Michigan Railway's 2400-Volt, Third-Rail Line

This 94 Mile Road, the First of Its Kind to Be Built, Has Just Been Placed in Operation, Being Designed for Speeds Up to 90 M. P. H.—The Project, Which Was Conceived by the Late W. A. Foote, Includes a 44-Mile Section of Electrified Steam Line

Another link in the chain of interurban railways and electric light and power lines owned by the Commonwealth Power Railway & Light Company, Grand Rapids, Mich., has just been turned over to the Michigan Railway, the operating company. This new line marks a milestone in high-speed electric railroad development, since it is the first 2400-volt, third-rail line ever constructed. Moreover, it represents the culmination of another dream of the late W. A. Foote, who as vice-president of the Commonwealth Company had the courage to install the first 140,000-volt transmission line.

The 50-mile Kalamazoo-Grand Rapids section of the new line has been built for speeds up to 90 m.p.h. and is probably as fine an example of finished, modern electric railway construction as will be found in this country. The 44.5-mile steam road which forms the remaining part of the route was purchased from the Michigan Central Railroad and runs between Allegan and Battle Creek.

NECESSITY FOR NEW LINE AND ITS SERVICE

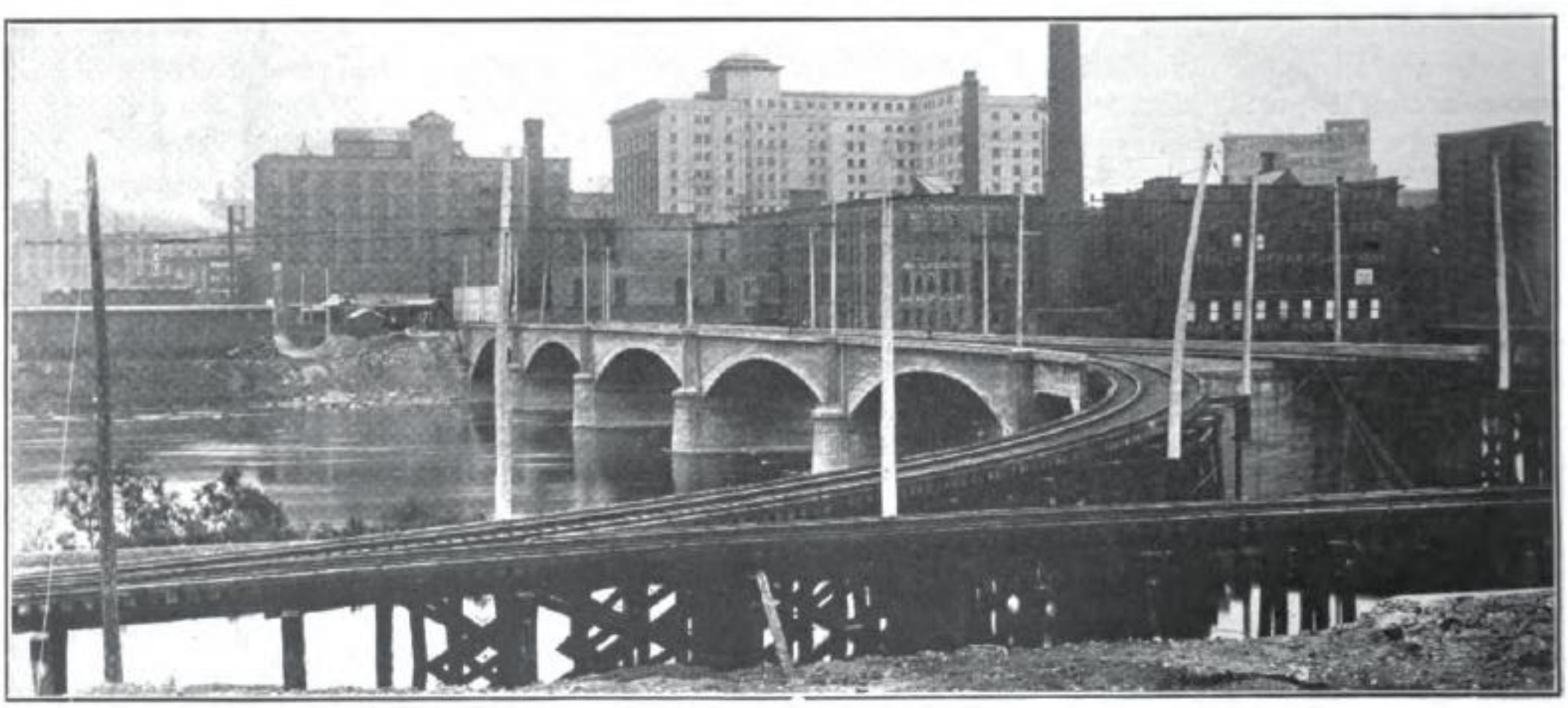
Infrequent steam-road service or none at all was the prime reason for connecting Grand Rapids with Kalamazoo by means of this high-speed electric line. In general, lower Michigan is peculiarly situated, being bounded on three sides by three great lakes, and as a result, only the extreme southern part of the peninsula is served by steam railroad trunk lines. During the entire year there is traffic east and west across the state, and during the summer months, the north and south traffic to the numerous summer resorts in this State reaches considerable proportions, so that steam railroads have been built only to cater to the transcontinental service and to furnish ingress and egress to the summer resorts. As a result but little provision was made for intercommunication between the different parts of the State.

In recent years, Grand Rapids, Kalamazoo and Battle Creek have grown rapidly, and there has arisen a demand for frequent high-speed service between them. Grand Rapids is a large furniture manufacturing center with a population of over 125,000, and a natural line of intercommunication existed between this point and Kalamazoo, another manufacturing city of 40,000 people, and Battle Creek, the home of prepared breakfast foods, a city of 30,000 inhabitants. Before the completion of this new line there was no direct railroad route between Battle Creek and Grand Rapids and only infrequent service between that point and Kalamazoo.

To develop the passenger, freight and express traffic between these points three classes of train service have been inaugurated. These include both local and limited trains, and a special service known as the "Flyer." Single cars from Kalamazoo and Battle Creek are coupled together at Monteith Junction, which is 18 and 30 miles distant respectively from the two terminals, and from this point they run as a two-car train into Grand Rapids, a distance of 32 miles.

