THE DEVELOPMENT OF MAJOR TIMBER TRANSPORTATION
by
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____________________________
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As often happens, in a work of this nature, due credit is not always given to persons and publications responsible. A spoken word here and a written sentence there, assists in one's education; yet, one is often at a loss to remember the exact source of this information. However, an effort was made in this paper to give credit where credit was due, but it must be realized that without several terms of "exposure" to this subject under the direction of the Logging Engineering department, this paper could never have been written.
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Preface

In the early nineteen hundreds, before northern Washington had been surveyed, my father "took up" a timber claim near Metaline Falls. Here I spent my early years playing among great tall pines, firs, and larch trees which bordered our cabin on all sides. Here I first learned the language of "timber cruisers," "lumberjacks," and "river pigs." Here I vowed that some day I, too, would be a timber cruiser and woodman.

In later years I saw this timber removed—saw it sent down the mountains in long winding flumes, steep chutes, and trailed behind horses—down to the river and to the mills at Metaline Falls.

Still later I spent three winters top loading horse-drawn sleighs in northern Wisconsin—loading white "cork" pine for match stock and fine finishing, hard maple and yellow birch for flooring and veneer, and hemlock for lumber and paper pulp.

Shortly thereafter the picture began to change with horse teams giving way to huge caterpillar tractors which could take the place of six or seven teams of horses on the road and travel at a pace of about five miles per hour. Three years later, few teams were found in northern Wisconsin pulling timber laden sleighs to the mills. The machine had taken over.
Soon thereafter I witnessed railroad logging in the yellow pine region of eastern Oregon and saw how fast motor trucks were taking an ever larger share of timber from the woods to the mills. I saw where truck roads were being pushed beyond the rail heads and large portions of the major haul being done by motor trucks.

Subsequent to 1934, I have seen old railroad shows in the mixed shortleaf pine and hardwoods of the South, reopened with flexible motor trucks depended upon for the entire major hauling job.

Now from the huge timber of the west coast, one often sees huge fir, cedar, spruce, and hemlock logs being transported for many miles over hard-surfaced roads by motor trucks. Here, only a few years ago, the railroads were looked upon to transport most of the timber from inland tracts to the mills and to the open markets.

Looking back over twenty-five years that I can well remember, I marvel at the development of timber transportation. It is because of seeing such vast changes in the lumber industry that this paper is written, but at the same time, I cannot help but wonder what developments the next twenty-five years will bring.

Thus to the future of the lumber industry I dedicate this paper. May it be as colorful and
profitable, but somewhat steadier than in the past. May it solve its own problems and find men to stand at the helm of the industry comparable to the fine old woodsmen the industry has always known. May our timber always maintain a major industry in our United States.
Introduction

From the days of transporting timber via bull teams, horse teams, and mule teams, the lumber industry has gone a long way in solving the time factor in the transportation of logs. From two miles an hour for loads of one thousand board feet or less, the speeds have gone higher and higher and loads larger and larger until loads of over 20 M.B.F., traveling at speeds of twenty miles per hour on good roads are actualities.

Our early logging history of transportation of logs, though colorful and spectacular, was made at a slow pace, with this pace increasing as new improvements were made and different sources of power utilized.

In the South, wagons proved to be the main method depended upon for the transportation of logs. Bull teams, horses, and mules were used for power to pull these wagons to the mills. Even though yearly cuts were large, individual units traveled slowly, with the size of loads limited. Where railroads were available, the pace was faster, but until about 1885 railroads were few and the percentage of the logs thus transported to the mills was small.

In the New England and Lake States regions, wagons were also used, but sleigh hauls were much
more common; and since the area was blessed with numerous streams, spring log drives were made to bring in the entire winter's cut in one vast drive.

Here, too, railroads were used when available, but were little used until the late "eighties."

Much of the timber in the Southeast, and Lake States was cut before the lumber industry developed noticeably in the West. However, this region also has its early history and not without mention of bull teams and horses.

Due to a small population, poor transportation, and great size of the western timber, not a great deal of logging was done in this part of the country until transcontinental railroads had pushed to the west coast. From then on, the lumber industry in the West grew with leaps and bounds and it was here in the vast stands of virgin Douglas fir, cedar, spruce, and hemlock, as well as redwoods, that railroad logging made its greatest development in conjunction with steam engines of the stationary type.

Water transportation, when possible, made advancement on the west coast and Rocky Mountains with rafts and barges on deep waters and river driving on mountain streams.

Even under modern practices, streams are being driven and rafts are being towed along coastal waters, water transportation still being the cheapest method
of log transportation ever developed.

Fast tractors and motor trucks are appearing in larger numbers yearly. These units form flexible methods of timber transportation. There is little doubt that these units will become of greater importance in years to come.
Bull teams, horses, and mules have been used on timber hauls in most sections of the United States, at some time or another, during the early logging days. Bull teams date back to the early days in New England. The use of them is believed to have been started due to a shortage of horses. The idea of using bull teams spread to other parts of the country and until about 1900, they furnished us with one of our chief methods of major timber transportation.

Bull teams were slow, but steady. Pound for pound of weight, they could pull larger loads than could horses. On sleigh and wagon hauls, the average speed of travel was about two miles per hour. On improved ice roads, huge loads were hauled on sleighs with bunks up to eighteen feet long, though bunk lengths of ten or twelve feet were more common.

Horse teams did not replace the bull teams suddenly. Rather as horses became more plentiful, they were more commonly used. About the year 1900, horses had replaced most of the bull teams on sleigh hauls,
however, bull teams were used in local areas many years later. The last bull team seen on a timber haul by this writer was in 1920, in northern Wisconsin. The team was used on a sleigh haul for about four months in the winter and used as a plow team in the spring and fall.

