III Design of Yielding System

III-1 Selection of model place

The nominated places in the domain of District Forest Office West Pekalongan are almost all in the sloped places of more than 15 degrees and are so called best fit places for yarding by yarder, and only 20 ha is fit for tractor skidding of the slope of less than 15 degrees.

But, in general, the two systems of the mountain logging, the one is by skyline system and the other by tractor, are both available, we selected the model places for these two logging systems and designed and cost calculated for the both.

The exploitable standard standing tree is the Pinus Merkusii of diameter breast high 30cm, height 20m, raw specific weight 1.2, the stem volume 0.65 m^3, the weight 780 kg.

The yarding area of each system are shown, in the following figures and pictures.

The #69 compartment is for the yarding system by yarder, area 6.56 ha, yielding volume 754 m^3. On the other hand, the #67 compartment is for tractor, area 3 ha, and the yielding volume is 393 m^3.

Model place #69 compartment (object place for yarder) seen from #67 compartment (place for tractor).

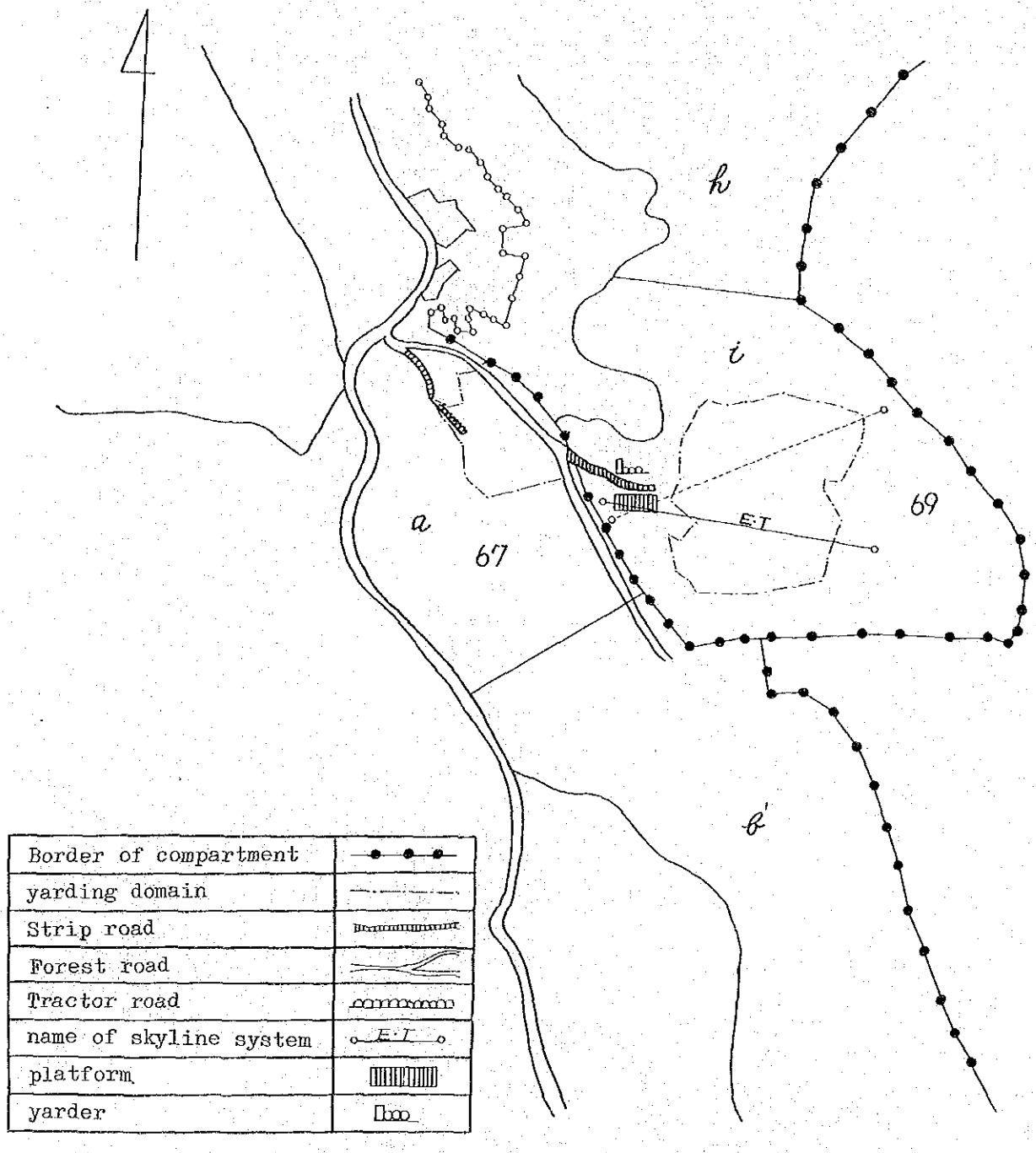
Model place #69 compartment (object place for yarder) seen from #67 compartment (place for tractor).

Fig. III-1 Model yarding domain

PETA PERUSAHAAN BAGIAN HUTAN PEKALONGAN BARAT

K.P.H. PEKALONGAN

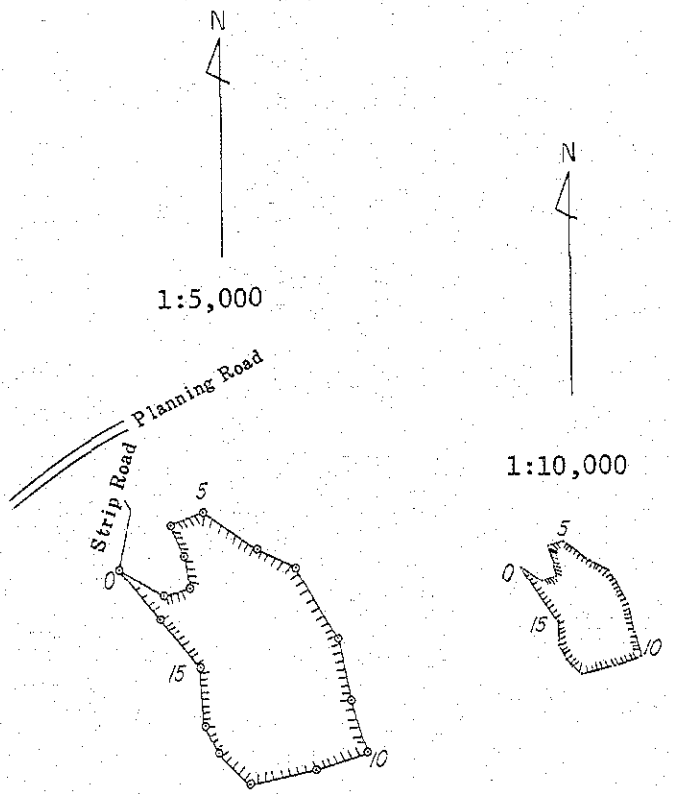
Scale 1:10,000



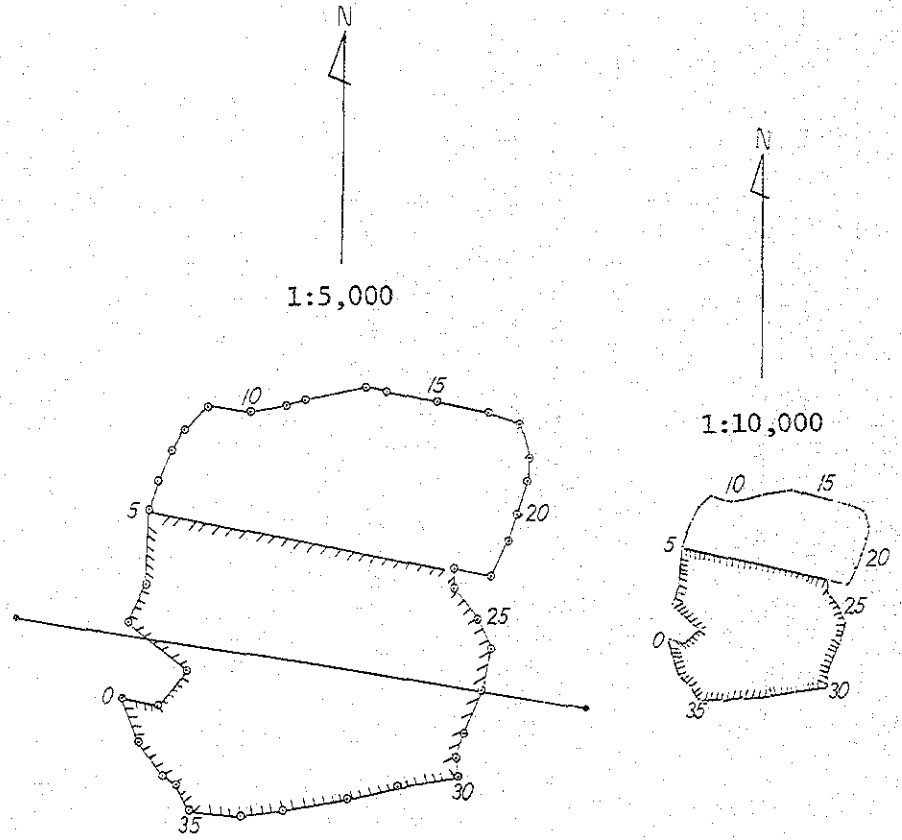
Border of compartment	
yarding domain	
Strip road	
Forest road	
Tractor road	
name of skyline system	E·T
platform	
yarder	

Fig. III-2

Standard Place for Tractor
#67 compartment, a-sub-compartment
Area 3.0 ha



Standard Place for Yarder
#69 compartment, i-sub-compartment
Area 8.4 ha
(Actual object area for yarding
is 6.56 ha.)



#69 compartment & #67 compartment are located near Doc Tunga, and the former is in steep ground and the latter in somewhat level ground, and the both two are neighboring the farm land.

III-2 The felling and bucking operations in the model places

About the felling and bucking operations, which are the other processes of logging system, we adopted the operations by traditional manual works.

Because, we can employ abandantly the skilled workers of the manual bucking operations at low wages, and there is no need of availing the chain-saw.

As the results of scrutinizing the actual data of the past, we found that the felling operation done by one man per day is 5 m^3; the operation is done by two-men hand saw and 10 m^3 per day, per pair is the results.

About the bucking operation 20 m^3 per day per pair is the standard.

Therefore, felling and bucking 20 m^3 per day, we need four personnels for felling and two personnels for bucking and totaly six personnels are necessary.

To fix the wages 500 RP per man, per day, the cost amounts to

$$500 \text{ RP} \times 6 = 3{,}000 \text{ RP}$$

and, therefore the cost per m^3 is as follows.

$$3{,}000 \text{ RP} \div 20 \text{ m}^3 = 150 \text{ RP/m}^3.$$

We calcurated the cost, availing this value.

As the yielding process we adopted the tree length logging, the pattern of which is as follows.

tree length logging ⟶ yarding by yarder ⟶ or skidding by tractor ⟶ bucking at the collecting spot ⟶ piling up.

As for the transportation by truck, it is the matter of the buyer or the contract with the express agent.

Therefore, we do not touch with the truck transportation.

From the truck road to the collecting spot the strip road is necessary, and therefore the construction of the strip road and the platform will be added to the above mentioned process.

Clear cutting in the steeply sloped place of more than 30 degrees may cause the erosion and the destruction of farm land, and so to prevent these we practice the small area clear cutting for the former and to

reserve the 10% of remaining belt stand for the forest neighboring to the farmland. As we designed the yielding plan considering these conditions, the yielding volumes diminished from the report of Mr. Rochmadi's.

Two man saw, Ax, Measuring pole

III-3 The outline of skyline system

Before designing the model case by skyline system which is one of the yielding systems, we must know, at first, about

What is the skyline system?

What sort of machinery and its

accessories are used? and

How they are used?

Therefore, we describe about the general outlines of it to understand more deeply about the design of model case.

The skyline system is the one which hang up the logs in the air and transport and gather them from the felling area to the collecting spot near the transportation facilities like the forest road, utilizing

the yarder, its accessaries like blocks, towers and wire ropes.

This system will display its highest performance in case of steep slope of mountainous area, much of rain volume, volcanic soils which necessitate the prevention for erosions, and of securing the water resources, like the Japanese mountain forest.

When operating by this system, the process may be divided in four stages as follows; that is, to draw up the logs near to the skyline, to gather the logs to a predetermined spots in the felling area along the skyline, to transport them from the felling area to other places, and to shift them to other transporting facilities, but in ordinary case two to three stages are done by one yarder.

About the yarder operation, the knowledge about the yarder, its accessaries, wire rope and the skyline setting system is necessary.

III-3-1 Yarder

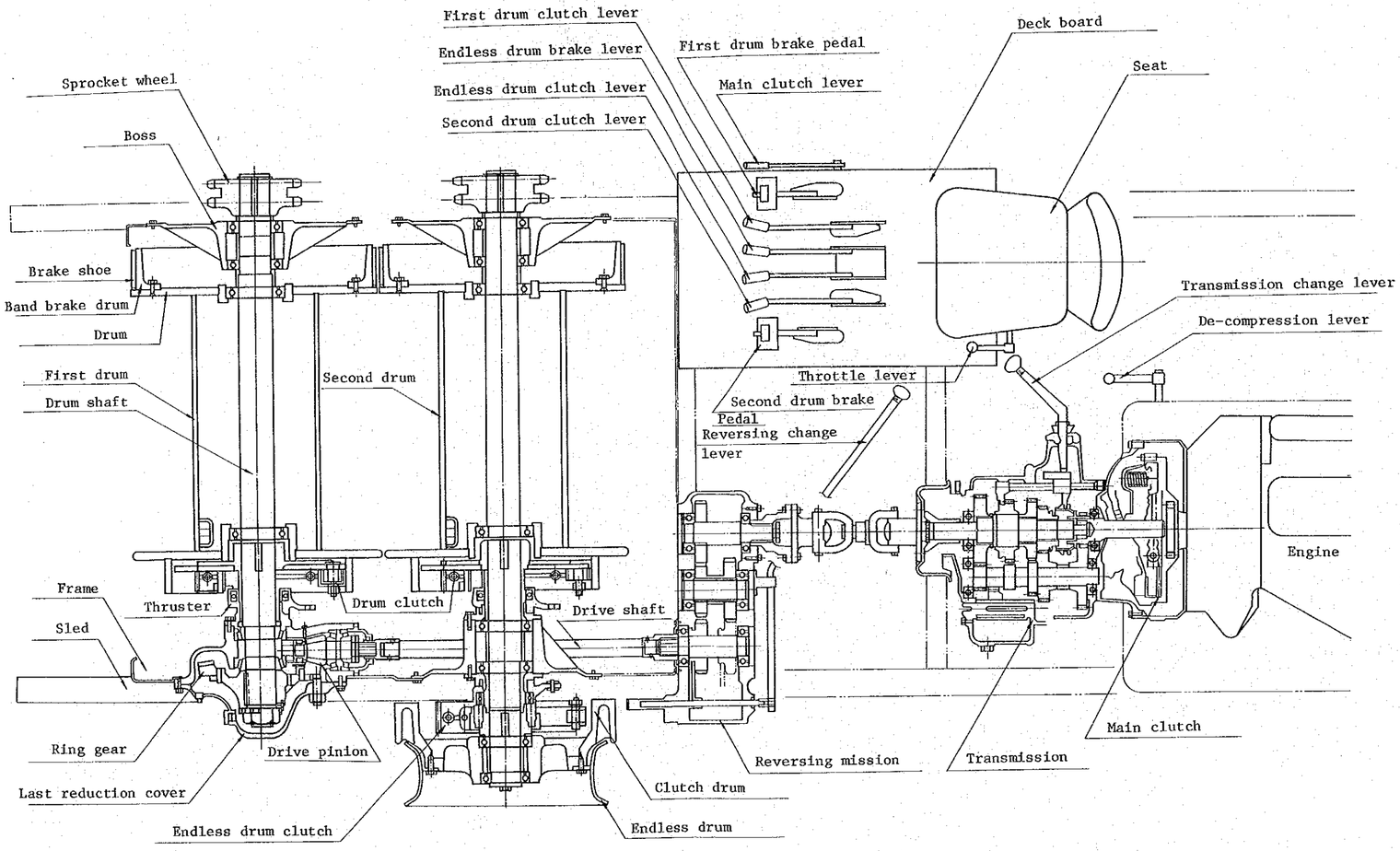
Yarder is a sort of winch driven by power, but is different from other general use winches like the one for civil engineering and marine use, in the following aspects and these are the characteristics of it.

1) Must be high speed.
2) Must be light weight.
3) Therefore, the power-transmission part is necessarilly be precision made, small sized, oil-immerged and entirely sealed.
4) Winding capacity must be far greater than the others.
5) Must have a large capacity and high reliability of brake.
6) Have many steps of speed changing, and especially the forward and reverse must be the same.
7) As the driving operation is complicated and needs the speedy operations, that is must be operated easily.

(1) Outline of construction

Y-32EA type Triple drum yarder.

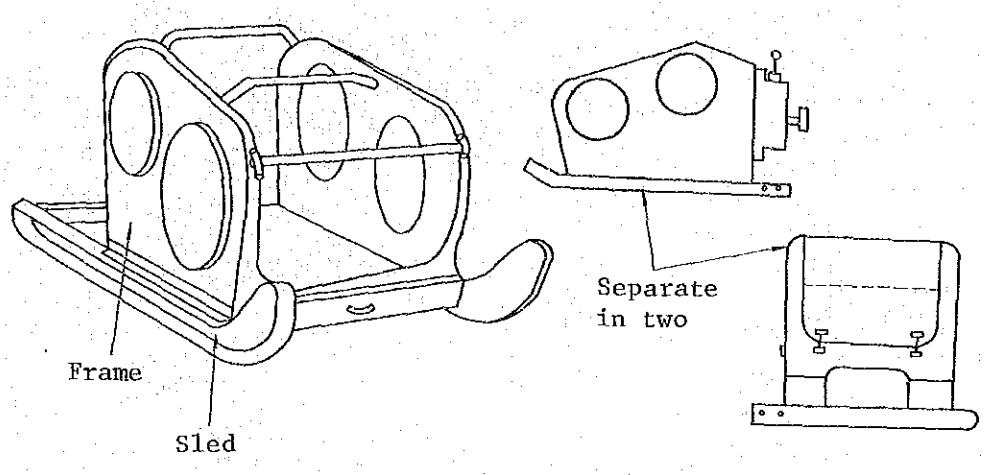
Fig. III-3



(2) Frame.

In order to make it light, the frame is made by semi-monocoque construction of welded steel sheets. The frame and the sled are assembled together by several bolts and the sled is so made as to separate at the middle into two of front part and rear part, enabling the moving of it easy in the heart of a mountain.

Fig. III-4



(3) Prime mover

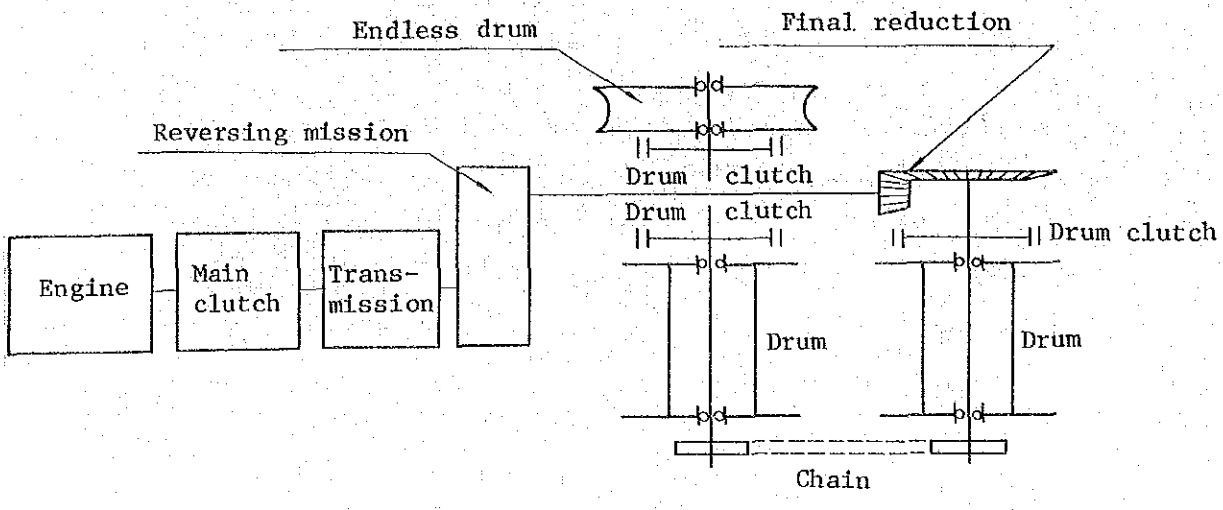
As for the engines for yarder, select and adopt in general the automobile diesel engines, according to the size of yarder.

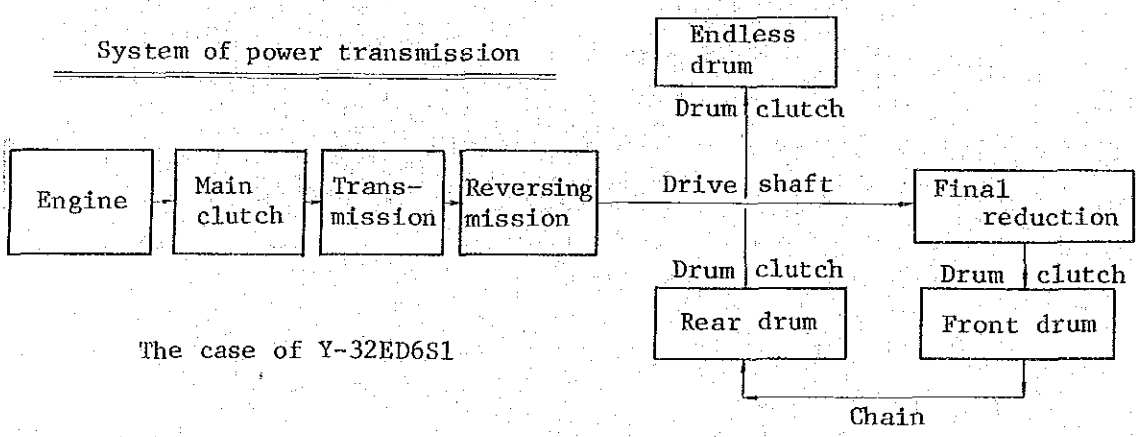
Automobile engines are light in weight and easy in getting the spare parts.

(4) System of power transmission

Power from the engine is transmitted to the main clutch, transmission, reversing-mission, last reduction gears, drum clutch, and drum successively.

Fig. III-5





The case of Y-32ED6S1

(5) Transmission

Engine power is transmitted to this through main clutch.

This is for the transmission of engine power to each drum, and changing its revolution speed and torque selectively according to the needs of drums by changing the gears just like that of the automobiles.

But in case of yarder the construction is more complicated, because it must drive three drums individually.

(6) Drum

The principal functional parts of yarder are consisted of the drums to wind up the ropes, the clutches (drum clutch) for engaging or disengaging the drive shaft to the drums, and the brakes (drum brake).

Drum varies in winding capacity according to the size of yarder, but it is constructed mainly of the shell and the flanges.

