Novel Girder Design Employed in Grade Separation Structure

Used in federal reconstruction project on D. L. & W., where reinforced concrete highway bridge, on sharp skew, replaced inadequate structure

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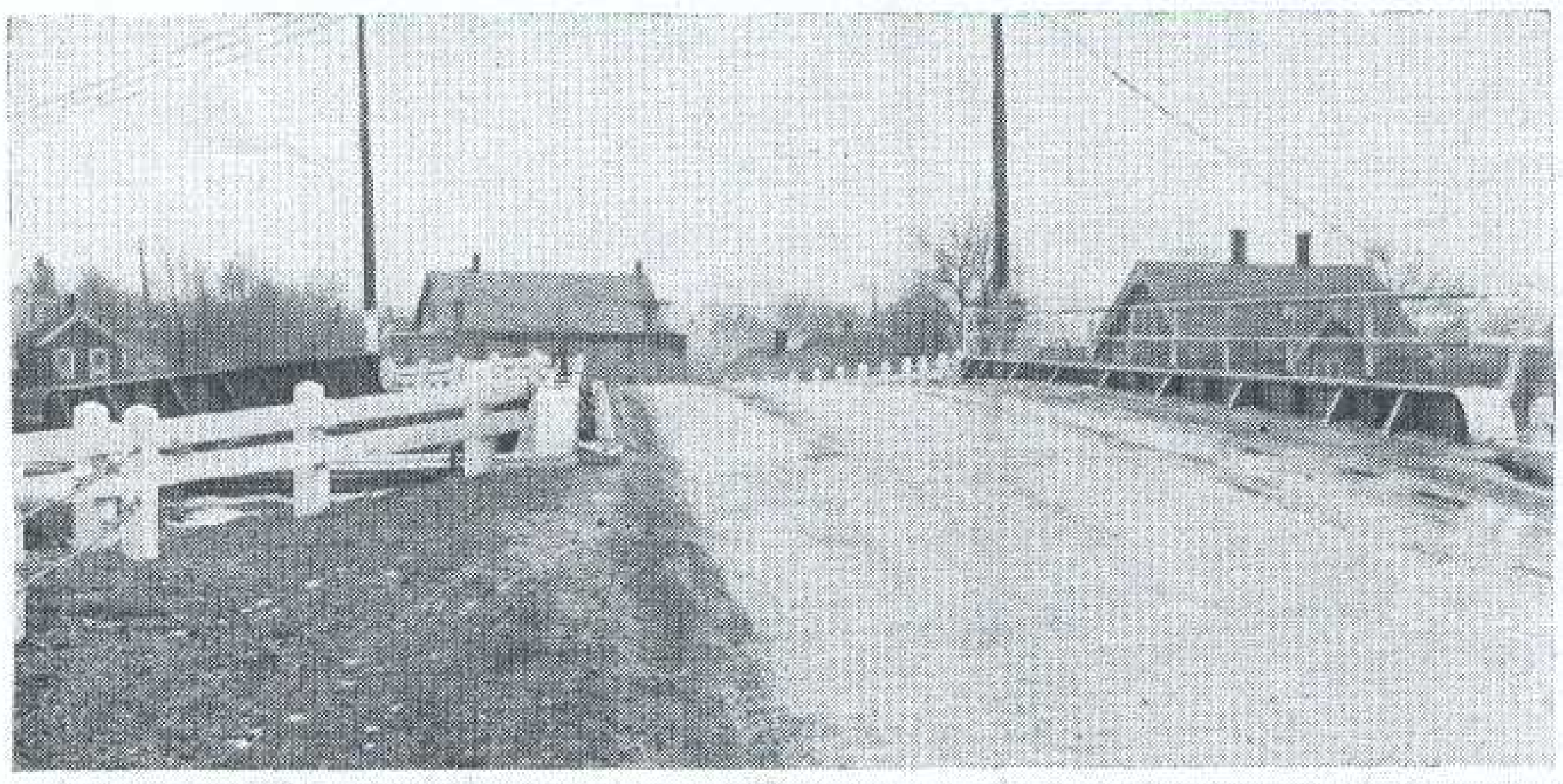
AMONG the projects which have been included in the federal program of railway-highway grade crossing elimination in the various states, there have been a number of interesting reconstruction projects involving crossings that had been eliminated through grade separation earlier in the century to meet conditions then existing but, at points where the facilities provided had become inadequate to take care of the increase in vehicular traffic which has taken place during the last decade. One such project, which involved the rebuilding of a highway bridge, is the subject of this article and is given special consideration because of the interesting use which it makes of long-span, reinforced concrete girders, so designed as to utilize to the greatest extent possible the elements of the structure which it superseded.