Horses proved to be faster than bulls and formed more flexible units. Perhaps the pace was faster after 1900. However, we do know that after that date, horses were found on most operations. In the "big timber," along the west coast, bull teams were still in use in large numbers and were used until they were replaced by steam engines. These engines made their first appearance in 1881, but several years passed before they were in universal use.

Due to excessive heat in the South, mule teams were more often found in the southern pine and hardwood regions. Carts in the South and sleighs in the North with railroads and river driving resorted to wherever possible, seemed to be the trend. Roughly, one may say that both bull teams and horses lasted for about thirty years in major timber transportation. By 1925, little major hauling was being done by animals, with trucks rapidly making inroads in timber hauling. The usefulness of horses and mules did not pass away with the development of machinery, but were used years later for minor transportation.
Even now, in the steep white pine country of the Inland Empire, as well as other places, they are still used extensively for trailing logs.

Even though animals will be entirely replaced in the lumber industry, we will always remember the part they played in its early development.
CHAPTER II
RAILROAD TRANSPORTATION

In the year 1826, our first railroad transported granite in Massachusetts for about fifteen percent the price paid for wagon hauls. From that date our railroads were destined to become the leading carriers of freight in the United States. However, it was several years before this advantage in hauling was made available to loggers. (1)

By 1840, the railroads had built a network of roads throughout the Eastern States, but it was not until 1853 that the first railroad was built into Chicago. (1) From that time on railroads made fast progress, not only in extending their main lines, but by developing a network of feeder lines into new territories. The huge lumber business that was developing at that time was a great influence in making this vast road-building campaign possible.

As these lines were extended into timbered areas, lumbermen made use of them to transport logs to mill sites and log markets. Some of the larger companies built their own roads, using standard or narrow gauge track, with the standard gauge predominating in most cases. Rails were of all makes and sizes, with wooden rails not unheard of. As the years went by, railroad
logging became common practice with companies that controlled sufficient timber to warrant their construction. Most timbered sections of the United States have known these private systems, but it was in the "big timber" of the west coast that railroad logging reached its greatest development. Here, private roads costing in excess of a million dollars were built.

With the development of railroad logging, new problems arose to confront the logger. Such problems as location, proper bridging, correct locomotives, cars, rails, etc., had to be worked out. Most of these problems have been ironed out and new ones have taken their places. However, railroad logging continued. The railroads increased in number and in mileage of maintained track, until a large percentage of logs transported were hauled by rail. Timber of all descriptions and sizes has been successfully transported, and until recent years, when trucks have made inroads in major transportation, no method of transportation ever offered as sure and steady a flow of logs to the mills as did railroads.

Even though truck logging is progressing rapidly, there are still companies that are extending rails deeper into their holdings. These companies are primarily railroad loggers and have good reasons for making further expenditures in this type of construction.
Railroads require a great deal of thought and ground work. Many questions arise which should be answered before a company is justified in making expenditures of this nature. Some of these questions are as follows:

1. Is the terrain such that a railroad can be built without excessive cost?

2. Can the road be brought into the holdings in a manner that will be advantageous to logging?

3. Is there sufficient timber available to warrant the expense of building the road and purchasing the necessary rolling stock?

4. Will there be adverse grades, and if so, will they impair the advantages that road would otherwise offer?

5. What will be the maximum tonnage per train?

6. Will there be supplies of water available for locomotives at necessary intervals along the line, and will it be useful for locomotive consumption?

7. What will be the life of the operation, and how much money can be spent on the road and charged off, on a per thousand basis, against the timber that will be removed?
8. Will there be a residual value when the operation will cease to function?

All of these questions and many more will arise from local conditions and should be satisfactorily answered before a railroad is built in order to assure a successful operation.

History of Oregon and Washington railroad logging brings to light the fact that these questions were not always answered before railroad building was begun. Because of this fact, a number of operators have found to their sorrow that once the railroad was built, money to carry on the operation was lacking, thus causing unnecessary hardships. Further, lumber companies have been known to be niggardly in the allotment of funds for railroad construction only to find that the road was not meeting its requirements, due to improper practices.

To say that railroads are here to stay in the lumber industry may prove to be a false statement, but to say that at this time railroads are of major importance is no overstatement.

LOGGING CARS

Several types of logging cars are used by both private roads and common carriers. Special cars have been developed for special hauls. The common flat car is often used in the South, East, and Lake
states, but is seldom used in the "big timber" on the Pacific coast. This car is usually about 40 feet long and can load two tiers of short logs or one tier of long logs.

Skeleton flats are designed for large timber and can be found in lengths up to 70 feet. The logs lie on steel bunks and are held in place with a patented device at the ends of each bunk. This type of car has the advantage of accommodating long logs and still remaining a compact unit. They are light and easily transported; further, they are easy to unload by tripping the device that holds the logs in place. This is an improvement over the common flat car which used car stakes, driven into pockets at the side of the car to hold the load intact.

Disconnected trucks are used in large timber, particularly on the west coast. These trucks can be entirely disconnected from each other and spread to a distance that will accommodate logs, piling, or poles of up to 150 feet in extreme cases. These trucks are extremely useful in that they are light, flexible, and not costly. The main disadvantage is that they are not a compact unit and no way of connecting the air from truck to truck is used. As a result, the braking must be done by hand brakes and the locomotive. On steep grades this may prove to be a serious disadvantage and traffic accidents may result from overloaded trains.
Loads for railroad cars vary from five thousand to twelve thousand feet depending upon the type of car used and size of logs loaded. The number of cars per train will depend upon the size of the locomotive used, condition of the track, type of cars, and the size of the operation. However, fifteen or twenty cars or more per train is not uncommon on private roads and speeds of twenty miles per hour will be about average for main-line travel.