Winding capacity of drum is calculated by the following equation,

$$L = 0.000725 \times B \times \frac{D_o^2 - D_i^2}{d^2}$$

where $Di > 20d$

L : Rope winding capacity (m)

B : Width of drum (m.m)

Di: Diameter of drum (m.m)

Do: Diameter of flange (m.m)

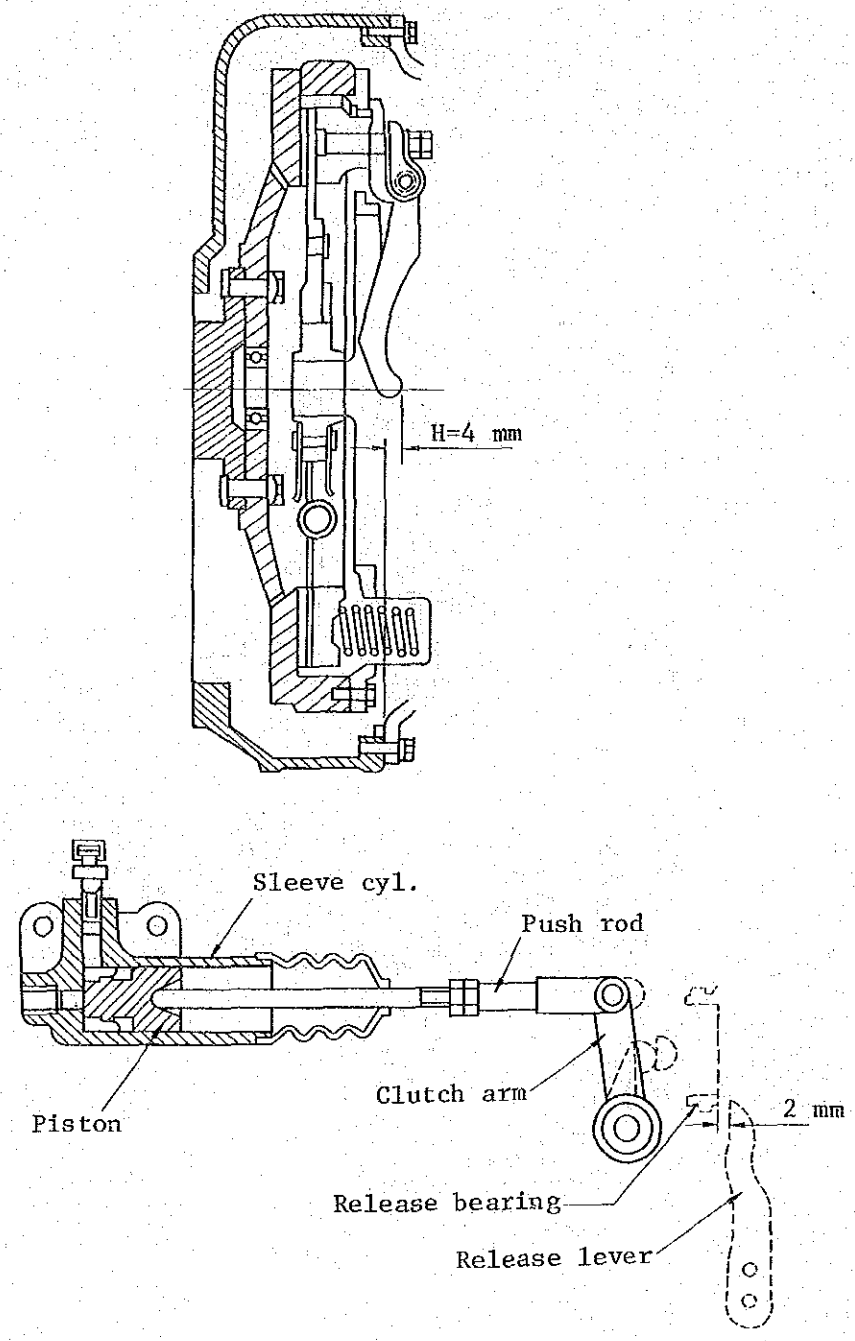
d : Diameter of wire rope (m.m)

(7) Main clutch

Main clutch is of the dry single disc type, and manually operated by handle.

The operating power is transmitted hydraulically, that is, the handling is manual but the process is just like that of the automobiles.

Fig. III-6 Main clutch



(8) Drum clutch

(First, Second & Endless drums)

Drum clutch is of the mechanical expanding type, manually operated by handle, and the operating force is transmitted by link motion.

Fig. III-7 Clutch assy

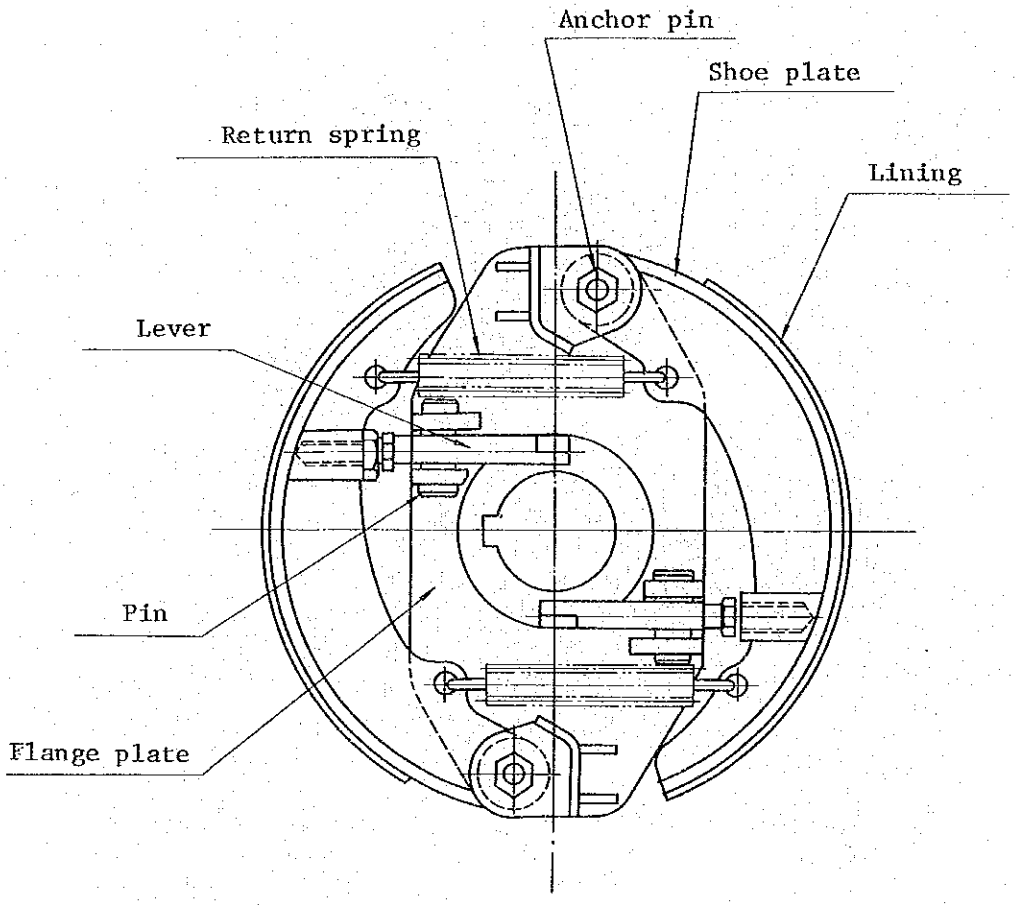
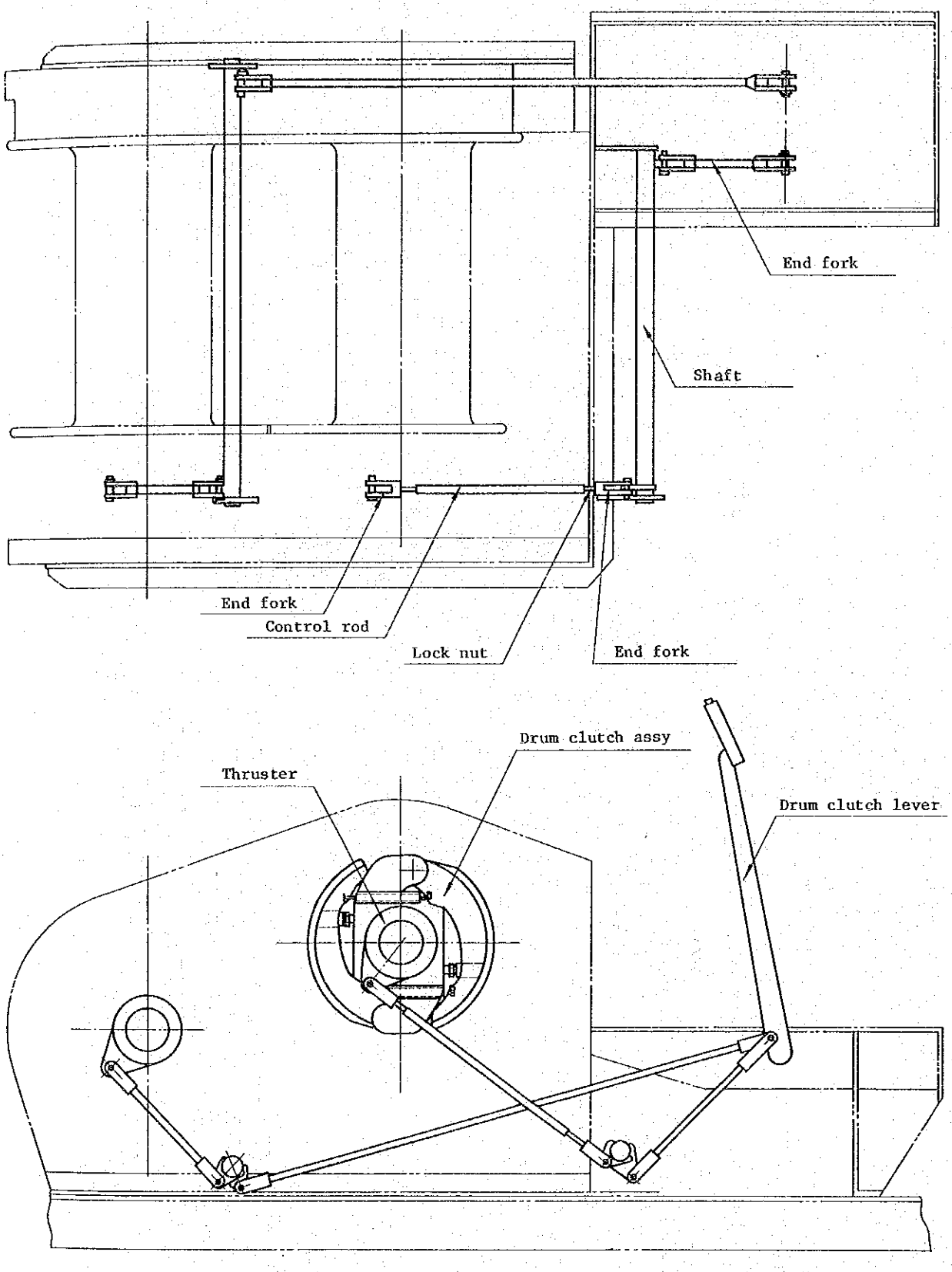


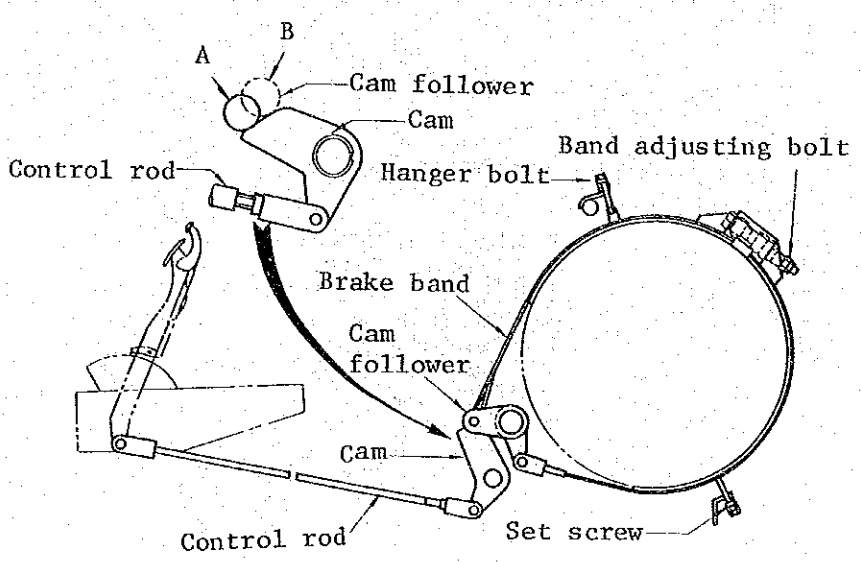
Fig. III-8 Drum clutch

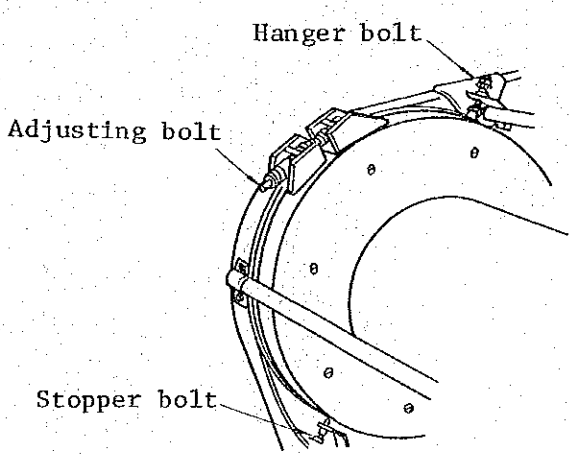


(9) Drum brake (First & Second drums)

Drum brake is of the band type, and its operation is done by pedal, and the operating power is transmitted by the link motion.

Fig. III-9 Drum brake





(10) Drum brake (Endless drum)

Brake of the endless drum is the external contracting type and of the post brake system. Operation is done manually by handle, and the operating force is transmitted by link motion.

Fig. III-10 Endless drum brake

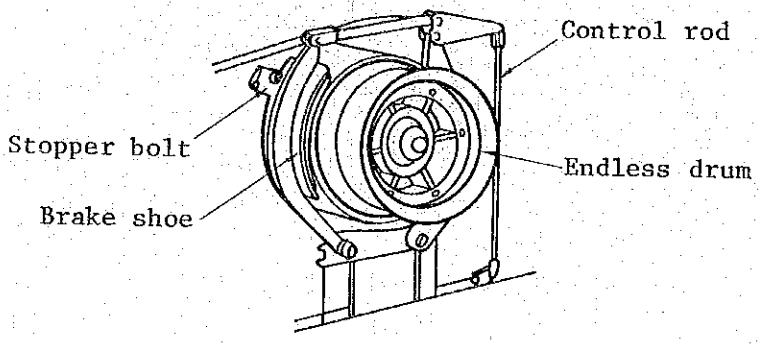
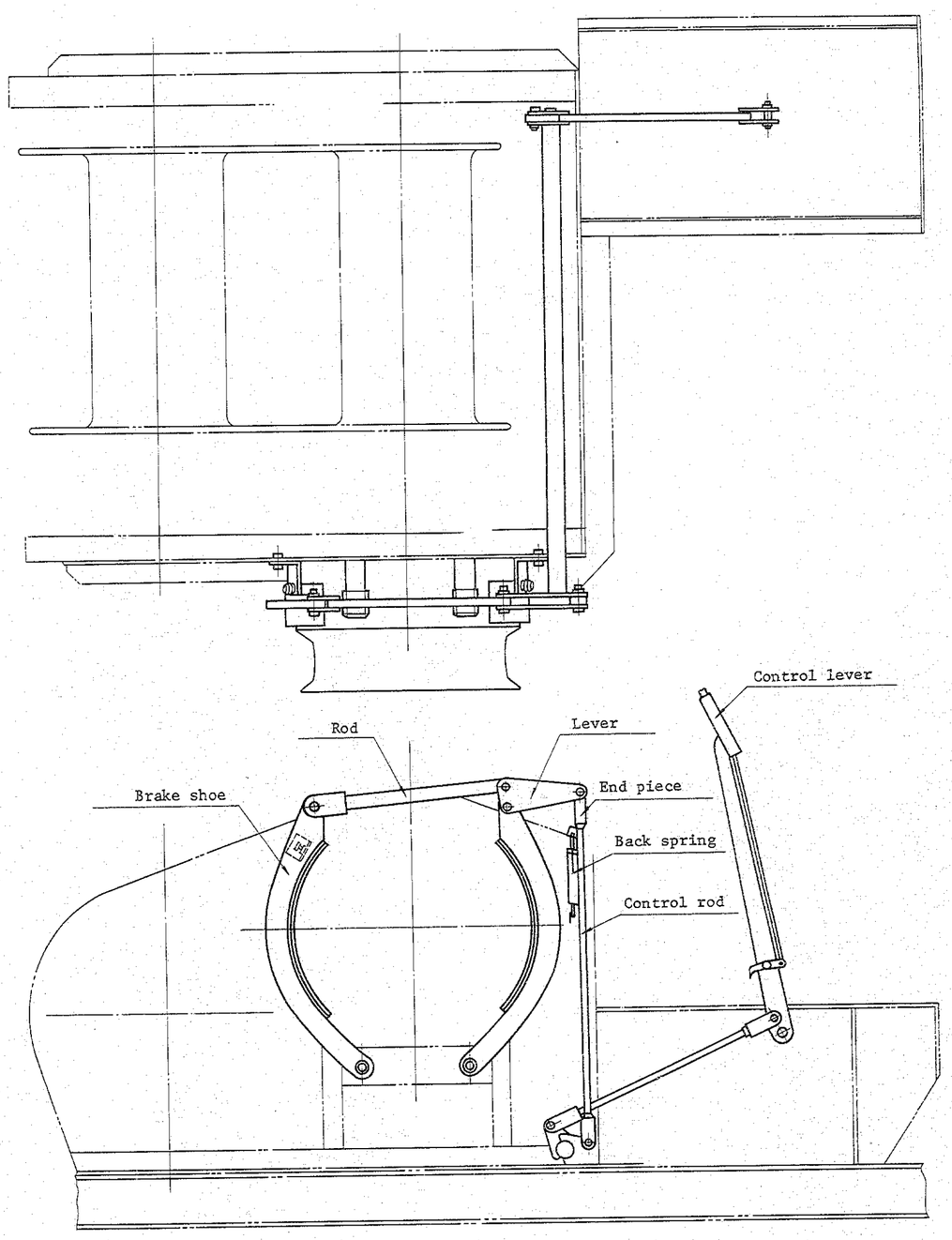


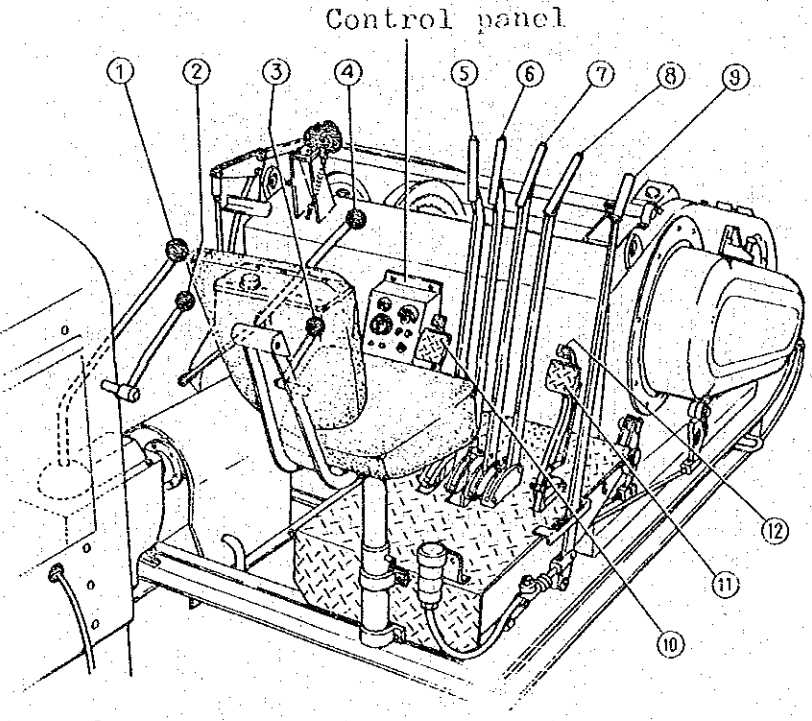
Fig. III-11 Drum brake

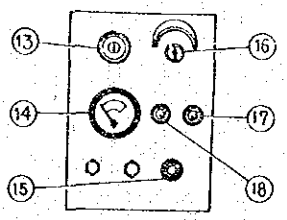


(11) Arrangement of operating levers and pedals.

Differences are seen between the types of yarder, but this yarder is arranged as the following diagrams.

Fig. III-12 Names of apparatus around the driver's seat





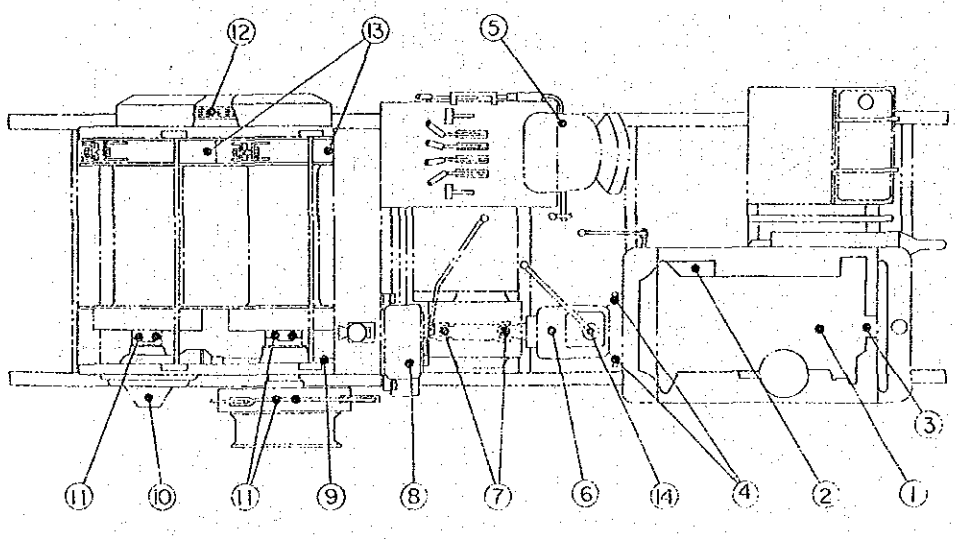
Details of Control Panel

(1) Change lever, transmission.
(2) Decompression lever.
(3) Throttle lever.
(4) Reversing lever (Switching lever for foward & reverse)
(5) Clutch lever, 2nd drum.
(6) Clutch lever, endless drum.
(7) Brake lever, endless drum.
(8) Clutch lever, 1st drum.
(9) Main clutch lever.
(10) Brake pedal, 2nd drum.
(11) Brake pedal, 1st drum.
(12) Parking lever.
(13) Control resistance.
(14) Thermometer.
(15) Fuse holder.
(16) Starter switch.
(17) Warning lamp.
(18) Battery charge lamp.

(12) Lubricating system

Lubricating system is arranged as follows.