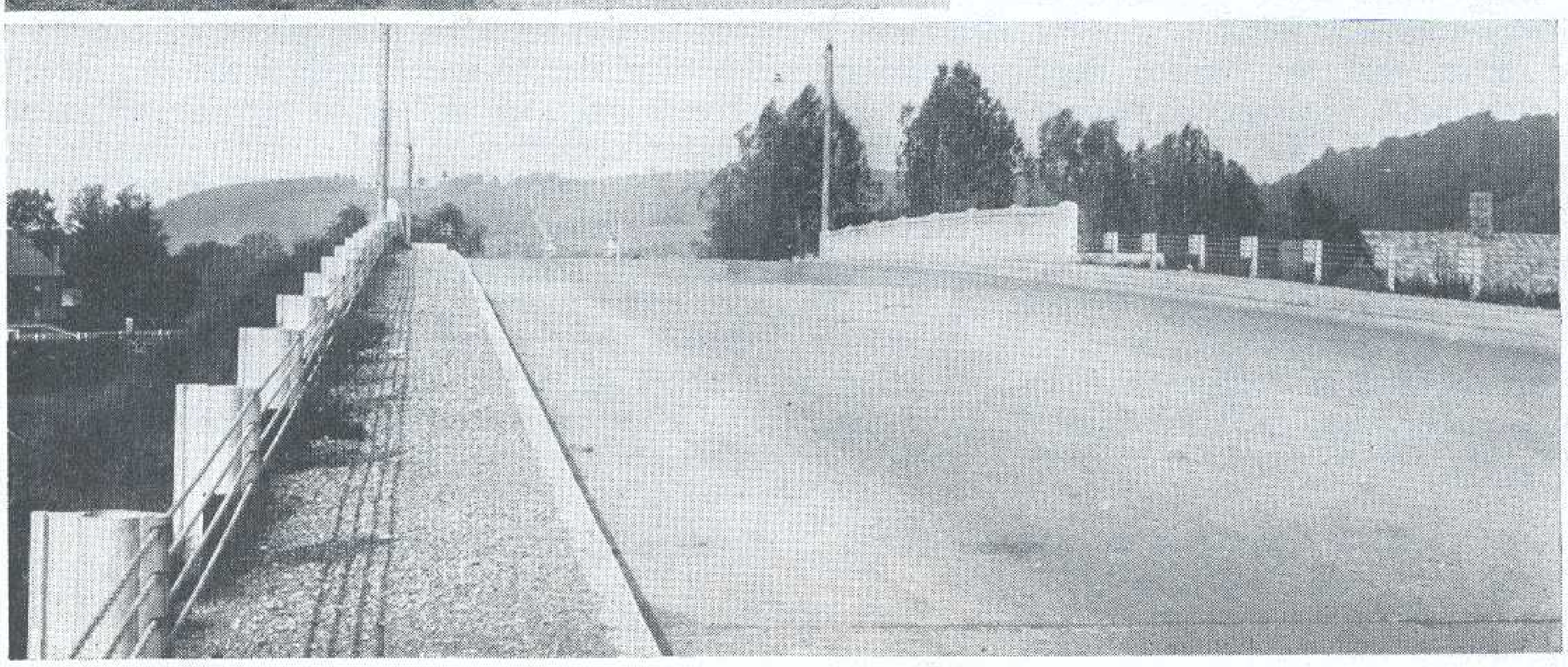
Old Structure Far from Adequate

The project in question is located on New York State Highway route 208, between Cortland and Homer, N. Y., and called for the replacing of a steel girder bridge over the two tracks of the Syracuse division of the Delaware, Lackawanna & Western. The original structure was built in a grade separation project completed in 1921, and provided a 20-ft. width of paved vehicle roadway, with a separate span (trough) for a single-track high-speed trolley line of the Cortland County Traction Company. The superstructure was of the structural-steel, through-girder type, with steel floor beams and a solid concrete deck for the highway, and with conventional open-deck track construction over the trolley span. The substructure consisted of concrete abutments at right angles to the girders, with intermediate steel columns to reduce the girder span lengths, so located as to provide the required lateral clearance on each side of the double-track railroad, which passed beneath the bridge at an angle of 45 deg.