**LOCOMOTIVES**

Two types of locomotives are used in the logging industry. The geared type is often used on short and difficult hauls, on spurs, and for switching. This type of locomotive carries its entire weight, or nearly all of its weight, directly upon the drivers. This type is generally of the Heisler, Shay, or Climax makes. However, these locomotives are gradually being replaced by the "saddle tank" type in the Northwest. (2)

The other main type of locomotive is the rod or direct-connected type. These locomotives are used for main-line hauls. On roads that do not have excessive curvature or adverse grades of over 2%, this type is more practical than the geared type. They are faster and are capable of pulling heavy loads if given a good track. The Mallet and Mikado are often seen in west coast operation. (2)
Locomotives are classified according to the arrangement and number of drivers and truck wheels. Some of the main classifications are shown on Plate 1.

Since the tractive power of a locomotive is dependent upon the adhesion to the rails, it can be readily seen that the types which have fewer truck wheels will have greater tractive power per ton of weight, other things being equal.

The power of a locomotive is expressed in pounds of draw-bar pull. The draw-bar pull on level tangents is equal to the cylinder tractive power less the sum of the train resistances. These resistances are as follows:

1. Resistance internal to the locomotive
2. Wheel resistance
3. Brake resistance
4. Velocity resistance
5. Grade and curve resistance
6. Inertia resistance. (3)

The draw-bar pull will vary with the speed of the train. At slow speeds, the draw-bar pull will not be figured greater than 30% of the weight on the drivers. As the speeds increase, the total amount of the resistances will decrease. (3)

Of these resistances, the locating engineer will be concerned only with grade and curve resistances. Grade resistance can be exactly computed mathematically.
PLATE 1.

CLASSIFICATION OF AMERICAN LOCOMOTIVES.

∠ ○○○○ ○
American 4-4-0

∠ ○○○○ ○○
Atlantic 4-4-2

∠ ○○○○ ○○○
10-Wheeled 4-6-0

∠ ○○○○ ○○○○
Pacific 4-6-2

∠ ○○○○ ○○○○○
Mountain 4-8-2

∠ ○○○○ ○○○○○○
Mastodon 4-10-0

∠ ○○○○ ○○○○○○○
Articulated 2-8-8-2

∠ Indicates the front end of the locomotive.
○ Indicates the truck wheels. ○ Indicated the drivers.

(From "Principles of Locomotive Operation" by A.J. Wood).
The formula: \( G = W \times G \) the rate of grade, will indicate the required force necessary to draw a train up a grade when \( W \) is the weight of the train and grade is expressed as \( 1/100 \) (for a 1\% grade). By substituting 2,000 for \( W \) the force per ton can be determined. This will be 20 pounds per ton per percent of grade. Then, \( 20 \times \) the weight of the train in tons, \( \times \) the percent of grade will give the resistance for any train. (4)

Curve resistance will increase with the degree of curvature and velocity. The total curve resistance will depend upon the central angle, rather than the radius of the curve. This is at least partially due to longitudinal slipping, since the trucks must be twisted around by the amount of the central angle. (4)

**TRACKS AND ROAD BED**

Railroad construction is costly in favorable terrain and is often prohibitive in mountainous country. The locating engineer must bear in mind that his chosen location must not only be feasible of construction, but must also fall within proper limits of cost. Grades must be maintained that can be operated over with the equipment at hand or that which is recommended for the job. Curvature must not be so sharp that wrecks will result or excessive maintenance costs will be inevitable. Railroad grades are built either for standard or narrow gauge track. Few narrow gauge roads are in use today, since rolling
stock from these roads cannot be transferred to regular standard gauge lines.

Standard gauge is 4 feet 8 1/2 inches or 4.7083 feet. The gauge is measured from inside of rail head to rail head. (5)

Railroad grades are usually well drained and ballasted. Ties are laid in this ballast, which will act as a cushion as well as to prevent excessive moisture from collecting adjacent to the ties.

Ties are cut from 8 to 8 1/2 feet in length for regular sections and up to 12 feet and more for switches, trestles, and bridges. Main-line ties are hewn or sawn in sizes ranging from 6 to 8 inches thick and 6 to 9 inches wide. They are cut from both hardwood and conifers, with hardwood ties usually being more costly and serviceable. To increase the life of ties, they are often treated with creosote. The additional cost is usually more than compensated for by added years of life of the ties.

Spurs often utilize poorer material for ties and sometimes round poles are used on poorer construction if small equipment is in use and the life of the spur will be short.

Engineers have had considerable trouble with the problem of determining the proper formula to use for superelevation on curves. A train rounding a curve has a tendency to be thrown outward by centrifugal force. In order to offset this force and allow a train to pass
around the curve without danger of its leaving the track or spreading the rails, the outer rail is elevated. This elevating of the outside rail is known as superelevation. A formula for finding the amount of superelevation must take into consideration the speed of the fastest train that will round this curve. Further, it must take into consideration a train that will be barely moving around the curve and yet not throw too much weight upon the lower rail. (6)

An engineering formula that is sometimes used in determining superelevation is as follows:

\[ E = \frac{V^2 G}{32.16 R} \]  

In which \( E \) is superelevation

\( \sqrt{V} \) is the square of the velocity in feet of the fastest train.

\( G \) is the gauge of the track.