Fig. III-13



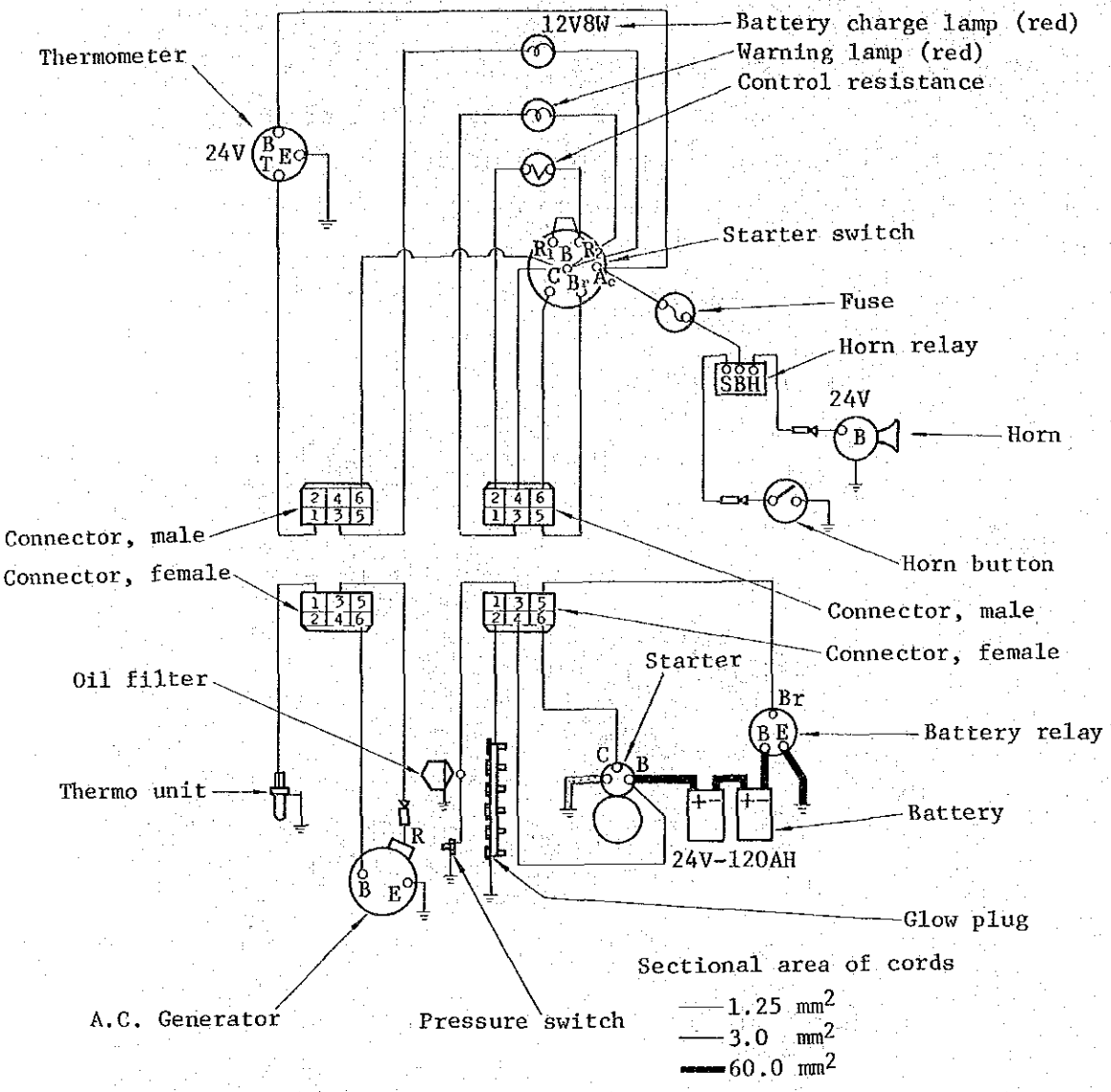
No.	Lubricating spot	Operation	Sort of Lubricant	Lubricating intervals (1) monthly (2) every 3 month (3) yearly	Remarks
1	Oil-pan, engine	level check, replenish	E.O	(1)	
		change the lubricant		(2)	Quantity 10 L
2	Starter	Lubrication	E.O	(1)	Few drops
3	Bearing, water pump	replenish grease	G	(1)	2 or 3 strokes of grease gun
4	Take off shaft, main clutch	replenish grease	G	(1)	2 or 3 strokes of grease gun
5	Master cylinder, main clutch	replenish brake fluid	B.F	(1)	Quantity 0.2 L
6	Transmission	level check, replenish	G.O	(1)	
		change the lubricant		*(2), (3)	Quantity 4 L
7	Universal joint	replenish grease	G	(1)	2 or 3 strokes of grease gun
8	Reversing gear case	level check, replenish	G.O	(1)	
		change the lubricant		*(2), (3)	Quantity 1.5 L
9	Coupling, drive shaft	replenish grease	G	(3)	spline part, every over-hauling.
10	Last reduction housing	level check, replenish	G.O	(1)	
		change the lubricant		*(2), (3)	Quantity 2 L
11	Drum clutch	Replinish grease	G	(1)	Contact point of cam lever, sliding surface of thruster
				(3)	Thrust bearing, every over-hauling
12	Chain	lubrication	E.O	(1)	Daily check and lubrication
13	Brake links	lubrication	E.O	(1)	Few drops
14	Shift rod	replenish grease	G	(3)	Every over-hauling

Note: * Apply only at the begining

(13) Electric system

Voltage used is D.C 24V, (-) earth type.

Fig. III-14 Electric wiring diagram



III-3-2 Accessaries of yarder

a) Carriage

In ordinary case, the carriage of one side opened overhang type is necessary to pass through the intermediate supports.

b) Blocks

As the blocks, there are snatch block, heel block, loading block, saddle block and others. As for the snatch block, we must select the one which does not grip the wire rope derailed from the shieve and get in between the yoke and the sheave.

Heel blocks are used for pulling up the skyline, by multifying several times the pull of the yarder.

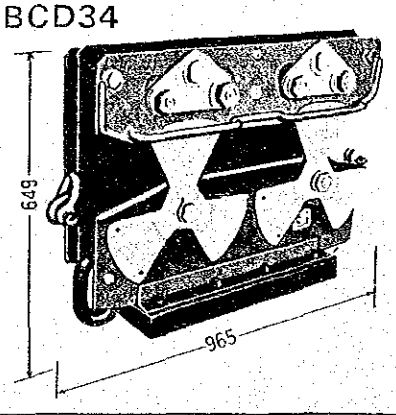
Loading block is the one, hanging from the carriage and goes up and down holding the load with it.

Saddle block will hold the skyline, being fixed to the head tree and the tail tree, and which is constructed with two triangular side plates and two sheaves.

Many other blocks are available according to the necessity.

Carriage (overhang type)

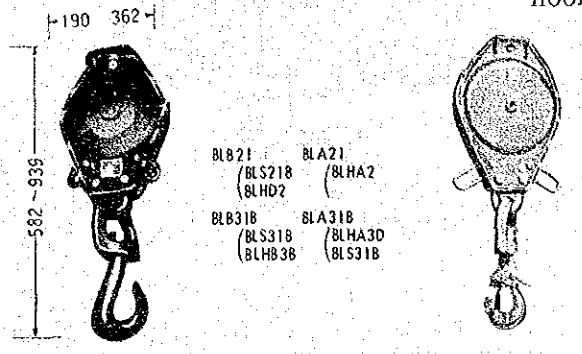
Type : BCD34



Type,	rated load,	sheave diam,	skyline diam,	weight,	matching support
BCD34	3t	6"	22~28mm	113kg	BN24C BN28

Loading block

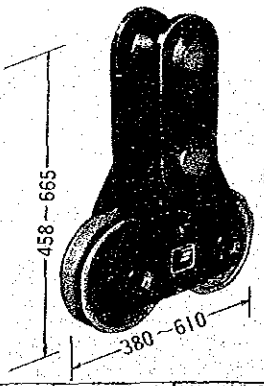
Type: **BLB21, BLB31B**(Open type hook)
BLA21, BLA31B(Closed type hook)



Type	rated load	line size	sheave diam	weight
BLB21	2t	8~14mm	9"	16kg
BLB31B	3t	12~14mm	12"	30kg

Saddle block

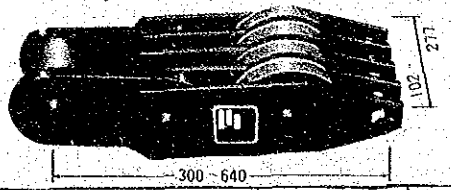
Type: **BD24, BD28**



Type	rated load	skyline diam	sheave diam	weight	remarks
BD24D	15t	20~24mm	7"	29kg	double sheave
BD28A	20t	24~28mm	8"	46kg	double sheave

Heel block

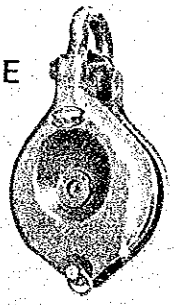
Type : **BH16,BH20,BH24,BH28,BH32**



Type	rated load	heel line size	sheave diam	matching skyline clamp	weight
BH16	6t	8~12mm	4½" ×3	BG20	6kg
BH20	10t	8~12mm	4½" ×3	BG20	11kg
BH24	15t	12~16mm	7" ×3	BG24	29kg
BH28	20t	12~16mm	7" ×4	BG28	35kg
BH32	28t	14~18mm	8" ×4	BG32	62kg

Snatch block

Type : **BS7A, BS9, BS12PE**



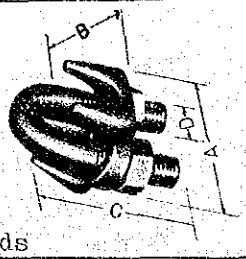
Type	rated load	line size	sheave diam	weight
BS7A	3t	8~14mm	7"	7kg
BS9	3t	12~14mm	9"	10kg
BS12PE	3t	12~14mm	12"	15kg

c) Wire clip

To fix the skyline or guy line to the stumps or to fix the wire rope in operation, we use a lot of fixtures called wire clip.

Wire clip

Type RC10-24



JIS Standarized goods

Type	line size	dimensions				weight kg
		A	B	C	D	
RC 10	9-10mm	45	35	50	10	0.145
RC 12	12 mm	51	39	60	12	0.219
RC 14	14 mm	33	45	65	12	0.310
RC 16	16 mm	60	48	75	14	0.400
RC 18	18 mm	62	53	80	14	0.450
RC 20	20-22mm	78	62	100	18	0.800
RC 24	24-25mm	86	68	110	20	1.160

III-3-3 Wire rope

The structure of wire ropes which are used in yarding is consisted of six strands, each one is made of 7 or 19 fine and strong steel strings (wire element) twisted together, and these strands are twisted around the fully oiled fiber core.

Wire rope is divided in two sorts by the direction of twisting and the right hand twisting is called Z-lay and the left hand twisting, S-lay.

Normaly the Z-lay is used and the S-lay is used in special case.

And in case of Z-lay there are again two sorts. One is called the Lang's-lay and this one is consisted of the Z-twisted strands and the strand itself is also made up with Z-twisted wire elements.

The other is called ordinary lay and this one is consisted of the Z twisted six strands with the S-twisted wire elements.

The Lang's-lay when compared with the ordinary lay.

a) is more favorable about the wearing and tearing, because the wire elements touch with the sheave of the block in longer range.

b) In case of the same size and the same number of wire elements, this one is more flexible.

c) As this one is easily untwist, it is not good to be used in the place where the end can twist freely.

d) has a tendency to kink easily.

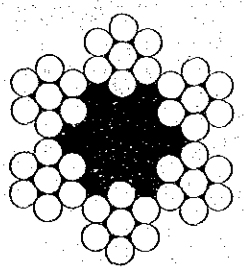
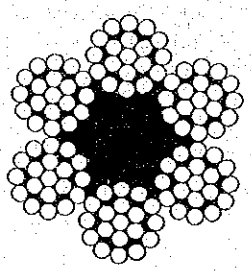
Above mentioned are the merits and the demerits.

Considering these, we had better to choose them in yarding operations as follows.

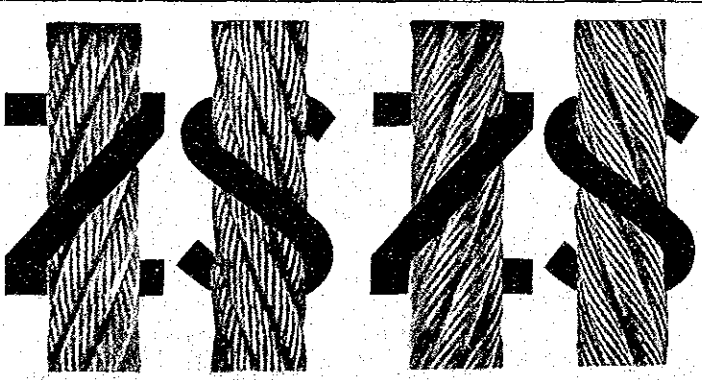
For the skyline (SKL) and the anchor line (ANL), which need big strength, and the ends are fixed, Lang's lay of six strands with seven wire elements (6 x 7) are used, and for the operating line like lifting line (LFL) and haul back line (HBL), the ordinary lay of six strands with 19 wire elements (6 x 19) are used.

There are many sorts of wire rope, and each maker makes its characteristic products.

Sort of wire-rope

Construction	7 wire elements 6 strands, fiber core	19 wire elements, 6 strands fiber core
Sign of construction	6 × 7	6 × 19
Section		

Lay of wire-rope



For instance, in yarding by yarder, the SKL becomes bigger when the span becomes longer or the load becomes heavier by adopting the full tree or tree length logging, but this will increase the self weight, and therefore, special rope is made for the SKL, which has greater breaking load for the same diameter.

As for the operating rope, filler type rope is also used, which hold the finer strings in the gap of wire elements.

As a conclusion, in yarding by yarder, the most important point to be marked is the trouble caused by the breaking of wire rope.

These troubles will, not only decrease the operation performance, but also threaten the life of operater.

Therefore, we must be very careful in selecting the wire rope.

While using, it is very rare to set the cable work fixed in one place for a long time, and in most cases we must use them repeatedly as we change the place. Therefore, we must constantly remove the dust and dirt stick to it in the forest ground, and coat it with oil, and handle with care not to be kinked or to be bent extremly. And also in case of rubbing the ground or passing through the rocky spot, use the supporting medium to protect it from wearing and tearing.

If the diameter decreases more than 7% of the nominal diameter, or the number of broken wire elements for one pitch of wire rope exceed the numbers, more than 4 - 6 for 7 elements 6 strands, and more than 12 for the 19 elements 6 strands then that part must be cut off and the remaining parts be jointed together, or the entire rope must be thrown away.

And also the same with the case, of more than one strand become loose, or corroded, or deformed by kinking.

Usage	Construction of rope	Sign
Skyline	6 x 7 Lang's, bare, A-grade coated with composition (black oil)	6 x 7 C/L A-grade
	" " " " B-grade (High tensile)	6 x 7 C/L B-grade
	special rope	
Operating line, guy line	6 x 19 Ordinary lay, bare, A-grade coated with red oil	6 x 19o/o A-grade
	6 x Fi (19 + 6) Filler	6xFi(19+6)o/o A-grade
line of blocks	6 x 19 Ordinary lay, bare, A-grade	6 x 19 o/o A-grade
	6 x 24 Ordinary lay, bare, A-grade	6 x 19 o/o A-grade
Sling	6 x Fi(19 + 6) Filler steel center	6xFi(19+6)1WRCo/o A-grade
	6 x 19 Ordinary lay	6 x 19 o/o A-grade
Changing Line	Nylon rope	
	6 x 19 Ordinary lay	6 x 10 o/o A-grade

III-3-4 Nylon rope

In setting the long span cable work, the weight of the rope to be carried about is fairly great and to extend it by drawing on the ground is a very toilsome labor.

Therefore, if we can prepare the light and strong nylon rope of about 10 m/m in diameter and the length equal to that of haul-back line, we carry it about at first, and by winding it with yarder. We can draw out the HBL, and by this HBL draw out other lines.

Nylon rope is somewhat costly but it is strong for corrosion and is very slippy, that it is very convenient to use.

But it is very elastic (for ordinary use it elongates about 20 - 30%) that if you leave the drum wound with this rope, the drum would be deformed by the big pressure generated on it in proportion to the turns of rope wound on it.

Therefore, you had better unwind it from the drum after operation, or to pull up the rope by using the endless drum.

But the nylon rope is weak for the traverse slip on the sharp edge of the rock and also for the heat (230°C), as we may call these for the defects.

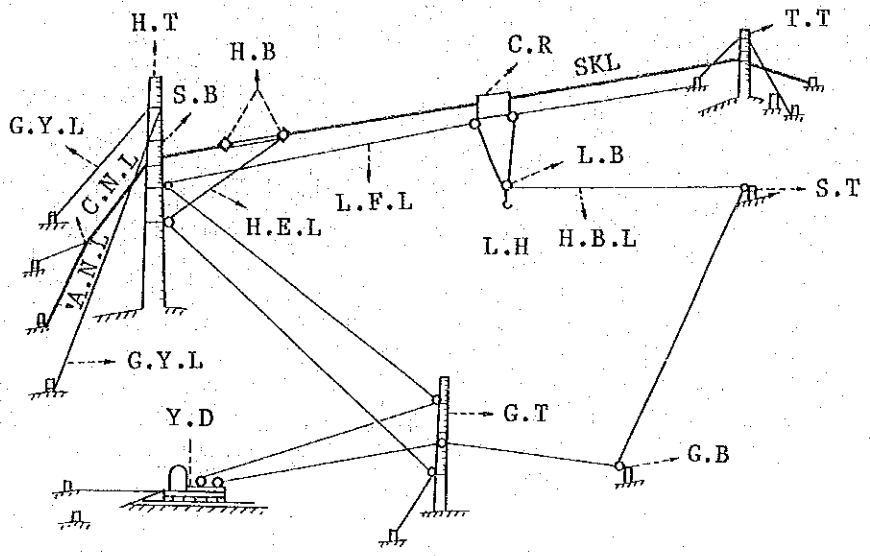
In setting the cable work, also the wirerope of about 6 m/m in diameter is used, instead of the nylon rope.

III-3-5 Skyline setting and its special terms

The skyline setting systems of the yarding by yarder are full of varieties and numerous, but you must choose the one best fit for the actual operation field.

Now we are going to explain about the skyline setting system and its special terms by the case of Tyler system, the typical one.

Fig. III-15 Skyline setting diagram



The Tyler system is fit for the operations of transporting the logs from the forest of higher position to the lower places.

Skyline (SKL) is stretched from the head tree (H.T.) at the foot of the slope and passing through the saddle block attached to the H.T. to the tail tree (T.T.) at the higher spot. Skyline is the rail for the carriage (C.R.) to run.

To stretch up the rail rope, use a pair of heel blocks (H.B.) and pass the heel line (H.E.L.) between these two blocks several times multifying the pull of yarder several times and stretch it up.

In case the yarder can not be set just to face the head tree by the ground conditions of the place, select the guide tree (G.T.) and make the yarder face to it and set it flat.

To lift up or let down the logs hung on the carriage, we wind up or unwind the lifting line (L.F.L.) by yarder.

Lifting line pass through the two guide blocks (G.B.) attached to the carriage, passing through the loading block (L.B.) hanging between these two and extend farther until it reaches to the tail tree and there it is fixed.

To the loading block the haul back line is fixed and this goes to another drum of the yarder, passing through many guide blocks set at the necessary places, and you can stop the carriage at any point by braking the drum.

Sign	Name
HT	HEAD TREE
TT	TAIL TREE
GT	GUIDE TREE
SKL	SKY LINE
HEL	HEEL LINE
CNL	CONNECTING LINE
ANL	ANCHOR LINE
GYL	GUY LINE
LFL	LIFTING LINE
HBL	HAUL BACK LINE
CR	CARRIAGE
LB	LOADING BLOCK
GB	GUIDE BLOCK
HB	HEEL BLOCK
SB	SADDLE BLOCK
LH	LOADING HOOK
ST	STUMP
YD	YARDER

III-3-6 Process of skyline setting

Before setting the skyline, you had better scrutinize the design book on skyline setting, survey the actual operating field, setting place of each towers, stumps, and the yarder, and also make certain the position of unloading spot, and check the machines and tools about its maintenance and their numbers. To promote the operation safely and efficiently, it is necessary to make the instruction book of the operation process.

At first we must set and fix the yarder to the place as flat as possible and the unloading operation can be seen ahead by the operator of yarder, besides yarder site should offer a wide vision of yarding field as the operation of yarder can be done without seeing backwards.

Then arranging the logs flat and set the yarder on it, and if the platform is necessary, then make it strong and ample enough and set it firmly.

Next, construct the head tree, the tail tree and if necessary also the guide tree.

If you use the standing trees as the towers, then choose the trees which have strong roots, free of hollows or damages in the stem, and can bear enough load.

In this case you had better patch the trees with protective plates at the pile of rope fixing, lest the tree should be bitten by wires and diminishes it strength.

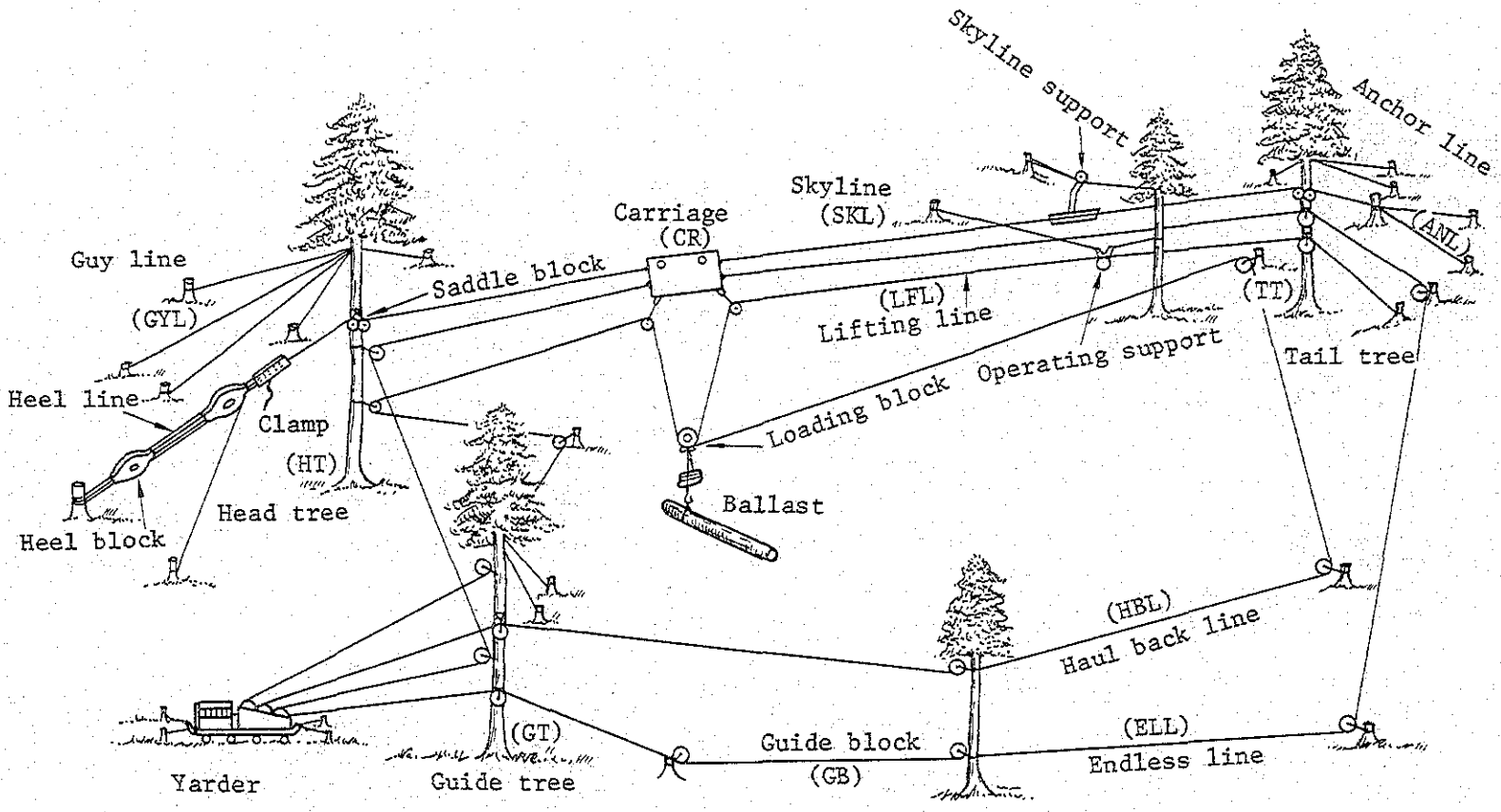
If you can not get the standing trees as the towers, then use the wooden or steel artificial towers, instead.

When using the artificial towers, you must fix the base firmly, lest it should sink or slip aside.

You must strengthen the tower by the guy-ropes both for live standing tree tower and for artificial one.

Illustrate the setting of towers as following figures.

Fig. III-16


Skyline support
Anchor line
Skyline
(SKL)
Carriage
(CR)
Guy line
(GYL)
Saddle block
(ANL)
(LFL)
Lifting line
(TT)
Tail tree
Heel line
Clamp
(HT)
Loading block
Operating support
Heel block
Head tree
Ballast
(HBL)
Haul back line
(GT)
Guide block
(GB)
(ELL)
Endless line
Yarder
Guide tree

(1) Preparation

Refering to the design book, which is prepared beforehand, survey the actual field affirming the location of each spars, stumps, yarder, and the unloading spot, and then cut open the yarding line, check the machines, tools and wire ropes, lubricate the necessary spots and ascertain the numbers of materials.

(2) Bringing in the yarder

To bring in the yarder to its appointed place, avail the truck as far as the forest road and the strip road may be used. But if it is necessary to bring it further in, avail the yarding line or by self travelling.

2-1 Transportation by truck

(1) Loading and unloading

a) Hook the transfer plank or the sliding rods to the loading plat-form of truck and load or unload by using "Tir-for".

b) Make a tri-pod and set a chain block at the top, and load or unload by hanging up.

(2) Prevent the sliding on the plat-form of truck.