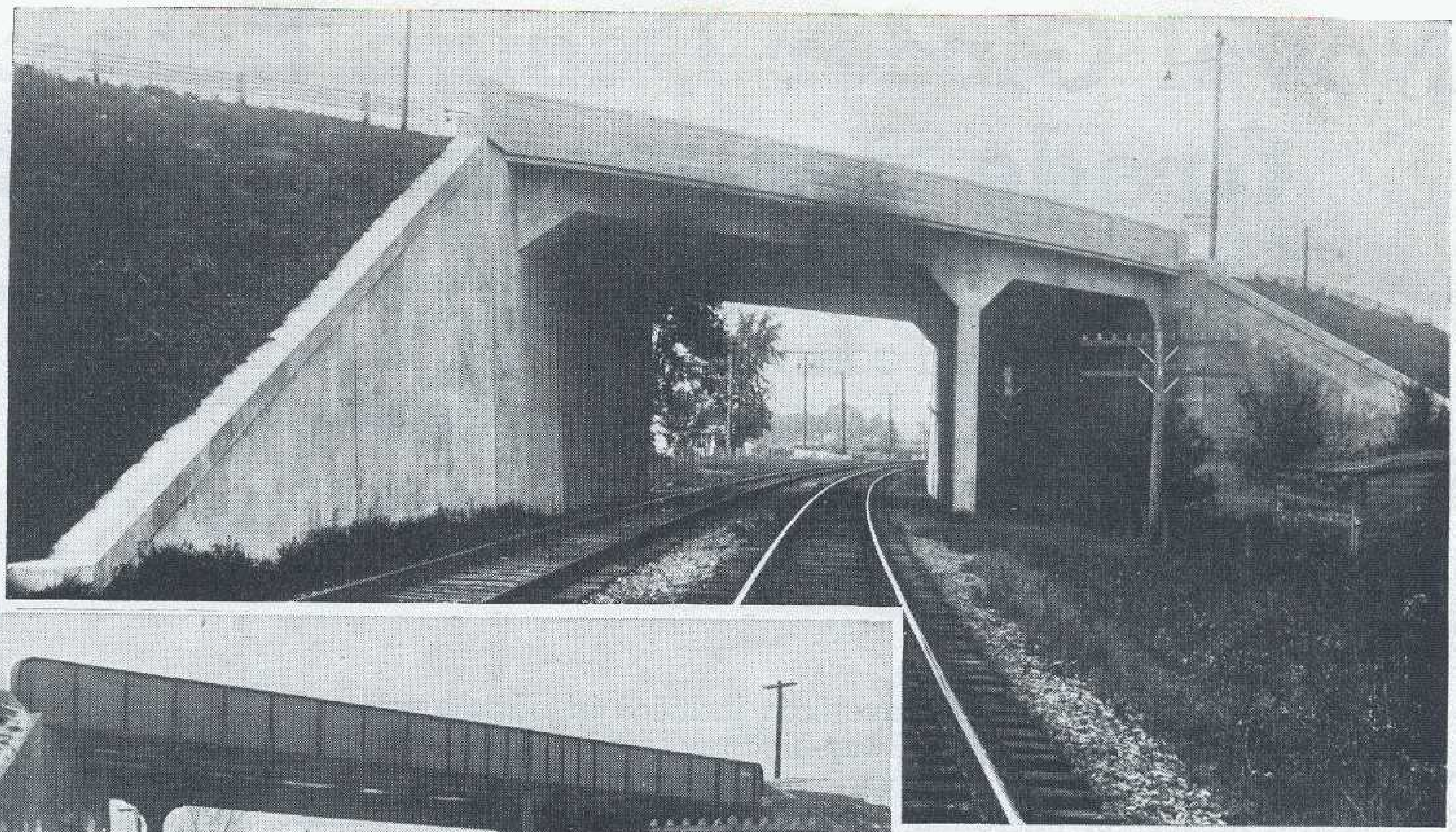
It was not many years after the elimination of the grade crossing at this point that changes in methods of transportation resulted in the substitution of buses for the trolley cars which had used this bridge, throwing the additional roadway traffic on to the highway span and making the track span valueless. At the same time, a marked increase in the number of private automobiles and trucks soon overtaxed the capacity of the highway span. In view of these factors, consideration was given to various methods of increasing the roadway capacity of the bridge, including the altering of the former track span to accommodate motor vehicles. The final result of attempts in this regard was a major change in the general alinement of the highway, including a change in the angle of crossing over the tracks to the sharper skew of 55 deg. 10 min. 17 sec., and requiring an entirely new superstructure with an increased width of roadway, and the elimination of the trolley span.

