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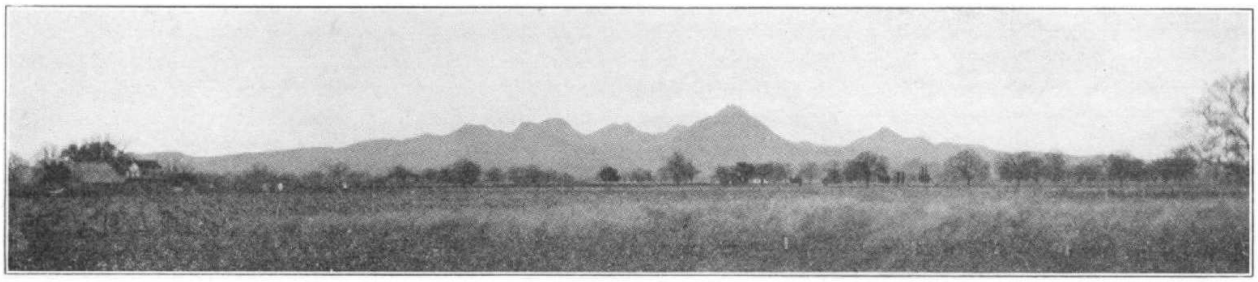


"The Marysville Buttes."

THE NORTHERN ELECTRIC RAILWAY

By Rudolph W. Van Norden

Member A. I. E. E., A. S. C. E.

After two or three days of travelling 'mid the everchanging landscapes of desert and mountain, the tourist on an overland train,—or possibly he may be a settler, looking for new fields to till in a land full of promise—looks out over the wide expanse of the great central valley of California with a sense of relief. His train is reeling off the last few miles before entering Sacramento, the Capital City.

As his gaze rests upon the seemingly limitless expanse of almost level country, he will, perhaps, ask somebody (and if it be a Californian he cannot resist telling of the beauties and possibilities of his country), what is it good for; can it be cultivated; what will it raise and a hundred other questions. Probably he will ask why all this land has not been settled on and cultivated long ago. The answer will be that it has, in spots, but that it is too big and there have not been enough people, or the facilities for transportation, to do it all at once.

If he is wise, he will stop over at Sacramento to seek further knowledge. Is this great country being built up, are the Californians doing it, or must I and those who follow me supply the necessary energy to start this great work? To the first query he is answered, Yes; to the second, he is told to look for himself, the way has been paved.

He is handed a time-table and his eye is attracted to the reminder below a copious list of trains, "a. stands for A. M., p. stands for P. M., and Northern Electric stands for development of the Sacramento valley." Now he knows the whole story and when he boards the spic and span electric train, whose very color breathes California romance in its reflection of the Golden Poppy, whose blossoms cover like a mantle the fields through which he is destined to pass, to be whisked by miles of fertile lands and to pass through towns where prosperity is evinced on every hand, he marvels at the work already done, the enormous possibilities for the future and then he feels like making a profound obeisance to the train, when he leaves it, for its share in making this development possible.

Description of the Country.

The Sacramento Valley has a length of about 200 miles and a width averaging 50 miles. The Sacramento river passes through its entire length from north to south and divides it about equally. The land adjoining the river on both sides is, as a rule, low and fairly flat and as it recedes from the river gradually rises and becomes more undulating until the foothills of the Sierra Nevada on the east and the more precipitous mountains of the Coast Range on the west are reached.

The one exception to this general condition is furnished by the "Marysville Buttes," a jagged group of volcanic peaks which appear to have been forced out of the depths of the earth in defiance with nature's plan of arrangement, into the very centre of the valley. These buttes can be seen from all points of the valley and are a picturesque contrast with the level expanse surrounding them.

The land throughout the valley has always been known to be fertile, but the bottom lands along the river are particularly so. Many sections on both the west and east sides have been under a high state of cultivation for years, but the bottom lands, due partly to the cost of reclamation works to prevent the overflow from the Sacramento river and also the lack of railroad facilities, have not had the opportunity for development that their value would seem to assure.

That the country with its relatively meagre population has much wealth is shown by the prosperous cities and towns scattered throughout the valley, the numerous and well equipped banks and the carefully appointed stores and business houses.

The cultivation of hops, wheat, sugar-beets, oranges, olives, the deciduous fruits and many other crops, of the finest quality and greatest quantity, wherever undertaken, aside from the possibilities for the recovery of gold in the rivers, pointed a reason for a rapid growth in population and wealth that might be expected with the advent of rapid and convenient transportation.

The great necessity was transportation. It was not expected that this would turn miles of uncultivated or overflowed land into a highly productive garden in a moment. But it was the late Mr. Henry Butters who believed in the country and the people and saw that the establishment of a modern railroad, affording swift means of transportation between the towns and through country having high potential values, would be the means of inducing a rapid but healthy growth and be the nucleus of a great system surrounded and fed by a great country.

It is no easy matter to inaugurate a new railroad through a more or less undeveloped territory. The financial start is often a hard thankless problem and the work which Mr. Butters and his associates had undertaken represented the faith and courage, characteristic of all the great enterprises in this, a comparatively new country.

The start was made at Chico and under the engineering direction of Mr. J. B. Robinson, a veteran railroad engineer, and Mr. J. Paulding Edwards, the electrical and mechanical engineer, to whose skill and ingenuity the system now owes its well designed and successfully operating equipment, a road 24.8 miles long was built to Oroville. These cities were growing and prosperous, the former in the midst of a fertile and well cultivated district, with growing industries of great promise, the terminus of a lumber railroad, a number of stage lines and the distributing point for a large mountain territory; the latter city, being in the foothills, likewise a stage line terminal and distributing point and the center of one of the greatest gold producing localities in the world.

There was no direct means of transportation between these cities, except by stage and the first section of this system seemed justified by these conditions.

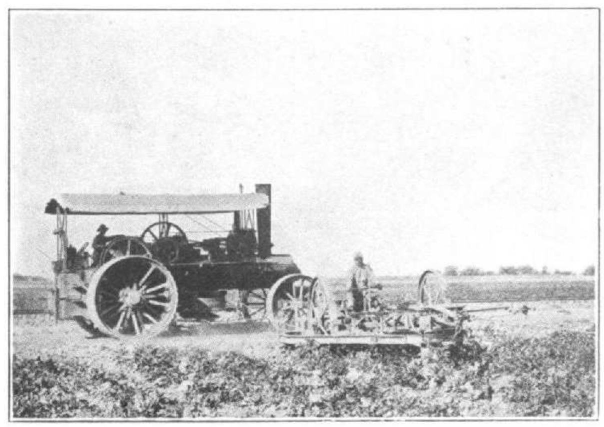
The first car from Chico to Oroville was run through on April 25, 1906. The success of this piece of railroad was an inspiration to spur on the work of further construction and on December 2, 1906, the line was completed to Marysville, an additional distance of 30 miles and regular operation was commenced.

There was in Marysville a primitive street railway system, its diminutive cars being hauled by mules. This was purchased, the road relaid with heavy rails and made standard gauge and extensions made to give a first-class local service throughout the city and between it and Yuba City, across the Feather river.

A local system was also purchased in Chico and in Oroville, a loop was built and a local service between that town and Thermolito was inaugurated. Thus these towns not only were provided with a means of rapid and frequent inter-communication, but were enabled to enjoy the benefits of urban transportation.

During 1907 construction was continued between Marysville and Sacramento and on September 1st of this year regular service was commenced.

Sacramento while literally not the head of navigation is practically so. There are several lines of steamers which tie up at this point; the possibility of making the road an outlet for a large freight transportation business, having steamer connection with the Bay Cities was apparent. Aside from a passenger terminal in the heart of the business section a branch to a freight terminal on the water front was built. This then gave a clear line of railroad reaching 122 miles up the Sacramento valley.

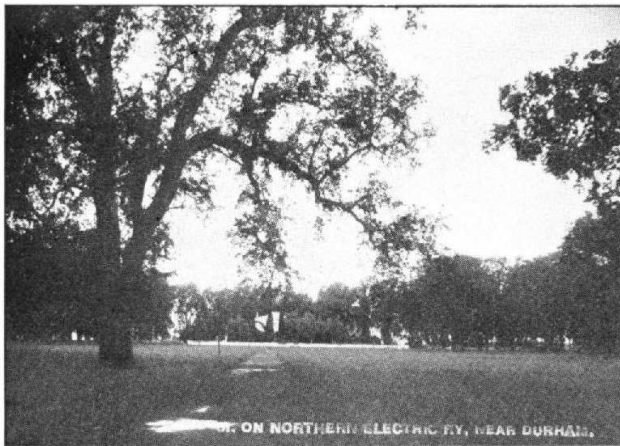


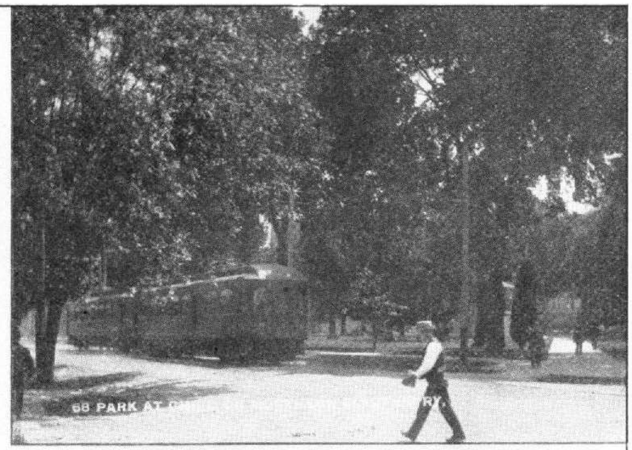
Plowing Sugar Beets Near Hamilton by Steam Power.

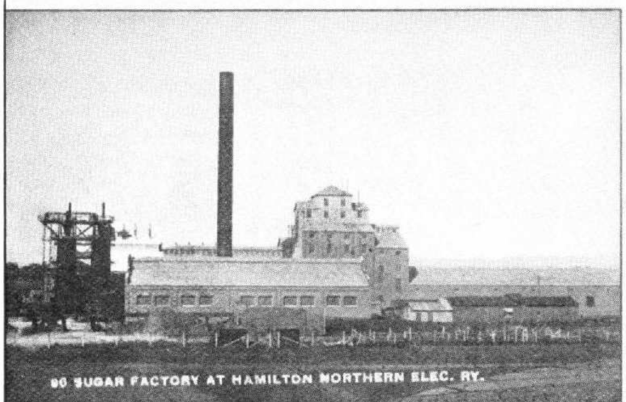
On the west of Chico and adjacent to the Sacramento river is a large section devoted to the cultivation of sugar-beets. There is at Hamilton a sugar factory. A line was therefore built from Chico, due west to the Sacramento river and after crossing the river, following the west side to Hamilton, a distance of 11 miles.

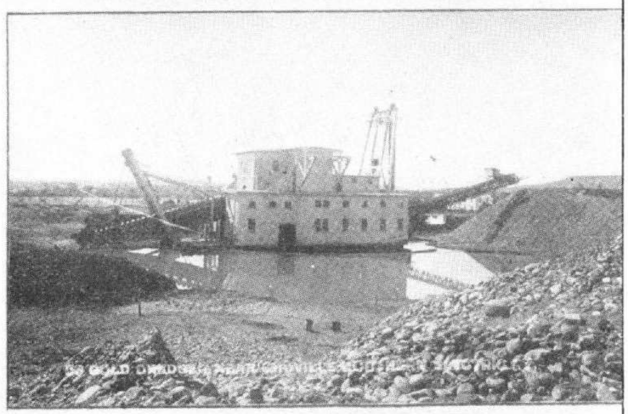
It is now proposed to continue the main line north from Chico, and following up the valley for 41.7 miles, to the city of Red Bluff. Surveys for this work have been made and much has been done toward the completion of this extension.

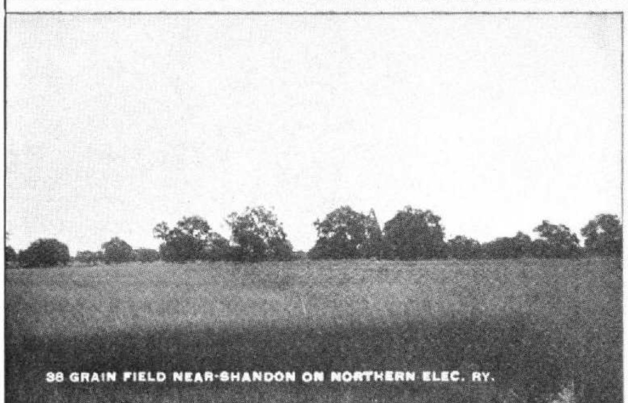
Another extension is in process of construction. This leaves the main line 4.4 miles north of Marysville and will extend due west to Meridian and after crossing the river, proceed northward to Colusa, a town on the Sacramento river. This branch will be 22 miles long and traverses a wonderfully fertile, but more or less undeveloped country. The land adjacent to this new line is mostly of sufficient height above the level of the overflow from the rivers to enable cultivation without the necessity of drainage. The soil here is from 18 to 25 feet in depth and has been pronounced

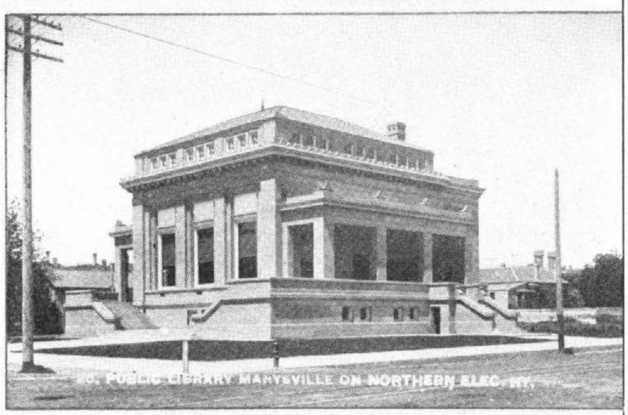


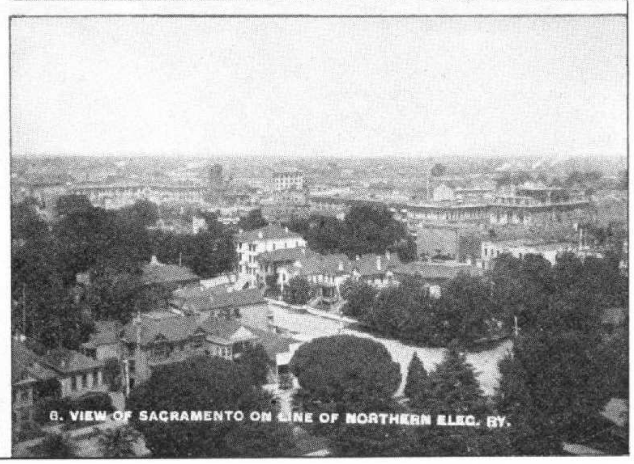












Views Along the Lines of the Northern Electric Railway.

On Main Line Between Marysville and Chico.

by the soil expert of the U. S. Government to be the premier of all California lands.

The absolute lack of transportation facilities is the only thing that prevented development here and illustrates one of the great possibilities for business of this system.

When that section between Marysville and Sacramento was commenced, the conditions were much the same; thousands of acres of the richest land were lying idle; today there are a half dozen towns laid out. Where three years ago there was not a person to be found for miles at a stretch, there are today scores of farms springing up and a rapidly increasing population. And the well filled, frequent trains are a tribute to the wisdom and sagacity of the founders.

General Description of Main Lines.

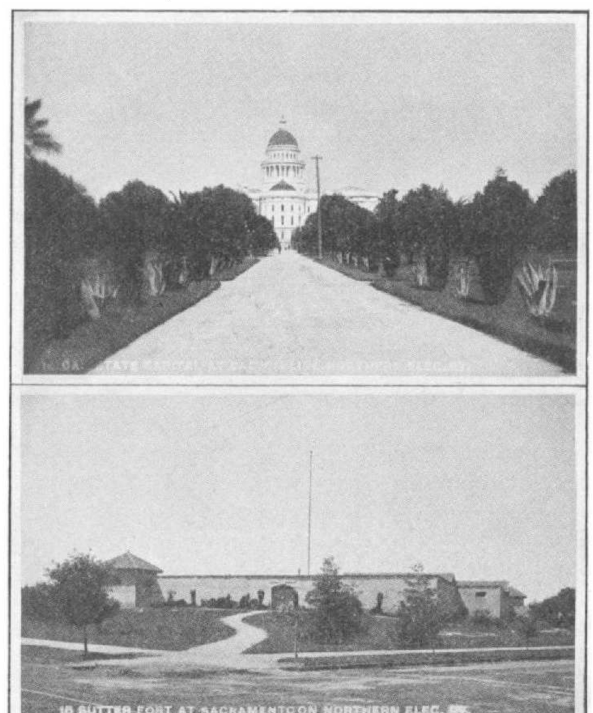
The Northern Electric has a total of 122 miles, not counting the local street railway systems which have a total of 17 miles of track; when the extensions, now under construction are complete, this will be increased to 193.5 miles.

The road between the present terminals, Chico on the north and Sacramento on the south, lies practically north and south in a generally straight line. That section of the road into Oroville is treated as a branch: it joins the through line at Tres Vias and runs east for a distance of 5.5 miles to Oroville. Except for that section where the foothills are approached nearing Tres Vias and the Oroville branch, the road is essentially level; the maximum grades at the points mentioned do not exceed 1 per cent.