Push in spacers between the yarder frame and the side flap of truck, and moreover, fix it by rope.

2-2 Transportation by skyline

a) Hold the machine horizontal by using 3-4 pieces of sling ropes.

b) When the slings pass through the under side of the yarder, attach the logs and the like to prevent the slings from being folded by the edge of the frame.

c) Hanging angle of slings should be less than 60 degrees.

d) If the weight of yarder surpass the limiting load of skyline, disassemble the yarder.

2-3 Transportation by self travelling

(1) Make the transportation road

Select the stumps beforehand to which the winding up line would be fixed and set the route.

a) Slopes must be less than 30 degrees and be as gentle as possible.

b) The width of the path should be wide enough for the operators to go around the yarder during the self travelling.

c) On the sloped area, construct the cut-in soil road as possible, and set the ground-sill at the shoulder and prevent the sinking of stickers. If this can not be done, then construct it as semi-sticker-way.

d) In case of dale crossing, it should be the sticker-way.

e) In the heavy curve, where the changing of stumps is necessary, the slope of road must be less than 5 degrees.

f) Place the log base, on the surface of the road. The log base are of the broad-leaf tree of about 10 cm in diameter, submerged about 3/4 of it in earth, and is fixed by the pile. In sticker-way, fixed by nail.

g) The sticker-way is consisted of three beams and the intervals of spar is 1.5 m as a standard. Stiffened by the cross member and the auxiliary spars. Jointing spots are fixed with clamps.

h) At both ends of the beam, there are the sleepers and the beams are fixed by the clamps to them. At the junction, the beams are suspended by the "Torii" type spars and are fixed by iron strings.

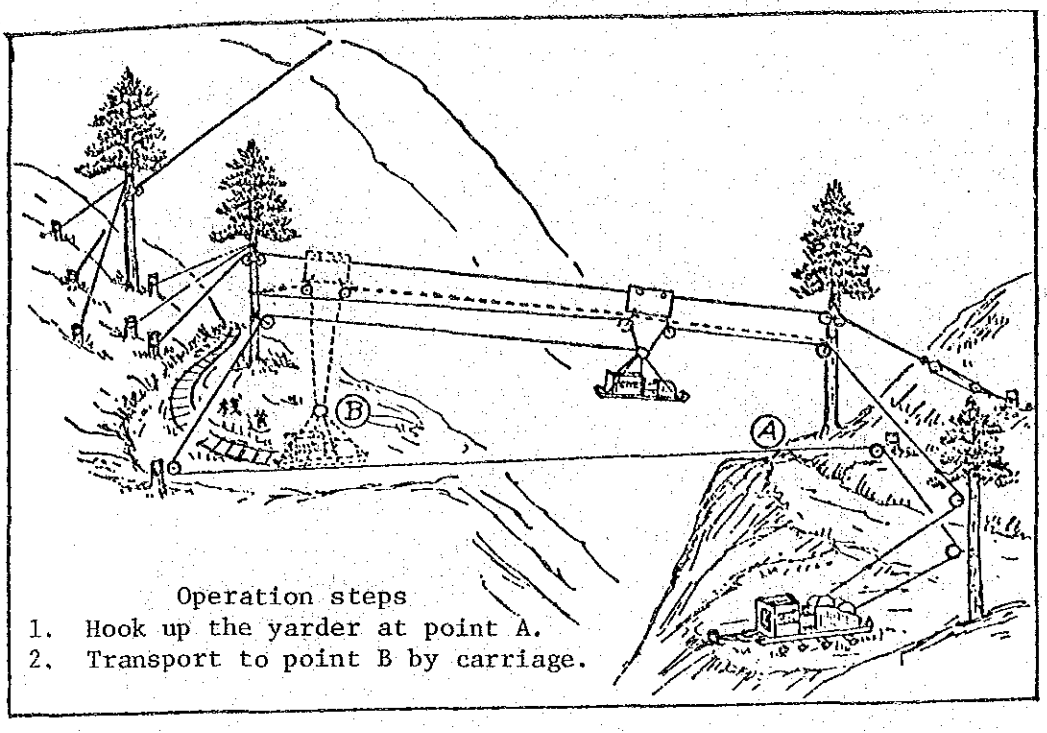
i) Make the shunts on its way.

(2) Driving

a) If the slope of the leading road is steep, then increase the quantity of oil in the engine oil pan.

b) If the straight road is long, set a guide block to a standing tree or a stump in front and pass the winding up line through the block and fix its end to the frame of yarder.

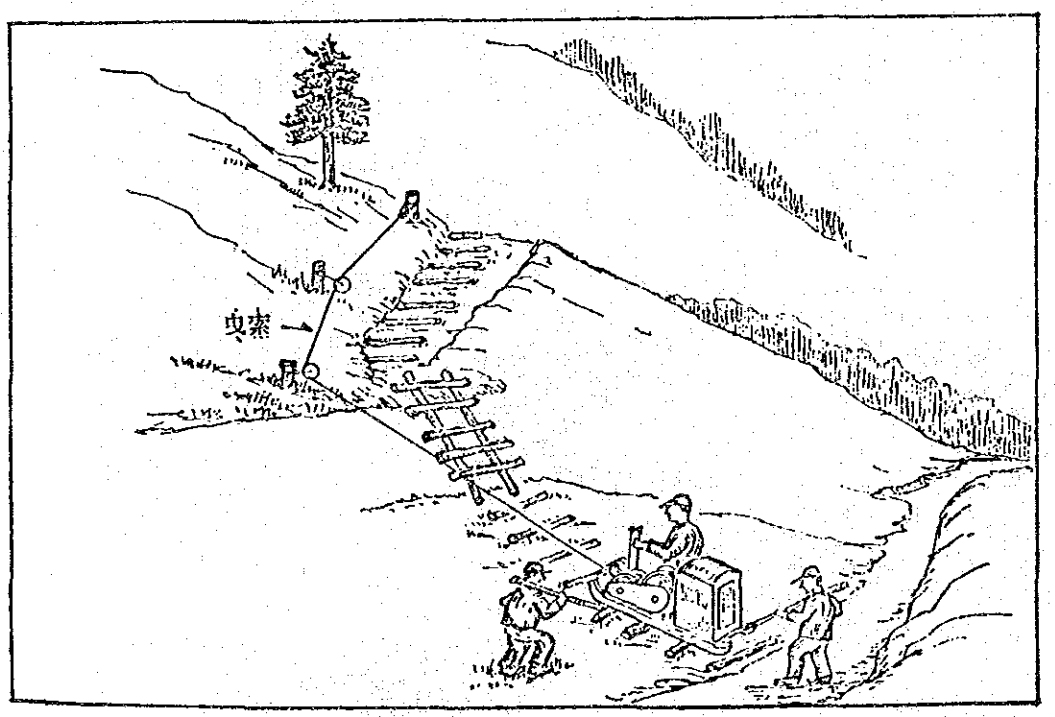
Fig. III-17 Transportation of yarder by skyline



Operation steps

1. Hook up the yarder at point A.
2. Transport to point B by carriage.

Fig. III-18 Self travelling of yarder



Operation steps

1. Preparation of transportation road.
2. Set the tracting line along the road.
3. Winding up the tracting line by the drum of yarder, assisting the movement by bar.

Fig. III-19 Self travelling

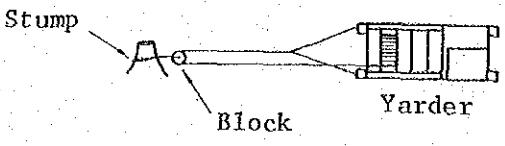
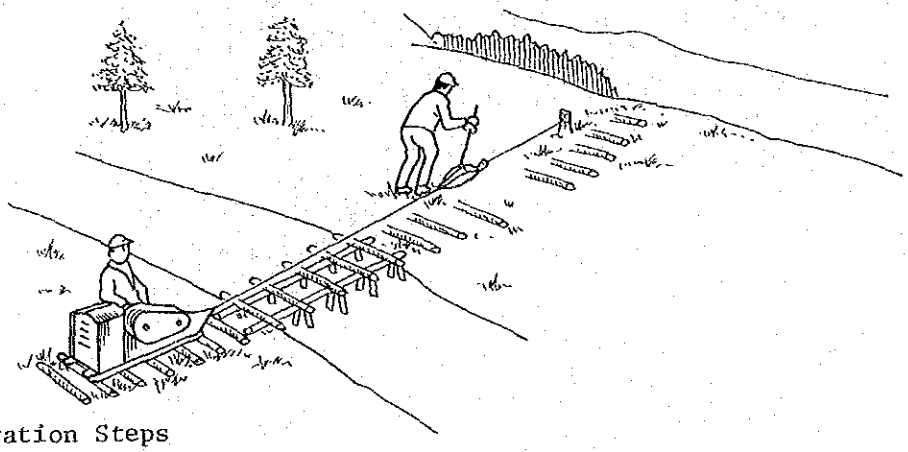


Fig. III-20 Movement by portable winch "Tir-For"



Operation Steps

1. Construct the transportation road.
2. Set the "Tir-For" ahead in the direction of travelling of the yarder.
3. Wind up the pull line.

Fig. III-21 The sticker way for the transportation of yarder

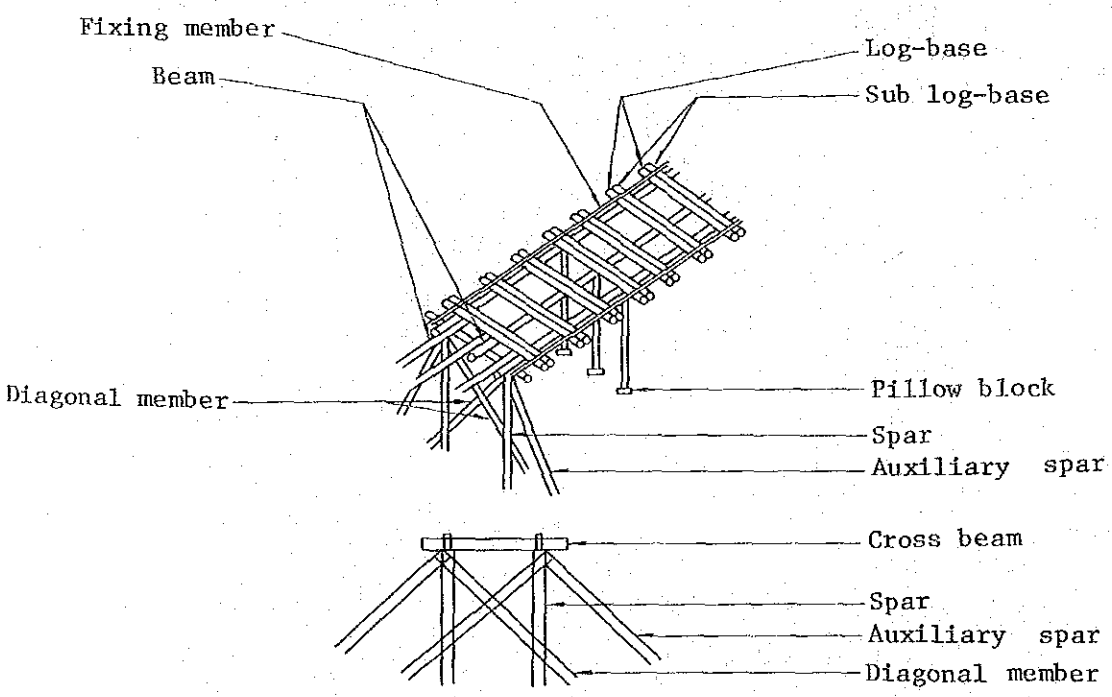
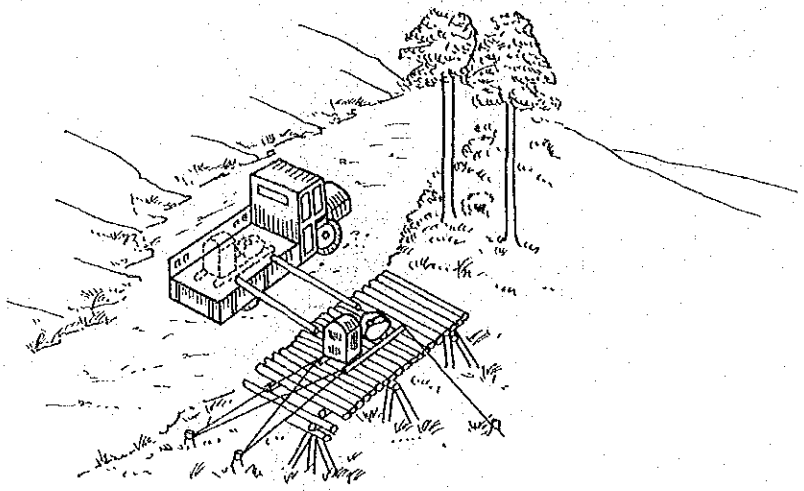


Fig. III-22 Setting of yarder



Operation steps

1. Put a yarder on the platform.
2. Fix the yarder.
3. Put up a shed.

Fig. III-23 Fixing of yarder

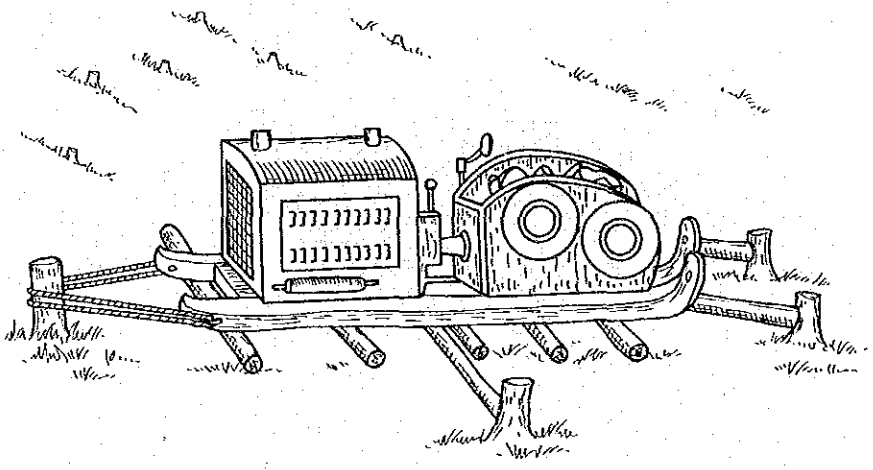


Fig. III-24 Distance between yarder and G.T.

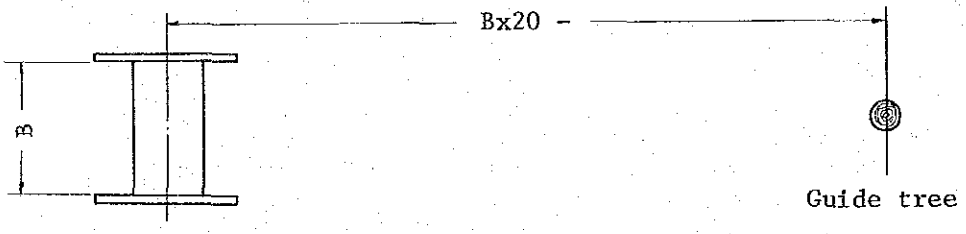
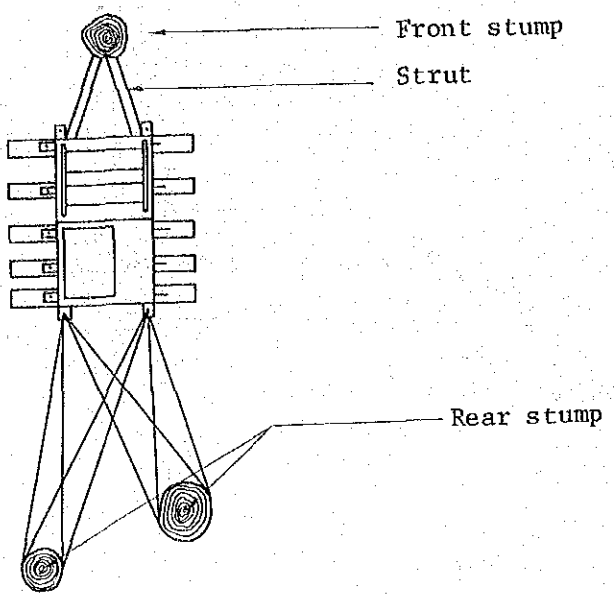
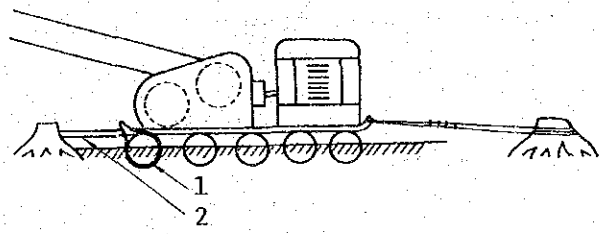


Fig. III-25 Fixing the yarder





1 Wire rope to prevent the forward sliding.

2 Logs, strut

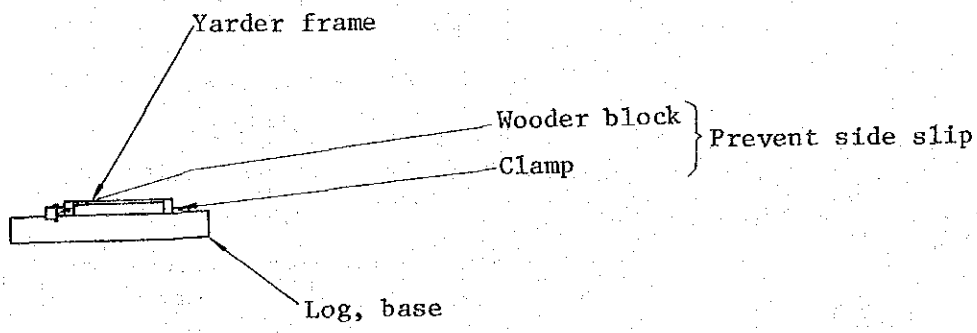
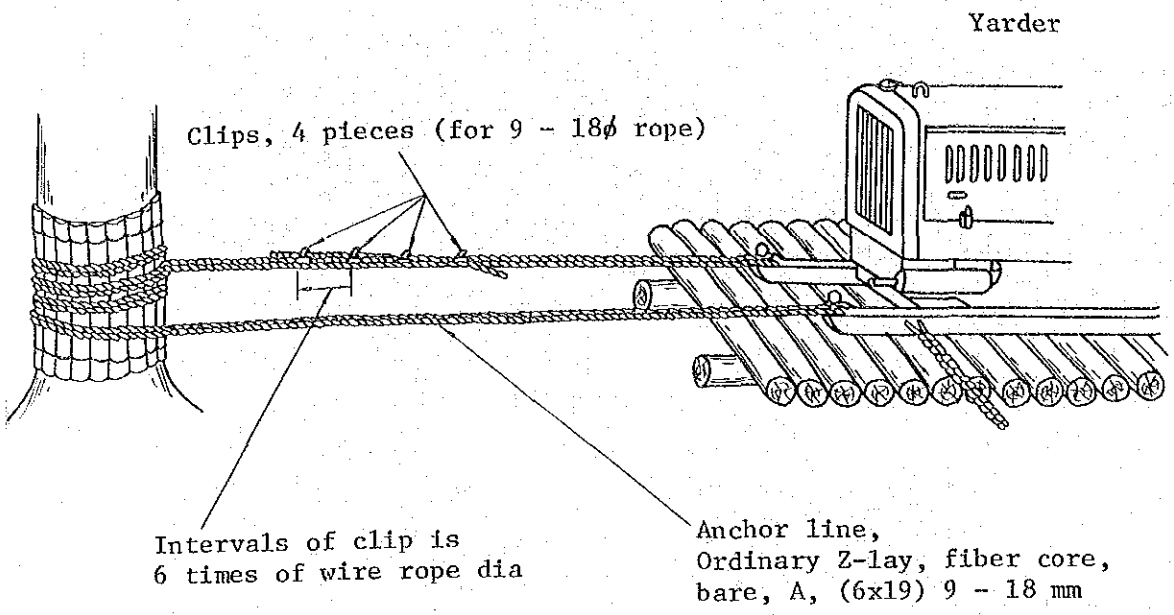


Fig. III-26 Fixing the yarder



(3) Setting of yarder

3-1 Construction of platform for the yarder

In constructing the platform, beware of the following items.

a) Cut the mountain side and level the earth and then arrange the logs side by side in the direction traverse to the yarder and horizontally.

b) If the slope is steep at the setting place, build up the platform with the logs to become horizontal.

c) The platform should be located in place, from where the unloading spot and the yarding area can easily be seen.

3-2 Setting of yarder

1) Yarder must confront to the guide tree, and the distance between the yarder and the guide tree should be more than 20 times of the breadth of drum.

2) Fixing of yarder

a. Prevent the forward sliding - fix the rear firmly.

b. Prevent the side slipping - spike the clamps or the wooden blocks to the layer logs.

3-3 Put up a shed

In putting up a shed, pay special considerations upon the field of vision of carriage, unloading spot, and etc., and also whether it would become the obstacle or not in driving operation, and moreover, upon the fire caused by the exhaust gas of engine.

(4) Constructing the spars

4-1 Fitting the caul (wooden protector)

1) Object of caul: To prevent the sever decreasing of the strength of the spar resulted from the deeply immerged rigging rope.

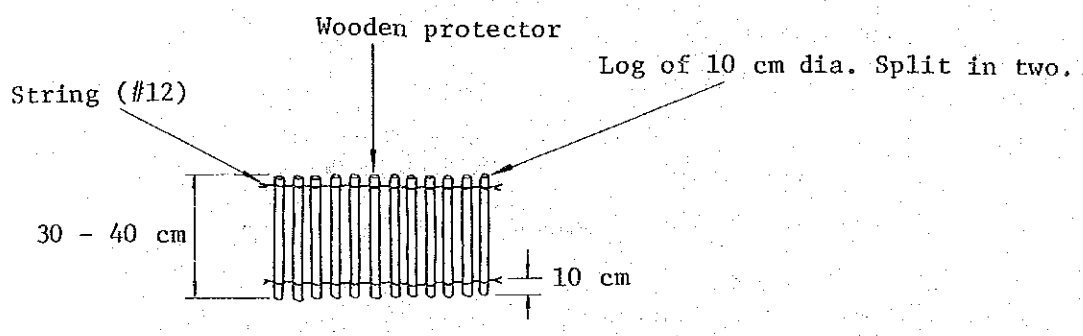
2) How to make the caul

a. As for the caul, the straight log split in two will best fit for the trunk of the tree and is easy to use.

b. The size of the material will depend on the scale of yarding and the tension exerted on the spar.

c. Arrange the materials and braid them at two lines, upper and lower, with the cord of iron strings of #12 twisted in one, or the wire rope (10 m/m) of the annealed strands.

Fig. III-27



4-2 Climbing up the tree

As for the tree climbings, there are snowshoe climbing, rope shaking climbing and ladder climbing, all with the waist safety belt.

4-3 Setting the guy line

1) Guy line

Guy line is set also to stiffen the spar not to be broken by the stress from the operation and prevent the stressing point from moving about.

2) Method of setting

a. Position of setting

Setting point of guy line should be higher than the setting position of each blocks.

Anchor must be fixed firmly to the stump or the foot of the standing tree.

b. Numbers and stairs of setting

i) More than two, and tightly.

ii) If the spar is tall or slender and weak, then more than 4 in 2 stairs, and this is the same about the artificial spar. When the snatching is operated, increase the number of guy line to the direction opposite to the snatching.

c. Method of setting

i) Make the "eye" at both ends and turn 2 or 3 times and fix by a shackle.