Local trains make eleven round trips daily on the Grand Rapids-Kalamazoo line, and the run requires one hour and forty-five minutes. Two local trains make round trips between Grand Rapids and Battle Creek, which requires two hours and twenty-five minutes each way. Limited runs between Grand Rapids and Kalamazoo are made in one hour and twenty minutes and the run from Grand Rapids to Battle Creek takes two hours and ten minutes. The limited service comprises four trains to Kalamazoo and seven to Battle Creek. The third class of service, known as the "Flyer," is furnished only between Grand Rapids and Kalamazoo, and the 50-mile run is made in one hour and ten minutes. Both at Kalamazoo and Battle Creek, the Michigan Railway connects with the lines of the Michigan United Traction Company, a subsidiary of the same holding company. Passengers for points east of Battle Creek or between that point and Kalamazoo, are required to transfer. At Grand Rapids the new line intersects the Grand Rapids, Holland and Chicago Railroad, which is planning to abandon its entrance over city streets and will use the double track line and terminals built by the new road.

All the cars purchased for the new line are of steel

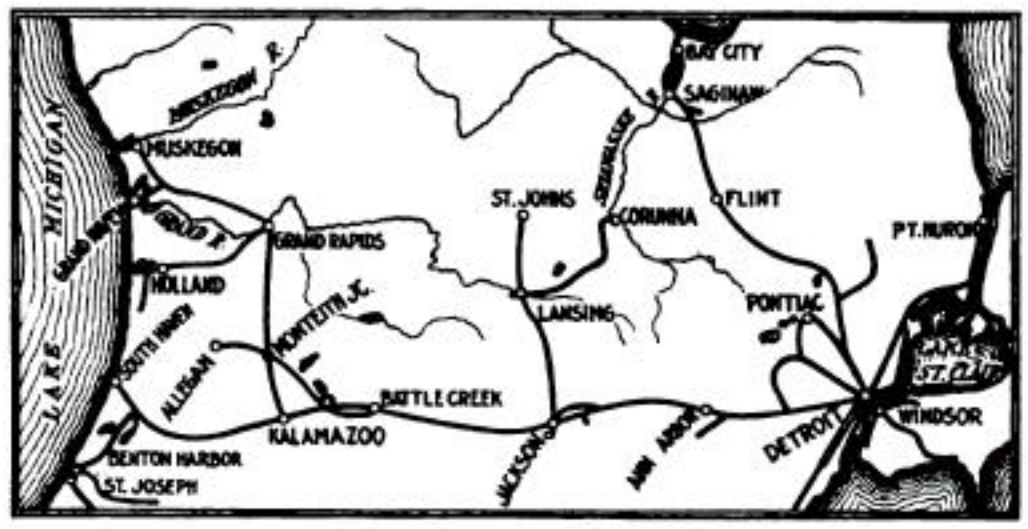


MICHIGAN 2400-VOLT LINE—CONCRETE BRIDGE OVER GRAND RIVER AT GRAND RAPIDS

construction, particularly well equipped and finished. Those in the "Flyer" service are especially fine all-steel coaches with side doors and observation chair-car compartments. These were described on page 1087 of the May 16, 1914, issue of the ELECTRIC RAILWAY JOURNAL. The cars used in local and limited service are also of all-steel construction, but are of the standard arched-roof interurban type with the entrance and exit doors in a rear vestibule. These cars were described on page 106 of the ELECTRIC RAILWAY JOURNAL for July 18, 1914. All-steel express trail and motor cars were also purchased for the package freight service. On the electrified steam road division, the Michigan Railway took over a bulk-freight and express business, and the development of this class of traffic is also planned for the new line.

ROADWAY CONSTRUCTION

The territory traversed between Grand Rapids and Kalamazoo is slightly rolling, some rather heavy cuts and fills being necessary, both near Grand Rapids and near Kalamazoo. The electrified steam road was built through a country where a number of curves and grades were required. Except for the track in the city streets of Kalamazoo, and on a section of private right-of-way in Grand Rapids, a maximum curvature of 3 deg. and a maximum grade of 1 per cent were obtained. Roadway standards provide for an 18-ft. roadbed on fills with $1\frac{1}{2}$:1 slope and a 24-ft. roadbed in the cuts with the same slope. No unusually heavy grading was necessary on this line, although the total for the 50 miles was about 1,000,000 cu. yd. The heaviest cut, however, contained 85,000 cu. yd. and was 20 ft. deep and 2000 ft. long, while the maximum fill contained 60,000 cu. yd. and was 30 ft. deep. Reasonably cheap right-of way made it possible to standardize on a 100-ft. width except where grading requirements made more width necessary. A section of private right-of-way several miles long and sufficient for double track, was purchased through Grand Rapids.

