Popular Skyline Cable Systems used in the Mountain Forests of Japan

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For the purpose of timber extraction, skyline cranes and cableways have been extensively developed in Japan during past fifteen years, especially in the mountain forests. Generally, skyline cranes are installed for downhill yarding on the steep mountain sides. Average transport distance may be 300–500 m, some times more than 1,000 m. Average gradient of the cable line may be 7°–25°. Very often, performance of timber output lies between 30 to 50 m^3 per day (8 hours) with 4–6 workers including a machine operater. But, operational efficiency or productivity of the individual skyline crane varies in wide range. Various skyline cable systems are employed case by case, according to the topography of the land as well as to the varied conditions of logging operation. Among them, the "Tyler" system, the "Falling-block" system and the "Endless traction-cable" system are said to be the most successful and popular. The former two systems were learned from the West Coast practice of U.S.A. more than thirty years ago, and considerably improved to meet the significant nature of the Japanese forestry, while the last system was originally invented by Japanese forest-engineers and has been rapidly developed within past ten years.

These three systems are employed in the various logging projects, each of which is operated under quite differant condition of logging due to quite different type of the forest itself. Consequently, each one of these cable systems is considerably modified in many cases. The writer would like to illustrate here the basic principles of the three fundamental systems mentioned above.

I. The "Tyler" system (Fig. 1)

The down hill yarding system, when it is applied on a steep slope, usually offers a serious problem of brake trouble. But, by this system, less braking force is required, because a certain amount of braking effort is gained by the lifting-line which is reversely bent between the carriage-blocks and the lioadng-block. Some portion of the kinetic energy of the runing carriage is turned over to the bending strain-energy of the wirerope. This is, indeed, a merit of this system. On the contrary, comparatively fast wear out of the lifting-line, due to its reverse bend and strain, is observed in most cases. Notwithstanding this disadvantage, most loggers prefer "Tyler" for it's simple arrangement of the cable system and easy operation of the yarder.

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Functions and characteristics of this system could be explained as follows:—

Head-tree (1): A strong living tree, as thick as more than 40 cm B.H. diameter, is selected for the head-tree, which should be reinforced by several guy-lines.

Tail-tree (2): Selected and reinforced in the similar way to that of the head-tree.

Tight skyline (3): The upper end of the line is anchored to a stamp by means of cable crips. The cable is tensioned at its lower end and fixed to another stamp with an adjustable instrument. This skyline is kept tight during the logging operation. Usually, a wirerope of JIS (JAPANESE INDUSTRIAL STANDARD) 6×7, ϕ 22–26 mm is employed for this line.

Lifting-line (4): One end of this line is fixed to a stamp selected behind and not so far from the tail-tree, while the other end is lead to the 1st drum (rear drum) of the cable-winch or the yarder (8). When this line is wound by the drum, the roading-block (6) is lifted until it reaches the carriage (5). On the contrary, the loading-block falls down to the ground by its own weight, or it can be pulled aside by the haulback-line (7), when the same drum is unreeled or the lifting-line is released. Logs are loaded or unloaded in this state of the lifting-line. The lifting-line is supported by the lead-blocks attached to the head-tree and the tail-tree, because the line has to be operated at every time of loading and unloading. For this line, usually, a wirerope of JIS 6×19 or Fi 6×25, ϕ 12–14 mm is used.

Carriage (5): A carriage, equiped with two or four wheelrunners, is hung on the skyline cable (3). The carriage is also equiped with two additional blocks or pulleys attached to the lower part of it. The lifting-line (4) passes through and supported by these two blocks or pulleys.

