ELECTRIC LOGGING

IN THE DOUGLAS FIR REGION

by

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I Introduction

Yarding logs is an arduous task and requires much power. For many centuries loggers were dependent upon animal power. It is a far cry from man power to electric power --from the most ancient to the most modern source of power.

Early day logging in the western United States depended upon oxen or horse teams. The first logging machines were vertical spool steam donkeys--no drums, no haulback. They depended upon line horses to take the lines out into the woods. Gradually wire ropes were improved, drum systems and power haulbacks were devised, and boiler pressures were raised. The last step was the adoption of two speed transmissions and the adoption of oil for fuel. Heavier, faster machines were demanded by the loggers, and the manufacturers of logging equipment designed machines of mammoth proportions to meet this demand. Tremendously big steel tower skidders were built. These machines needed steam in huge quantities, and the larger the boilers became, the heavier the machines became, until it was apparent that some source of power other than steam was needed if the machines were to be able to traverse logging railroads, where sharp curves and steep grades are common. Some of these machines actually exceeded the bearing capacity of the soil with the result that machines overturned when subgrades failed.

Electric motors weigh far less than steam engines per horse power; they have an unlimited source of power in that they can be operated continuously at full capacity, and have many other advantages, enumerated elsewhere in this paper. For these reasons, the logging industry, in its search for more powerful machines, was eager to try electricity if it could be proven satisfactory. It was tried and found eminently satisfactory for the heavy machines the industry desired.

Some difference of opinion exists concerning the first electric logging machine. Bryant, in his book, "Logging", says that in 1908 an electric road engine was tried out in British Columbia, but that it did not work satisfactorily because of its inability to vary its speed and to take up the slack on downhill pulls. Others claim that the first electric logging machine was owned by the Morse Manufacturing Company of Puyallup, Washington. This crude donkey used a direct current street car motor for the power source.

The first successful electric logging machines were put in use about the year 1911. They proved quite satisfactory. A few of the earliest operators were the Potlatch Lumber Company in Idaho white pine, and the Smith Powers Logging Company and the C. A. Smith Lumber Company in Douglas fir. All these earlier machines were merely converted steam donkeys with the boiler, cylinders, and other steam fixtures removed and replaced with electric motors and suitable gearing to connect the new power plant to the old drum system. These motors ranged from 150 to 265 horsepower and used alternating current. These old time installations were slow when compared with modern electric logging engines. They used single speed motors and transmissions with a main line speed of 300 feet per minute and a speed of 850 feet per minute on the haulback. These machines were used only in small timber.

There were very few new machines put in use, and very few new developments in electric logging until 1917. In that year the Snoqualmie Falls Lumber Company, operating in heavy Douglas fir timber, converted a heavy steam yarder to electric drive using a 200 horse power alternating current motor. These machines were handicapped by insufficient transformer capacity. They were troubled, too, by lack of facilities for operating the motors at dead low speeds. This made the machines dangerous to the crew. Early machines were operated under strict orders against taking men up on the pass lines. In spite of these difficulties the machine proved so satisfactory in handling heavy timber that in 1920 they installed an electric duplex loader, thus having one completely electrified side.

Costs and performance data gathered on the operation of this one electric side were so satisfactory that in the following year the company decided to electrify its entire operation. Taking into consideration all the experience and data gathered in ten years, entirely new machines were designed with larger and more rugged motors and controls.

The hey-day of electric machines was short lived. Internal cumbustion power plants began to draw the serious attention of loggers shortly after the war. Auto trucks had been found satisfactory and were improving fast. Track-laying tractors had proved their ability in military service and were rapidly finding favor in all types of hauling service. It was only natural that loggers should give them a test. They did this and were impressed with their many advantages. They fitted into the scheme of selective logging, they were flexible, and they came in small units. With the coming of diesel power, which means reduced fuel costs, their future was assured. Today the logging industry is rapidly going over to the tractor and truck combination.

At the present time, electric machines are limited to the rough terrain where tractor logging is not practical. It seems quite capable of holding its own in rough country. Its future elsewhere depends upon the future costs of fuel for internal combustion motors.

Diesel electric yarders have been suggested to get away from the cost of maintaining power lines, and to get the improved performance of constant speed diesel motors, but none have yet been constructed. At least one company, however, has tried diesel electric shovels and found them so satisfactory that they are considering the purchase of a diesel electric yarder. Diesel electric locomotives have been found very successful on logging, industrial, and common carrier railroads, thus indicating the possibilities of diesel electric power plants for yarding logs.

II Types of Electric Equipment

There are two general classes of electric equipment--self contained and not self contained.

Straight electric machines belong to the second class in that they depend upon an electric generating plant at some distant point with the transmission lines between them. The savings with such machines are dependent upon the economies of a large central generating plant, preferably hydro-electric.

There are two types of self contained units--storage battery machines and electric drive machines. The former has found no applications in the logging industry, though it is much used in mines and occasionally in sawmills.

There are two types of electric drive equipment--those that use internal combustion motors, and those that carry steam power plants. Internal combustion motors burn diesel oil, gasoline, alcohol, or gas. The diesel electric plant is the most promising type in this class. Most steam (or other vapor) plants burn fuel oil and use the steam in reciprocating or turbine engines. Neither of these appear to have a very great future in the logging industry except for main generating plants where sawdust and other wood waste could be burned to generate power for straight electric installations.

To summarize--the only types of electric machines with any immediate future in the logging industry are the straight electric and diesel electric machines.

III Advantages of Electric Logging Machines

The use of electricity in the woods has many advantages.

Fire hazard from an electric logging engine is practically non-existent. Steam equipment is notoriously dangerous, due to flying embers, or with oil burning steam equipment, burning carbon scale. While there are many spark arresters on the market, none of them are entirely satisfactory. The best of them cut down draft and thus lower the steaming ability of the machine. Spark arresters on diesel and gas machines to prevent burning carbon scale from being blown out of the exhausts increase the back pressure on the pistons with resultant lowering of efficiency and power.

Since electric machines use no water whatsoever, the oft-times difficult and expensive problem of supplying water is entirely eliminated. Diesel and gas machines share this advantage except for the problem of protecting their cooling system from freezing in cold weather.

No night watchman is necessary on an electric side if the corner blocks and lines are inspected for possible fires before the crew comes in at night. The switch is pulled at the transformer and the lines and machine are dead. This advantage is shared by diesel and gas engines. When the crew comes on in the morning, they close the switch at the transformer and the machine is ready to run. No one need to get up steam and the crew need not wait as in diesel rigs for the motor to be started and warmed up. Much time is lost starting and warming up diesel rigs in cold weather.

Fuel supply is sometimes a difficult problem for oil burning machines cold decking away from the railroad. Wood burners require at least two additional men--a fireman and a wood splitter. In addition the entire yarding crew loses time while wood logs are being yarded in and spotted for position. Diesel machines carry sufficient fuel to tun them for a long time, but even they are occasionally troubled with fuel supply if they operate for long periods at a distance from the railroad. Electric power lines, once installed, carry electricity without further attention. Furthermore, electric lines can be strung over even the most difficult of terrain.

Electric motors consume no power when they are not working. Steam rigs must keep up steam all day, and they burn fuel continually. Gas and diesel machines consume fuel all the time, as it is not convenient to shut them down while waiting.

Electric machines have a tremendous advantage over steam in that they can be run continuously at full throttle. No steam yarder has the steaming capacity necessary to operate continuously at full throttle. Much time is lost yarding heavy logs long distances in waiting for steam. This means that the entire crew, with the exception of the fireman is idle.

Electric machines are entirely free from this trouble; the power supply is from a large central generating plant and the supply is not diminished even by prolonged abnormal demand.

Companies using electric power in the woods have the advantage of a cheap and dependable power supply for other uses. Companies using electric logging equipment find it advantageous to electrify all their shop equipment, and to use electric lights, electric water supply, and other electric conveniences in camp. One camp in the northwest is using an electric rock-crusher for supplying ballast to their railroad and they find it to be very economical to operate.

Electric power on railroad inclines has many advantages over any other power supply. The intermittent use of lowering engines makes any power source other than electricity an expensive item. Electric power is always immediately available and is not consumed except when the engine is in actual operation.

Repairs to electric equipment are much more speedily made than on any other type of machine. The entire motor can be replaced on an electric machine in four hours without bringing the machine in from the woods. After the spare motor has been installed, the motor in bad order can be overhauled at leisure in the shops. Other types of machines have none of these advantages--a serious break down means closing down a side.

IV Power Lines

Electric power is purchased and transmitted to the main distribution point of the logging company at 66,000 volts. At the main distributing center the voltage is stepped down to 13,200 volts for distribution to the field transformers, where it is again stepped down to 600 volts and delivered at this voltage to the machines. See diagram, plate 2.

High tension (i.e., high voltage) electricity can be transmitted with lower power losses than can low tension electricity. The reason is that the drop in voltage is the same no matter what the original voltage is. There is no drop in amperage. A sample problem will illustrate this. Consider the relative advantages of transmitting 1,000 amperes at 66,000 volts or 10,000 amperes at 6,600 volts. These figures are for the electricity delivered at the generating plant. The number of kilowatts impressed is the same in either case for voltage times amperage divided by 1,000 equals kilowatts.

Or, expressed by formula:

$$K = \frac{VA}{1{,}000}$$

For the first case:

$$K = \frac{66{,}000 \times 1{,}000}{1{,}000} = 66{,}000 \text{ kilowatts}$$

For the second case:

$$K = \frac{6{,}600 \times 10{,}000}{1{,}000} = 66{,}000 \text{ kilowatts}$$

However, the <u>voltage drop</u> is the same in either case. Using an assumed loss of 1,000 volts between the generating plant and the consumer, we have:

For the first case:

$$66{,}000 - 1{,}000 = 65{,}000 \text{ volts}$$

$$K = \frac{65{,}000 \times 1{,}000}{1{,}000} = 65{,}000 \text{ kilowatts}$$

For the second case:

$$6{,}600 - 1{,}000 = 5{,}600 \text{ volts}$$

$$K = \frac{5{,}600 \times 10{,}000}{1{,}000} = 56{,}000 \text{ kilowatts}$$

This represents a saving of 9,000 kilowatts in favor of the high tension line. This saving is partially offset, however, by the increased cost of constructing high tension lines and the cost of the necessary transformer stations. For this reason only long lines are economically feasible for high tension power transmission. Shorter lines are more economically operated at lower voltages. The economics of attaining the most efficient distribution system is the concern of the electrical engineer and is beyond the scope of this paper.

The 66,000 volt lines are carried on pairs of cedar poles with crossarms carrying hanging insulators. See plates 3 and 5.

The main transformer station is equipped with oil cooled transformers, switches, overload protection and lightning protection. See photo, plate 4.