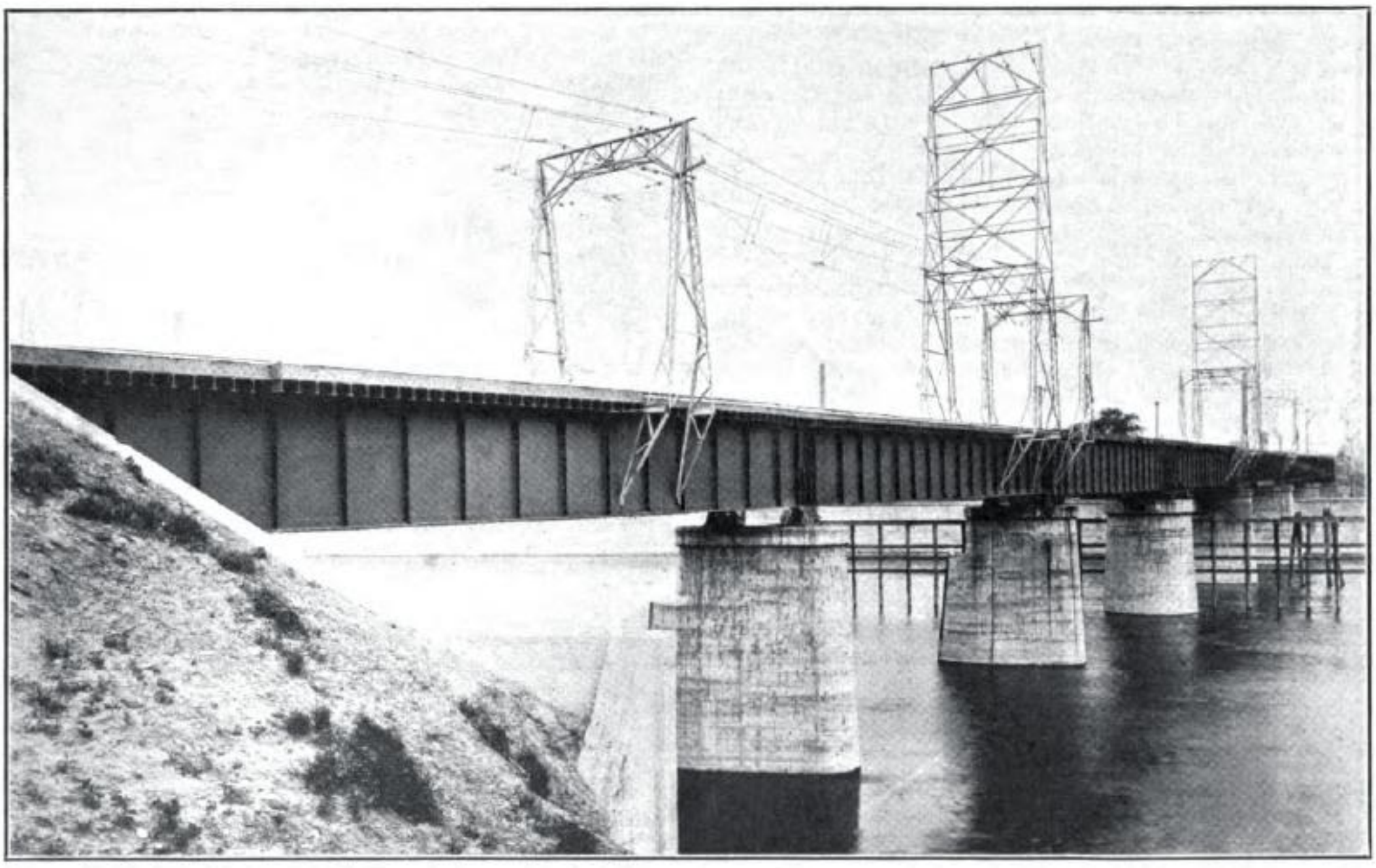


MICHIGAN 2400-VOLT LINE—MAP OF SOUTHERN MICHIGAN, SHOWING MICHIGAN RAILWAY AND ALLIED LINES

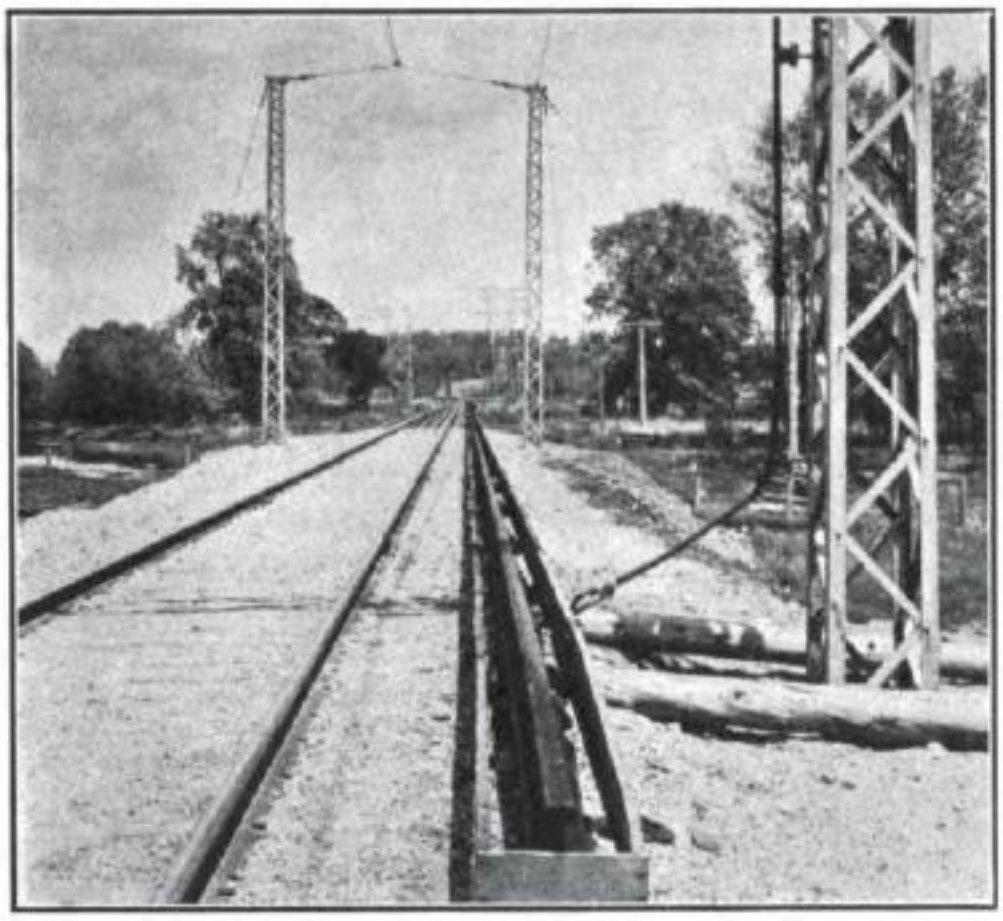
All right of way is fenced with a 48-in., No. 9 American Steel & Wire Company's woven fencing, fastened to 5-in. top, 8-ft. cedar posts, spaced $16\frac{1}{2}$ ft. apart. Wing fences and cattle guards are provided at all road crossings where the lower half of the fence is formed of 27-in. hog-tight woven wire. Above this are nailed two 1-in. x 6-in. boards, which are painted white so that the motorman can see a crossing well in advance of his train. A 14-ft. American Steel & Wire Company's tubular steel gate is used as standard at all private crossings, and the cattle guards are formed of ingot-iron metal strips with projecting angular spikes, laid side by side and spiked to the ties.