The new superstructure, which is of reinforced con-





From These Illustrations of the Old and New Highway Decks, There Is No Question as to What Interests Received the Entire Benefit From This Reconstruction Project



Right — The New Structure Utilized the Elements of the Former Structure as Far as Possible

Left — The Original Structure, Built in 1921, Became Entirely Inadequate From the Standpoint of Roadway Capacity

crete construction throughout, involving specially designed side girders supporting a roadway slab, provides a 40-ft. width of roadway and two sidewalks, the 5-ft. widths of which are reduced to a net clear width of 4 ft. 6 in. because of the necessity of providing a second step in the curb for reasons to be explained later. The overhead clearance is 22 ft. minimum from top of rail. The revised angle of skew resulted in the unusually long concrete girder spans, which are the most interesting feature of the structure.

The design of the new structure was based on revolving the elements around the point of intersection of the old center lines of the highway and the railroad tracks in order to permit utilization of as much of the existing substructure as possible for the new construction. To accomplish this, new piers were located through the center lines of the existing columns on each side of the tracks and were made continuous with the lines of the existing wing walls, portions of which, in turn, were built up to act as abutments to carry the new girders and deck slab. The existing abutments were utilized and extended and new wing walls were provided for retaining the altered highway approach fills.

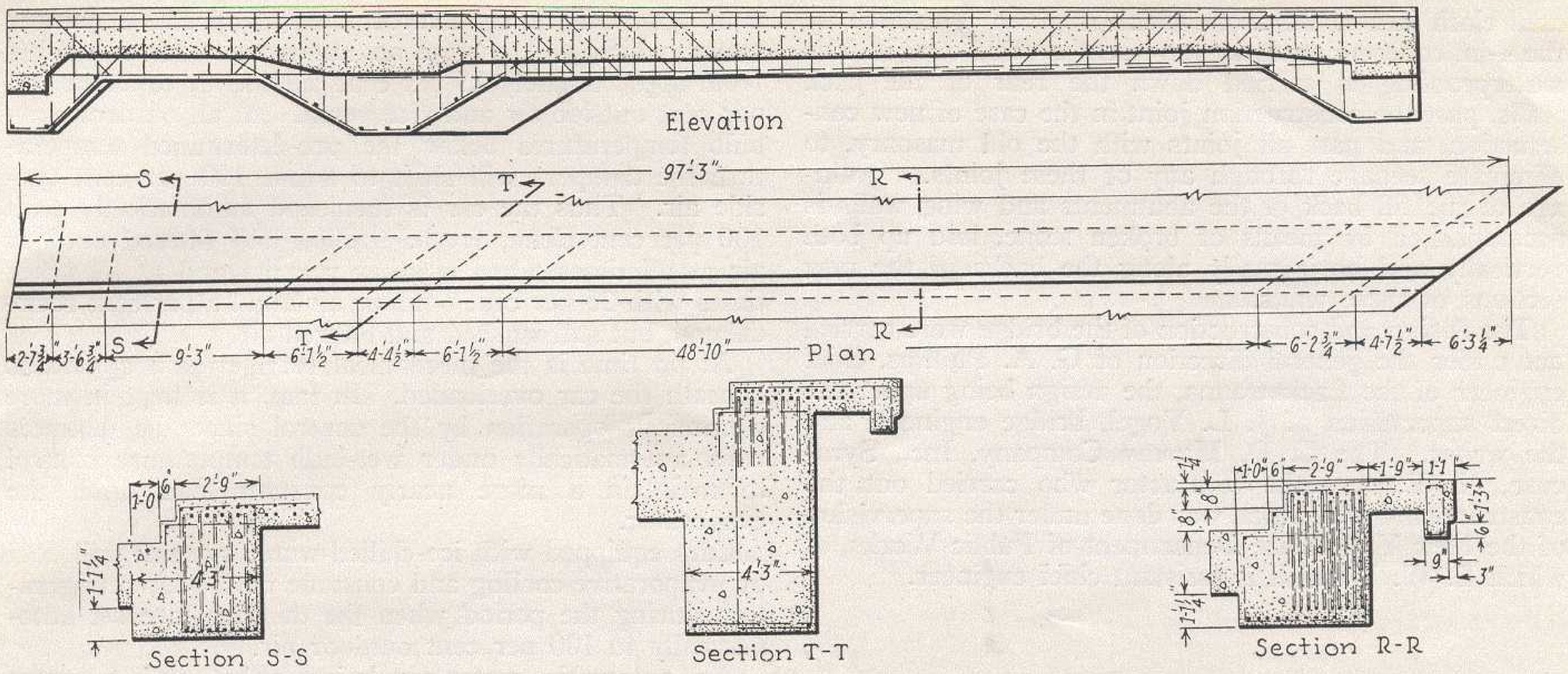
It was evident at the outset that the limited depth of deck possible from the standpoint of clearance requirements, without altering the grade of either the highway or the railway tracks, which was undesirable, would necessitate that every possible advantage be taken to reduce the depth of the new girders. This was accomplished by reducing the dead load transferred by the slab; by designing the girders as continuous over the intermediate piers; and by the use of compressive reinforcement; but the conditions imposed still necessitated the use of a novel section of girder to meet the moment requirements.