\( R \) is the radius of the curve in feet.

Other formulas have been developed, some of which are practical, others not practical to all conditions. On logging roads a limit is sometimes set at 2½ inches and the speed of the train made the variable. In this way the speeds will be limited to the allowable speed, indicated by the formula.

RAILS

Rails for logging roads are usually purchased by the long ton from public carriers. Rails for main-line logging and on better roads are likely to be of 70 or
80 pound steel. Since steel is purchased from used stocks, prices will vary considerably.

Rails are originally built according to specifications as recommended by: 1. American Railway Association, 2. American Society of Civil Engineers, or 3. American Railway Engineering Association. Since specifications will vary, depending upon these various associations, a purchaser of used rails, frogs, or angle bars should ascertain whether the entire order is of one kind. If they are not and they are not interchangeable, complications will arise on the job. (8)

BRIDGE TRUSSES, TRESTLES, AND CULVERTS

These structures are built to span depressions, in the case of bridge trusses and trestles, and to allow for the flow of water under the road bed without disturbing the road bed, in the case of all three above named structures.

BRIDGE TRUSSES

A bridge truss consists of two or more trusses, which lie in vertical planes parallel to the center line of the road. Such a truss consists of an upper and lower chord with web members connecting them together. Some of these members will be in tension while others will be in compression, depending upon the type of truss indicated. Plate 3 illustrates a Howe truss and shows which members are in compression and tension. Such a
structure is capable of carrying heavy loads over a considerable distance. The length of the span, the dead weight of the span, and the heaviest expected load which this span will carry, as well as the materials of which the span is to be built, will determine the size of the members necessary. In order to allow for the heaviest possible load which the span will carry, two large locomotives, followed by a heavy train, are often taken as the live load in figuring stresses for the various members. A diagram, such as shown in Plate 2, will assist in determining moments, reactions, and shears in trusses. In the diagram it will be noticed that on horizontal lines are shown the total accumulated weights to each wheel and the distance of that wheel to the first wheel of the locomotive. The vertical lines show the moment of all preceding wheels with reference to that wheel. Such a diagram can be made for any locomotive if the weight on each wheel is known and the distance the wheels are apart. (9)

Both wooden and steel spans are found on logging roads with wood spans being more common.

A number of different kinds of trusses have been used in the past, some of which are in common use today. Some of these trusses are as follows:

1. King post truss
2. Queen post truss
3. Howe truss (see Plate 3)
Diagram for a 112 ton decapod locomotive and its tender which can be used in determining reactions, moments and shears in trusses.

(From "Roofs and Bridges", by E.A. Bowser).

Scale

10 feet = 1 inch.
PLATE 3

HALF SECTION OF A HOWE TRUSS.

Scale

10 feet = 1 inch.

Heavy lines indicate compression members.
Light lines indicate tension members.
Broken lines show counter braces.
4. Warren truss
5. Pratt truss

All of these trusses are useful and have certain advantages for various uses.

The Howe truss was patented by William Howe in 1840 and has been a popular truss in timbered areas ever since. In this truss, the inclined members are in compression and the vertical members in tension. The chords and the diagonal web members are of wood and the vertical ties are made of iron. (9)

TRESTLES

Trestles are constructed of driven piling, properly supported, caps, and stringers. The caps are placed across the tops of each bent and fastened securely to each pile. Stringers are placed across the caps and lie parallel to the road. If the trestle is on a railroad, ties are laid across the stringers to hold the rails. If the trestle is a part of a motor road, a deck is constructed above the stringers.

Where practical, trestles are usually less costly than trusses and are simpler of construction. They are commonly found on logging roads because of availability of piling and rapidity of construction. Costs will vary with individual trestles, but a common figure used in estimating costs is $10 per linear foot for trestles of heights up to 30 feet. For heights greater than 30 feet, other factors enter and costs may rise noticeably.
These structures are substantial and often outlive the road of which they form an integral part.

CULVERTS

The size of a culvert placed in a grade will depend upon the amount of water that it is expected to carry. Flows are not uniform during all times of the year, but the culvert must be large enough to carry the flow at flood stage.

Formulas have been built to assist in determining sizes necessary under local conditions. These formulas are empirical in nature and have proved to be useful where information concerning flows is lacking.

Talbot's formula

This formula is built to allow for fast or slow runoff by the use of various coefficients. The steepness of the terrain will determine which coefficient to use. The formula is as follows:

The area of the culvert in square feet is equal to \( C \) times the fourth root of the cube of the drainage area in acres. \( C \) is a coefficient and can vary from one sixth in flat country to one in steep mountainous terrain. (10)

Meyer's formula

This formula is much like Talbot's formula and gives comparable results. This formula is as follows:

The area of the culvert in square feet is equal to \( C \) times the square root of the drainage area in acres.
Here, too, $C$ is a coefficient and varies from one in flat country to four in steep mountainous terrain. This formula is simple to use and is valuable in making quick estimates. (10)

**COSTS OF RAILROAD LOGGING**

Costs of railroad logging are computed in dollars per thousand and are prorated over the amount of timber transported over the road.

These costs will vary considerably with various roads depending upon the initial investment of the road, efficiency of operation, maintenance costs, character of the road itself, size of locomotives used, length of haul, and the amount of timber transported over the road.

One method of computing these costs is as follows: compute the average annual investment; taxes and interest will be based on this figure; add to interest and taxes the depreciation charge, maintenance costs, and costs of operation; the total of these costs divided by the number of thousands of board feet of timber transported will give the cost per thousand; these costs, when added to the logging costs, will indicate the total cost of the timber at the mill or market. This amount will be exclusive of stumpage costs.