The 13,200 volt lines are hung on trees. These are ordinarily topped at about 100 feet and are peeled if they are to be in service over two years or so. Old trees are occasionally guyed. This is for the safety of the linemen. Lines passing over areas being logged are carried at about 200 feet. See plates 5, 6, and 7.

The field transformers are oil cooled and are equipped with cut-out switches. See photo, plate 8.

The six hundred volt cables are laid on the ground. They are submarine type. See plates 9 and 11. New cables are put on the sled-mounted machines where long unspliced cables are desirable. As they become worn, the bad parts are cut out, and the good parts are spliced and put into service on the car-mounted machines, where the usage is less rough and splices are not so undesirable. For methods of splicing, see plate 10. Present practice is to use lugs and bolts. Socket type connectors have been tried, but were found to be dangerous due to moisture collecting in the sockets, causing dangerous explosions. Wire wrapped cables are not desirable because of danger to the men. Men occasionally receive shocks from carelessness in not keeping the splice insulation tubes in place, but fatal accidents from this cause have not occurred with lug type connections.

The power lines are tested at about 5:30 A.M. of each working day with a test kit in the electrician's residence.

The most common source of power line trouble is from falling timber on spur lines. The right-of-way for main power lines is swamped out for safety. Power lines over areas to be logged are carried high enough that whipping rigging cannot touch them.

During the winter months sleet sometimes forms on the lines, but rarely heavily enough to break wires. However, when the sleet falls off the lowest wire, the wire sometimes flies up and hits the other wires, causing short circuits. Breaks or short circuits in the power lines occur only once or twice a year, on the average.

The per M cost of power line construction, according to users of electric logging machines, approximates the per M cost of water supply for steam rigs, and on difficult water, shows the cost of power line construction, operation, and maintenance is much lower.

V Description of Present Day Machines

Electrical logging equipment does not differ greatly from conventional steam equipment in general features of design. Early electrical yarding and loading units were assembled from standard team units; electric power being substituted for steam, and air-electric controls substituted for or added to the manual controls of the steam machines. Later models are newly designed throughout.

The most common electric machine is probably a high lead yarder and loader. In the machines built by Washington Iron Works and Westinghouse Electric, the units are built to conform closely to the standard arrangement of drums and fittings used on steam donkeys.

There are two general types--one speed motors and two speed motors. The former are used for loading or for yarding, in which case they are usually supplemented by a two-speed transmission. The latter have two complete sets of windings, one for high speed and one for low speed and greater power. The change-over from one set of winding to the other is entirely automatic and is handled by the overlead relays. The overload relays are also intended to cut off all power in the event that the motors are slowed down beyond the safety point of the low speed windings, but with experienced engineers operating the machines it has been found safe to leave it to the discretion of the operator as to when there is danger of burning up a motor. With such men it is the custom to discinnect the overload relay. This does not interfere with the cut-over from high speed to low speed windings. Two speed motors are used principally for yarding. Yarders and swing machines have only one motor, though loaders have two motors--one to lift the load and one to swing it.

It has been found to be advantageous to cool the heavy motors with motor-driven fans. These were not furnished on the equipment built to date, but were added after the machines were put in use. This permits handling heavier loads without overheating and the accompanying danger of burning out the insulation in the windings. The windings are insulated with mica, covered with an asbestos tape. These windings are not designed to withstand temperatures in excess of 100 C. (212 F.), though actual operating temperatures under heavy pulling far exceed this limit. This precludes the use of any resinous or rubber compound for water-proofing the windings. Since the asbestos is prone to absorb moisture from the air, all the windings must be dryed out before the machines can be operated after a shut-down period of a week or more in wet weather. This is done with electric "heating straps" inserted in the windings for a day before the machines are to be put in use again. The danger from moisture in the windings is a very real one. If the motors are used without slow and careful drying the heat resulting from their use results in a rapid vaporizing of the water and the steam thus formed within the insulation having no free escape may burst the insulation, causing expensive and dangerous short circuits.

The motor windings consist of copper bars insulated in the manner described in the preceding paragraph. Each segment of the windings may be separately replaced. In the event that a single segment is burnt out, it may be disconnected but left in place until enough of the segments are out of use that it becomes necessary to tear down the motor and replace the burnt out windings. At such a time the entire motor is generally checked and overhauled.

In the event that a motor is injured on the job to such a degree that it cannot be safely used, the entire motor is removed and replaced with a spare. This takes about four hours from the time the machine is down until it is running again. It costs approximately one hundred fifty dollars to change motors, including the wages for electricians, and the cost in wages and fuel for the special train and crane.

Each motor is equipped with motor-brakes, controlled by the engineer. These are superior to the conventional brakes because they operate so quickly that the drums may be stopped without backing off part of a turn after the power is shut off. The brakes are air operated from the control circuit or are straight electric solenoid type. The motors are never used as brakes by reversing the current, though all motors my be reversed at will.

The motors are geared to the durms in precisely the same way as in steam machines. The frictions are air-operated and are controlled by the forty-volt control circuit.

The motor speeds are controlled by a standard controller using resistance grids to vary the voltage.

All controls are of the electric-air type. It is never necessary for the engineer to handle the full motor voltage in actual operation. A motor generator set furnishes a supply of 40 volt electricity for the control circuits. Whenever the motors are to be started or stopped, the motor speeds to be increased or decreased, frictions applied or released, or brakes to be applied or released, the engineer moves a controller handle and the control circuit opens and closes the proper air valves to operate these switches. See plate 12.

A few machines substitute straigh air brakes and frictions and use an air valve control similar to a train brake valve controller.

The Washington-Westinghouse tower skidder is equipped with:

One 300 H P skidding motor

One 125 H P transfer motor (for rigging, car-spotting, etc.)

One 250 H P loading motor

One 50 H P beam swinging motor

One 40 volt motor-generator set (for control circuit)

Two 15 H P, 175# air compressors

The Washington-Westinghouse high lead yarder is equipped with:

One 200-300 H P two-speed yarding motor

One 250 H P loading motor

One 50 H P boom swinging motor

One 40 volt motor-generator set

Two 15 H P, 175# air compressors

The Willamette-General Electric tower skidder is equipped with:

One 450 H P skidding motor

One 200 H P transfer motor

One 200 H P loading motor

One 35 H P beam swinging motor

One 40 volt motor-generator set

One 15 H P, 175# Westinghouse air compressor

VI Operation

The greater number of electric yarders and skidders are "car-mounted" and are designed to work only along the railroad. They are spotted on a short siding at the site of the spar tree by the locomotive and the transformer is set alongside the track about fifty or a hundred yards from the machine. The transformer is connected up, the cables strung out between the transformer and the machine, a metal ground bar is driven into the ground and connected to the machine, and everything is ready to run. The first thing done is to start one of the motors slowly. It it starts backwards it is shut off and the engineer throws the reversing swith in the control cab. This switch makes it unnecessary to pay careful attention to the polarity of all the connections between the main transformer station and the machines.

After all the electrical connections are made, the machine is jacked up on to cribbing by the built-in hydraulic jacks.

The routine is the same for machines working away from the railroad, except that they are, of course, sled-mounted and move themselves into the woods.

On most settings, because of the scarcity of well located and suitable trees, it is necessary to "raise" the head tree, using a "dummy" spar. This is a shorter tree which is rigged temporarily to assist in raising the head tree.

Operation of electric machines is exactly the same as the operation of steam machines, except that the controls are all of the air-electric pattern, requiring much less "mam-power." Engineers on the electric machines say that they greatly prefer to operate these than steam, gas, or diesel rigs. They are quick and snappy in operation, and much more quiet than other machines, the only noise being in the gears. The motors produce only a low hum. Vibration is less than on steam machines, where heavy reciprocating parts subject the engine frames to steadily recurring strains which in turn are hard on the rest of the machine.

Toots E whistle systems are used, drawing electricity from dry cells. There appears to be no reason why the whistles cannot be operated from the 40 volt circuit.

VII Costs

The initial investment in electric logging equipment exceeds the investments in other types of equipment of comparable size, but the savings effected through lower operating costs, lower depreciation charges, and fewer shutdowns result in a lower net cost per M for electric machines.

The following analysis of costs is typical of conditions in the Douglas fir region:

INITIAL COSTS

HIGH TENSION SUBSTATION EQUIPMENT

1 6000 volt Lightning Arrester	$2700.00
1 Disconnecting Switch, Choke Coil, and Fuse	780.00
3 Single-phase, Oil-cooled Transformers	9750.00
1 Overload Oil Switch	1350.00
Freight at $2.50	1920.00
Cost of Electric Equipment, Delivered	$16500.00
Installation Cost; Labor and Materials	4000.00
Total	$20500.00

TRANSMISSION LINES (13200 volt)

11 miles at $2000.00 (six sides)	$22000.00

TRANSFORMER SUBSTATIONS at "SIDES"

Each equipped with:

1 13200v./600v. 3-phase Transformer	$2600.00
1 Disconnecting Switch and Fuse	240.00
1000 feet 3-Conductor Armored Cable	2000.00
Freight at $2.50	450.00
Cost each	$5290.00

Electric Equipment delivered for 6 Substations	$31740.00
Installations; Labor and Material at $1750.00	10500.00
Total for Six Sides	$42240.00

ELECTRIC EQUIPMENT FOR ENGINES

6 Motors and Controls for Yarders, Delivered	$36000.00
Installing and Miscellaneous Expense	6000.00
6 Motor Sets and Controls for Duplex Loaders	36000.00
Installing and Miscellaneous Expense	6000.00
Total for Six Machines	$84000.00

SUMMARY

High Tension Substation	$20500.00
Transmission Lines	22000.00
Substation Equipment for Six Sides	42240.00
Electric Equipment for Six Yarders and Loaders	84000.00
Total Expenditure for Electric Equipment	$168740.00

This includes $26500.00 for spare parts, etc.

DEDUCTION FOR STEAM EQUIPMENT OMITTED

6 Boilers and Engines for Yarders	at $3500.00	$21000.00
6 Boilers and Engines for Loaders	at $1750.00	10500.00
6 Water Supply Systems	at $2000.00	12000.00
Total		$43500.00

Electric Installation	$168750.00
Deduction	43500.00
Net Excess Cost of Electric Equipment	$125250.00

No allowance made for investment in equipment (tank cars, pumps, lines, tanks, etc.) necessary with oil burning machines. This would be a further saving in favor of electric machines.

