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FIG. 1. MAIN AVE. BRIDGE (IN FOREGROUND) PROVIDES A NEW CROSSING OF THE CUYAHOGA RIVER IN CLEVELAND.

Lakefront Freeway Speeds Cleveland Traffic

Contents in Brief *— For years out-of-town motorists have avoided Cleveland because of downtown traffic congestion. Now, the new Main Ave. Bridge and 6 miles of lakefront boulevard, with grade separations of bold engineering design, will provide for continuous flow of traffic through the city. The bridge and about 4 miles of the boulevard are already in service.*

FARSIGHTED REGIONAL PLANNING in Cleveland has resulted in the inauguration and partial completion of a plan to carry traffic along the Lake Erie waterfront from Gordon Park on the east to West Blvd. at Edgewater Park on a road free from the usual restrictions of cross traffic and bottlenecks. Known as the Lakefront Freeway, this road consists of broad multi-lane highways and a continuous cantilever truss viaduct over the downtown industrial area and the Cuyahoga River, known as the Main Ave. Bridge. Advantage is taken of a lakefront location to avoid cross traffic, but where it may occur, especially at entrances to lakefront recreational facilities, adequate provision has been made to carry it with structures utilizing the latest design advances in welding and rigid frames.

From the east, connecting with States Routes 2 and 283, four miles of new macadam road 50 ft. wide has been constructed as a WPA project sponsored by the City of Cleveland, from Gordon Park to East 9th St. From the terminus of this road a section known as the Lakefront Ramp is now under construction. This crosses the New York Central and Pennsylvania Railroad tracks at a skew of 57 deg. and a grade of 4.15 per cent on a three-line, four-span continuous steel girder. One of these spans is 270.8 ft. long, said by the engineers to be the longest plate girder span in North or South America. The girders are 12 ft. deep through the central portion, increasing in depth from a point 60 ft. from either end of the span to 15 ft. 8 in. at the piers. The bridge deck is carried on cross joints resting directly upon the three lines of girders and forming the top lateral system of the truss. Cross frames of the Vierendeel type are provided at about 18-ft. intervals. The roadway in this section consists of two 12-ft. traffic lanes and an escape walk in each direction separated by a raised center strip.

Connecting to the continuous girder section is a series of eight steel rigid frame structures 1,206 ft. long with the same roadway section carried on two lines of frames 35 ft. apart. This section is built on a 1,000-ft.-radius horizontal curve. Because of this curvature and a number of skew supports, spans for the two lines of frames vary from 13 to 122 ft., making design for secondary stresses and detailing very difficult.

Westerly approach

The Lakefront Ramp and this rigid frame section constitute the easterly approach to the Main Ave. Bridge. On the west, equally elaborate approaches are provided, involving separated pavements with six or eight 12-ft. traffic lanes, a large number of grade separations, a minimum number of points of entry, accelerating and decelerating lanes at entrances and exits, and auxiliary truck roads. Easy vertical and horizontal curves permit 1,000-ft. sight distances. The slab thickness is 8 in. with an 8-in. depth of curb to permit later surfacing if required. A 4-in. insulation course is used with adequate tile to insure a properly drained subgrade.

This westerly section will have four grade separation structures all designed for H-20 loading. Two of these are to accommodate traffic to the recreational facilities of the lakefront, with special provision for considerable pedestrian use. One is a reinforced concrete rigid frame of the barrel type with a clear span of 66 ft., longest in the area.

Another structure is of the steel beam and girder type notable in its provision for lateral expansion. This bridge is on a 54-deg. 33-min. skew so that the wide roadway requires an unusually great length measured parallel to the abutments. It is this length which makes provision for expansion desirable and introduces the unusual problem of providing for movement in two directions.

Longitudinal expansion is provided by means of rocker bearings at the ends of the 90-ft. outside girders and two sliding plate bearings for all longitudinal floorbeams bearing on the abutments. A steel grease box is framed around each of these plate bearings and filled with a suitable lubricant to prevent "freezing."