The reduction of the dead load of the roadway slab was effected by spanning at right angles to the center line of the railroad and by figuring both continuity and end restraint at all points where such advantages were available, as well as by the use of compressive reinforcement, rather than by the use of lightweight aggregate. The maximum span of the slab is 34 ft., which occurs fortunately where the condition of continuity obtains, so that it was possible to hold the maximum slab thickness down to 28 in., which could be reduced in meeting the reduced requirements at the sections of the slab adjacent to the girders.

The maximum girder span occurs at the north side of the structure (because of slight track curvature) and amounts to 61 ft. 4 in. clear along the skew, or 65 ft. 10 in. center to center of bearings. To meet the moment requirements of the long girders, the plans for the roadway curb limited to 8 in. in height by the Department of Public Works of New York state, which was to be incorporated in the inside top face of the girders, had to be modified to permit the provision of another 8-in. step. In addition, it was necessary to incorporate a part of the sidewalk on each side of the structure with the girder on each side, and to provide an additional 2-ft. 10-in. width of sidewalk slab integral with the top of the girder to give it a one-sided "T"-shaped section, as will be noted in the accompanying plans. To obtain sufficient width of girder to accommodate the reinforcement in two layers only, as well as to provide sufficient area of section for compressive and shear resistance at the supports, the bottom width of the girder in each case was extended for a distance of 1 ft. beneath the roadway slab, making the total bottom width of each girder 4 ft. 3 in. The maximum moments and shears were determined by means of the theorem of three moments, considering as a short span the length directly over each pier support, which span was assumed unloaded and not subject to deflection.

System of Loading for Girders

The loading on each girder consists of the uniform dead load of the girder itself and the triangular dead



Elevation, Plan and Cross Section of the North Girder, Showing Its Novel Features of Design to Take Care of the Moments Involved