Loading-block (6): This heavier block is hung on the lifting-line (4) between

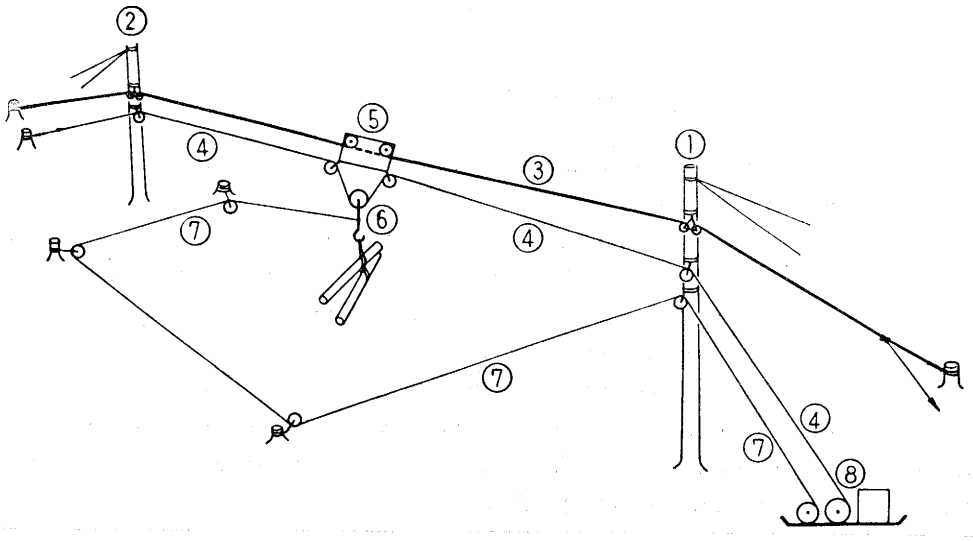


Fig. 1. "Tyler" system, Downhill yarding

the two blocks or pulleys of the carriage. The loading-block has a choker hook to which the logs are hooked by means of the sling-ropes. One end of the haulback-line (7) is fixed to this block. In many cases, an adequately determined counter weight is fixed to the block to ensure easy falling of the empty loading-block at the loading place.

Haulback-line (7): This line is provided for hauling back of the empty carriage as well as for control of the loaded carriage during it's downhill travelling. One end of the line is fixed to the loading-block (6), while the other end is lead to the 2nd drum (front drum) of the yarder. The line runs through several snatch-blocks (the end-block and the corner-blocks fixed to the adequately selected stamps, and the lead-block fixed to the head-tree). Usually, a wirerope of JIS 6×19 or Fi 6×25, ϕ 10–12 mm is used for this line.

When the line is reeled by the 2nd winch-drum the carriage can be hauled back, provided that the lifting-line (4) is in the state of fully pulled and braked by the 1st drum. When the lifting-line is released, reeling of the haulback-line results the pulling of the loading-block (6) apart from the carriage. Therefore, it is able to pull the loading-block toward the end-block stamp. The end-block stamp is selected at a convenient place for loading and can be changed to the next one. The end-block is usually replaced several times to any suitable stamp one after another. Thus, the felled timbers, scattered over a certain extent of the area, average 30–40 m, maximum 80 m wide on each side of the skyline, could be assembled by this cable system.

Yarder (8): A yarder or a cable winch, equipt with at least two drums, is required for this system. The 1st drum is for the lifting-line (4), which requires greater torque but less speed and shorter rope-capacity. The 2nd drum for the haulback-line should have higher winding speed but smaller torque. Both drums should be provided with reliable brakes.

Various modifications of this system is employed in the practical use. For example, "Three-drum Tyler" system is applied when the gradient of the cable line is not steep enough to allow the carriage to travel down by gravity. In this case an additional haul-line is attatched to the loading-block and hauled by winding of the 3rd drum of the yarder. Therefore, three-drum yarder is necessarily required for this system. "Endless traction-cable Tyler" system is another modification, usually applied for long distance and insufficient gradient. In this case, haulback-line and the haul-line is united in one traction-cable, which is driven by a cable-sheave of the yarder, just alike a cableway or "Umlaufseilbahn". Therefore, the yarder should be provided with one ordinary drum for the lifting-line and one driving sheave for the traction-cable. This sheave is driven both way, fore and reverse or haul and haul-back.

Some times, an automatic coupling is inserted between the carriege and the loading block. The wear of the lifting-line is considerably reduced by this device.