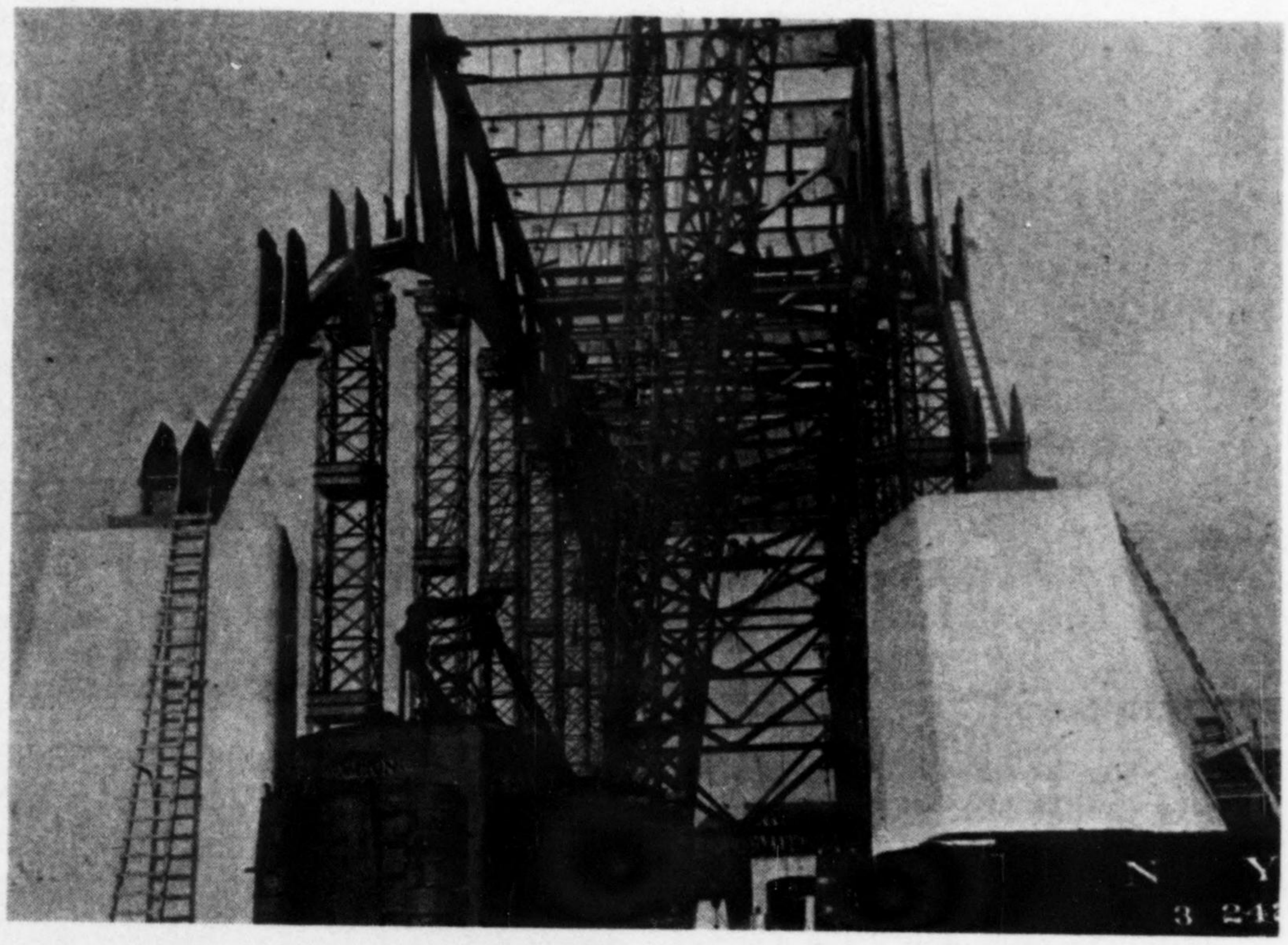

Fig. 3. **Towers at alternate panel points support land spans during erection with long-boom crawler crane.**

Main Avenue Bridge

The principal structure of the Freeway is the Main Ave. high level bridge. Alignment of this structure was dictated by necessity for maintaining the existing Main Ave. swing bridge over the Cuyahoga River and by the desire to keep land condemnation costs in this area to a reasonable minimum. Two curves are necessary in the main spans of the bridge.