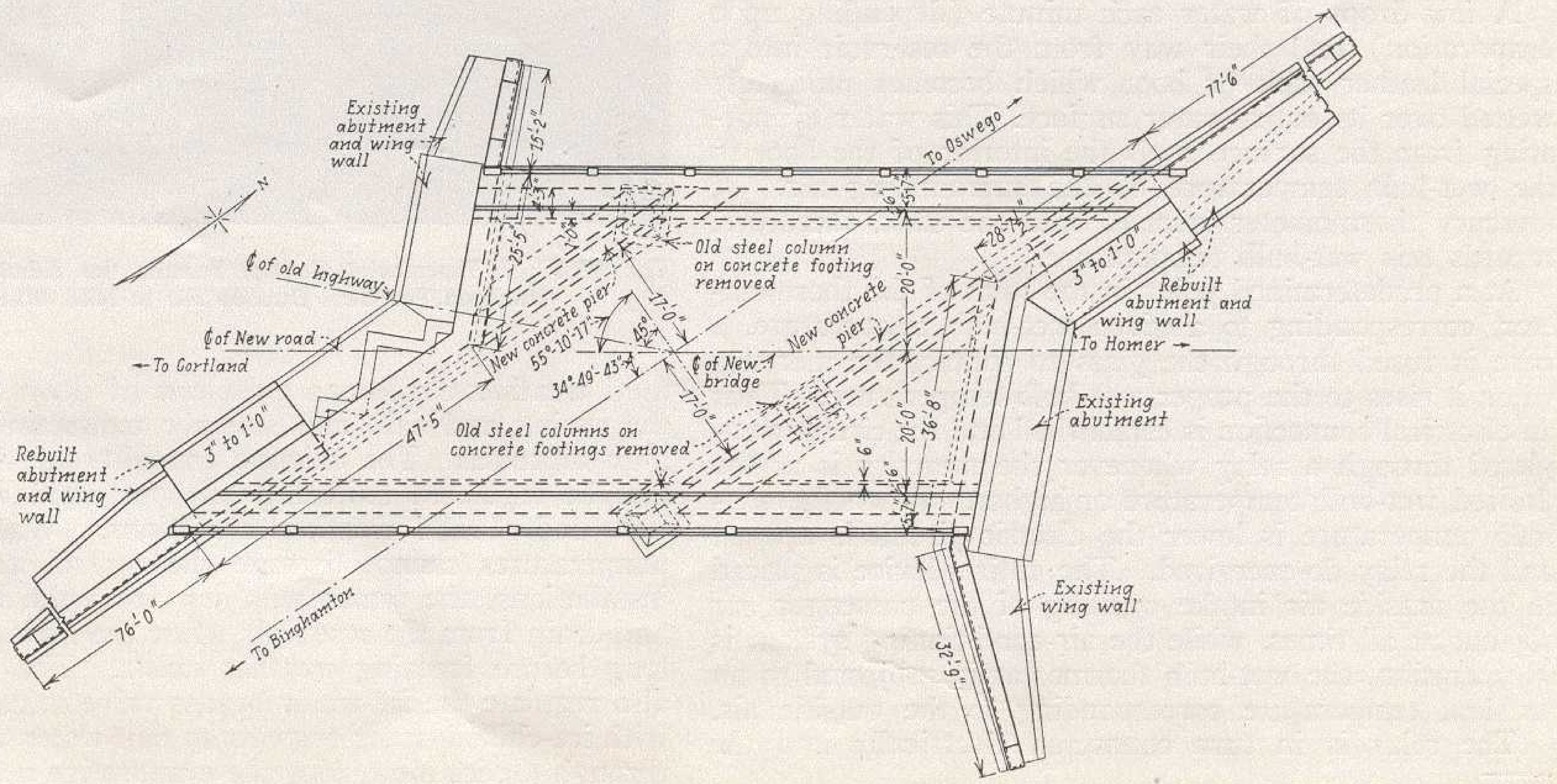
and live loads transmitted to it by the slab. The maximum positive moment near the center of the main span of each girder, with a maximum available girder depth of 57 in., required reinforcement consisting of thirteen 1¼-in. square bars and ten 1-in. square bars placed in two layers near the bottom for tension, and three 1¼-in. square bars placed in the top plane to take care of compression. All of the 1-in. square bars in both the long and short spans of each girder are bent up over the pier supports, providing a total of fifteen 1-in. square bars at this point, which, with fifteen 1¼-in. straight square bars extending into both spans, meet the maximum negative moment requirements of the girders at the edge of corbels and over the support. Stirrups of ¾-in. round bars are provided in addition to the bent bars for shear reinforcement. Cross-sections of the girder on the north side of the bridge at its intermediate pier support and at the centers of its long and short spans are shown in the accompanying illustrations.

The piers on both sides of the tracks are designed with openings of 10-ft. span, with intermediate columns of 3 ft. 6 in. width, which resulted in a reduction of load on the footings as well as economy of concrete. The design of the piers for the eccentric loadings transmitted to them required that their footings be located off center to obtain uniform distribution of soil pressure for the condition of maximum loading, and to yield lower unit pressures for lighter load conditions, under which a greater eccentricity of soil pressure resultant occurs.

Designed for H-20 Loading

The structure was designed for the standard H-20 loading called for in the specifications of the American Association of State Highway Officials, with the permissible reduction for four lanes loaded, but the allowable unit stresses were restricted to 16,000 lb. per sq. in. in the tensile steel and 650 lb. per sq. in. for extreme fibre in compression in the concrete. No attempt was made to give special architectural treatment to the structure; and the simplicity of the design avoided emphasizing the dissymmetry of the structure.