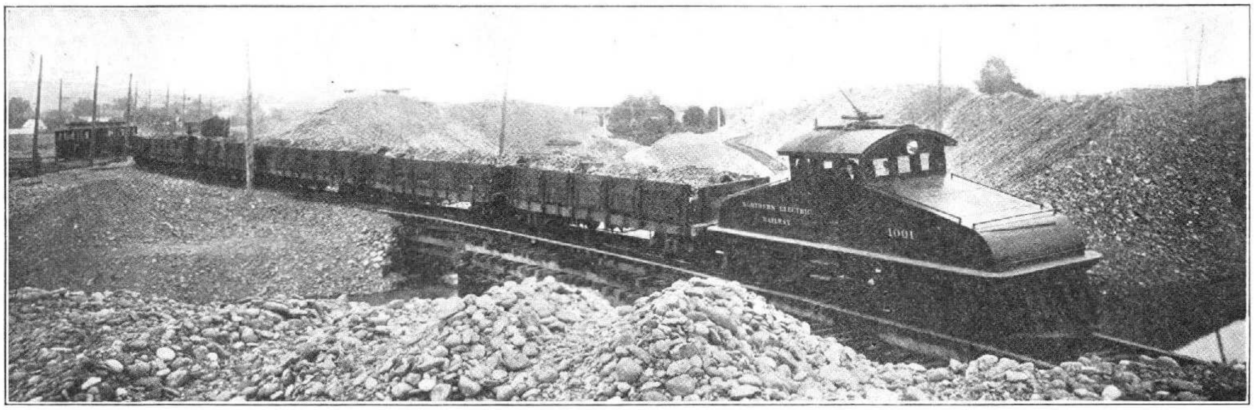
The rail equipment throughout is of 60 lb., A. S. C. E. standard profile.

Sawn cross ties from the hearts of pine and fir timber were laid throughout the system, this timber being of good quality and supplied by the Diamond Match Company from their forests in the nearby Sierra Nevada mountains.

Throughout the system a high class of track construction is in evidence; the nature and height of embankment show a careful study of conditions. Except for about ten miles on the Sacramento end, the track is thoroughly stone-ballasted. Rock for this purpose has, for the most part, been hauled from the tailing pits of the gold dredgers at Oroville. A crush-



Views in Sacramento.



Hauling Rock for Ballast from Dredger Pits at Oroville.

ing plant at this point consisting of a No. 5 Gates crusher, electrically driven, with the necessary equipment, was provided for this purpose. This rock is all in the form of boulders and cobbles and much of it very hard. There is, of course, a large percentage that does not require crushing.

From Chico to Yuba City the road passes through a number of towns—Durham, Live Oak. Gridley, Biggs and several prospective colonies which are rapidly becoming populated. There are few curves and those are of long radius, while there are long tangents, the longest being fifteen miles.

Particular attention has been given to the design and construction of culverts, cattle-guards and fences. The first, while of little use during a large part of the year, become very important factors during the rainy season, disposing of the sometimes rapid run-off gathered from the broad flat lands adjacent to the road.

The country is being cut up into small farms and holdings which are becoming more numerous every year. These necessitate many crossings, some public, some private, and therefore the greatest care must be exercised to prevent animals being driven or wandering over these crossings from getting on to the right of way and coming in contact with the third rail. A number of standard designs have been adopted for installation where the height of embankment varies.

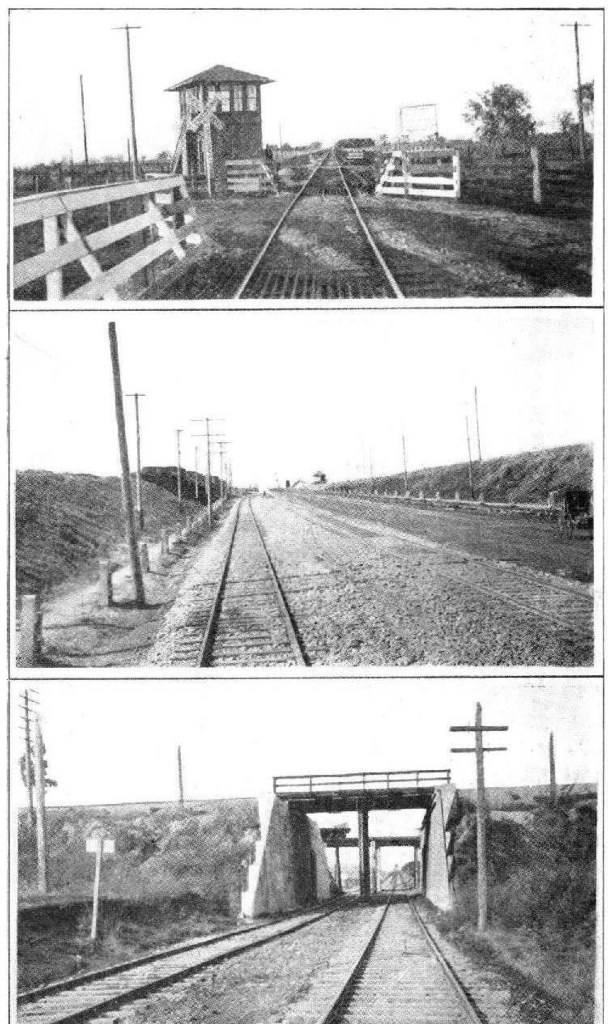
It is, of course, necessary to have fences on either side of the right of way, which are not only sufficient to keep out cattle and other domestic animals, but even dogs and rabbits.

The right of way is from 80 ft. to 100 ft. in width.

Being a single track system, it is necessary to pay great attention to meeting points in the running of trains. There are sidings at all the principal stations, but additional sidings at the proper points have been provided for this purpose. At these sidings there is a box mounted on a post; this contains a telephone connected to the private wires of this road. A train conductor can, by this means, get into communication with the Dispatcher and may readily ascertain the position of any and all trains he has orders to meet.

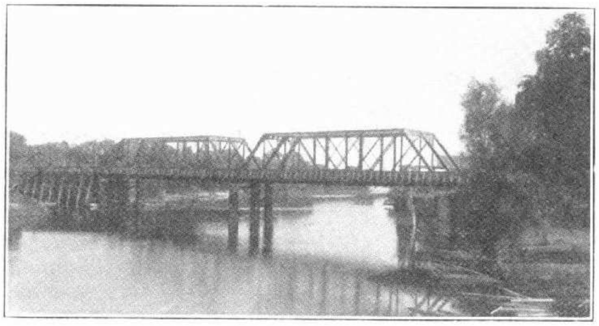
At Live Oak the road crosses the line of the Southern Pacific at grade. There has been placed here an interlocking switch tower at which an attendant is constantly on duty. This tower was built and is maintained jointly by both railroads.

From Yuba City the road crosses the Feather River on a steel truss bridge into the city of Marysville. This bridge is owned jointly by the railroad and the counties of Yuba and Sutter, and supports a roadway, as well as the track. A very difficult and interesting problem was encountered during its construction. It



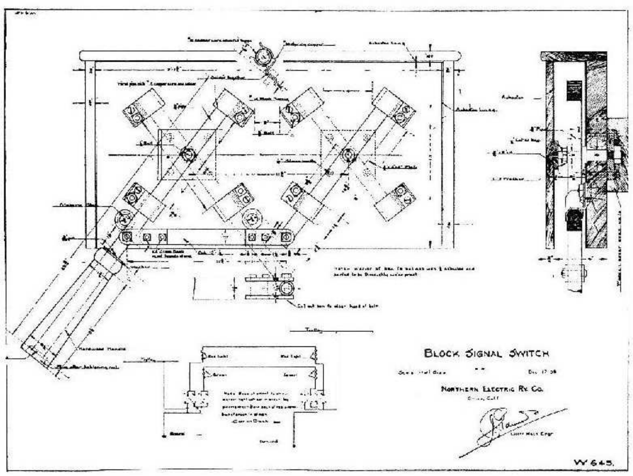
1. Interlocking Tower at Live Oak.
2. Approach Into Marysville Between Wing Levees.
3. Subway Through Levee at Sacramento.

was built to replace an old wooden structure and while the work was in progress, both the railroad and the wagon road were at all times in use.



Steel Bridge Over the Feather River at Marysville.

There is a single track over this bridge and so, to prevent the possibility of an interurban train and a local street car from meeting on the bridge, a simple block system has been installed. It consists of a box at the commencement of the embankments at either end of the bridge, in which is a switch. The throwing of these switches cause a danger signal to show at the opposite end from the switch thrown. A diagram of this switch is herewith reproduced.



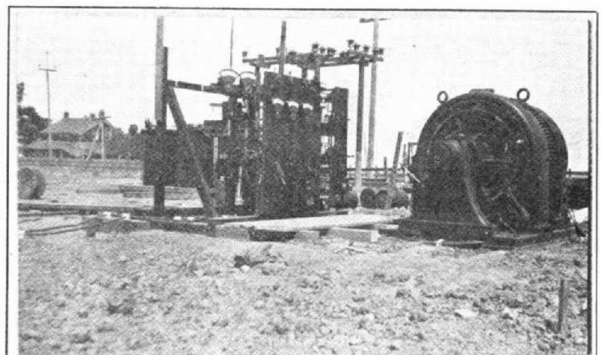
Marysville lies between the Feather and the Yuba rivers, the latter joining the former at this point, forming a right angle. The city is at times below the water level of the rivers, and is thus surrounded by levees. In order to give a proper grade from the bridge to the streets of the city, it was necessary to cut the levee. This was accomplished by building wing-levees and the resulting roadway has been made into a sort of boulevard.

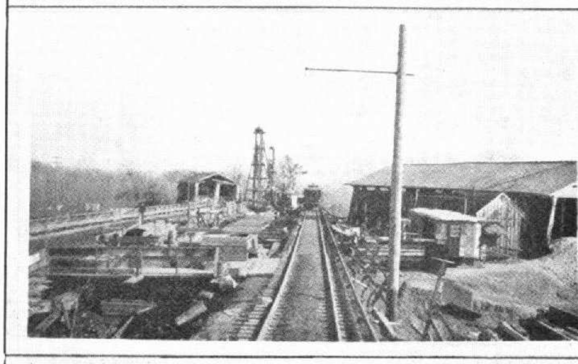
After passing through the principal streets of Marysville the road turns south and crosses the Yuba River, this time on a timber pile trestle. The United States Government is at present undertaking the work of altering the course of the Yuba River so that it will eventually join the Feather River at a point south of the present junction. In anticipation of this change the trestle was not constructed as a permanent structure, but at the point where the track will cross the new channel there have been placed nineteen 40-ft. steel spans supported on permanent concrete piers.

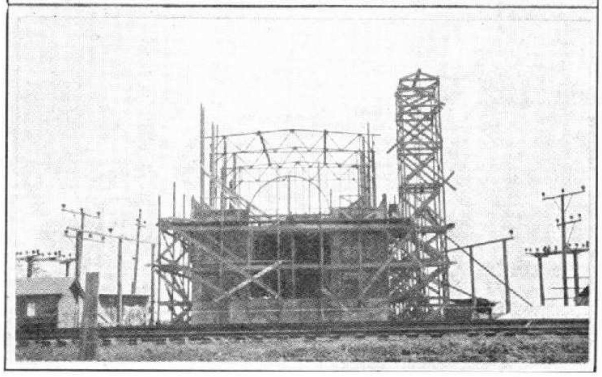
Following the crossing of the Yuba River the road enters a low flat country which, while not actually subject to overflow from the Sacramento River, has as yet not been thoroughly diked, and is subject to overflow, during periods of very high water, from the Yuba and Bear rivers. This fact and the sometimes quite heavy current of the overflow necessitated a class of roadbed construction which would at once resist any current pressure to which it might be subject and at the same time turn the currents into proper channels through culverts and other openings. This has been accomplished by first building substantial pile trestle and then filling it out with an embankment consisting of the tailing cobbles and gravel from the dredger mines at Oroville. This material will remain in place under the most adverse conditions of flood and current.

Dikes and levees are now nuder construction for the reclamation of this district.

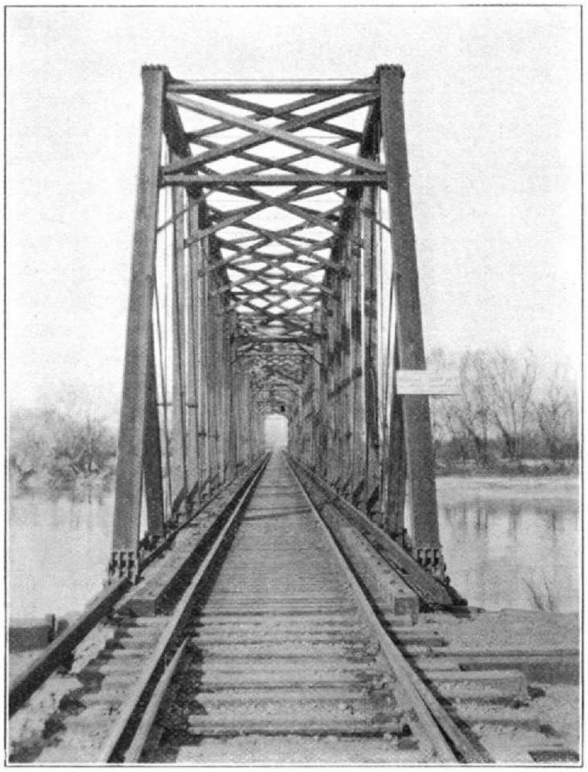
The last thirty miles of the road before reaching Sacramento is in a flat but well-drained country, and is not subject to the possibility of overflow. There are throughout this section a number of well laid-out town-sites and from the frequent sales of real estate,







1. Temporary Sub-Station.
2. Replacing Wooden Bridge Across the Feather River at Marysville with a Steel Bridge.
3. Sub-Station No. 8 at Nicolaus under Construction.



Bridge Over the American River Near Sacramento.

in small holdings, give every evidence of a very rapidly growing population.

The road enters Sacramento after crossing the American River. This it does on a composite Howe truss bridge. In entering Sacramento very much the same condition is encountered as that at Marysville. It is necessary to go through a levee. Wing-levees are built to allow of this entrance. At the lowest point of the cut, at the center of the levee, it has been found that water would seep through from the river and collect in the cut. Provision to obviate this has been made by installing a small motor-operated pumping rig. The cut is heavily constructed with concrete piers and wing walls and supports several railroad tracks, laid lengthwise of the levee.

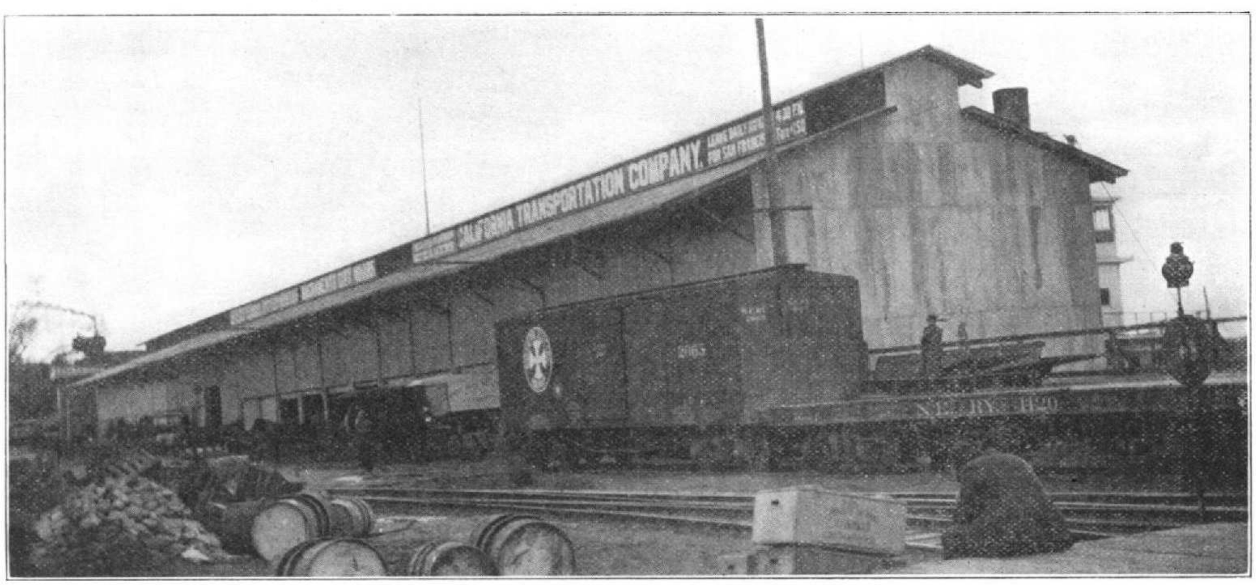
Within the city the road has a double track and passes through a number of streets until the passenger terminal at Eighth and J streets is reached. There is a "Y" provided here to enable the turning around of cars or trains.

Soon after entering the city, a branch line has been constructed to a freight terminal at the city wharf on the Sacramento River. This line practically circles the city, as it was not possible to secure a franchise to operate freight trains through the streets. This branch is 5.7 miles long and its construction throughout is equal in quality to the high standard maintained by the system.

