L O G G I N G

The

Principles, Methods, and Costs of Operation West of the Cascades in Oregon and Washington, with Respect to Timber Appraisals.

Part I

by

W. H. Gibbons, Forest Examiner.

District 6
1914

FOREWORD

This circular has been prepared primarily for use by Forest officers who are called on to make timber appraisals in medium and small-sized sales in District 6. It is hoped that it will be of assistance to those officers who are already interested in logging costs and methods and that it will be the means of interesting others. Furthermore, the treatment should suggest to readers that there is much work to be done along this line, and that they can help in doing it.

The subject is broad in scope and no attempt has been made to treat it fully and comprehensively. Only the more important features of Pacific Coast logging in Oregon and Washington have been covered. It has been assumed that readers [illegible] r less familiar with the ordinary logging operation [illegible] gion.

The greatest emphasis is laid on costs, especially [illegible] s about which there is not much written material available. It, however, has not been deemed practical to deal with costs without entering to some extent into a discussion of methods. This is especially true of the more modern methods.

W. H. Gibbons

Portland, Oregon
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C O N T E N T S

Contents

PART I

LABOR

Character.

Since the successful conduct of a logging operation depends in a large measure on the character, supply and efficiency of labor, appraisers in fixing the value of National Forest timber should not fail to take note of the labor situation. Laborers prefer to work near settlements and may demand higher wages on remote operations. In addition, the labor secured for remote operations is generally less efficient. Then, too, camps that run practically the entire year are able to secure cheaper and more efficient help than those that can run only part of the year. While the effect on the scale of wages and the relative efficiency of the help is a difficult matter to get at, it cannot be ignored.

Length of Employment.

Many camps on the Pacific Coast can operate practically the year round. There are other camps where the snowfall limits the operating period to eight or nine months. This, as has already been pointed out, results in a less efficient crew; also curtails the output and increases the overhead, depreciation, and maintenance costs.

Methods of Employment and Payment.

The basis of employment in the logging camps on the Pacific Coast is by the day or month, with or without a charge for board. Day labor with a charge for board, however, pre-

dominates in these camps, as only a few men in the camp are paid by the month. The foreman, bookkeeper, storekeeper, timekeeper, and engineer are generally paid by the month, which wage generally includes board. Sometimes the master mechanic, blacksmith, locomotive engineer, scaler, and hook-tenders are paid by the month. Seldom do the monthly wages of the employees in this last group include board.

Comparatively little contract work is done. Once in a while the felling and bucking and railroad grading are contracted. As a rule the making of ties and the cutting of fuel wood for locomotives are contracted. In a few cases the whole operation is contracted, the owners furnishing tools, supplies, equipment, etc.

The wages of most of the employees are discussed in another part of this circular. In the following list are given the salaries of those employees that are not mentioned later on. Needless to say the rates vary greatly.

Foreman	$125 to	$250	per	month	with	board
Bookkeeper	75 to	125	"	"	"	"
Timekeeper	75 to	100	"	"	"	"
Storekeeper	75 to	125	"	"	"	"
Engineer	75 to	125	"	"	"	"
Scaler	75 to	125	"	"	"	"

<u>Workmen's Compensation Acts.</u>

"For many years the responsibility of compensating laborers injured in the performance of their work was regulated

by Employer's Liability laws. These held the employer liable for accidents which occurred by reason of his failure to conform to the laws. Lawsuits were frequent and usually proved expensive to all concerned, often resulting on the one hand in a denial by the courts of compensation to parties to whom it was due, and on the other in granting heavy damages to those who were not entitled to them.

"The employers protected their interest through liability insurance companies but a great waste of money resulted since only from 29 to 50 per cent of the premiums paid reached the injured employees or their dependents and fully 40 per cent of this was expended by the injured party for attorneys' fees.

"Compensation through liability laws has tended to create an antagonistic feeling between employer and employee and for many years this method of settlement has been regarded as unsatisfactory.

"In recent years several states have abolished the liability laws and have passed Workmen's Compensation Acts which provide without trial by court or jury for the payment of specified sums for injuries received. The injured workman secures a definite compensation without any legal expense and without regard to the cause of the accident, provided it was not self-inflicted. In return he must waive all rights to the common law defenses of 'contributory negligence', 'assumption of risk' and the 'fellow servant rule' which were prominent features in litigation under liability laws.

Washington. "One of the most satisfactory Workmen's Compensation Acts, from the standpoint of the lumber operation, is now in force in the state of Washington, having gone into effect in October, 1911. This law provides for an Industrial Insurance Commission to administer the law and the payment, by the State, of all expenses of administration of the Act, placing the burden of compensation on the employer.

"Among the features of this law are the following:

(1) When engaged in hazardous occupations the provisions of the Act are obligatory on both the employer and employee, and are optional with others. Those who come under the provisions of the law waive all rights to the common law defense, and the employee must accept the awards of the Commission, in lieu of his right to sue at common law.

(2) An employer, workman or beneficiary has the right of appeal to the Superior Court in the County of his residence when the award is not satisfactory. If the court deems the award unjust, the Commission must pay the plaintiff's costs and attorney's fees out of the administration fund.

(3) The awards are made from a fund contributed by the employers, who pay a certain percentage of their payroll to the Commission.

(4) The various industries and parts of industries are grouped separately according to the degree of hazard, and each class has a fund of its own from which awards are made for such accidents as arise to its employers. In case of the de-

pletion of the fund, provisions are made for special assessments to cover the deficit. Although the fund is not intended to be cumulative, there is no provision for a reduction of the assessment fixed by law.

(5) It is unlawful for the employer to deduct from the wages of the employee any portion of the premium paid into the accident fund.

(6) All forms of injury are classified and a standard schedule of awards is fixed for each.

(7) In case of the death of an employee a pension is granted to the widow during her unmarried life, including an allowance for each child under sixteen years of age, up to a maximum of three children. Orphans receive an allowance twice that granted to children who have a parent living. Provision is also made for dependents when the deceased has no immediate relatives.

(8) Pensions are met by setting aside a specified sum, based on mortality tables, which is deposited with the State Treasurer, and from which the payments are made when due.

(9) If a workman deliberately injures himself, or causes his own death, no award can be made from the accident fund. On the other hand, if the employer brings about such injury or death through negligence, the widow, children, or dependents come within the provisions of the Act, and further have cause for action against the employer for any damage in excess of those awarded by the Commission.

(10) Provisions are made for penalizing an employer who fails to observe the safeguards by law. He must not only pay the regular percentage on his payroll but, in addition, 50 per cent of the award granted to the injured party. If the workman removes, or allows to be removed, any safeguard and he is injured thereby, the award is reduced 10 per cent.

(11) Employers are required to report all accidents to the Commission, and their books must be opened to inspection by the traveling auditor of the Commission.

(12) Application for relief under this Act must be made within one year from the date of the accident.

The specified rates on the logging industry are as follows: logging railroads, 5 per cent; logging operation proper, 2½ per cent. It would seem that the class listed under the 5 per cent rate includes not only labor employed in the operation of trains, but those employed in the construction or maintenance of track. It does not include railroads under federal jurisdiction by reason of their being engaged in interstate commerce. Work of line extension, however, or any work done on track not yet turned over to the operating department, and work of construction done by contractors is held to be under the Act.

While it would seem that the Act does not provide for any reduction in the specified rate, the 1915 report of the Commission suggests that the Commission may or does assess a less rate. In the report the following is found in con-

nection with Class 7, ~~under which logging~~ railroads fall:

"Average rate assessed during first two years, 3%"

"Average rate required to pay awards approved up to October 1, 1913, 2 3/4%".

"Adjustments for calendar years were made as follows:

1911, (3 months) 5%

1912, 5% on six-twelfths of payroll.

1913, 5% on only four-twelfths of payroll."

Under logging, which bears a specific rate of 2½ per cent, it seems are included all employees of the camp not included in the class which bears the specific rate of 5%. The 1913 report of the Commission suggests that the following rates were actually assessed:

1911, (3 months) 2½%

1912, 2½% on eight-twelfths of payroll.

1913, 5% on only four-twelfths of payroll."

Until such time as the approximate average rate can be stated, it may be best for appraisers to use the average rate.

Oregon. The state of Oregon passed a Workmen's Compensation Act at the last session of the legislature, which Act becomes effective July 1, this year. The striking difference between this Act and the Act in force in Washington is the elective feature. Under its terms both the employer and employee may be relieved of the obligations imposed by the Act by filing with the Commission written notice of an election

not to be subject to those provisions that provide for the payment by the employer of certain sums of money to the State and the acceptance by the employee of certain awards from the State because of personal injuries sustained while at work for an employer who is subject to the Act. The authors of the Act, however, anticipate that practically all employers and employees will elect to come within the provisions of the Act. The rate for logging railroads and logging is 3 per cent.

FEEDING AND QUARTERING MEN

General.

From the standpoint of the operator the housing and feeding of the crew is an important matter. On the other hand, the estimating of this cost per M feet is not necessarily a difficult task. The men pay their own board, and in many cases the money received by the operator in this way not only pays for the food, but for the cost of preparing and serving it; also provides a depreciation fund on the kitchen, dining room, bunk houses, and all equipment. This is said with a knowledge that many operators claim they lose money in feeding the men at current rates.

That some operators lose money when feeding men at 25 cents per meal cannot be questioned. Some seemingly authentic cases have come to the attention of the writer where the loss to the operator when feeding men at 25 cents per meal amounted to 4 cents per meal per man; the average cost of 29

cents being the cost of the meals, not including a rental on the buildings and equipment used by the men. The quality of the board varies at different camps. This will, to some extent, explain the fact that some operators seem to do a little better than break even when feeding men at 25 cents per meal, while others lose money.

<u>Feeding Men</u>.

Most operators charge $5.25 per week per man. Some charge $5.50 per week, and a few charge only $5.00 per week.

It would not be practical to estimate what it costs, or should cost, to feed men. If there is no loss in feeding men, this expenditure can be eliminated from the appraised problem. If there is a slight gain, the amount could be construed as taking, or partly taking, care of the housing of the men.

If there is a loss per meal, and the loss can be assumed, it is a simple matter to estimate the loss per M feet. The writer knows of camps where the average cost per meal per man for the year 1912 averaged as low as 21 cents, and others where it averaged as high as 29 cents. It may be safe to figure that the cost of serving meals amounts to 25 cents per meal per man. It would not be advisable to use a lower figure, and in some cases it might be well to use a higher one. It will not be necessary to consider the men employed on railroad maintenance and grading work in this connection. This work is generally done by foreigners who run their own mess.

In accordance with the above, the writer would not consider the cost of feeding the crew, and of maintaining the cook house equipment in making an appraisal unless there is a good reason for thinking that the cost will exceed 25 cents per meal per man.

Quartering Men.

The cost per M feet for housing men varies in different camps. This is due to several factors. If the buildings are stationary, the cost per M feet will depend for the most part on the total original cost of the buildings, the total amount of timber logged from that location, and the value of the buildings when the operation is moved to a new location. The value of stationary camp buildings when the operation is moved to a new location amounts to little or nothing. If the buildings are built on skids, wheels, or in sections, so that they can be moved from one location to another, their cost per M feet will depend on the same factors, except that the amount of timber they will be used to log will be larger.

Needless to say, the original cost of camp buildings varies greatly, depending on the type of buildings and on how much the men are crowded. The first step in estimating the cost of camp buildings is the determination of the average number of men to be housed. The second is the determination of the type of bunk house and the number of men that will be quartered in a bunk house. With this done the next step is to estimate the cost of the buildings.

Portable Camp. The following gives a brief description, also the cost, of a portable camp in Oregon. It consists of 10 camp cars, each 14 feet wide and 46 feet long. The water supply for boilers, dynamo car, cook house, etc., is provided by means of a 2000-gallon tank which is erected at such a height as to give good pressure and furnish an adequate supply without in any way interfering with the water supply for the "donkey" engines. One pumping plant provides water for the "donkeys" and the camp. Sometimes, of course, the water is supplied by a gravity system.

Old 34-foot flat cars are used. To cause the cars to over-hang six feet on each end, three fir sticks 4"x6"x46' are laid lengthwise upon the floors of the cars and securely spiked. Across these supersills a floor of 2-inch planks is laid. This floor of planks, which is 14' wide, formed a truss and serves as a sub-floor. The frames of the houses were mounted on the sub-floor. Upon the sub-floor a top floor 1"x4"s 4 s was laid.

Bunk Cars. Five of these cars are fitted with 16 bunks each, giving accomodations for 80 men, the sixth car being shelved and used as a store-car for package goods. The bunks are made of 1-inch pipe, with an upper and lower bunk in each set. Each bunk is provided with regulation woven wire springs and an excelsior cotton mattress. The arrangement of the bunks is more or less original in that they are set at right angles to the side of the car instead of along the walls.

There is a space between each set of bunks which gives the pair of men occupying a set a certain amount of privacy. The usual deacon seats are provided, also two shelves against the wall in the end of each department for the use of the men. Wire hooks are provided on the under side of these shelves for suspended articles. Each of the bunk cars is provided with steam coils made of 1-inch pipe and return bands on the wall line on each side of the front door and underneath the windows. Above these coils is suspended a wire upon which wet clothing can readily be dried in front of the coils, the louvered windows in each end giving sufficient circulation to carry off odors. Each bunk car is also equipped with two tables and several benches.

Cook Car. There is a door in the end which butts on the dining car; three doors in the front at the ends of the car; and a run of swinging sash windows (3'x3'8"), seven windows in the front and nine windows in the back of the car. The height of ceiling in all the cars is 8½ feet. The car is equipped with a 3x7' dish-up table, 3x8' range, 40-gallon galvanized iron boiler, 3x5' sink, 2x4' drain board, 30"x6' portable bread mixer, 30"x4' pastry table, and shelving, hooks, etc.,for dishes. The kitchen occupies 24 feet of this car, leaving 22 feet for the store room; a partition being run across the car separating the store from the kitchen. The store room has spaces for barrels, heavy boxes, etc., and is lined with shelves. In one corner a stationary washtub is set for the cook's laundry, to which cold and hot water is piped.

This compartment is also used as a eating room.

The meat house is located away from the camp spur in a cool position, and is entirely enclosed with galvanized iron fly screen in order to get good circulation of air.

Dining Car. This car accommodates 80 men. There are four tables, placed in two rows, with a break in each row for the convenience of men in going to and from their places at the table. The benches are made in the customary way and can readily be moved when desired. A suspended shelf is located over each table, upon which can be placed syrup, catsup, butter, etc.

Power and Bath Car. One car is equipped for power and bathing purposes. A space 14'x16' is reserved at one end for the cook's quarters. Another space 14x14' is reserved for two 30x72' upright boilers. These boilers are connected with the dynamo engine and heating pipes. The compartment is also equipped with a switch board, engine and dynamo. The generator is capable of supplying 100 16-candle power 110-volt lamps.

Store Car. In addition to the cook store house, there is one car which is designed to carry package goods both for cook house and commissary, so that goods can be ordered in quantities.

