の新らしい索張り法，機械化林業，99，19～22，(1962)
228) 嶋田富士夫：嶋田式自動搬器及び曲線集材について，蒼林，5，12，84～89，(1954)
229) ――：集材機用改良搬器について，64回日林講，277～279，(1955)
230) ――・伊藤伍助・佐々木春男：小型集材機による全幹集材の木寄について，蒼林，173，13～16，(1964)
231) 七五三木久雄：新型集材架線サイドアームキャレージ方式の使用結果，前橋局林業技術研究集録（各部門合併）(46年度)，294～297，(1973)
232) 清水賢一：F型集材による高密路網支障木の搬出，山林，1068，55～62，(1973)
233) 清水道明：Y27A小型集材機による集材について，前橋局製品生産事業研究発表集（35年度），2，30～40，(1961)
234) 新保　仁：集材機作業におけるエンドレス方式について，帯広局業務研究発表論文集（事業部）(39年度)，8，69～84，(1965)
235) 塩田郡次・川原井辰彦：F型架線の実験結果について，東京局業務研究発表集，1，244～255，(1969)
236) 白木一雄・丸岡正雄・原田喜之助：定山渓製品事業林の施業体系（第2報），札幌局業務研究発表集録（1970），16，257～274，(1972)
237) ――・野上　厳：路網地域におけるホイルタイプトラクタ（T-50）による集材作業について，札幌局業務研究発表集録，(1972)，188～201，(1974)
238) 染谷定能：サイドアーム・キャレジの使用結果について，東京局業務研究発表集，2，146～149，(1970)
239) 曽根　進：簡易変型エンドレス集材法，名古屋局業務研究発表論文集(44年度)，386～389，(1970)
240) 菅原長三郎：小面積帯状皆伐区のテスト集材について，青森局林業技術研究集録（1971），146～148，(1973)
241) 須釜嘉平・清水道明・堀江文雄：F型架線集材について，前橋局林業技術研究発表集，10，87～100，(1969)
242) Suttoff, J. R.: Lawson skyline yarding and loading system. Timberman, 27, 12, 46～48, (1926)
243) 田畑　実：移動式簡易集材，山林，1048，26～33，(1971)
244) 田上　勲・蔵持武夫：択伐林における集材機導入について，72回日林講，383～387，(1962)
245) 高木三夫・大石　豊：曲線運集材の新方式について，高知局国有林野事業に関する研究考案事項発表会，64～69，(1961)
246) 高橋　幸・佐々木重雄：コレクター集材方法実験の中間発表，青森局林業技術研究集録（1971），

133～138，(1973)
247) 高橋　重：択伐林における根室式索張りの一考察，帯広局業務関係研究発表論文集（製品生産の部）・(37年度)，42～51，(1963)
248) 高橋重敏：単線循環式軽架線における器具・作業方法の改良と考案，山林，1061，44～49，(1972)
249) ――――：低位利用材の簡易搬出法に関する研究，高知県林試研報，71～82，(1973)
250) ――――：複線循環式軽架線，機械化林業，242，17～26，(1974)
251) 高橋哲夫・沼倉　勉：スマックウインチによる木寄作業について，沼田林業機械化技術指導所試験報告，124～138，(1969)
252) 高橋哲夫・高浜重義・丸山耕一：旭川式フォーリング・コレクターの開発について，旭川局業務研究発表集録（47年度），19，62～67，(1973)
253) 高倉　章・瀬林　智：円型集材方式について，長野局製品生産事業研究報告集（38年度），12，61～74，(1964)
254) ――――：円型集材方式の考案，林業技術，283，31～34，(1965)
255) ――――：円型集材作業の実績と効果，長野局製品生産事業研究報告集（39年度），13，124～136，(1966)
256) 高倍宗次・大関長春：鑑別方式（変形フォーリングブロック方式）集材方法について，帯広局林業技術研究発表集（総合）（45年度），210～214，(1971)
257) 田丸武美：ロジングブロック誘導索の考案とその使用について，高知局国有林野事業に関する研究考案事項発表会講演集（34年度），100～103，(1960)
258) 田中弘次：エンドレスタイラー式集材の作業功程について，秋田局直営生産事業研究発表論文集，3，129～131，(1956)
259) 田中保雄：漸伐作業に於ける機械集材作業について，札幌局製品生産事業研究発表会報告集，8，135～143，(1965)
260) ――――：漸伐区における機械集材方法について，札幌局製品生産事業研究発表会報告集，9，86～94，(1966)
261) ――――：漸伐作業における機械集材方法について，札幌局製品生産事業研究発表会報告集，10，71～79，(1967)
262) 田中義夫・山内良一・中村正男：主索循環式簡易曲線集材方法について，秋田県林試林業試験報告（41年度），79～91，(1968)
263) ――――：主索循環式軽架線による低質広葉樹の搬出，山林，1024，23～31，(1969)
264) ――――・中村正男：低質広葉樹の簡易搬出方法に関する研究，秋田県林試林業試験報告，22，32～41，(1970)
265) ――――・――――：単線循環式軽架線による低位利用材の簡易搬出法に関する試験，秋田県林試林業試験報告，24，80～94，(1971)
266) ――――・――――：間伐木の効果的搬出技術に関する研究，秋田県林試林業試験報告，25，72～79，(1973)
267) ――――・――――：低位利用材の簡易搬出法に関する研究，秋田県林試林業試験報告，25，59～71，(1973)
268) 土岐豊三・佐藤　仁：S曲線集材について，青森局林業技術研究集録（1964），124～127，(1965)
269) 東京営林局作業課：間伐林の搬出方法改良を目指して，スリーエムマガジン，96，2～9，(1969)
270) 鳥巣節雄・金子幸徳：択伐跡地の皆伐作業における機械化集材について，林機情，32，26～33，(1954)
271) 土屋利昭・菅原幸夫：ヒバ天然林における択伐施業について，国有林技術研究発表集（48年度），58～65，(1974)
272) 塚本　勉：伐倒木集材による架線方式について，前橋局事業技術研究発表集（37年度），4，110～