The concrete slab deck of the structure was completely waterproofed by a two-ply membrane of bitumen-satur-



General Plan of the New Grade Separation Structure, Showing Its Sharp Skew and Irregular Shape

ated cloth laid in bitumen, which is given protection by the 4-in. concrete roadway pavement applied over it. The waterproofing is carried down the rear of the back walls, past the construction joint in the case of new construction, and past all joints with the old masonry, to eliminate seepage through any of these joints. Drainage of the fill back of the abutments and wing walls is accomplished by means of broken stone, laid up both vertically and horizontally along the backs of the new sections of these walls.

The design and construction of the bridge were carried out under the general direction of G. A. Phillips, chief engineer of the Lackawanna, the design being under the direct supervision of J. L. Vogel, bridge engineer, and the writer. The C. D. Murray Company, Inc., Syracuse, N. Y., was the contractor who carried out the construction work, which was done under the supervision of the New York State Department of Public Works, of which E. W. Wendell is assistant chief engineer.

Wet-Bulb Air-Conditioning Control

THE Vitalized air-conditioning system of the B. F. Sturtevant Company, Hyde Park, Boston, Mass., consists essentially of a blower and spray-cooling unit, an ultraviolet-ray sterilizer, and a wet-bulb thermostat control.* The wet-bulb thermostat is designed to operate in conjunction with other control apparatus of any standard or special design for the control of temperature and humidity in passenger cars. Its function is to produce economy in ice consumption in cars equipped with ice-chilled-water air-conditioning systems and to reduce the maintenance of Freon or steam-jet-equipped cars by effecting more continuous operation.

The thermostat consists essentially of a small hard brass alloy reservoir to which a supply and return-water connection is made from the main spray-nozzle water-pumping system through a small copper tube. This tubing is installed as readily as electric wiring since it can be bent around corners and connected with standard flared fittings. Insulation against sweating is provided by standard commercial hollow sponge-rubber tubing and felt where necessary.

A few drops of water each minute (depending upon evaporation) find their way from the reservoir into a special leather sack or boot which becomes uniformly wetted over its entire outer surface. This water evaporating from the surface cools the interior of the boot to the wet-bulb temperature of the surrounding air. A mercury thermometer inserted into the sack, therefore, records this wet-bulb temperature.

At a predetermined point in the stem of the thermometer, corresponding to a given wet-bulb temperature, a wire is fused through the glass to contact the mercury when it rises to the proper wet-bulb temperature. Thus an electrical connection is established and the circuit completed through a relay whenever the mercury is at the desired wet-bulb temperature or higher. When the wet-bulb temperature is lower the electric circuit is opened and the relay de-energized. The entire device is placed in the outside air intake opening of the passenger car so that at all times, while the air-conditioning system is in operation, the wet-bulb thermostat is subjected to an ambient temperature corresponding to the outside air.