The general foundation material is a soft to medium hard clay soil to a depth of more than 150 ft. In some cases a wet sand overlies the clay. For these conditions, foundations partly on piles and partly on spread

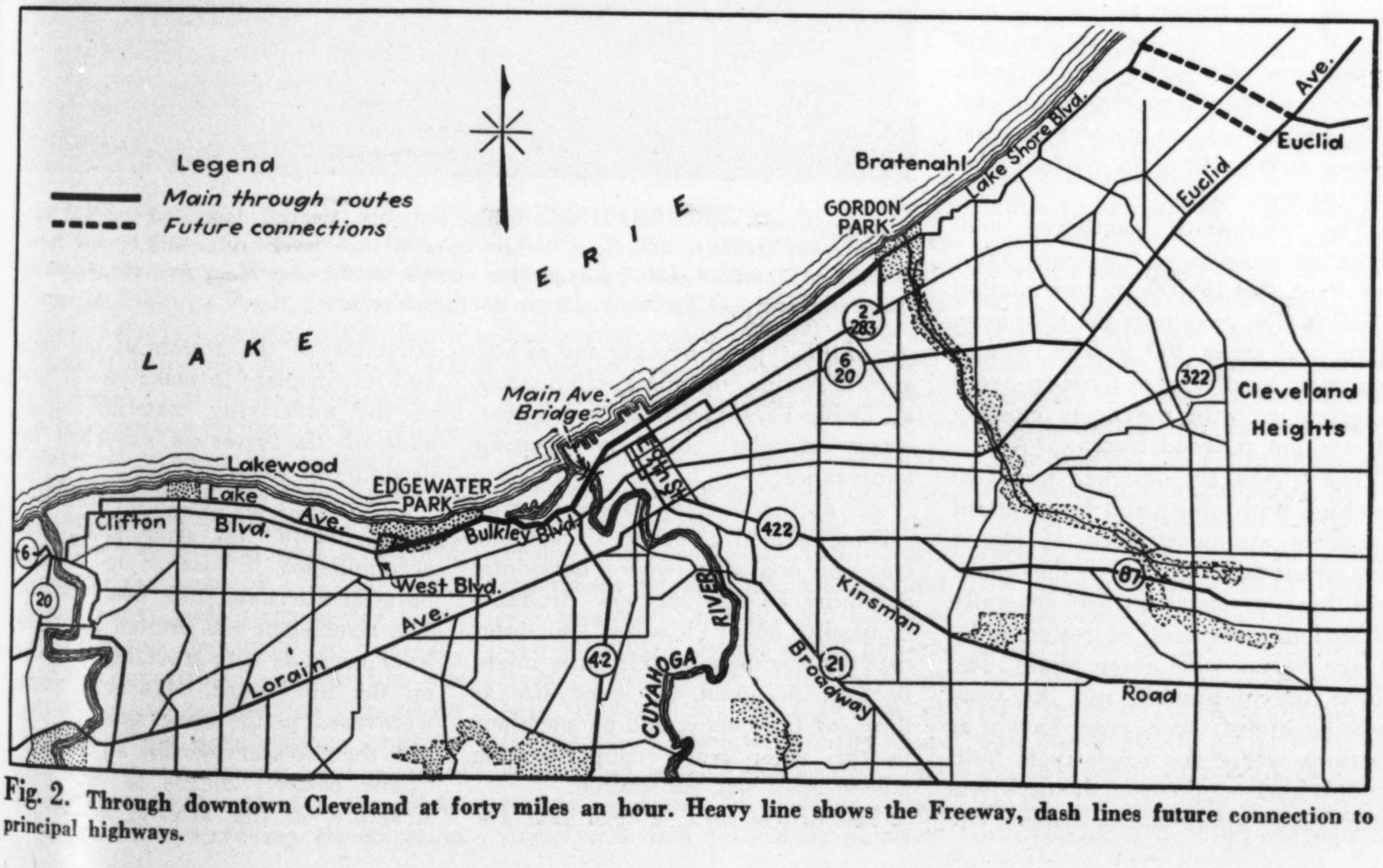

Fig. 2. **Through downtown Cleveland at forty miles an hour. Heavy line shows the Freeway, dash lines future connection to principal highways.**