The average annual investment can be determined by one of several formulas. A formula commonly used is hereby given:
The average annual investment = \( \frac{(I-R)}{D} \)

In which I is the initial investment.
R is the residual value.
D is the depreciation charge. (11)

Another useful formula is as follows:

\[
\text{Ar. annual investment} = \frac{I}{R} \times \frac{n}{y} \times \frac{d}{x}
\]

In which I, R D is the same as above.
n = years in use; y = years life of operation.

The usefulness of this formula lies in that the various items can be referred to and depreciated over the entire life of the operation rather than be figured separately. Average annual investment will also be computed not for the life of the item in question, but rather for the life of the operation as a whole. By totaling the average annual investments for the various items concerned, taxes and interest can be computed for the investment. (12)
CHAPTER III

TRANSPORTATION BY MOTOR TRUCKS

The use of motor trucks in transporting timber products dates back over 20 years, but it has been within the past decade that the greatest development of motor trucks on timber hauls has been made.

The change from trucks that could transport a cord of wood to trucks that have hauled in excess of twenty thousand board feet of saw logs weighing about 80 tons indicates that this development has been extensive.

Today many operators look towards the truck as the sole means of supplying their mills with logs. Many of these hauls are in excess of twenty-five miles, with from ten to twenty mile hauls being common.

When trucks are referred to in this paper, the truck and trailer will both be considered. Without the trailer, the truck would not be as important today as it is.

TRAILERS

Trailers are usually of the "semi" type with one or two axles. A loaded log lies with one end upon a bunk placed across the rear of the truck and the other end on the trailer bunk. Logs are held in place in various methods and are usually tied down with the use of chains called wrappers.

When not in use, the trailer is often loaded on the rear of the truck, thus allowing for greater
flexibility and preventing unnecessary wear of the trailer tires.

Trailers, like trucks, have made rapid advancement during the past several years. They are built to carry any load that can be handled by the truck to which they are attached.

MOTORS

During the past several years the motor unit of the truck has made rapid advancement. Gasoline engines were made larger and more powerful. They have been manufactured in numerous sizes and horse-power ratings. The maximum torque has been developed at various R. P. M. and the speeds have increased considerably. As a result the logger has been able to choose units especially adapted to special logging requirements.

During recent years, Diesel units have reached new stages of development. Larger and more powerful as well as more simple units resulted. Because of the massive construction and simplicity of these units, less upkeep resulted. Motors in trucks on steady hauls have been used up to and to exceed one hundred thousand miles of travel.

To further advance the Diesel idea is the advantage of cheap fuel. The cost of Diesel oil, which is used in these units, is approximately a half to a third the price paid for gasoline. Further, a greater mileage per gallon is often shown.
Diesel motors, due to their tremendous compression, must necessarily be made heavier per horse power than gasoline engines. For some types of hauling this is a disadvantage; however in the logging industry, the products hauled are both heavy and bulky; consequently heavier units are often desirable. The extra cost of Diesel units is often more than compensated for by extra power and lowered upkeep expenses and lower fuel costs.

TRUCKS VERSUS RAILROADS

Because of the heavy hauling capacity of trucks, their extreme flexibility, the low cost of truck roads, and the relatively small capital investment, the motor truck is fast becoming a real competitor of railroads. Few railroads are now being built by logging companies, and few existing roads are being extended.

Some of the advantages of trucks over railroads are:

1. Small initial cost;
2. More flexibility;
3. Cheaper road construction which will allow:
   a. Steeper grades;
   b. Sharper curvature;
   c. Lighter bridges and trestles;
   d. Greater choice of routes;
   e. Ability to avoid hazards and obstructions;
4. The operator can often take advantage of roads now in the logging area.

5. Scattered timber can often be logged which would be unavailable to the railroad logger.

6. Greater simplicity in moving from show to show;

7. Less loss due to accidents—a "crack up" on a railroad can cost hundreds and even thousands of dollars and may "tie up" the operation for a considerable time before repairs can be made.

With the removal of the timber from large blocks loggers have turned towards smaller stands in more isolated areas. It is here that trucks have a decided advantage over railroads. Because of the relatively small amount of timber to be removed from a particular tract, the cost of railroad construction may be prohibitive. Railroad construction on even short distance hauls is often beyond the financial means of a logging company.

Trucks offer a method of timber transportation that is positive and with little expense on the part of the operator who may have little financial backing. Often the operator can start logging with no road building by taking advantage of existing county or state roads. Once he has logs going to market he will have an income which will allow him to develop his road construction plan as he sees fit.

Many logs are brought to the open market in this manner. From this standpoint trucks have been a boon to
the "gyppo" loggers who are often excellent loggers, yet are short the necessary finances to get started in another manner.

Costs of operating trucks vary considerably on various shows. Costs per thousand will depend upon many factors, some of which are hereby listed:

1. Size of the timber hauled;
2. Method of scaling—gross or net scale;
3. Length of the haul;
4. Size of trucks used;
5. The road over which the trucks must travel;
6. Grades, adverse or favorable;
7. The extent to which the trucks are kept in repair;
8. Managing ability of the operator.