115, (1963)
273) 塚本義明・堀畑由雄：アベックキャレージの改良について，東京局業務研究発表集，4，147～150，(1972)
274) 佃　与四郎：集材架線と搬出功程について，北見局技術研究（直営生産），8，114～124，(1961)
275) 津曲明利：変形フォーリングブロック方式の改良について，熊本局製品生産事業研究発表集（40年度），7，52～63，(1966)
276) ――――：国立公園区域内における集材作業の一考察について，熊本局林業技術発表集録（44年度），305～308，(1970)
277) 鶴田政美：幼稚樹保存の架線方法とその実行結果について，北見局製品生産事業研究発表集（事業部）(41年度)，13，60～64，(1967)
278) 堤　右二郎・山口喜男・阿部光一・坪内昭三：天然下種更新第一類施業の各種連けい作業について，北見局製品生産事業研究発表集（事業部）(41年度)，13，37～46，(1967)
279) 内田明男・田中庸雄：天然下種第Ⅰ類における索張り方法について，北見局製品生産事業研究発表集（事業部）(40年度)，12，64～68，(1966)
280) 内田豊作・大野　巌：置戸の漸伐施業，国有林技術研究発表集（43年度），22～31，(1969)
281) 上田満洲男：多段集材におけるダンハム集材の有利性，大阪局林業技術研究発表集録（43～44年度），141～156，(1970)
282) 上田　実：岩原式エンドレス集材装置について，林機情，47，1～16，(1956)
283) Ueda, M., T. Saito, M. Tominaga and J. Shibata : Studies on the main cable in skyline logging (3), On the tension of the cable in the endless-Tyler system and in the skyline-highlead system. Bull. Gov. For. Exp. Sta., 188, 79～106, (1966) —in Japanese with English résumé.
284) 上田　実・斉藤敏彦・富永　貢・柴田順一：集材機の索張力について，単線循環式の場合，81回日林講，319～321，(1970)
285) 上野健開：軽架線用繋留式ブロックの考案について，北見局業務研究発表集（製品生産・土木）(43年度)，15，27～30，(1969)
286) 梅田昭二：集材機用自動搬器について，林機情，49，37～40，(1957)
287) 梅木登茂二：改良フォーリングブロック式集材の考案を紹介する，機械化林業，163，46～50，(1967)
288) U. S. Department of Agriculture : Northeastern loggers' handbook. Handbook, 6, Washington D. C., 160 pp., (1951)
289) Wackerman, A. E. : Harvesting Timber Crops. Amer. For. Series, McGraw-Hill Book, New York, Tronto, London, 437 pp., (1949)
290) 渡辺晴満・武藤要明：集材機による扇形面集材と特殊横取り機によるローディングの強制降下について，71回日林講，346～348，(1961)
291) Watanabe, H., M. Ota, M. Hotta, M. Oba and K. Muto : Studies on the hauling of logs by overhead endless cable system. Bull. Kyushu Univ. For., 25, 1～66, (1955) —in Japanese with English résumé.
292) 渡辺治人・太田　基・大庭正治・武藤和也：複線主索式架空線材に関する研究，林業技術，173，3～7，(1956)
293) ――――：わが国に於ける架空線集材の技術的変遷，暖帯林，11，11，16～25，(1956)
294) Watanabe, H., M. Ota, K. Aso and H. Nakao : Studies on the hauling of logs by overhead cable system with double main cables. Rep. Kyushu Univ. For., 19, 1～20, (1963) —in Japanese with English résumé.
295) 山田重夫：全幹集材機作業について，帯広局製品生産事業研究発表論文集，9，167～171，(1966)