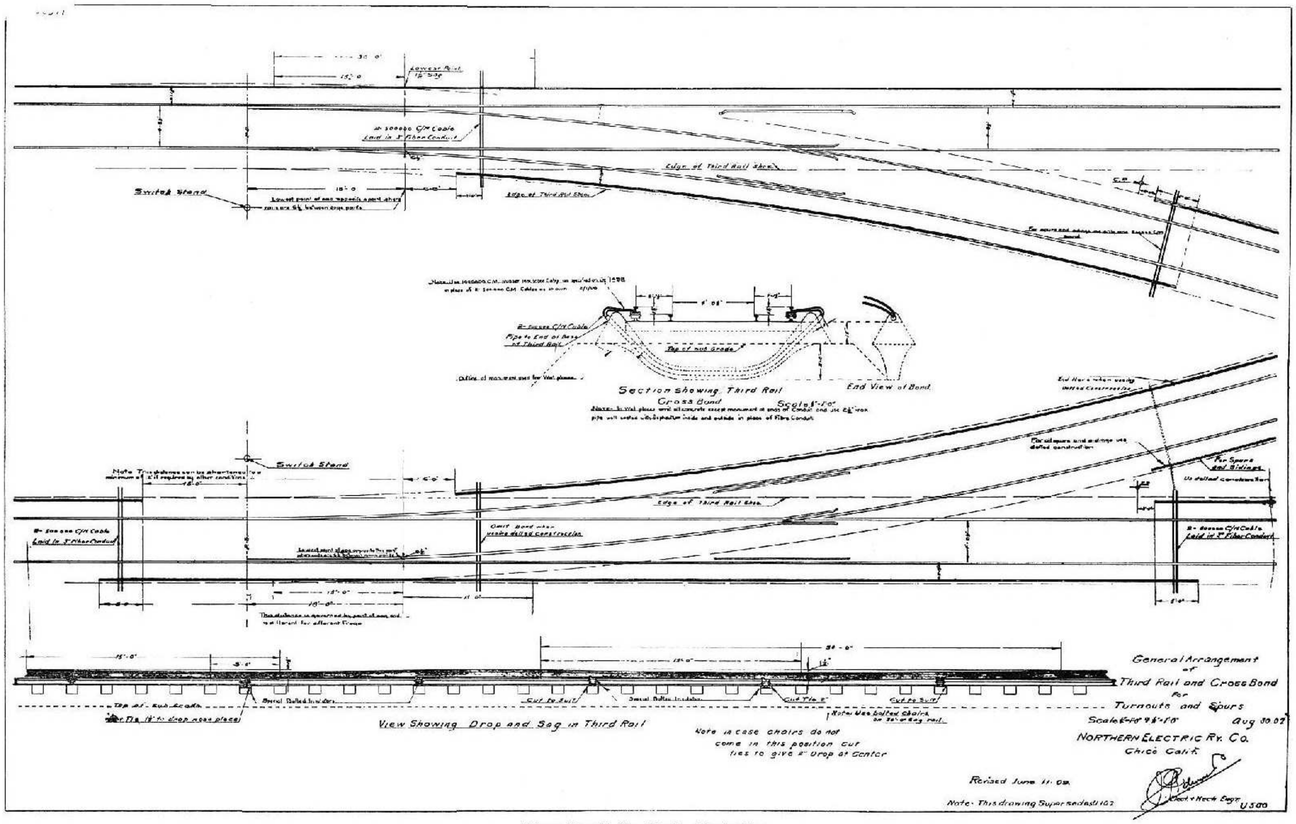
Freight Depot at Sacramento.

The freight depot is a commodious structure, of sufficient size to handle the cars and business for some time to come; it takes up a large part of a block east of the wharves. The tracks are so arranged that cars may be shunted directly on the wharf and loaded to or from the steamer.

The question of the method of supplying electricity to operate trains was one which received a great deal of thought and consideration. For long distance interurban work, both the various forms of trolley construction and the third rail have their advocates. The engineers in charge of this work were strongly in favor of the latter course and it was adopted. The subsequent result seems to point to their wisdom.



The Wharf at Sacramento; Steamer "Pride of the River" on Right.



Standard Switch Details.

Through cities and towns a plain trolley construction is used; the cars are therefore equipped both with the trolley and the third-rail shoe. In changing from the former to the latter and vice-versa, the trolley is raised and lowered in the ordinary manner. An ingenious device, controlled by interlocking automatic relays, cuts out electrical connection to the shoe when the trolley is in use. This is described elsewhere, together with the car control system.

Standard forms are used for switches and crossovers, passing tracks, etc.; this is important, as the position of the various arrangements for the third-rail must be accurate.

An ingenious but very simple device is used on switches to electrically disconnect the third rail when the switch is not in use. It consists of a break in the rail, in which is inserted an insulating wood block. Fastened to the rail at either end of the break and extending sideways in a horizontal direction are two hook-shaped receptacles. An iron rod, with a wood handle at one end, which acts as an insulator, is laid on these projections in such a way that it fits into the curve or hook of each. This closes the circuit. When the track is not in use, the bar is simply pulled out.

Third Rail Disconnecting Switch.

The third, or electric rail, is 60-lb. steel, having the A. S. C. E. standard profile. It is mounted on a special insulator, designed by the engineer of the road. This consists of a treated maple block, fitted to a malleable cast-iron base and supporting a cast-iron flaring top, to which the rail is fastened. The insulators are placed on every fifth tie, which is 18 inches longer than the others, for this purpose,

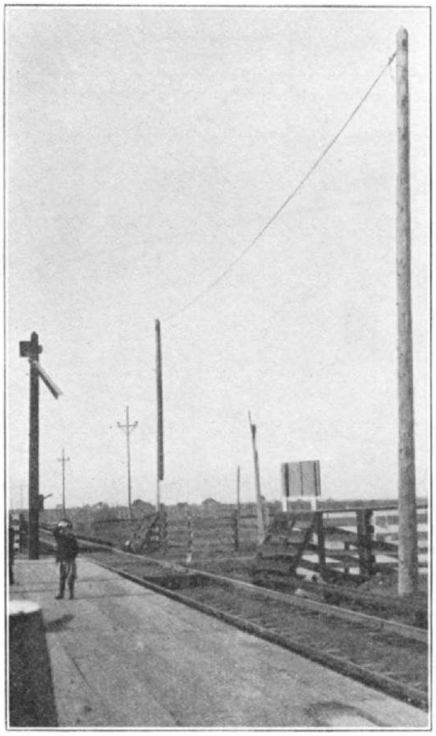
The loss by current leakage from the third rail is remarkably small, being one-half ampere per mile, under the most severe conditions of weather.

The track rails are bonded with two No. 0000 and the electric rail with two 400,000 cir. mil. Chase-Shawmut soldered bonds.

At road crossings, where there would naturally be an interruption in the electric rail, a heavily insulated cable was laid beneath the crossing; this was found to give trouble and resulted in changing a number of these underground cables to an overhead construction, two poles being used for the purpose. This conductor is made of two 500,000 cir. mil. copper cables.

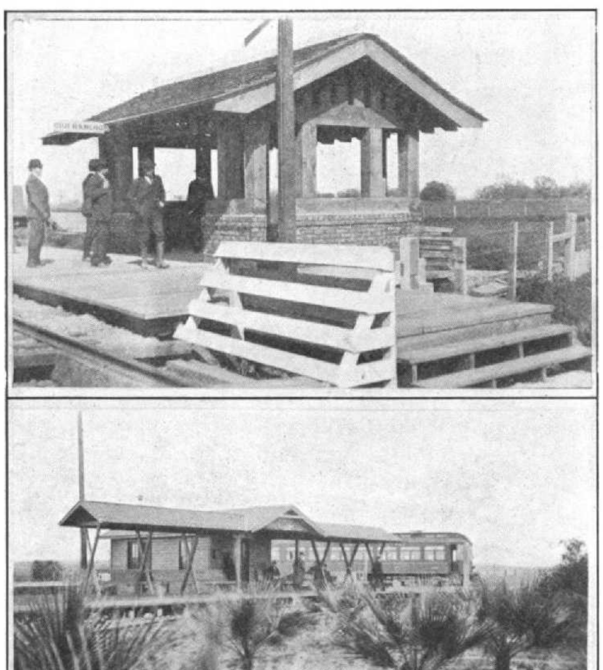
Stations.

A number of types of passenger stations have been adopted. A new depot at Thermolito built largely out of cobbles is of a very neat and artistic design. The illustrations give a good idea of this progressive type of building.



Method of Carrying Third Rail Conductor Over a County Road.

There are a number of points along the road which, while an attendant is unnecessary, afford considerable passenger business. These are simply shelter stations and are constructed on a standard design. They are equipped with a manually operated semaphore, which when in a horizontal position, lights a series of 5 lamps for night use. The cost with a 100 ft. platform is about $450.

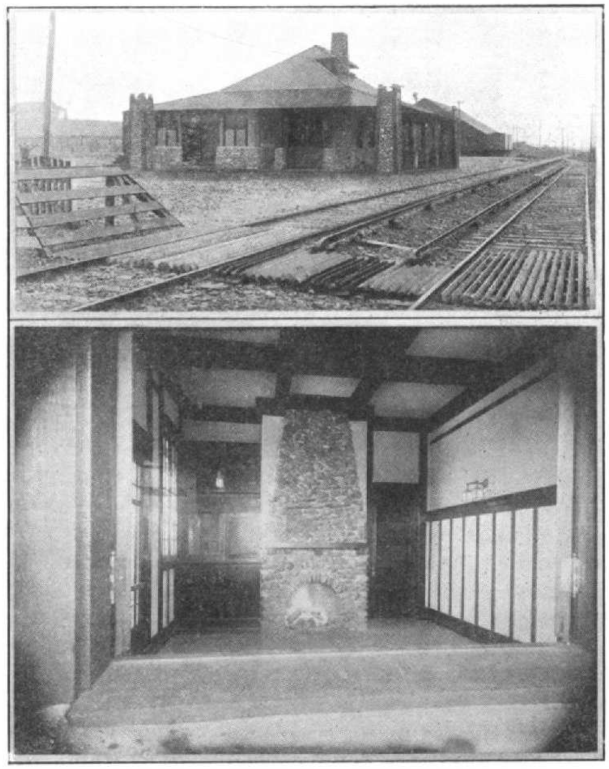


1. Shelter Station. 2. Station at Tres Vias.

Car-Houses, Repair Departments, Etc.

Located at Mulberry, a suburb of Chico, are the main car-houses, the repair-shop, the car-building shop and the administration offices. Here is also a sub-station and the office of the Chief Train Dispatcher.

The car-houses are conveniently placed, facing the county road, on which the main line operates. The building is a concrete and timber structure, 140 ft. by 140 ft., covered with corrugated iron, and contains eight tracks, all of which connect with the main line. Within the building there are pits throughout the length of the two tracks adjacent to the machine shop,



Depot at Thermolito and Its Artistic Interior.

so that temporary or permanent repairs may be made at any time to the working parts of coaches or locomotives. Doors at the rear of four of the tracks allow the passage of cars through to the car-shop, which is located directly in the rear of and a short distance from the car-barn.

On the right, as one enters, incorporated as part of the car-house building, is the sub-station, described elsewhere. Behind this is a machine shop, equipped with all the machines necessary for car-repair work. Next to these shops is the air-brake department, with equipment for repairing and testing of this apparatus. In the rear and adjacent to these shops is a forge-shop. This has six forges and one 300-lb. hammer.

To the left and at the rear of the car-house is the armature and electric repair department. Armature repairing is perhaps the most important of the various classes of repair work on an electric railway system. The repairing and rewinding of railway armatures has become almost an exact science and the work is thoroughly and expeditiously handled here. A little device, designed in this shop, for slotting commutators is of interest. After the commutator has been turned and finished, this slotting device, consisting of a steel circular saw, mounted on a mandrel and driven by a motor, is run between each commutator bar. The armature is mounted in such a manner that its axis is perpendicular to that of the mandrel and is turned automatically, after each slotting operation. This act of slotting removes the "burr" and a small portion of the insulation at the edge of the commutator bar, leaving the bar clean cut and every slot the same width; it increases the life of the commutator and the brushes and prevents "flashing over."

Passing from the car-house to the car-shop, one finds a well-constructed corrugated iron building, equipped for the erecting and finishing of cars. A wood-shop with machinery to turn out all the work from the heavy frames to the inlaid hard-wood finish is at one end; at the other is the paint shop.

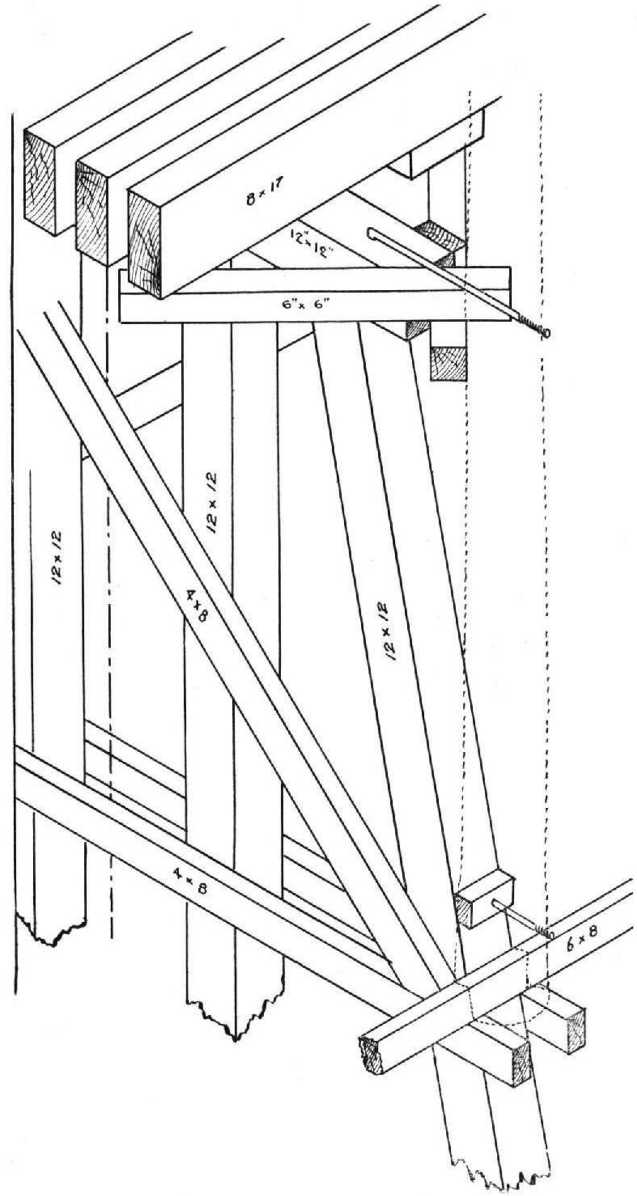
Many of the later cars of this company have been built in this shop and a minute examination evinces the care and thoroughness exhibited in their construction and a finish which it would be impossible to get on cars purchased in the open market.

One of the latest examples of the product of this shop is car No. 130. This is a combination passenger and baggage type; it has a length of 50 ft. over all and the weight equipped is 83,400 lbs. The interior finish is Honduras mahogany, the panelling being inlaid with white holly and ebony in a neat marquetry design. The ceiling finish is full "Empire." The seats were furnished by Hale & Kilburn and are covered with a figured blue plush. There are toilet facilities at both ends and in general the car is the embodiment of the most modern design for comfort and ease.

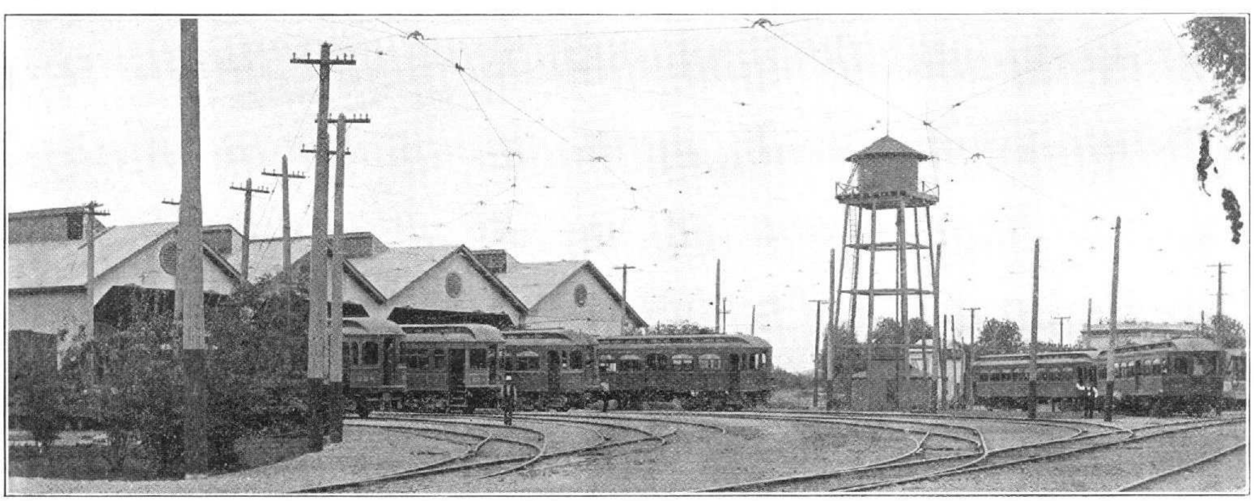
The motor equipment consists of four 90-h.p. Westinghouse No. 121-A motors mounted on Baldwin No. 200 single trucks with 36 in. standard rolled steel wheels.