II. The "Falling-block" system (Fig. 2)

The "Falling-block" system is similar to the old "Northbend" system of U.S.A. This system now in use in Japan is not a highlead system, as it was in U.S.A., but a perfect skyline system. Advantage of this system is the simple arrangement of the cable and easy falling of the loading-block. But it is hardly applied in the case of very steep gradient, because the hauling-line and the haulback-line should be controlled at the same time. It means a hard and difficult work for the operater of the yarder. On the contrary, in the case of hauling over a deep valley or of uphill yarding, this system is more often preferable.

Significant features of this system could be showed as follows:—

Head-tree (1), *Tail-tree* (2) and *Tight skyline* (3) are installed similar to those of the "Tyler" system. *Carriage* (4) is also similar to that of the "Tyler" system, but instead of two additional pulleys, only one pulley is attached to the lower part of the carriage. Through this pulley, the haul-line (5) is fixed to the carriage at the opposite side, while the loading-block (6) is hung on the haul-line between the fixing point and the pulley.

Haul-line (5): The haul-line (5), which is fixed to the carriage (4) as mentioned above, is lead to the lead-block attached to the head-tree, and then to the 1st drum (rear drum) of the yarder (8). Usually, JIS 6×19, ϕ 12-14 mm wirerope is used. When this line is released, the loading-block (6) falls down onto the ground by its own weight or by the aid of a counterweight fixed to it. Therefore, the name "Falling-block" has been given to this system. Logs are hooked on this block. Winding the 1st drum of the yarder the loading-block, which is already loaded

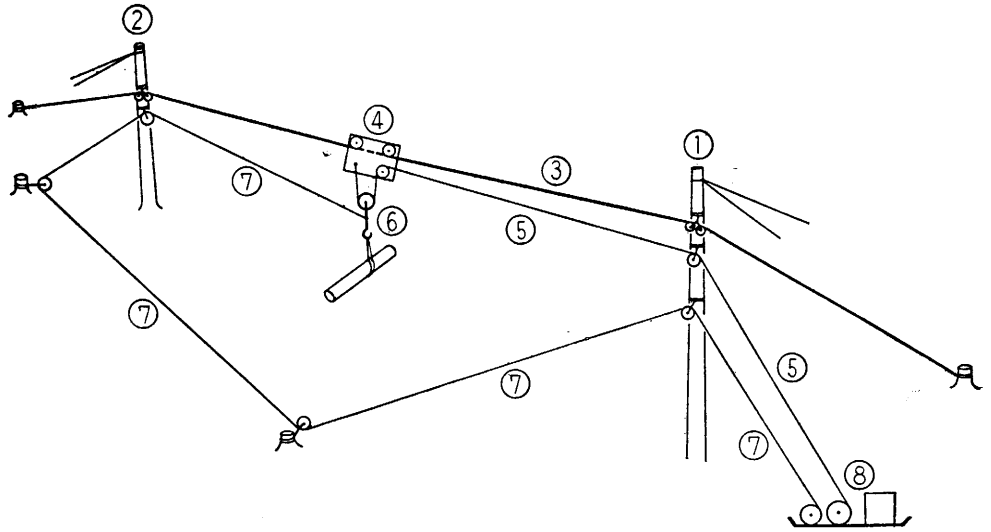


Fig. 2. "Falling-block" system

with logs, is lifted to the carriage, and at the same time the carriage is hauled toward the head-tree until it arrives at the landing place. During this hauling process, the motion of the carriage is controlled by the haulback-line (7). When the haul-line is released, the loading-block falls down again on the ground, where the logs are unhooked.

Haulback-line (7): One end of this line is fixed to the carriage, and the line is lead to the end-block fixed to an upper most stamp, then turns back to the 2nd drum (front drum) of the yarder (8). Usually, a wirerope of JIS 6×19, 10–12 mm is employed, and runs over the lead-blocks fixed to the spar-trees, sometimes it is also lead by intermediate snatch blocks attached to some adequately selected stamps. To halt the carriage at any desired point, as well as to control the running speed of the carriage, the haulback-line (7) is braked at the 2nd drum of the yarder. On the contrary, reeling of the line results the haulback of the empty carriage to the loading place; during this process, the haul-line (5) should be released and controlled by the 1st drum brake. To increase the operational efficiency, quick return of the empty carriage, in other words, high speed drive of the 2nd drum is required.