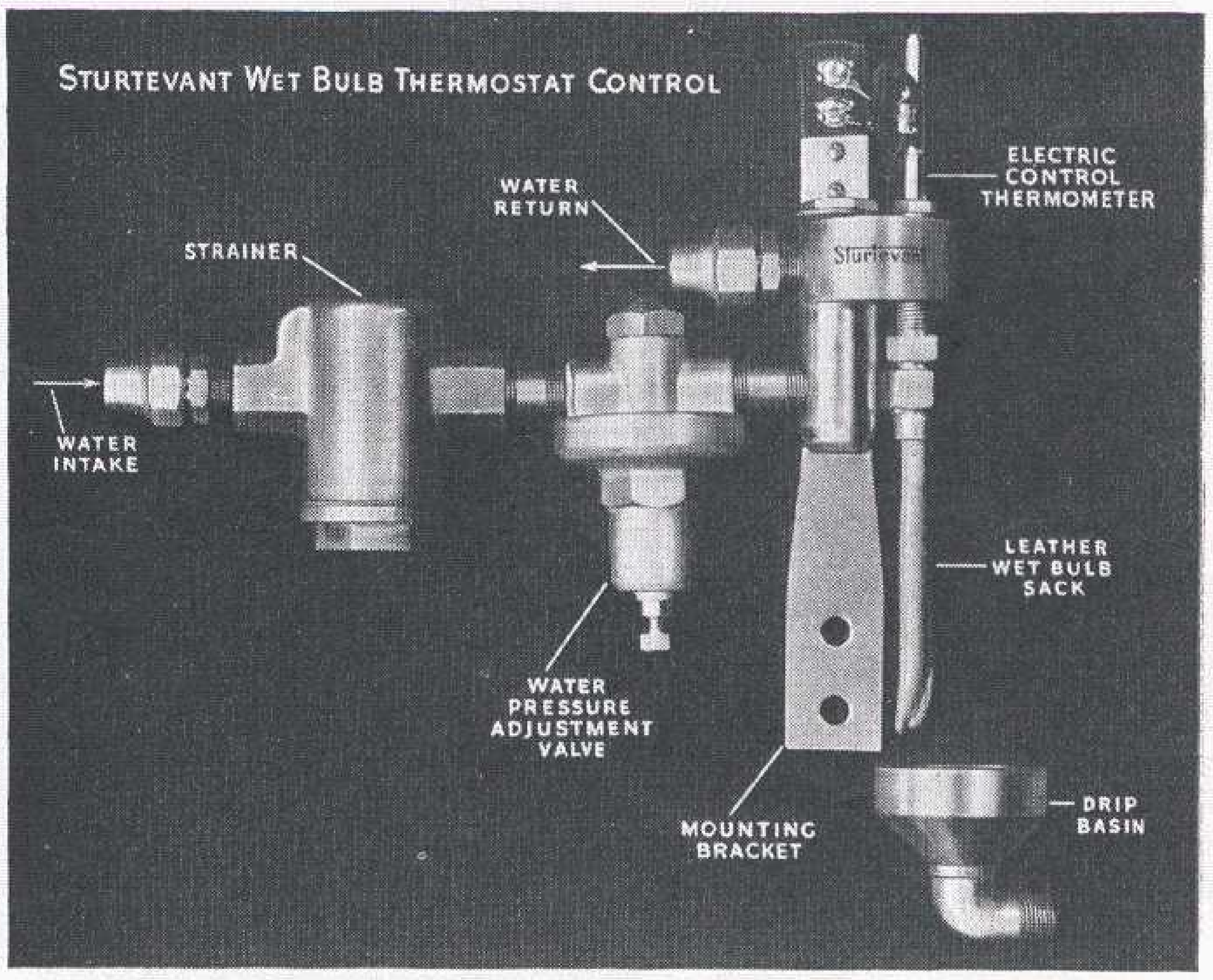
The relay is in turn connected electrically into the main air-conditioning control panel to operate a damper motor which will change an automatic damper setting from approximately 25 per cent outside air to about 100 per cent outside air and vice versa. At all outdoor wet-bulb temperatures below the pre-determined temperature the dampers will shift to admit 100 per cent outside air. Thus the car is furnished automatically with 100 per cent clean, fresh, washed and filtered outdoor air at all times when weather permits and at all other times with 25 per cent outdoor air and 75 per cent recirculated, but still washed and filtered air.

At no time is the mechanical refrigeration apparatus beneath the car overloaded. In fact, it is kept in more continuous operation by the control since the dampers reset automatically under wet-bulb temperature control to maintain a more nearly constant load upon the evaporator.

Cars equipped with ice-chilled-water systems will cool by evaporative cooling and consume no ice for refrigeration during the period when the dampers are set automatically to 100 per cent outdoor air.

An automatic water-regulating valve and a water strainer are furnished with each wet-bulb thermostat. These devices need only occasional attention. Experience has shown that when properly adjusted the valve will regulate the proper water flow for an entire summer without attention and the strainer need be cleaned no oftener than once or twice a season.

The wet-bulb thermostat may also be used for regulation of the ultraviolet sterilizer at all times when the outside air dampers are set to the 25 per cent position. This would include the heating season and periods when



The Wet-Bulb Thermostat Control Permits the Admission of One-Hundred Per Cent Outside Air in Mild Weather

mild weather conditions exist out of doors, such as in the spring and fall, and summer mountain weather at high altitudes. The relative humidity of the car may also be regulated uniformly without window condensation under such weather conditions. Water freezing temperatures cannot damage the control and, in most installations, the water will dry from the leather boot and drain from the reservoir when the main pump stops long before freezing weather exists. The control will also regulate the ice-water bypass valve in cars equipped with ice-chilled-water systems so that water will not pass through the ice bin during the evaporative cooling setting of the outside air dampers. This is essential for ice

* A description of the essential features of the equipment appeared in the November 27, 1937, issue of the *Railway Age,* page 762.