BASIS OF CHARGES TO COMPARE OPERATING COSTS

FIXED CHARGES

Interest at	6%
Taxes at	2%
Insurance at	3%
Depreciation Fund Compounded at (15 years life)	4.3%
	15.3%

COST OF WATER $.20 per M

COST OF FUEL

Fuel Oil including all charges $2.25 per barrel

Wood

Stumpage	$1.50
Yarding	2.00
Spotting	.50
	$4.00 per M

POWER REQUIREMENTS

Yarders, each	500 KWH per day
Loaders, each	400 KWH per day
Total, per side	900 KWH per day
Total, for six sides	5400 KWH per day
Rate	15¢ per KWH

YEARLY PRODUCTION

275 days at 8 hours per day, 6 sides, 132000 M per year

FUEL AND POWER COSTS	ELECTRIC	OIL	WOOD
6 Yarders, each requiring			
a-11 bbls. Oil per day or		$40838.00	
b-2.2 M ft. Wood per day or			$19965.00
c-500 KWH per day	$12375.00		
6 Loaders, each requiring			
a-7 bbls. Oil per day or		$25987.00	
b-1.5 M ft. Wood per day or			$13613.00
c-400 KWH per day	$ 9900.00		
LABOR FOR WOOD BURNING per "SIDE"			
2 Firemen at $4.50 each			$14850.00
3 Wood Buckers at $4.40 each			$21780.00
WATER COST at 20¢ per M			
132000 M per year		$26400.00	$26400.00
UPKEEP, SUPPLIES, REPAIR AND ADJUSTMENTS			
6 Yarders at $400 Steam, $150 Electric	$900.00	$ 2400.00	$ 2400.00
6 Loaders at $400 Steam, $150 Electric	$900.00	$ 2400.00	$ 2400.00
High Tension Substation	$200.00		
6 Substations at "sides" at $100	$600.00		
5% Breakage in Trans. Line Changes at $130 each Substation	$780.00		
Extra attendance for steam sides to cover extra firing, labor and fuel for unusual conditions at $250 per "side" per year		$ 1500.00	$ 1500.00
Fixed charges on Excess Cost of Electric Outfits 15.3% on $125,250.	$19200.00		
Totals	$44855.00	$99525.00	$102908.00
Saving in favor of Electric per Year		$54670.00	$ 58053.00
Saving per M		$.414	$.440

The above costs were based on conditions at the camp of a large Pacific Coast logging company. The Snoqualmie Falls Lumber Company reports a saving of $.52 per M by the use of electric equipment.

All companies agree that the cost of water supply and the cost of transmission lines almost exactly balance.

One company in Washington, logging Douglas fir, has made a very careful study of power consumption and reports the following results:

Month	KWH	Scale, bd. ft.	Av. vol. per KWH
April	122,300	14,141,514	115.6
May	150,700	17,549,712	116.4
June	153,700	20,827,225	136.0
July	138,600	19,128,742	148.0
August	179,500	22,609,813	125.9
September	181,300	22,416,499	123.6
October	178,600	23,953,439	134.1
November	167,900	21,414,356	127.5
December	128,000	16,877,645	131.8
Totals & Average	1,400,000	178,917,945	127.9

This averages about 7.7 KWH per M at the field transformer. Losses between the generating plant and the yarders which are charged to the operator's power bill amount to about 1.2 KWH per M. At a cost of 15¢ per KWH, this costs 13.4¢ per M for power. This is about twice the cost for diesel oil on a similar, adjacent show, but lower repair charges and freedom from lost time in connection with diesel break-downs far offset the added fuel cost. It is not at all uncommon for an electric machine to run an entire season with no lost time on account of motor trouble.

VIII Conclusions

It seems inevitable that the cost of petroleum fuels will rise with the passing of time and the depletion of the supply. The available petroleum is definitely limited, as are all mineral fuels.

The relative cost of electricity, on the other hand, seems equally destined to fall as better means of generating and transmitting electric power are developed. This fact favors the idea of the possible future use of electricity, although it is to be expected that logging methods and machines will change with changing practices in logging and forestry.

The future of electric logging is not assure, though, by the change in the costs of electricity and mineral fuels. The use of alcohol fuels in internal combustion engines appears imminent. This fuel can be produced from nearly any organic material such as sawdust, though not at a profit with the present demand and methods of production. In some European countries the manufacture and use of industrial alcohol for motors is an established practise and is proving successful. As long as the trend in logging is towards small, mobile units, and as long as improved methods of furnishing electric power to these mobile units are lacking, the use of electric logging equipment will not increase.

Opposed to the factors that indicate decreased future use of electricity is the certainty that if the use of wood products does not fall to unexpectedly low levels, this country will soon be dependent upon the less accessible timber stands, lying in remote and mountainous terrain, not suited to logging with tractor type machines.

Some operators anticipate the development of diesel-electric logging equipment. Such equipment has a decided advantage over straight electric equipment. Present day diesel motors do not perform as efficiently at varying speeds as at a constant speed. Diesel motors can operate at constant speeds and varying power output when transmitting their power through a generator. This means greater operating efficiency coupled with lower maintenance charges, because the electric power transmission saves the diesel motor from injurious shocks which are the prime cause of motor failures and costly repairs. Diesel-electric equipment has the advantage of straight electric equipment in that no transmission lines need be built and maintained, and there are no heavy line losses between the generating plant and the motors.

The diesel-electric combination has proved highly successful in other types of equipment. Many of the common carrier railroads are buying diesel-electric engines to replace steam and straight diesel units. One railroad, at least, has ordered steam-turbine electric locomotives, which are in many respects comparable to diesel-electric rigs. Diesel-electric shovels and other equipment have proved very successful.

ACKNOWLEDGMENT

This paper has been made possible largely by the gracious help of the manufacturers of electrical equipment and the logging companies using electric machines.

The pages of The Timberman and The West Coast Lumberman have yielded much information not elsewhere available.

These sources of information have been the only ones drawn upon.

Particular thanks are due to one of the larger logging companies, where I was permitted to spend several days watching electric machines at work.

PLATES

PLATE 1A

Right hand side of electric yarder showing motor resistances, control panel, motor brake, drum assembly, and air reservoirs. This machine has air frictions and brakes with auxiliary hand and foot frictions and brakes. The small air tank serves the control panel and the large tank serves the brakes and frictions.

This machine is not mounted for service, but was photographed while being tested prior to delivery.

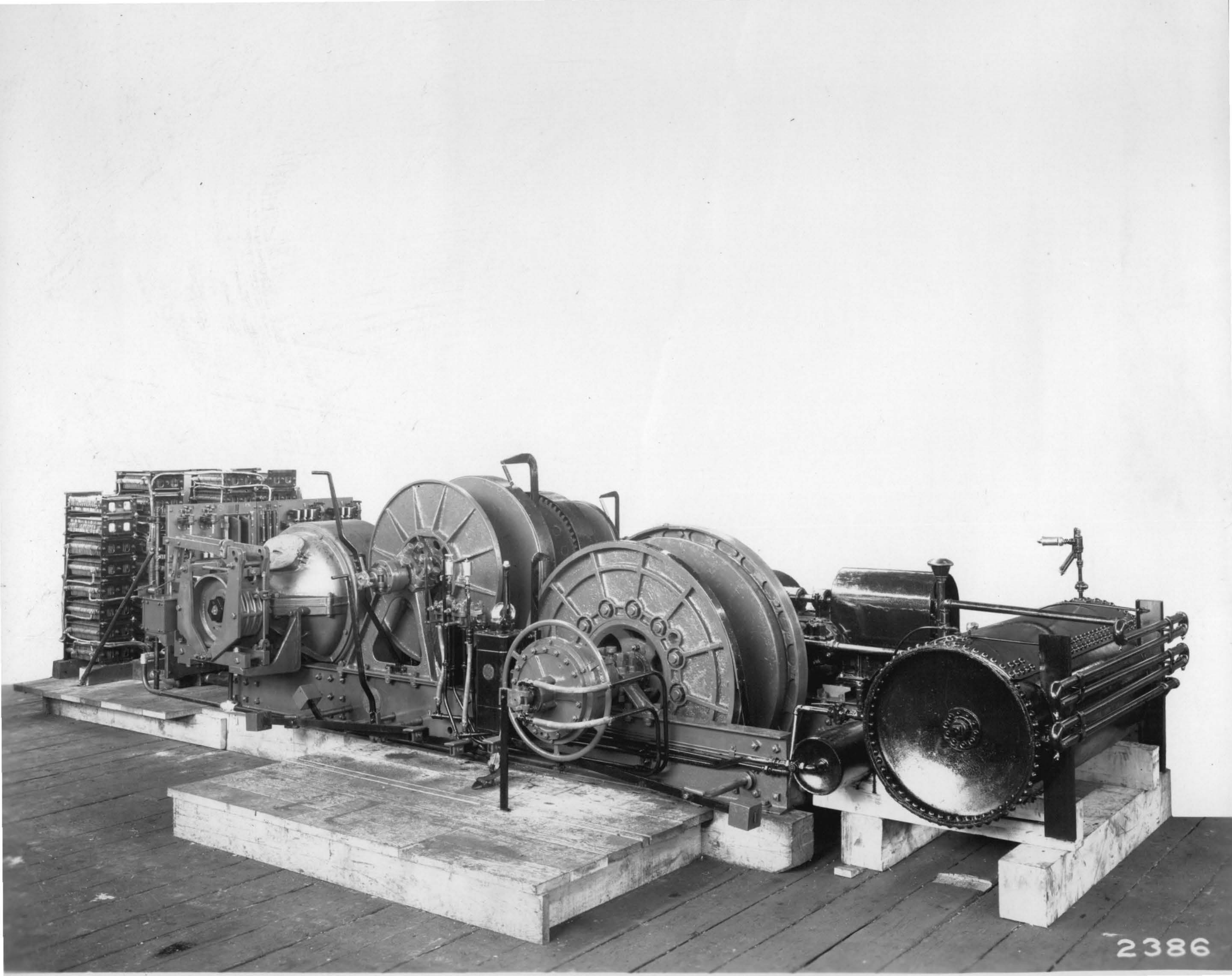

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PLATE 1B

Close up of controls for the same machine as in plate 1A. The large control box with the maker's nameplate affixed controls the motor speed. To the left of this are the two friction controls. The pedal directly below the main controller case operates the motor brakes.