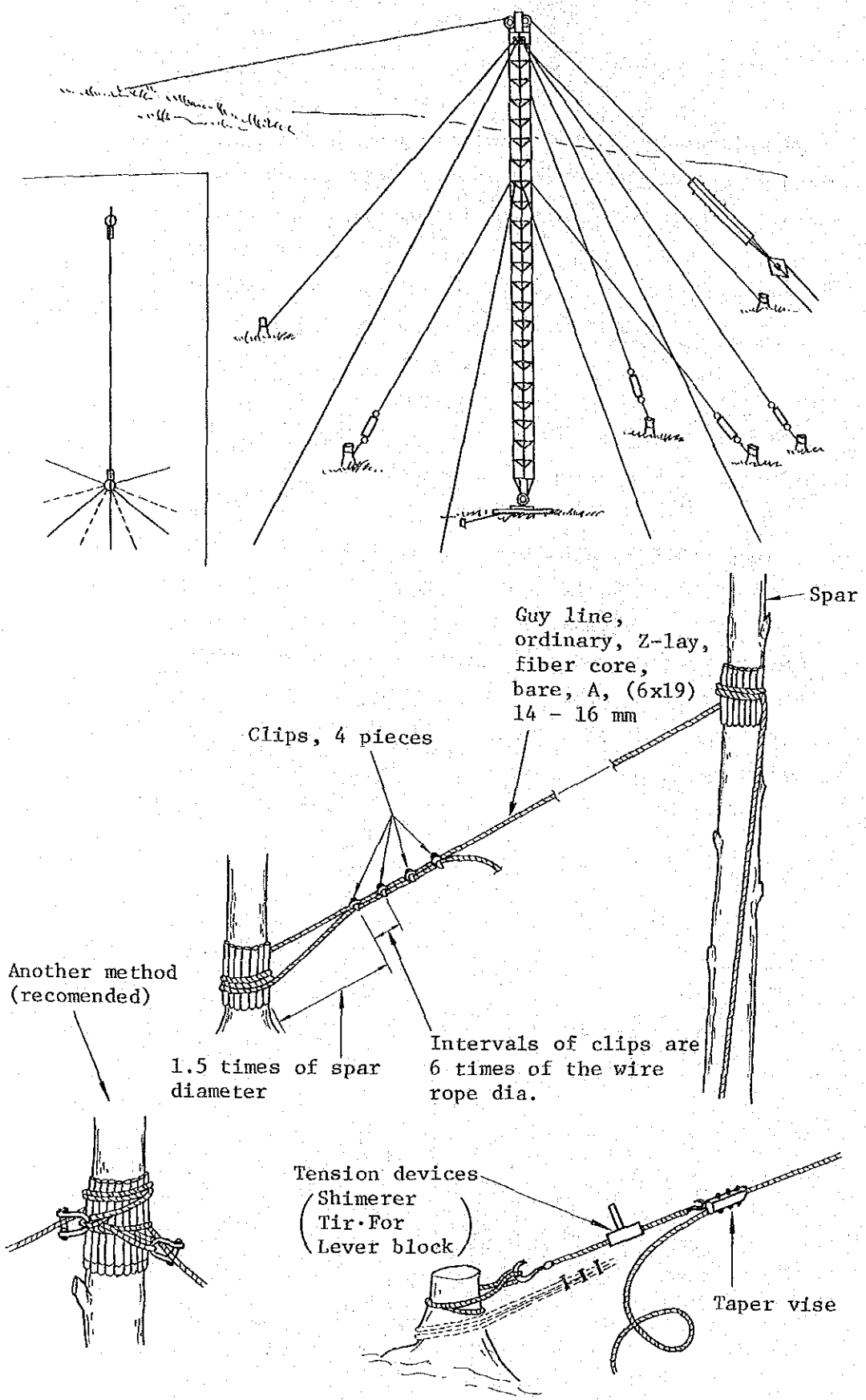
ii) To fix it turn more than twice around the stump and fix it by wire clips or the round up grip. Make each lines equally strained.

iii) Method of straining: Strain by means of tension devices. Turn buckle is efficient. To strain by twisting the wire is not good.

Method of straining by tension devices.

1. Use the rigging rope and hook it to the tension device.
2. Grip the guy line by the wedge clamp (taper vise) and hook it also to the tension device.
3. Operate the tension device and strain the guy line.
4. Wind up the guy line just beneath the rigging rope and fix it.
5. Release the tension device.

Fig. III-28 Setting the guy line



4-4 Blocks (including the rigging rope)

1) Fixing

In fixing the blocks to the spar and others, use the correct rigging rope.

a. Set in one the eyes of the both ends of rigging rope and hook the block to it, confronting to the direction of tension and care for the even straining of rigging rope.

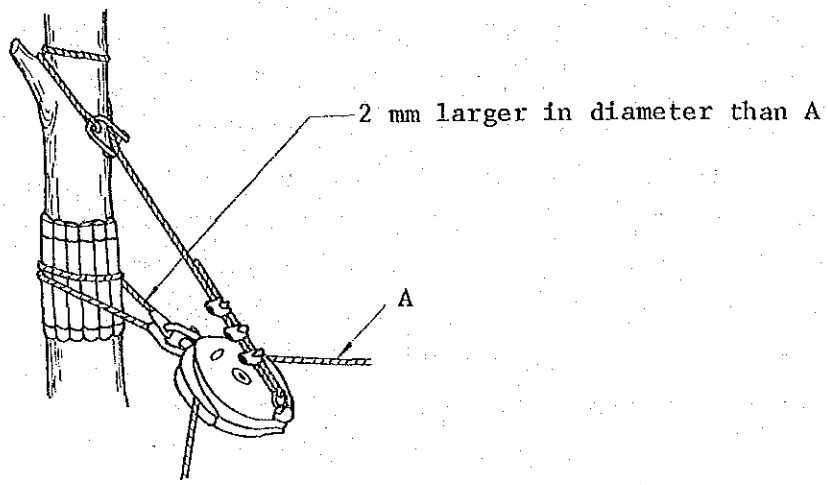
b. In fixing the guide block horizontally (slantwise also) it is effective to set a shackle between the block and the rigging rope.

c. If the angle of operating line, turned at the guide block, is small, it would apt to become neck hanging and so hang the end by the hanging ring from the higher spot than the rigging rope.

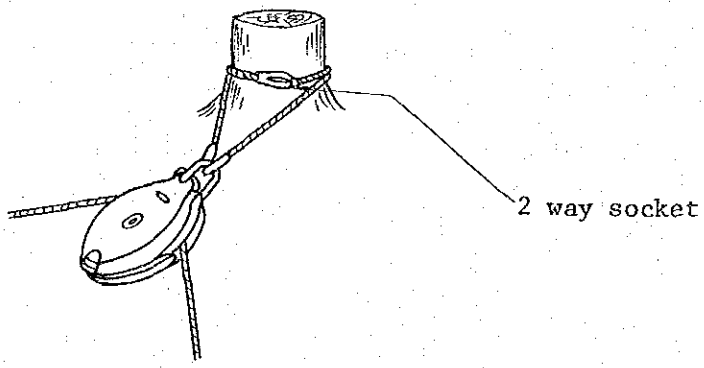
d. There are many ways to prevent the neck hanging, but to support it with the hand of 15-20 m/m width made from the automabile tube is efficient.

e. Setting spot of the blocks are desirable to be more than a meter high from the ground.
If there is no way but to set it low, lay the branches and twigs beneath it to prevent the splashing back of soil by rain.

Fig. III-29 Setting of snatch block
(Case 1)



Setting of snatch block
(Case 2)



2) Rigging rope

Many accidents have happened by the breaking of rigging rope, and therefore, the handling of it must exclusively be serious.

a. About the rigging rope, the strength of this one varies extremely by the skill and techniques of manufacturing of the "eye" part and so the manufacturing of this part should fully be careful.

b. The wire ropes whose wearings reached the limit of usage, must strictly forbidden to be used.

c. In case of fixing to the spar, take care not to overlap in the back side.

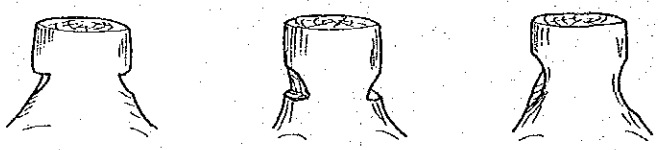
d. When the slipping down of this one is feared, set the anti slacking of rigging rope.

e. The angle which this wire rope makes at the guide block, (the rigging angle) is 60 degrees as a standard.

f. When to cut a notch for preventing the rope from escaping, cut it in at the spot, 10 cm below the cut - surface of the stump. The notch should be cut in by axe both from the top and the root sides making obtuse angle.

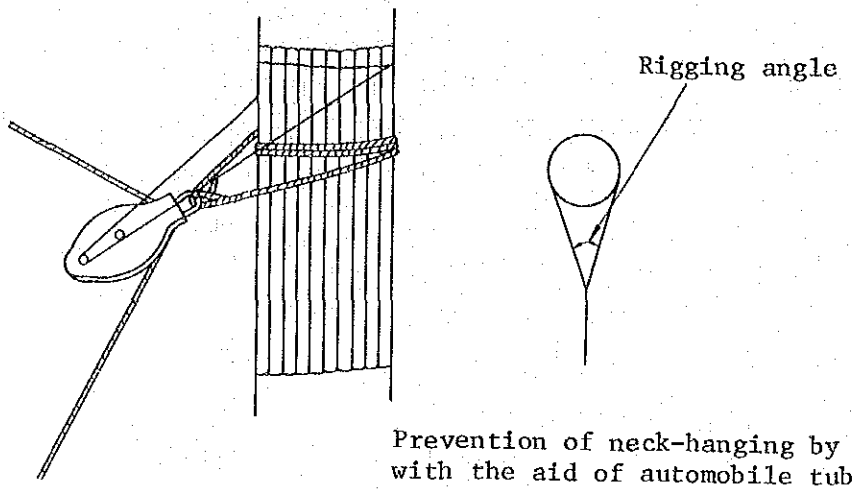
g. If the stump is too low to cut the notch on it, pass through the root opposite side to the spot of the block to be fixed.

Fig. III-30 Notching the stumps



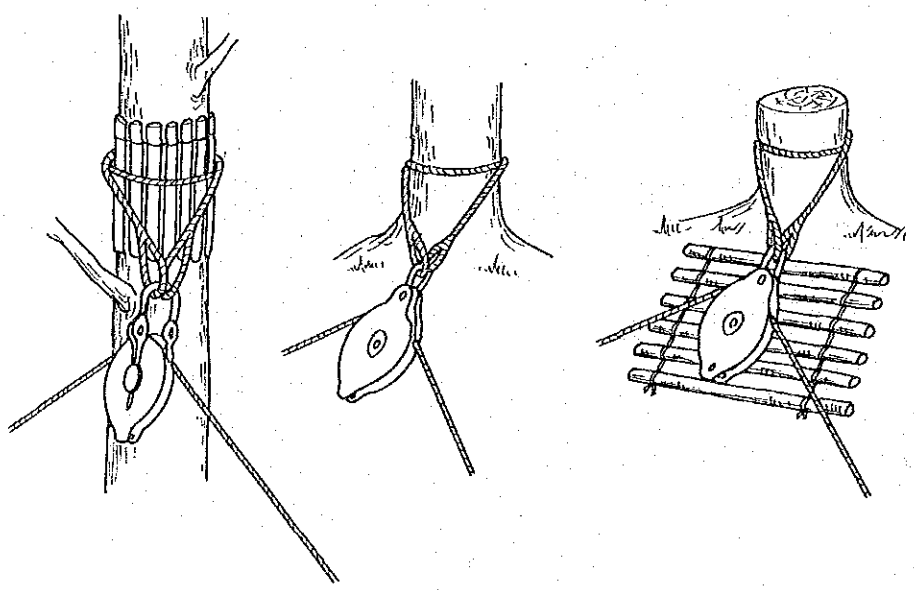
Good No good No good

Fig. III-31.



Prevention of neck-hanging by rope
with the aid of automobile tube band

Fig. III-32. Setting of guide block



4-5 Construction of guide tree

1) Guide tree

In order to carry out the yarding operation efficiently and safely, many conditions are required about the setting spot and the direction of setting of the yarder.

If you cannot set the yarder to confront the head tree, avail the guide tree to adjust the poor relative positions.

In some case, by the relative positions of yarder and head tree, the operating line passing therough the guide block on the guide tree makes an extremely sharp angle and this induce the side pull more than we expected and so in such a case we set auxiliary spar between the head tree and the guide tree to make the inner angle of the line larger.

2) Guy line of guide tree

Extend the bisector of the angle formed by the operating line passing the guide block on the guide tree, and set the guy lines about 40 to 45 degrees on both sides of this extended bisector.

Fig. III-33. Head tree and guide tree

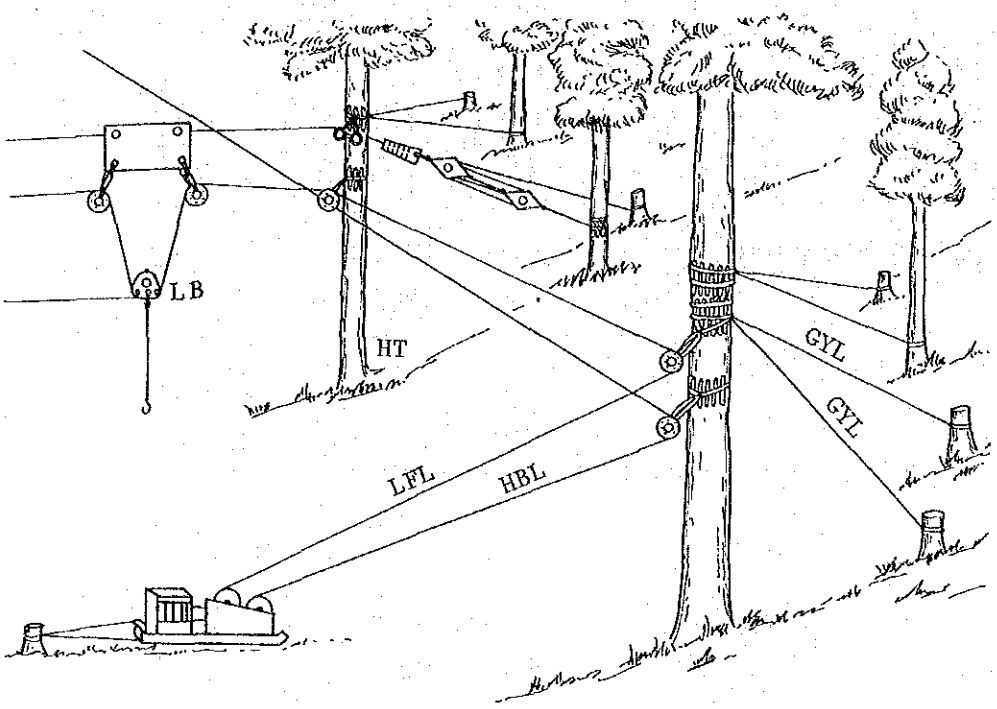
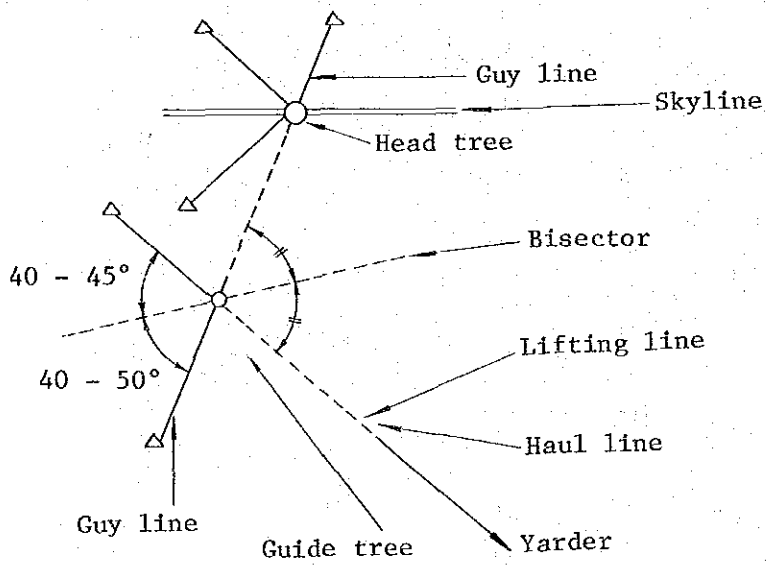


Fig. III-34.



4-6 Construction of head tree

1) The angle between the guy line and the spar must be over 45° and under 60°.
2) Guy lines of the head tree and the tail tree should be set to the stump side if the front angle is larger than the rear angle and to the span side if the former is smaller than the latter.
3) The angles formed by the guylines and the skyline should be more than 30° degrees in its plan-view.

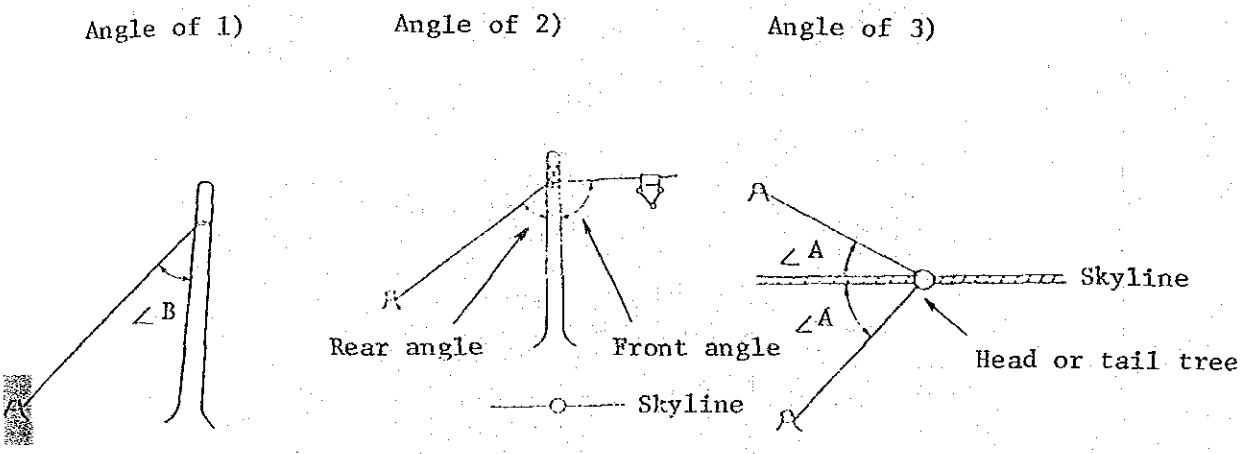
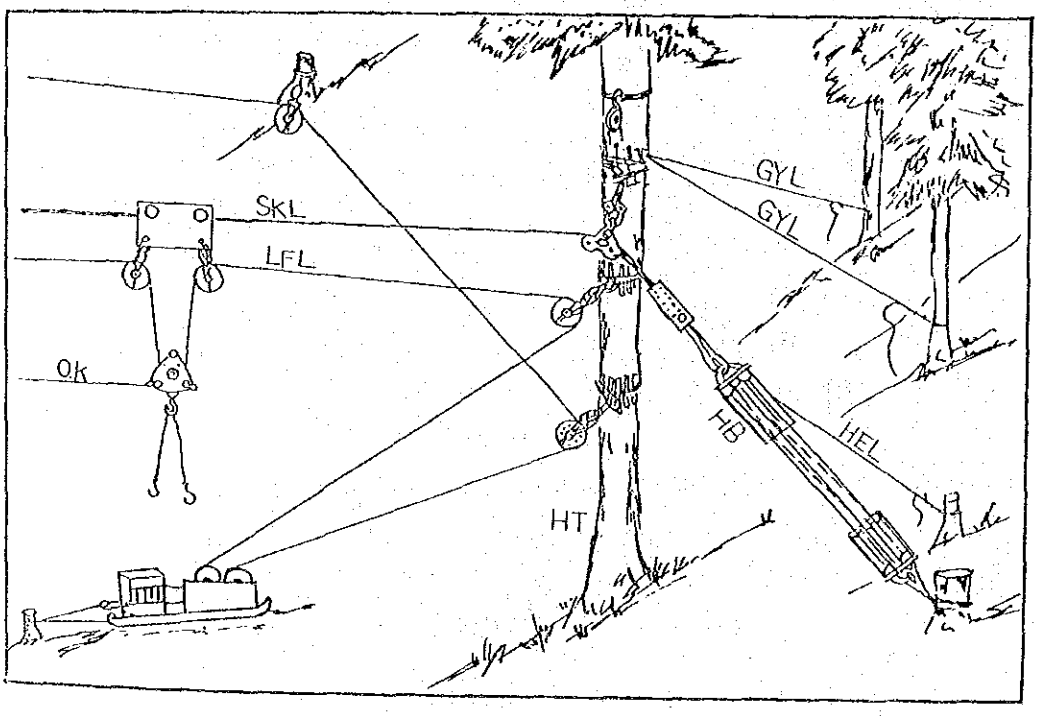
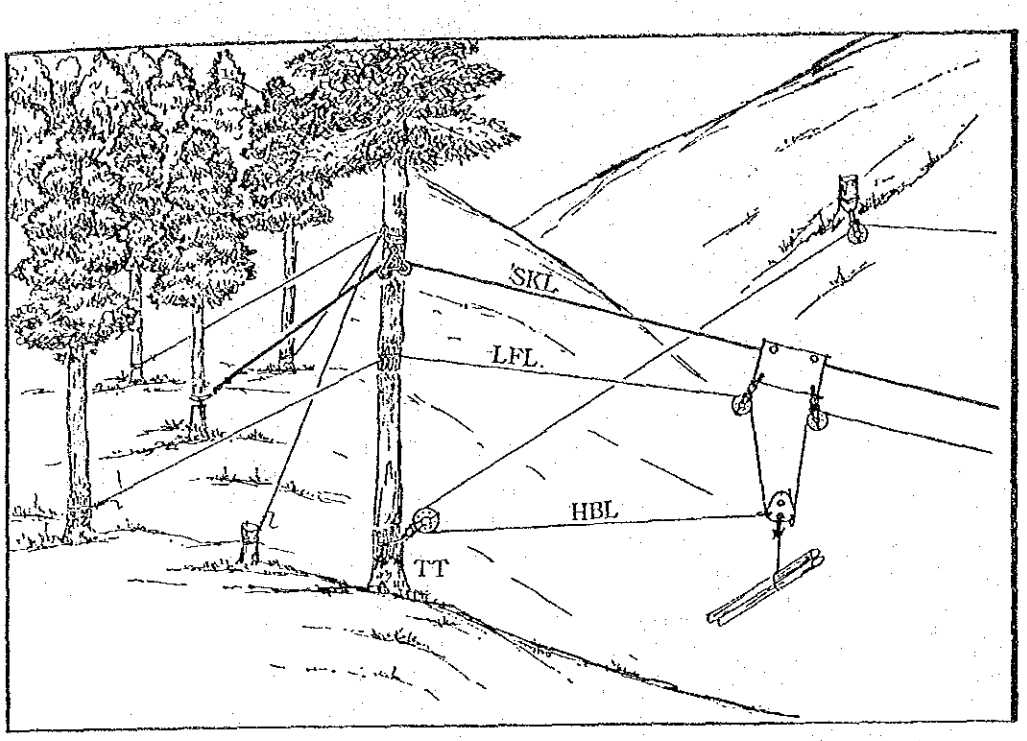


Fig. III-35. Head tree



4-7 Construction of tail tree

Fig. III-36.



(5) Extending of rope

5-1 Take about of the lead rope

Joining the nylon rope as the lead rope to the operating line and extend it by force of yarder.