With a number of companies who are using motor trucks as their chosen method of major transportation the tendency is towards larger truck and trailer units. It is likely that we have not as yet developed the proper sized truck for timber hauls. Whether the trend in years to come will be towards smaller and faster units or larger units is conjecture; however it is the belief of this writer that we will have medium-sized trucks for years to come and also larger Diesel units capable of hauling from fifteen to twenty-five thousand board feet for special hauling jobs. The turn that truck hauling will take in the next decade will be interesting to watch.
ROAD BUILDING FOR TRUCK HAULS

The type of hauling to be done and the geographical location of the hauling job, as well as the soil, terrain, etc., will affect road construction for truck hauls. Whether small or large trucks are to be sent over the road may make little difference as to grades, but road widths, surfaces, and the sizes of structures will be affected. Also, a road built in the "fog belt" may require more ballast than one east of the Cascades where the normal rainfall may be about a fifth that measured in the "fog belt." Finally, the terrain and the condition of the soil itself will be influencing factors which must be considered in road construction.

Regardless of individual conditions, any road must fulfill certain requirements:

1. It should provide a constant means of travel; rainy seasons or long dry spells should not impede travel if the road is intended to be used during these periods.

2. The road should be capable of handling the traffic for which it is designed. A road designed to carry a fleet of trucks on a routine schedule should be wide enough or have enough turnouts to allow for steady travel.

3. A road having bridges, culverts, trestles, or any other type of structures should have these
3. (Cont.) Structures strong enough to carry the heaviest load that the road is designed to carry. Failure of a single structure may stop travel for hours or even days.

As time goes on and the competition in the lumber business becomes keener, due to improved equipment and management, operators may find it necessary to do a greater amount of planning than formerly.

Road construction itself or construction costs may not be decreased per station by planning, but the cost of removing the timber may be lessened by placing the road where it will be most valuable. As a result of better planning engineering becomes more and more important in that it is often left to the engineer to plan this phase of the operation. Thus we find engineering entering into truck road construction much the same as in railroad construction.

Several ideas have been advanced as to how it is best to lay out truck roads to get optimum returns by finding the proper road spacing. Formulas have been advanced for finding this spacing for flat country logging; however in the rough country in our mountainous areas, every show has its own peculiarities which must be worked out on the site.

Two types of roads are common in logging practices. They are the conventional dirt and gravel roads and the fore-and-aft roads. Both are used with varying success.
A company in western Oregon reports success with a fore-and-aft road built in sections of from ten to twelve feet in length. When the road is abandoned, these sections are picked up and placed on a new grade.

It is to be remembered that trucks furnish a flexible method of logging; consequently one can expect new methods of road building to be developed.
PART II
MAJOR WATER TRANSPORTATION

CHAPTER I

RIVER-DRIVING

River-driving dates back to the early logging days in the state of Maine and in eastern Canada. It has been a spring event in some parts of the United States and Canada for about one hundred years.

This method of timber transportation has often been supplemented with horses and bull teams. It has proved itself to be one of the cheapest methods of timber transportation ever developed, providing the stream was a good one for driving and conditions were favorable.

Some of the advantages of driving can be listed as follows:

1. The method is cheap and fast. The entire year's cut will be brought to the mill usually within sixty days.

2. The method is adapted to remote areas on watersheds which have not been "opened up" with roads or railroads.

3. Initial investment is usually small.

Some of the disadvantages are:

1. In mixed stands where all species will not float, complications set in. This is true in mixed pine and hardwood stands of the Lake states.
2. Usually only one drive can be made in a single year.

3. There is not a steady flow of logs to the mill; thus it will be necessary to maintain a large space for storage.

4. Should a drive prove unsuccessful, the entire cut will fail to reach the mill.

Good driving streams are rare, since to be a good driving stream it should have the following qualities:

1. It should contain enough water to float all logs, including the largest ones.
2. It should be free from obstructions.
3. It should have high banks with no chance for the logs to drift into swampy areas or into the timber.

Some of the best driving streams have been found in eastern Canada and in northern Idaho. The Clearwater River in Idaho is considered by some drivers as the best driving stream in the entire West.

There is no limit to the distance that logs can be driven, providing there is sufficient water. However northern Wisconsin has reported unsuccessful drives because of lack of water, not due to insufficient water at the starting point, but rather because the water dropped to low levels due to prolonging the drive beyond the freshet season.

The equipment necessary on all drives is not the same. Hand tools do not vary noticeably, but the
equipment on the river may. Hand tools necessary on most drives consist of the following:

1. Axes
2. Peavies
3. Pike poles

Other equipment consists of the following:

1. Bateaux
2. Drive camps or tents
3. Pack strings or "Wanagan"
4. Splash dams
5. Powder, caps, and fuse

A large drive requires considerable preparation on the part of the operator. Once a drive is started, expenses are high for labor, transportation, and supplies; consequently during the drive, little attention is given to anything else and every effort is made to get the drive through as quickly and cheaply as possible.

All drives are not alike, but they have the same purpose—to deliver timber to the mills or to where it can be transported to the mill by other means. Drives may be from a few miles in length to fifty miles or more. The time spent in driving may vary from a few days to several weeks.

The writer spent about four weeks on a white-pine drive which transported about fifty million board feet of saw timber from the headwaters of the Little North Fork of the Coeur'd Alene River to the lower end of
Coeur'd Alene Lake, a distance of about thirty-five miles, for the Winton Lumber Company of Coeur'd Alene, Idaho, in the spring of 1930.

The procedure followed in this drive will be explained to give first-hand information on methods used.

The Little North Fork is not a good stream to drive, since it is fast, rocky, and does not have high, steep banks. It contains numerous sand bars and in many places is shallow. The company built several dams across this stream in strategic places for the purpose of collecting water for "splashing" in order to assist in floating the logs through shallow places in the river.

