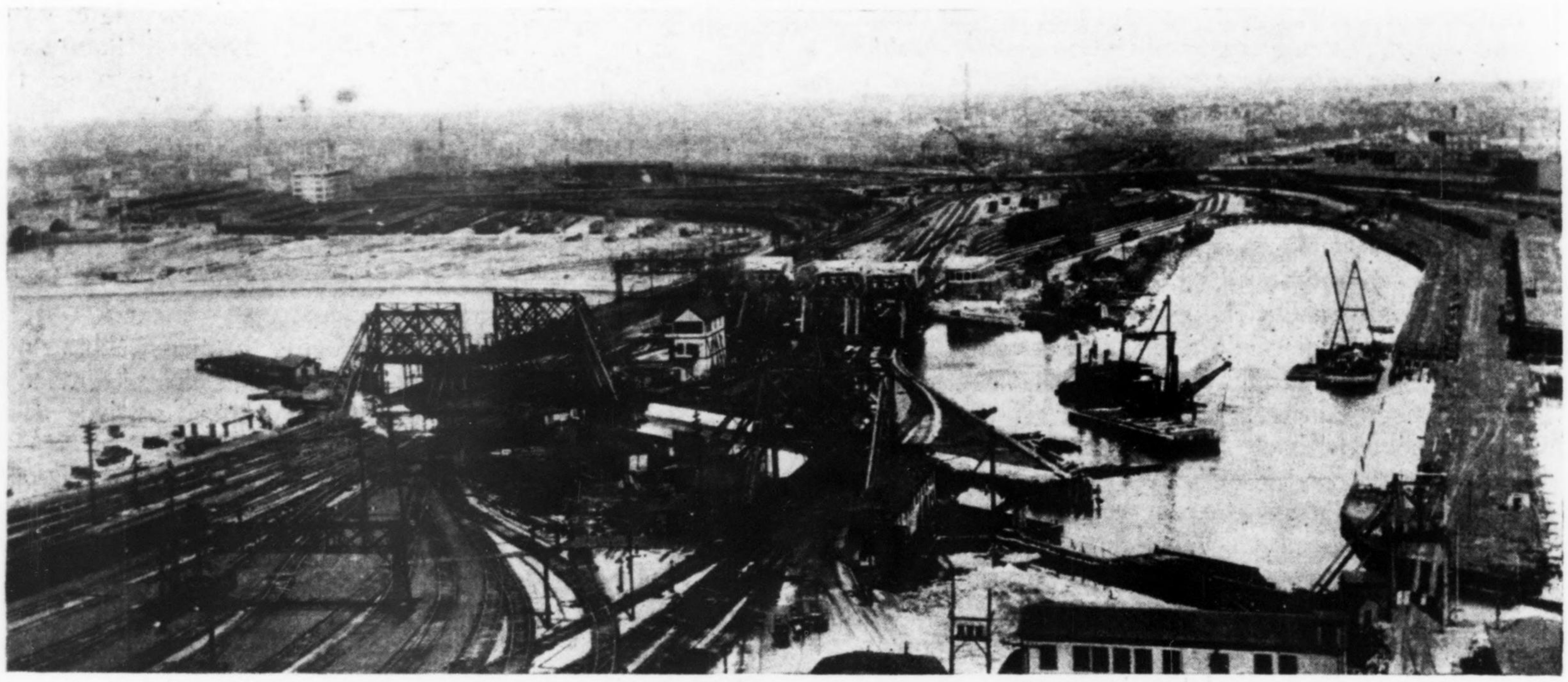


Fig. 1—Old bridges giving way to new structures, B. & M. terminal, Boston

Three of the old jack-knife draws are shown in foreground. Three of the ultimate four new bascules appear behind them. Trestle at extreme right is being removed to provide approach to the ship channel.

Rare Old Bridges Replaced in B. & M. Railroad Terminal Improvements at Boston

Six jack-knife-type structures dating back to 1835 give way to four single-leaf bascules—65 acres of trestle work removed—Construction and track changes carried on under heavy train traffic

SIX OLD-TIME true jack-knife movable bridges, probably the last of their rare type in the country, and nearly 3,000,000 sq.ft. (65 acres) of open trestle work have given way to modern structures and fills in the final step of the Boston terminal improvements made by the Boston & Maine Railroad. Four of the old bridges, spanning the Charles River, have been replaced by four single-leaf double-track bascules over a new channel; the other two, over Millers River, have been eliminated by a fill confining the stream to three 72-in. pipes 1,000 ft. long. A million and a half cu.yd. of fill now takes the place of the huge expanse of open trestle work formerly carrying the yard tracks adjacent to the passenger terminal.