WATERWAYS

All waterways and under or over crossings are of concrete or combined concrete and steel. A rather unusual feature in connection with the smaller openings is that all reinforced concrete pipe, which was furnished under contract by the Chicago Reinforced Concrete Pipe Company, was made on the right-of-way with a portable concrete mixing plant which was moved along the line to minimize the haul of the completed pipe. All bridges and viaducts, except those to carry



MICHIGAN 2400-VOLT LINE—OVERHEAD CONSTRUCTION AT DRAWBRIDGE



MICHIGAN 2400-VOLT LINE — VIEW SHOWING CHANGE FROM THIRD RAIL TO OVERHEAD CONTACT WIRE

foreign roads, are designed for Cooper's E-40 loading which is approximately equivalent to a 100-ton car. At points where the electric line passes under a steam railroad or a highway, a clear vertical and horizontal opening 16 ft. square has been provided. The standard overhead highway crossing comprises three short deck spans with the bridge ends resting on abutments and the central span supported on structural steel bents which in turn rest on concrete foundations.

Two bridges of unusual size have been constructed over the Grand River in Grand Rapids. The lower Grand River bridge is made up of seven 88-ft. deck girders resting on concrete piers, the two central spans of which rest on a circular pier and are designed as a draw span. Double-track approaches to this bridge from each side close into gauntlet tracks over the bridge. This structure, with the two 59-ft. towers giving a 210-ft. feeder span, are shown in one of the accompanying illustrations. A double-track, reinforced concrete bridge has been constructed at the upper Grand River crossing. The Grand Rapids passenger terminal yards are at one end of this structure and a freight yard and tracks leading to a repair shop at the other end. The bridge provides a 25-ft. roadway and comprises four 96-ft. arch-spans and one 99-ft. 9½-in. central span. This structure was designed by D. B. Luten of the National Bridge Company of Indianapolis, Ind., and is shown with the business district of Grand Rapids in the background in one of the illustrations.

TRACK CONSTRUCTION

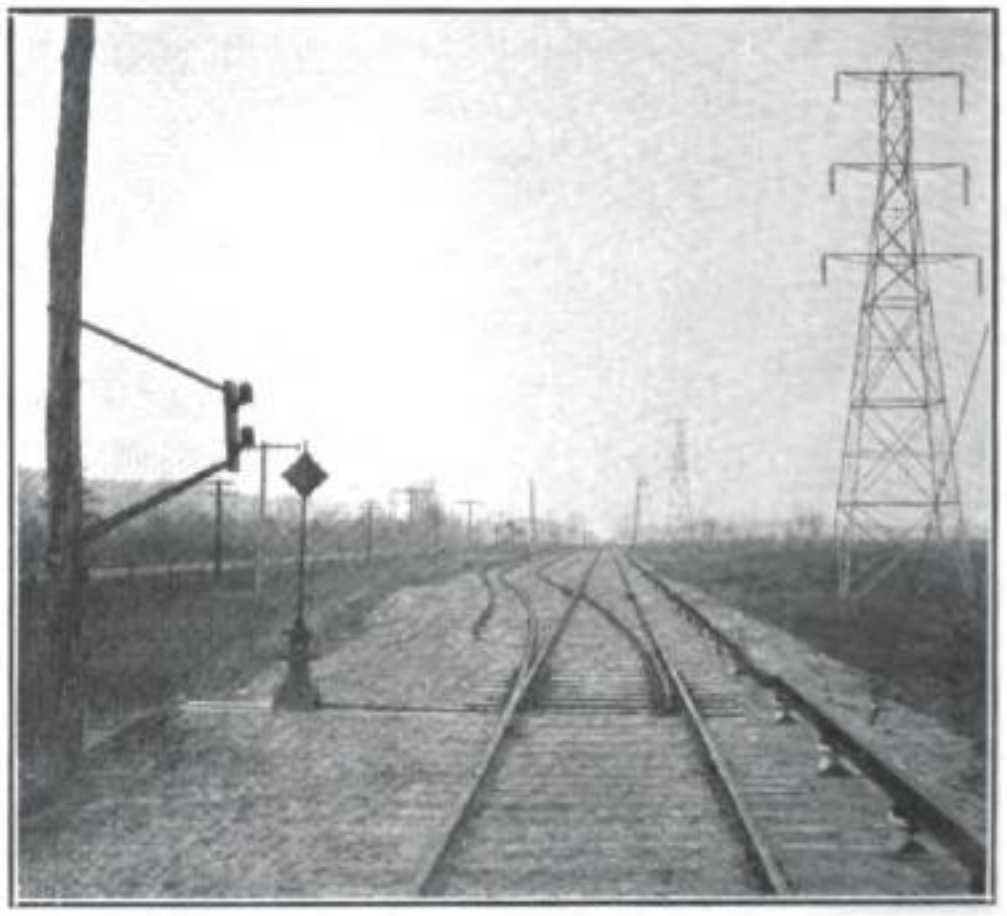
All track, including main line and sidings, is laid with 80-lb. A.S.C.E. rail on 6-in. x 8-in. x 8-ft. cedar ties spaced twenty to a 33-ft. rail. Every sixth tie is 10 ft. long and furnishes support for the third rail. Other track standards include No. 12 rigid frogs, 18-ft. switch points and 90½-ft. leads for all turnouts in the main track. All passing sidings are made approximately 1000 ft. in over-all length, and the standard of construction on passing sidings is equal to that on the main track. Special sawed-oak switch ties and high switch stands with fixed switch-targets are used in all main-track turnouts. All turnouts, including the switch stands, as well as the manganese-steel rail-bound crossings at all grade intersections with foreign roads were furnished by the Cleveland Frog & Crossing Company. It is interesting to note that all grade crossings with other railroads are interlocked, and the signal protection includes mechanically-operated home signals and electrically-operated distant signals for both lines.