The air-brake system is Westinghouse automatic, schedule AMM, with quick release and recharging feature. Air is supplied for the air-brake system by a Westinghouse D-3 air-compressor set, slung from underneath the car-body in the usual manner. The draft-gear is of the "radial" type, described elsewhere, and the control is by the electro-pneumatic system, which has been adopted on all of the cars of this company.

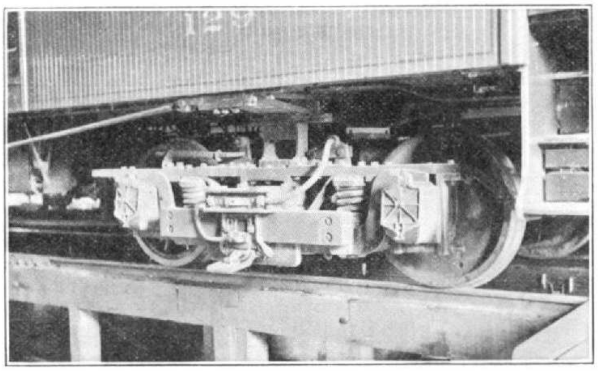
The third-rail shoe, or current collector, is of cast-steel; it has a hinged mounting and is fastened to the



Standard Connection Between Pole and Trestle Bent.



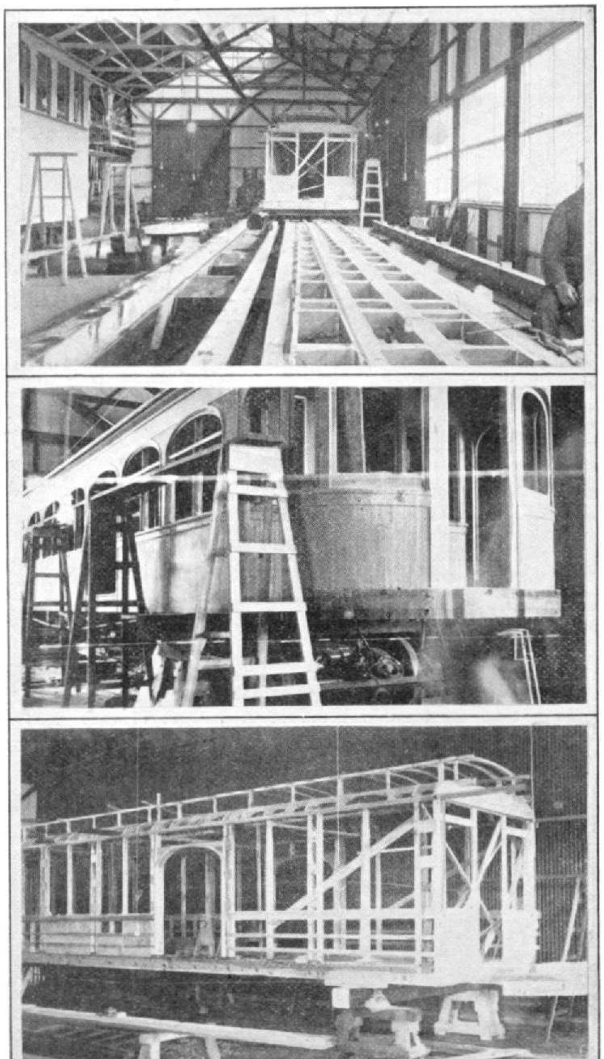
The Car-Houses at Mulberry.



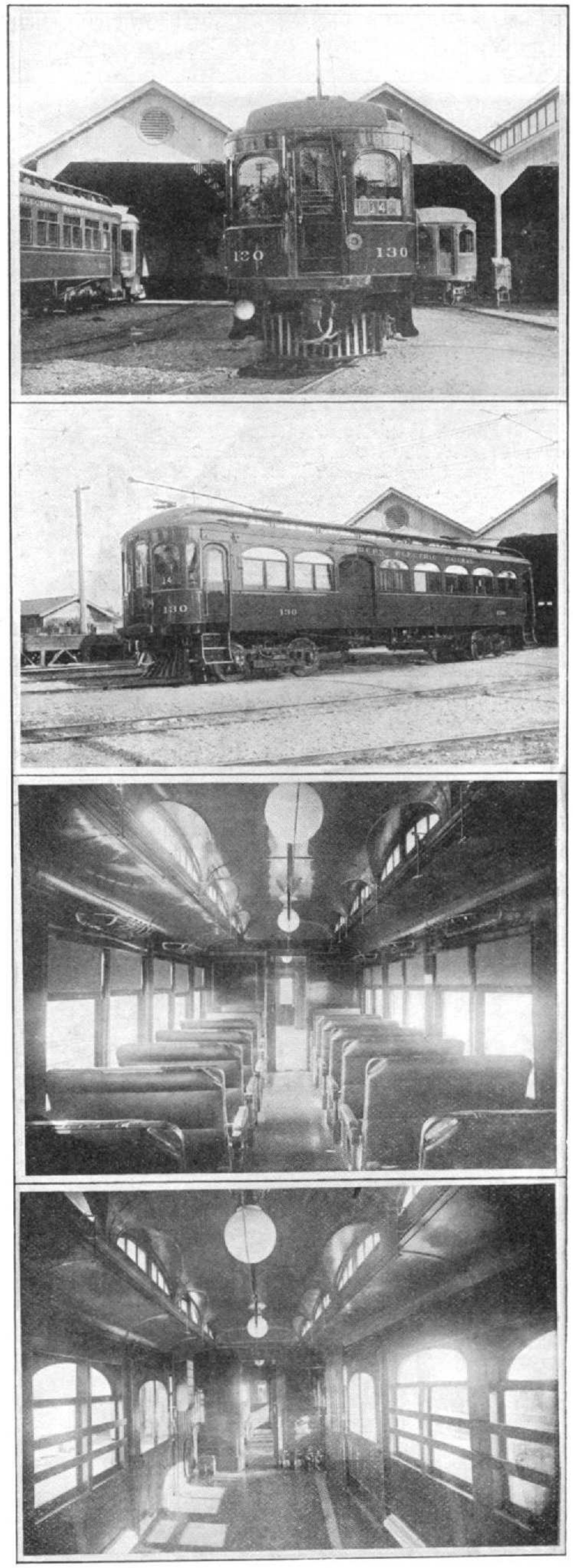
Third Rail Shoe in Use by the Northern Electric Railway.

truck in a simple and effective manner. This arrangement is another of the many features designed for this system by its engineering department.

A fuse is carried above the shoe, where it is readily accessible. This fuse is made from sheet copper and is a strip of the proper width to be effective; at its middle point a hole is drilled. When the fuse is ruptured it naturally breaks through the hole as the greatest current density is at that point. The inductive effect caused by the breaking of the fuse has a tendency to separate the broken ends, thus preventing the arcing over of the current.



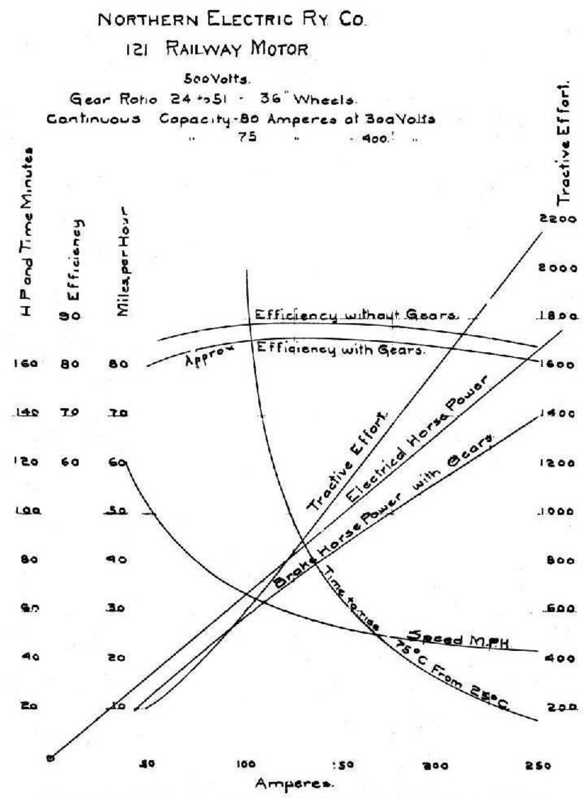
Views Showing Various Stages of Coach Construction at the Mulberry Shops.



Exterior and Interior Views of the Car No. 130.

LIST OF ROLLING STOCK AND EQUIPMENT

Type of Car.	No.	Weight.	Length.	Motor Equipment.	Trucks.	Brakes.	Shop.	Gear.
Combination (baggage, smoker, pas.)	2	85,860	56 ft.	Quad. West. 121	Bald. 200 36″ wheels	West. aut.	Reb.	24/51
" "	3	80,000	"	"	"	"	"	"
" (passenger and baggage)	6	83,400	"	"	"	"	Built	"
" (mail and baggage)	3	40,000	55 ft.	....	St. Louis 34″ wheel	"	Reb.	.....
Passenger coaches	3	55,000	52 ft.	....	"	"	.....	.....
" "	3	78,400	56 ft.	"	Bald. 200	"	.....	"
" "	1	76,000	52 ft.	"	"	"	.....	"
" trailers	10	61,250	56 ft.	....	....	"	.....	.....
Combination (open and closed)	2	49,500	39 ft.	Quad. West 93-A	"	West St.	.....	22/65
" "	3	36,000	39 ft.	Doub. GE-202	St. Louis	"	.....	15/71
Open 14-bench cars	2	30,000	40 ft.	Doub. GE-67	"	Hand	.....	19/65
Single truck, city cars	4	17,000	28 ft.	Doub. GE-800	Brill, 21E	"	.....	14/67
Locomotive (steel)	1	64,600	31 ft.	Quad. West. 121	Bald. 200	West. St. & aut.	Built	16/59
" (Cons. type)	3	79,500	40 ft.	"	"	"	"	"
" "	1	37,600	36 ft.	Quad. GE-67	St. Louis 47	"	"	16/65
" (steam)	3	120,000gr.	.....	16 x 24 cyl.		West.		
Flat cars	161	27,000	40 ft.	40 tons cap.				
Rodgers ballast cars	50	36,500	37 ft.	"				
Box cars	99	37,200	38 ft.	"				
"	36	22,800	28 ft.	20 tons cap.				
Flat cars	1	22,800	37 ft.	"				
"	22	16,300	31 ft.	15 tons cap.				
Wrecking car	1	......	.....	2 15-ton cranes.				
Line tower car	1							
Water car	1							
Steam pile driver	1	......	.....	30-h.p. engines, 3600-lb. hammer.				
Rodgers ballast plow	1							



Characteristic Curves of No. 121 Railway Motor.

Lighting is accomplished by five enclosed arc-lamps in the ceiling and there is also an arc headlight.

A maximum maintained speed of 52 miles per hour is possible and is about that to which all of the interurban cars are geared.

The freight locomotives are a development of this company; that is, each one has been built with the special conditions of operation in view and some novel features have been incorporated.

The first one put in use was a combination of the various parts which could be quickly procured. It was an ordinary flat-car, four second-hand street-railway motors, a controller from another source, and some lumber to build a cab. This primitive freighter has had a good record for work and is even now in use for switching purposes.

Designs for passenger coaches and freight locomotives, having steel framework and covering, have been made; none of the former have as yet been constructed, but one of the latter has been built and is proving itself to be highly satisfactory.

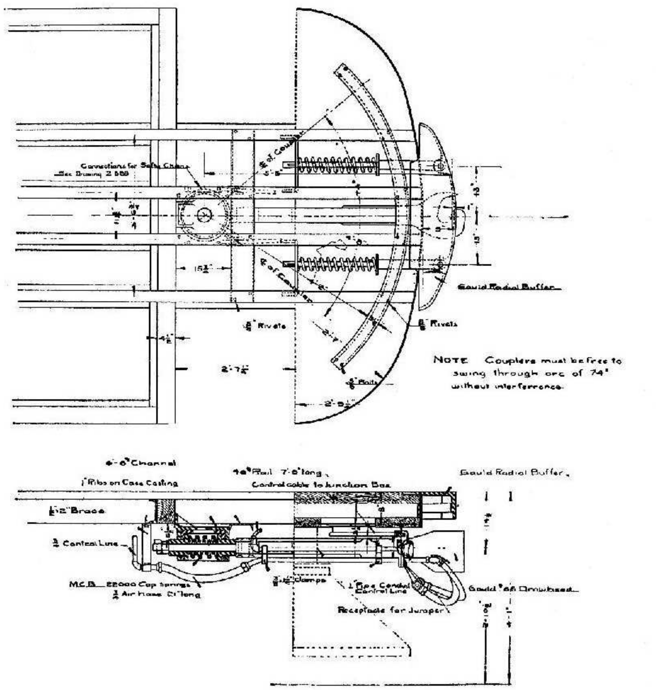
COST OF CAR NO. 130.

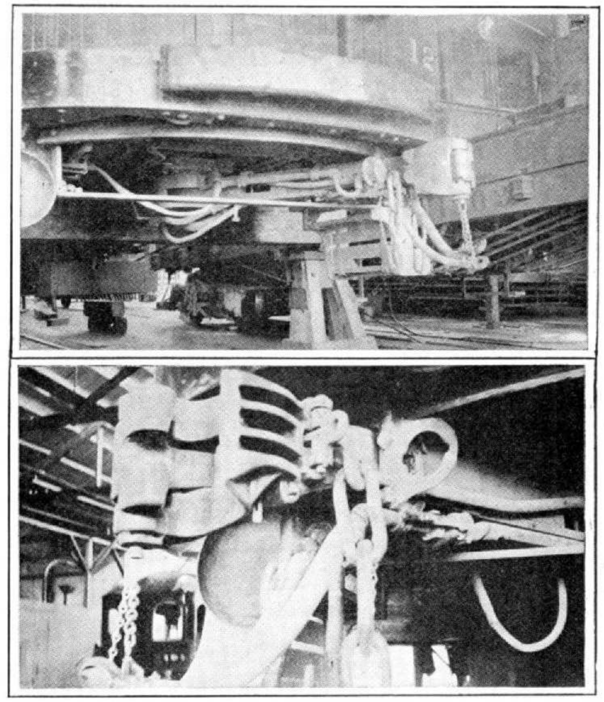
Class of Work.	Labor.	Material.
Body	$ 817.25	$1,126.04
Complete body	2,269.91	1,304.94
Paint	424.72	122.53
Electrical equipment	369.27	1,871.58
A. B. equipment	152.92	690.03
Radial draft gear	61.84	10.57
	$4,095.91	$5,125.69

Total shown	$ 9,221.60
Trucks not included	1,486.00
Motors not charged out	2,848.00
Cost complete	$13,555.60

The freight locomotives have the same motor equipment as the passenger cars, but are geared to a speed of 25 miles per hour.

There is a device installed, operating in conjunction with the multiple-control which consists of a switch that throws all four motors in series; this is for starting heavy loads. When the train is once started, this switch may be thrown back again, thus restoring the regular connections between the controller and the motors.




Views of Radial Draft-Gear.

The Westinghouse Electro-Pneumatic System of Car Control.

It has been already stated that this system has been adopted for the control of all interurban cars and trains. While it is a standard system, its working is not universally understood and a description in detail will be of interest to many.

At the request of the writer, this system as used by the Northern Electric Company is described by Mr. Edwards as follows:

General Description.

The system is designed for the operation of motor coaches for train service, consisting of a solid train of motor coaches, or a train of motor coaches with intermediate trailers, or for the operation of motor coaches, as single units. The motors throughout the train are operated simultaneously, each taking a proportionate share of the load and the control of these is affected at a single point at the head of the train.

The system is electro-pneumatic and utilizes compressed air from the air-brake system for the operation of the main switches in the motor circuit. Electro-pneumatic valves govern the admission of air to the operating devices; the operating coils being in a separate low-voltage circuit entirely independent from the motor circuit. This low-voltage circuit is the only one which it is necessary to establish from car to car, and is also the only one brought above the floor of the car. There are thus two circuits electrically independent, viz:

(1) The operating circuit, carried throughout the train and energized by a small storage battery.

(2) The motor circuit, confined entirely to each motor car, including the motors and switches for connecting these in series, and parallel, with the various resistance steps.

The apparatus for handling all main currents is located beneath the body of the car.

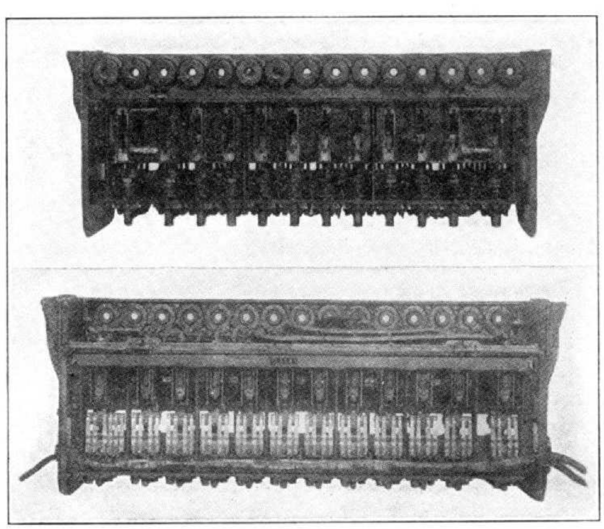
The Switch Group.