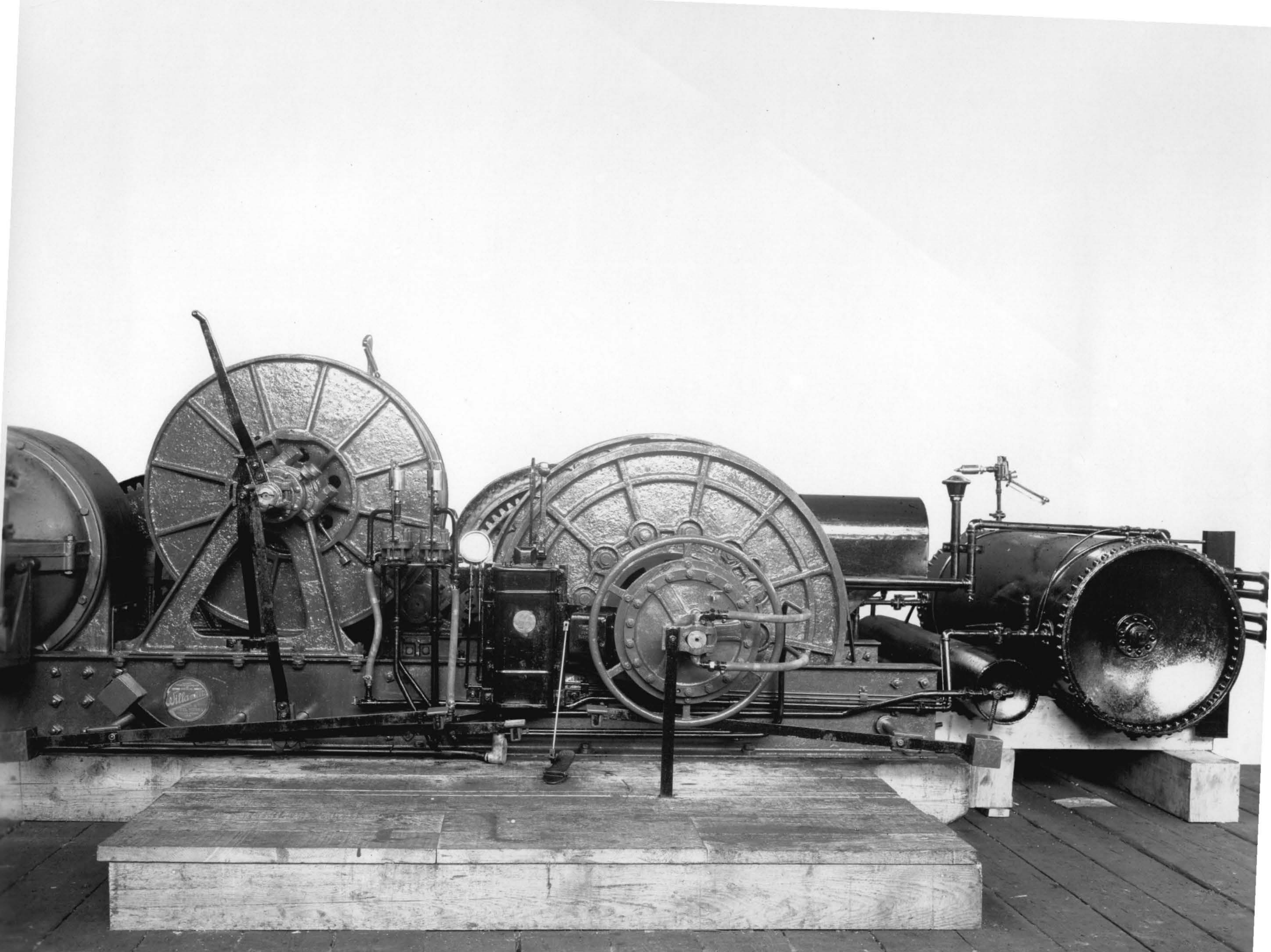

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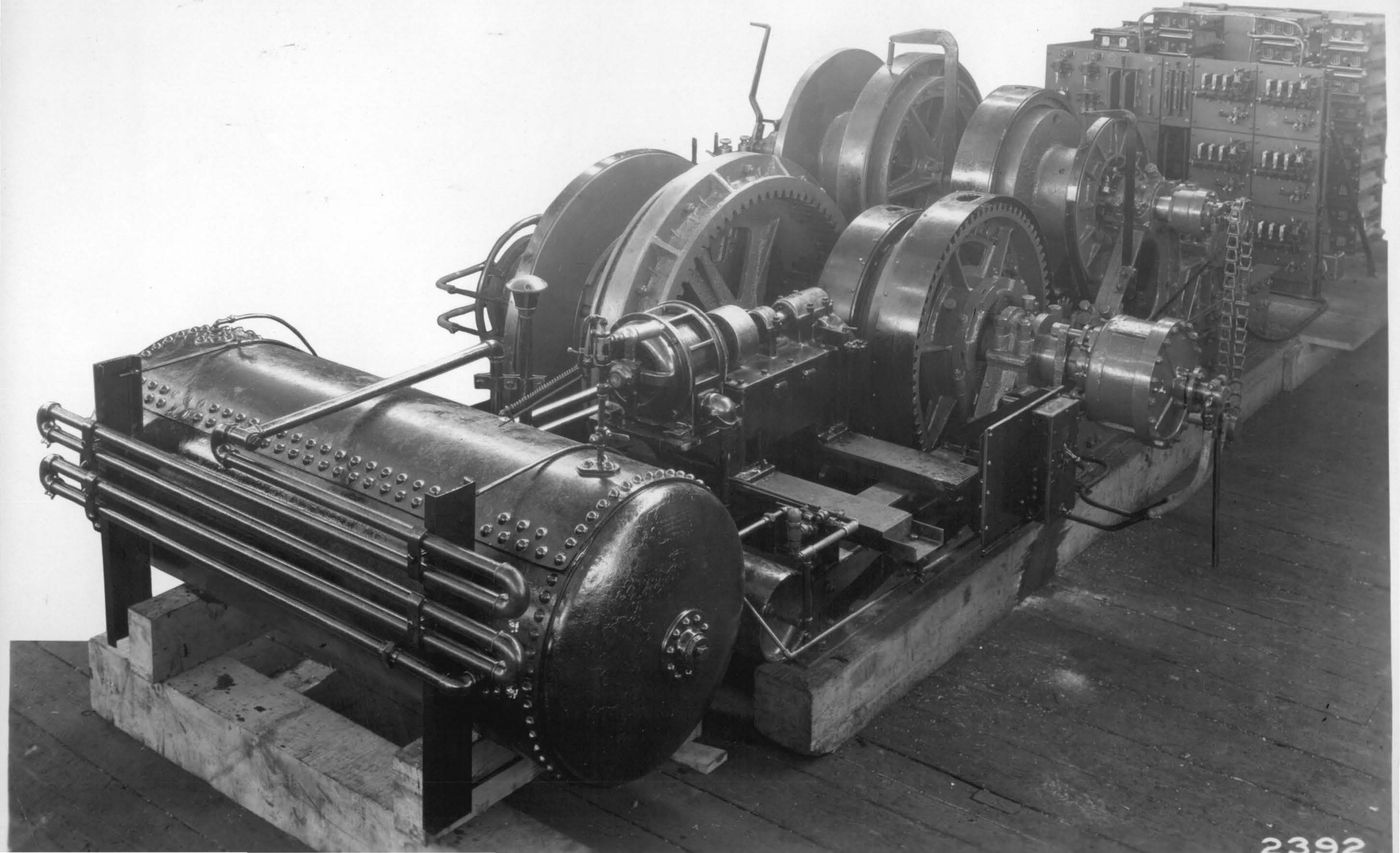
PLATE 1C

Left side of same machine shown in plate 1A. The gearing and the air compressor show particularly well in this view. This is the standard type of compressor furnished for railroad train brakes.



2392

PLATE 2

Power Distribution Diagram

Electricity at 66,000 volts comes from the generating plant (not shown) over a pole line to the main transformer station "A" where it is stepped down to 13,200 volts. The power is then conveyed by tree lines to the field transformer, one of which is shown at "B", where it is again stepped down to 600 volts. Power from the field transformer is conveyed to the machine "C" by two 600 volt insulated cables, lying on the ground.

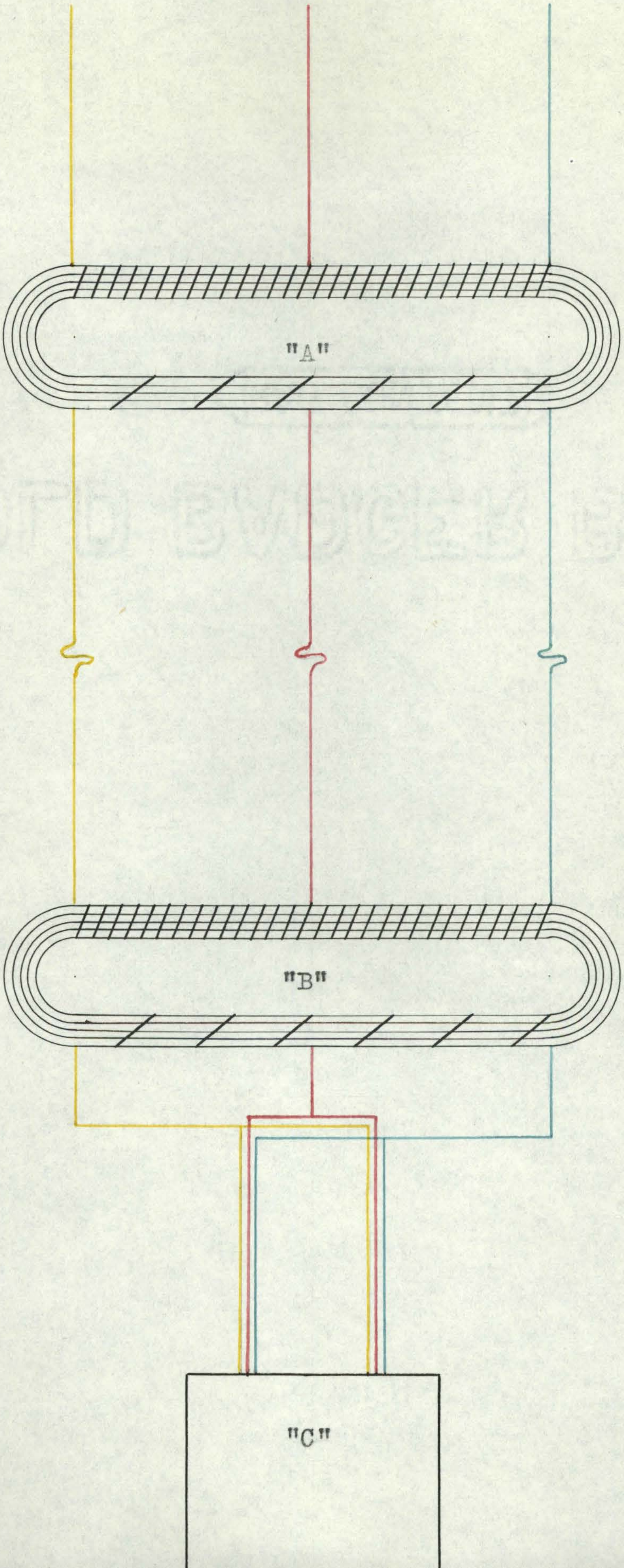

"A"
"B"
"C"

PLATE 3

Pole Line

This is used for the transmission of 66,000 volt power. The poles are cedar.