1) How to take about the lead rope

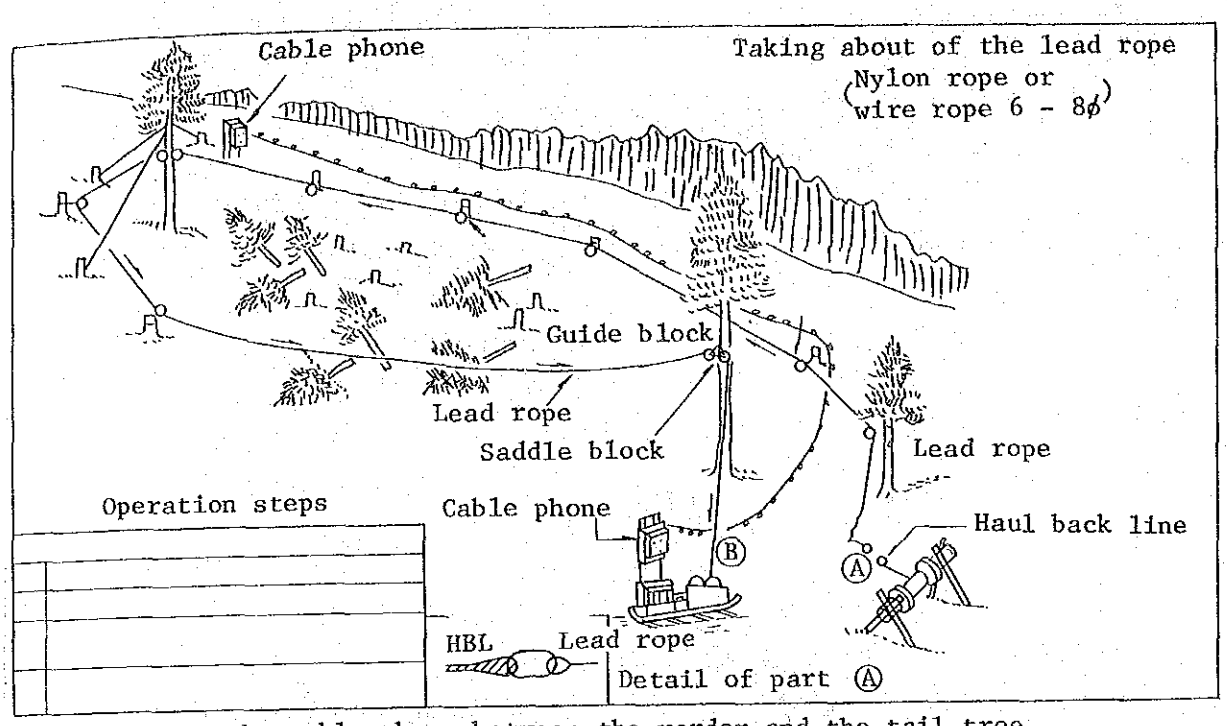
a. Take the draw down method as possible. In case of downhill yarding take the nylon rope up to the tail tree side and draw it down in two ways along the center line and along the guide block. If there is a deep valley on the way, it is easy in some case to take down both from the tail tree side and the head tree side and splice it in the valley.

b. The nylon rope taken down along the center line should pass through the saddle block on the tail tree, so as not to go under the branches or the top ends of the felled trees, and to the head-tree straightly and pass

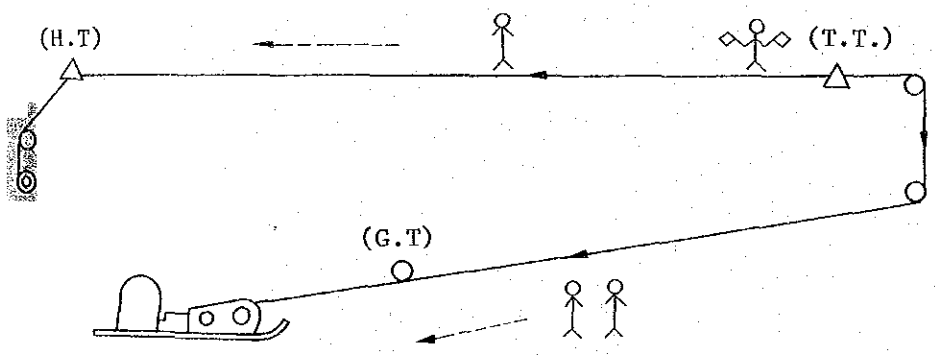
through the saddle block of the head tree and the block on the heel stump and be combined to the haul back line.

c. The lead rope taken down along with the guide blocks, pass the guide block near the skyline stump, then each guide blocks and to the vicinity of yarder and is wound up to the drum or capstan of it.

Fig. III-37 Process of rigging the cable work



1. Construct the cable phone between the yarder and the tail tree.
2. Arrange guide blocks and saddle blocks, then set them.
3. Take about the lead rope from A to B and wind it to the yarder drum.
4. Connect the end of lead rope to the haul back line.



Taking about the nylon rope

Carry up the lead rope to the tail tree, one person carries down along the main line, two persons along the haul back line, Last person takes care not to tangle the rope at the place of T.T.

2) Cautions in using the nylon rope

Nylon rope is light in weight and casy in handling but is weak for lateral wear and for heat, that pay attentions to the following points.

a. Expose to flame or give heat from friction caused by the slipping of endless drum are forbidden.

b. Don't rub the standing tree or the ground in the strained state. Especially don't rub to the edges of rocks and metals.

c. In making the "eye" the knacks of process are same as the wire rope but must be split spliced and the splicing must be more than five times. It is easy to splice it, if you heat the ends of the loosen strands by flame and solidify them.

d. When you cut it, the end must be solidified by the flame.

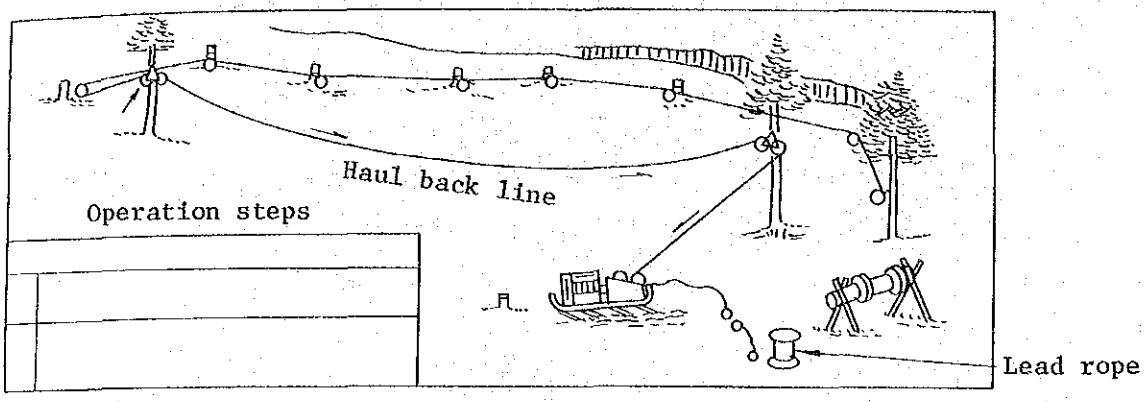
5-2 Taking around of the haul back line. Connect the end of the haul back line to that of the lead rope, drawn down along the center line and wind up the lead rope: In winding up the nylon rope rope be careful about the following points.

1) Winding is done by turning the rope 5 to 6 turns on the endless drum of yarder lest it should slip, and turn the drum as possible pulling the free side by hand always giving the tension on it between the drum and hands.

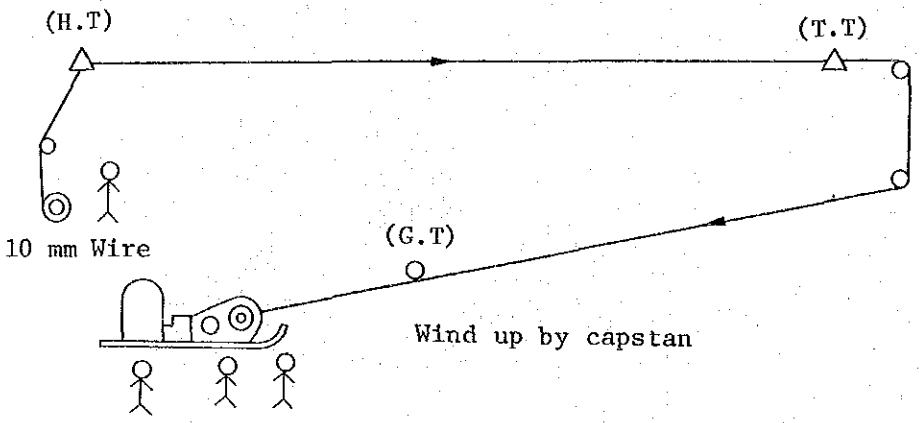
2) If the initial turns are insufficient and the rope slips, and you want to increase the turns, turns the drum reversely and release the tension of the lead rope and operate. When you stop winding temporary, loosen the tension and clamp it for the time.

3) The wound up nylon rope should be wound on reel, as a rule, but you can also wind it up to three stakes driven into the ground, forming the triangle, or to the two waist high logs set at the distance of 50-60 cm, and make the bandle of 200 to 250 meters each and arrange them.

Fig. III-38 Taking around of the haul back line



1. Wind up the lead rope to the endless drum of yarder and take around the haul back line by revolving the drum.
2. When the haul back line reached the yarder, detach the lead rope.



5-3 Extending the skyline, and setting

1) Conjunction of skyline and haul back line

Process of jointing is as follows.

a. Make the "eye" by elaborate splicing at one end of the wire of 10-12 m/m in diameter and the length one meter of the straight part.

b. Sieging the skyline at the point more than one meter from the end, and loosen the strands and out the fiber core off.

c. Put the straight part of the wire treated in a, in place of the fiber core and splice the strands.

d. Siege it from the sieged part of a. to the wire end by the corresponding sieging wire to the skyline diameter.

2) How to extend the skyline

a. Rotate the 1st drum at low speed.

b. Watch the junction of skyline and haul back line while extending.

c. If the obstacles are few in the center line, the lifting line may be extended to-gether in the same time.

3) Fixing the sky-line

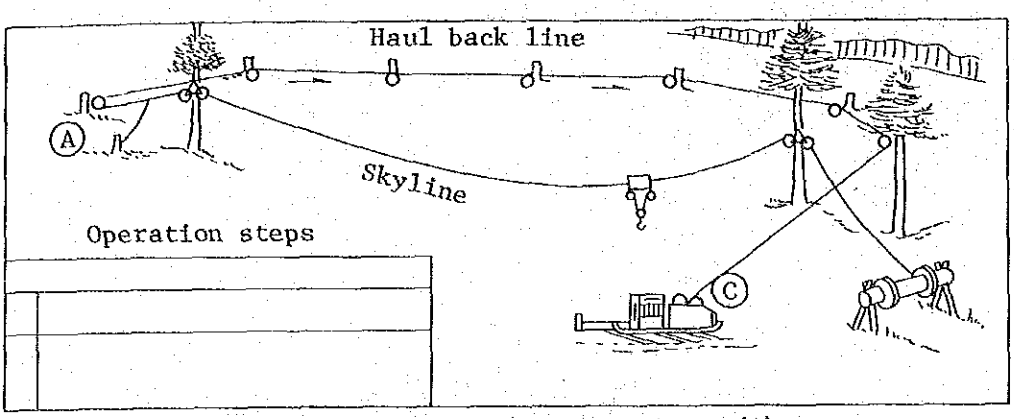
a. When the junction of sky line and haul back line passes through the saddle block on the tail tree and reaches the guide block behind the anchor, fix it temporary before the tail tree.

b. After temporary fixing, untie the junction and fix it to the anchor. If the anchor is a standing tree, lap the caul and wind more than 3 times at the lower part as possible and fix it by clips.

c. Pay attention not to lap the wire in winding.

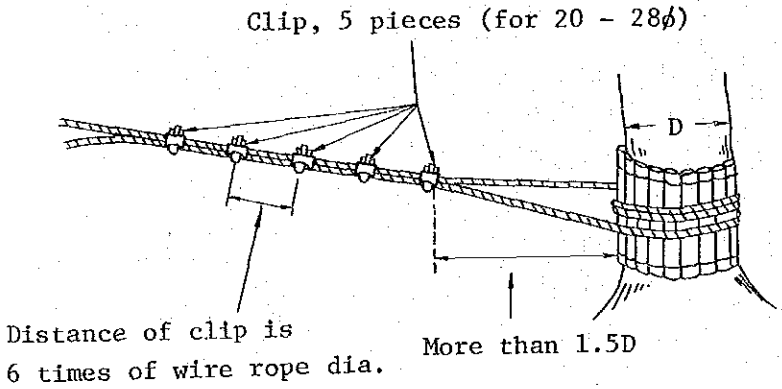
d. If the turn is much, take the distance between the clip and the anchor possibly long.

Fig. III-39 Taking about the skyline



1. Jointing the haul back line to the skyline. (A)
2. Fix the end (C) of the haul back line to the yarder drum and draw up the skyline to head tree and to tail tree.

Fig. III-40 Fixing the end of skyline



4) Setting of heel line

a. Setting position of heel line

Outside of head tree, as a rule. If be set inside, the checking, especially the additional tightening of the clamp is difficult to do.

b. Fixing the heel blocks

As a rule, use 6 x 19% or 6 x 24% wire of the same diameter to the skyline, with socket fitted ends as the rigging rope.

Fig. III-41 Fixing the heel line

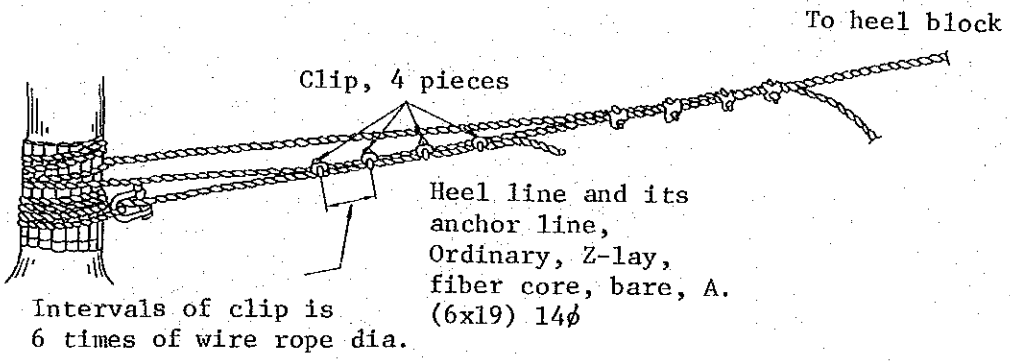
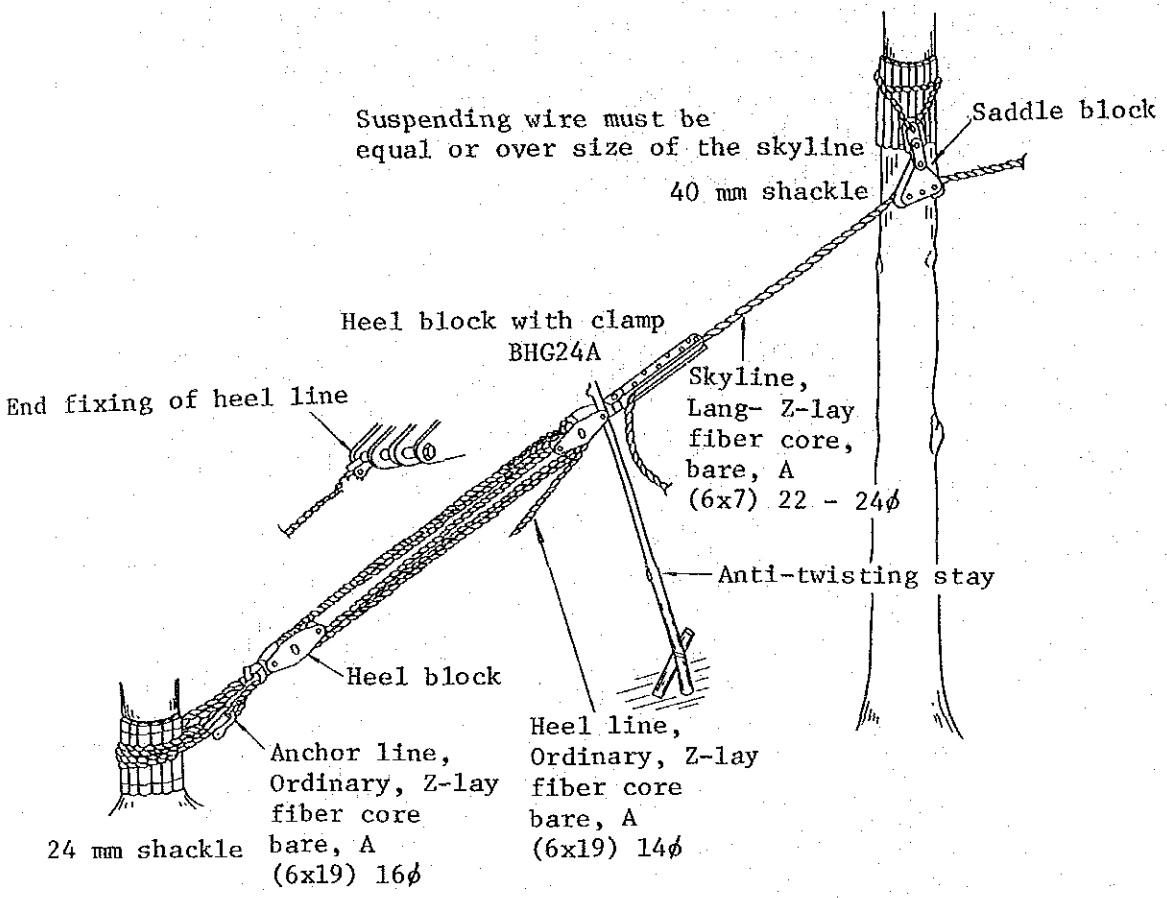


Fig. III-42 Fixing the heel block



c. Rigging of heel line

(a) Set a guide block at the foot of the head tree.

(b) Pass the spare rope through the (a) block and wind it to the 2nd drum.

(c) Fix the three-sheave heel block to the stump.

(d) Place the four-sheave heel block about 10 m in front.

(e) Set a guide block to the stump.

(f) Pass the line through the block (e) and set up the heel line. (Wire end is fixed to the three-sheave heel block)

(g) Fix the spare rope to the four-sheave heel block.

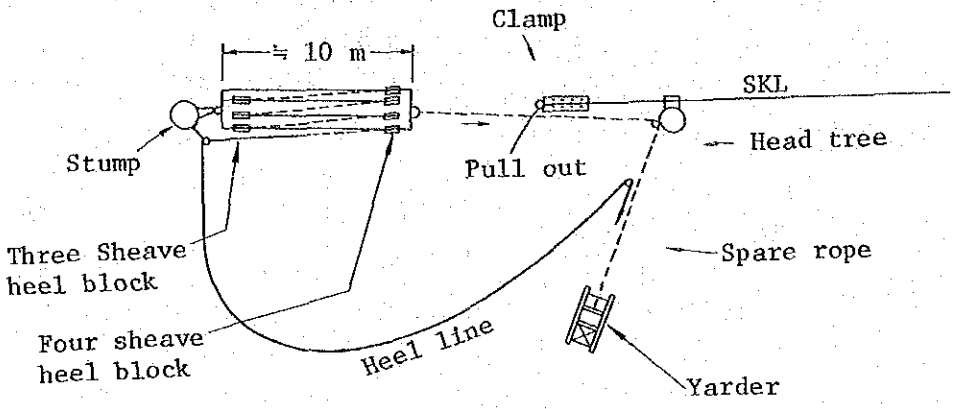
(h) Wind up the spare rope and pull out the heel to the clamp.

(i) Fix the clamp and heel block together.

(j) Pull out the spare rope from the 2nd drum.

(k) Wind up the heel line by the 2nd drum.

Fig. III-43 Rigging of heel line



d. Fastening the clamp.

Fasten each bolt evenly.

(a) Bolt can not be fastened perfectly when it is not oily. Therefore, dip in the lubricating oil beforehand.

(b) Don't fasten it strongly at a time. Tighten it twice alternately left and right from one end and in order.

(c) On the third time, adjust the fastening force even by using the torque wrench.

e. Coupling the heel block with the clamp.

As a rule, use the coupling metal fittings, but in case of the small scale, light load yarding system, use the rigging rope of the same strength to the skyline, wire rope made in endless, or the shackle.

In case of the long span, heavy load yarding system, it

is desireable to use the coupling metal fittings of the special made.

5) Trial stretching of sky-line

a. Wind up the heel line on the 2nd drum.

b. Prior to the trial stretching of the sky-line, check the center line in full range and dispace the obstacles for stretching.

c. Arrange the watchmen to the head tree side and the tail tree side. Wind up the heel line slowly at the low speed. When something unusual is felt, correspond to the driver at once and stop running and check.

d. When the sky-line rises up at full range and entirely afloat, stop running and check the following items.

i) Head tree side

(1) Whether the heel line is twisted or not.

(2) If the carriage is on, is it normal or not.

(3) The rigging rope of the heel block is evenly strained.

(4) Is anything unusnal in the coupling of heel block and clamp?

(5) Is there any sign of slip of sky-line at the clamp?

(6) Is each guy line working efficiently? Their anchor normal?

ii) Tail tree side

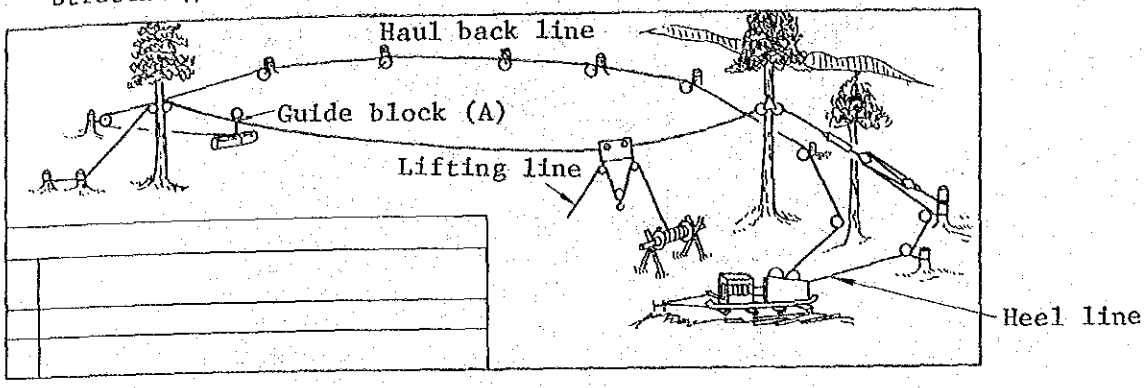
(1) Are the clips used for fixing the skyline working efficiently, and any fear of slipping of skyline is felt?

(2) Is the strengthening wire for the sky-line anchor is working efficiently?

(3) Are the guy lines of the spar working efficiently? Their anchor normal?

Fig. III-44

Stretching the skyline and returning the haul back line



Operation steps

1. Fix the tail tree end of skyline, then set up the heel blocks at the head tree side. Fix the heel line to the yarder drum.
2. Attach a light load to A , the end of haul back line.
3. Mount the carriage on the skyline and pass the lifting line through it.

6) Mounting the carriage

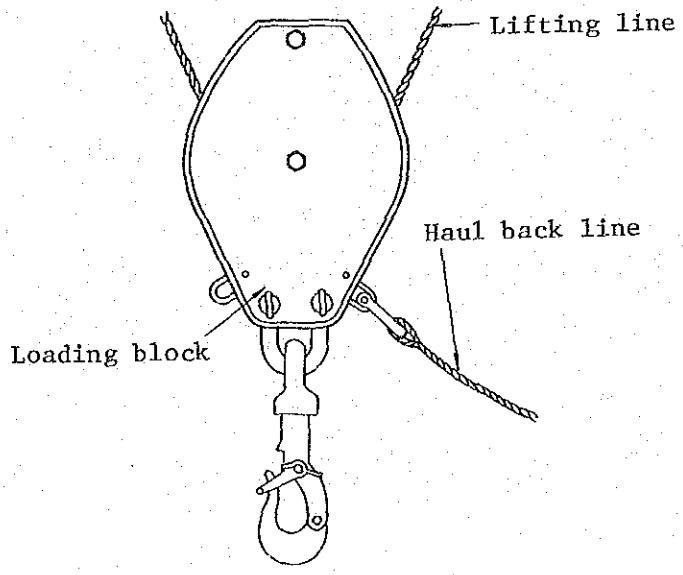
Box type carriage should be passed by skyline prior to its extention.

Cantilever type carriage should be mounted when the sky-line is raised to convenient height for the operation during its trial stretching.

Set a guide block at the foot of the head tree. Pull out the lifting line on the wooden reel and pass through the guide block at the foot of head tree, the loading block, and the guide block on the carriage.

Fix the falling block to the carriage.

Fig. III-45



7) Returning the haul back line

The haul back line which is used for extending the lifting line was stopped at the tail tree and which should be returned to the head tree side now.