Yarder (8): The same to that of the "Tyler" system.

Also various modifications of this system are applied for different logging conditions. Among them, especially for long distance or steep downhill operation, use of the automatic coupling of the loading-block and the stopper has been proved to be more or less effective. Recently, several kinds of such devices have been invented and successfully applied.

III. The "Endless traction-cable" system (Fig. 3)

This system is applicable to almost every case of difficult topography and longer transport distance. Because of the comparatively low speed of the traction-cable, this system is said to be suitable in the case of rather small amount of timbers to be hauled, but, practically, there is no remarkable limitation on the amount of timbers.

There are several unique types of installation of this system; among them the most popular one is here described:—

Head-tree (1), *Tail-tree* (2), *Tight skyline* (3) and *Carriage* (4) are quite similar to those of the "Falling-block" system.

Endless traction-line (5): Hauling and hauling back of the carriage is operated by one line which is arranged alike an endless traction-line of a cableway of the "Bi-cable" system. One end of the line is fixed to an edge of the carriage, the adjacent part of the line is supported by a pulley attached to the opposite edge of the carriage, and on this part of the line the loading-block (6) is hung. The other end of the line is also fixed to the loading-block, so that the line, as a whole,

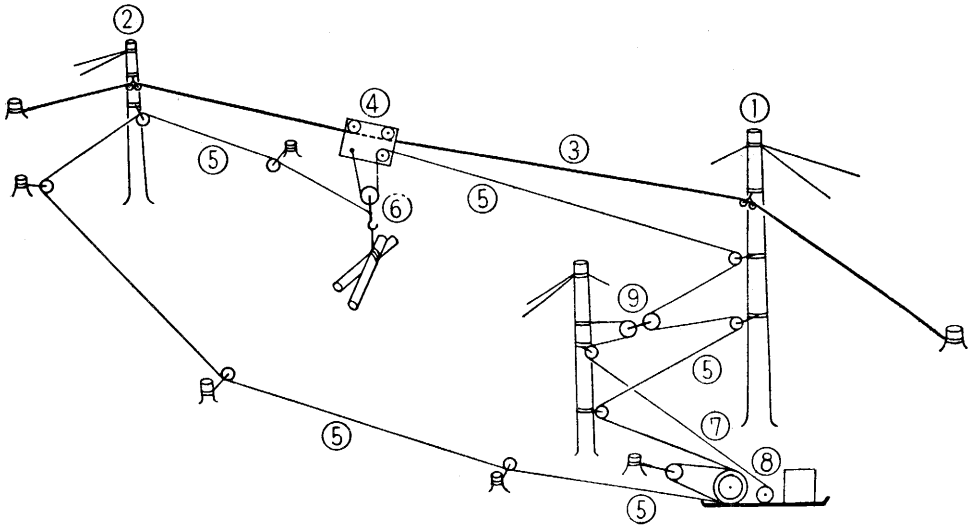


Fig. 3. "Endless Traction-cable" system

forms an endless circuit. The line is coiled around a cable-sheave of the yarder (8), and driven by the sheave to each direction according to the regular or reversed rotation of the sheave. Therefore, the carriage is hauled or hauled back merely by changing the gear of the cable-sheave from regular to reverse or *vice versa*. For this line, usually JIS 6×19 or Fi 6×25, 10–14 mm wirerope is employed.

Tensioning-line (7): To the tensioning-block (9), usually a twin-block is applied. The traction-line (5) passes through one of the two pulleys of this block, while the other pulley is pulled by the tensioning-line. One end of the tensioning-line (7) is fixed to a standing tree or a stamp, the other end of the line is lead to a drum of the yarder (8). When this line is wound by the drum, the slack of the whole traction-line may be gradually diminished until the loading-block (6) is lifted upwards and reaches the carriage. At this time, breaking of the drum is made effective, so that the tensioning-line is kept still in this state. Then, the carriage can be hauled or hauled back by the traction-line. Therefore, in this system, it is understood that the same line is used for the purposes of hauling and hauling back of the carriage as well as of lifting and falling of the loading-block. Usually, JIS 6×19 or Fi 6×25, 10–14 mm wirerope is used for this line.