296） 山口　清：低位利用材の簡易搬出法に関する試験（単線循環式軽架線による間伐材の搬出試験第一報），山形県林業指導所研報，3，77～100，(1973)

297） ————：単線循環式軽架線における木寄工程の機械化，山林，1084，46～49，(1974)

298） 山本武義・安藤　昭・市岡多賀男・金子和男：高密路網を利用した集約的森林施業法，国有林技術研究発表集（48年度），116～132，(1974)

299） Yamawaki, S., T. Iwahara, K. Ishii and K. Takatoi : On the hauling of wood by two-endless cable crane. Bull. Gov. For. Exp. Sta., **108**, 47～65, (1958)

300） 山沢　実：皆伐作業（保残木施業）における各種作業仕組の比較について，札幌局製品生産事業研究発表会報告集，81～95，(1967)

301） 矢野積一・安藤一郎：改良フォーリングブロック集材の一考察について，熊本局製品生産業務研究発表集（41年度），8，50～53，(1967)

302） 矢野藤三郎：面河式搬器について，高知局国有林野事業に関する研究考案事項発表会講演集（34年度），103～107，(1960)

303） ————・黒岩　偉：面河式搬器について，高知局国有林野事業に関する研究考案事項発表会講演集（35年度），10～15，(1961)

304） 安住邦雄：変形エンドレスの改良について，北見局製品生産事業研究発表集（事業部）・(41年度)，13，27～31，(1967)

305） 谷田部英雄：天然林におけるWキャレッジの使用結果について，東京局業務研究発表集，1，185～188，(1969)

306） 横超有正：F型架線方式による間伐材集材の実行結果について，名古屋局業務研究発表論文集（47年度），196～203，(1973)

307） 横山栄紀：帯広式集材法の改良について，帯広局業務研究発表論文集（事業部門）・(43年度)，12，134～139，(1969)

308） 横山準二・守山友幸・松　賢四郎：製品生産と造林部門の連けい，国有林技術研究発表（44年度），67～75，(1970)

309） 寄木公博・中村一二・小板橋英雄：択伐作業林における機械集材作業の一考察（その2），函館局業務研究論文集（47年度），18，87～90，(1973)

310） 吉田敬之助・大橋正春・蒲田常雄：変型エンドレスタイラー方式の考案について，長野局業務研究発表集（45年度），2，180～185，(1971)

（研　究　資　料）

わが国の架空線集材技術

小　沼　順　一[1]・柴　田　順　一[2]

摘　　要

(1) 山岳林の多いわが国において最も有効な集材手段である架空線集材法について，1920年以降現在までの技術の変遷過程を概説した。

(2) わが国の架空線集材作業に使われる集材機，索条あるいは索具類の特徴，および架空線集材法の特徴を要約した。

(3) 技術導入時より現在までの間に，わが国において応用されまたは開発された120種にのぼる架空線集材方式を系統的に分類するため，使用索条あるいは索具の種類，およびこれらの組合せ方にもとづいて，分類の基準となる次の10の基本索張方式を選定した。

1) タイラー式
2) ノースベンド式
3) クマモト式
4) ホイストヤーディング式
5) スラックライン式
6) エアリアルスナビング式
7) ダンハム式
8) ランニングスカイライン式
9) モノケーブル式
10) ハイリード式

(4) 主として1965年以降，森林に対する国民的要請の多様化に対応して開発された新しい森林施業向けの索張方式を整理し，残存木に最も大きな影響を及ぼす引戻索の処理方法を概説した。

(5) 数多くの架空線集材方式の中から，わが国で最も多く利用されているもの，新しい森林施業に適用可能なもの，あるいは優れた着想にもとづくものなど，代表的な集材方式39種を取りあげ，図面を付してその架設法，作業法，作業能率などを解説した。

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(1) (2) 機械化部