As the methods of returning.

a. In case it can move by itself (Tyler system)

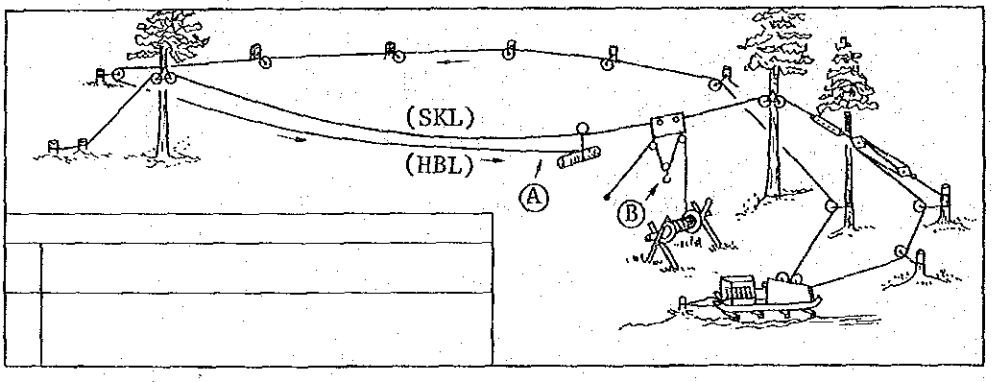
Hang the guide block to which the end of the haul back line is fixed on the somewhat stretched skyline, and hang some adequate weight (log, etc.) on it, and let it come down by itself near to the head tree and the position of carriage setting by controlling the stretching of sky-line.

b. In case it can not move by itself extend the lead rope along the center line to the place where the haul back line is fixed.

Couple the haul back line and the lead rope together.

Wind up the lead rope by means of the endless pulley.

Fig. III-46



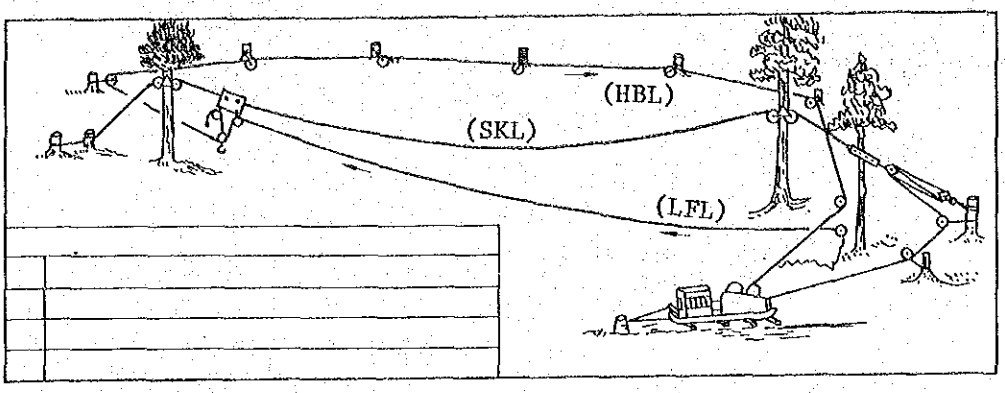
Operation steps

1. Wind up the heel line and stretch the skyline. Light load attached to the haul back line is carried down.
2. Connect the lifting line B to haul back line A

8) Fix the lifting line

Draw up the lifting line, fixed on the loading block, by the haul back line and anchor it to the tail tree or the stump behind it.

Fig. III-47



Operation steps

1. Stretch up the skyline.
2. Wind the haul back line, (Carriage to the tail tree side)
3. Fixing and stretching the skyline.
4. Wind up the lifting line to the yarder drum, and trial operation.

9) Stretching up the sky line

a. Turn slowly the second drum and stretch up the sky line. If the stretching is not sufficient though the heel line is fully wound, hold the sky line temporary with the automatic clamp (taper vise), reset the clamp and re-arrange the heel line.

b. When the skyline is stretched up, pay additional fastening on the clips and the clamps, etc.

c. Hold the heel line temporary in front of the drum by the automatic clamp (taper vise), and check the straining by braking the drum.

d. If the straining is under or over, re-adjust it to the designed value by tightening or loosening the heel line.

e. Clamping the heel line together with the anchor by the clips, or by the winding clip temporary and take it out from the second drum.

f. Wind up the heel line to the strong anchor and fix it surely and firmly.

g. Release the lifting line from the wooden frame, pass it through the guide blocks both of the head tree and the tail tree, and then wind it to the 2nd drum.

h. Wind up the lifting line and when the loading block is lifted afloat fix the weight to it.

10) Trial running

a. After the cable work is completed and the straining is adjusted, we conduct the test running.

b. Let the carriage travels up and down two or three times and make each wire rope warms up.

c. The loading of carriage begins from the 1/3 to 1/2 of the the designed load and increase it gradually checking every parts until the maximum designed load.

d. During the running arrange several personnels to the main spots for watching and corresponding, and drive it carefully under close connections of each other.

e. Hang up the designed load and stop the carriage at the middle and check the conditions of every blocks and the rigging ropes and also check whether the operating lines are rubbing the edges of rocks or the blocks or not.

f. As for the correspondence between the driver and the watchman, it is sure and handy to do it by means of sound like the simple radio or the telephone.

g. If the post of the watchman is not within the scope of the driver's seat, place the relaying signal man and make the signals surely.

(6) Removal operation

The standard operation of removal would be done by the following process.

6-1 Removal of haul back line

(1) Slacks the lifting line and lands the loading block to the platform.

(2) Disconnect the haul back line from the loading block. In case of the crossing valley skyline, and the straining is still remains, move the carriage to the tail tree side and disconnect it after the strain is removed.

(3) Wind it up to the yarder drum and then rewind it to the steel-bobbin and empties the drum.

6-2 Removal of lifting line

(1) Draw the lifting line sufficiently to the stump side to release the tension of the line, by using the "Tir-for" at the stump of the tail tree.

(2) After assuring that the tension is entirely removed, take off all the fasteners like clips and etc. from the lifting line.

(3) Wind up to the yarder drum, then rewind it to the steel-bobbin and empties the drum.

(4) Remove the loading block, hook and the ballance weight and collect them.

6-3 Removal of endless line

(1) Draw the carriage to the head tree, and fix the spare wire rope or the hemp rope to it and wind it to the near-by standing tree more than three turns and stump it.

(2) Set the automatic clamps (taper vises) to each two threads (or ends) of the endless line in front of the yarder drum and draw to the drum side to slacks them and out it apart.

(3) Connect the spare wire rope wound up on the yarder drum to one of the cut ends of endless line which is drawn about to the tail tree, and wind it up by turning the drum and release the tension of "Tir-for" line and collect the "Tir-for" and etc.

(4) Release by the "Tir-For" the tension of the endless wire, drawn about to the head tree side, and collect the "Tir-for" and etc.

6-4 Remove the heel line

(1) After assuring the temporary clipping of the heel line, remove the regular clipping of the heel line.

(2) Set the end of the heel line to the empty drum and strain it up by theyarder slowly and release the temporary clamping of heel line.

(3) Slacks the heel line slowly and land the skyline on the ground.

(4) After assuring that the sky line is perfectly slacked, remove the clamp which combined the skyline and the heel block.

(5) Remove the connection of the clamp and the heel line.

(6) Remove the end of the heel line from the block and wind it up to the yarder drum and then rewind it to the steel-bobbin.

(7) Collect the heel blocks and the clamp.

(8) Release the stumping of the carriage which is drawn to the head tree and lands it to the plat-form and remove the endless line.

6-5 Remove the skyline

(1) Release the sky line from the stump

a. Set a guide block at the foot of the tail tree and pass the endless line through this.

b. Connect the end of the endless line to the sky line about 10-20 m from the tail tree by means of the automatic clamp (taper vise) and etc.

c. Rotate the yarder drum on which the endless line is wound up and draw the sky line to the tail tree side.

d. Assuring that the tension of the skyline is removed at the stump of the tail tree and remove the clips of the skyline.

e. Slacks the endless line till the skyline perfectly stops, and remove the connection with the endless line.

(2) Remove the sky line

a. Wind up the endless line of the tail tree side on the yarder drum, rewind this to the steel-bobbin, disconnect from the spare wire rope, and connect this to the endless line of the head tree side and wind it up.

b. Remove the sky line from the saddle block on the head tree and wind it to the steel-bobbin.

c. Set the automatic clamp (taper vise) to the sky line and draw up the sky line and wind this to the steel bobbin.

6-6 Disassembling the spars

(1) Check the hoisting block and the hoisting rope

(2) If there is not the adequate foot hold make the hanging scaffold.

(3) After removing the clips of the guy line, remove the shackles and collect the guy line.

(4) Bind the sheave of the guide block with the hoisting rope and by hoisting the block release the tension of rigging rope and then remove the hook from it and lower it down hanging.

(5) Lowers the saddle block likewise the guide block.

6-7 Checking and treating of the tools and the accessories

(1) Check the numbers of the collected clips and shackles and excluding the wrong ones put in the oil bath and stock them.

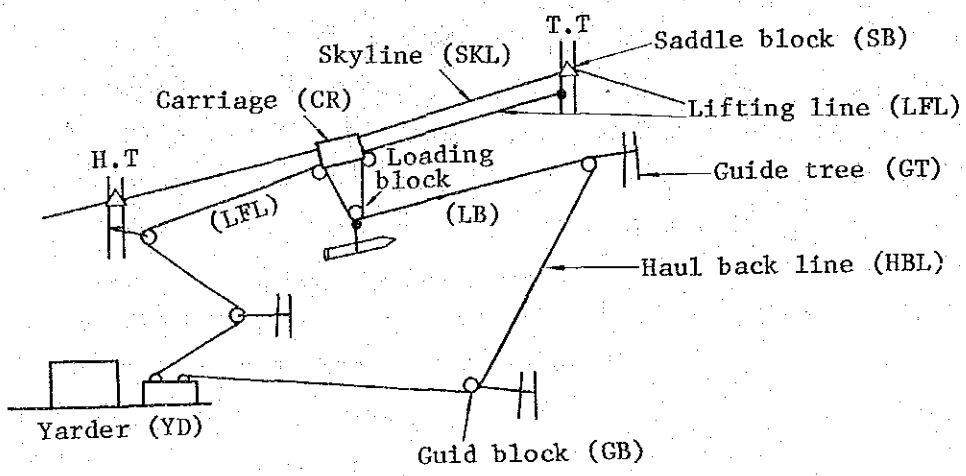
(2) Check the numbers of blocks and the wear of the sheaves of them, and select the ones which need repairing and the others which do not, and after treating them with anti-rusting process, stock them.

(3) As for the wire ropes check the wear and the broken strands when they are wound up to the yarder drum, and paint oil to them when they are re-wound to the wooden frame.

III-3-7 Fundamental type of skyline setting system and its characteristics.

As the skyline setting system fit for the Merkusii pine stand of Central Java, the following fundamental type of the most simple one will be applied in most cases, considering the land features the stand conditions and the technical conditions of skyline yarding.

Fig. III-48 Tyler system



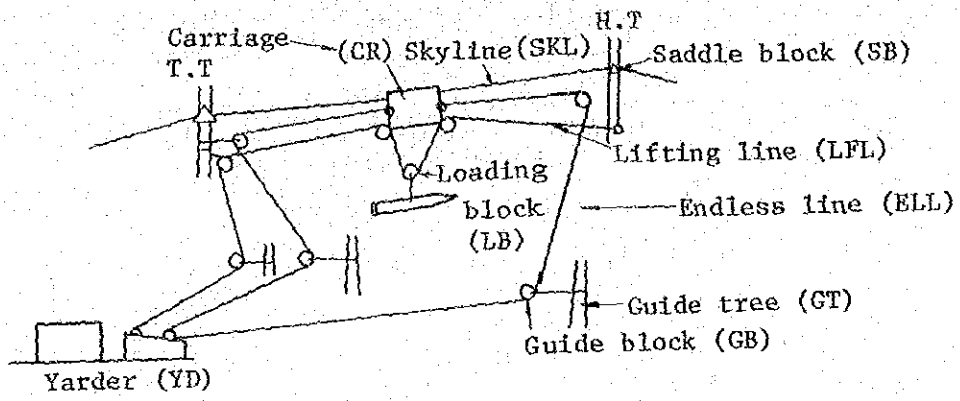
Adaptable Operation	Clear cutting						
Adaptable condition	Tree length or short cut	Tree length short cut		Number of drums(piece)		2	
	Gradient of skyline(degree)	10 - 25		Span (m)		300-800	
	Weight of the load (t)	0.5-1.0		Lateral yarding distance(m)		50-100	
	Setting(Removing) (man-day)	25(5)		Yarding volume per day (m^3)		20-30	
	Yarder	Large-Medium		Balance weight with or with-out		with	
	Diameter of Wire rope(mm)	SKL	LFL	HAL	HBL	ELL	CLL
		16-24	10-12		10-12		
	Operation Personel(man)	3 - 6		driver	loading	unload-ing	logging
				1	1 - 2	1	1 - 2
	Remarks	One end of the HBL is sometimes fixed to CR.					

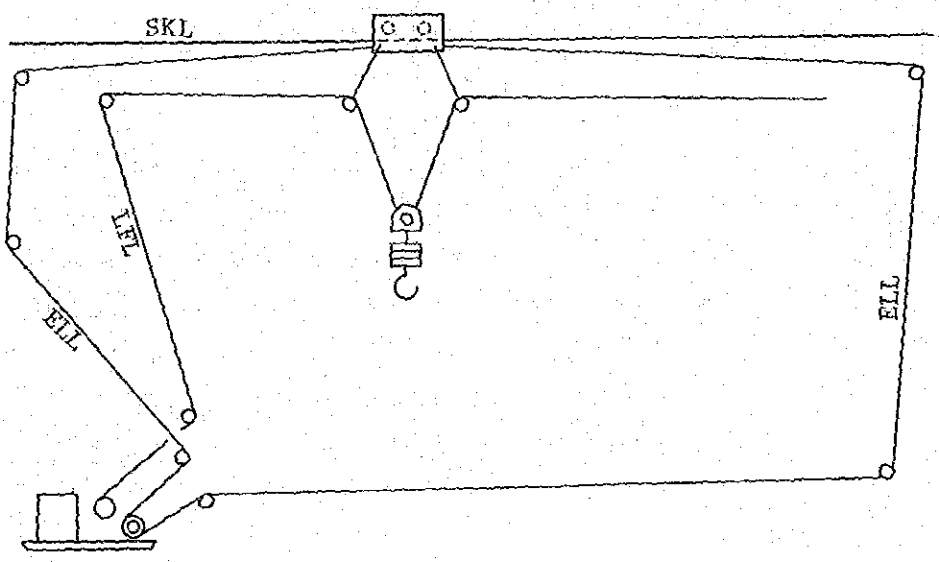
In this system one end of the LFL is always fixed to the tail tree (T.T.) and the LFL passes through the two blocks fixed to the CR and the LB and then wound to the drum, and on the other hand, HBL fixed to the LB passed through the G.B fixed at some convenient spot and then wound on other drums. Therefore, by winding up the HBL, bring the LB near to the G.B., that is, fairly wide range on both sides of skyline can be lateral yarded.

But the defect of this system is that, when the CR travels, LFL, bearing the load, will be roughly rubbed to the LB and the blocks fixed on CR, thus causing the sever wearing of wire rope.

This system is easy to operate, and mainly used in the hauling down case and is adopted in the case of the somewhat steep slope (10-25°), when the carriage can go down by its weight.

Fig. III-49 Endless tyler system



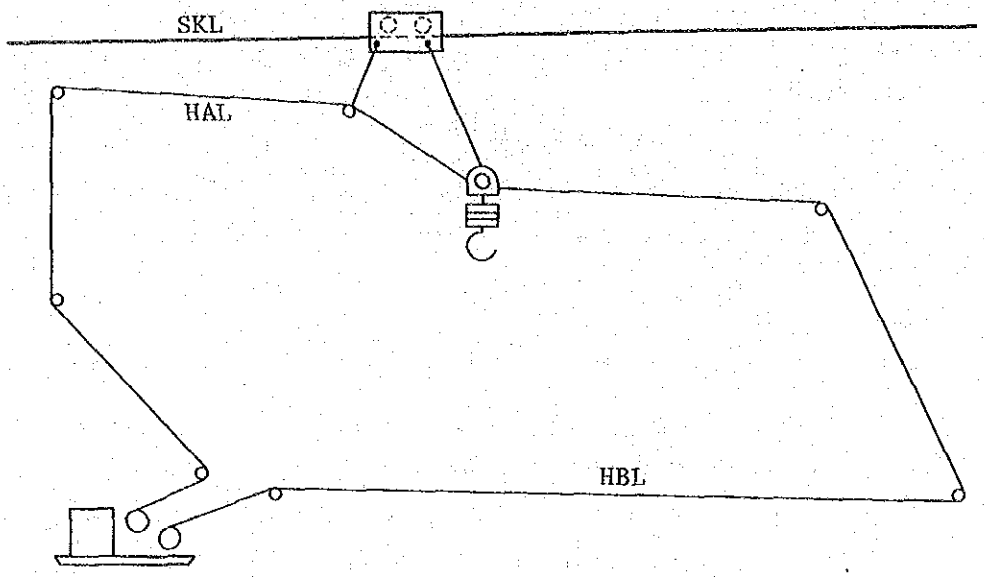


Adaptable Operation	Clear cutting						
Adaptable condition	Tree length or short cut	Tree length short cut		Number of drums(piece)		2	
	Gradient of skyline(degree)	5 - 25		Span (m)		300-1,000	
	Weight of load (t)	0.5-1.0		Lateral yarding distance(m)		10-20	
	Setting(Removing) (man-day)	30 (10)		Yarding volume per day (m^3)		30-40	
	Yarder	Large-Medium		Balance weight with or without		with	
	Diameter of	SKL	LFL	HAL	HBL	ELL	CLL
		16-24	10-12			10-12	
	Operation Personnel (man)	3 - 6		driver	loading	unloading	logging
				1	1 - 2	1	(1 - 2)
	Remarks						

In this system, the LFL is the same as the Tyler system, but the HBL is the endless line (ELL), driven by the sheave attached to the drum of yarder, and this moves the carriage (CR).

Mainly in case of the gentle slope of less than 10 degrees, when the carriage can not move by it-self or in the case the skyline support is necessary, or in the case of steep slope of more than 20 degrees, when the braking force would be shorted other than this system.

Fig. III-50 Falling block system



Adaptable Operation	Clear cutting							
Adaptable condition	Tree length or short cut	Tree length short cut		Number of drums(piece)		2		
	Gradient of skyline(degree)	5 - 10		Span (m)		300-500		
	Weight of load (t)	0.5-10		Lateral yarding distance(m)		50-100		
	Setting(Removing) (man-day)	25 (5)		Yarding volume per day(m^3)		15-25		
	Yarder	Large-Medium		Balance weight with or with-out		with		
	Diameter of wire rope(mm)	SKL	LFL	HAL	HBL	ELL	CLL	
		16-24		10-12	10-12			
	Operation Peronnel(man)	3 - 6		driver	loading	unload-ing	logging	
				1	1 - 2	1	(1 - 2)	
	Remarks							

This system is used mainly in yarding on flat area or in upward yarding on gentle slope. Especially, the forced hauling is possible, that it is used frequently in tree length yarding.

In this system, to take down the carriage (CR) you must wind up the LFL by power and at the same time brake the HBL, and so the loss of power is great and also the high speed operation can not be expected.

And the load is apt to move up and down during travelling. That the driving operation need very much skill, adjusting it constantly.

But in case the skyline support is used, the passing through this support is easy, and also the lateral yarding is easy.

III-3-8 Calculating method about the skyline designing

About the skyline setting for yarder, we should pay a greatest attension to use the wire rope strong enough to bear the load while in operation and never breaks down.

In Japan, the safety factor of wire rope is defined in the Sanitary and safety of labor regulation.

Usage of wire	Wafety factor
SKL	2.7
HBL	4.0
LFL	6.0
GYL	4.0

In general, if the stretching is too tight, the tension would become too great, and if we were to keep the determind safety factor we must use the bigger size one or to diminish the load.

On the contrary, if the stretching is too loose the sag of the line becomes too much and the carriage load hang down so much as to touches the obstacles on the ground, and also the line swings too much to prevent the smooth operation.

The degree of stretching is indicated by the central sag span ratio (the ratio between the sag amount at the center and the horizontal distance between the two supports.)

As the minute amount of difference of this value has a very great influence to the line form and its tension, we must decide it very carefully.

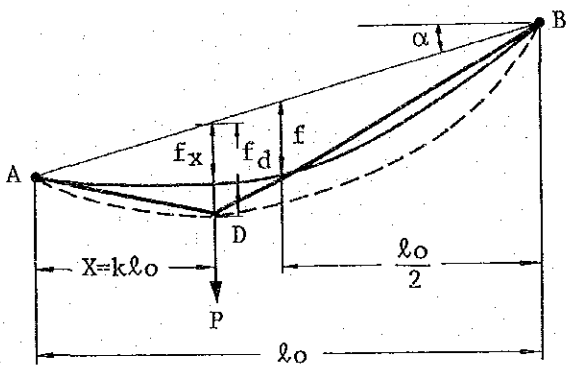
As a standard it goes between 0.02 to 0.06, but from 0.03 to 0.05 is desirable. Therefore, we fixed it as 0.035 in this design. If the safety coefficient is low in this case, then by fixing it from 0.04 to

0.045, and raise the safety coefficient.

a) Calculation on skyline form

The curve of original line and the locus of carriage load.

Fig. III-51 Original cable form, Load-locus curve



Central sag amount of the original curve of main cable is

$$f = S.\ell o$$

Sag amount at any point on the curve AB (horizontal distance x from A) is

$$fx = m.f \qquad \text{where } m = 4(k-k^2)$$

m is the coefficient determined by the horizontal distance from the lower end.

$K = \frac{x}{\ell o}$ and is the coefficient of horizontal distance at any point measured from A.

Generally, divide ℓo equally into 20 parts and take it horizontally, then the value k, and also the value m will be as follows.

k	0.05 0.95	0.10 0.90	0.15 0.85	0.20 0.80	0.25 0.75	0.30 0.70	0.35 0.65	0.40 0.45	0.45 0.55	0.50
m	0.19	0.36	0.51	0.64	0.75	0.84	0.91	0.96	0.99	1.00

By these values we can draw the curve of original form of main cable.

Next, we calculate for the locus curve of the loaded running of carriage-load.

If the load hang at a certain point between A & B, the cable will come down to point D and ballance there.

To define the horizontal distance from A to D as x, and the sag of the original cable without load as fz, and its sag when loaded as fd, then

$fd = r.fx$ where r is the coefficient of the sag increase relating to the situation of the carriage, and is calculated by the following formula

$$r = \frac{1 + 2n}{\sqrt{1+12\ (n+n^2)\ (k-k^2)}}$$

$k = \frac{x}{\ell o}$ coefficient of load situation.

$n = \frac{P}{W}$ load ratio

P : Weight of carriage

W : Self weight of cable between the spars.

b) Calculation of correction

As the cable of skyline is stretched very tightly and then fixed, that the spar may move sometimes, and also the temperature changes and the cable elongates elastically.

Therefore, we can get more acculate value by correcting the above mentioned terms.

(1) Correction for the displacement of supporting points

The span between the two spar may slightly changes by leaning towards inside, and the span becomes shorter that amount, resulting in the increasement of the sag.

Assume this minute displacement between the supporting points as $\Delta \ell$ and the distance between the two spars along with the cable as ℓ, then the displacement ratio Δd dwill be,

$$\Delta d = \frac{\Delta \ell}{\ell}$$

Assume the sag when the displacement is not existing is f_D and the same when displacement is existing is f'_D

then $f'_D = Ed \cdot f_D$

$$\text{where } Ed = \sqrt{\frac{1 + \frac{3}{8s^2 \cos^4\alpha}\Delta d.}{1 - \Delta d}}$$

s : Central sag-span ratio of original cable.

α : Inclination angle of the span.

(2) Correction for the change of temperature.

The temperatures may be different between the setting time (or the adjusting time) and the running hours, and by this change of temperature the wire rope would be elongated or shrinked, resulting in the change of sag amount.

The elongation ratio of wire rope W is,

$$W = 11 \times 10^{-6}/\text{degree}^\circ C$$

and is rather a small amount.

To assume the initial sag amount at a certain point on the original cable as fx, and the same after change as fx', then,

$$fx' = Et.\ fx$$

$$\text{Here,} \qquad Et = 1 \pm \frac{3}{16s^2 \cos^4\alpha} W\, t^\circ$$

Et : Coefficient of correction for the sag amount refering to the change of temperature t°C.