THIRD-RAIL CONSTRUCTION

Special interest attaches to the third-rail construction because it is the first to be installed to conduct a 2400-volt propulsion current. Along the main line this is an 80-lb. A.S.C.E. section, low-carbon rail rolled especially for this road. The specifications provide for carbon to be not over 0.14, manganese to be not over 0.40, sulphur to be not over 0.08 and phosphorus to be not over 0.11. The rail is guaranteed to give a relative conductivity with copper of one to eight. The rail is mounted on a three-petticoat insulator furnished by the Ohio Brass Company, and this in turn rests on the 10-ft. track ties. The center of the third-rail is 32 in. from the nearest gage line of the track, and the top is 8-15/32 in. above the surface of the track rail. It is also interesting to note that, on continuous stretches of 1 mile or less in length, this third-rail is laid with expansion joints one and one-half times as wide as those allowed for standard track joints. Where the stretch of third-rail is more than 1 mile long, twice the standard track expansion is provided at joints.

Approaches to the third-rail level at all crossings are provided by bending the rail to form a 4-ft. incline with a total rise of 3 in. The third-rail is drilled with one hole at each end to serve for bolting the malleable-iron fish plates, these being so designed as to produce no strain or unusual friction and being slotted to allow for expansion. The third-rail rests on malleable-iron castings, which in turn dowel to the 8¼-in. two-petticoat, two-piece insulators. These insulators were tested at 5000 volts. They are held in place on the ties by a square, malleable lug, which is fastened with a lag screw and fits into a recess in the insulator base. The dimensions of the cap casting are such as to prevent free longitudinal movement of the third-rail. Lugs on this casting, 1 3/16 in. high, keep the rail from shifting out of line. Third-rail joints are bonded with 7-in. 500,000-circ. mil. bonds of the copper-ribbon compressed-terminal type furnished by the Electric Service Supplies Company.

On industrial sidings and passing tracks the third-



MICHIGAN 2400-VOLT LINE—VIEW SHOWING THIRD-RAIL BEFORE INSTALLATION OF GUARDS. TELEPHONE JACK BOX AT LEFT

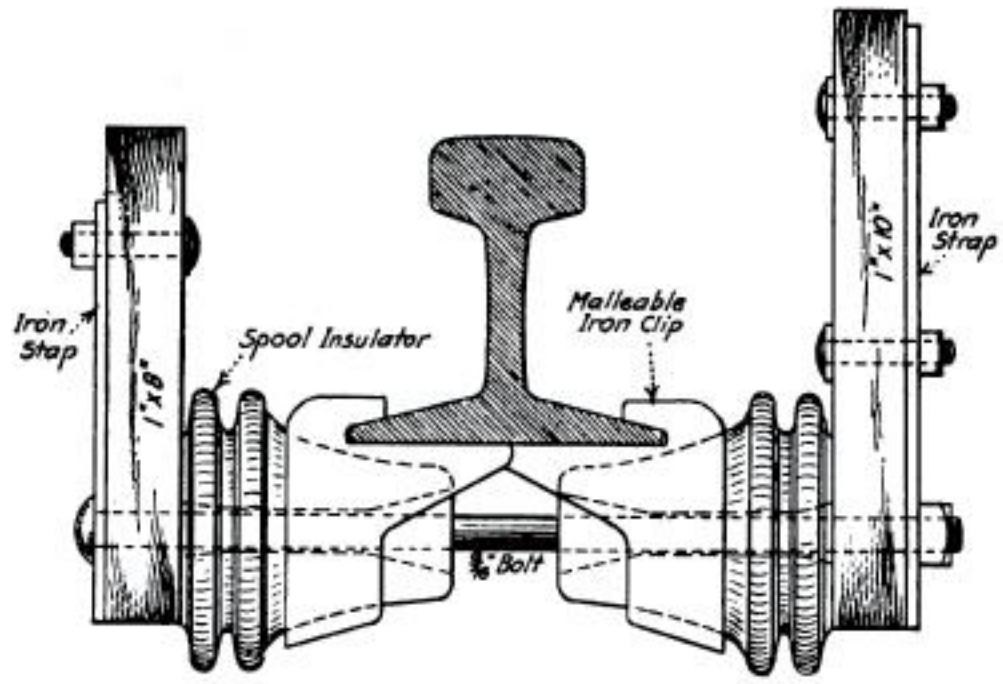
rail insulator is the same as that on the main line, but the third-rail is of 52-lb. weight. To obtain the same horizontal and vertical clearance as that for the main track third-rail, special malleable-iron cap castings were employed. The third-rail at these points is bonded with 250,000-circ. mil bonds of the same type as those used on the main track.

The third-rail is guarded on both sides to afford protection to men working on the track. The guard on the track side is a 1-in. x 8-in. fir board, the top of which is level with the third-rail. The guard on the outside is 1 in. x 10 in. in size, and the top is 2 in. higher. In this position these guards prevent a bar or any other piece of metal which may drop across the third-rail from coming in contact with it. The guard boards are 16-ft. long and are fastened together at the ends with malleable-iron plates containing holes punched oblong to permit expansion and contraction. They are fastened to the rail by two malleable-iron clip castings, which fit on the bottom of the rail and are insulated by two porcelain spool insulators. One end of this insulator sets into a recessed casting, and the other sets flush against the guard board.