Fig. 1 is a front view of the switch group with the covers removed, showing clearly the contacts and arc chutes, and electro-pneumatic valves.

Fig. 2 is a rear view showing interlock fingers and contacts.

These switch groups consist of twelve independent unit switches grouped together in a line and mounted on a frame forming a small capacity air reservoir. Between the switches are arranged blow-out coils. These blow-out coils are either connected together in series in the main circuit, or in single switch circuits, as may be the case; dependent on the various switch movements.

The switches and blow-out coils are surrounded by incombustible vulcabeston boxes, the switch box being lined with asbestos and soapstone arc shields. The switch arm is hinged upon a support and carries


Figs. 1 and 2.

a contact proper, which has an independent movement affected by a spring acting between contact and arm. The operation of this spring secures the initial contact at the point of removable contact tips, and the final or resting position further along the surface, giving a wiping and rocking motion of the fingers, maintaining a positive contact upon which deterioration is a minimum. The piston of each cylinder is connected through an insulated joint to the switch arm. On the piston rod there is an arm holding an interlock segment, securing simultaneous movement of interlock and piston. The air cylinders are bolted to the cylinder head, which also forms a shell for valve magnet, this casting having a channel connected with the air chamber to which it is bolted. The switches are bolted to a substantial base plate bolted to the air chamber frame, the switch bolts forming terminals for motor leads and inter-connections between switches, all connections being thoroughly insulated by vulcabeston sleeves and washers.

A section of the individual switch units is shown by Fig. 3.

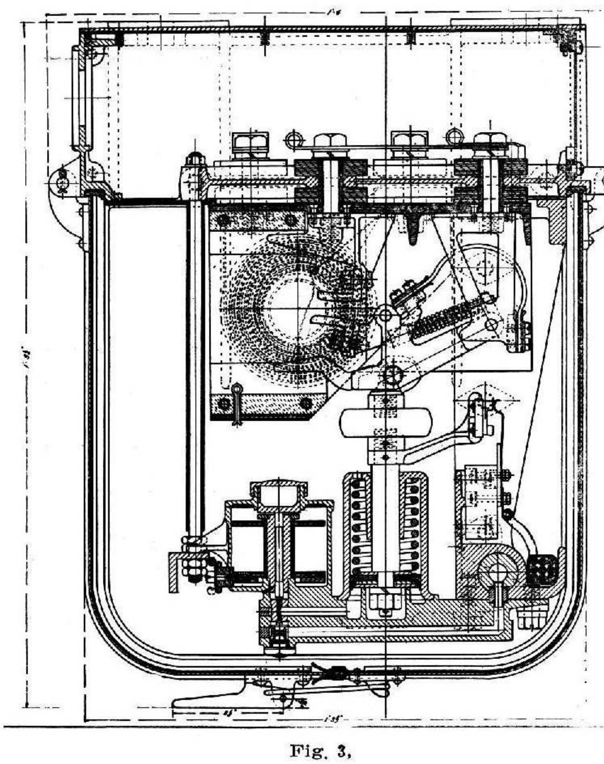


Fig. 3.

The interlocking switches consist of spring contact fingers sliding on segments and are electrically connected with the magnet valve in such manner that the closing of one switch energizes the magnet of the next succeeding one, thus producing automatic progressive action.

An exterior view of a single unit magnet valve is shown by Fig. 4.

When the magnet is energized its armature is attracted and opens valve from air reservoir to the cylinder. The air reservoir is supplied with air at 70 pounds pressure per square inch from the supplementary control reservoir. The piston making its stroke compresses the piston spring and closes the switch at the same time closing or opening the interlock contacts. When the magnet circuit is open the cylinder exhausts to atmosphere and switch opens through the action of the piston spring. It will be noted that the normal position of the switch is open, and the failure of the air supply or interruption of the circuit opens all the unit switches. The use of air gives great power for closing the switches and renders the operation of them entirely independent of fluctuations of line voltage. Curves shown in Fig. 5 give some data on the relation between carrying capacity and air pressure on the piston head exerted on the contact. A sheet iron

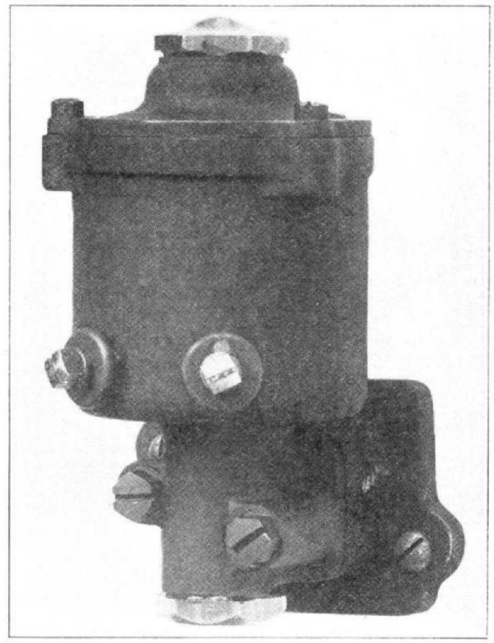


Fig. 4.

cover made in halves which are hinged from the base and easily opened for inspection, effectually protects the switches, interlocks and magnets from dust and moisture. The switch groups are tested with 3000 volts alternating current between main wiring to frame and between all the different wires.

Change-over Switch.

While the Northern Electric Railway's secondary distribution consists almost entirely of third rail construction, it was nevertheless necessary to install overhead trolleys where the line traverses cities and towns. This necessitated wiring arrangements of such a character that third rail shoes would be "dead" while equipment operated within town limits. The old method of attaining this result was either by the use of large knife blade switches, manually operated, or of third rail shoes manually lowered. Both of these systems are cumbersome and inconvenient. An automatic device known as a change-over switch was, therefore, developed for this service.

This change-over switch, an exterior view of which is shown by Fig. 6, consists briefly of a pair unit of electro-pneumatic valves operating pneumatically a block contact held in guides, and operated therein, wiping fingers in contact giving the desired changes in connections to either trolley or third rail circuits. This apparatus is entirely automatic and is operated and protected by two interlocking relays respectively connected to trolley circuits and third rail circuits. The detail of these connections is shown in the "Diagram

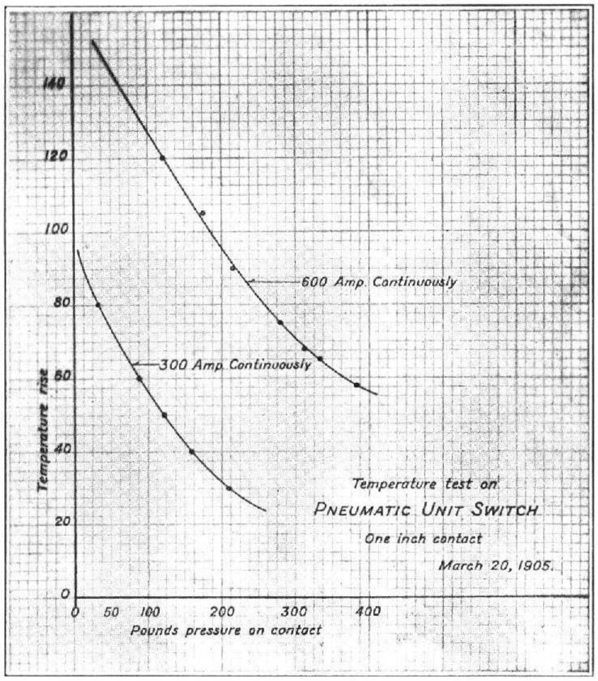


Fig. 5.

of Connection of Main and Control Wiring with Unit Switch Control," as shown on page 384.

Line Switch.

Shown by Fig. 7 closed and by Fig 8 with covers removed.

Current from the trolley or third rail connections after passing through the change-over switch passes then through the line switch. The line switch is a single unit of identical construction with the switch group. It is an independent circuit-breaker provided with automatic overload trip, the trip consisting of a

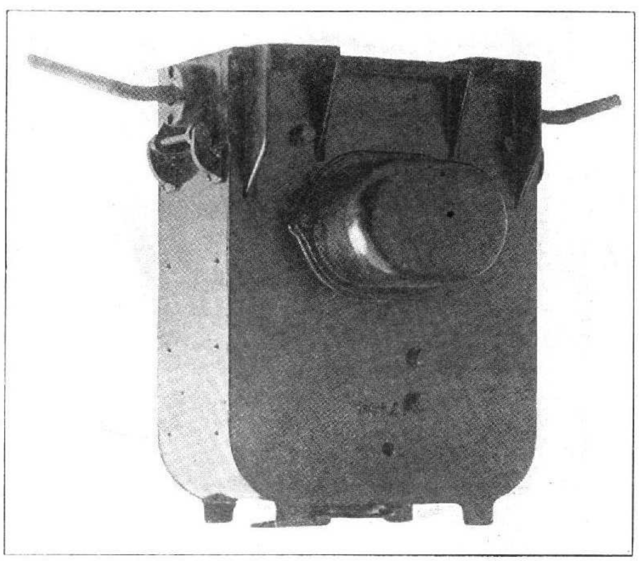


Fig. 7.

plunger acted upon by the blowout coil, the plunger opening a small switch in the control circuit. The trip is also provided with a resetting magnet, the whole being substantially protected by cast iron cap bolted to the main switch and plate.

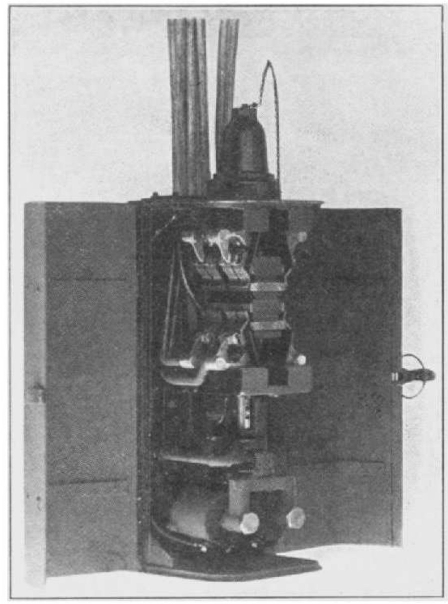


Fig. 6.

Reverse Switch

Shown by Fig. 9 with cover removed.

The function of the reverse switch is to interchange the armature leads of the motors with respect to the field, and thereby reverse the direction of rotation. It consists of two rows of stationary fingers connected through a contact drum rotated by the action of two air pistons, the admission of air being controlled by electro-pneumatic valves similar to those on the switch group and likewise operated from the controller. The drum may be manually moved

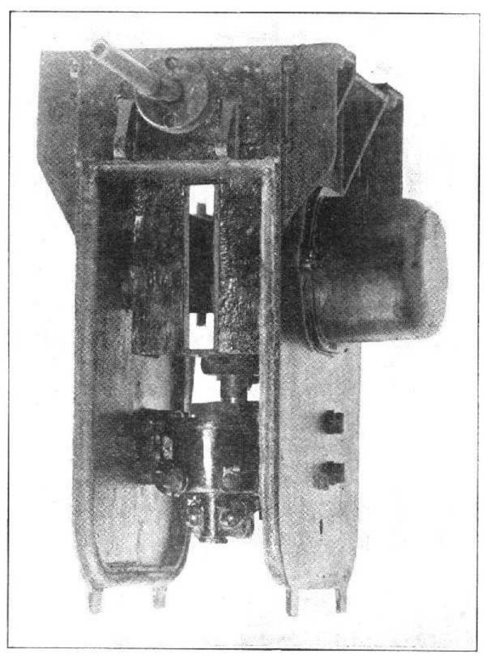


Fig. 8.

to the "off" or "central" position. This arrangement is to open-circuit motors in case the car is being hauled. This open circuiting prevents motors from "bucking" or generating one into the other. There is also an interlock which acts so that the switch group cannot be operated unless the reverse switch is fully

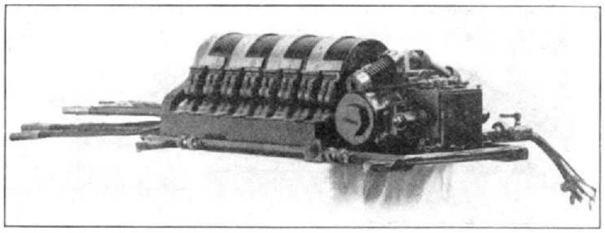


Fig. 9.

thrown in the direction indicated by the master controller, and an interlock closing the retaining circuit preventing reverser from opening while trolley circuit is closed on the motors.

Grid Resistances

Are of the unit type of grid diverters shown on Fig. 10 made up in boxes for facility in mounting and handling.

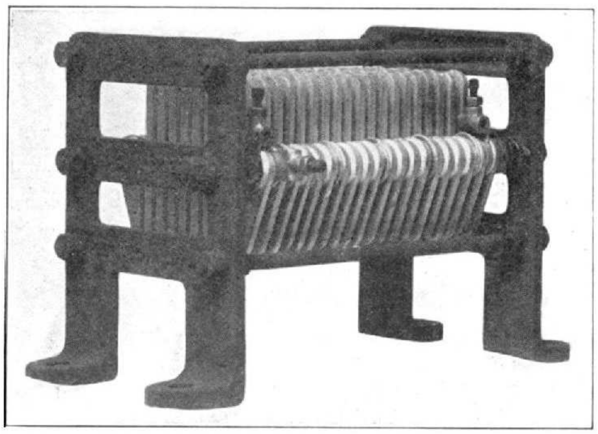


Fig. 10.

Master Controller.

The master controller shown on Fig. 11 is the governing type controlling the switch group and is located in the motorman's cab. It is of simple and compact construction, measuring approximately 7 inches high, 7 inches wide and 5 inches deep. It consists of a movable drum and stationary contact fingers which are electrically connected to the various magnet valves throughout the train. There are three positions for each direction of movement, the "off" position being in the center. These are:

(1) "Switching."
(2) "Series Running."
(3) "Multiple Running."

Intermediate positions of the unit switches can be secured by moving from the running positions. In the "off" position the drum is disconnected from all live wires. When the handle is thrown over without stop to any position; e. g., "Multiple Running," the switches follow in such a sequence that the car starts and is brought up to full speed at a uniform acceleration until full voltage is applied to the motors. This is done without current interruption to the motors at any time.

All current for the operation of unit switches passes through the particular master controller being operated, but control current for each motor-car is obtained from its own battery, so that the number of

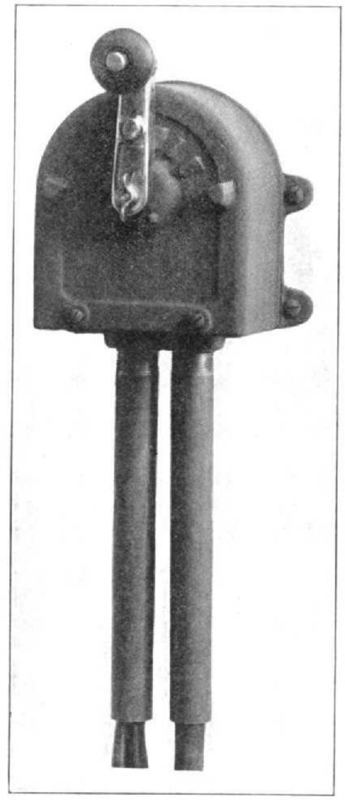


Fig. 11.

cars that may be in a train is not limited. While the operating voltage is 14 volts only, these controllers are submitted to a shop test of 2000 volts alternating current.

Motor Control Cutout.

Shown with cover removed, Fig. 12.

This switch is hand operated and is designed to

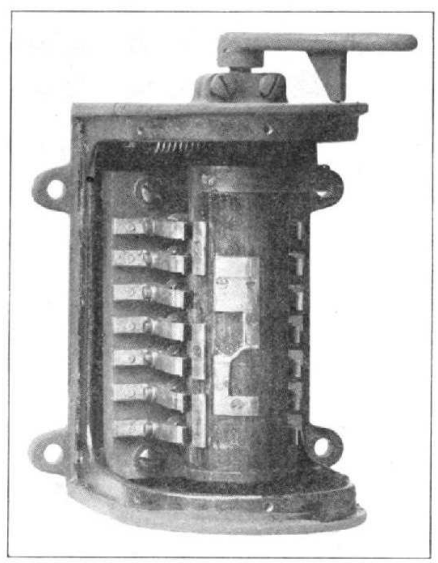


Fig. 12.

cut out operating circuits of certain unit switches, thereby cutting out either pair of motors should they be disabled. There is an interlock provided which prevents the switch group from reaching the "Multiple" position except when all motors are in circuit.

Limit Switch.

This switch with cover removed shown by Fig. 13.

The rate at which the resistance is cut out of circuit so as to give uniform acceleration current, is

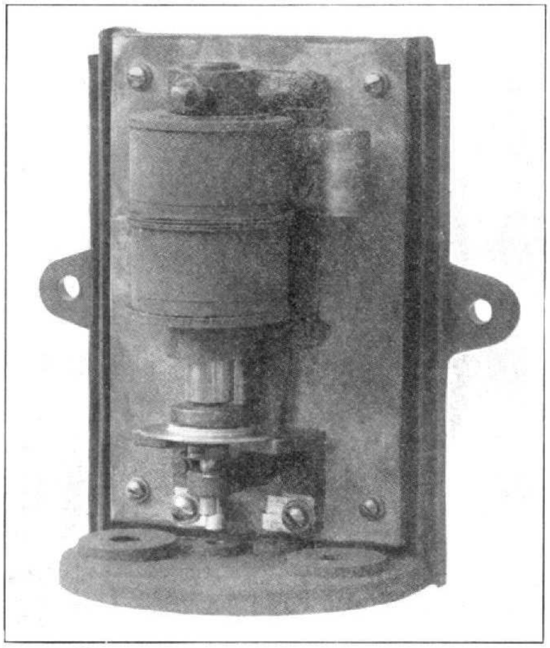


Fig. 13.

affected by the limit switch. This feature is a valuable one as it gives smooth and economical acceleration. It prevents abuse to equipment due to throwing on of power in excess of the predetermined rate.