Commissary and Office. This car is designed not only for the commissary store and office, but also to provide sleeping quarters for the general foreman and store-keeper. The door is in the center of the car and opens into a lobby 5'

deep and 12' long. At the right hand side of the lobby is the counter over which the commissary stores are delivered. The commissary room is 14x15', provided with shelving and a glass show-case on the counter, containing cigars, etc. The office is 8x20' with an ell 5x8'. From this room a small window opens into the lobby. Shelving and lockers are provided in this room for stationary, baskets, packing, hospital supplies, etc. It is also provided with a flat and stand-up desk for the storekeeper (who is also the timekeeper) and a desk for the general foreman. The bunk room is 10x14' and is provided with two double-tier pipe bunks of the same style as provided in the regular bunk cars. This car is well lighted throughout, not only by windows but by the use of sash doors and sash windows set in all partitions.

Cost. The cost of the complete outfit was approximately $6500. This cost does not include the value of the old flats.

<u>Stationary Camps.</u> One company quarters its help in three-men cabins. Each cabin is 10 feet wide by 14 feet long by $7\frac{1}{2}$ feet high, with a 3-foot gable, built of 1x12" material. The front has a door $2\frac{1}{2}$x$6\frac{1}{2}$' and two windows in the rear (set so as to slide open) 24x26". The cabins, for convenience in moving, are set on runners 6x6" by 17' long. The roof is made of 1x12" material, covered with rubberoid roofing. The interior of each cabin is furnished with three separate bunks (one for each man) and a stove. The cabins are set approximately

50 feet from the railroad track and in two lines, one on each side of the track. Twenty-three of these cabins, all logging tools and equipment, etc., were loaded and hauled a distance of $3\frac{1}{2}$ miles in 13 hours. The logs were loaded with the aid of a log jammer or log derrick in an average of 10 minutes time. The approximate cost of each cabin was $50. The efficient life of these cabins will range from 7 to 10 years. To furnish these cabins with single iron bunks, mattresses, a stove, etc., will amount to $25, or a total cost of $75. At this rate cabins for 99 men would cost $2475.

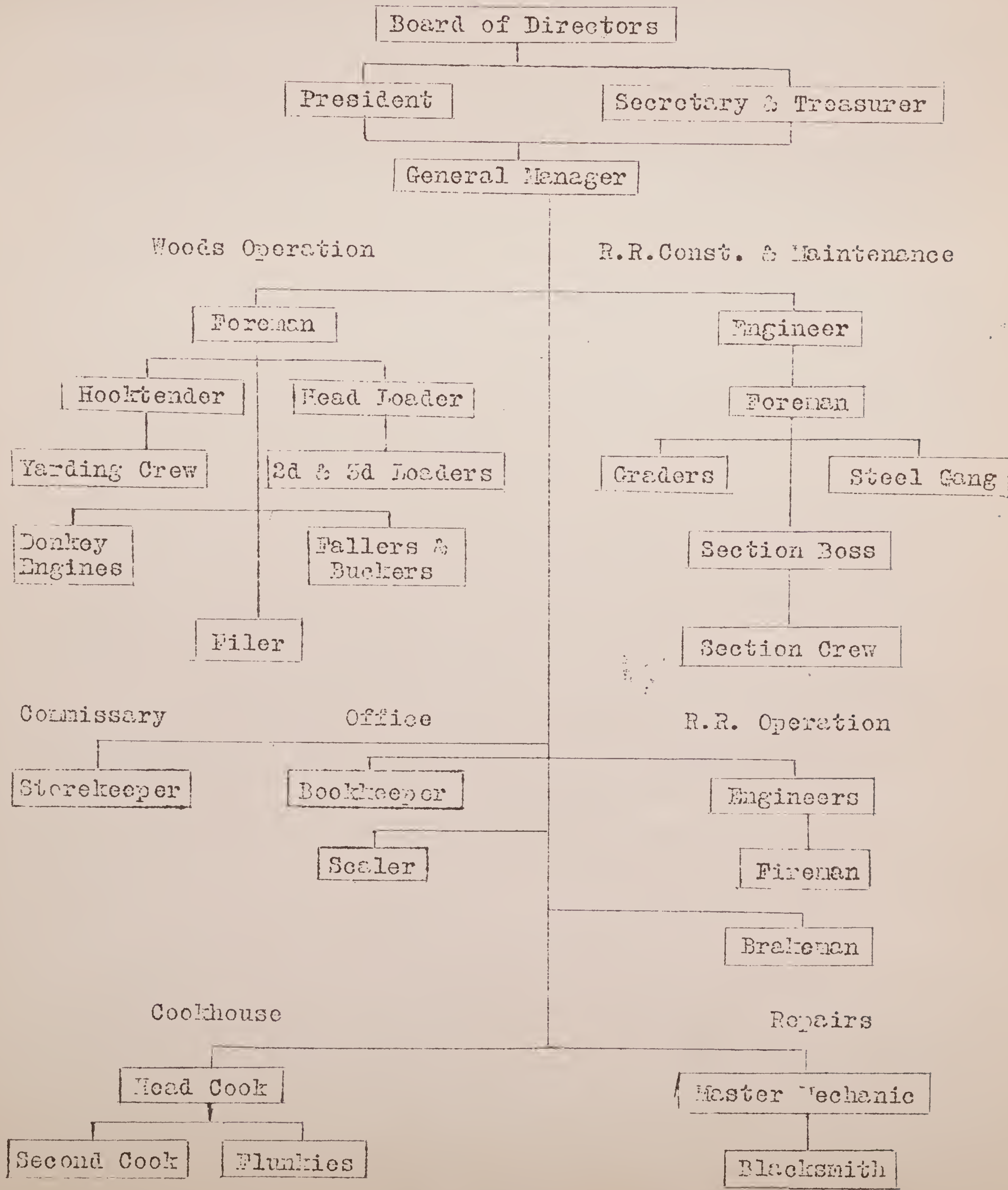
Another camp houses its help in eight-men bunk houses which are built on skids. These houses cost about $100. They are substantially built, well lighted, and attractive. With proper care they should have a life of from 8 to 10 years. To furnish these cabins with double iron bunks, mattresses, a stove, etc., will cost about $50, making a total cost per cabin of $150. At this rate cabins for 96 men would cost $1800.

The cost of the dining room and kitchen will vary, depending on the type of building and size, also whether it is a portable or stationary building. One stationary building, large enough to take care of 90 men cost $900. Another stationary building, large enough to accommodate 200 men, cost $1500. These figures include the tables, bins, etc. The dining room and kitchen equipment - range, cooking utensils, dishes, etc. - for one outfit of 160 men cost $600. Bryant in "Logging" estimates the cost of this equipment for sixty men

at from $200 to $225. His list of articles includes a six-hole range.

To get the total cost of housing men, one should include the cost of clearing land for a site, putting in side tracks if necessary, installing a water and sewerage system, etc. The cost of the water and sewerage systems in some cases is a rather heavy item of expense. It will also be necessary to include the cost of moving camps. To equip the camp with electric lights will cost from $600 to $2000.

ORGANIZATION OF A PACIFIC COAST LOGGING OPERATION



This diagram of the organization of a Pacific Coast logging operation was prepared by a Forest officer who is familiar with the organization of logging companies. Needless to say, all companies are not organized in the same way, and so it is not possible to make one diagram fit all organizations without modifying it to such an extent as to make it complicated.

The organization as it relates to the woods may be considered as being made up of a number of departments, which departments vary in number and organization in different camps. In the absence of the general manager the camp foreman is in charge of the camp. He can employ help for practically all the departments, and can discharge any man he has authority to employ. As a rule he does not discharge an employee unless such action is recommended by the head of a department.

The woods end of the operation may be considered as being made up of the following departments:

Felling and Bucking
Yarding
Loading
Transportation
Unloading
Filing
Engineering
Railroad Grading
Track Laying

Railroad Maintenance

Clearing Right-of-way

Landing Construction

Machine and Blacksmith Shop

Scaling

Office

Store

Cook House

<u>Felling and Bucking</u>. The fallers and buckers may be in charge of a head bucker who indicates the trees to be felled and divides the felled timber into log lengths. He may or may not have authority to discharge members of his crew. In all cases he may have a member of his crew discharged by recommending such action to the camp foreman. In a number of camps the fallers and buckers are still directly in charge of the camp foreman. The second faller works under the head faller, but seldom, if ever, can he be discharged by him. If the head faller is not satisfied with his assistant, he may secure another by recommending it to the camp foreman. This sometimes results in the second faller being discharged. Where the fallers and buckers are working under a bonus system, a felling and bucking scaler may be employed. In a case of this kind the scaler would be in charge of the foreman. Occasionally the head bucker has an extra man to assist him in dividing the timber into log lengths.

Yarding and Loading. In some camps "Yarding and Loading" is considered as one department, the work being in charge of the hook tender. When the operation is organized in this way the hooktender may or may not have authority to discharge members of his crew. In any case the hooktender may have a member of his crew discharged by recommending such action to the camp foreman.

In other camps "Yarding and Loading" constitutes two departments; namely, "Yarding" and "Loading". Where this division is found the hooktender will be in charge of the yarding and the head loaders in charge of the loading. These men may or may not be authorized to discharge help.

Transportation. The train crew as a rule is in charge of the head brakeman. He may or may not have authority to discharge members of the crew. The foreman in turn works under the locomotive engineer.

Unloading. As a rule the unloading is done by the train crew. If extra help is employed, it works under the direction of the foreman.

Filing. The filer works under the direction of the foreman. If two filers are employed, the head filer directs the work.

Engineering. As a rule the camp engineer works directly under the general manager. If, however, there is any friction between the engineer and foreman, the engineer is the one who is removed. In most camps the engineer does not do

other work than to locate railroads. Where the location work does not keep him busy he is supposed to do any work in connection with the construction and maintenance of railroads that he is called upon to do.

Railroad Grading, Track Laying and Maintenance. The work may be done by one, two, three or more crews, depending on the size of the operation. Each crew is in charge of a foreman who is generally responsible to the camp foreman. In some camps these foremen are directed by the engineer.

Clearing Right-of-way, Landing Construction. This work may be done by one, two or more crews. Each crew is in charge of a foreman who is responsible to the camp foreman.

Machine and Blacksmith Shop. The work is directed by the master mechanic; that is, where there is one.

Scaling. As a rule there is only one scaler who is responsible to the camp foreman.

Office and Store. Quite often there is only one man connected with the office and store, and he may be responsible to either the general manager or foreman, depending on the organization.

Cook House. The cook house is in charge of the head cook who may be responsible to the general manager or the camp foreman.

TAXES

According to the revenue laws of the State of Washington, "All property shall be assessed at its true and full value of real or personal property. The assessor shall not accept a lower or different standard of value because the same is to serve as a basis of taxation; nor shall he adopt as a criterion of value the price for which said property would sell at auction; or at a forced sale or in the aggregate with all the property in the town or district; but he shall value each article or description of property by itself and at such sum or price as he believes the same to be fairly worth in money at the time such assessment is made. The true cash value of property shall be the value at which the property would be taken in payment of a debt for a solvent debtor. In assessing any tract or lot of real property the value of the land exclusive of improvements shall be determined; also the value of all improvements and structures thereon, and the aggregate value of the property, including all structures or other improvements, excluding the value of the crops growing on cultivated land."

It will be seen from the foregoing that the valuation required by law in the State of Washington is the true value. This, however, is not observed in any of the counties of this state either in theory or practice. The State Tax Commission does not uphold the provisions of this law but recommends to the assessor an assessment based on 60% of the

true value. In theory each assessor determines what proportion of the true value of the property to be assessed in his county he shall use, and this percentage usually runs below 60%. The same condition obtains in Oregon, with the exception that the State Tax Commission has not recommended any percentage to the assessors. Fifty per cent is generally used in Oregon.

The levy varies in different counties and in the same county by years - possibly ranging from $2\frac{1}{2}$ to 4 mills. In dealing with a particular block of National Forest timber appraisers should familiarize themselves with the method of making the valuation and the average levy in the county in which the timber is located.

RAILROADS

General

Here on the Coast, as a general thing, logs are transported from the landings to the mills or large bodies of water by railroads. These roads may be owned entirely by the logging operator, or the operator's road may be used only to lay the logs down at some point on a trunk line. With the exception of two or three, these roads are standard gauge. There are no narrow gauge roads in use on the Coast in Oregon and Washington. Not infrequently these roads have to be built across lands owned by other than the operator. If necessary, under such circumstances a right-of-way can be forced across

such foreign holdings by condemnation proceedings and the payment of just compensation to the owner, the operator at the same time forfeiting certain rights.

Engineering.

The cost of engineering and administration on logging railroads will vary from \$200 to \$400 per mile. On the "main-line" railroads it is customary to estimate about 5% of the total construction cost for administration and engineering.

Location.

A knowledge of railroad locations, both main and spur lines, is very essential to a timber appraiser. In the discussion of this subject the writer has given extracts from articles and addresses by men who are qualified to speak on this subject. No attempt has been made to treat this phase of the subject fully. What is given is intended to be only suggestive.

One man in a discussion of railroad location made the following statement: "The location of the main line logging railroad is of great importance, for the engineer must preserve a proper balance between the cost of construction and the maintenance and operating charges. He must choose between an expensive roadbed, with less grades and easy curves, or a cheaper roadbed and increased maintenance and operating expenses.

"Roads in rolling or rough regions should enter the tract at the lowest point and follow natural drainage, because

it usually affords the best grade out of the region and the operator can bring his timber to the main line on a down grade. (There are times when such a location would be wrong.) Roadbeds along natural drainage should be placed above high-water mark when possible, although on roads which are to be used only for a short period it may be cheaper to build near the stream and suffer a few washouts rather than incur a very heavy construction expense.

"The shortest possible route is usually desirable, but it is better to increase the length of line if heavy cuts, fills, bridges and trestle construction can be avoided.

"'Velocity' grades are often used to advantage in crossing 'draws' or depressions but they are feasible only on straight tracks, for it is extremely dangerous to run trains at high speed on a curved track which has a descending grade. In addition to the influence on the hauling ability of a locomotive, steep pitches are a disadvantage on a road because the track tends to work towards the lower levels and not only is the expense of maintenance greater than on fairly level road but also the danger of wrecks is increased.

"When logging railroads cross ridges or cover sharp changes in grades in a short distance, 'switch-backs' are usually preferable to doubling back with a curve, since the latter method often necessitates a heavier construction expense. Switch-backs often are the only means at hand of securing timber from above or below the mainline."

The following is taken from an article printed in the "Timberman":

"Without entering into the technicalities and refinements of railway location, a discussion of some of the fundamental principles of an economic location of a logging railway would perhaps be of service and interest.

"The fundamental principle of good location is common sense.

"A railway should be adapted to the traffic it has to carry.

"A logging railroad is built solely to carry logs.

"There is a direct relation between the location of a line and the cost of maintenance and the cost of operation, while the traffic remains, whether the line be good or bad.

"The cost of transportation subdivides itself into the cost of construction and equipment, the cost of maintenance, and the cost of operation, and all are affected by the location of the line. To so adjust these several costs so that the total cost per M feet for transportation will be as low as possible is the aim of the locator.

"It is the opinion of the writer that the values given to rise and fall, total curvature and distance, in the location of 'common carrier' railroads, should generally be ignored. In logging railroads, the life of the road is short and the annual saving per train mile so small for these minor factors that it would rarely equal what might be saved in

construction by introducing curvature, rise-and-fall, and distance, provided you keep within the maximum curvature and gradient adopted.