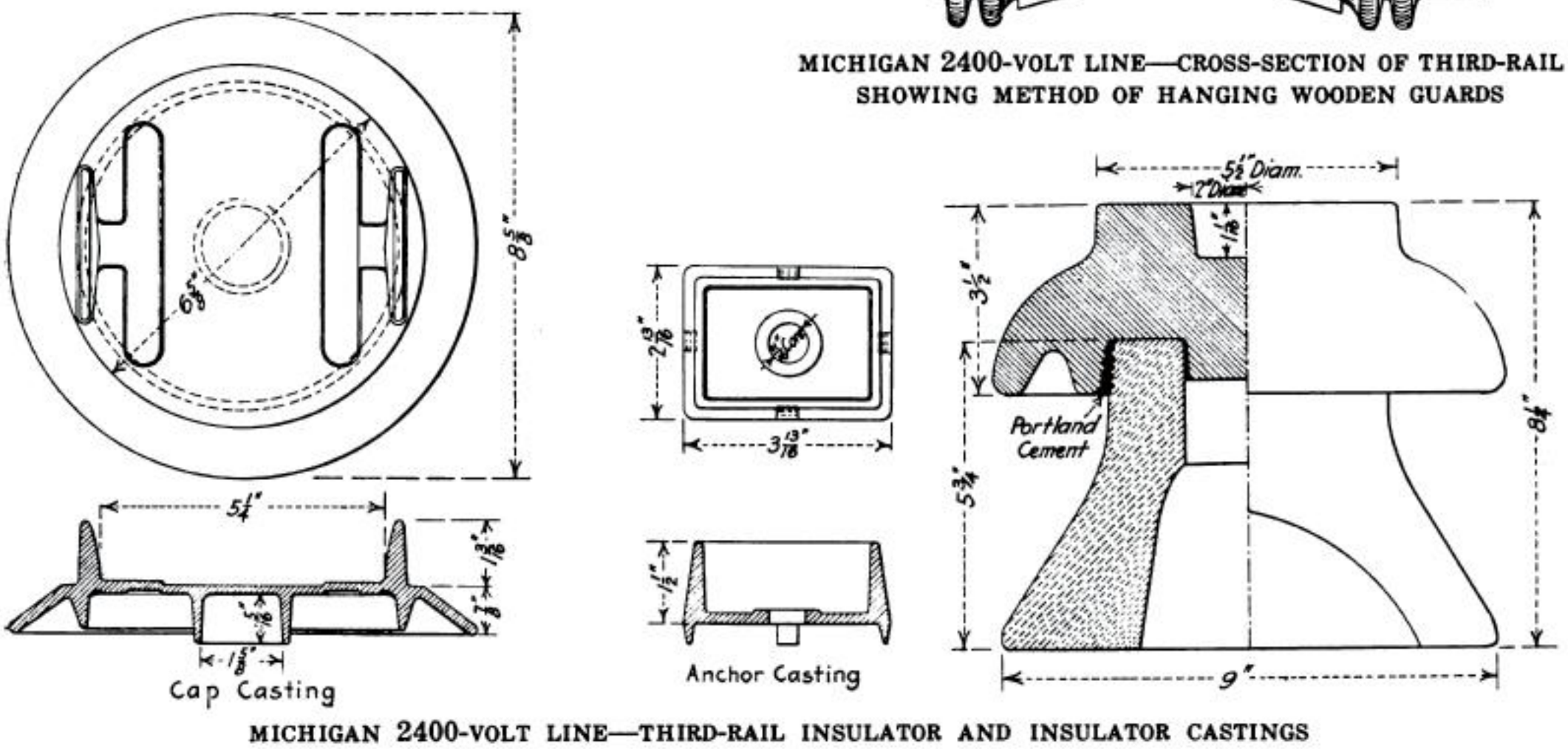
At all highway crossings, as well as at points where the propulsion current conductor changes from third-rail to overhead, jumpers are provided. At the high-

The clear width between the legs is 29 ft. 10 in. In connection with the design of these bridges it is interesting to note that each is required to withstand a vertical load of 1200 lb. with a factor of safety of two. The structure is also designed for horizontal load parallel to the line of 12,000 lb., distributed at four points on the upper channel. At right angles to the line and equally distributed on both sides, the bridge must carry a load of 4000 lb. with a factor of safety of two.

Trolley suspension on the 300-ft. spans is of the



MICHIGAN 2400-VOLT LINE—CROSS-SECTION OF THIRD-RAIL SHOWING METHOD OF HANGING WOODEN GUARDS



MICHIGAN 2400-VOLT LINE—THIRD-RAIL INSULATOR AND INSULATOR CASTINGS

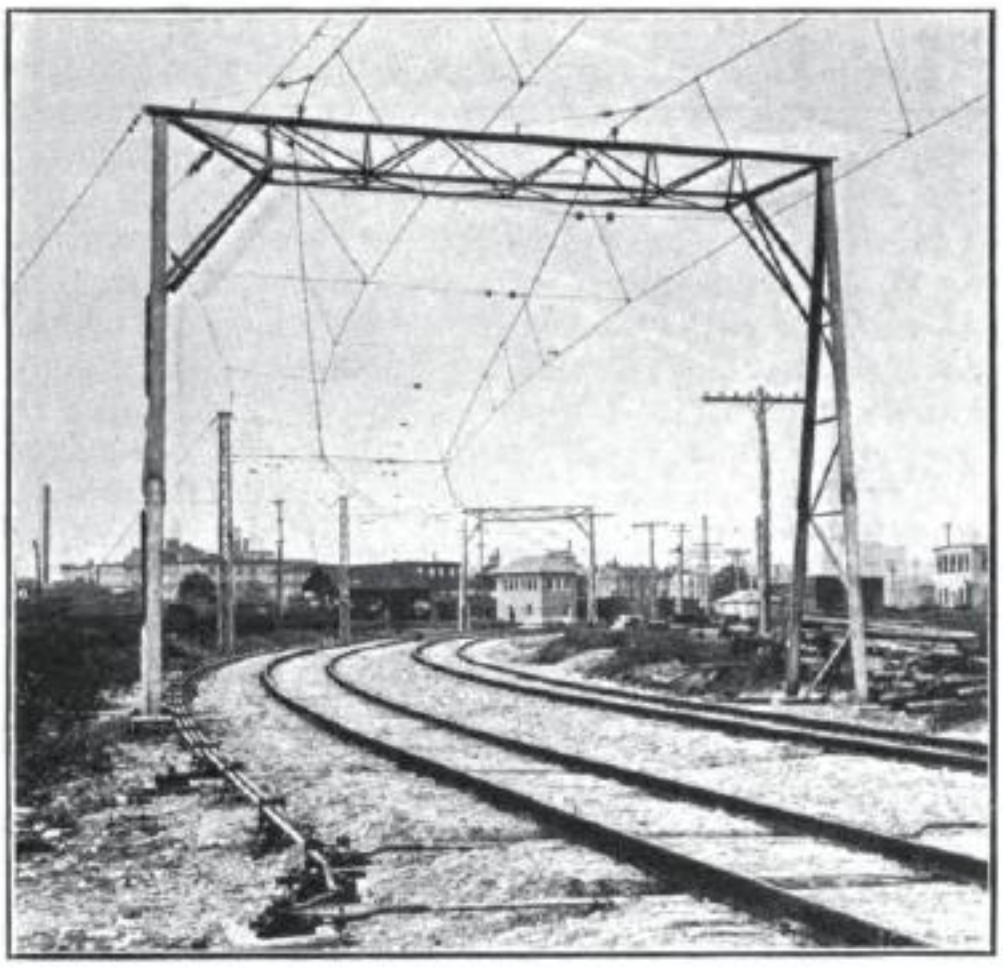
way crossings these consist of 1,000,000-circ. mil bare-copper feeders suspended from a ½-in. steel messenger cable strung from two 30-ft. wooden poles over the crossing. The ends of the jumper are connected to the third-rail by special terminals. An overhead clearance of 21 ft. above the crossing is provided, and the poles are securely anchored to dead men. The same cable and special terminals are used in the jumpers where the third-rail joins with the overhead trolley. At these points, however, the jumpers pass from the third-rail to insulators on the latticed steel poles which are standard in all overhead construction.