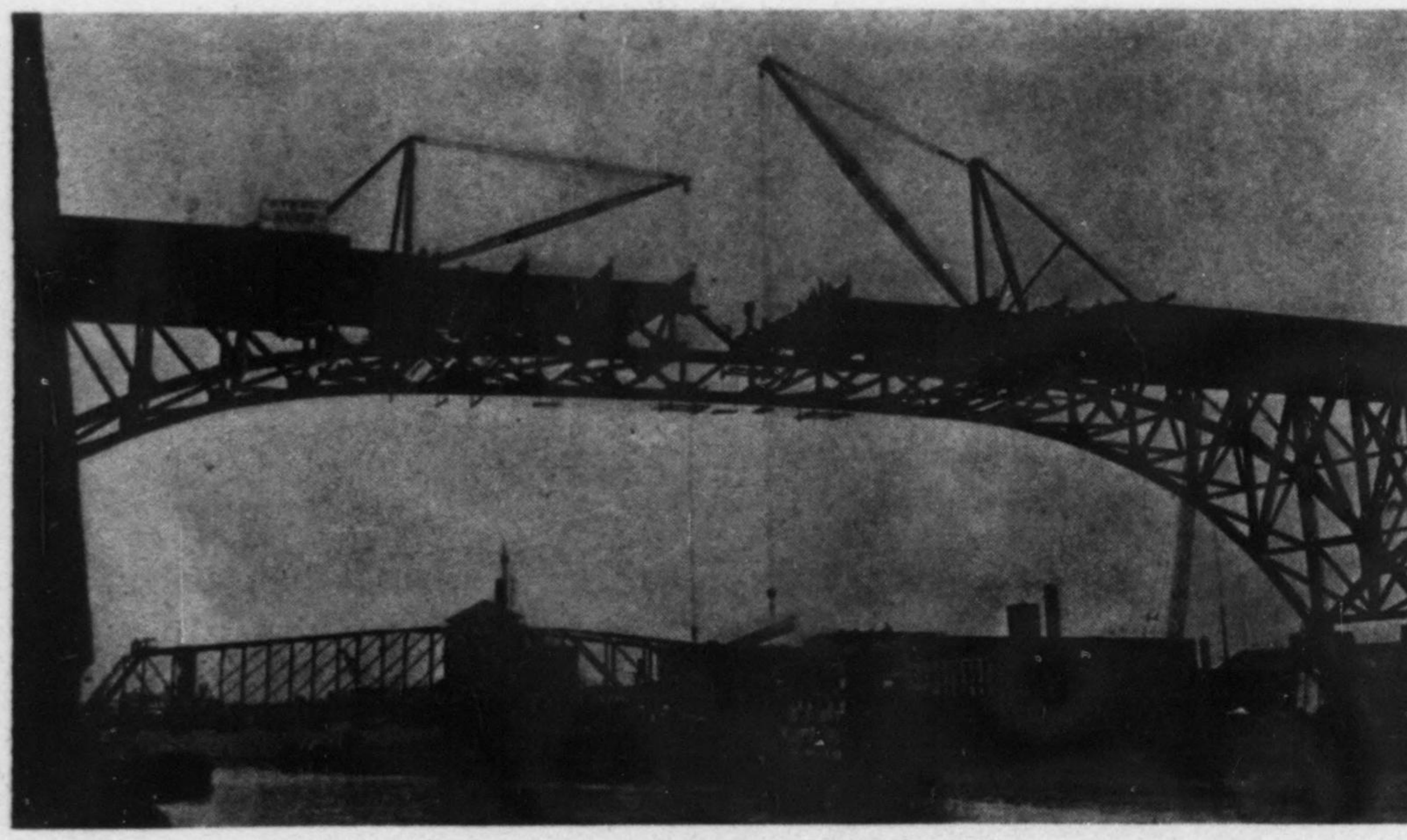

Fig. 4. **The 400-ft. span over the Cuyahoga River was erected by cantilevering, with derricks on the deck. Note old swing span, to be maintained for industrial area.**