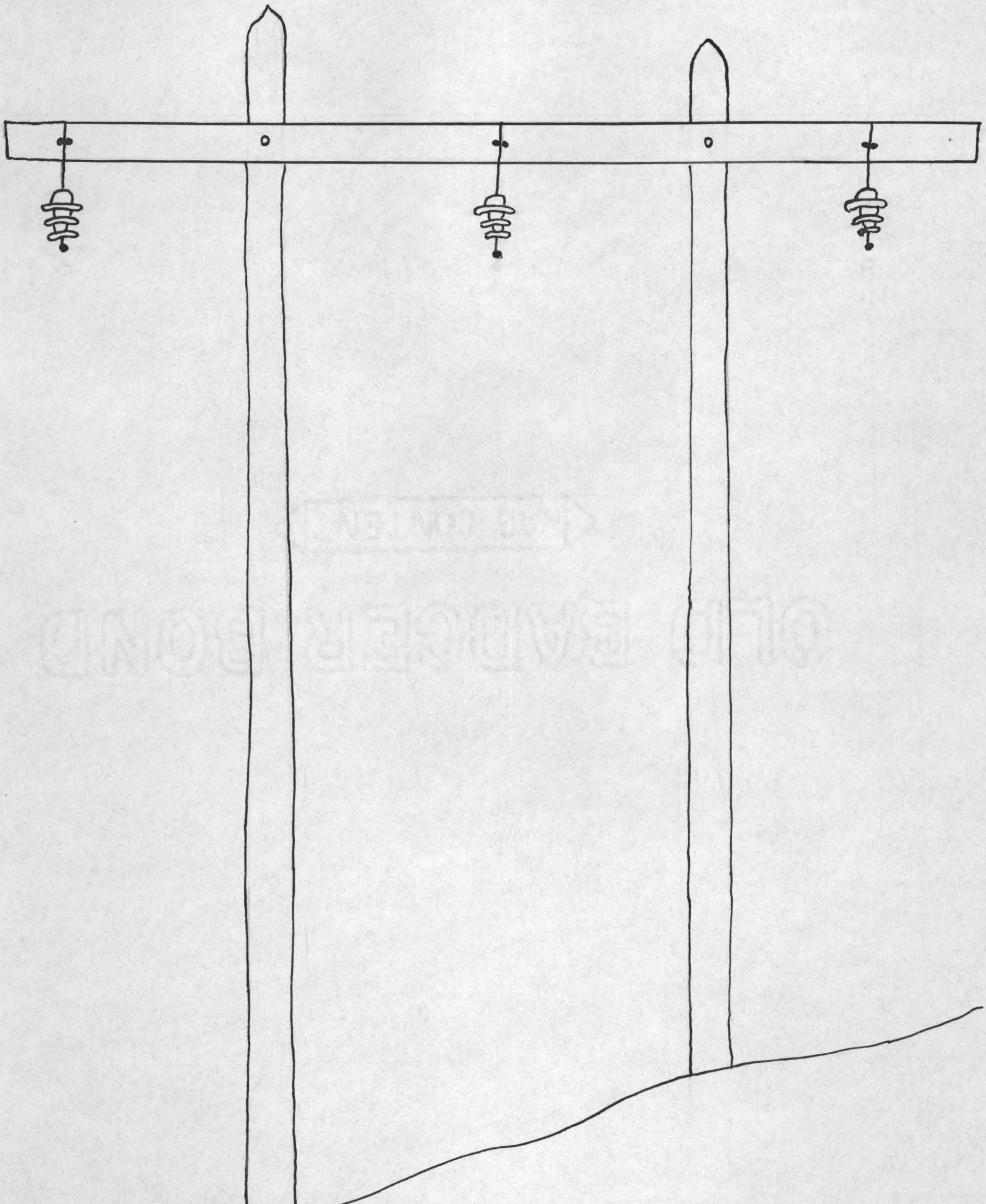


PLATE 4

General view of main transformer station where the line voltage is stepped down from 66,000 volts to 13,200 volts.

PLATE 5

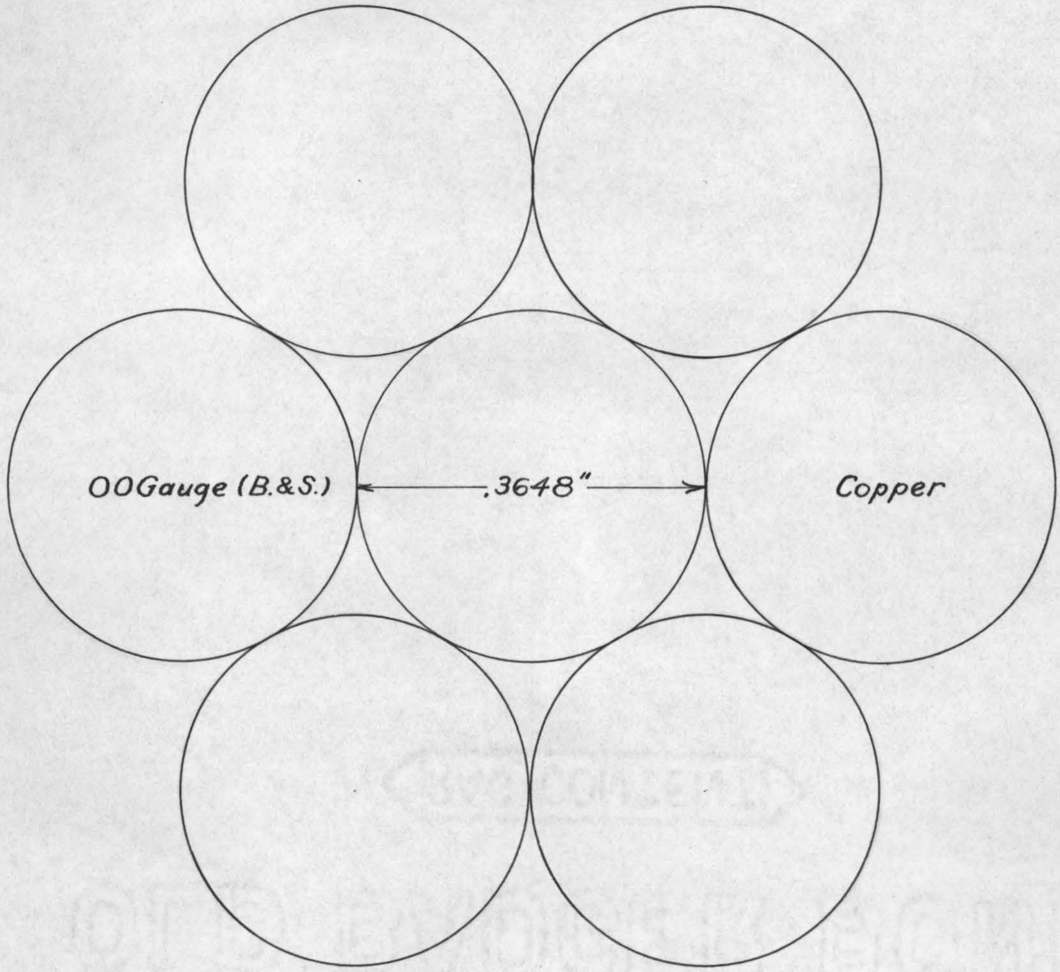
High Tension Transmission Wire

This cross section, enlarged five diameters, shows the type of bare copper wire used on the 66,000 and 13,200 volt lines. Three of these wires are used, each on its own insulator.

Diameter of individual wires in the strand is 0.3648 inch (Gauge 00, B.&S.).

Diagram enlarged five diameters.

No Insulation



Enlarged 5X

PLATE 6

The dotted portion of the drawing illustrates the height at which the tree line was hung after falling the timber, but before yarding it. This is about 200 feet.

After logging the area, if the line is still needed, it is lowered to about 100 feet high, and the trees topped to reduce windthrow. If the line is to be used many years the trees are peeled for safety in climbing.

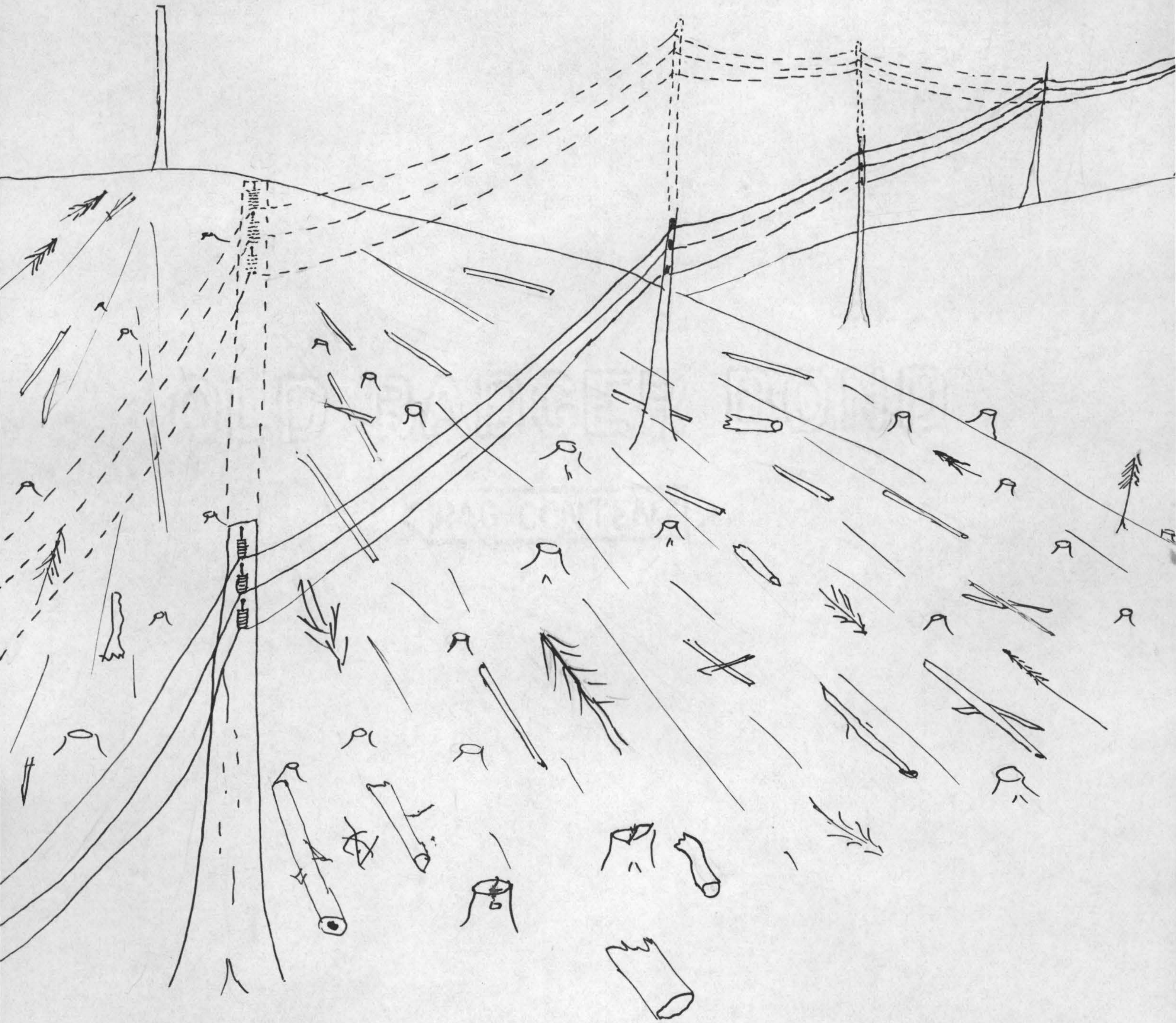


PLATE 7

General view of 13,200 volt tree-hung transmission line.