Yarder (8): The yarder used for this system should have at least one cable-sheave. It is sufficient to employ a drum with less rope-capacity and low winding speed. The diameter of the cable-sheave should be larger than that of the cable-drum, but usually the cable-sheave does not require more than two groves to maintain the adequate friction. Therefore, a specially designed simple yarder can be employed. Sometimes, also an ordinary 2-drum yarder could be used, provided that, an additional cable-sheave is attached to the central part of the 2nd drum (front drum) of it.

When a special carriage, combined with stoppers, is applied to the "Endless traction-line" system, lifting and falling of the loading-block is performed by an independent lifting line, which is attached to the carriage or the traction-line. There is no need of slack-pulling in this case, and even a most simple yarder, equiped with only one cable-sheave, could be employed.

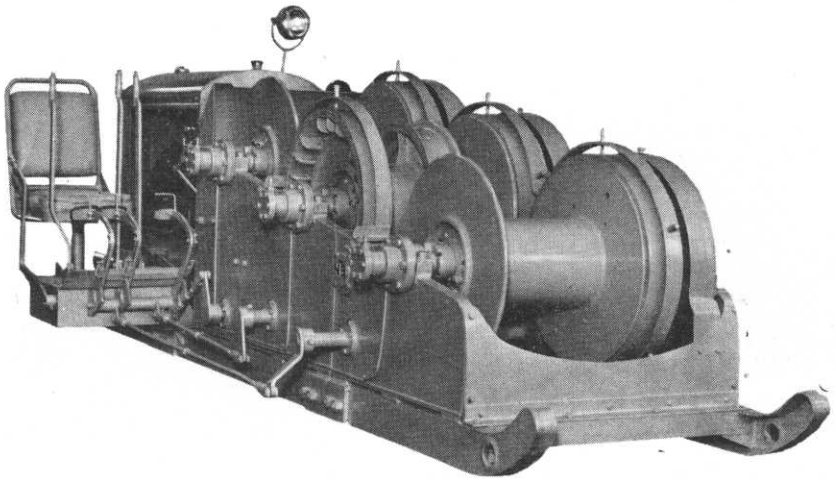
IV. Yarders or cable-winches made in Japan

Various kinds of yarders or cable-winches for the skyline cranes are now manufactured by Japanese makers. Much progress has been seen also in this field. Lighter, robuster and more compact machines are made to meet the requirements of easy transportation and frequent change in setting on the spot. In the other nand, considerable improvements have been accomplished from the view point of easy operation and high efficiency. The writer would like to note here four typical examples: (1) MORITO, Model SDY-353, (2) IWATEFUJI, Model Y-25, (3) TANIFUJI, Model TE-58, and (4) NANSEI, Model NK-59. These machines are shown in the pictures, and specifications are listed on the table.