tem 4¼ in. deep filled with concrete, carries two 34-ft. roadways for three-lane traffic in each direction, separated by a center strip 2 ft. wide and 1 ft. high. A 5-ft. sidewalk and railing on each side make a total width of 82 ft. for the superstructure.

The trusses rest on hollow reinforced concrete pier shafts extending to as much as 37 ft. above the footing. The pier shafts, except for the two river piers, are supported on closed-end fluted steel sheet piling driven from 50 to 60 ft. into the underlying clay soil and filled with concrete. The shafts of the two river piers rest on footing mats 93 ft. by 38 ft. by 5 ft.-6 in. thick about 24 ft. below ground level. The mats are surrounded by steel sheetpiling driven

footings surrounded by deeply driven sheetpiling were chosen while a series of truss anchor spans with cantilever arms and short intermediate suspended spans was found to be most economical for the superstructure. This type of construction combines economy of continuous trusses with the possibilities of providing a pleasing outline for the structure and at the same time eliminates difficulties which might result from differential settlement of the various piers on clay soil. Simple span trusses were not considered because of the difficulty of combining good appearance with reasonable economy. The lower chords of the trusses are curved, giving the structure the architectural appearance of a series of arches. In order to produce a more pleasing outline, the trusses are made somewhat deeper at the piers than necessary for maximum economy.

The continuous cantilever construction consists of ten spans varying from 200 to 400 ft. and totaling 2,520 ft. The span over the Cuyahoga River was set at 400 ft. The remaining span lengths were fixed to avoid interference with the many existing streets and railroad tracks.

The trusses are designed for H-20 loading. Both upper and lower chord members are constructed of closed box sections. Verticals, diagonals, and bracing members are generally H-sections consisting of rolled wide-flange beams with cover plates. The lower lateral bracing and the sway bracing are of the K type. Except at sections where the roadway is built to fit a horizontal curve, the deck acts as the only upper lateral system. The use of this type of bracing and of box and H-section members eliminating all lacing bars, produced a clean-cut, sturdy structure of very pleasing appearance.