"A better idea may be had as to the value of these minor factors by reference to the following generally accepted statement of annual cost of operating one train per day:

Distance per foot -	$0.03	up to 530 feet
Curvature per degree -	.23	
Rise-and-fall per foot -	.65	up to 30 feet

"In the case of curvature and rise-and-fall, the price given is the cost in excess of operating a train over a level straight track. Inasmuch as speed is not a factor, except on velocity grades (where a run is taken for the hill) the question of maximum degree of curvature to be used becomes one of judgment and safety and will be determined by the amount of traffic to pass over it, the character of motive power to be used, and cost of construction.

"The cost of operating and maintaining a curve is determined by the amount of central angle and not by the degree of the curve.

"The lumberman has a cruise of his holdings and knows just how much traffic will have to pass over his main line and each of the small branches. To so adjust these several costs so that the total cost per M feet for transportation will be as low as possible is the aim of the locator.

"The topographic map, or a careful reconnaissance, will determine the total amount of rise-and-fall which must be overcome. These, and a knowledge of the speed at which the timber is to be removed, are the determining factors which must decide the character of the roadbed to be built, the kind of motive power to be used, and, most important of all, the grades to be adopted for the several lines.

"Herein lies the lumberman's greatest opportunity for economy in transportation. The cost of maintenance, which will run anywhere from 15 per cent to 30 per cent of the total cost of operation, is determined largely by the character of the roadbed adopted. Now this may seem to be a question of construction rather than of location, but the location has much to do with the roadbed - easy grades mean lighter motive power to do a given amount of work, lighter motive power means lighter steel, less ballast and less work to keep the track up. It may be well to say here that the center line and the grade line should always be so laid as to admit of thorough and proper drainage, for this, after all, is the most important feature in maintaining a logging road where ballast is almost limited, and sometimes prohibitive.

"When one stops to consider that in a road costing, say, $8,000 per mile, with 60-pound steel, and 6 inches of ballast, three-fifths of the cost is above subgrade. But the expenditure of the other two-fifths determines almost wholly the cost of maintenance and the cost of operation and also how much

business the road will be able to handle and the character of the motive power to be used - that more attention should be paid to the location of a logging railroad than has been done in the past.

"In planning on operation where railroads are involved the most important consideration is one of grades.

"There are no two propositions just alike, and it would be impossible in an article like this to do more than indicate the method by which a solution can be reached. It is evident to everyone that to secure a well balanced line when motive power, roadbed and grades are fitted to each other and all to the work to be done, is the aim of every locator.

"The direction of the traffic, whether or not there will be adverse grades, is a consideration of prime importance. In deciding on a system of grades, it is a good plan to assume the weight and traction power of an engine, and then compile a table similar to the one shown here, giving approximately the number of thousands of logs the engine could handle, both uphill and downhill, on various grades. When the traffic is downhill, the number of empty trucks the engine could return would, of course, determine its capacity.

Table Showing Capacity of Road
and
Traffic Downhill

Rate of Grade	Resistance in lbs. per ton	Weight of Engine (tons)	No. of cars per train	Capacity of train in M logs	Capacity of each car in M logs	Weight of empty cars (tons)
1%	30	60	62	310	5,000	10
2%	50	60	35	180	5,000	10
3%	70	60	25	125	5,000	10
4%	90	60	19	95	5,000	10
5%	110	60	15	75	5,000	10

With Traffic Uphill

						Weight of loaded cars (tons)
1%	26	60	19	95	5,000	27
2%	46	60	14	70	5,000	27
3%	66	60	9	45	5,000	27
4%	86	60	7	35	5,000	27
5%	106	60	5	25	5,000	27

This operation may need to be repeated a number of times, with various weights of engines, until the lumberman has found the weight of engine and rate of grade that best suits his needs and the topography of his holdings.

"Should the country fall away faster than the grade adopted, switchbacks will need to be used to gain distance,

as generally heavy construction is involved in doubling back by means of a curve. In locating a switchback, the ascending grade should be continued to the end of the tail of the switchback and not put it on a level, as is too often done so that when the switchback is thrown and the brakes released, the train will start of itself and have gathered some momentum on reaching the ascending grade in the opposite direction. When grades are so arranged, the trainmen soon acquire great skill in handling the trains and very little time is lost at the switches.

"Having decided on a system of maximum grades to be used, adhere to them. Compensate for curvature on maximum grades .04 of a foot degree of curvature. To establish a maximum grade and then put in 12 degrees to 16 degrees curves without compensation, as is sometimes done on logging roads, is absurd. That curve limits the capacity of the road. Proper vertical curves should be put in at all abrupt changes of grade. These cost little or nothing to put in, but real money to keep out. Where it is necessary to exceed the maximum grade for economy of construction in crossing draws, it can be effected by means of velocity grades. To illustrate: if the maximum grade is 1 per cent and the speed of train 10 miles per hour, a descending grade can be laid into the draw of such a length or steepness as to allow the train to acquire a speed of 30 miles per hour at the foot of the grade. It will then have acquired momentum enough, together with the

traction power of the engine, to rise on a 3 per cent grade for a distance of 1400 feet, on a 4% grade 900 feet, or 700 feet on a 5% grade, at which point the train would be going 10 miles per hour and would need to pick up the 1 per cent grade again. Thus the vertical maximum grade remains 1 per cent, while the actual grade used has been 3, 4, or 5 per cent, as the case might be.

"Many opportunities for velocity grades are spoiled on logging roads and the capacity of the roads limited because the grades have not been properly laid. It is obvious that sharp and dangerous curves should not be allowed at the foot of a grade where a run is to be made for the hill.

"The adjustment of the center line so as to balance cuts and fills, avoid obstacles to construction, etc., will depend on the experience, skill, and ingenuity of the engineer.

"Whatever the engineering may or may not be, so far as it relates to the location of a logging railway, or any railway, it is both a science and an art. A vast amount of data have been gathered by many men and reduced to workable formula. A knowledge of this constitutes the science, but the application is an art."

The following extracts were also taken from an article in the "Timberman":

"The question of what maximum grades to adopt for use on logging railroads is governed by several more conditions

than are considered in making this decision on a road to be operated for general freight. The general railroad is usually considered as a permanent structure; the logging road is essentially a single purpose line - its sole mission being the removal of the timber from a certain area. With the average railroad, the direction of loads hauled is fairly well balanced. As a general proposition the logging road is directly opposed to this - the load being one way. Again, theeaverage railroad is usually of such length, and trains of such frequency, that it is possible, and at times advisable, to put in a few miles of heavy grade and use a helper engine for putting trains over this section of the road, whereas the logging road is ordinarily too short, and the putting on of an additional engine means simply having two engines doing the work that one could do as far as the length of the haul is concerned.

"We will admit that there are cases where the establishment of a heavy grade is absolutely necessary on account of the character of the country, but this excuse does not apply when a track is extended over a hill on a grade that limits the hauling capacity on the whole line, simply because we happen to have a spur built into the foot of the hill, and we do not go back far enough on the old line to get over on a grade that will correspond to the remainder of the road. In the consideration of grades we are too apt to magnify the actual construction cost of today and neglect to consider what it will cost tomorrow and the next day and every day that we continue to

use it.

"In general railroad work the underlying principle governing the determination of what rate of grade to use as a maximum may be expressed as: 'The most economical grade is that one which will render the sum of annual interest on original cost and annual operating expenses a minimum'. As noted before, this applies to a permanent investment. From a logger's standpoint we must modify this standpoint to: 'That one which will render the sum of annual interest or original cost, annual operating expenses, plus original cost, divided by probable number of years to be operated, a minimum'.

"In order to get the above formula expressed in dollars and cents the engineer must be furnished with the following information:

(1) Approximate daily output of camps

(2) Approximate number of years to log area

(3) Kind and weight of locomotives

(4) Number of cars.

With this data the engineer is ready to go to work on surveys.

"After our preliminary surveys are made we can make a close estimate of the cost of construction on whatever grade lines we may desire.

"Knowing the kind of cars we are to use, we know how many carloads we have to haul daily.

"The hauling power of any locomotive cannot exceed the power it takes to overcome its adhesion to the rails, which runs from 20 per cent to 22½ per cent of the weight on driving wheels (25 per cent may be attained in starting by the use of sand). An engine is usually built to develop this amount of power, though it is well to check hauling capacity by calculating from cylinder sizes and steam pressure to prevent overestimating this most important item.

"The resistance of a train in motion on level track is from 6 to 8 lbs. per ton of weight of train. The resistance due to grade is 20 lbs. per ton for each 1 per cent of grade. From this it is seen that the hauling power of a locomotive on a grade is nearly proportional to the rate of grade.

Operating expenses consist of:

Maintenance of roadway and bridges

" " locomotives and cars

Wages of train crews

Fuel

Oil

Waste and other train supplies.

"Maintenance of roadway is nearly a constant expense, though it will increase materially with an increase in grades that cause material increase in number of trains, due to track being hammered down more by passage of engines than by cars. Too, from a standpoint of safety, it is necessary to maintain the roadbed on a heavy grade better than on light grades.

"With this information at hand, we are now in a position to make comparison of different grade lines. To make this a little clearer, let us compare two imaginary lines - assuming distance from woods to dump to be ten miles. On line "A" we have 5 miles of level line, then 5 miles of 4% grade. On line "B" take ten miles of 2% grade; both grades ascending towards woods, consequently against empty cars. Engine to be used - 40 tons, with 65,000 pounds on drivers - equivalent to traction power of 13,000 pounds; flat cars, 12 tons each when empty; output of camps 40 carloads per day; operation to last, say 10 years at 200 M feet per day. We have the following:

Line	A	B
Estimated cost of construction	$120,000	$150,000
Traction power of engine (lbs.0	13,000	13,000
Maximum resistance per ton of train (lbs.)	90	50
Tons that can be handled	144	260
Deduct weight engine & tender (tons)	60	60
Net loads (tons)	84	200
Number of cars	7	18
Number trips per day, approx.	6	2
Engine miles per day	120	40
Approximate time per trip	$2\frac{1}{2}$	3
Time on road daily (hours)	15	6
Annual charge to cover interest and wipe out cost of construction	16,000	20,000
Annual maintenance	6,000	5,000
Annual charge exclusive of train operation	$ 22,000	$ 25,000

	Case "A"	Case "B"
Annual engine repairs	$2,100	$ 700
Annual engine depreciation	1,200	600
Train wages (200 days) road engine	3,450	2,300
Switch crew in woods (200 days)	2,300	
Fuel	4,500	2,500
Miscellaneous train expense	1,000	500
	14,550	6,600
Annual charges exclusive of train operation	22,000	25,000
Total	$36,550	$31,600

"In considering this statement, under line "A", it is readily seen that one engine is worked to its utmost capacity, even possibly a little more than should be figured on, and it is of course necessary in this case to put in a switching engine in the woods for yarding out from landings and having train made up for road engine when it arrives; whereas, in the other case the road engine would have sufficient time to do necessary switching at camps itself.

"In making up the above statement the annual engine repairs are considered as being proportional to the mileage made by engines. Depreciation is considered in case "A" on two engines, and in case "B" on one engine. The investment in other equipment in this particular case is not considered as a probable amount would be about the same with each line. Case "A" requires more engines but less cars.

"We have not considered the cars and repairs to same, as it would be practically the same in both cases, although it probably would be heavier in case "A" on account of more extensive use of air brakes than in the other case.

"Taking all this into consideration, the lighter grade shows a saving of something over $5,000 per year, or on the total estimated operations for ten years about $50,000, which is certainly worth considering; and if more land should be secured or lands necessarily operated longer than expected, this would of course be increased.

"The question of grade expense is one that cannot be paid off by any certain amount spent at one time and be done with it, but is something that costs an increasing amount every day that the line is operated.

"Probably it may be considered that we have assumed a condition that does not come up very often, but results would show just the same if, instead of assuming a 5 mile of 4 per cent that we had assumed 2 or even 1 mile stretch of this rate of grade, as it would limit the haul on the whole road, and would not in all probability show such a corresponding saving in the first cost.

"There are, without doubt, many cases where heavy grades are necessary and advisable, and the writer is not arguing against them merely on account of heavy grades, but is taking this stand to rather show how it works out. There are lots of cases where short stretches of heavy grades can be used

that will materially reduce the cost of construction and at the same time not limit the hauling power of engines or the size of the train. That is, for instance, you have a piece of level grade or place where you can get a run at the hill. If the grade is not too long, the momentum of the train will carry it over far enough so that the engine can take it over with as little effort as if the grade were built lighter, but care must be exercised in putting in grades of this kind, and it must also be considered that no stops are to be made on or near the foot of the grade.

"As a case of this kind the writer is operating now over a grade of 3¼% of about 2,000 feet in length, and the engine, by taking a run at this grade, can handle a train that would stick on a long 1½% grade further up the line.

"In the constructing of logging spurs the one trouble with the average engineer, familiar with standard railroad construction, is that he wants to give a little too much weight to the question of costs of operation over heavy grade or line with a broken grade line - that is, hills and hollows, the tendency being to unduly increase the cost of construction and rather overlook the fact that the life or time the road is to be operated is limited, and this time limit is a very important factor in determining what is really the true economy of grade lines."

A logging superintendent in discussing steam railroads at the 1910 session of the Pacific Logging Congress made the following statement:

"The function of the steam railroad in the heavy timber of the Pacific Coast is to place a car within five hundred feet of every tree that can be reached at reasonable grading cost without exceeding twenty degree curves or seven per cent grades, and after the car is loaded to move it at a speed of twelve to fifteen miles per hour over a safe road bed to the mill, lake, or connecting line. This requires the cooperation of the owner, the superintendent and the engineer, but results in a maximum output at minimum cost, the proper goal in all productive industry. On any line which must carry traffic for three years, keep the grades below three per cent, the curves below twelve degrees. On branches, don't pass seven per cent grades if any reasonable grading cost will permit. Don't pass ten per cent anywhere, and keep these steep grades free from sharp curves and as short as possible."

Readers will gather from the above statements that the cost of transporting logs from the stump to the mill, water or connecting line will depend on the character of the road, which latter is determined to a great extent by the location of the road; that there is a relation between the location of the line, the total length, grades, curves, formation of roadbed, etc., and the cost of operating it; and that the proper location of a line constitutes a difficult task.

When the operator is not hampered by lack of funds and factors other than the topography and formation of the

country, the proper location of the mainline is probably not so difficult as the proper location of the spur lines. In the case of the mainline the aim is to haul the logs as cheaply as possible and three factors - the cost of constructing, cost of operation and amount of timber to be moved - have to be considered. In the case of the spur road these three factors which determine the cost of transporting the logs over such lines have to be considered in connection with the cost of moving the logs from the stump to the landing.

Quite often the topography of the country is such that there is only one feasible route, for the mainline. If there is more than one feasible route, the appraiser or locator has a difficult task set for him, the proper solution of which will require a high grade of engineering ability.

In the past, spur lines have possibly been located with less care than the mainlines. Such is not the case at the present time. Under the heading "Ground Yarding" the writer has pointed out the important relation between the cost of moving the logs from the stump to the landing and the cost of transportation over the spur lines. These spur lines may follow natural drainage or may be placed on high ground.

Construction.

Cost of Building Four and Three-Fourths Miles of Track, 1911.

Character of Construction.

The first 975 feet consists of pile-bent trestle.

Height, about 3 feet. Penetration, about 15 feet. Except in front of the dump (stationary unloading rig) where four piling to the bent were used, the bents consisting of three piles.

A branch trestle, 2325 feet in length and running in the same general direction as the graded track, is included. The bents in the trestle were made of three piling. Here, as in the first trestle mentioned, the caps and stringers were made of hewed stringers, with a bent spacing of 15 feet from center to center.