PLATE 8

Field transformer set alongside the railroad. This transformer is serving a cold-decking machine over a quarter of a mile away. The line voltage is here stepped down from 13,200 volts to 600 volts. Power is conveyed to the transformer via tree lines, and power goes from this transformer to the machine in twin three conductor cables, submarine type.

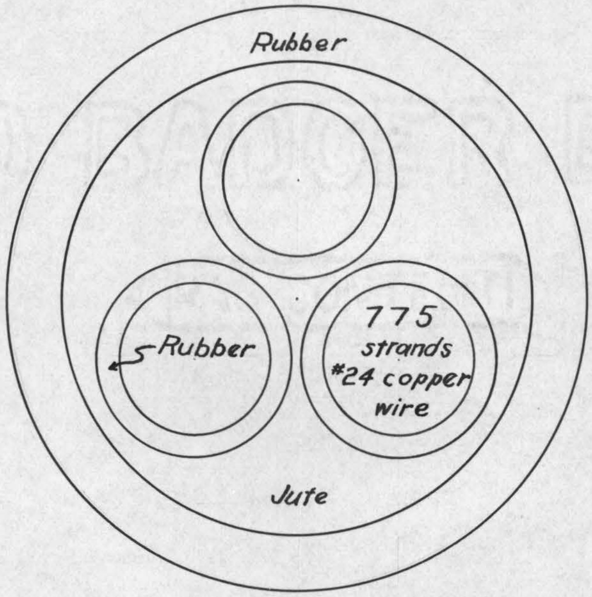
PLATE 9

Insulated Cable

This is a full scale cross section of one of the cables carrying power from the field transformers to the machines at 600 volts. Two are used on each machine.

Each of the three conductors is made up of 775 strands of #24 copper wire (diam. .0201 inch) and is covered with tellurium rubber insulation. Jute is used for a filler, and the whole cable covered with a tough tellurium rubber cover.

The tellurium rubber is very similar to the rubber used in automobile tire casings.



Full Scale

Robert M. Snyder

PLATE 10

Splice in Insulated Cable

This is a part of the insulated 600 volt cable. The outside wires are here shown with the fiber sleeves slipped back to show the lug connectors bolted together. The lugs are brazed to the copper wire.

The center wire is shown with the sleeve in place, ready for use.

Diagram to a much reduced scale.

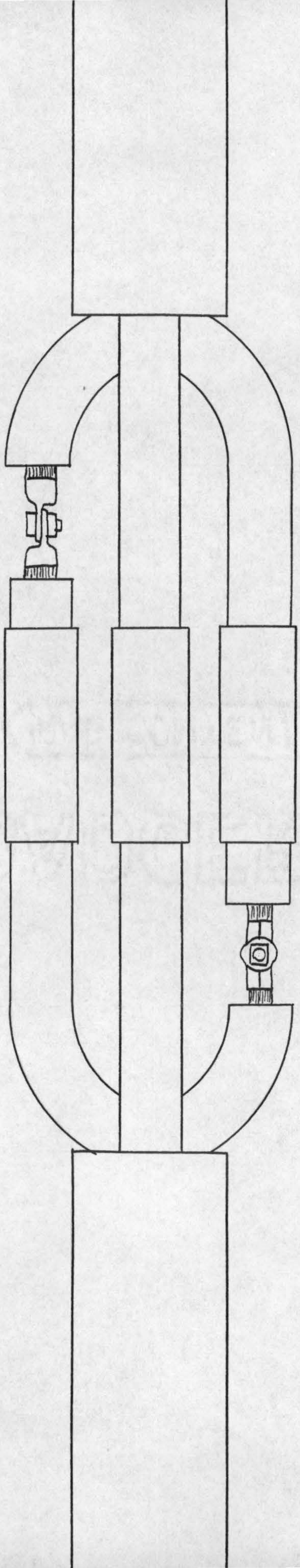


PLATE 11

This shows the type of abuse that the cables must stand up against. The cables are laid on the ground, but they withstand the kinks and rough treatment here shown. The average life of cables is eight years and the newer types are expected to last much longer.

The black loops in the foreground are the cables.

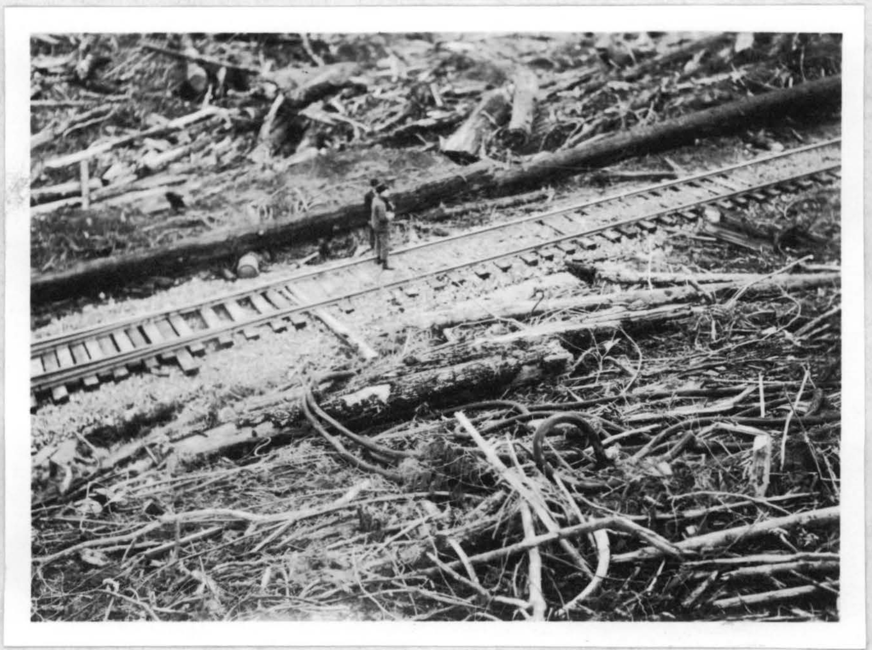


Plate 12

Typical Control Circuit

This schematic diagram of the control circuits operating a solenoidal motor brake simplified by omitting the intermediate positions of the operating arm. It is typical, however, of all control circuits.

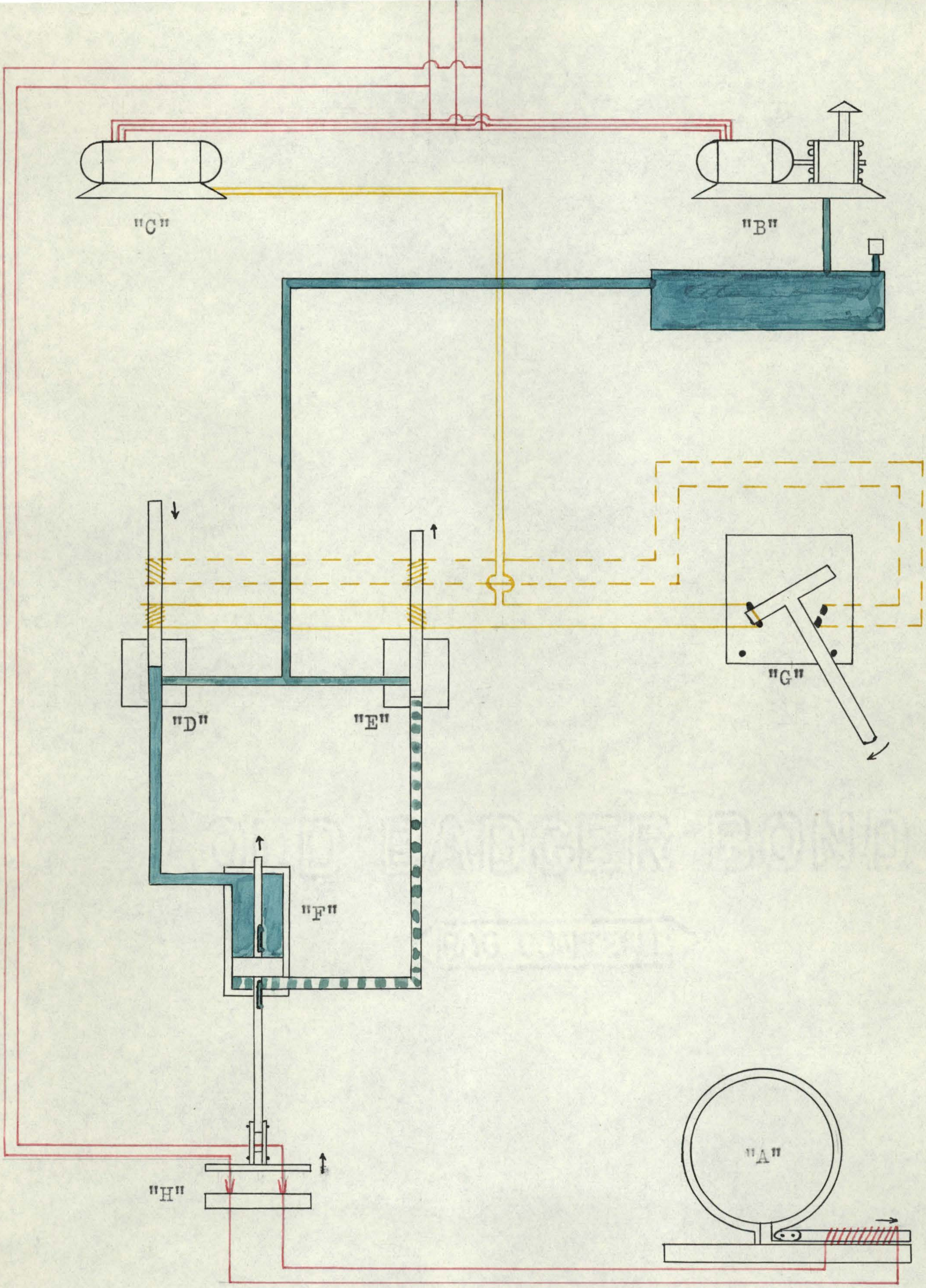
The red lines indicate the 600 volt alternating current wiring. It supplies power for operating the motor brake (A), the air compressor unit (B), and the motor generator set (C).