This amount Et would remain after the load is charged that is the initial sag amount under loaded condition fd will change to f'd, when the temperature changes.

$$f_D' = Et \cdot f_D$$

As for the plus and minus, plus is for rising and minus for decreasing, and the sag will increase or decrease accordingly.

(3) Correction for the elastic elongation of wire rope.

Wire rope will increase its tension when loaded, and this cause the elastic elongation of wire rope and the increasement of sag amount, accordingly.

As the original cable is already stretched under somewhat strong tension, the elongation by the initial tension is thought

to be settled.

If we define the elastic elongation as ΔL and the length of of original cable as L, the elastic elongation ratio Δe will be as follows,

$$\Delta e = \frac{\Delta L}{L}$$

To assume the sag amount when the elastic elongation is not considered is fd and when considered as f'd, then

$$f_D' = Ee \cdot f_D$$

$$\text{where } Ee = \frac{1}{2}\left\{1 + \sqrt{1 + \left(1 + \frac{3}{8s^2\cos^4\alpha}\right)\Delta e}\right\}$$

Ee : Coefficient of correction for the sag amount caused by the elastic elongation of wire rope under the increasement of tension from the load.

$\Delta e = \lambda \cdot Td$

Δe : elongation ratio.

$$\lambda = \frac{1}{A \cdot E}$$

$$Td = Tmax - To$$

A : effective sectional area of wire rope.

E : elastic coefficient of wire rope.

Tmax: Maximum tension under loading state before correction.

To : Maximum tension of original cable.

(4) Over-all correction

In case the displacement of spar, the change of temperature and the elastic elongation may occur at a time, the over-all correction coefficient E will be

$$E = Ed \cdot Et \cdot Ee$$

Therefore, the over-all corrected sag amount f_D' will be

$$f_D' = E \cdot f_D = Ed \cdot Et \cdot Ee \cdot f_D$$

By plotting these f'd at each position of k from the straight line A.B to downwards, and tie each these points, and then you can get the corrected locus curve. You can check the obstacles on the surface of the ground by this curve, and keep the safety against them.

III-3-9 Checking the design of skyline system

When the fundamental design is completed by refering to the items already mentioned, we must check it to avoid the troubles like the breakage of wire ropes or the case that the system does not work smoothly when the actual load like logs is charged.

In designing the skyline system, to use the bigger size ropes than necessary, only for the sake of safety, is useless, and in the fundamental designing we are to use as smaller ones as possible, and therefore we must check it from the stand point of safety ratio (coefficient of safety) as a base.

a) Tension of skyline and its safety coefficient

As for the carriage load we adopt not only the self weight of the carriage and the weight of the load, but also the impact-load and the estimated weight of operating line hanging on the carriage.

The impact load is indicated by the impact coefficient I, and the weight of operating line W' is the weight of the wire half the length between two supporting points.

Total carriage load P is

$$P = (Po + Pc) \times (1 + I) + W'$$

where,

Po ... Weight of logs.

Pc ... Weight of empty carriage.

I ... Coefficient of impact 0.2 - 0.3

W' ... Weight of operating line, hang on the carriage.

When the carriage ride on the original cable, stretched with the rated tension, the tension of the loaded cable would be increased, of course.

The intensity of tension depend not only on the load but also on the position of the carriage. The maximum tension will come to the upper supporting point when the carriage is at the middle of the span.

The maximum tension T_1, which appears at the upper supporting point is,

$$T_1 = (W + P) \times \Phi$$

where W : Weight of main cable.

P : Carriage load calculated as above mentioned.

ϕ : Coefficient of maximum tension

$$\phi = \frac{\sqrt{1 + (4s_1 + \tan\alpha)^2}}{8s_1}$$

α : inclination angle of the span.

$s_1 = Z_1 \cdot s$ and

S : central sag-span ratio of the original cable.

Z_1 : Coefficient of the equivallency which is determined by the line-load ratio.

$$Z_1 = \frac{1 + n}{\sqrt{1 + 3n + 3n^2}}$$

n : load ratio $\frac{P}{W}$

Assume the maximum tension derived from the above mentioned calculation as T_1, and the guaranteed breaking strength of the wire rope that is used, as B, then the coefficient of safety N

$$N = \frac{B}{T_1}$$

If the resultant of calculation becomes less than 2, then the system is dangerous. The value of N must be more than 2·7.

Also in this case, the coefficient of correction must be calculated in it.

(b) The tension and the coefficient of safety for the operating line.

Maximum tension of the lifting line of endless Tyler system will be calculated by the following formula

$$T'_1 = \frac{P\ell}{No} + P'_1 \times h'$$

$P\ell$: load of loading block.

P'_1 : Weight of unit length of the lifting line wire rope.

h' : Maximum hoisting height.
(Maximum distance between the main cable and the ground.)

No : Number of ropes which suspend the loading block.

This formula for the lifting line is not only for the endless tyler system, but also for tyler system and falling block system.

Calculate the coefficient of safety N, as follows.

$$N = \frac{B}{T'_1}$$

and check if the value of N is more than 6.0 or not.

Next, the tension of endless line T'_2 is calculated by the following formula

$$T'_2 = To' + Tp$$

T'o: Fundamental tension.

Tp : Tracting force for the load.

The endless line must be tightened so as the sag span ratio (fundamental sag span ratio)S' of the endless line should be 1.2 - 1.3 times of that of the skyline, when the carriage stay near at the upper spar or near the lower spar.

$$T'o = (P'_2 \times \ell) \times \phi$$

P'_2: Weight per unit length of the wire of the endless line.

ℓ : Oblique length of the span.

ϕ : Coefficient of the maximum tension.

The tracting force for the load Tp should be calculated seperately relating to the position of the carriage, and Tp_1, for the case when the carriage is not near the supporting point, and TP_2 for the case near the supporting point.

$$Tp_1 = P \times \sin \beta_1$$

$$Tp_2 = P \times \sin \beta_2$$

P : Carriage load.

β_1: Inclination angle for the curve of the locus of carriage-load, when it is not near the supporting point.

β_2: Inclination angle for the curve of the locus of carriage-load, when it is near the supporting point.

Maximum tension of the endless line is T_1, when the carriage is not near the supporting point, and T_2, when near the supporting point.

$$T_1 = T'o + Tp_1$$

$$T_2 = T'o + Tp_2$$

Calculate from these the safety coefficient,

$\frac{B}{T_1}$ & $\frac{B}{T_2}$ for each case and check and keep it more than 4.0.

III-3-10 Practical designing process of skyline system

To select the yarding line, survey closely the land features of the felling area, by practicing plane survey, profile leveling, and cross sectioning survey if necessary, using the pocket compass and make the drawings.

Most important point in designing the yarding line is the strength of wire ropes, and they must bear enough the load and should not be broken during operations.

Therefore, in designing the skyline system the designing calculation is necessary to prove the sufficient strength for the loads.

But these designing calculations are based upon the higher grade knowledges are required, and more over there are some facts which are not yet theoretically explained.

Therefore, we describe about the process to calculate easily for the safe operation by using the simple formula and tables.

(I) Fundamental Conditions

Wiring System

Span: (1) Horizontal distance ℓo = m

(2) Inclination angle α = degree

(3) Oblique length (of the span) $\ell = (\ell o/\cos\alpha)$ = m

(4) Vertical distance $h = (\ell o \cdot \tan\alpha)$ = m

(5) Sag-span ratio of original skyline So =

Wire Rope

Usage	Construction of rope	Rope diameter	(6) Guaranteed breaking force	(7) Weight of rope per meter	(8) Weight (7) × (3)
Skyline		mm	B = kg	P = kg/m	W kg
Lifting line		mm	B_1' = kg	P_1' = kg/m	W_1' = kg
Haulback line Endless line		mm	B_2' = kg	P_2' = kg/m	W_2' = kg

Load: (9) Weight of load P_0 = kg

(10) Designed weight of carriage P = kg

	Items		Maker's standard	Numbers	Unit weight	Weight
Weight of empty carriage	Carriage	P_C				
	Guide block	P_C				
	Loading block	P_C				
	Ballast	P_C				
	Slings line	P_C				
Weight of operating line	Lifting line	W_1'				
	Haul line	W_2'				
	Haul back line	W_2'				
	Endless line	W_2'				
(9)	Weight of load	P_0				
(10)	Total	P				

(2) Calculation of Safety Coefficient of Skyline

(12) Total load $\overset{(8)}{W} + \overset{(10)}{P} =$ kg

(13) Load ratio $n = \overset{(10)}{P} / \overset{(8)}{W}$

(14) Coefficient of the equivalency which is determined by the live-load ratio Z_1 (Table-2)

(15) Equivalency sag-span ratio $S_1 = \overset{(14)}{Z_1} \times \overset{(5)}{S_0}$

(16) Maximum tension coefficient ϕ_1 (Table-3)

(17) Maximum tension $T_1 = (W+P) \times \phi_1$

(18) Safety coefficient $= \overset{(6)}{B} / \overset{(17)}{T_1}$

(3). Calculation of Safety Coefficient of Operating Line

(A) Lifting line

(19) Maximum lifting height $h' =$ m

(20) Load of loading block $P\ell =$ kg

If the haul back line is fixed to the loading block, this would be the sum of above mentioned total weight and the tension of haul back line. But in this case we must calculate the tension of haul back line prior to this calculation as in case (B).

(21) Number of lifting line $n_0 =$

(22) Maximum tension $T_1' = P\ell / n_0 + P_1' \cdot h'$ kg
(20)(21)

(23) Safety coefficient $N = B_1' / T_1'$
(6)

(B) Haul back line or Endless line

(i) Load pulling force T_p

(24) $S_B = 0.8 \times S_0$
(5)

(25) Coefficient of load pulling force. $\sin\beta$ (Table-4)

(26) Load pulling force $T_p = P \times \sin\beta$ kg

(ii) Fundamental tension of endless line T_0'

(27) Fundamental tension $T_0' = W_2' \times \phi_0'$ (Table-3)

(28) Endless Tyler system
maximum tension $T_2' = T_p + T_0'$

(29) Safety coefficient $N = B_2' / T_2'$

This table is so made as to be filled up by simply calculating the numerical values by the attached tables and simple formulae and putting them in, according to and in order of the number within the ( ).

I. Fundamental Conditions

Describe the name of wiring system to be used in the column of "Wiring system".

Span

(1) ℓ_0 Horizontal distance (m)

Get by surveying. In actual case, you had better to survey the inclination angle α of (2) and the oblique distance ℓ of (3) as the following description, and calculate by the formula.

$$\ell_0 = \ell \cos\alpha$$

here $\cos\alpha$ will be got from the Table-I of Triangular functions.

(2) α Inclination angle

Get by surveying the angle from the head tree to the tail tree.

(3) ℓ Oblique distance (m)

Get by surveying

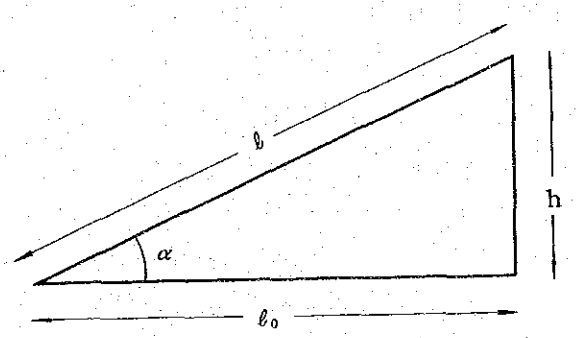
(4) h Vertical distance (m)

Delived from the following formula, using the ℓ_0 of (1) and α of (2).

$$h = \ell_0 \times \tan\alpha$$

here $\tan\alpha$ will be got from Table-1.

The relations between them are shown in the following diagram.



(5) S_0 Sag-span ratio of original skyline

In actual case we assume the about value of S_0 and wind up the skyline, and therefore S_0 and the center sag amount f_0 would be settled accordingly refering to each other.

The relations between these are

$$S_0 = \frac{f_0}{\ell_0}$$

the definition of original form sag amount of skyline refere to III-3-8-a.

Wire rope

Wire ropes to be used may varies in its construction type and diameter (of wire rope) according to its usage, we must note down each usage, construction type and diameter, and get the following each value from the table of wire rope.

(6) B, B_1', B_2' Guaranteed breaking force

(7) P, P_1', P_2' Weight per meter.

(8) W, W_1', W_2' Weights.

Here the weights means the ones which concern the calculation of the tension of skyline, and will be delived from the following equations using P, P_1', P_2' of (7) and ℓ of (3).

$$W = P \times \ell$$

$$W_1' = P_1' \times \ell$$

$$W_2' = P_2' \times \ell$$

Load

Weight of load, weight of empty carriage, and weight of operating lines are summed up together and the load on the carriage is calculated.

(9) P_0 Weight of load

Assume the maximum load weight according to the conditions and write it in. This value would be decreased and calculated again if the safety coefficient would turn out to be insufficient.

(10) P Carriage load (Designed load)

Delived from the following equation.

$$P = P_0 + P_C + W'$$

P : (9) Weight of load

Pc : Weight of carriage (from the catalogue)

W' : Weight of pulling wire. (Operating line)
varies according to the wiring system.

In case of Endless Tyler

$$W' = \frac{W_1'}{2} + \frac{W_2'}{2}$$

II. Calculation of Safety Coefficient of Skyline

(12) W+P Total load weight, derived from W of (8) and P of (10).

(13) n Load ratio

Derived from the following equation by applying the value W of (8) and P of (10).

$$n = \frac{P}{W}$$

(14) Z_1 Coefficient of the equivalency which is determined by the live-load ratio. Can be got from the table of equivalency by using the value n of (13).

(15) S_1 Equivalency sag-span ratio delived from the following equation by using the Z_1 of (14) and S_0 of (5).

$$S_1 = Z_1 \times S_0$$

(16) ϕ_1 Coefficient of maximum tension. Calculate from the table-3 of coefficient of maximum tension, by applying the value α of (2) and S_1 of (15).

(17) T_1 Maximum tension. Calculate by the following equation, by applying the value (W+P) of (12) and ϕ_1 of (16).

$$T_1 = (W+P) \times \phi_1$$

(18) N Safety coefficient. Calculate by the following equation by applying the value B of (6) and T_1 of (17).

$$N = \frac{B}{T_1} \geqq 2.7$$

In case the value is below 2.7, readjust it to reach 2.7, by increasing the sag-span ratio of original line or decreasing the maximum load. Increasing the diameter of skyline may be considered but this changing of skyline is not agreeable as it has many influence upon other parts. Actually, in many cases, it is difficult to change the main cable, and also it should not be changed too easily as one of the fundamental materials.

III. Calculation of Safety Coefficient of Operating Line

(A) Lifting line

(19) h' Maximum lifting stroke

Take the maximum vertical distance between the skyline and the ground, and be measured at the time of completion of wirings.

(20) P_ℓ Weight of loading block

Total weight of loading block, ballast, sling, and logs. When the haul back line is fixed to loading block, put in the resultant force of the above mentioned weight and the tension of haul back line.

In this case the calculation of haul back line as in the article (B) should be done at first.

(21) n_0 Number of ply of the lifting line.

V - hanging $n_0 = 2$

W - hanging $n_0 = 4$

(22) T_1' Maximum tension

Apply P_ℓ of (20), n_0 of (21), P_1' of (7) & h' of (19) to the following equation.

$$T_1' = \frac{P_\ell}{n_0} + P_1' \times h'$$

(23) N Safety coefficient

Apply B_1' of (6) & T_1' of (22) to the following equation.

$$N = \frac{B_1'}{T_1'} \geqq 6.0$$

If the value is smaller than 6.0, adjust the weight of load and let the value increase and surpass 6.0.

(B) Haul back line or endless line.

Haul back line must hold the running direction component of carriage load. This force is called the load pulling force.

(24) S_B (This value is necessary for calculation)

When the carriage does not come up near to the upper spar, that is within 10% of the skyline length between these two spars, calculate by the following equation.

$$S_B = 0.8 \times S_0$$

Where S_0 is the sag-span ratio of the original skyline. But when the carriage can comes up nearer (within 10% of the span length), then use the following equation.

$$S_B = (1 + 2n)\ S_0$$

here n is (13), the load ratio.

(25) Sinβ , load pulling coefficient

Get the value of sinβ from the Table-4 applying α of (2) and S_B of (24).

(26) T_p Load pulling force

Calculate by the following equation applying P of (11) & sin β of (25)

$$T_p = P \sin\beta$$

But if the sin α is used instead of sin β then the increasement is necessary and must use the following equation.

$$T_p = (P \times \sin\alpha) \times 1.4$$

(27) T_0' Fundamental tension of endless line.

Apply W_2' of (8) and also read out the value ϕ_0' from the maximum tension coefficient calculating table Table-3, applying the value α of (2) and S_0 of (5) and put these values in the following equation.

$$T_0' = W_2' \times \phi_0'$$

(28) T_2' Maximum tension

$$T_2' = Tp + T_0'$$

(29) N Safety coefficient

$$N = \frac{B_2'}{T_2'} \geq 4.0 \sim 6.0$$

But here the value 6.0 is for the endless line of endless system.

Table 1 sin α, cos α, tan α

Degree Minute ° "	sin α	cos α	tan α	Degree Minute ° "	sin α	cos α	tan α
0.00	0.000	1.000	0.000	16.00	0.276	0.961	0.287
0.30	0.009	1.000	0.009	16.30	0.284	0.959	0.296
1.00	1.016	1.000	0.018	17.00	0.292	0.956	0.306
1.30	0.026	1.000	0.026	17.30	0.301	0.954	0.315
2.00	0.035	0.999	0.035	18.00	0.309	0.951	0.325
2.30	0.044	0.999	0.044	18.30	0.317	0.948	0.335
3.00	0.052	0.999	0.052	19.00	0.326	0.945	0.344
3.30	0.061	0.998	0.061	19.30	0.334	0.943	0.354
4.00	0.070	0.998	0.070	20.00	0.342	0.940	0.364
4.30	0.078	0.997	0.079	20.30	0.350	0.937	0.374
5.00	0.087	0.996	0.087	21.00	0.358	0.934	0.384
5.30	0.096	0.995	0.096	21.30	0.367	0.930	0.394
6.00	0.105	0.995	0.105	22.00	0.375	0.927	0.404
6.30	0.113	0.994	0.114	22.30	0.383	0.924	0.414
7.00	0.122	0.993	0.123	23.00	0.391	0.921	0.424
7.30	0.131	0.991	0.132	23.30	0.399	0.917	0.435
8.00	0.139	0.990	0.141	24.00	0.407	0.914	0.445
8.30	0.148	0.989	0.149	24.30	0.415	0.910	0.456
9.00	0.156	0.988	0.158	25.00	0.423	0.906	0.466
9.30	0.165	0.986	0.167	25.30	0.431	0.903	0.477
10.00	0.174	0.985	0.176	26.00	0.438	0.899	0.488
10.30	0.182	0.983	0.185	26.30	0.446	0.895	0.499
11.00	0.191	0.982	0.194	27.00	0.454	0.891	0.510
11.30	0.199	0.980	0.203	27.30	0.462	0.887	0.521
12.00	0.208	0.978	0.213	28.00	0.469	0.883	0.532
12.30	0.216	0.976	0.222	28.30	0.477	0.879	0.543
13.00	0.225	0.974	0.231	29.00	0.485	0.875	0.554
13.30	0.233	0.972	0.240	29.30	0.492	0.870	0.566
14.00	0.242	0.970	0.249	30.00	0.500	0.866	0.577
14.30	0.250	0.968	0.259	30.30	0.508	0.862	0.589
15.00	0.259	0.966	0.268				
15.30	0.267	0.964	0.277				

Table 2 Coefficient of the equivalency which is determined by the line-load ratios.

(A) No. of load is one

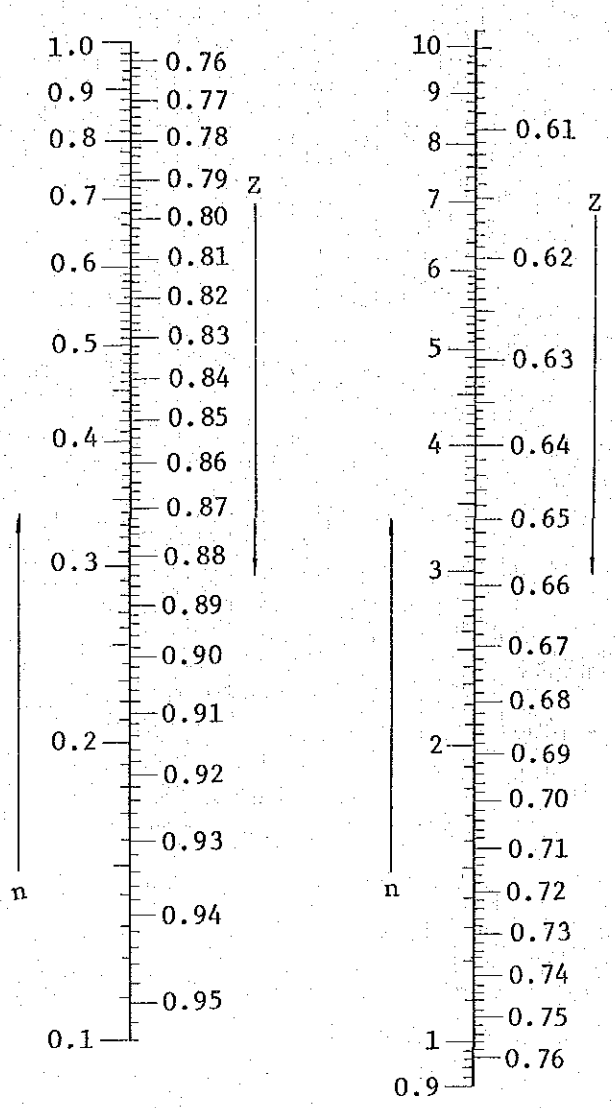


Table 3 Calculating graph of the max. tension coefficient

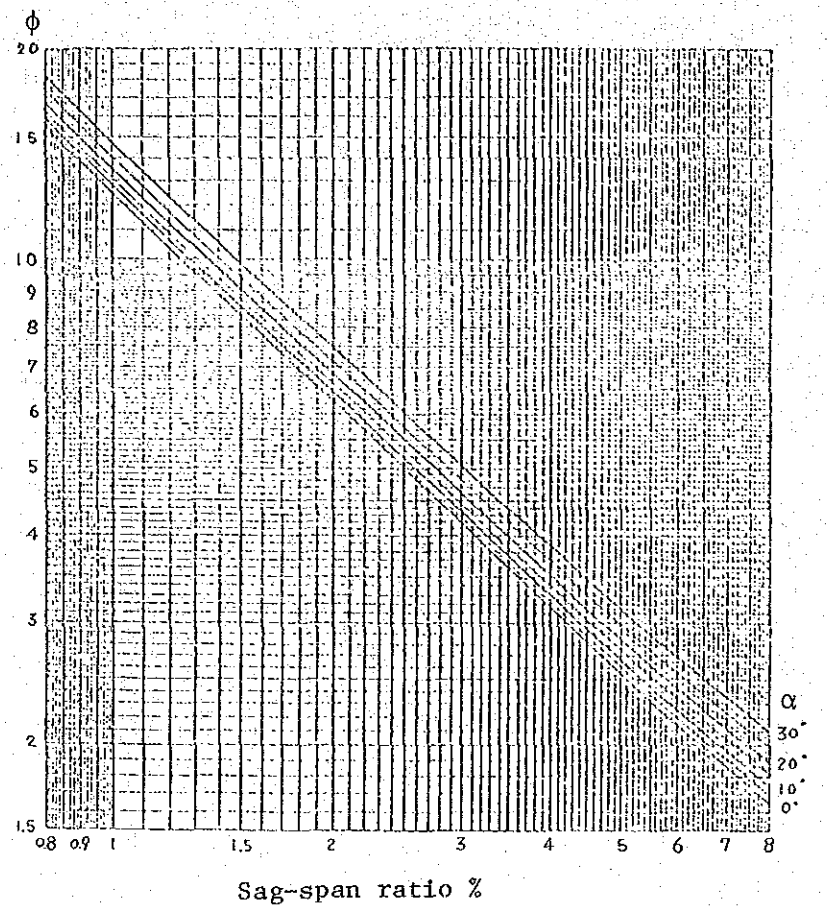


Table 4 Nomograph of load pulling coefficient

For example $\alpha = 18°$, $S_B = 0.101$

$\sin\beta = 0.589$, $\beta = 36°$