From the end of the first trestle, the road passed along a very steep hillside, over one switch-back and around an ox-bow. From the beginning to the end of the first $2\frac{1}{2}$ miles of graded track, the direct distance is about three-fourths of a mile. The last $1\frac{3}{4}$ miles was fairly light construction, traversing rolling-flat-swampy ground.

The maximum curve used was 30°. The maximum grade was 7 per cent. After the top of the hill was reacged there was an adverse grade of 5 per cent. The longest straight stretch (plus 7 per cent grade) was 1000 feet. The longest straight stretch of adverse (5 per cent grade) was 500 feet. The grade from the botton to the top of the hill averaged about 4 per cent.

Organization.

The work was organized as follows: chief engineer, resident engineer, foreman (grades), foreman (bridges), foreman

(right-of-way). The chief engineer located the line and directed the more important parts of the work. The resident engineer was directly in charge.

Cost of Engineering and Supervision.

The cost of this work, including original location, direction, supervision, salary and expenses of resident engineer and wages of assistants to resident engineer when engaged in surveying work, was $2012.25.

Preliminary Work.

This cost includes the cost of building temporary buildings for laborers, quarters for the pile-driving crew, and a float for an office. These buildings were later wrecked or put to other uses. Twenty-five per cent of their cost was charged against the construction work. The cost of the structures was as follows:

Material - - - - - - - - -	$127.30
Labor - - - - - - - - - - -	112.65
Total cost	$239.95

Depreciation. Twenty-five per cent of the total cost amounted to $60.00.

Grading Tools.

Practically all the work was done by hand. The total cost of grading tools was $308.29. They were later transferred to the logging department, and 33-1/3 per cent of their cost, or $102.76, was charged against the construction.

Bridge Tools.

This item covers the cost of wire rope for pile

driver, donkey, and tight line for bridge-erecting crew; also blocks, hooks, peavies, pike poles, repairs on donkey, oil, grease, waste and packing. The total cost was $975.17. At the completion of the work all tools other than lines and blocks were transferred to the logging department and the construction work was credited with $100, which leaves $848.17 to be charged against the construction work. This $848.17 was segregated into two parts, as follows:

$448. charged against "hill trestles"
427. " " "slough trestles"

Clearing Right-of-Way.

The grading on the side of the hill was done by hand. On the top of the hill the work, about two and one-half miles of line, was done with a donkey engine. No charge is made for the donkey engine and rigging.

The work, including felling and bucking, and clearing, amounted to $2,295.00; labor, $2,035.35; powder, $259.65.

The right-of-way was made about 30 feet wide; 3.64 acres to the mile.

Cost. Hand work per mile, about $528.00; machine work, about $419.00. Hand work per acre, $150.00 (labor $135; powder, $15.00); machine work, $115.oo (labor $100, powder, $15.00). Powder delivered, cost $.105 per pound.

The right-of-way was through a fairly heavy growth of second-growth Douglas fir; stumps were not large but numerous. Several openings along the line. On the side of the hill

the timber was felled clear of the right-of-way. The down timber was cut up in such length as could be handled easily with peavies. Large charges of powder were used. The machine work was fairly efficient. No allowance has been made for clearing for bridges, which work was done by the bridge crew.

Wages.

Hand Clearing.

Foreman - - - - - - - -	$3.50 per day
Powder man- - - - - - -	3.00 " "
Laborers- - - - - - - -	2.00 " "
Head fallers- - - - - -	3.75 " "
Second " - - - - - -	3.40 " "
Buckers - - - - - - - -	3.25 " "

Machine Work.

Foreman - - - - - - - -	$5.00 per day
Engineer- - - - - - - -	3.40 " "
Rigging men - - - - - -	5.00 to 3.25 per day
Fireman - - - - - - - -	2.75 per day

Grading.

The grading was all done by hand, the material being classified as follows:

90 per cent earth
8 " " loose rock or soft sand rock
2 " " solid rock

Eliminating the bridge and trestle work, there were three miles and 2,834 feet graded.

The average 100-ft. station required the moving of 211 cubic yards of earth; there were 39,402 cubic yards moved on the whole line.

Cost.

Labor - - - - - - - - - - - -	$8,824.05
Powder- - - - - - - - - - - -	1,247.57
Total cost (3.53 miles) - - -	$10,071.62

Average cost per mile based on 3.53 miles of actual grading, $2,853.00.

Average cost per mile based on 4.75 miles or the total length of the line, $2,120.34.

Wages.

Grading foreman per day - -	$3.50 to $4.00
Laborers, per day - - - - -	2.00

The laborers were fairly efficient.

The road was 16 feet wide on the ave   e; 50% of the work was side-hill grading.

Bridges.

Stringer Work. On top of the hill 1450 feet of stringer work was built through swampy ground. The conditions were ideal for this kind of work as the timber through which this work was extended was long, straight, second-growth fir.

The mud sills were spaced about 20 feet apart. The long stringers were not barked, nor was the top of the stringers hewed.

The labor cost of the work amounted to $565.50, or at the rate of $.39 per linear foot.

Trestles on Hill. These trestles, 15 in number, were frame-bent structures, erected by the tight line method. In length they ranged from 48 to 224 feet; in height, from 10 to

45 feet, averaging about 20 feet. Their total length was 1656 feet. The bents were 16 feet apart from center to center. Caps, 12 feet long and hewed to a 12-inch face on two sides, were used. The stringers were hewed on two sides; faces, 8 inches; thickness, 15 inches.

Cost.

Labor - - - - - - - - - - - - - - - - - -	$3,567.10
Bracing (27,040 ft. @ $14.00 per M)	378.56
Spikes and drift bolts- - - - - - -	229.80
Bridge tools (see item another part of statement) - -	448.17
Total cost exclusive of timbers-	$4,623.63

Labor per linear foot - - - - - -	$2.15
Bracing per linear foot - - - - -	.228
Spikes, etc., per linear foot - -	.132
Bridge tools per linear foot- - - -	.270
Total per linear foot exclusive of timbers - - - - - - - -	$2.78

The stumpage value of the timber used for bridges and stringer work is not included in the above cost statements.

"<u>Slough</u>"<u>Trestle</u>.

This item includes the cost of getting the trestle ready for the ties and steel, which was segregated as follows:

<u>Cost</u>.

	Total	Per linear ft.
Labor - - - - - - - - - - - - - - -	$2,187.00	$.63
Bracing - - - - - - - - - - - - - -	70.00	.021
Drift bolts - - - - - - - - - - - -	122.00	.037
Piling, caps and stringers- - -	1,242.00	.373
Brow skid straps- - - - - - - -	84.00	.025
Tools (see item "Bridge tools")	427.00	.127
Total - - -	$4,132.00	$1.213

Labor. Includes the building of 3,300 feet of 3-piling bent trestle, including the cost of driving the piling, hewing and placing the caps and stringers; also driving rollway, and hewing and placing stringers and caps for same.

Bracing. Approximately 5,000 feet of lumber was used, which has been included at $14.00 per M feet.

Other Segregations. The logging camp was given credit as follows:

Piling, caps and stringer, 41,400 ft. @ 3 cents per linear foot - - - - - - - -	$1,242.00
Brow skid straps - - - - - - -- - - - - -	84.00
	$1326. 00

The trestle averaged about 8 feet in height. Bents were 15 feet apart. Penetration of piling was about 15 feet.

Laying Track.

As 85 per cent of the line was on very heavy curves, with short tangents between, the cost of track laying was high. All bridges were double guard-railed, and all curves single guard-railed.

Cost. $2,821.50; $4\frac{1}{2}$ miles; $594.00 per mile (3000 ties to the mile, 56 lb. steel)

Wages.	Foreman - - - - - - - - - -	$3.50 per day
	Laborers- - - - - - - - - -	2.00 " "

Surfacing. The b

The ballast was blasted out of a pit and loaded by hand. Twelve to 15" was put under $3\frac{1}{2}$ miles of line. This was very expensive work as a great deal of the rock had to be broken by hand.

Cost. The total cost of ballasting $3\frac{1}{2}$ miles was $6,223.65, which is the rate of $1,778.18 per mile.

The road was put up in fine shape. Gauge 42 in.; ties, 8 ft. long (hewn in camp); steel, 56 lbs.

Total Cost.

The total cost of the $4\frac{3}{4}$ miles of track, exclusive of the cost of steel, fixtures, ties and certain other items, indicated in the above statements was as follows:

Items	Total Cost	Cost per Mile
Engineering & superintendence	$2,012.25	$423.63
Preliminary work, buildings	60.00	12.63
Grading tools	102.76	21.63
Clearing right-of-way	2,295.00	483.16
Grading - labor	8,824.05	1,857.70
Grading - powder	1,247.57	262.65
Stringer bridges	565.50	119.05
Trestles on hill	4,623.63	973.40
Slough construction	4,132.00	869.89
Laying track	2,821.50	594.00
Surfacing	6,223.65	1,310.24
Total -	$32,907.91	$6,927.98

Cost of Constructing One and One-half Miles of Track.

The following figures were given by the builder and are only approximately correct:

	Per Mile
Grading - - - - - - - - - -	$500.00
Laying track- - - - - - - -	300.00
Ballasting- - - - - - - - -	500.00
Clearing and grubbing - -	500.00

It was mostly a scratch grade, with only a few light cuts and fills. The line traversed an old cutting, making it necessary to swamp out considerable second growth timber, about

7 inches in diameter.

It cost about 40 cents per cubic yard to move the earth; $1.15 to move the rock. Sawed ties were used. Steel, 56 lbs. The laborers received $2.50 per day.

Gravel, taken from the river at the end of the line, was used as ballast.

<u>Trestles Used for Spur Logging Roads.</u>

The following is taken from an address delivered before the Pacific Logging Congress in 1910. More of the address is given than is necessary to develop the major subject. This has been done for the reason that other steps in railroad construction are covered in a practical way.

"In the winter of 1908 we constructed about two miles of railroad. The ground we had to build on was more or less swampy as we followed close to the creek bottom, and the high land was of a reddish soil and very soft and slippery.

"As we extended our logging railroad we tried different schemes in constructing it, with the object in view of making a more solid roadbed and which would be less expensive to keep up. Through the wet ground we first put small underbrush from one to two feet deep and then graded dirt on top of the brush to make our roadbed. Our experience showed that it was rather expensive to build in this way, as the dirt had to be shoveled on top of the brush first by hand before using a scraper. We found it just as costly to keep up the track when building railroad in this way.

"We then tried to construct a piece of railroad by first laying 4x12" stringers lengthwise and covering them solid with 3" planks the same as they construct regular plank road. We first bedded the stringers in the ground and then covered them with 3" plank so they rested on the ground in order to make it a solid road, and laid the rails on the stringers. The traffic settled the outside stringers, causing the plank to break in the center. - - - - We had to abandon this method of building road.

"This locality had no gravel, our ground is very soft, and we found it advantageous to use wider ties n the standard, making them 5" thick and from 10 to 16" wi , as the wide ties held the track up better. The wide ties were harder to tamp under on account of their width, but we overcame this by jacking up the track a little higher so we could throw the dirt under the ties.

"When we first started to construct our railroad we used horses to clean up the right-of-way, but we soon found that it was more expensive than a donkey on account of the soft ground which caused the horses to mire. Scraper work is the severest work you can put horses to.

"We next used a donkey for clearing out the right-of-way, using a scraper to make the grades; but experience taught us that this was a very expensive way to build railroad as we were continually breaking our rigging on account of so

many roots the scraper would come in contact with, and it made it very expensive to keep up the donkeys for this kind of work. Hence we abandoned trying to build railroad with a donkey scraper.

"Our railroad crosses several little canyons and we used logs at first to crib with to make out trestles. While this makes a very strong trestle we found that some of the logs would settle more than others as some would probably be on soft ground and others on roots, and found it was very difficult to keep the track level and in line when using logs for cribbing. We believe if the ground was firm this way of cribbing would make a good trestle.

"When building railroad one's object should be to get it as straight as possible, to avoid curves, and get it level. When building a straight graded railroad the stumps have to be blasted, which takes considerable powder, then you have to pull them out of the way with a donkey, clear your right-of-way, and do your grading.

"The construction of a railroad depends largely on the kind of a locomotive you are using. The locomotive we were using was a 24-T Baldwin with six 33" drivers, built direct, and of the regular Mogul type. This style of locomotive is harder on the track than a geared locomotive, as the weight is all on the drivers, and the whole weight of the locomotive is on a 7' wheel base, making it very hard on the track.

"We handle a great many cars that are loaded with lumber to full capacity of 100,000 pounds, and this kind of traffic is very hard on the track. In order to overcome this heavy traffic and to save expense in building railroad, two years ago (1908) we purchased an 8x10" hoisting engine to be used for a pile driver. We use six men on our pile driver, which clears up the right-of-way, and does away with the blasting of stumps. If a stump comes in the way we either saw it off or put our piling a little closer together or spread them a few feet. We drive our bents 10 feet apart and only use two piling to the bent. The six men clear up the right-of-way, cut their own piling, make and place the caps and stringers, constructing about 100 feet per day on the average. This would make them drive about 20 piling per day.

"We build this trestle railroad clost to the ground, running from one to six feet, averaging about two to three feet. Most of our piling is cut about 10 feet in length; the shortest 5 feet; the longest 24 feet; there being only a few 24 feet in length.

"The timber used for piling is cedar, fir and hemlock, whichever is handiest to the right-of-way. Diameter of piling 8" and up. The piling being short and small in diameter, we generally find enough close to the right-of-way that the pile driver can reach.

"The size of the caps is about 12x12"; stringers 12x14"; ties 5"x whatever width comes from the mill.

"Since we started building piling road we are building a straighter track and keep it more level and find that we have practically no expense to keep up the track that we have built on piling in the past two years.

"The cost of construction depends largely on the kind of ground you have to build on, whether it is level or whether it contains a good many ravines and canyons. We think the ground our railroad is constructed on is a fair average as we run along a creek and side hill and have not many ravines to cross.

"We find from what graded railroad we have built that the cost of construction is about as follows: Six men and a donkey will clear up about 300 feet of right-of-way per day, blasting stumps and moving the logs to one side so that the grading crew can follow. Six men and one team will grade and lay ties and steel and construct about 100 feet per day, or take 18 men and three teams to construct and keep up with the donkey which is clearing out the right-of-way. On some ground this number of men could build twice this amount of railroad, but when you take into consideration the canyons and bad ground that a logging railroad runs through we think this is a good average and it would cost $1288 to build a mile of graded road, basing the men's and teams' wages at $2.50 per day, without counting the cost of hauling the ties to the woods or the cost of ties, rails, bolts, splices, etc. We think this is a very

low estimate on building graded railroad.

"It was very wet land where we built our piling road and it would have cost us several hundred dollars more to build a mile of graded road. We use six men on our pile driver and they clear away the brush 100 feet in width so as to protect the road from fire, cut their own piling, drive two piles to the bent, cap same, build 100 feet per day, and pull the stringers alongside where they are to be used. Six men will pull the stringers and lay the ties and rails and construct 100 feet in a half day. Basing their wages at $2.75 per day, it will cost $1306.80 to construct one mile of piling railroad without counting the cost of timbers, ties, rails, etc. This would make a mile of piling railroad cost $18.80 more than a mile of graded road.