All of the new construction, with accompanying multitude of track changes and shiftings, was carried on under the heavy traffic of 348 scheduled trains per day, all double moves because of the stub-end passenger terminal, making a total of 1,110 scheduled movements in and out of the terminal daily.

These changes are but a part of the terminal improvement program that has been under way for four years. The new North Station has been built with the novel inclusion of a coliseum, the Boston Garden (*ENR*, Feb. 28, 1929, p. 339). New freight yards, including an automatic hump layout, new coach yards, and a new 50-stall engine terminal are all included in the improvement program.

Originally the four main lines of the B. & M. Railroad that now enter North Station consisted of individual railroads, each with its own passenger station in the vicinity of the present terminal. These were: the Boston & Lowell Railroad, now the New Hampshire division of the B. & M.; the Eastern Railroad, now the eastern main-line route to Portland via Portsmouth; the original B. & M., now the western main-line route to Portland via Dover; and the Fitchburg Railroad, now the Fitchburg division of the B. & M. Each of these original roads had its own bridge over the Charles River; and two, the B. & M., and the Eastern, crossed the Millers River on similar structures. The locations of the old bridges, at the time of dismantling are shown in Fig. 3.

A brief history of each structure follows, the numbers corresponding to location numbers shown in Fig. 3.

All of the drawbridges, with the exception of the Boston and Lowell bridge (No. 5), were reconstructed about 1893 when the original North Station was built. The general line of these draws in Charles River was fixed, and their locations slightly changed in the year 1870. The Millers River bridges were altered about the same year. Before that time each railroad had its own bridge, built without much reference to the location of the other structures.

Drawbridge No. 1, Charles River—This bridge is approximately in the same position as the double-track bridge built in 1853, leading into the old Eastern Railroad station on Causeway St., and the two-track bridge built in 1856, leading into the first Boston and Lowell Railroad station on the same street. In final years this bridge carried eight tracks, and most of the passenger trains in and out of North Station were handled over it.

Drawbridge No. 2, Millers River—This bridge was approximately in the same position as the old Eastern Railroad bridge built in 1853. The Boston and Maine and Fitchburg railroads used in later. It was removed in 1927, when the channel was replaced with pipe conduits.

Drawbridge No. 3, Charles River, and Drawbridge No. 4, Millers River—These bridges are on the location of the Boston and Maine Railroad Extension Co. of 1844. Improvements were made on them in 1869 and again in 1887. Bridge No. 4 was eliminated by the installation of pipe conduits.

Drawbridge No. 5, Charles River—This was the Boston and Lowell Railroad bridge. The original bridge was authorized in 1832 and was opened to traffic June 26, 1835. The bridge was used for both passenger and freight traffic until 1857, from which date it was used for freight only. Between 1835 and 1905 various alterations were made to the old bridge. When the Charles River dam was built (about 1905) the old bridge was removed to a point downstream from the original location.

Drawbridge No. 6, Charles River—This was the old Fitchburg Railroad passenger bridge, originally built about 1847 for two tracks. A third track was added later, these tracks leading directly into the old Fitchburg Railroad stone passenger station on Causeway Street. In later years this bridge carried but one track.

In general, the original design was adhered to in altering the old bridges from time to time. Each track rail was carried on an independent girder, hinged on a vertical pin at one end. The girders, connected by S-shaped struts, were unequal in length to permit folding. The opposite end of the girders rested on shoe plates on top of the pier. Usually the girders were assembled in sets of four, carrying two tracks, with one or two sets making up a separate bridge. When a draw was to be opened, cables passing over a timber frame at the fixed-end pier to a cradle near the free end of the girder lifted each set off the shoe plate. A rack-and-pinion arrangement then swung the girders around clear of the channel, a true jack-knife movement. To the very last cable lifts and swinging racks were air and steam-operated.