The yellow lines indicate the 40 volt direct current control circuit. With the brake handle (G), in the position shown the solid lines indicate the circuit. Current flowing through the solenoid coils on valves (D) and (E), hold them open and shut, respectively, by holding the magnetized valve plungers up or down.

Compressed air at 100 pounds per square inch, shown in green, flows through the open valve (D), holding the piston in the cylinder (F), in the down position. This keeps the switch (H) closed, allowing 600 volt current to put on the brakes at (A). Any air that might leak through valve (E) escapes through the hollow part of the connecting rod in the cylinder assembly (F).

When the brake handle (G) is pulled to its other position, the 40 volt current follows the dotted yellow line, reversing the valves and opening the 600 volt swith (H), releasing the brakes. Arrows indicate movements of parts when the brakes are to be released.

Varying the brake tension is accomplished by introducing more points at the brake controller (G) and more valves, cutting in resistance in the red circuit and lessening the pull on the solenoid at (A).



"C"
"B"
"D"
"E"
"G"
"F"
"H"
"A"

Plate 13

This shows the simplicity of the controls on electric logging machines. The left hand photo show the controls used by the yarding engineer and the right hand photo shows the controls used by the loading engineer.

PLATE 14

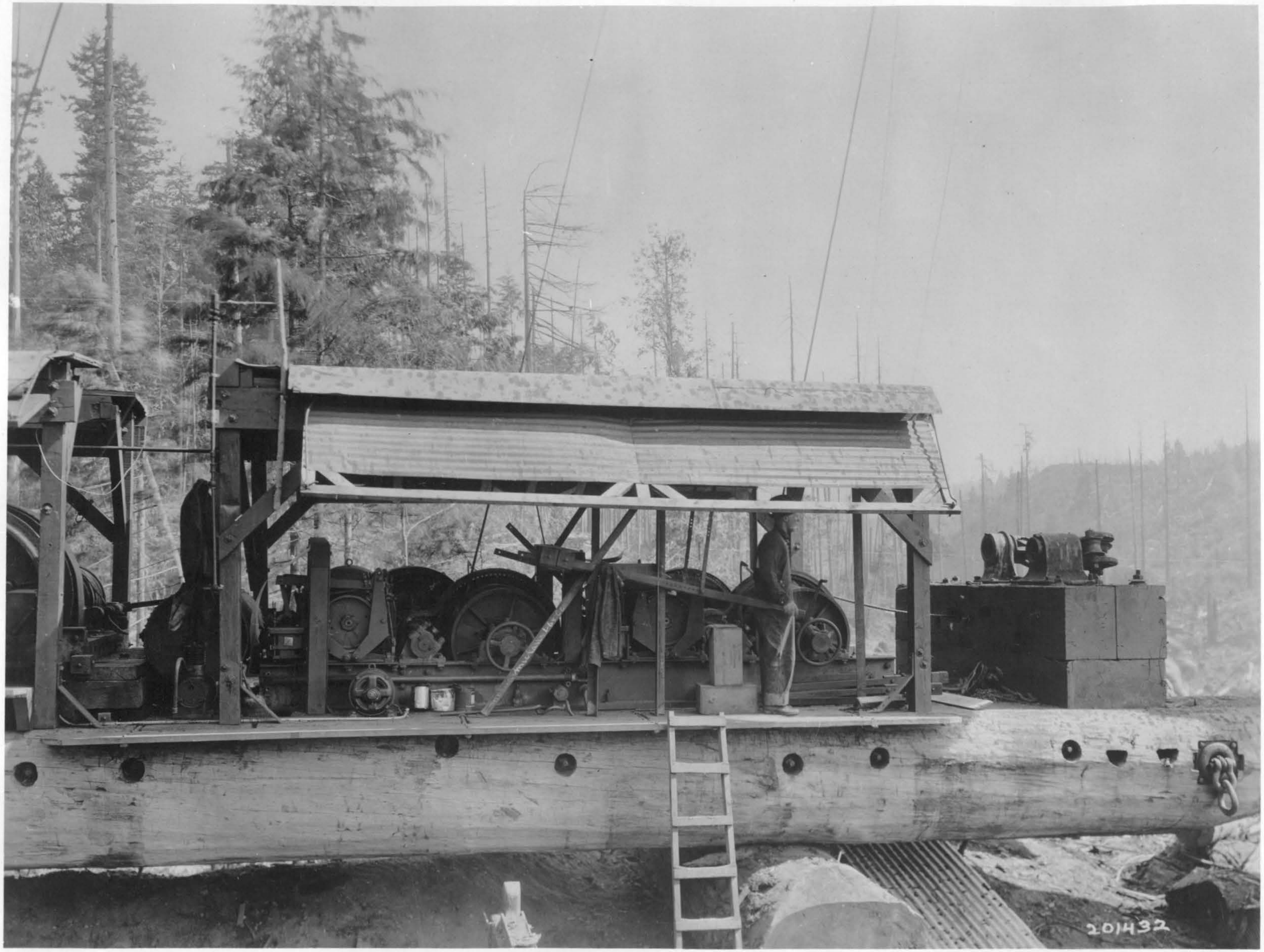
A typical view of the terrain in which electric skidders are proving successful. Much of the area is more rugged than this, and very little of the area is more gentle.

This particular view shows a turn of logs coming in to a tower skidder. The carriage is of the "canyon" type with positive action on the slack puller. The slack pulling line engages sheaves which in turn engage the load line, assuring slack being pulled under any circumstances.

PLATE 15

Photographs showing yarding and loading operations. The similarity to steam equipment will be instantly remarked.

The photographs on the following sheets are all self-explanatory. They have been furnished by courtesy of the General Electric Company.



331196 ELECTRIC DUPLEX LOADER USING TWO HITC-5013-A-75HP-600RPM-3 PHASE-60 CYCLE-550 VOLT MOTORS WITH CR9510 BRAKE AND SOLENOID LOAD BRAKE INSTALLED AT SNOQUALMIE FALLS LUMBER CO., SNOQUALMIE FALLS, WASHINGTON.

INDEX E-327

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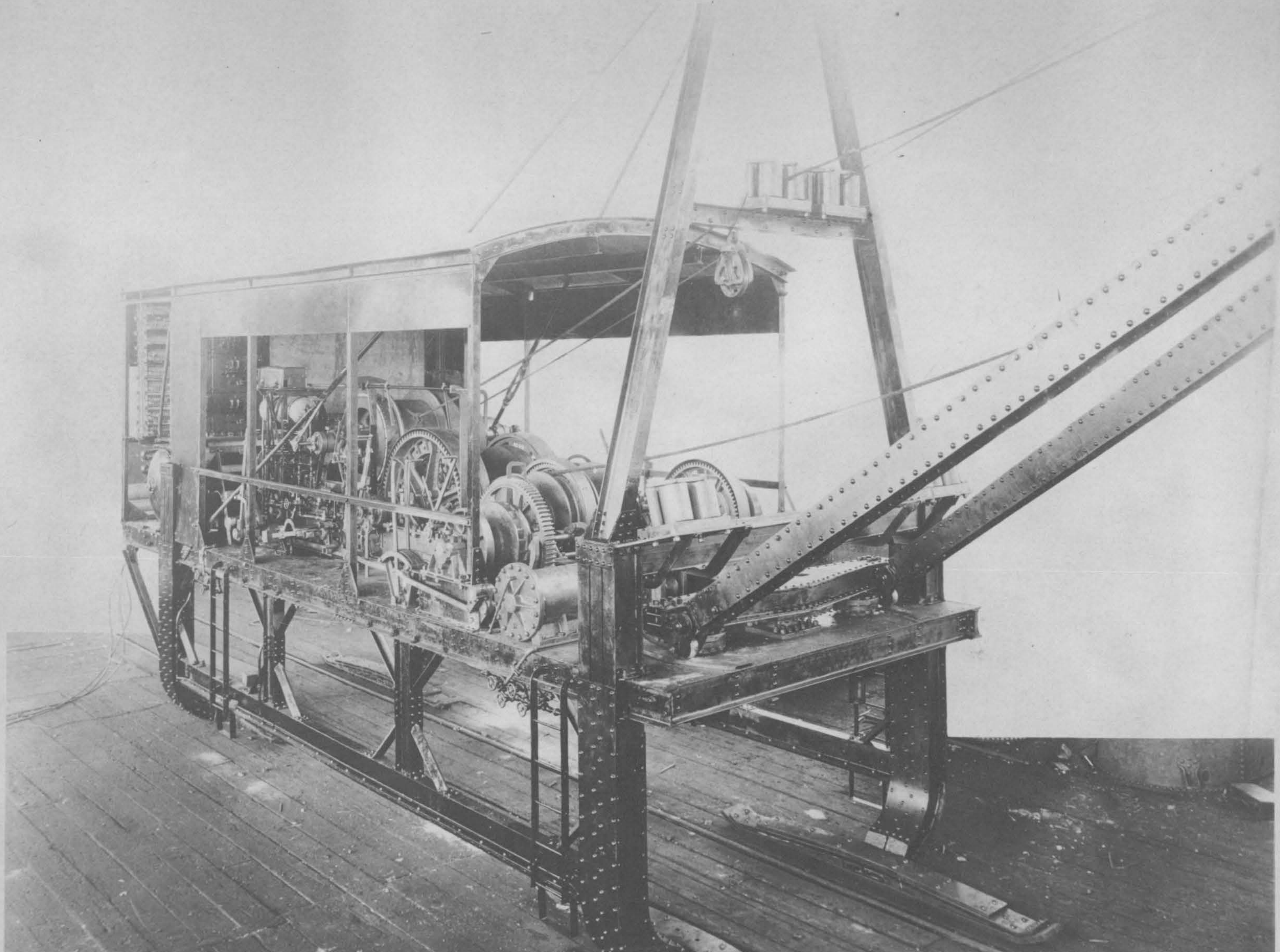

405308 ELECTRIC BOOM SKIDDER EQUIPPED WITH HITC-5015 A-12-200 HP-600 RPM-3 PHASE-60 CYCLE-550 VOLT MOTOR CR-9510-418 SOLENOID LOAD BRAKE, CR-9510-416 SOLENOID BRAKE, CR-7417 MAGNETIC CONTROL PANEL CR-3012-C-378-A MASTER SWITCH CR-9741-20 STARTING RESISTOR CR-9749 RESISTOR FOR THE 418 BRAKE, CR-9749 FOR THE 416 BRAKE, AIR COMPRESSOR.