The limit switch consists of a small switch actuated by a solenoid through the coil of which current of one pair of motors passes. When this current exceeds a predetermined limit for which the switch is adjusted, its armature is attracted against gravity, opening the switch which is connected in the operating circuit, and remains open so that no further unit switches can close (those already closed being retained) until the accelerating current falls below the predetermined limit. The armature then drops again completing the operating circuit and allowing the unit switches to continue their progression of closing. They are thus interrupted at each step of resistance. The limit switch can be adjusted to any desired accelerating current.

Line Relay.

This relay shown by Fig. 14 opens the unit switches should the current supply be interrupted. It consists of an electro-magnet, the coil of which is connected across the supply mains. The armature of this magnet acting against gravity holds three contacts closed in the operating circuit.

Another important function of this device is its interruption of control at third rail gaps and crossings which "drops out" the switch group contactors. Its return to normal when third rail shoes are again in contact with conductor rail restores the switch group control circuits so that the switch group "notches up" progressively restoring the controller connections within the period of a few seconds to the original position. If it were not for this relay interposed in the control circuits full voltage would be impressed upon motors immediately after passing a third rail gap. This sudden rush of current with its allied

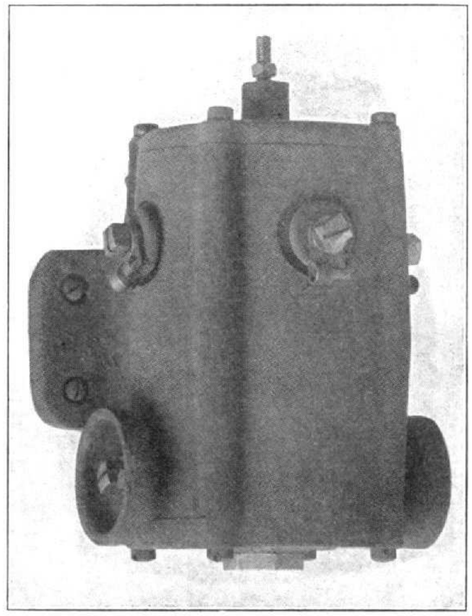


Fig. 14.

magnetic inductive surge would open breakers in sub-stations and otherwise abuse motors and generating apparatus.

Junction Boxes.

Fig. 15 shows a typical view of the cast iron junction boxes in which are enclosed wooden blocks having the requisite number of terminals for control wire connections.

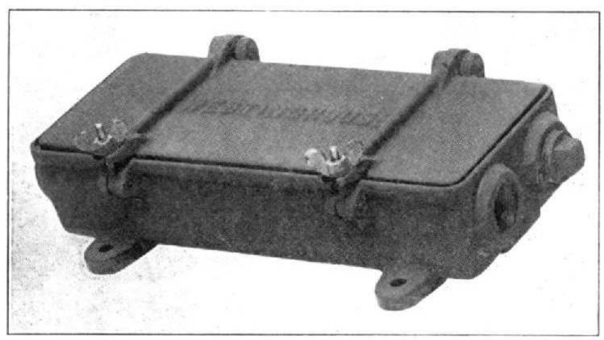
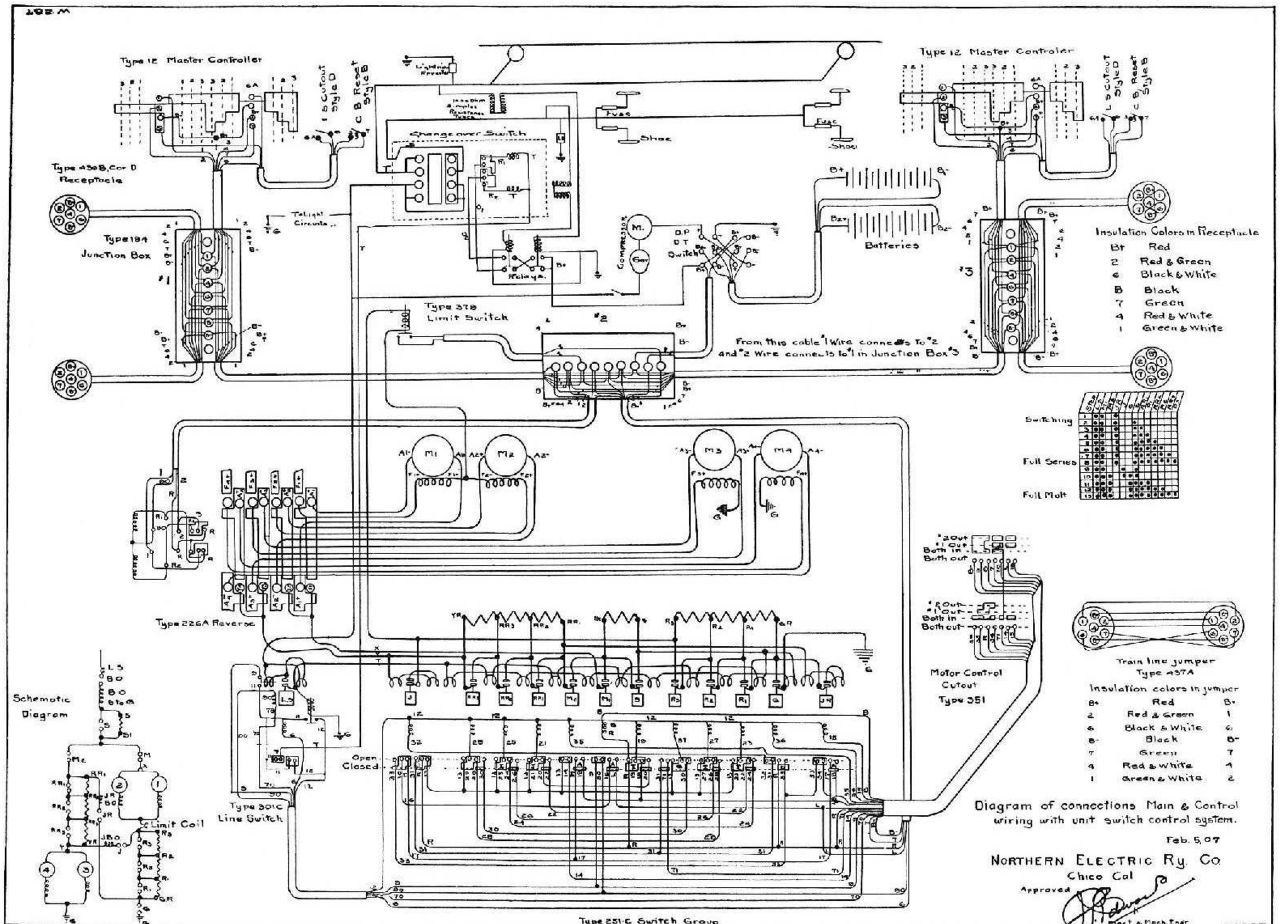
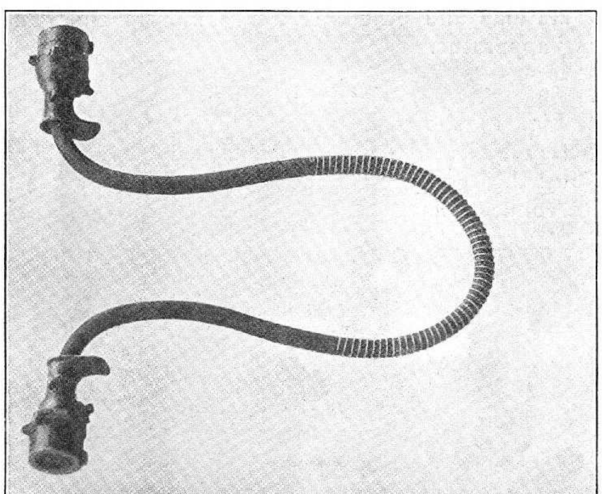


Fig. 15.

Train Line Receptacles.

As illustrated by Fig. 16 are used in train service and are employed to complete the control line bus connections between cars. The usual location of train line receptacles in which train line jumpers, as illustrated by Fig. 17, are located is slightly above the buffers upon one side of the cab. Because of the necessity of negotiating short radius curves in train service, this location was found undesirable and the





Figs. 16 and 17.

train line receptacles have been made an integral part of the radial draft rigging. These receptacles move together with the couplers. Details of this arrangement and a description of the same has been given in another portion of the "Journal of Electricity."

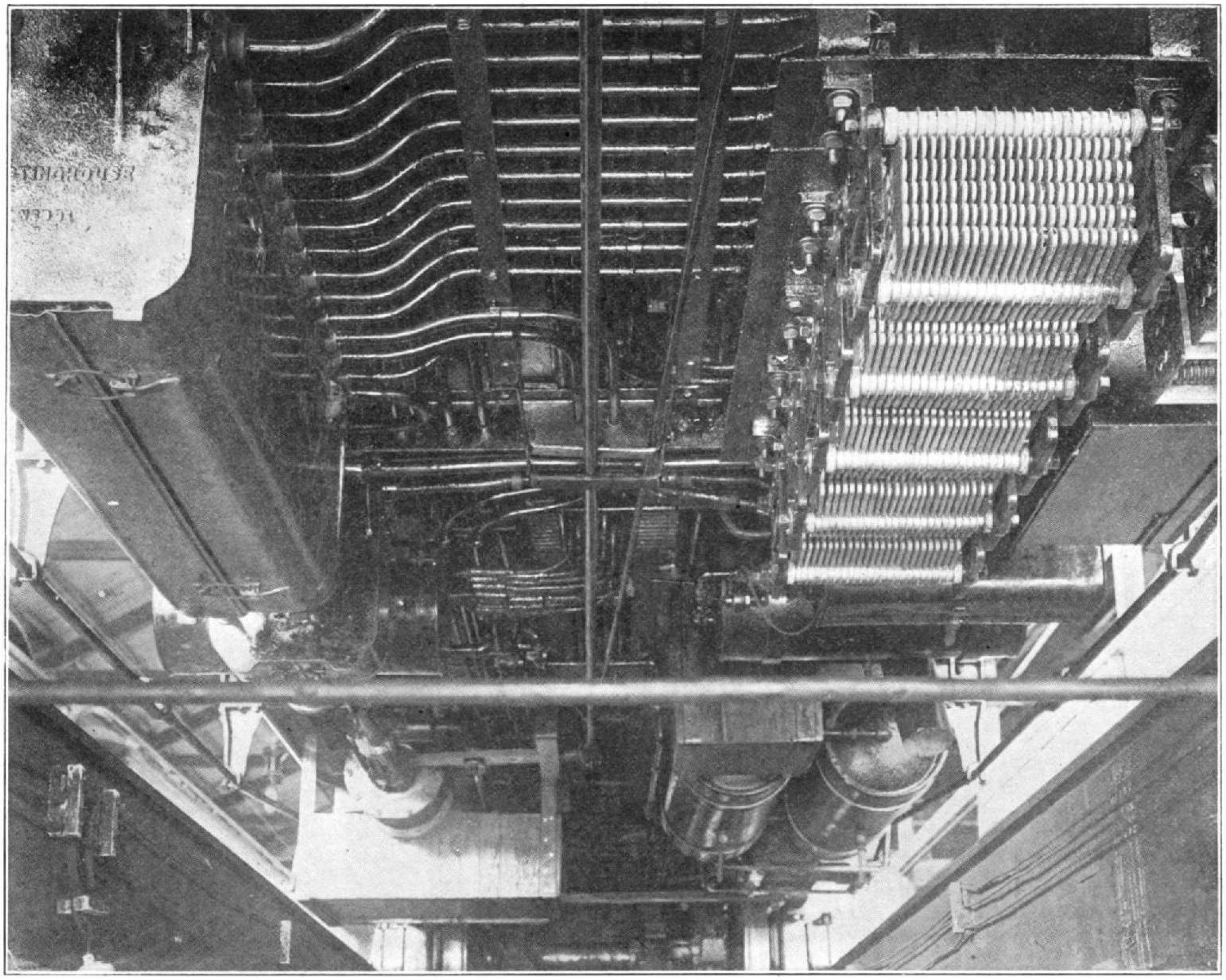
Storage Batteries.

Current for the operation of the magnet valves is secured from a storage battery in duplicate, each consisting of seven cells, having a capacity of 20 ampere-hours. One battery is on charge in series with interior arc lights, while the other is on the operating circuit, these connections being made by two double-pole, double-throw switches.

The batteries of each car are connected to two common leads, which are extended through the entire train as positive and negative of the train line. This connects the batteries of the different cars in parallel. The negative side is also connected to one side of the magnet valves on the same car, making the demand on the battery more or less local.

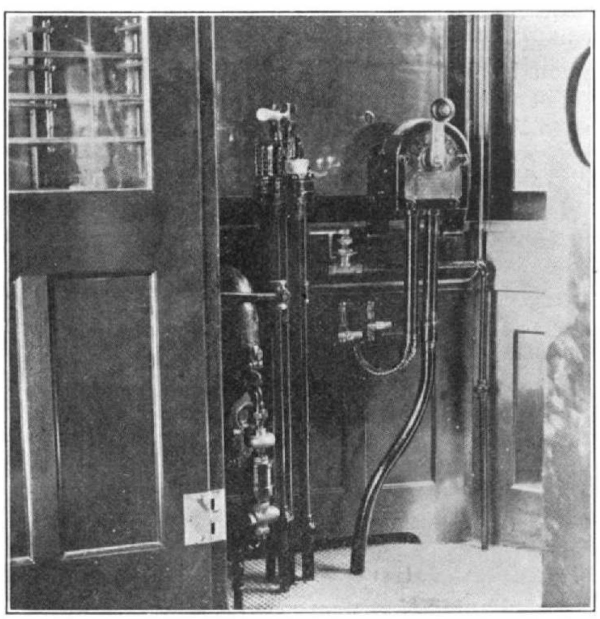
Line Switch Cutout and Circuit-Breaker Reset Switch.

These are two small knife switches located near the controller and conveniently within reach of the operator. By opening the line switch cutout the initial energizing of the control train circuits is opened and none of the line switches throughout the train can close. In this open position of the line switch cutout the switch groups of a train may be operated through their cycles for purposes of test. In a similar manner reversers may be thrown and an emergency braking



Under-Side of Coach Showing the Electro-Pneumatic Control and Air-Brake Systems.

effect secured. This entirely independent of line current or circuits.



Control Apparatus in a Motorman's Cab.

The circuit-breaker reset switch is nominally held open by a spring. The overload trip on the line switch is provided with a catch which, when the switch has been opened by a short circuit or other excessive current disturbance, holds it at that position, keeping the operating circuit open on that car with the master controller in the "off" position. The closing of the reset switch completes the circuit through a magnet, which withdraws the catch from the overload trip allowing the circuit breaker contacts to close.

General.

The control apparatus as above described has been in operation on the lines of the Northern Electric Railway for the past three years. The same has given complete satisfaction and by its performance in service has proven the correctness of its details of design and capacity for continuous operation under the exacting conditions of service required of it.

Sub-stations and Electrical Supply.

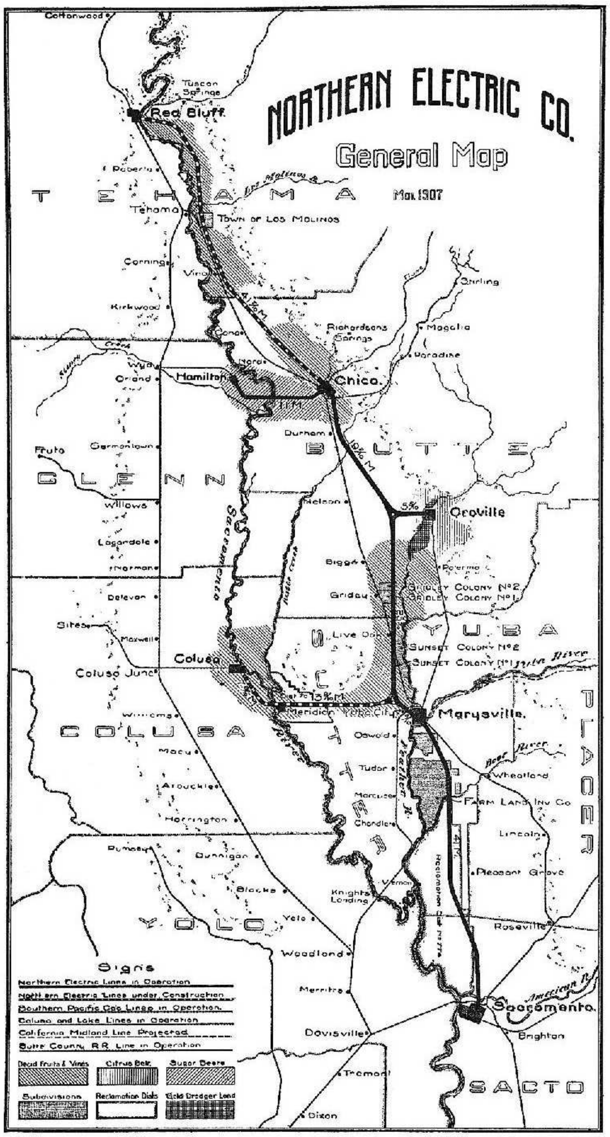
With an electric railroad, the question of a power supply is paramount. One of the features which made this project feasible was the abundant supply of low priced electrical energy, generated by hydraulic power in the nearby mountains, which was available at all points in this system. The question of expensive steam generating plants did not enter into the problem and it was not even necessary to parallel the road with a high-tension distributing line, although this has been partially done.