Millers River Conduits

One of the first steps in the improvement of the terminal yards was the filling in of the old Millers River channel, no longer used for navigation, extending for 1,000 ft. across the yards, connecting Charles River with the Millers River tidal basin. To provide drainage for the basin, three elliptical concrete pipe conduits, 68x74 in., were laid in the bottom of the channel before it was filled in. This improvement eliminated the two original Millers River jack-knife bridges (Figs. 3 and 4).

Because of a constant varying water depth from 6 to 16 ft., depending upon the tide, shallow clearance under the bridges and restricted width of the channel at several points, pipe laying by usual methods would have been difficult. Instead, the contractor floated and sunk the pipe in multiple sections into place, a procedure made possible by the use of an ingeniously devised collapsible wooden bulkhead placed in the end of sections of pipe. Three parallel lines of pipe, of four to twelve 6-ft. sections of pipe, were built up on a raft. The assembly was towed to place and sunk with the aid of a falling tide and by flooding. Although the pipe was the bell-and-spigot type, special end sections with part of the bell removed permitted the pipe lines to be dropped vertically into place, tight against the adjoining lines already in place.

When the pipes had been landed, a pull on a line collapsed the bulkheads and brought them to the surface.

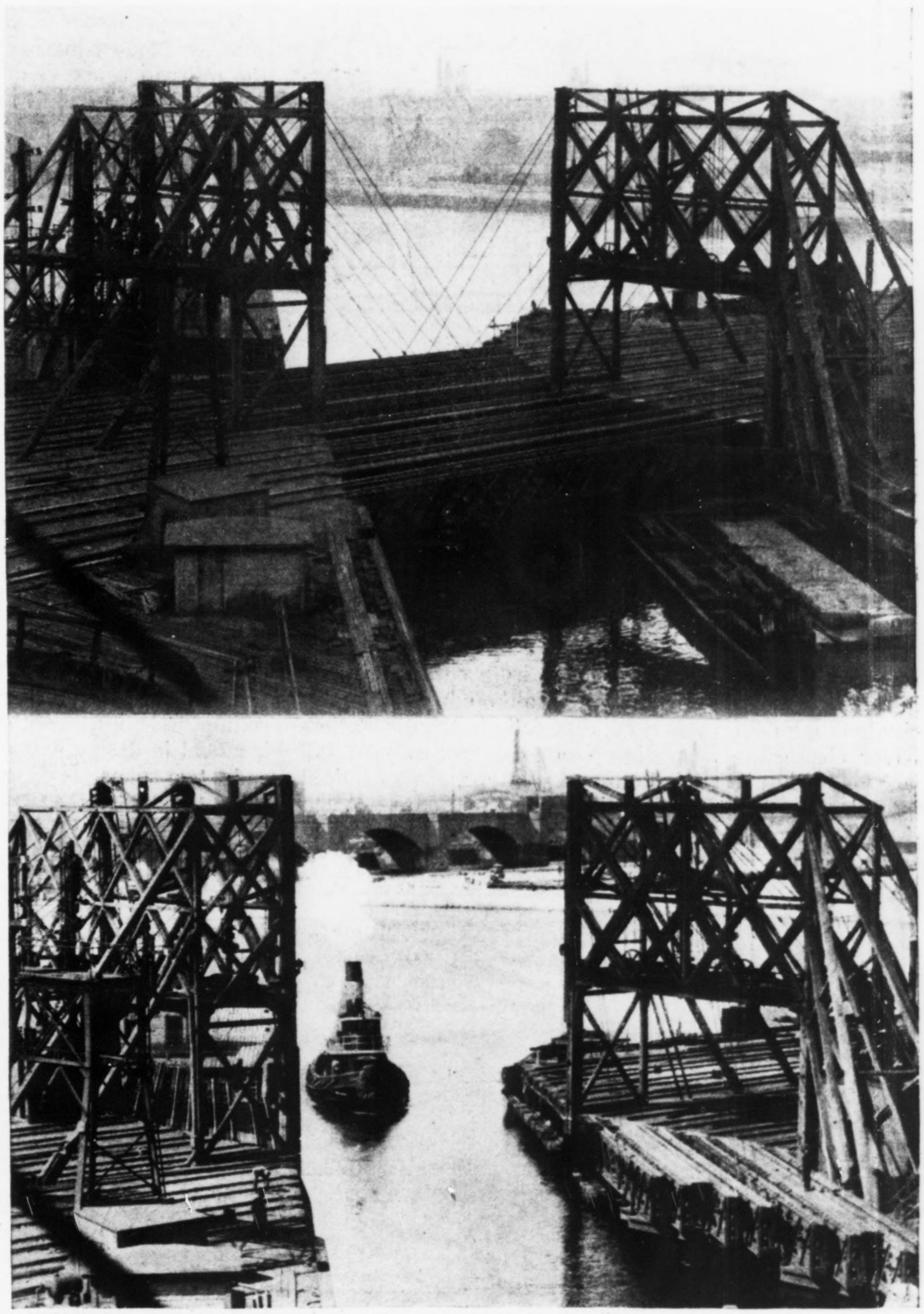


Fig. 2—This type of jack-knife draw has served Boston for 96 years

Two of the old structures over Charles River, which have now been eliminated.