"When building a dirt road the cost of labor is less as you can generally use commoner and cheaper labor. The only disadvantage we see in the piling railroad is that it is in more danger of being destroyed by fire and if it should butn up the rails would be destroyed, but by clearing it well on each side of the track we have minimized the fire danger.

"We have about $6\frac{1}{2}$ miles of railroad, about $4\frac{1}{2}$ miles of it graded road. It takes four men continually to keep up this $4\frac{1}{2}$ miles of graded road, and on the other two miles of piling road there is practically no expense to keep it up. Generally a logging railroad is only in one place from 7 to

10 years until it is torn up and moved into a new body of timber. We believe our piling road will last us this long with very little expense to keep up; hence we cannot speak too highly in favor of the piling railroad where you do not have good ground and gravel to build on."

Total Cost of Clearing Right-of-way, Grading, and Preparing Roadbed for Track.

The average cost per annum of clearing right-of-way, grading, and preparing roadbed for ties at a camp in Washington during 1910, 1911 and 1912 was $2,300. The cost per station ranged between $28 and $64. The average cost per station was about $44.

The work was contracted, and done by hand. It includes the cost of felling and bucking on the right-of-way.

The above cost does not include the cost of building trestles, of which there were few.

At the present time the contractor receives $40 per station where the cuts and fills do not exceed a depth of 3 feet.

The 25 miles of grade built include 6 or 7 miles of rather hard side-hill work. Very little rock work had to be done.

Cost of Clearing Right-of-way, General.

The cost of clearing right-of-way varies greatly. Seldom is the cost of this work segregated in such a way as

to make it possible to get cost data that is at all satisfactory. To those who are not at all familiar with this work, the following cost statements may be of some value. Here again cost data published for the use of railroad engineers will be helpful. R. C. Bryant makes the following statement: "In the Pacific Northwest clearing a 50-foot right-of-way costs from $2 to $12 per 100 feet, depending on the amount of brush, down timber and standing timber on the site and the difficulties of moving it". The average should not exceed $500 per mile if the stumps are blasted and the timber is dragged from the right-of-way by a yarding engine.

Cost of Clearing Right-of-way.

The following is the labor cost of felling timber on 400 feet of way:

Number of trees felled - - - - - 13

Diameters of trees felled were as follows:

Trees (hemlock)	Diameter in inches
2	16"
1	28"
1	18"
2	30"
2	17"
1	32"
1	20"
2	24"
1	60"

Cost - $3.75

Cost per linear foot - - - - - - - - - - .0100

Labor, two men, one-half day;
wages per day; one man at $4.00,
one man at $3.50.

Cost of Clearing Right-of-way for Fallers.

Labor cost of bucking dead and down timber and swamping ahead of the fallers for a distance of 1100 feet.

Cost. The total labor cost was as follows:

6½ days @ \$2.75 - - - - - - -	\$17.88
½ day @ \$3.00 - - - - - - -	1.50
	\$19.38

The cost per linear foot was \$.0176.

Cost of Clearing Right-of-way.

Labor cost of clearing 500 feet - - - - - -	\$75.48
" " per linear foot- - - - - - - - -	.15
Time: 17 hours @ \$4.17½, 20 hours @ .22½	
Average distance per day- - - - - - - - - -	290 feet

Wages Per Day. Chunking crew: hook tender, \$4.50; engineer, \$3.50; fireman, \$3.00; woodbuck, \$2.75; 4 rigging men, (each \$3.25), \$13.00; laborers, \$2.25.

The laborers placed holes under the stumps and the chunking crew loaded and shot the stumps. No machine moving or pipe laying is charged against this work, nor is the cost of felling the timber included.

Cost of Clearing Right-of-way, Powder Work (Hemlock Timber).

Distance -	200 feet
Number of stumps and snags blown - - - - - - -	8

Diameter of stumps:

1	hemlock stump - - - - - - -	16	inches
1	" - - - - - - -	60	"
1	" - - - - - - -	17	"
1	" snag - - - - - - -	16	"
1	" stump - - - - - - -	24	"
1	" " - - - - - - -	32	"
1	" " - - - - - - -	42	"
1	" " - - - - - - -	48	"

Rate of Wages - - - - - - 2 men @ $3.25 per day

Time taken- - - - - - - - $\frac{1}{2}$ day, 2 men

Total cost labor and supplies -

5 boxes lionite powder @ 11¢ per lb. - -	$27.50
Caps, (#8, $1.40 per 100)- - - - - - - - -	.55
Fuse, (45¢ per 100 ft.)- - - - - - - - - -	.20
Labor- - - - - - - - - - - - - - - - - - - -	3.25
Total cost - - - - - - - -	$31.25

Cost per linear foot - - - - - - - - - - - - - .15$\frac{3}{5}$

Cost per mile - This would make a cost of $836.00. If, however, there were cuts and fills the cost would not run so high as some stumps would not have to be removed and others would not necessarily be removed with powder.

Cost of Clearing Right-of-way, Powder Work (Hemlock Timber).

Distance - - - - - - - - - - - - - - - - - - 600 feet

Number of stumps and snags blown - - - 24

Diameter of stumps:

3	hemlock	stumps	- - - - - - - - 16 inches
3	"	"	- - - - - - - - 60 "
2	"	"	- - - - - - - - 17 "
4	"	snags	- - - - - - - - 16 "
4	"	stumps	- - - - - - - - 24 "
2	"	"	- - - - - - - - 32 "
2	"	"	- - - - - - - - 42 "
4	"	"	- - - - - - - - 48 "

Cost:

5 boxes of powder @ 11¢ per lb. - - - -	$27.50
1 man @ $3.50 per day - - - - - - - - - -	3.50
1 day (four men @ $2.25 per day)- - - -	9.00
Total- - - - -	$40.00

Per linear foor - - - - - - - - - - - - - - .0666

Cost of Clearing Right-of-way.

The labor cost of clearing 13,350 feet was $2,454, which was at the rate of abour $977.00 per mile. The timber, consisting of Douglas fir and hemlock, was cutting out about

45 M feet per acre, and averaged about 32" D.B.H. The "show" from the standpoint of down timber, brush and dead snags was bad. There were no heavy cuts and fills.

Cost of Clearing Right-of-way, Powder Work.

One powder man estimated the amount of powder required on hemlock stumps as follows:

Stump diameter	Sticks 20% Lionite Powder
16"	10 sticks
18"	11 "
20"	11 "
22"	12 "
24"	12 "
26"	13 "
28"	14 "
30"	15 "
32"	16 "
34"	17 "
36"	18 "
40"	19 "
50"	20 "
60"	30 "

Experience has shown the estimate to be about 10 per cent too low when compared with the amount of powder used by the estimator and other powder men.

Grading.

This includes the construction of the roadbed as it relates to the movement of earth and rock for cuts and fills. The cost of grading in a given case is a difficult thing to estimate, even where the estimator has a grade profile and the material classified. To estimate the cost of grading the main and spur railroads in a given case with a rather limited knowledge of the country is an exceedingly difficult thing to

do. To do it with any degree of accuracy is impossible. It is largely a question of "judgment". Here on the Coast, grading might be done on short stretches for as little as $10 per station (100 ft). On the other hand, it might cost $20, $30, $40, $60, or more, per station.

Practically no cost data dealing with the cost of grading is given in this circular. This is due to the fact that little has been secured by the writer. It is quite impossible to secure. It is not a difficult thing to secure the amount of money expended by a logging operator during a year for railroad construction, but when one tries to get it segregated into clearing right-of-way, grading, etc.; tries to get the total length of line built, the total amount of earth moved, a classification of the material moved, etc., it is a different matter. The companies as a rule cannot give this information. They have not got it. The writer does not mean to say that information along this line cannot be secured, but rather that any information that can be secured is not in such form as can be put down on paper.

Any one desiring to develop the ability to estimate the cost of grading should familiarize himself with what is said on this question in standard works on railroad engineering, also works on cost data published for use by railroad engineers.

Cost of Grading With Pick and Shovel.

The labor cost of grading 13,350 feet was $6,664.00, which is at the rate of about $2,630.00 per mile. This cost

does not include the cost of clearing right-of-way which amounts to about $997.00 per mile. It, for the most part, was a scratch grade, there being no heavy cuts or fills.

Cost of Grading with a Scraper.

During the first 6 months of 1913 the cost of moving dirt with a power scraper at a camp in Washington ranged from 28 to 38 cents per cubic yard.

Equipment

Donkey engine
Bagley scraper

Crew and wages

Engineer, per day - - - - - -	$3.40
Fireman, " " - - - - - -	3.00
2 wood bucks, per day - - -	2.75
Hood tender, " " - - -	4.25
1 or 2 men, " " - - -	3.25

The two following records show the cost of moving dirt with a power scraper in 1912, also how the record is sometimes kept.

Cut No. 1 Sta. 3 + 75 to Sta. 7 + 30 Spur off Spur 1.

16.7 yds. per hour actual scraping time ______ feet average haul

60	hr. moving machinery to place..........................	$37.50	.0095
____	hr. chunking right-of-way..............................	262.50	.0668
85	hr. placing water line.................................	40.50	.0103
235	hr. rent of machinery @ $1.50..........................	352.50	.0897
235	hr. Engineer @ 31½¢-Fireman @ 27½¢-Woodbuck @ 25¢.	206.39	.0525
235	hr. Hooktender @ 50¢..................................	117.50	.0296

____	hr. Rigging men @ ____	$153.43	.0390
____	hr. Laborers finishing @ ____	69.33	.0176
	Yarding wood logs	16.55	.0042
	3927 cubic yards cost	$1256.20	.3192

Ground - Good averages. Alignment - 40° curve.

Remarks: On account of alignment this cut was scraped from each end. One-half the cost of grading Spur 1 off Spur 1 has been placed against this cut (sloping down the cut). The hours chunking includes this part of the spur from Station 0 to 7 + 30.

Cut No. 20 Sta. 317 + 50

228 yds. per hour actual scraping time ______ feet average haul

61½	hr. Moving machinery to place	$15.85	$.0031
158½	hr. Chunking Right-of-way	99.12	.0193
21½	hr. Placing water line	11.45	.0022
223	hr. Rent of machinery	329.50	.0650
282	hr. Engineer @ 32½¢-Fireman @ 30¢-Woodbuck @ 27½¢	203.30	.0395
225½	hr. Hooktender	94.18	.0183
346½	hr. Rigging men	110.38	.0215
2488	hr. Laborers finishing @ 25¢	622.00	.1210
59½	hr. using powder	26.78	.0052
	Yarding wood logs	71.85	.0139
	500 pounds powder @ 11¢	55.00	.0107
	5143 Cubic yards cost	$1639.41	$.3197

Ground - average. Alignment - 24° Curve _ and 18° Curve L.

____________Engineer in charge 20 Average trips per hour.

Remarks: This cut was scraped from both ends on account of length of haul and account of springs. Because of springs the cut was taken considerably below grade and the alignment changed so as to obtain a solid roadbed. The item "finishing" includes 100 feet general grading (this yardage lying between the scraper work and Bridge 14).

Cost of Scrapers.

The cost of a Bagley two-yard scraper is about $225.00.

Timber Work.

The work consists of trestles, culverts, cribbing, revetments, etc. It is not thought advisable to discuss the character of structures and the method of building in this circular. For this phase of the work standard works on railroad engineering should be consulted. A simple treatment is given in "Logging" by R. C. Bryant.

Trestles.

These are used in crossing streams, depressions, and swampy ground where the cost of a fill would be excessive, or where a fill would not be practical. They are cheaper to build than heavy fills and when the road is used for a short time only, parts of the trestle can be taken up and used on another line.

They are built in two types known as pile-bent trestles and frame-bent trestles, the bents forming the sections of the trestle on which the stringers rest.

Pile trestles are used largely in stream beds and swampy spots where good foundation for framed trestles cannot be secured. If the formation is such that piling cannot be driven, the frame-bent type will be used. If there is a large amount of trestle work to be done and the formation will permit the driving of piles, the pile-bent type will probably be used. If only occasional trestles have to be built and those small ones, it will probably be found cheaper to use the frame-bent type.

Cost of Trestles. Much information dealing with the cost of building trestles can be secured from logging cost data published for railroad engineers. "Frame-bent trestles are frequently built by contract, the price being regulated by the amount of timber used and the height of the trestle. The labor charge for trestle construction where the structure is less than 10 feet in height is from $2 to $4 per M feet of timber used, while high trestles may cost from $7 to $10. Payment for pile trestles, when built by contract, is made on the basis of the number of piles driven and the amount of sawed timber used in the remainder of the structure."

Cost of Pile-bent Trestles. An engineer who has had considerable experience in building pile-bent trestles stated in 1912 that the labor cost would be about as follows:

Cost of Pile-bent Trestles. An engineer who has had considerable experience in building pile-bent trestles stated in 1912 that the labor cost would be about as follows:

Labor Cost, Piling Trestles:

Average height:		Cost per linear foot:
5 to 10 feet	No bracing	$2.00
10 " 15 "	" "	2.20
15 " 20 "	" "	2.20
20 " 25 "	With bracing	3.00
25 " 40 "	" "	4.00
40 " 60 "	" "	5.00

Type of Trestle.

Length of span -------------16 feet.

No. of piling to bent: Up to an average height of 25 feet, 3; over 25 feet, 4.

Bracing: Any trestle over 25 feet would be braced by standard methods. If curve is heavy, braces would be used even though the trestle was not more than 15 feet high.

Size of piling: No material having less than a 10" top would be used, and this size only in low trestles.

Stringers: Hewed, 16 to 32' in length, 17" and up in thickness, face 12" and up; 16" faces are very satisfactory.

Caps: Hewed, 14' long, 12" and up in thickness; not less than 12" face.

Cost includes the cost of yarding the material to the site.

The following is the cost of several small trestles built in logging camps during the past two or three years.

<u>Cost of Pile-bent Trestle</u>. The following trestle was built in 1913 for $287.00 or $2.05 per linear foot, as follows:

Excavating - - - - - - - - - - -	$237.30
Rent of machinery- - - - - -	27.50
Finishing- - - - - - - - - - - -	22.59
Total - - - - - -	$287.39

This cost includes all labor used in yarding piling to the location, driving piling, moving machinery to location, cost of surveying, laying track, and the rent on machinery which was figured at $5.00 per day.

<u>Cost of Pile-bent Trestle</u>. The labor and iron cost of the following structure amounted to $900, or $.50 per linear foot. It was built in 1910.

Character of structure -

Length --- - - - - - - - - - -	1800 feet
Average height - - - - - - -	5 "
No. piles to a bent- - - -	3
Caps - - - - - - - - - - - - -	Hewed timbers
Stringers - - - - - - - - -	" "

Only occasional ties were spiked to the stringers, the ties being kept in place by a 1 x 4" strip nailed along the ends of the ties. The piles, caps and stringers are mostly hemlock. The value of the timbers is not included in the above cost.

Cost of Pile-bent Trestle. The following trestle was built in 1912 for $464.00, or $2.90 per linear foot, as follows:

Excavating	$106.25
Labor (including surveying-$40.73)	265.68
Rent of machinery	60.00
Finishing (including laying 1f steel)	33.00
Total	$464.93

Length - - - - - - - - - - - - - - 160 ft.

It was of three-pile-bent construction. The average height was 20 feet. It was not braced as the piling was driven through a fill. Caps and stringers were made of hewed timber. The above cost does not provide for the value of the timber used, nor the cost of the iron. It does provide for the cost of yarding the timber to the site.