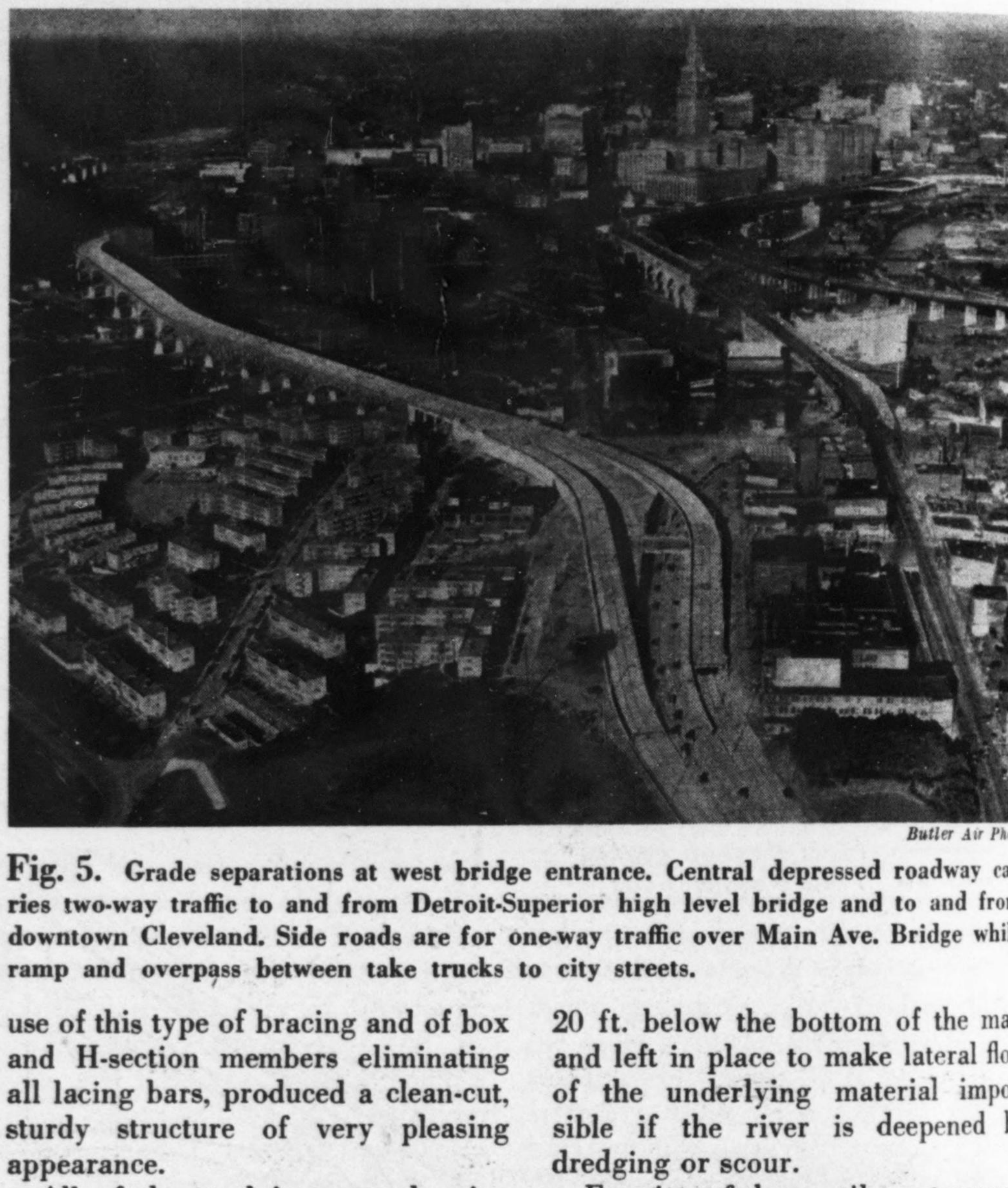

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Fig. 5. **Grade separations at west bridge entrance. Central depressed roadway carries two-way traffic to and from Detroit-Superior high level bridge and to and from downtown Cleveland. Side roads are for one-way traffic over Main Ave. Bridge while ramp and overpass between take trucks to city streets.**

All of the steel is copper-bearing carbon, structural grade, except one truss of one span where horizontal curvature of the roadway produces unusually heavy loading. In order that the members of this truss might be kept to about the same size as those of the corresponding members in the other truss, copper-bearing silicon steel was substituted.

The bridge deck, a steel grid sys- 20 ft. below the bottom of the mats and left in place to make lateral flow of the underlying material impossible if the river is deepened by dredging or scour.

Erection of the cantilever truss sections, except the river span, was accomplished by use of tower supports at alternate truss panel points. The river span was erected by cantilever methods with traveling derricks on the top chord. Hydraulic jacks were used in the river span to provide the necessary closing adjustment.

The easterly access to the main structure is the arterial Lakefront

Ramp, described above, and two 34-ft.-wide three-lane ramps from the city streets to carry traffic on and off the bridge. The ramp pavement is placed on fill ground between concrete retaining walls. From this point to the continuous truss spans the roadway is carried on conventional steel column and girder supports except for a single simple truss span across several railroad tracks. For some distance the column and girder construction carries two decks, the lower providing access to the fifth floor of an adjacent warehouse building.

The westerly access to the bridge is complicated by the necessity of serving heavy city-bound traffic using the main approach roads but not desiring to cross the bridge and of accommodating trucks wishing to use the bridge but not permitted on the approach roads. This problem is solved by the three level crossing shown in Fig. 5. The lower level carries passenger car traffic between the approach roads and main traffic arteries on the west side of the river on two 24-ft. roadways. The second level provides a connection from adjacent city streets principally for truck traffic. The two upper level roadways carry traffic on and off the main structure on three-lane 34-ft. roadways.