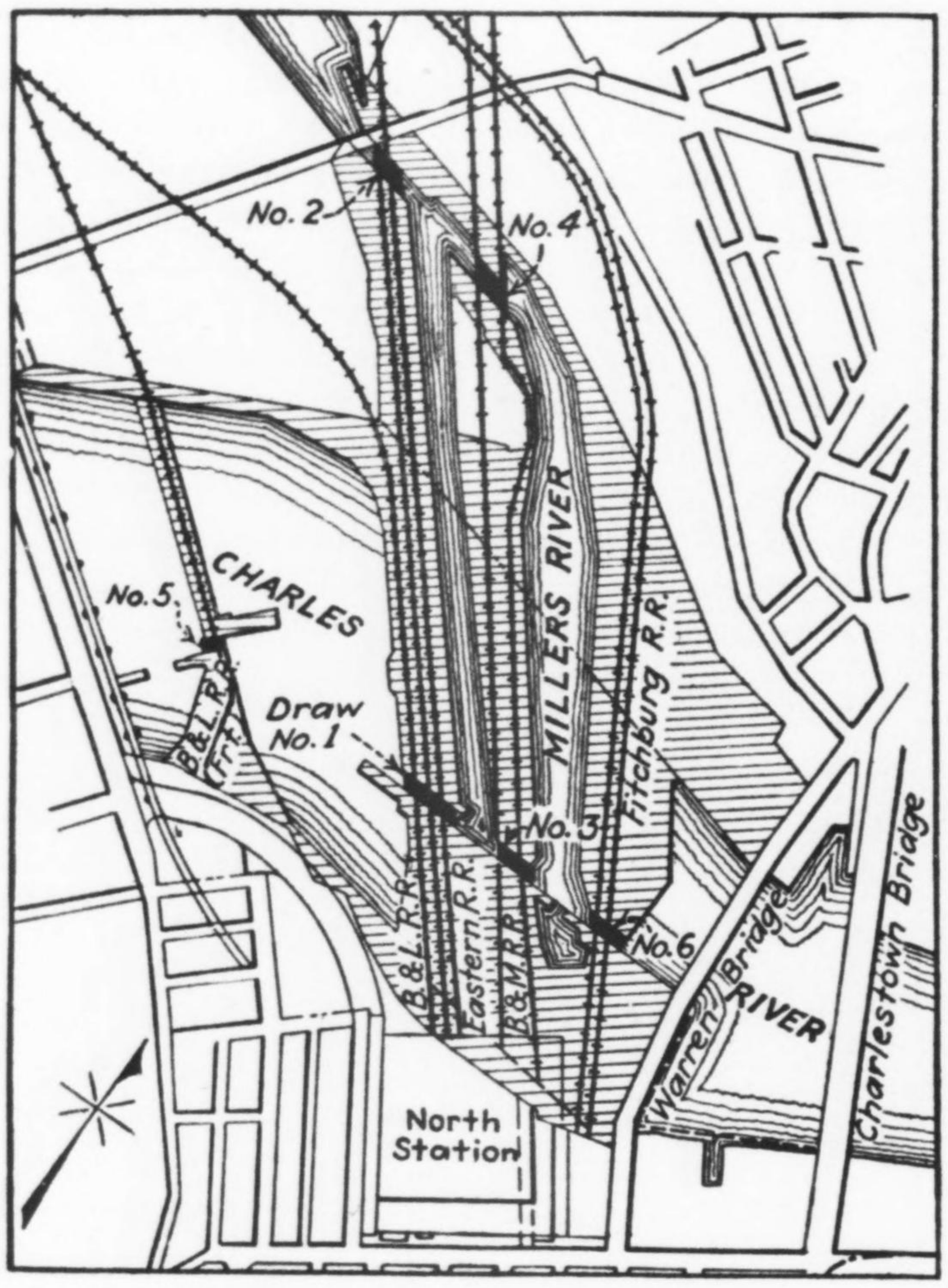


Fig. 3—Location of old drawbridges

The four separate railroad lines shown are now part of the Boston & Maine system. Original trestlework indicated by shading.

Flooding of the pipes was controlled by a small valve in the bulkhead, operated by a rod extending above water. Previous to laying the pipes, the channel bottom was leveled off with a bed of gravel. The raft timbers were not removed, being left in place as a cradle to hold the pipe lines to permanent grade and alignment.

Filling and Channel Changes

Filling-in of the old trestle work was begun in 1928. Most of the filling material came from cutting down a hill adjacent to the freight yards, although considerable city building debris was used, especially in the old Millers River channel. Excavation from the freight-yard hill was loaded into gondola dump cars. Material was sluiced into place by a jet from an old fire-engine pump. When the fill approached grade, clamshell buckets were used for unloading.

The results of years of maintenance on the old timber trestles can be seen from Fig. 7. No treated timbers or piles had ever been used. Piles had steadily deteriorated, requiring frequent building up, until several feet of blocking and cribbing were piled on top of the caps. Such structures became difficult and expensive to maintain. In the filling process the timber blocking was removed, but no piles were pulled.

Prior to the start of the improvement program the Charles River occupied a wide waterway through the trestle work, although its navigation channel was but 35 ft. wide from fender to fender. The original Fitchburg Railroad approach had been converted to industrial lead tracks, carried on trestles separate from and east of the main yards. These tracks were eliminated in the improvement, the old trestle torn out and not replaced by a fill.