During the summer timber was brought to the river by flumes, chutes, and trailed behind horses. The river was kept open by a crew of men known as "space makers." This crew made "space" at the mouths of flumes and chutes and kept the river open as far down as possible. The logs gradually filled the upper reaches of the river with some logs floating down for several miles before "hanging up" on sand bars or forming "centers," "wings," or "jams."

During the winter, deep snows caused the shutting down of the operation until the "break up" in the spring. Directly after the ice began to break, an initial crew was sent to break jams. This was a picked crew. They found it necessary to use snow shoes to get to the river. Starting at the jam furthest down the river, the crew worked up to where the jams were larger. Additional men were sent to work and a peak of about
two hundred men were employed before the jams were all broken and the logs were riding freely down the river.

Gradually the jams were broken and new ones formed which in turn were broken until the drive was spread over the entire river, from the "rear" to the sorting gaps at Dudley, Idaho.

The larger part of the crew was now working the "rear." This crew left a clean river behind them. "Splashes" were made twice a day, at six in the morning and again at twelve noon. During the useful time of these "splashes," which lasted about an hour and a half for the small dams, to about two and a half hours for the larger ones, every effort was made to keep the logs floating. "Wings" and "centers" were broken as soon as they formed, whenever this was possible. During low-water periods, logs were rolled and dragged from sand bars and from the brush where many of them would float during high water. As many as thirty men were necessary to move a single log to where the next high water would take it down the river.

Man power was plentiful and the "rear" made from a fourth of a mile to a mile and a half a day.

Hand tools consisted of peavies and pike poles. Peavies were used for rolling and dragging logs as well as for breaking jams. Pike poles were used for "pole eating" and "sluicing" the dams. Once the logs accumulated behind a dam, they were worked forward as near the
dam as possible. With a crew on the dam and another
riding the logs, the gates were opened and the logs sent
over the aprons. Until all of the logs were sent through
the gates or until the water above the dam was exhausted,
this operation was continued. Should more logs remain be-
hind the dam, the process was repeated six hours later
or with the next "splash."

With the last log through the dam, the "rear"
continued down the river. The dam was manned as before
and continued to be used for "splashing."

Low banks and flat marsh areas along the river
caused considerable trouble. Logs floated far inland,
and when the water went down after a "splash," these logs
must be dragged back into the river. This called for
man power, but to see from eight to thirty men on a single
log was common. The "rear" left no logs behind and tre-
mendous though the task seemed, it was always accomplished
in the shortest space of time possible.

Tall pines, spruce, and cottonwoods grew on the
banks of the river. These banks were continually being
gutted by timber and fast water and often gave way,
bringing trees with them. These trees often fell into
the stream and many times reached entirely across it.
Immediately jams would begin to form behind these logs or
"sweepers," which must be cut out before logs could be
sent beyond this point.
For a week the writer cut "sweepers" with a double-bitted axe. The work is extremely tiring when the tree is above water, but it becomes nearly impossible when the tree is submerged. When it becomes impossible to cut these out by hand, powder is resorted to and the tree will be blasted to shreds.

"Centers" and "wings" are continually forming. These must be broken rapidly or they will grow into complete jams. Special crews are often used to break them. If the "center" was large, additional men were sent, until man power could be brought to bear to remove the "key log" or throw off logs from the top until the "key log" could be reached and removed.

In fast water, breaking "centers" is dangerous work. One or more bateaux were held above the center, and once it begins to "pull," the drivers race for the bateaux and are taken away to safety.

Jams are more difficult to handle than "centers" or "wings," since they are usually formed by one or the other or both. They often grow into huge proportions with water and logs piling high. In large jams, millions of board feet may be involved. The largest jam seen by the writer contained about twenty million feet. The face of the jam stood about forty feet high. Every known method was used to break it, and it was finally blasted. Hundreds of man days were spent on this jam which cost the company several thousands of dollars.
Here and there along the river, stream development was done. Log booms were cabled securely to stumps or rocks. These booms rose and fell with the water and prevented logs from floating into other channels or into roots which would be sure to cause "hang ups." Above the dams hundreds of feet of booms were strung out to narrow the approach to the dams and thus facilitate "sluicing."

Once the last log arrived at the sorting gaps, the drive was over for that year. At the sorting gaps the bark marks were inspected, the logs placed in booms and towed across the lake to the mill, where the entire drive was cut in a few months.

Log driving is going out of the picture of modern logging, not because the method is obsolete or expensive, but because the timber within the watersheds of good driving streams is rapidly being cut out. Given timber on a good driving stream, a company would be foolish not to consider this method of transportation before expensive roads were built.
CHAPTER II
OCEAN GOING RAFTS

Rafts have been used throughout the United States and Canada in various makes and sizes for transporting saw logs, piling, shingle bolt, posts, poles, and sawn lumber for many years. These rafts never reached huge proportions until ocean-going rafts were developed.

Ocean-going rafts are of two main designs. The Benson raft is used for long ocean voyages and the Davis raft is used for short voyages, largely along sheltered coastal waters. (13)

The forerunner of our present ocean-going raft was the Robertson raft which was built in Nova Scotia in 1884. The raft was unsuccessful and Robertson came west and built another raft on the Columbia River. After several attempts to raft logs to San Diego, California, he was eventually successful and transported several rafts to southern California. His raft had several weaknesses which were corrected later in the construction of the Benson raft. (13)

THE BENSON RAFT

The Benson raft was first built in 1906 in the Columbia River. This raft was patterned after the Robertson raft with improvements made to the locking devices and the towing gear. This raft was built in a cradle, much the same as the Robertson type. A great
number of tree-length logs were used to give the raft rigidity. When completed, the raft resembled a huge cigar, contained nearly six million board feet of logs, and utilized about one hundred seventy-five tons of chains for bindings. (13)

Once a raft is completed, the cradle locking devices are opened and the cradle is towed away in two pieces. Large steel hausers are affixed to the raft, and it is ready to be towed behind tugs built especially for that purpose. (13)

Over one hundred such rafts have been successfully delivered to San Diego, California. These trips, about eleven hundred miles long, require about two weeks and cost of towing amounts to about $1.50 per thousand board feet. (13)

It requires about six weeks to construct a Benson raft with a crew of 11 men. Five rafts are considered a season's work. (13)

This method of transporting timber is excellent for coastwise shipping. It is cheap and furnishes a positive supply of logs to the mills. Due to toredo action in salt water, it is customary to build the cradles in fresh water.