Electric power is supplied at the low-tension side of the transformers by the Pacific Gas & Electric Company who own and furnish the transformers and high-tension apparatus necessary for use at the sub-stations. All other sub-station equipment, including the buildings themselves are owned by the Northern Electric Company.

There are three standard types of sub-stations in use, which have been designed and built by the engineers of the company. These are distributed so as to energize about 10 miles of road each.

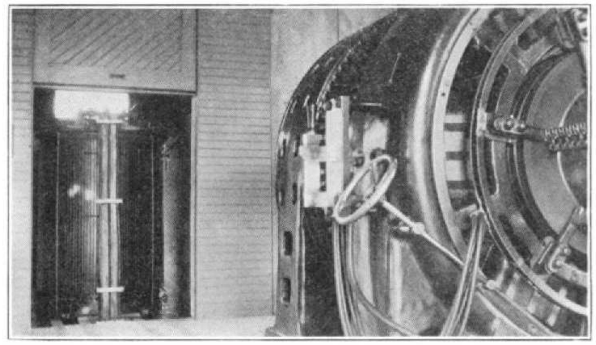
There are at present nine stations, although provision has been made for ten and they are numbered accordingly.

The equipment throughout is similar, both in the type and size of the motor-generator sets and style of switchboard.



Current is supplied from the transmission lines at a potential of 60,000 volts, with a frequency of 60 cycles. It is supplied to the motors at 2000 volts.

Motor-generators were adopted instead of rotary converters, for a variety of reasons; they consist of a Westinghouse, type CCL induction motor, rated at 580 hp., direct connected to a Westinghouse, 6-pole, 600 volt generator of 400 kilowatts capacity. The two machines are set close together, are mounted on a single base, and have but two bearings. This arrangement presents a neat appearance and the machines have proven themselves dependable and highly efficient.



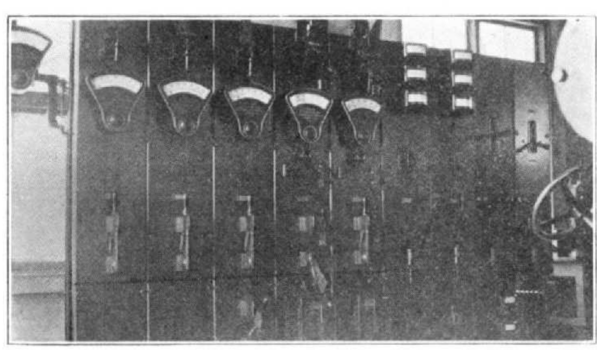
Machines and Transformers, Sub-Station No. 2.

The switchboards are of slate of the standard General Electric type for this purpose and the instruments and switches are of the same make. The switchboards were assembled and the mountings made by the Northern Electric engineers in accordance with their own ideas.

Connection between the switchboard and track are made with 1,000,000 cir. mil copper cable.

The first station is, as before mentioned, at the car house at Mulberry. There are no transformers, as current is supplied from the sub-station of the power company in close proximity. There are two motor-generator sets, so that the total output is 800 kilowatts.

Number 2 is 9.4 miles from Mulberry. It represents one of the types of sub-station buildings adopted by the company. The building is almost square; it has a concrete foundation under the walls, transformers and machines. Provision is made to rapidly drain the transformers of their oil, should a burn-out occur and in carrying out this idea a system of ducts has been incorporated so as to cause a natural draught of air, drawn from beneath the building and next to the ground, where it will be coolest, to pass up



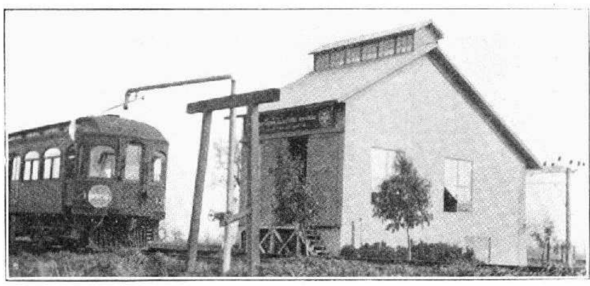
A Sub-Station's Switchboard.

and around the transformer cases and out through special transformer cell ventilators.

The switchboard is mounted well away from the wall and behind it is an elongated pit through which all cables are carried; this is covered with a grated wood floor. The oil-switch for the induction motor is of the remote control, manually operated type and is contained in a fire-proof enclosure, outside of the building.

The framework of the building is of wood, but it is covered with wire lath which is also used for the panel walls. Two coats of cement plaster both inside and out cover the lath, making a thoroughly serviceable and practically fire-proof building.

At No. 2 station there is but one motor-generator set. There are three, 150 kw. transformers.



Sub-Station No. 4.

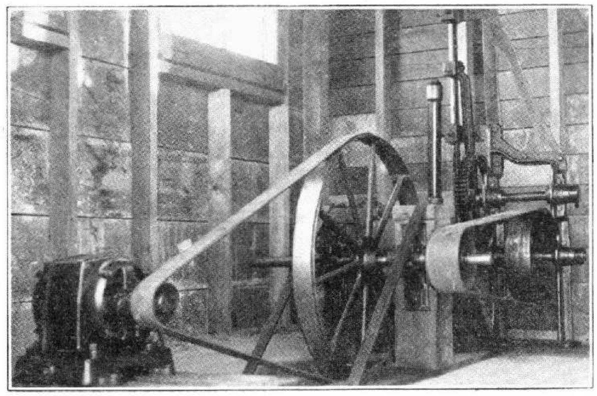
The transformers may be moved forward out of their cells, but ordinarily the opening between the cell and the operating room is closed by a counterweighted sliding door.

Sub-station No. 3 is at Tres Vias and energizes, not only a section of the main line, but the branch into Oroville as well. This station is similar to No. 2 in all respects, except that the transformers are 300 kw. capacity each, and there are two 400 kw. motor-generator sets.

Sub-station No. 4 is again similar to No.'s 2 and 3 and is equipped with one motor-generator set. This station is located near Gridley.

At all the sub-stations, it is necessary to have water for the various purposes of domestic supply, irrigation and as a means for cooling transformers, although some of the transformers are oil-immersed but air-cooled. Water is near the surface of the ground at almost any point, but it is necessary to pump it. A tank elevated to give the proper head for all purposes is supplied from the well by a simple but dependable pumping rig. This is installed in a small pump house near the station and operated by the attendant, whenever necessary.

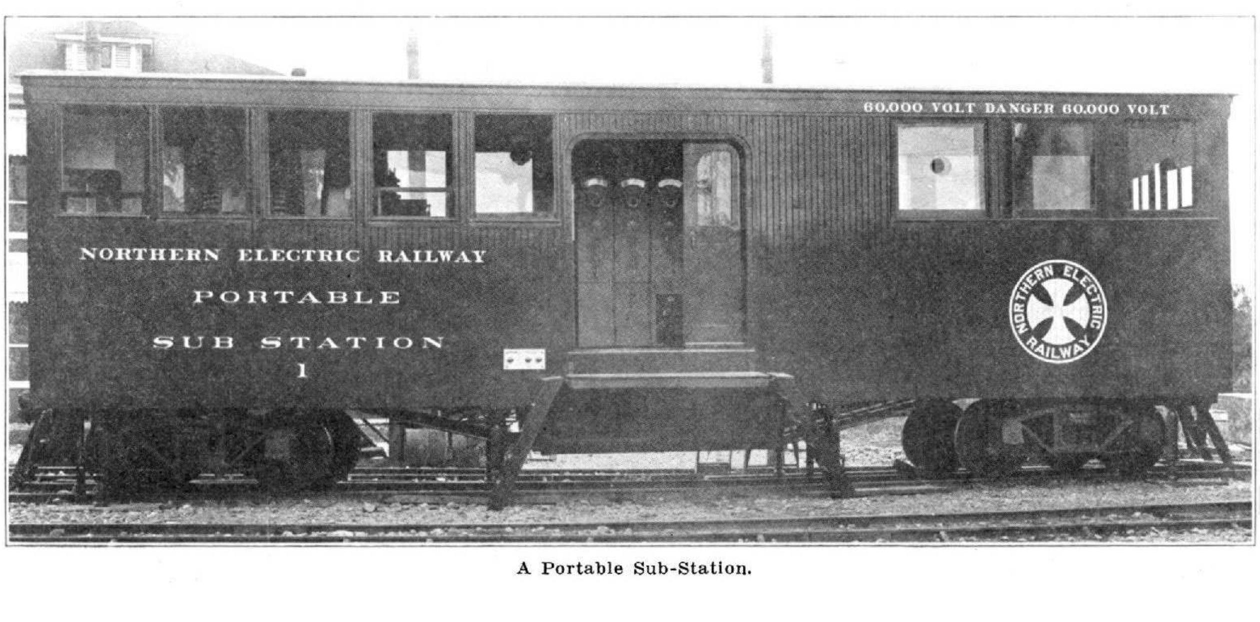
No. 5 sub-station represents another type in that it is portable. This consists of two standard freight cars, reconstructed however throughout for the pur-



Pumping Rig at Sub-Station No. 4.

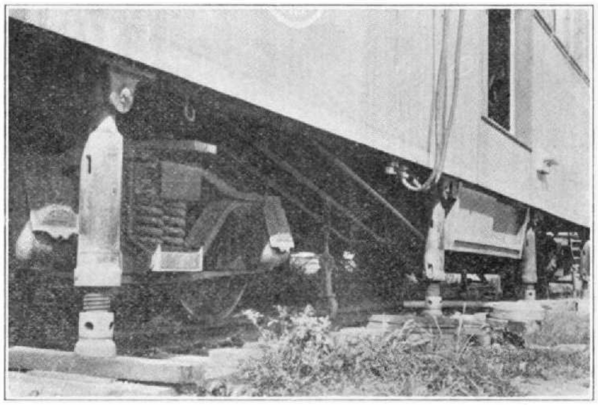
pose. One of the cars contains three 150 kw. lowering transformers. The high-tension lines are brought into the car through three windows. These are 36 in. square and have two glass panes each, the wire passing through a hole at the centre of the pane. High-tension disconnecting switches are mounted on poles outside of the car.

The sub-station proper contains one standard 400 kw. set and the accompanying switchboard. One end is partitioned off to make a tool room. This station being mounted on wheels, it is very important that it shall not only be level, but also not subject to vibration. This is accomplished by means of wrought-iron hooks fastened to the under side of the car-body and which grip the ball of the rails. Acting against the strain imparted by these hooks are screw jacks, which bear up against the car-body. The accompanying illustration shows the simplicity of this device and the clearness of the view of the interior, which was made while the machines were in regular operation, proves their effectiveness.



A Portable Sub-Station.

Sub-station No. 6 is in the city of Marysville. Current is supplied from the local station of the Pacific Gas & Electric Company, there are therefore no transformers. This station is similar to Nos. 2, 3 and 4, it is equipped with two motor-generators, but differs in



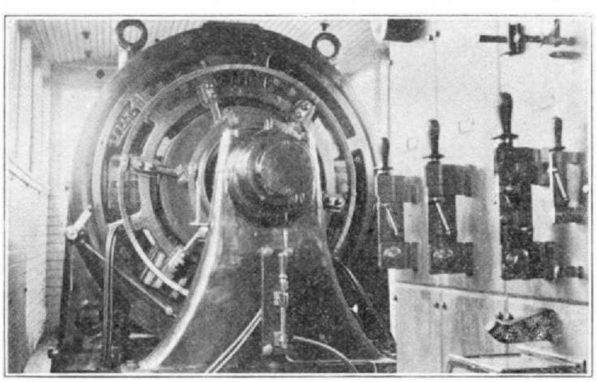
Method of Fastening a Portable Sub-Station to the Track.

the arrangement of the machines, in that, while the building was originally designed for but one machine set, another was subsequently added by invading two of the spaces reserved for transformers, and setting the machine at 90 degrees in respect to the first one.

There is as yet no sub-station numbered 7 and the gap between Marysville and Nicolous, where No. 8 is located is 16 miles.

No. 8 sub-station is the newest and most complete of any yet built. It has a steel frame and the roof which consists of reinforced concrete slabs, is supported on steel trusses. The walls are of reinforced concrete construction. The building has a main floor on which are placed the transformers and two 400 kw. motor-generator sets, arranged much as in the older stations; there is also a second or gallery floor, this contains compartments and high-tension oil switches and is in reality a sectionalizing house for the power company and a switching house to enable this station to derive its source of electrical supply from any one of three transmission lines.

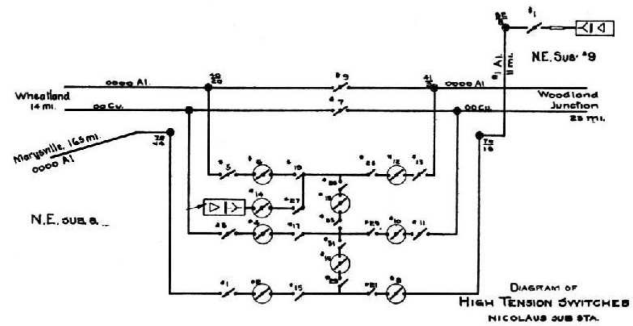
The main, double transmission line of the Pacific Gas & Electric Company between Colgate and Oakland passes through this station. A transmission line of the same company from Marysville, paralleling the



Interior of a Portable Sub-Station.

road also comes to this station and continues to sub-station No. 9. With this arrangement of switches and disconnecting switches which are mounted on poles, outside of the building, current may be taken from the Marysville line or from either of the Bay lines.

The following diagram shows the arrangements of these circuits:



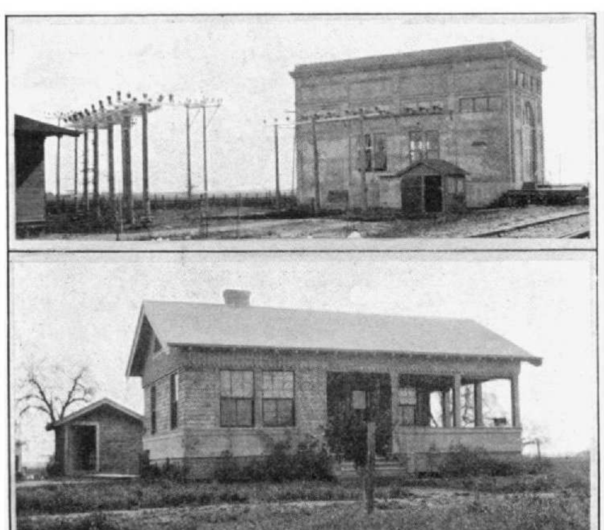
Sub-station No. 9 is of the portable type and is about half way between Nicolous and Sacramento. It is similar in all respects to No. 5.

The last source of energy is at Sacramento. This is derived from the sub-station of the Pacific Gas & Electric Company at 6th., & H Sts. There is one motor-generator set similar to all of the others in use and this is owned by the Northern Electric Company.

The total installed capacity of the sub-stations is 5,200 kilowatts.