The old Charles River channel was entirely too narrow for modern navigation requirements. It cut across the railroad property on a sharp skew for a distance of 450 ft., being located adjacent to the terminal trainshed. A new navigation channel 65 ft. wide was dug some distance north of the old channel, far enough away from the station proper to allow the terminal tracks to converge into eight main leads crossing the four new bridges. As these bridges are side by side, the new channel is only 110 ft. long, with one 50-ft. wing fender on each end. Removing the old Fitchburg Railroad trestle now provides a wide approach to the channel from the east or bay side.

Changing the channel location also permitted the construction of the four new bridges clear of the old bridges and channel. New U. S. pierhead and bulkhead lines established an open waterway 375 ft. wide through the railroad property. Outside of the main bridge structures the tracks are carried across the waterway on new timber trestles, all piling and timbers being creosoted. Fig. 4 shows the area of the old trestles removed, the limits of the new fills, the old and new channels, the new waterway, the location of the new bridges, and the Millers River conduits.

Design of New Bridges

The four new bridges are double-track, single-leaf, rolling bascules, with skew ends (Fig. 5). They are identical in design except for length and degree of skew ends, two spans crossing the channel at a slightly greater skew than the other two. The spans are made up of through-trusses, 31 ft. c. to c., varying in length from 88 ft. to 118 ft., c. to c. bearings.