OVERHEAD CONSTRUCTION

Three types of catenary trolley suspension are used at different locations along this new line. Where there are two tracks, the line is spanned at 300-ft. intervals by double-track, special-galvanized steel bridges, built by the Aermotor Company, Chicago. The legs are 32 ft. 1 in. long and set 5 ft. in concrete, and this gives a trolley clearance of 19 ft. above the top of the rail. catenary type with a 500,000 circ. mil hard-drawn, copper-cable messenger having maximum sag of 6 ft. 6 in. This cable is designed to withstand 6324 lb. in tension, which will obtain when both the cable and the trolley are subjected to a coating of ½ in. of ice and a wind velocity of 65 m.p.h. The No. 0000 trolley is attached to the messenger by rigid hangers furnished by the Ohio Brass Company. These hangers are spaced at 15-ft. intervals, and hence give a twenty-point catenary suspension on the 300-ft. spans. On curves up to 4 deg., no pull-offs are necessary, the messenger being so attached to the bridge that it permits the trolley to take a natural curve. This pulls the plane of the messenger to a 45-deg. angle from the vertical, and in this position the hangers hold the trolley in its proper position.

SINGLE-TRACK OVERHEAD CONSTRUCTION

Single-track overhead construction is suspended from special galvanized, hot riveted, steel latticed poles set in concrete. These poles also were furnished by the



MICHIGAN 2400-VOLT LINE — CATENARY-BRIDGE CONSTRUCTION NEAR GRAND RAPIDS

Aermotor Company. They are designed with a factor of safety of two, for a load of 2000 lb. applied at the top and at right angles to the line. They will also support a vertical load of 1600 lb. at a point on the mast arm 10 ft. from the center of the pole.

These poles are set 165 ft. apart on tangent track, or thirty-two to the mile. The messenger on single track is also a 500,000-circ. mil hard-drawn, copper cable with a total tensile strength of 26,400 lb. In the 165-ft. pole spacing, the messenger sags 4 ft., giving a tension not to exceed 3200 lb. when both the messenger and trolley are coated with ½ in. of ice and the velocity of the wind is 65 m.p.h.

The No. 0000 trolley wire is attached to the messenger with rigid hangers 15 ft. apart. In the single-track overhead construction, no steady strains or pull-offs are used on curves up to 6 deg. since the messenger is so hung that it serves both as a messenger and a brail wire.

In order to give to the overhead circuit the same conductivity as the third-rail, a 500,000-circ. mil copper cable is provided. On single track this feeder is carried on a small arm on the inside of the pole, and on double-track bridge construction this feeder is suspended beside the messenger and has a sag of 6 ft. Sectionalizing switches are installed at each town so that any section of the third-rail and overhead may be de-energized.

Where siding tracks parallel the main track the latticed pole with a mast arm is used for the main track, and a wooden pole for the side track. The overhead construction for the side track usually comprises a No. 00 steel trolley wire attached to a cross-messenger suspended between the wooden pole and one end of the mast arm on the steel pole.

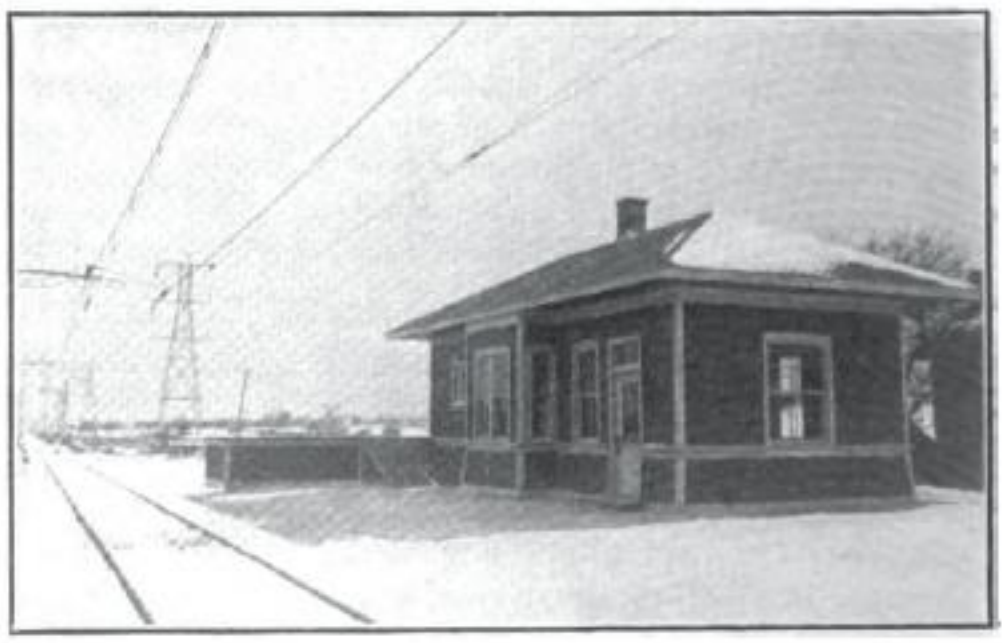
SURGE PROTECTION

With a conductor as large as the 80-lb. third-rail, it was necessary to provide surge protection. This consists of a series of aluminum cells with shunting resistances in each to balance the discharge. The series of cells is connected to the line through proper switches, fuses and self-clearing gaps. Each cell comprises a pair of concentric aluminum plates, positive and negative, properly separated and immersed in an electrolyte. Each plate is coated with a special electrolytic film. The air gap is set at a predetermined value and operates only when an excess energy impulse or surge is produced by an instantaneous release of the inductive energy of the rail due to a short circuit or other external cause.