The structure was financed in part by PWA funds made available in October of 1937. Actual construction started in May of 1938. The structure was opened to traffic in October of 1939, an unusual record of accomplishment in design and construction of such a bridge.

Personnel

The engineers directly responsible for the design and construction of the bridge were: John O. McWilliams, county engineer; W. E. Blaser, county bridge engineer; Fred L. Plummer, chief designing engineer; and R. W. Deitrick, chief resident engineer. Wilbur J. Watson served as consulting engineer to the Board of County Commissioners until his death. Legal and financial aspects of the project were handled by Joseph F. Gorman, James S. Reynolds, and John F. Curry, county commissioners of Cuyahoga County.

The principal contracts for construction were executed by the following firms: Lombardo Bros. Construction Co. of Cleveland, river piers and parts of the east approach; Sam W. Emerson Co. of Cleveland, west approach and part of the east approach; A. J. Forschner Construction Co. of Chicago, principal land piers; R. C. Mahon Co. of Detroit, steel superstructure; and National Engineering & Contracting Co. of Cleveland, the east approach and the Lakefront Ramp.

65,000 Yards Daily at Hansen

***Contents in Brief*—Compaction 95 per cent perfect was attained with a fleet of fifteen large carrying scrapers, working at record speed. Job equipment valued at $1,250,000 made it possible to place a 14,700,000-cu. yd. fill at bid prices averaging 20.7c. per cu. yd.**

NOTABLE SPEED in making a dry fill, experiment with novel equipment and a record for success at low unit prices mark the approach to completion of Hansen Dam, a 14,700,000-cu. yd. flood control structure on Tujunga Wash, a major tributary of the Los Angeles River. Easily the world's largest dry fill dam (100 ft. high, 9,500 ft. long), special interest has been focused on the job because of the low bid on earth handling which amounted to 20.7c. per cu. yd., average, in the fill. This figure included excavation and transportation of the material (14.2 to 14.5c. per cu. yd.) and a charge for placement in the dam ranging from 2c., where no artificial compaction was required, up to 6.5c. in impervious zones where specifications required spreading, moistening, and compaction by eight passes of a sheepsfoot roller. The intervening classification (where material was flushed with a hose) was bid at 4c. per cu. yd. Of the total volume 9,825,000 cu. yd. is in impervious zones and 4,875,000 cu. yd. is in pervious zones. Contract price, including change orders, will exceed $7,000,000. Design features and construction methods were described in *Engineering News-Record*, June 22, 1939, p. 846 and July 6, 1939, p. 10.

With such a low price per cubic yard, the only prospect for profit to the contractor lay in a highly efficient program of operation. Accordingly, equipment valued at about $1,250,000 was assembled and the job mechanized to a high degree in all departments. Two new types of equipment here tried out for the first time in large scale operations were the dragveyor and the Tournapulls. The former, a device for loading dump trucks, was used until many boulders were encountered in borrowpits. These resulted in so much lost time that the conventional method of loading with power shovels was resumed. The Tournapulls, on the contrary, were used continuously throughout the job, excavating and hauling impervious material, and contributed much to the speed with which the work progressed. These are motive power units mounted on a pair of large pneumatic tires designed to pull carrying scrapers at higher speeds than would be possible with a tractor. Thus this new equipment competes on a speed basis with motor trucks.

On this job the Tournapull-scraper combination averaged about 12 to 14 mph fully loaded and 16 to 18 mph empty, on level hauls. In climbing the grades to the higher lifts, the speed, loaded, was reduced to 6 or 8 mph. Tires on the Tournapulls are 24 x 32 size (80 in. outside diameter), carry 70 lb. of air pressure and cost about $1,500 each. With 15 of the Tournapull-carrying scraper units on the job, the rate at which earth was spread in 6-in. layers (and com-