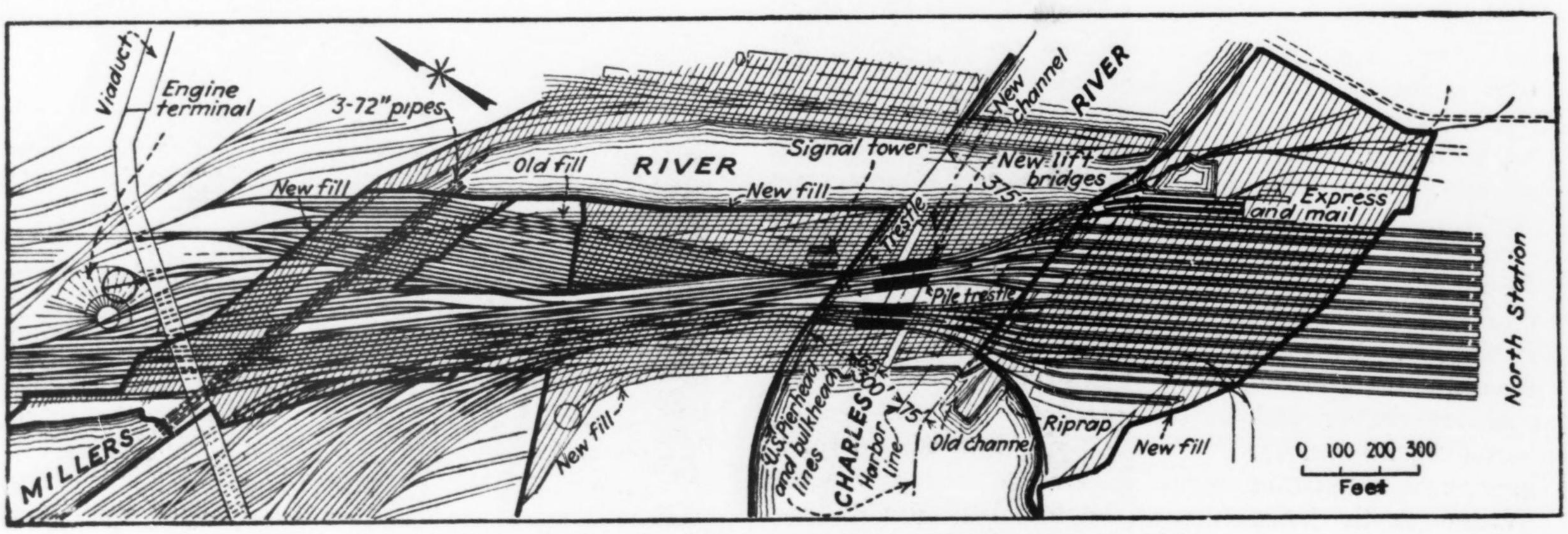


Fig. 4—General plan of terminal yards after improvements were made

Extent of old trestlework, now all removed, shown by cross-hatching. Limits of new fills shown by heavy lines.