Cost of Pile-bent Trestle. The following trestle was built in 1911 for $5430.76, or $4.52 per linear foot, as follows:

Material, stringers, caps and iron	$1450.81
490 piling, (25' in length) @ 7¢ per ft.	857.50
Towing, piling	70.00
14 M ft. of lumber @ $8.00 per M	112.00
Labor: May	186.00
June	1416.00
July	432.00
August	248.00
September	656.00
	$5428.31

Pile-bent structure; 1200 ft. in length; average height, 10 ft.

Cost of Pile-bent Trestle. The following trestle costs $5.20 per linear foot in 1912, which cost includes the labor cost of yarding the timber to the site, building, and a

rental of $5.00 per day on the machinery. It does not include the value of the material, sawed or otherwise.

Length	135 feet
No. of piling to bent	4
Length of span	16 "
Greatest height	47 "
Average	28 "

Material: Hemlock piling, hewed hemlock caps, sawed stringers and bracing. There were 3 sets of bracing, made of 3x8" and 3x10" material. Longitudinal braces were made of 3x8" lumber.

Cost of Pile-bent Trestle. The following trestle cost $2.50 per linear foot in 1912, which cost includes the labor cost of yarding the material to the site, building, and a rental of $5.00 per day on the machines.

Length	160 feet
Greatest height	20 "
Average "	12 "
Length of span	16 "
Number of piling to a bent	3 "

Material: Hemlock piling, hewed hemlock caps and stringers, and no bracing.

Cost of Pile-bent Trestle. The following trestle cost $2.40 per linear foot in 1912, which cost includes the labor cost of yarding the material to the site, building, and a rental of $5.00 per day on the machines:

Character of structure -

Length	160 feet
Greatest height	12 "
Average	8 "

Length of span	16 feet
Number of piling to bent	3

Material: Hemlock piling, hewed hemlock stringers and caps, and no bracing.

Cost of Pile-bent Trestle. The following trestle was built in 1911 for \$388, or \$2.28 per linear foot, itemized as follows:

Moving machinery to place	\$42.77
Yarding piling to location	33.75
Driving piling	117.36
Placing stringers and caps	77.46
Laying track	18.50
Excavating	17.12
Surveying	19.09
Drift bolts, 200# @ \$2.25 per 100#	4.50
Rent of machinery	58.50
Total	\$389.05

Total length of structure	170 ft.
No. of piling	39
Av. length of piling	20 ft.
" penetration of piling	10 "
Sawed caps	7

Sawed stringers, 8 x 16 D. fir
Alignment: 100 ft., 28° curve; 70' tangent
Bracing 300 ft. B.M. (3x12")

The above cost does not take care of the cost of the timber used for piling and caps, or the cost of the sawed lumber stringers, caps and bracing.

Cost of Frame-bent Trestle. The following trestle was built for a labor cost of \$1611.00 or \$5.00 per linear foot:

Length	322 feet
Height	41 "
No. of bents	8

It was made of hewed sills, caps and stringers. The value of the material which was yarded from near the site is

not included in the above cost.

Cost of Frame-bent Trestle. The following is quoted from the April number of "The Timberman":

"Yacolt, Wash., March 12, 1914. The Timberman: Inclosed please find photos of bridge just rebuilt by the Twin Falls Logging . two miles east of Yacolt. The bridge was first built eleven years ago, and is a four-deck wooden trestle, on a 12 per cent curve, with a 2 per cent grade, and consists of 36 bents with 16-ft. centers and the highest part 130 feet. The general fire three years ago last summer burned the top deck, also bents 1 to 8 and 32 to 36, from the ground up, and we tore down and rebuilt with new timber bents 8 to 32, up to the fourth deck, and the fourth deck was taken off and replaced. There are 314,000 feet of new lumber in the bridge and the cost of rebuilding was about $11,000.

Edw. P. Scanlon,
Logging Engineer."

Cost of Driving Piling. The following is the daily cost and output of a pile driving crew:

Crew

Engineer - - - - - - - - - - - - - -	$3.00
4 men @ $2.75- - - - - - - - - - -	11.00
Wood buck @ $2.75- - - - - - - -	2.75
One day's cost - - - -	$16.75

Output - 4 bents of 4 piling each with caps.

The average height of bents was 20 feet; penetration, 8 feet.

__Cost of Pile-driving by Contract.__ In 1911 the _____ Bridge Company proposed to build about 2,000 feet of trestle for the __________ Lumber Company for the following quoted figure: " - - - - to drive, cut off and cap your three-pile rollway and trestle bents, 16' centers, for seventy-five cents ($0.75) per linear foot in a longitudinal direction of trestle or rollway." The logging superintendent of the _____ Lumber Company advised his company that seventy-five cents per linear foot, or twelve dollars per bent was excessive, and that they could not afford to pay more than forty cents per linear foot, estimated as follows:

__Daily Labor Cost__ -

Foreman - - - - - - - - - - - -	$4.00	per day
En ineer- - - - - - - - - - - -	3.50	" "
Fireman - - - - - - - - - - - -	2.75	" "
3 men @ $3.00 - - - - - - - -	9.00	" "
Total, labor- -	$19.25	" "
Rent, pile driver - - - - - -	10.00	" "
Total - - - - -	$29.25	" "

Driving 16 piling per day - - - -	$1.86	per pile
Contractor's profit (15%) - - - -	.28	" "
	$2.14	" "

This is equivalent to $6.42 per bent, or 40 cents per linear foot. Length of piling above ground, 10 feet; penetration, 15 feet. Before making this estimate the superintendent made a study of the cost of building another trestle. The following is his note: "The contractor for the _____ Railroad Company drove piling and capped them for an average of $1.62 apiece. It cost them $0.80 apiece to do the work."

Log Crib Bridges.

Practically no log crib bridges are used in the logging camps of the Northwest, experience having shown that the trestle - pile or frame-bent - is cheaper and more satisfactory. The following gives the cost of several of these structures:

Cost of Log Crib Bridge. The following log crib bridge was built for $2.70 per linear foot, itemized as follows:

Excavating - - - - - - - - - - - - -	$12.50
Labor- - - - - - - - - - - - - - - -	116.25
Rent of machinery- - - - - - - - -	90.00
Finishing- - - - - - - - - - - - - -	5.00
Total - - -	$223.75

This was a low crib bridge, having three stringers. Length, 83 ft. Average height, 5 ft.

Cost of Log Crib Bridge. The following log crib bridge was built for $5.43 per linear foot, itemized as follows:

Excavating - - - - - - - - - - - - -	$66.75
Labor- - - - - - - - - - - - - - - -	290.63
Rent of machinery- - - - - - - - -	172.00
Finishing- - - - - - - - - - - - - -	13.00
Total- - - -	$542.38

This structure constitutes the tail of a switch-back, with two bridges resting on one foundation. The average height is 10 ft. The alignment necessitated 3 stringers. There is one span 50 feet in length and two 25 feet in length.

Cost of Log Crib Bridge. The following is quoted from a report by a logging engineer to his company, which resulted from a visit to a neighboring camp: "The bridge work is of the log crib type, and here again excessive cost is noticeable. A bridge over _____ Creek cost $800, being 120

feet in length, or a cost of $6.66 per linear foot; another, 20 feet high and 140 feet long cost $860.00, or $6.14 per foot. Further, these costs do not include the value of the spruce and fir timber in the bridges."

Track Laying and Removal.

As far as the writer knows this work is always done by hand in the logging camps of the Coast in Oregon and Washington. It is done both by contract and by day labor, although the latter is by far the more common practice. It is difficult to say just what it costs logging operators to lay and lift track. This is due to a number of factors. In the first place, very few operators keep their accounts in such shape that they know themselves. Then, again, this work does not always include the same expenses. Furthermore, conditions, wages of labor, efficiency of labor, etc., vary greatly. Those desiring to secure an idea of this work should familiarize themselves with the cost of this work on mainline railroads, bearing in mind that logging operators generally have to pay higher wages, secure less efficient help and seldom work under as favorable conditions.

Track Laying.

Track laying is here considered as the operation of loading the ties, rails, etc., to the cars, unloading the ties, rails, etc., placing the ties and rails, and curving the rails and joining them. The cost of the train service is not in-

cluded in cost data given unless it is so specified.

Cost. The cost of track laying, exclusive of the cost of the train crew, probably ranges between $275.00 to $350.00 per mile. One logging superintendent who has directed the building of more than 25 miles of logging road during the past 3 or 4 years, estimated the cost of laying 1,000 feet of standard gauge track with new steel as follows:

Use of locomotive - - - - - - - - - -	$10.00
Train crew, firemen & engineer- -	7.00
Foreman - - - - - - - - - - - - - - -	4.00
12 hands @ $2.50- - - - - - - - - - -	30.00
Total - - - -	$51.00

This is at the rate of about $270.00 per mile.

Cost of Laying and Lifting Track.

A logging superintendent stated that it cost from $10 to $12 per station to lay and lift track. A section foreman who has had considerable experience in laying and lifting logging railroad track stated that track could be laid and lifted for about $10 per station, figuring wages at $2.50 per day.

Cost, Installing Switches.

A section foreman stated that the labor charge for installing a switch amounted to from $20.00 to $22.00. Wages, $2.50 per day.

Cost of Track Laying and Surfacing.

The following is taken from Gillette's Hand Book of Cost Data: "Contracts for track laying on new railway con-

struction are not at all uniform as to specified methods of payment, largely because of varying practice as to the time and method of ballasting. If the ballast is not placed at the time of track laying, it is customary to divide the payment for track work in two parts - (1) track laying, and (2) surfacing track.

"Track laying involves the unloading of the ties and rails from the cars, trimming the earth to true grade to receive the ties, delivering and placing the ties and rails thereon, curving the rails and joining them.

"The railway company usually stands the cost of loading the ties, rails, etc., at the material yard and the transportation to the site of track laying work. This expense is charged upon the railway company's books as 'train service'.

"Surfacing track consists in shoveling earth in between the ties, aligning the track and tamping. Where suitable material for filling between the ties is not at hand, it is hauled in on cars at the expense of the railroad company, and the contractor loads and unloads these cars at a separate unit price agreed upon. Such material if hauled in is usually gravel, and is called ballast.

"On the Northern Pacific Railway the contract prices for track laying and surfacing have been quite constant for the last 30 years, being about $250 per mile for track laying and $200 per mile for surfacing. The engineer's preliminary estimates of the cost of 'train service' have usually been about

$100 a mile, but the actual cost has ranged from $75 to $150 a mile.

Summarizing we have:

	Per mile
Track laying (contract price) - - - - - -	$250.00
Surfacing (" ") - - - - - -	200.00
Train Service (including loading) - - -	125.00
Total - - - - - - -	$575.00

"Of course the length of all permanent siding is included in arriving at the mileage.

In addition to this item of 'train service' there is the cost of transporting workmen to the site of the work, ---------. The cost of transporting men and plant has seldom exceeded $25 per mile of track. This brings the total cost up to about $600.00 a mile. An allowance greater than this is generally an error on the side of liberality.

"Where all the track is to be ballasted at once, the present practice is to include the cost of 'surfacing track' as a cost of the ballasting.

"To indicate how the contract prices run under such conditions we may cite the bids on the Portland & Seattle Ry., in 1906, which were as follows:

"Track laying, including loading of track materials but not including unloading in the yard, $300 per mile. Tie plating (fully tie-plated), $75 per mile. Labor on single tie plates, 1-3/8 cents each; labor on switches, $25 each; ballast 27 cents per cubic yard.

"This price is for ravel ballast and includes all the cost of loading and unloading the same and tamping it under the ties, and lining up the track, but does not include the train service nor the wear and tear on the steam shovel which is furnished by the railway company. The train service rarely exceeds 8 cents per cubic yard and another 1 cent will usually cover steam shovel repairs and depreciation. This 9 cents added to the contract price of 27 cents gives a total of 36 cents per cubic yard of gravel ballast in place. This is a liberal estimate under ordinary circumstances."

Surfacing.

Surfacing track consists of shoveling earth in between the ties, aligning the track and tamping. Where suitable material for filling between the ties is not at hand it is hauled in on cars. Such material if hauled in is usually gravel or broken rock, and is called ballast.

Cost.

The cost of surfacing probably ranges between $250.00 and $350.00 per mile, depending on how well the work is done and the amount of ballast used. This does not include the cost of foreign material.

Cost of Ballast.

The cost of surfacing as discussed by the writer only includes the labor cost of shoveling the material between the ties, from along the track and tamping. If the material has

to be hauled in on cars, as is usually the case where the track is to be used for a considerable period of time, the total cost of surfacing will be considerably higher. Whether some material other than that found along the track will be used for ballast will depend on the formation of the roadbed, the kind of material along the right-of-way, when the track is used, the time it is used, and the traffic. The same factors will determine the amount of gravel or broken rock, etc., it will be necessary to use. This suggests that in estimating the cost of surfacing one should know the character of the ground and where ballast can be secured. Where ballast is scarce and has to be hauled in, the cost per mile is considerable. One case has already been given where the cost of surfacing amounted to $1799 per mile, which high cost is due to the high cost of delivering the ballast along the track. The writer has in mind another case where the cost of ballast delivered along the track was $1200 per mile.

The cost of ballasting the mainline road will be higher than the spur railroads.

If a spur is going to be used only during the dry season, it may not be necessary to use any rock ballast. There is direct relation between the amount of rock ballast used and the cost of railroad maintenance, and most operators are finding it economical to use plenty of rock, gravel or other ballast.

Track Materials

Crossties.

Both sawed and hewed ties are used. Most camps use hewed ties which are cut on or near the right-of-way. The price of sawed ties varies, ranging from $8 to $11 per M feet. It is easy at any time to secure the cost of sawed ties, also the cost of transporting them from the mill to the camp. The following is a copy of an agreement entered into between a logging company and a tie-making contractor. The ties were cut from on the company's ground and along the right-of-way or track. The company was operating in second-growth fir and plenty of first-class tie-material could be found close to the track. It was never necessary to skid the ties more than 300 feet.

"In compliance with our verbal agreement, we agree to buy from you alongside, or within twenty feet of our railroad tracks, at such points as will be designated by us, 50,000 railroad ties of Class #1 and Class #2 and 1,000 per month of Class #3. The following are the specifications under which the ties are to be made:

Class #1 - Hewed ties of Class #1 shall be of red or yellow fir, not less than 8 feet, nor more than 8 feet and 2 inches long, with ends sawed off square; shall be peeled and shall be hewed on two sides, straight and true to an even thickness of 7 inches throughout. They shall not be less than 6

inches wide at the narrowest place, nor more than 9 inches wide at the widest placd on the face. Cross sections shall not be less than 56 square inches at the smallest place. Ties shall be made from sound live timber, taken out of wind and free from splits, shakes and unsound knots and score hacks.

"Class #2. Hewed ties of Class #2 shall be similar in every respect to hewed ties of Class #1, except that ties shall not be less than 7 feet, 11 inches, nor more than 8 feet, 3 inches in length. Cross sections shall not be less than 50 square inches at the smallest place.

"We will accept 10 per cent of Class #2 ties.

"Class #3. Hewed ties of Class #3 shall be what is known to us as camp ties, which are to be used for our railroad tracks. These ties shall not be less than 7 feet 9 inches in length, nor longer than 8 feet 3 inches. They shall not be less than 6½ inches in thickness, and must have at least a 6½-inch face at the smallest end.