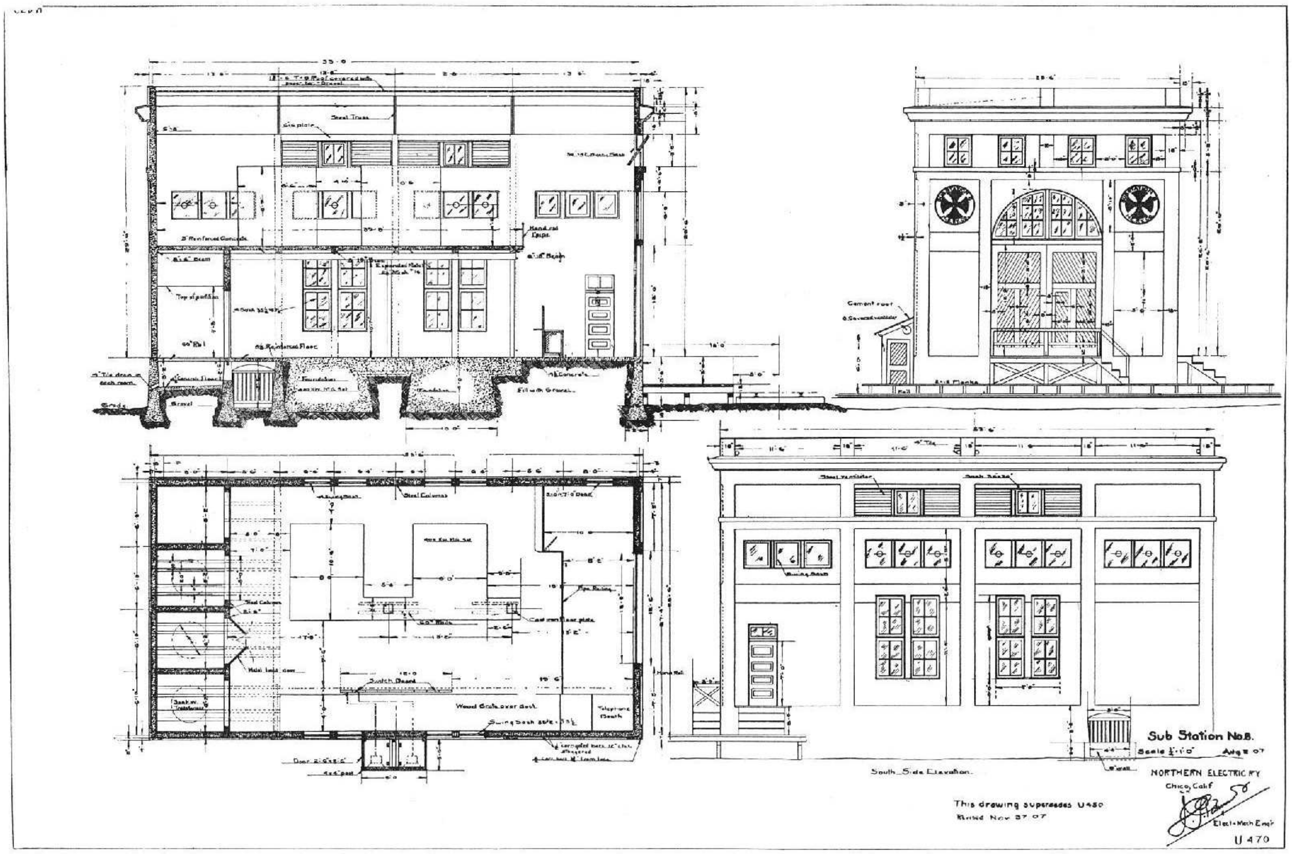
The cost of two sub-stations (not including transformers and high-tension switches, which are the property of the power company), representing the two stationary types, is as follows:

	No. 4.	No. 8.
Capacity	400 kw.	800 kw.
Cost.		
Property	$ 400	$ 250
Foundation	3,100	1,850
Building Superstructure	" (inc.)	6,400
Electrical Machinery	6,600	13,200
Switchboard	1,500	3,000
Pumping Plant	160	180
Tank	690	300
Erection of Machinery and Installation.	500	1,000
Cartage	1,200	600
Incidental Expense	300	750
Total	$14,450	$27,530



1. North Side of Nicolaus Sub-Station.
2. Type of Cottage for Sub-Station Operators.

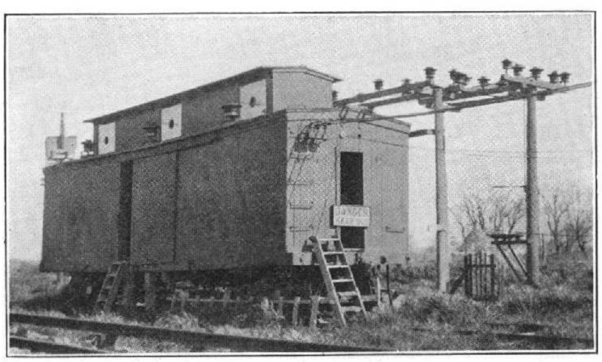
Electricity supplied from the transmission system is measured on the alternating side of the motor-



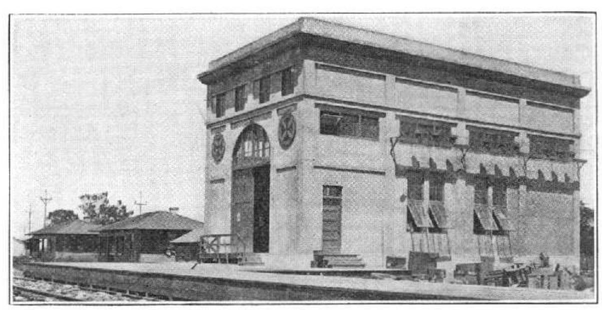
generators. For this reason all calculations of efficiency and losses between the power supplied and the trains are based on these measurements.

The motor-generators are operated in such a manner as to pick up the load as it comes on, thus maintaining a high converting efficiency at all times.

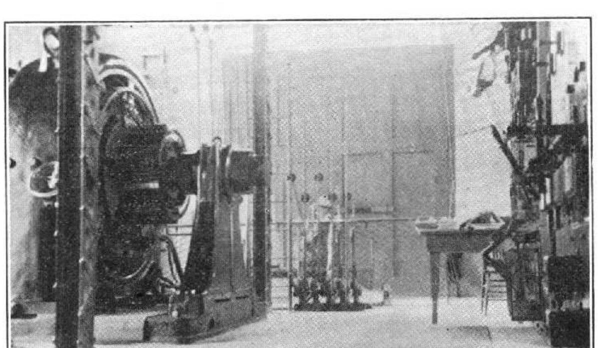
The efficiency of transformation from the alternating current side of the motor-generators to the



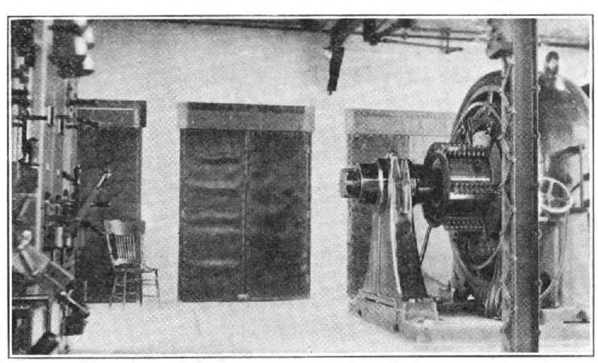
Portable Transformer Station.



Sub-Station No. 8 at Nicolaus.



Machines, Switchboard and High Tension Switch-Levers in Sub-Station No. 8.



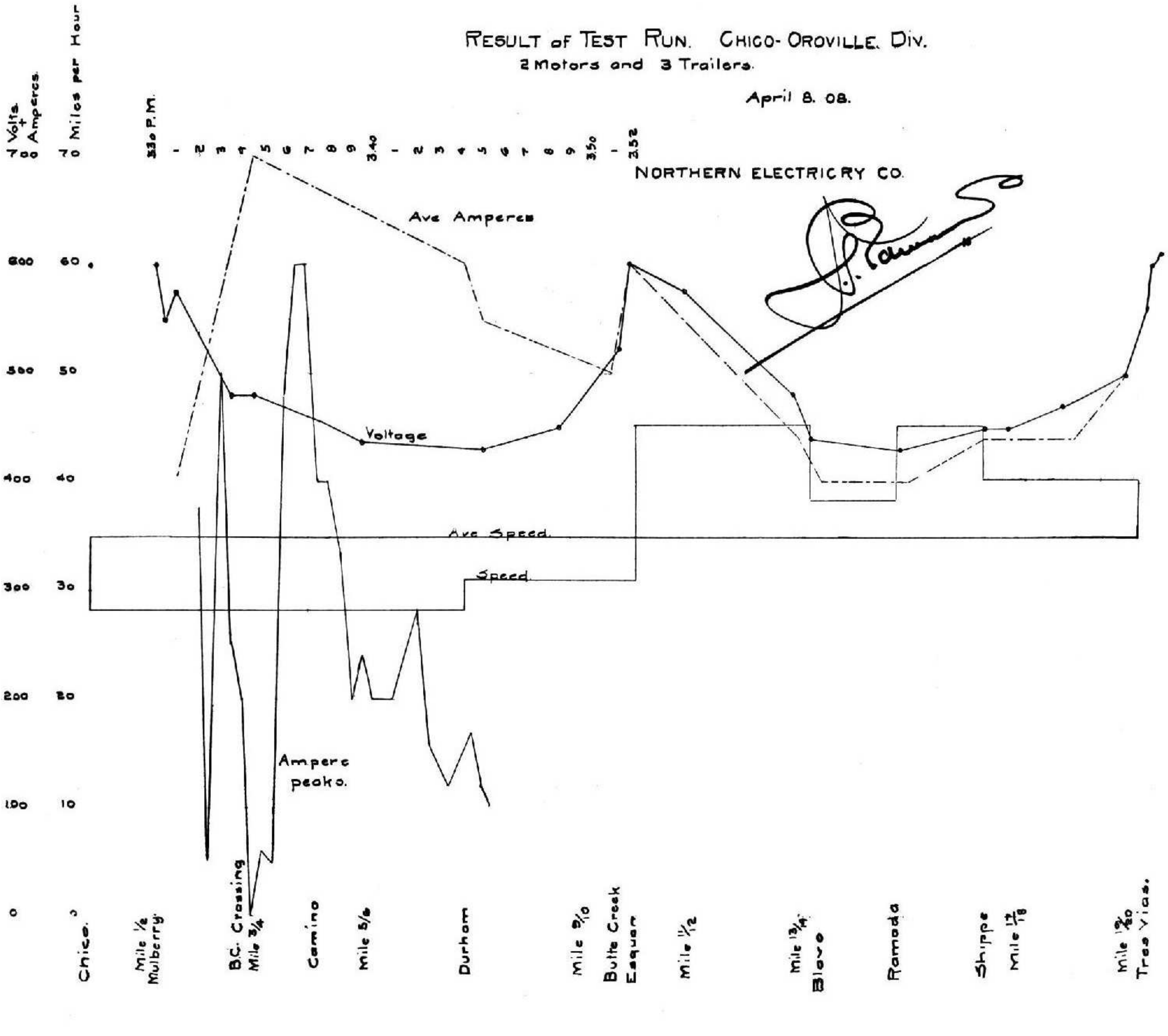
Machines, Switchboard and Transformer Cells in Sub-Station No. 8.

direct current at the switchboard varies in different stations, due to the character of the load, from 50 to 80 per cent. The average for all sub-stations is 66 per cent.

The distribution losses between the direct current switchboard and the train, taking an average from all points, is 6.05 per cent.

The amount of power consumed per car mile, taken from data covering the year 1909, measured at the alternating current side of the motor-generators, is 4,266 watthours. The consumption of power, measured as before, per ton mile, for passenger train service, is 113 watthours. The actual consumption of the direct current at the train is 69.73 watthours per ton mile. During an average day there is run a total of 1500 car miles.

Following are diagrams showing the results of test runs, giving the time between stations, current consumed, etc.



Train Operation.

As a rule all trains consist of two or more cars. The first is a combination baggage and smoking car and the second a passenger car. If more than two cars are used, a trailer passenger car is placed in the center of the train. For short runs, where there is need of but one car, a combination baggage, smoking and passenger car is used.

Through trains are run at an interval of about 2½ hours throughout the day and evening. The running time from terminal to terminal is three hours.

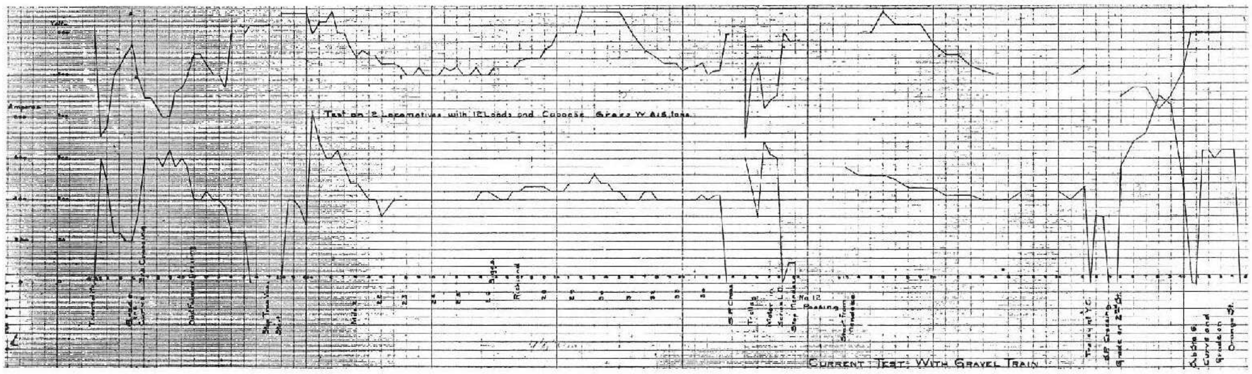
All trains are manned by a motorman, conductor and one brakeman.

A private telegraph and telephone system extends the length of the road, the poles being placed 3 ft. from the western edge of the right of way.

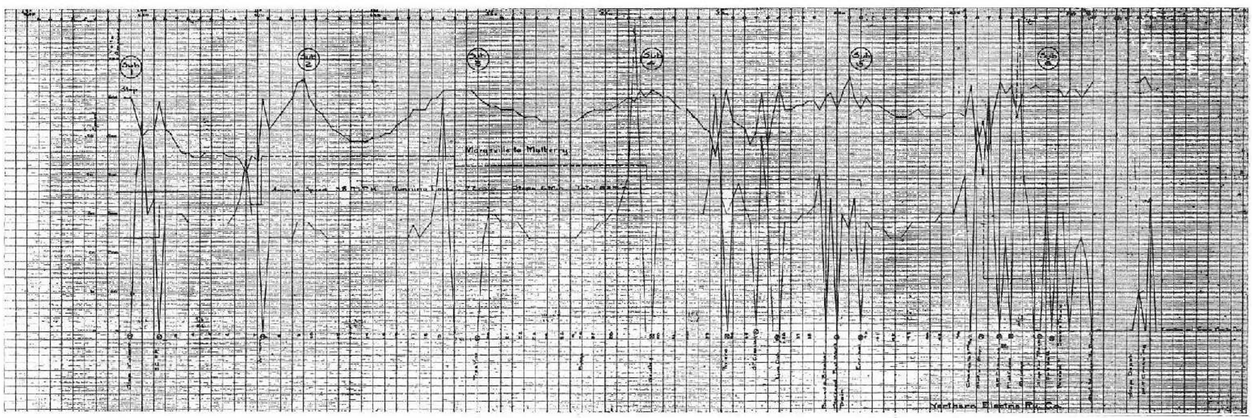
The operating offices, including that of the Chief Dispatcher, are at Mulberry (Chico). Offices having telegraph operators are at Durham, Tres Vias, Thermolito, Oroville, Live Oak, Yuba City, Marysville, Nicolous and Sacramento. At these points train orders are issued.

The road is operated in accordance with Standard American Railway Practice Rules; train order forms "19" and "31" being used.

Throughout the day and the early evening, the road is given over entirely to passenger traffic. Between the hours of midnight and 6 o'clock a. m., all freight transportation is accomplished. Were it not for the possibility of this arrangement, the fast and frequent passenger schedules could not be maintained



Running Test of Freight Train Between Marysville and Mulberry.



Running Test Between Marysville and Mulberry of Passenger Train.

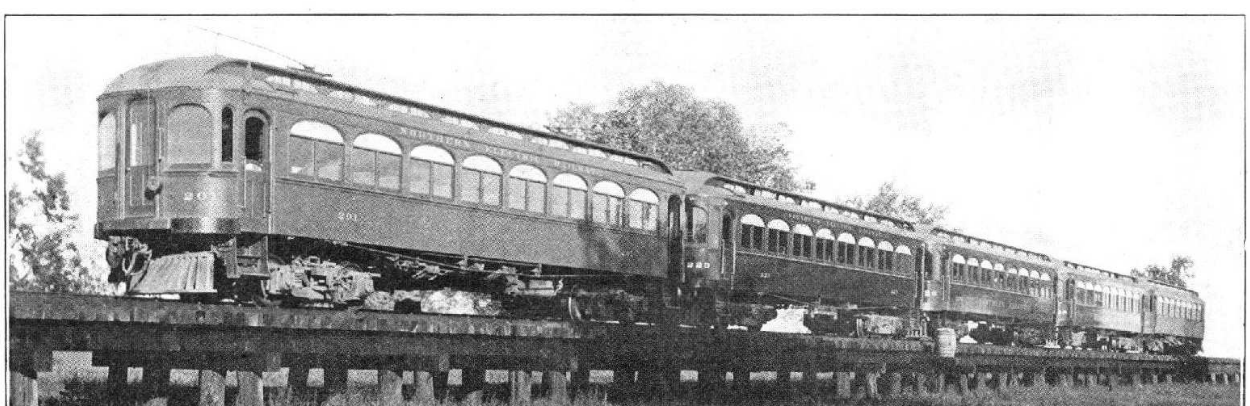
without seriously inconveniencing freight traffic which is rapidly increasing in importance.

The Northern Electric Company has the distinction of being a thoroughly California corporation; that is, it was founded and is owned and operated by California interests.

The executive offices are at San Francisco; the president is Mr. E. R. Lilienthal; the vice-president, Mr. Louis Sloss, and the secretary, Mr. Norman Logan.

The actual operation of the system is under the supervision of the general manager and purchasing agent, Mr. A. D. Schindler, whose office is in San Francisco, and who is responsible for the admirable results obtained. He has an able assistant in Mr. Melville Dozier, whose headquarters are at Mulberry. Mr. J. P. Edwards is, as before stated, the electrical and mechanical engineer, and to him is due the credit of the design and construction of the varous electrical and mechanical features.

All of these gentlemen have given the writer every assistance possible in his attempt to make an accurate and creditable description of this system, of which all Californians may feel proud.



Five-Car Northern Electric Train.