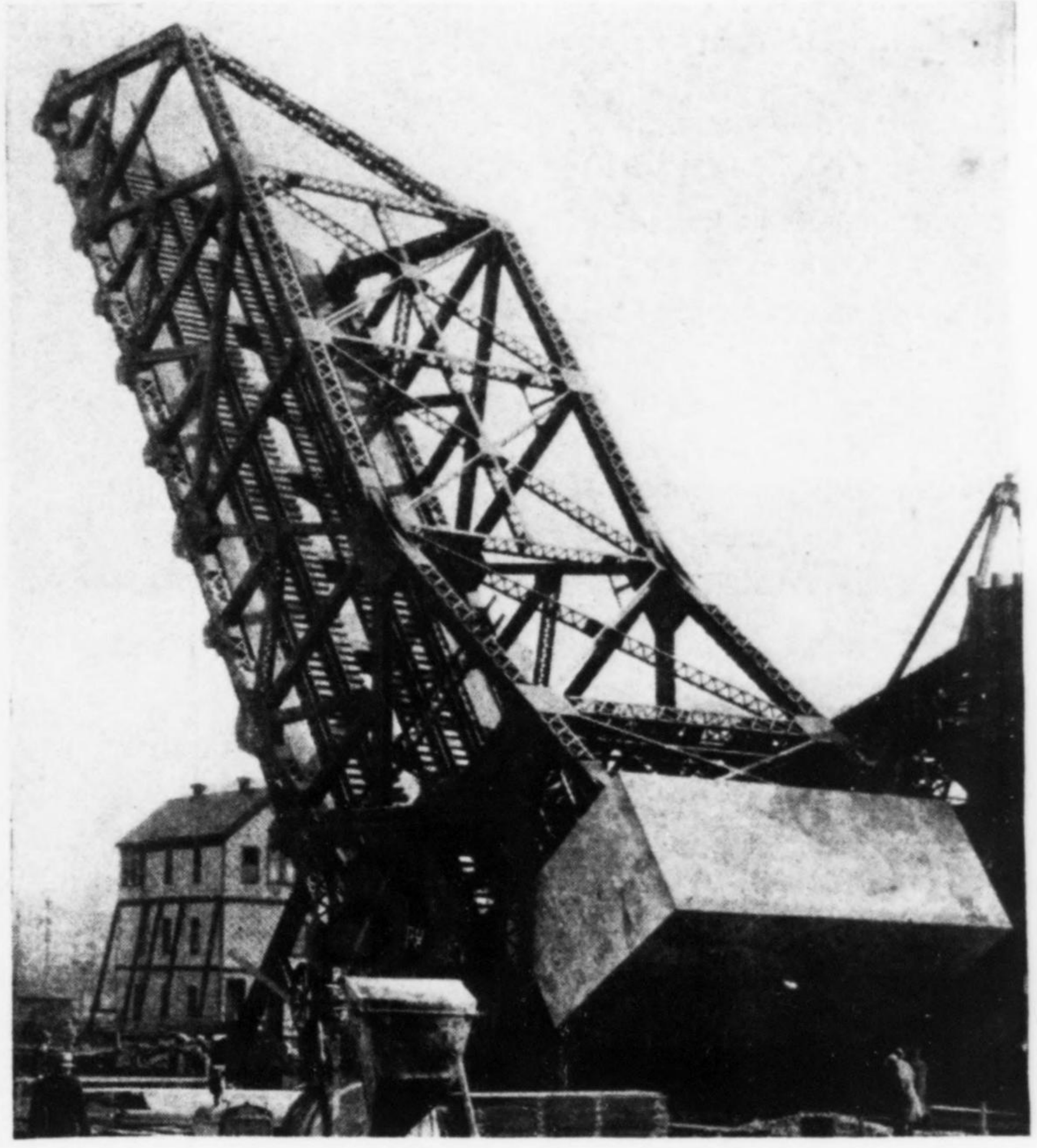


Fig. 5—One of the four new bascule spans

Each span carries a single 629-ton overhead counterweight, made up of concrete loaded with steel punchings, weighing from 148 to 290 lb. per cubic foot. In addition, each counterweight is provided with 45,000 lb. of removable concrete blocks, weighing 183 lb. per cubic foot, for adjusting purposes.

All erection was done with two locomotive cranes, working alongside the spans, which were erected on falsework. The railroad company's wrecking crane assisted in handling several girders weighing 58 tons each. Dimensions of the bridges are shown in Fig. 6.

Both the trunnion and rest piers are founded on circular caissons, from 6½ to 9½ ft. in diameter, sunk in the open 35 to 53 ft. deep. In three cases two of these circular caissons were combined into 8x20-ft. caissons.

Track Changes and Schedules

A carefully planned schedule of track changes provided for two major and ten minor shifts. The first major shift was made to permit the construction of the new spans. During the second major shift the new channel was dredged out, the old channel filled in, new trestles built and the tracks placed in final position across the new bridges. The river was closed to navigation for five days at this time. Besides these two main moves there were ten general shifts, all scheduled in advance to the smallest detail. During these changes, the tracks were shifted from trestles to fills. In addition to the general moves, individual tracks were constantly being changed. Despite the many track changes, full signaling and tower-control equipment was maintained at all times. A special train master was assigned to the work of coordinating track moves, train movements and the various construction operations.

The final track layout provides for 23 stub-end tracks at the terminal station. These converge into eight across the new bridges, then spread out into four double-track main lines, through coach and suburban coach yards, and an engine terminal yard. All curved rail, including the switch leads, in the terminal yards is 130-lb. heat-treated steel. These rails were bent, drilled and marked at the mills for specific locations. All frogs are solid manganese, self-guarded.

One new interlocking tower controls all switches in the terminal yards. This tower, of brick and steel, replaces an old frame structure. It was necessary to move the old tower 35 ft. without interrupting service. About 35 ft. of slack was cut into each of the 640 wires leading from the tower. The building was then jacked up, skidded to another location and operated until the new tower was completed. All signals in the terminal yard are the color-light dwarf type, electric-pneumatic operated. Signal and switch stands are concrete, precast by the railroad at its Concord, N. H., concrete plant.