"We agree to pay 23 cents apiece for the ties of #1 and #2 class on the railroad company's inspection. It should be borne in mind that the railroad company will only accept 10 per cent of #2 class ties.

"These ties are to be taken off the land we have logged over, and everything must be cleaned up and made into ties that will make ties. We will pay 19 cents apiece for Class #3."

The tie contractor sublets the making of the ties, paying 11 cents for #1 and #2 ties in the string and $8\frac{1}{2}$ cents for the #3 ties. The sub-contractor barks the #1 and #2 ties. Where the sub-contractor hews, barks and saws the ties, the contract price for #1 and #2 ties is 13 cents. The contractor has to skid the ties with horses an average distance of from 150 to 200 feet.

Specifications.

Anything that may be said here has to do with ties intended for a standard gauge road. The extract quoted above gives the specifications of hewed ties used on the mainline. The #3 ties were used on the logging spurs, and possibly are above the average in grade. Both Douglas fir and hemlock are used, and the width, length and thickness varies considerably.

Cost.

In the above quoted extract the cost of the three classes of ties to the operator are given, also the cost of subletting parts of the work. At least two other operators pay tie contractors 16 cents apiece for ties delivered along the track. These ties are for logging spurs and are not barked. They possibly are not as good ties as the #3 ties described above.

To get the total cost of the ties to the operator, it will be necessary to include the value of the stumpage.

Number per Mile.

The number of ties to the mile used by different operators varies, depending for the most part on the traffic, formation of roadbed, size and quality of ties, and the ideas of operators. The number ranges from 2,700 to 3,000 ties to the mile. Under ordinary conditions, with the average tie used by logging companies, 2,800 will possibly be ample.

Life.

The life of ties will vary because of a number of facts. Appraisers in this District estimate the life of main logging road ties at from five to six years. When the ties are used more than once, as is the case with those used in spur logging roads, they will not last so long. Here they estimate that a tie can be laid three times, provided the total period of use does not exceed the above figure.

Steel Rails.

Rails are classified according to their weight in pounds per linear yard. They are sold by the long ton. While the standard rail length is 30 feet, shippers reserve the right to include 10 per cent of from 24 to 28-foot rails in a given order.

Weight of Rails Used.

Rails varying from 45 to 60 lbs. per linear yard were observed in use on the logging roads of Oregon and Washington,

in the year 1915. Rails from 56 to 60 pounds are the most common; 56-lb. rails on the spurs, and 60-lb. rails on the main-lines. Many operators, however, use 60-lb. steel on their spurs.

The long tons of rails of different weights required per mile of road may be found by multiplying the weight per yard by 11 and dividing the result by 7 as follows:

Example: weight of rail 60 lbs. per yard, then $\frac{60 \times 11}{7}$ = 94 tons, 640 lbs.

<u>Table of Tons per Mile Required of Rails of Following Weight per Yard.</u>

Weight per yard pounds	Weight per mile tons	Weight per mile pounds
40	62	1920
45	70	1600
50	78	1280
56	88	
60	94	640
65	102	320

<u>Cost.</u>

The price of rails fluctuates. The following were the f. o. b. prices at Chicago (Illinois Steel Company, Chicago) in March, 1914:

50 lbs. and up	$28.00 per long ton
45 " " "	27.00 " " "

The freight rate from Chicago to Pacific Coast terminal points is $11.00 per ton. To the cost of the rails and the freight rate to terminal points should be added the cost of transporting the rails from the terminal point to the camp when the total cost of the rails to an operator is desired.

The price of relaying rails varies. This is largely due to where they are. At terminal points they are worth about as follows:

First-class inspected -

50 lbs. and up - - - - -	$36.00 per ton
45 " " " - - - - - -	35.00 " "

Second-class inspected -

50 lbs. and up - - - - -	$30.00 per ton
45 " " " - - - - - -	29.00 " "

Life.

The life of rails can vary greatly, depending mostly on the traffic and whether they are laid on a tangent or curve. Appraisers in this district estimate the rails on main logging roads at 20 years; on spurs at 15 years.

Rail Fastenings.

Angle Bars. Either angle bars or fish plates may be used to strengthen and brace the rails at the joint. As far as the writer knows, operators in this section use angle bars. They are bolted on each side of the joint with from two to three bolts in each railhead.

The length of rails as usually sold is: 90 per cent 30 feet long, and 10 per cent 24 to 28 feet long, requiring 357 splice joints per mile.

Weight of Angle Bars per Joint.

Weight of Rails (lbs.)	Weight of Bars per pair, (lbs.)
45	18.75
50	25.50
55	28.90
56	34.00
60	36.40

Cost of Angle Bars (f. o. b. Pacific Coast Terminal Points, Feb. 1914.)

50-lb. steel and up - - - - - - - $2.25 per hundred
45-lb. " " " - - - - - - - 3.00 " "

Bolts and Nuts.

Weight of Bolts per Joint.

45-lb. steel - - - - - - - - - - - 2.9 lbs.
50 " " - - - - - - - - - - - 3.0 "
55 " " - - - - - - - - - - - 3.12 "
56 " " - - - - - - - - - - - 3.18 "
60 " " - - - - - - - - - - - 3.18 "

Cost (f.o.b. Pacific Coast terminal points, March 1914)

$3.10 per hundred lbs.

Spikes.

Weight per Mile of Track.

Rails used: pounds per yard	Size measured: under head inches	Average number per keg of 200 lbs.	Ties 2 ft. between centers Four spikes to a tie: Pounds	Kegs
45 to 70	$5\frac{1}{2}$ x 9/16	375	5870	29-1/3
40 to 56	5 x 9/16	400	5170	26

This is the weight of spikes when 2640 ties are laid per mile.

When more or fewer ties are to be laid the following table will be of assistance:

Crossties per Mile.

Center to Center	Ties
$1\frac{1}{2}$ feet	3520
$1\frac{3}{4}$ "	3017
2 "	2640
$2\frac{1}{4}$ "	2348
$2\frac{1}{2}$ "	2113

Cost. (f.o.b. Pacific Coast terminal points, March 1914) - $2.60 per hundred lbs.

Depreciation on Spikes, Bolts, and Angle Bars.

Spikes and bolts depreciate more rapidly than rails; then, too, many are lost or otherwise destroyed. One Service appraiser estimates the life of this class of material at 7 years. Angle bars depreciate less rapidly than rails, but the action of the elements has a marked effect on them. The same appraiser estimates the life of angle bars at 20 years.

Switches.

The cost of a switch for 60-lb. rail, f.o.b. Pacific Coast terminal points, is about $80. This, of course, does not include the guard rails.

Rolling Stock.

Locomotives.

There are two general types of locomotives, namely, rod and geared.

Rod.

This is the type that is universally used on the main - line railroads. "They have the power transmitted from the

cylinders to the drum by means of a connecting rod. They have a longer wheel base than geared locomotives, consequently they cannot take as sharp curves, but are the best type for a smooth, well-maintained road of easy grade, and because of their speed are especially serviceable for mainline engines" where the haul is long.

"A special form of rod locomotive, known as tbe Mallet Articulated Locomotive, has recently come into use on logging roads that have sharp curves. The essential features are two sets of engines mounted under the boiler, each connected to independent groups of drivers. The rear engine is fixed rigidly to the boiler in the same manner as for the regular pattern of rod locomotive. The forward engine and driving wheels are so attached to the boiler that the truck may have a lateral motion when taking curves. This truck is connected to the rear engine by means of a radical draw-bar and steam is transmitted to the cylinders on the front truck through an articulated pipe. The forward pony truck is pivoted and may swing from side to side, independent of the trucks bearing the engines. The cylinders are single or compound expansion, and the exhaust steam of the rear engine is used in the cylinder of the forward engine, thus effecting a saving in fuel.

"The advantages of this type of engine are that the wheel base is materially shortened by having two separate sets of drums which permit the use of a heavy rod locomotive on a road having curves that are too sharp for the regular type of

rod engine of the same weight; and it is so constructed that live steam may be used in the cylinders of both engines to secure greater power to start loads, which increases the hauling power of the locomotives in comparison with that of an ordinary rod engine of the same weight, since an engine can keep in motion a greater load than it can start. Another feature claimed for this locomotive is that the drivers slip less than on other types of rod engines because the forward engine depends on the rear one for steam, and should the drums connected to the latter slip, the exhaust would fill the feed pipe of the forward engine faster than it could be relieved and the resulting back pressure on the high pressure piston would reduce the speed and prevent further slipping.

"Locomotives of this type, ranging in weight from 81 to 121 tons, are in use on logging roads in the Pacific Northwest. The minimum weight in which they are built is 50 tons." One weighing 121 tons is in operation on the Pacific Coast on a road having 35-degree curves and 8 per cent grades.

Geared.

"The first geared locomotive was construrted about 1885 by E. E. Shay, a Michigan logger, and this locomotive, with some modifications and improvements, is in extensive use today. Several forms of geared locomotives other than the Shay are now on the market.

"The objects sought in geared locomotives are to se-

cure a maximum amount of tractive force with a minimum of weight, a short truck base that will enable the engine to take sharp curves with ease, and a form of truck that will adjust itself readily to an uneven track. These ends are accomplished by making every wheel under the engine and tender a driving wheel; by transmitting power to the driving wheels through a series of bevel gears that bear a relation to each other of from 2 to 1 or $2\frac{1}{2}$ to 1; and by the use of swivel trucks on which the drivers are arranged in pairs and connected, one with another, by means of an articulated driving rod. The weight is distributed over a long wheel base which permits the use of a smaller rail, fewer ties, lighter bridges, and poorer track than for a rod locomotive of the same weight.

"On poor track where a speed of from 6 to 12 miles per hour only is possible, geared locomotives are preferable to the rod locomotive because they have large fire boxes, short stroke engines and a high piston speed. The slow cylinder speed of rod engines causes defectiv draft on grades."

There are two types of geared locomotives, namely, the center shaft and the side shaft.

<u>Center Shaft</u>. There are several patterns on the market, the ones most commonly used being the Climax and Heisler.

"The Climax is mounted either on two or three four-wheel swivel trucks. When two trucks are used, one is placed under the forward and one under the rear end of the locomotive.

When three trucks are used, two are placed under the engine proper and one under the tender. The boiler is of the horizontal locomotive type, mounted on a steel channel frame, reinforced with truss rods. Two single-cylinder engines are attached to the frame, one on each side of the boiler, and transmit the power directly to a heavy crank shaft, placed under the boiler and at right angles to it. This shaft is held in position by a frame fixed to the boiler, and power from the shaft is transmitted by gearing to a central articulated line shaft, which passes to the forward and rear trucks and runs on bearings on top of each truck axle. Pinions fitted on the shaft mesh into gears on each axle and thus transmit power to the driving wheels.

"Locomotives of this class are built in weight ranging from 18 to 75 tons. Those from 18 to 60 tons weight have eight drivers and those of from 65 to 75 tons weight have twelve drivers.

"The Heisler locomotive is built in weights ranging from 18 to 75 tons. The locomotive and tender are carried on a heavy steel frame mounted on two pairs of swivel trucks, one set being placed under the forward end of the locomotive and the other under the tender.

"Power is furnished by two single-cylinder engines attached to the frame, one on each side of the boiler. Each is inclined at an angle of 45 degrees from the vertical. The

reciprocating parts of the engine are connected directly to a cerrral single-throw articulated driving shaft.

"Spur wheels are fitted to the center of the forward and the rear axle and pinions attached to each end of the driving shaft mesh into them. The spur wheels and pinions are enclosed in a tight case which is designed to prevent the entrance of grit and other foreign substance.

<u>Side Shaft</u>. "The Shay locomotive is the only one of this type on the market. It is built in weight ranging from 13 to 150 tons.

"The frame is made of heavy steel "I" beams braced with trusses, and is supported on from two to four pair of four-wheel swivel trucks. Locomotives weighing 55 tons and less have two trucks; those from 65 to 105 tons, inclusive, three trucks; and the 150-ton locomotive, four trucks. The additional trucks in the two latter are used to carry the tender.

"The boiler is of the horizontal locomotive type with extra large fire box and steam space. The engines are of the vertical type and are attached to the boiler plate on the right-hand side just in front of the cab. Locomotives of from 13 to 20 tons weight are equipped with two cylinders, and those of greater weight with three cylinders, placed side by side and directly connected, 120 degrees apart, to a driving rod which is supported on a heavy bearing attached to the boiler. The driving rod is broken both with universal joints and also with two slip joints

to permit either an increase or a decrease in the length when passing around the curves.

"The right-hand wheels on each truck are fitted with gear rims into which mesh the pinions which furnish the driving power for the locomotive.

Cost.

Baldwin (rod engine)

Weight in working order (Tons)	Cost Pacific Coast Terminal Points.
42	$9,500
55	11,200
67	13,900
71	14,500

Heisler (geared)

Weight in working order (Tons)	Cost Pacific Coast Terminal Points.
32	$7,290
42	8,790
60	11,115

These prices include air brakes and oil burners which cost separately as follows:

Weight of Locomotives	Cost Air brakes	Cost Oil burners
32 - ton	$350	$400
42 - "	400	500
60 - "	400	500

Shay (geared)

Weight in working order (tons)	Factory price with steam brake	Freight to Coast	Air Brakes	Total Cost.
32	$5760	$850	$400	$7,010
42	7130	700	400	8,230
50	8200	800	400	9,400
60	9200	1000	400	10,600

These prices do not include oil burning equipment. It could be installed for approximately the same rates as given for the Heisler locomotives.

Climax (geared)

Weight in working order (tons)	Factory cost (Corry, Pa.)
32	5,800
42	7,000
60	9,300

Life.

It is difficult to say what the life of locomotives is. One operator estimated it at from 12 to 20 years; another from 10 to 12 years. It may be safe to estimate the life of a rod engine at 15 years; geared engine at 12 years.

Maintenance.

It is impossible to speak confidently of the maintenance cost of a locomotive as the cost depends on so many factors. One logging superintendent was of the opinion that the yearly maintenance cost of locomotives ranges between $600 and $1000, and stated that the up-keep of three Shays, - a 45, 37 and 17-T Shay, during the year 1912, amounted to $2425; that the up-keep of a 60-T Shay which made 80 miles per day amounted in 1912 to $1121, which cost includes the cost of retubing. Another logging superintendent estimated the maintenance cost per year of locomotives as follows: Rod, $600; geared, $1,100. The following data was furnished by a logging superintendent from the records of his company. It is based on a period of 4 years

and 4 Shay locomotives - a 60-T and 3 52-T machines.

Year	No. of locomotives	Total yearly cost	Average yearly cost per locomotive	Total amt. timber handled	Average amt. handled per locomotive
1908	4	$1540	$385	28 million ft.	7 million ft.
1909	4	1620	405	27 " "	$6\frac{3}{4}$ " "
1910	4	3000	750	40 " "	10 " "
1911	4	1102	275.50	38 " "	$9\frac{1}{2}$ " "
	Total	$7262	$453.87		

If locomotives are given the peoper kind of treatment, the maintenance cost per M will probably amount to from $400 to $700 for geared locomotives and from $300 to $400 for rod locomotives.

Hauling Ability.

"The hauling ability of a given locomotive depends largely on (1) the tractive force, (2) the resistance of a load to gravity and (3) the frictional resistance.