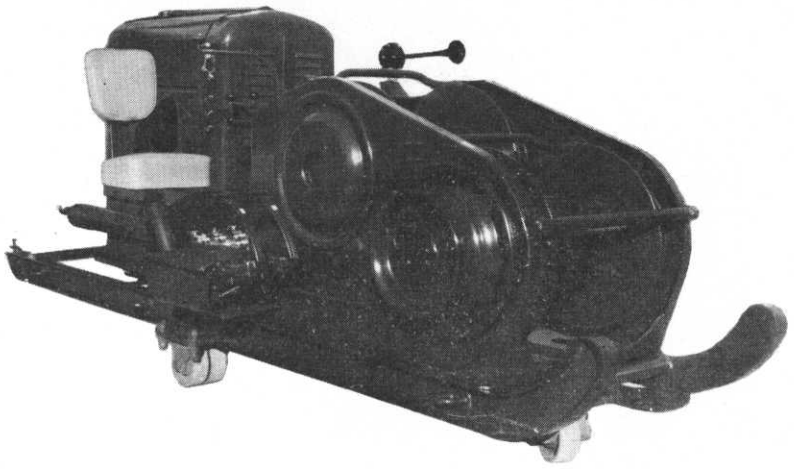
日本の山岳林における架空線集材機の代表的な索張り方式（摘要）

教授 加 藤 誠 平

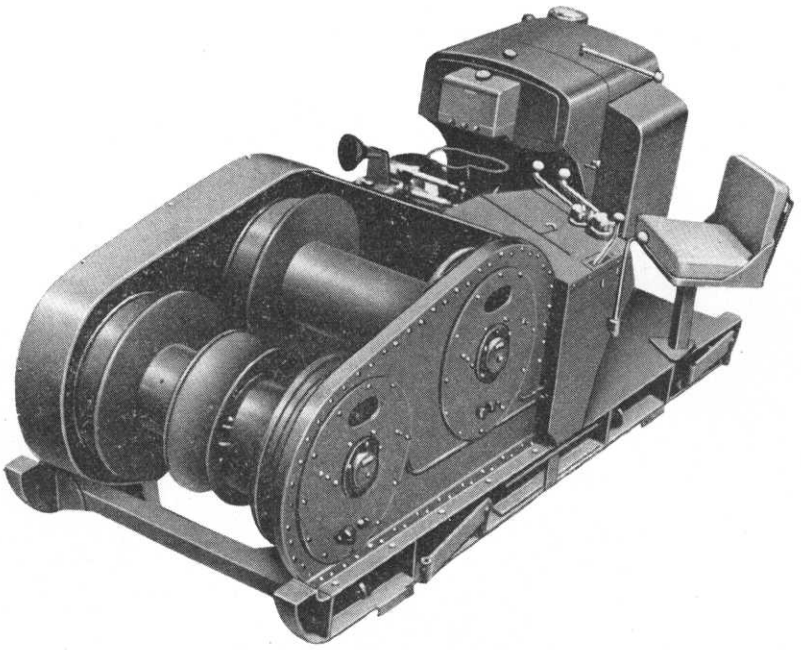
過去 15 年間に，架空線集材機と索道は日本の山岳林に急速に普及した。架空線集材機は一般に急峻な林地における下げ荷集材に使用され，各種の索張り方式があるが，その中で最も代表的なものは，タイラー式・フォーリングブロック式・エンドレス式の3方式である。3方式とも更にいろいろの変型があるが，ここではそれぞれの基本型を解説した。集材機（ヤーダー）も優良な国産品が多数製作されているが，ここにはそれぞれ特徴のある4機種を紹介した。