The energy release manifests itself as an increase in voltage, the current approaching zero and the voltage increasing rapidly. The aluminum cells drain this excess energy from the rail to the ground through the large discharge surface of the aluminum plates. The effect of the plates is to produce a large current in the cell, due to the low resistance of the electrolyte. Accordingly the voltage peaks may be limited to any amount simply by increasing the number of cells, and caring for any known condition is simply a question of arriving at the right number of cells. The effect of these cells is similar to that of a safety valve on a steam boiler in that energy in excess of the normal value is permitted to escape by means of the air gap when abnormal conditions obtain.

SOURCES OF ENERGY

For the present the road, which is 94.5 miles long, is being fed from substations at Grand Rapids and Kalamazoo. A third source of energy will be furnished as soon as the transmission line can be completed into Battle Creek. At the Grand Rapids and Kalamazoo substations, energy is supplied at 2400 volts by connecting two 1200-volt rotary converters in series. The Battle Creek substation will feed the line at the same voltage, but from a motor-generator set. At Monteith Junction, where the Allegan-Battle Creek and the Kalamazoo-Grand Rapids lines cross, disconnecting switches have been installed so that either of the three branches of the road may be cut off. The feed from Monteith Junction to Grand Rapids is 28 miles, to Battle Creek 29 miles, and to Kalamazoo 18 miles. A short section of feeder line also extends from Monteith Junction to



MICHIGAN 2400-VOLT LINE—STANDARD BRICK AND WOODEN WAITING STATIONS

Allegan, a distance of 11 miles. The substation equipment and protecting devices were furnished by the General Electric Company.

WARNING SIGNS

An electric line that uses energy at this unusually high potential in a third-rail must necessarily be thoroughly fenced and supplied with warning signs. All the signs used are uniformly of blue enamel with white letters. At each side of every road crossing, there is suspended from a copper cable, a small danger sign. Also fastened to the wing fences on each side of the road, signs approximately 18 in. x 24 in. in size warn trespassers against the dangerous third-rail. Other types of signs displayed along the right-of-way include whistle, station, distant siding and bridge signs, and all are made of sheet metal with blue and white lettering. Where it was necessary to mount these signs on independent posts, they were attached to special galvanized angles set in concrete.

Unusual signs are also employed to indicate to the motorman the change from 2400-volt to 600-volt trolley, which is necessary when the cars leave the new line to enter the city streets of Kalamazoo, Grand Rapids and Battle Creek. These signs are illuminated by three 40-watt Mazda lamps, receiving their energy from the 600-volt trolley, and each one is 15 in. wide by 39 in. long, being suspended from four I-bolts beneath the mast arm about half-way between the trolley wire and the pole. An arched metal hood projects from the top of the sign over the lamps and serves both as a reflector and as a protection against the weather.

TELEPHONE LINES

Three copper metallic return telephone lines were strung on separate poles set along the edge of the right-of-way. Two of these lines are used by the railway company, one for commercial purposes and the other for train dispatching, and the third line is for the Commonwealth Power Company's dispatchers. Jack boxes on angle brackets are installed beside the head blocks at all passing sidings. If the telephone line is on the side of the track opposite the head block, the wires are carried down the line poles in conduits, thence underground to a special pole set beside the head block which supports the jack-box brackets. If the head block is on the same side of the track as the telephone pole line, the special pole is fitted with a cross-arm and merely serves to carry the telephone line to the conduit which extends from cross-arm to jack box.

STANDARD STATIONS AND SHELTERS

Two types of stations were constructed at the cities and villages along the new line—one a permanent brick and concrete building and the other a wooden building similarly arranged, but smaller in dimensions. At important crossroad points, wooden shelters, which cost approximately $200, are provided. These shelters are fully inclosed and rest on concrete foundations. Each one is provided with a small concrete platform.

GRAND RAPIDS AND KALAMAZOO TERMINALS

At Grand Rapids and Kalamazoo property was purchased in the heart of the business district and converted into commodious passenger stations with yard tracks for storing eight or ten passenger and express cars. At Grand Rapids the passenger and express terminal building is situated in the business district on the west side of the Grand River, and the freight house and team tracks are on the west bank of the river opposite the terminal. The freight facilities include a warehouse 50 ft. wide and 185 ft. long, built of brick, concrete and steel. Quite an extensive team-track yard, as well as a storage yard leading to a repair shop also situated at this point, have been installed.

At Kalamazoo, the terminal building combines a passenger station, baggage room and freight warehouse. Four storage tracks of sufficient length to hold two cars each, make up the terminal yards. Two of the tracks are used exclusively for passenger coaches and the other two for loading an unloading freight.

The work of building this high-grade, 2400-volt, third-rail line, and electrifying the steam road between Allegan and Battle Creek, was under the immediate supervision of George L. Erwin, president and general manager of the Michigan Engineering Company, and G. J. Wagner, superintendent of construction. During the construction period, the Michigan Railway Company was represented by the late W. A. Foote, vice-president, who promoted the line and who was responsible for many of its unique features.

Jitneys for Sale in Kansas City

The accompanying picture represents the third stage of the jitney transportation industry in Kansas City. A firm of three men which started three buses, each carrying twelve passengers, on April 1, 1915, is now offering the buses for sale. Three of the men had other lines of business and are said to have invested about $5,800 in the two Appersons and one Velie, making two

MONTH-OLD BUS FOR SALE IN KANSAS CITY

of the bodies in the planing mill of two of the company members. Two of these men drove the buses for awhile, until they found that their own business needed their attention. The third bus was driven by an outsider, who finally obtained a small interest in the company. They claim that the business would be profitable if they could give their personal attention to it, which they cannot do.

The Public Service Commission for the Second District of New York has completed moving from rooms in the Capitol and scattered offices in two buildings on Washington Avenue, Albany, to quarters provided by the trustees of public buildings on the three upper floors of the office building at 58 North Pearl Street, corner of Steuben Street. The offices of the commissioners, general offices, hearing room, filing divisions and the various engineering, legal and accounting bureaus gathered under one roof will greatly facilitate the business of the commission. The general offices are located on the fifth floor.

The side wheeler May Graham was the last riverboat to ply the waters of the Grand commercially.