Tractive Force. "The tractive force of a locomotive, sometimes improperly called the 'draw-bar-pull', is the power possessed by a locomotive for pulling a train, including the weight of the locomotive itself. If one end of a rope is passed over a pully and fastened to a weight hanging in a pit, and the other end is attached to a locomotive running on a straight level track without regard to speed, the tractive force of the locomotive will be represented approximately by the amount of weight the locomotive can lift. Tractive force increases in

direct proportion to the area of piston head, length of stroke and steam pressure in the cylinder, and decreases directly as the diameter of the driving wheels increases.

"Tractive force is dependent on the weight of the locomotive on its driving wheels because it adheres to the rail only by the friction developed between these wheels and the rail head, and the resistance to slipping increases with the weight on the driving wheels. The weight on wheels other than drivers has no tractive force. If the engine is too light in proportion to its power it will be unable to hold itself to the rails and exert a strong pull, while on the other hand if the weight of the locomotive is too great in comparison to its power, it will not haul maximum loads because of the excess weight in itself that must be moved. In industrial locomotives the economical ratio between the weight on the drivers and the tractive force ranges from 4½ to 1 to 5½ to 1; i. e., the tractive force in pounds is from 23 per cent to 20 per cent of the total weight on the drivers.

<u>Resistance to Gravity</u>. "The resistance to gravity increases in exact proportion to the grade and is always 20 pounds per ton of 2000 pounds for each 1 per cent rise in grade; e. g., for a 0.5 per cent grade it is 10 pounds per ton and for a 4 per cent grade it is 80 pounds per ton.

<u>Resistance Due to Friction</u>. "The resistance due to friction varies with the character and condition of the roadbed and the rolling stock.

"Poorly laid or crooked rails and overloading increases the rolling friction, which is also greater in cold weather than in warm and greater for empty cars than for loaded ones."

Logging cars of good construction and with well-oiled bearings should have a frictional resistance of from 12 to 15 pounds per ton of weight handled on straight track. In determining the amount of frictional resistance due to curves it is the general rule to assume the resistance for standard gauge to be ½ pound per ton per degree.

Calculation of Hauling Capacity. The hauling capacity of a locomotive in tons of 2000 pounds is determined by dividing the tractive force of the locomotive by the sum of the resistance due to gravity, rolling friction, and curve resistance, and then deduct from the result the weight of the locomotive and tender. This gives the tonnage the locomotive can haul, including the weight of the cars.

Cars.

Three types of cars are used, viz: flat cars, skeleton cars and trucks.

Flat Cars.

These are seldom purchased by loggers but are used where the logs are hauled for a portion of the distance over a trunk line road. Of course every logging company will have a few of these cars which they use for construction purposes. There are a number of makes and sizes on the market. For the

purpose of an appraisal the standard low logging flat car, built by the Seattle Car Manufacturing Co., will answer. The car is 41 feet long, accomodating a 42' log. It has a capacity of 80,000 lbs., weighs 26,700 lbs. and costs, f.o.b. Seattle, $850. This car, when equipped with the Hercules patent bunk and Knight patent chock, costs $925 f.o.b. Seattle.

Skeleton Cars.

This type of car consists of two pairs of 4-wheel trucks joined together by a heavy bolster of wood. As far as the writer knows this type of car is not used to any extent on the Pacific Coast in Oregon and Washington. There are several makes and sizes on the market. For the purpose of an appraisal the skeleton truck No. 150, built by the Seattle Car Manufacturing Co., will answer. The car is built in lengths up to 56 feet over all. It has a capacity of 80,000 lbs., weighs about 19,000 lbs. and costs f.o.b. Seattle $750, when equipped with Hercules bunks, Knight chocks and automatic couplers.

Trucks.

When the logs do not have to be hauled over a trunk line trucks are generally used on the Pacific Coast in Oregon and Washington. There are a number of makes and sizes on the market. For the purpose of an appraisal either the Hercules or Snohomish logging truck may be used. The Hercules truck, when equipped with a cast steel bolster, has a capacity of 80,000 lbs., weighs 13,000 lbs. per set and costs about $750

f.o.b. Seattle when equipped with the Hercules bunks, Knight ch cks and automatic couplers. The Snohomish trucks have a ca acity of about 70,000 lbs., weigh 18,000 lbs. per set and cost about $750 f.o.b. Seattle.

Maintenance.

The maintenance of flat cars per year will probably amount to about 10 per cent of the purchase price; trucks, about 6 to 8 per cent.

Life.

For the purpose of an appraisal the life of flats and trucks may be figured at from 10 to 12 years.

Number of Logging Cars Required.

The number of logging cars required on an operation is dependent on the following:

(1) The amount of timber handled daily.

(2) Capacity of the individual cars or the volume of the average load.

(3) The average number of cars hauled per train load; spurs and mainline.

(4) Method of loading. If it is possible to store logs on the landing without interfering with the work of transporting the logs from the stump to landing, fewer cars will be necessary than where it is not practical to store logs on the landing.

(5) Method of unloading. The longer it takes to unload the logs the greater will be the number of trucks required.

(6) The distance that the logs have to be hauled or the time the logs are on the road between the landing and dump.

This list of factors is not complete and is intended only to be suggestive.

Operation.

Under this heading will be discussed the cost of transporting the logs from the landing to the dump. The cost of this step in a logging operation varies greatly. The elements of cost per M feet in a general way are as follows:

Labor
Depreciation
Replacements
Maintenance
Supplies
Output

Labor.

A train crew is generally made up of the following men:

1 Locomotive engineer - - -	$100.00	to	$125.00	per mo.
1 Fireman- - - - - - - - - -	3.00	to	3.50	" day
2 Brakemen - - - - - - - - -	3.50	to	4.50	" "

If the train is long 3 brakemen may be used. In some camps where oil is used for fuel, a fireman is not used.

The estimating of the number of train crews that will be needed to transport the logs from the landing to the mill is a difficult task. It means an estimation of the number of locomotives and cars that will be used, and has a direct bearing on the items of depreciation, replacements, maintenance and supplies as well as the item of labor.

The number of train crews will depend on the following:

Length of haul
Grades and curves
Weight of locomotive
Weight of trucks or flat cars
Output

The total amount of timber included in the sale, the period allowed for the removal of the timber, and the length of the cutting season, will fix the average daily cut. Whether the transportation of the estimated average cut will require the services of one, two, three, four or more locomotives is the next thing to be decided. If a satisfactory field examination has been made the appraiser will know the approximate lengths of different hauls during different periods of the operation. He will know the approximate rise and fall on different parts of the track. From these he will decide on the type and weight of locomotive and the work that can be expected from this motive power. From this he will estimate the number of locomotives or the number of train crews that will be required. He may decide that one locomotive will be ample for the first year, that it will require two after the fourth year of operation, and three after the sixth year. From the latter he will estimate the labor cost for operating trains.

Next to estimating the cost of transporting the logs from the stump to the landing, the estimating of the cost of railroad operation is possibly the most difficult step in the making of a Service timber appraisal. Needless to say, every-

thing being equal, the more intensive the field examination, the more accurate will this estimate be. From what has been given readers will be able to estimate approximately the number of loaded and empty cars that can be hauled by one locomotive at one trip over different parts of the line. A knowledge of the grades should enable one to estimate the mileage that can be expected of a given locomotive working on a given section of track. It must not be overlooked that locomotives working on the spur railroads lost considerable time at the landings and in switching, and locomotives working on the mainline lose time at the dump, the amount depending on the method of unloading. On an ordinary logging railroad locomotives should travel about 12 miles per hour. This suggests that they should travel 60, 70 or 80 miles per day. Seldom, however, do they do this; 25 to 35 miles per day is good work for a locomotive working on spurs or relatively short mainlines. Not infrequently they make less than this.

Most operators charge the cost of hauling men to and from their work, hauling water for yarders, roaders, etc., and hauling rails, ties, ballast, etc., used in constructing and maintaining railroads, under the general heading "Railroad Operation". It can be charged under this heading or under a special heading. In any event it has to be dealt with. Furthermore, it has to be considered in connection with the cost of hauling logs. It may be that the locomotive used to transport

men, track material, water, etc., can help the locomotives regularly employed in the transportation of logs, or vice versa. Then, too, in estimating the number of locomotives that will be needed one will have to consider the amount of track to be built, the location of ballast, whether portable or stationary camps are to be used, and whether water for donkeys and camp will be pumped, hauled, or supplied by a gravity system.

Depreciation.

The depreciation on locomotives, cars, track material, etc., has already been discussed under the headings "Construction", "Track Material" and "Rolling Stock".

Replacements and Maintenance.

A replacement charge is really a maintenance charge, and is sometimes handled as such. With the exception of track maintenance, this subject has already been dealt with.

Maintenance-of-way.

Section crews are employed to keep the road ballasted up, maintain the gauge, keep the ditches open, replace broken or decayed ties and to make any repairs that may be required. The cost of this work varies greatly, and in many cases operators do not know what this cost amounts to. To quote from a logging superintendent:

"In the large majority of cases the cost of maintenance has hardly been a factor to be recognized, but many of us are becoming aware of the necessity of not only determining

just what this cost is, but further, how to estimate it.

"The former use of light rail and equipment can hardly be said to have fitted us to cope successfully with this question, which becomes more important with the natural development of the logging industry, bringing as it does increased mileage of railroads and the use of heavier equipment, etc., nor can we to any great extent be guided by the figures which may be obtained from common carriers, inasmuch as conditions governing the operation of a common carrier and a logging railroad are quite different.

"I will venture the opinion that few of us present have carried a maintenance account on our books, largely because in most instances it has not yet become a factor to be reckoned with, for even today a short logging railroad is in the majority.

"We have all realized, however, the necessity of building better railroads, knowing that the well built road can be maintained at a minimum cost, whereas the poorly built road is generally rebuilt to reduce the cost of maintenance.

"The logging railroad which is and will become the outlet for a considerable belt of timber must today be built in a permanent way. The location of the necessary buildings and water tanks, the quality of the bridges, the grade and quality of material used, and the weight of the rail per yard, together with the equipment, must all be reckoned with as important

factors affecting the cost of maintenance.

"The most recently built logging railroads have been subject to considerable criticism from those failing to recognize these points, and it is frequently said that such and such a road has been extravagantly constructed. These criticisms can hardly be said to be just unless those making them are thoroughly familiar with all the requirements which the builder of the road is going to make of it, because what may seem extravagant for the present becomes future economy.

"The increased mileage of the logging railroad is today, and will become so more and more, the controlling factor in this cost of maintenance. It is important, too, that we get it clearly settled in our minds that the investment in a railroad is apart from its maintenance. A logging railroad having a belt of considerable timber will, in most cases, be worth what it cost to build it but the maintenance of this railroad is an item of expense which must be in close relation to the work which the road accomplishes.

"The writer has had occasions in the past year or two to realize this in our own operations. We are now operating over some sixteen miles of railroad, which railroad is very amply justified by the volume of timber to come over it, but the cost of maintaining this length of road is a very large factor in the cost of production, particularly when the annual output of the road is limited by market conditions, as has been

the case at certain times past.

"While an exceedingly heavy traffic requires possibly more of an expenditure to keep a railroad in condition, at the same time a small volume of traffic required more proportionately. We are, therefore, brought to the conclusion that as our railroad increases in length so must the volume of business done over these railroads increase in volume, in order that the cost of maintenance does not become excessive.

"I am unable to present any accurate figures in the discussion of this for the reason previously given; that few have segregated this cost from the general operating expenses of the road. In our own case, I should say that the cost of maintenance of our railroad will amount to $1,000 per mile per annum, with the output restricted to the hauling of logs of from 25 to 4 million feet per year.

"This cost applies only to the up-keep of the road and does not take into consideration the maintenance of rolling stock. Moreover, this cost is destined to increase from year to year as the railroads are increasing in mileage, and we should all devote considerable thought and attention on our present operations to minimize this cost in the future.

"As before stated, when warranted by an adequate belt of timber the use of good material, the proper grading of the roadbed, the proper use of ballast, the clearing of the right-of-way, the use of heavier steel for the railroads which we may

now be building will do much to lessen the cost of maintenance on that railroad in the future. If we could secure proper figures as to this cost of maintenance I believe many of us would be much surprised to note the large proportion of this cost as against the whole."

To quote from another writer: "A crew of five men under a section foreman will keep in order six miles of main-line or from eight to twelve miles of spur road." Another man figures that one man can look after from one to two miles of track.

<u>Fuel</u>.

The fuel used on logging roads may be wood, coal or oil. Wood is generally used when it is impossible to secure coal or oil, or when the latter would be more expensive than the former. Of course operators sometimes use oil, although the cost is a little greater than for wood or coal, because of the elimination of the fire risk. While bituminous coal is possibly as dangerous from the standpoint of forest fires as wood, it is preferred to wood when it can be secured at a reasonable price. This is mostly due to the following: firemen prefer it because the labor is not so exhausting, a more even fire can be maintained, and it takes less time to take coal on. Fuel oil has met with much favor when it can be secured at a cost not greatly in excess of other kinds of fuels. It has the following advantage:

(1) The danger from forest fires is eliminated.

(2) Cost of handling is less than handling coal or wood.

(3) It does not take as long to take on oil as wood or coal, resulting in the saving of considerable time in a day.

(4) "A saving in fuel and water is effected on heavy grades and the hauling ability increased because the steam pressure can be held at a desired point by increasing the oil feed under the boilers. It is not possible to do this with wood or coal, since merely opening and closing the fire box has a marked effect on the efficiency of the locomotive under strained conditions."

No especial skill is required to fire an oil burning locomotive. This results in a saving in wages. Sometimes no fireman is employed.

The relative value of the three kinds of fuel is approximately as follows: "One ton of good grade bituminous coal is equivalent to one and one-half cords of oak wood or from two to two and one-half cords of soft wood, and from 130 to 190 gallons of crude petroleum."

A Pacific coast logger, in discussing the comparative cost of coal and oil for fuel in locomotives, made the following statement: "Our logs are hauled over the _____ Railway with a 60-T Shay. The distance from the camp to the dump is 20 miles. This engine makes two trips each day, making 80

miles per day. We have had a very good opportunity to compare the relative cost of coal and oil in this particular engine and find the comparison to be about as follows: with coal, making 5 trips averaging 120,000 feet per trip or 600,000 feet of logs, it took 15 tons of coal at $4.25 per ton - - - $63.75.

"With oil, making the same number of trips and hauling the same amount of timber, it took 45 barrels of oil at $1.10 - - - $49.50.

"This shows a saving in cost of $14.25 on five trips or $2.85 per trip in favor of oil." This statement suggests that a ton of Coast coal is equivalent to 126 gallons of oil.

The amount of fuel consumed daily by a logging locomotive is extremely variable, depending on the mileage traveled, the loads hauled, the number of heavy grades traversed and the efficiency of the fireman. Roughly, a logging locomotive will burn from 150 to 200 pounds of coal per mile; 150 pounds when the grades do not exceed 2%, 175 pounds when the grades range between 2 and 5%, and 200 pounds when the grades exceed 5%. These approximations are based on a 50-ton geared locomotive making about 36 miles per day. Using these figures and assuming that one ton of coal is equivalent to 3 barrels (126 gallons) of oil we have a locomotive burning about 9½ gallons of oil per mile where the grades do not exceed 2%, 11 gallons when the grades range between 2 and 5% and 12½ gallons when the grades exceed 5%.