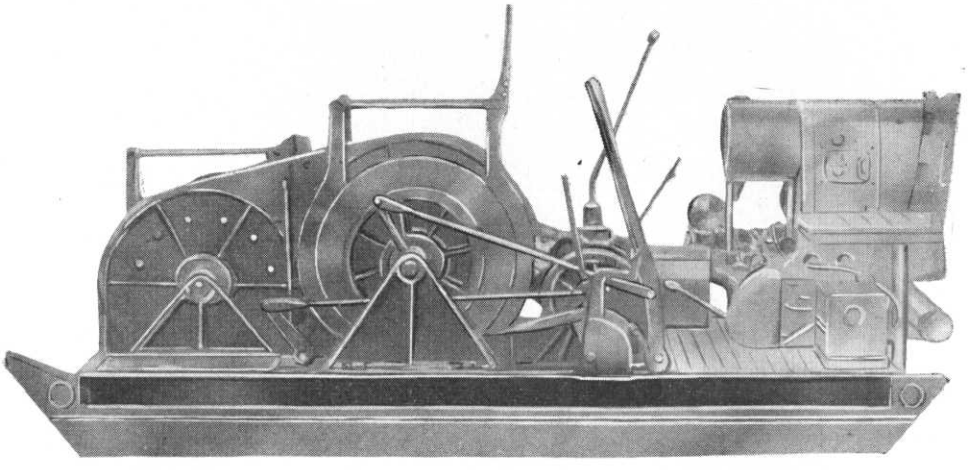
1. MORITO Yarder, Model SDY-353



2. IWATEFUJI Yarder, Model Y-25 FDB



3. TANIFUJI Yarder, Model TE 58 W (SPIDER)



4. NANSEI Yarder, Model NK-59 A

Specifications of Typical Japanese Yarders

Yarder	MORITO SDY-353	IWATEFUJI Y-25 FDB	TANIFUJI TE-58 (SPIDER)	NANSEI NK-59
1. Gross weight (kg)	2,000	1,850	1,500	1,500
2. Overall dimension Length×Width×Height (mm)	4,223×1,410×1,200	3,715×1,360×1,350	2,760×1,089×1,090	2,900×1,150×1,000
3. Number of drums	3	2	2	2
4. Drum size (Sheave Size)				Main drum / Front drum
Drum diameter (mm)	265	320	250	235 / 235
Flange diameter (mm)	640	630	550	610 / 580
Drum width (mm)	450	666	540	365 / 365
Sheave diameter (mm)	——	——	(Detachable) 370	380
5. Engine (Power unit) Type	ISUZU DA-220 Water cooled diesel	ISUZO DA-220 Water cooled diesel	WISCONSIN VG4-D Air cooled gasoline	VOLKSWAGEN-122 Air cooled gasoline
Output (HP/r.p.m)	75/2,600	75/2,600	36/2,200	34/3,600
Weight (kg)	380	380	——	85
6. Drum clutch	Double faced corn clutch operated by oil pressure	Automatic centrifugal clutch in addition to selective gear clutch	MINSEI internal expansion clutch operated by oil pressure	Double faced corn clutch operated by hand
7. Transmission	TOYOTA gear selective sliding type. 4-Speeds	Semi-automatic type 4-speeds	Spur gear selective sliding type 3-speeds	Spur gear selective sliding type. 3-speeds
8. Torque converter	——	——	OKAMURA M-15	——
9. Reversing converter	Two opposed bebel gear type	Gear selective type	Gear selective sliding type.	Idle gears changing type
10. Brakes	Bandbrakes operated by hand levers	Internal expansion brakes operated by oil pressure	MINSEI internal expansion brakes operated by oil pressure	Shoe type brakes operated by hand levers
11. Pull capacity (kg)	(At 2,400 r.p.m)			
Gear I (Low)	1,800	2,820	4,200~884	max. 2,000 / 1,200
〃 II (2nd)	1,400	1,595	2,435~512	600
〃 III (3rd)	780	1,095	1,130~276	300
〃 IV (Top)	390	620	——	——
12. Cable speed (m/min)				
Gear I (Low)	47	57	0~106	min. 55 / 95
〃 II (2nd)	98	165	0~182	190
〃 III (3rd)	173	248	0~341	400
〃 IV (Top)	340	424	——	——
13. Winding up capacity (m)				Main drum / Front drum
Wirerope φ 9mm	1,400	1,370	1,120	1,100 / 950
〃 φ 10mm	1,150	—	——	850 / 780
〃 φ 12mm	780	770	630	630 / 530
〃 φ 14mm	590	570	——	430 / 400
14. Approximate domestic price Incl. Engine Excl. Wireropes, carriage and other cable attachments	¥ 1,600,000 ($ 4,440)	¥ 1,500,000 ($ 4,170)	¥ 1,100,000 ($ 3,050)	¥ 800,000 ($ 2,200)
15. Maker	MORITO KIKAI SEISAKUSHO Co., Ltd.	IWATEFUJI INDUSTRIAL Co., Ltd.	TANIFUJI KIKAIKOGYO Co., Ltd.	NANSEI KOSAKUSHO Co., Ltd.
Factory	Kawaguchi-shi, Saitama-ken.	Mizusawa-shi, Iwate-ken.	Shinagawa-ku, Tokyo.	Kumamoto-shi, Kumamoto-ken
Tokyo office	Kokusai Bld. No. 84 Kurumazaka, Daito-ku, Tokyo.	No. 73, 2-chome, Tsunohazu, Shinjuku-ku, Tokyo.	No. 1, 2-chome, Kudan, Chiyoda-ku, Tokyo.	No. 20, 3-chome, Shiba shimbashi, Minato-ku, Tokyo.