Since the towing charges are much less than railroad freight, this method of transportation is likely to continue.

THE DAVIS RAFT

The Davis raft, also an ocean-going raft, differs considerably from the Benson raft. It is designed to
utilize from fifty thousand to seven hundred thousand board feet and can be quickly built, utilizing a floor built up of logs laced over and under with cable or chain. The ends of these cables are fastened securely to boom sticks on either side of the raft. These boom sticks are held a fixed distance apart by cross logs or "swifters." Both ends of the booms are chained together. Once the floor is built, loose logs are laid endways on this floor and finally bound down with more cable. These binders are pulled tight with steam power and bound to the boom sticks with trip hooks. (13)

When completed, a large Davis raft is about one hundred fifty feet long, seventy feet wide, and contains about seven hundred thousand board feet of timber. The raft can be built in about twenty feet of water, and when completed, does not sink to a great depth. (13)

These rafts are towed by tugs at slow speeds. Being much more flexible than the large Benson rafts, this type of raft can be used to advantage on short hauls up or down the coast. This method of transportation can be expected to be used for many years to come.
CHAPTER III

FLAT RAFTS

Flat rafts have been used both in the United States and Canada. They are built in sections, usually about seventy or eighty feet in length and from sixty-four to seventy-six feet in width. There may be from one section to twelve in a completed raft. Eight sections constitute a normal raft as found along the Pacific coast. (14)

These rafts are held together by the use of boom sticks with cross members at either end of the section. Long hausers are attached to the front of the raft and affixed to tugs for towing.

Costs of this type of construction are a minor item, and towing costs amount to about a cent per thousand per mile of travel. Several billion board feet of timber are towed along coastal inland waters along the Pacific annually. (14)

This method is positive, inexpensive, and a small capital outlay is necessary. During the past few years, there seems to be a trend to utilize more fully water routes. An approximation of the difference of costs in land and water can be found in the example of the Willamette River and the Southern Pacific Railroad. The water transportation from Albany, Oregon, to the log market in Portland, late in 1940, amounted to approximately $2 per thousand. The same haul on the railroad amounted to approximately $4 per thousand. With this difference,
there is little likelihood of rafting going out of the picture in the near future.
CHAPTER IV
CONCLUSIONS

The trend in major timber transportation during the past decade was toward fast, flexible methods which do not require huge initial capital investments. Motor trucks have made tremendous advancement and it is expected that they will make even more progress in subsequent years. As yet, the most economical size truck does not seem to have been ascertained; however the tendency seems to lean towards larger trucks and better roads. Somewhere there seems to be a size of truck that, when used on a specified road, will give most economical returns. It may be found that in the future, medium-sized trucks which can haul from five to eight thousand board feet will be the answer to the loggers' demands, or then again, it may develop that best results can be obtained with huge monsters that can haul from twenty to twenty-five thousand board feet per trip. Time alone will decide this point.

Water has always been the most economical method of transportation. My belief is that it will be used more and more in the future whenever it is available. More flat rafts can be expected on our rivers and built from logs "dumped" into the rivers from fast, flexible truck units.

Railroads have been with us for many years and can be expected to remain with us and form a major means of
log transportation for many years more. On long hauls of from thirty miles or more in length, which are off the water courses, railroads should have no trouble in maintaining supremacy in major timber transportation. It is expected that railroads will work in conjunction with fast motor trucks which will bring the timber to the reach of the railroad by transferring the timber to the rail heads. This method is now in use in many operations and is expected to develop further.

Ocean-going rafts have been successful in both short and long distance hauls. This type of transportation is sure and cheap. It is expected to continue at about the same rate as at the present.

River driving is going out of the picture because of lack of timber in areas where river driving could be continued. With but a few exceptions, river driving is a thing of the past.

The greatest development in transportation can be expected with the use of motor trucks of the Diesel type. Improvements of this method of timber transportation may revolutionize the industry. The password may well be, "watch the truck logger."

One cannot cite figures for transportation costs from stump to mill or log market. Many factors enter which make this impossible. Some of these factors include:
1. Condition of the roads
2. Size of the logs involved
3. Size of trucks used
4. Methods used in loading and routing trucks
5. Labor prices paid, etc.

A study of a number of operation costs of various logging companies on the west coast and in eastern Oregon for truck hauling jobs convinced me that all these above factors are decidedly important. I could find no way to place these operators on an equal footing and determine base costs.
BIBLIOGRAPHY

11. From H. R. Patterson, Professor of Logging Engineering, Oregon State College.
Fig. 1

Framed Railroad Trestle across Powder River near Baker, Oregon
Fig. 2

Flat Raft on the Willamette River
Fig. 3

Truck Transportation on Concrete Roads
Albany, Oregon
Fig. 4
Railroad Logging in Eastern Oregon

Fig. 5
Skeleton Flats on Southern Pacific Tracks
Corvallis, Oregon