INDEX E-327 6 15 23

331199 SPAR TREE AND RIGGING FOR ELECTRIC LOGGING OPERATIONS. SNOQUALMIE FALLS LUMBER COMPANY. SNOQUALMIE FALLS. WASHINGTON.

INDEX E-327 10 22 20

331200 SPAR TREE AND RIGGING FOR ELECTRIC LOGGING OPERATIONS, SNOQUALMIE FALLS LUMBER COMPANY, SNOQUALMIE FALLS, WASHINGTON.

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331195 ELECTRIC YARDER AND DUPLEX LOADER MOUNTED ON SLED USING HITC-5015-200HP- 600RPM- 3 PHASE- 60 CYCLE- 550 VOLT MOTOR WITH SOLENOID BRAKE AND SEMI MAGNETIC CONTROL ON YARDER AND 2 HITC-5013-A-75HP-600RPM- 3 PHASE- 60 CYCLE- 550 VOLT MOTORS WITH CR9510 BRAKE AND SOLENOID LOAD BRAKE ON LOADER INSTALLED AT SNOQUALMIE FALLS LUMBER COMPANY, SNOQUALMIE FALLS, WASHINGTON.

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331197 ELECTRIC YARDER AND DUPLEX LOADER MOUNTED ON SLED USING HITC-5015-200HP- 600RPM- 3 PHASE- 60 CYCLE- 550 VOLT MOTOR WITH SOLENOID BRAKE AND SEMI MAGNETIC CONTROL ON YARDER AND 2 HITC-5013-A-75HP-600RPM- 3 PHASE- 60 CYCLE- 550 VOLT MOTORS WITH CR9510 BRAKE AND SOLENOID LOAD BRAKE ON LOADER INSTALLED AT SNOQUALMIE FALLS LUMBER COMPANY, SNOQUALMIE FALLS, WASHINGTON.

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331198 PORTABLE TRANSFORMER SUBSTATION 2-250KV-A- 3 PHASE-13200/600 VOLT TRANSFORMERS.

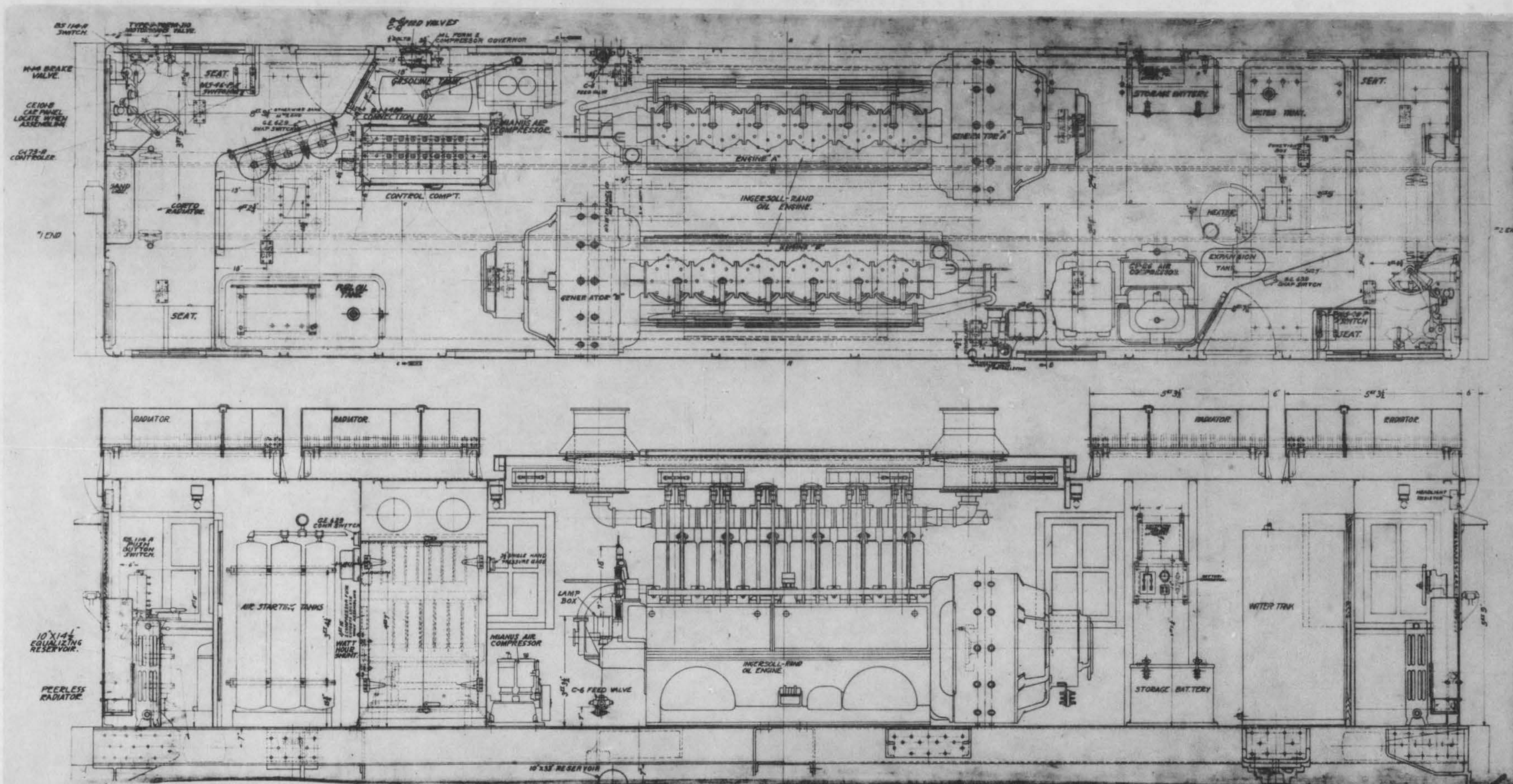
INDEX E-323 10 22 20

396307 TYPE "H" TRANSFORMERS GOING TO WORK. NINE OF A TRAINLOAD OF TEN PORTABLE SUB-STATIONS, SUGAR PINE LUMBER COMPANY, FRENO, CALIFORNIA, USING TYPE HT-60-500-KVA-20,000-600 VOLT TRANSFORMERS.

INDEX E-310.03 9 18 23

331194 SPAR TREE AND RIGGING FOR ELECTRIC LOGGING OPERATIONS, SNOQUALMIE FALLS LUMBER COMPANY, SNOQUALMIE FALLS, WASHINGTON.

INDEX E-327 10 22 20



427852 LOCATION OF APPARATUS ON 100 TON OIL-ELECTRIC LOCOMOTIVE
EQUIPPED WITH 2- INGERSOLL-RAND OIL ENGINES.

INDEX E-318.34 3 4 25

NORTHAMPTON AND BATH RAILROAD, NORTHAMPTON, PENNSYLVANIA

DESCRIPTION OF OPERATION

Placed in service in 1932. Main line haul, trains up to 2500 tons. Also general switching, and inter-plant haulage for large industrial works.

PERFORMANCE

Tractive effort, starting, lb. (30 per cent adhesion)	69,000
Tractive effort, continuous, lb.	23,000
Speed at continuous tractive effort, mph.	10.2
Maximum safe speed, mph.	45
Minimum radius of curvature for locomotive alone, ft.	100
Minimum radius of curvature with trailing load, ft.	175

WESTINGHOUSE POWER EQUIPMENT

Engine	2—6 cylinder Diesel, 9 x 12, 400 hp., each 900 rpm.
Generator	2—Type 477-B-8, 270 kw. each, 500 volts d.c.
Auxiliary Generator	2—Type YG-15-A-2.
Traction Motors	4—Type 360-A, 600 volts.
Motor Gearing	16:67 ratio
Control	Electro-pneumatic, dual, series, parallel, field -- shunt, torque.

MECHANICAL PARTS Baldwin — Class B-B, fabricated, swivel trucks, visibility type raised center cab, aisles around engines.

AUXILIARIES

Air Brakes	Westinghouse	Schedule 14-EL, straight and automatic.
Compressors	Westinghouse	2—Type D-3-F, displace 35 cu. ft. per min. each.
Radiators		Water and lubricating oil, force ventilated by motor driven fan, automatic control.
Battery	Exide	32 cell, 204 ampere-hour.

DIMENSIONS

Track gauge	4 ft. 8½ in.
Length inside coupler knuckles	47 ft. 8 in.
Width, overall	10 ft. 7 in.
Height, overall	14 ft. 8 in.
Wheel base, rigid (truck)	8 ft. 6 in.
Wheel base, total	33 ft. 10 in.
Wheel diameter	44 in.

115 TON - 800 HP DIESEL-ELECTRIC LOCOMOTIVE

OPERATED BY SHORT LINE RAILROAD, WESTERN PENNSYLVANIA

DESCRIPTION OF OPERATION

Locomotive placed in service in 1933. Main line haul 3 miles. Traffic handled principally coal. Also performs switching duty for industry served.

PERFORMANCE

Tractive effort, starting, lb. (30 per cent adhesion)	39,000
Tractive effort, continuous, lb.	10,000
Speed at continuous tractive effort, mph.	12.2
Maximum safe speed, mph.	40
Minimum radius of curvature for locomotive alone, ft.	50
Minimum radius of curvature with trailing load, ft.	225

WESTINGHOUSE POWER EQUIPMENT

Engine	2—4 cylinder Diesel, 9x12, 265 hp. each, 900 rpm.
Generator	2—Type 183-D-2, 170 kw. each, 500 volts d-c.
Auxiliary Generator	2—Type YG-16-D-4.
Traction Motors	4—Type 562-E-6, 600 volts.
Motor Gearing	16:61 ratio.
Control	Electro-pneumatic, parallel, dual, series-parallel, differential.

MECHANICAL PARTS Baldwin — Class B-B, fabricated, swivel trucks, visibility type raised center cab, aisles around engines.

AUXILIARIES

Air Brakes	Westinghouse	Schedule 14-EL, straight and automatic.
Compressors	Gardner-Denver	2—Class AA Duplex; direct drive, displacement 74 cu. ft. per minute each at 900 engine rpm.
Radiators		Water and lubricating oil, force ventilated by motor driven fan, automatic control.
Battery	Exide	32 cells, 204 ampere-hour.

DIMENSIONS

Track gauge	4 ft. 8½ in.
Length inside coupler knuckles	40 ft. 4 in.
Width, overall	10 ft. 2 in.
Height, overall	14 ft. 2½ in.
Wheel base, rigid (truck)	6 ft. 8 in.
Wheel base, total	29 ft. 0 in.
Wheel diameter	33 in.

65 TON - 530 HP DIESEL-ELECTRIC LOCOMOTIVE