Personnel

Engineers—The entire terminal equipment is under the direction of W. J. Backes, chief engineer of the B.&M. Railroad. W. F. Cummings, assistant chief engineer, is in charge of design. H. F. Fifield, engineer maintenance-of-way, T. G. Sughrue, division engineer, and J. F. Talbot, track supervisor, were in direct charge of the work for the railroad. E. W. Wiggin, New Haven, is consulting engineer for the B.&M. The

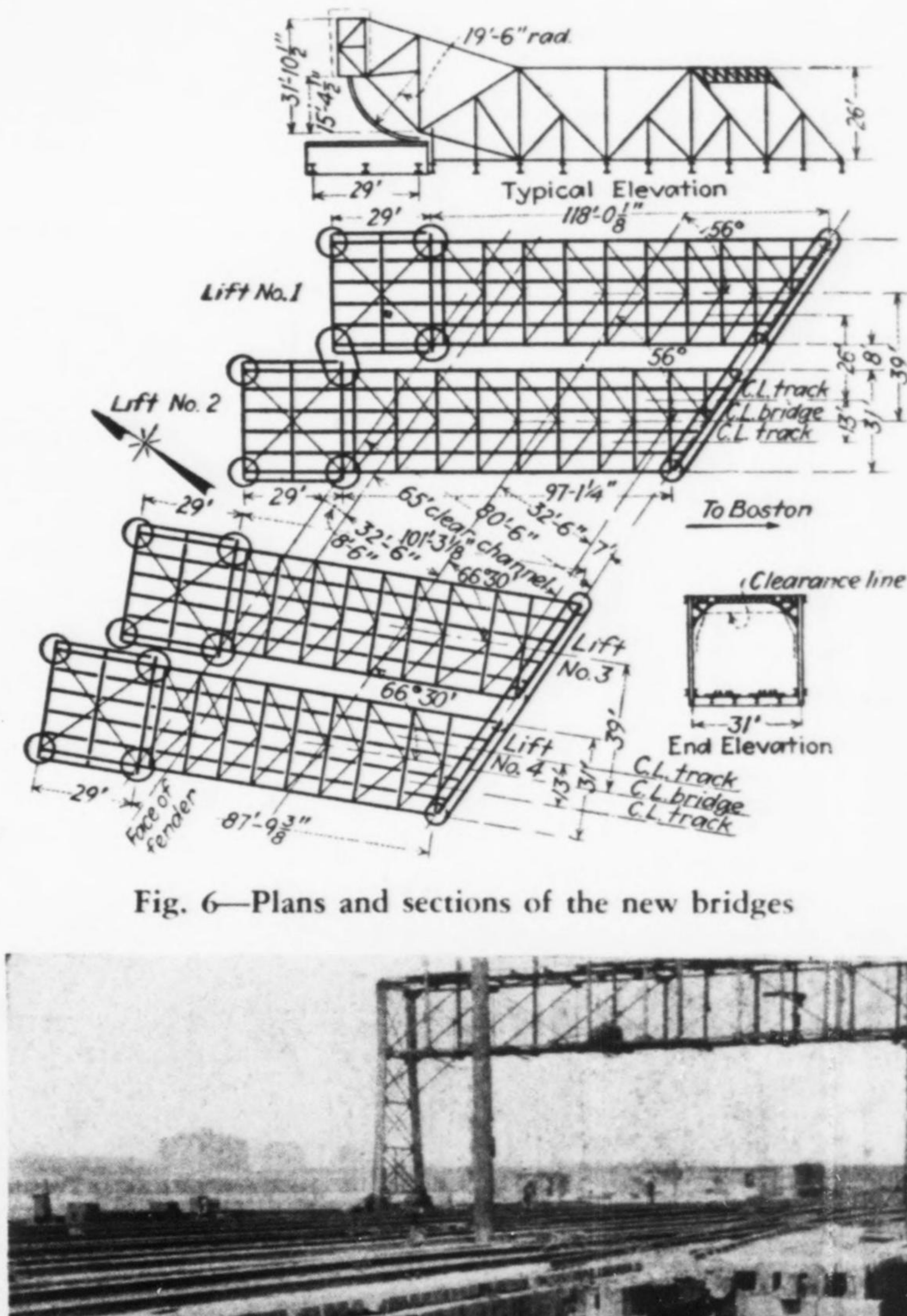


Fig. 6—Plans and sections of the new bridges

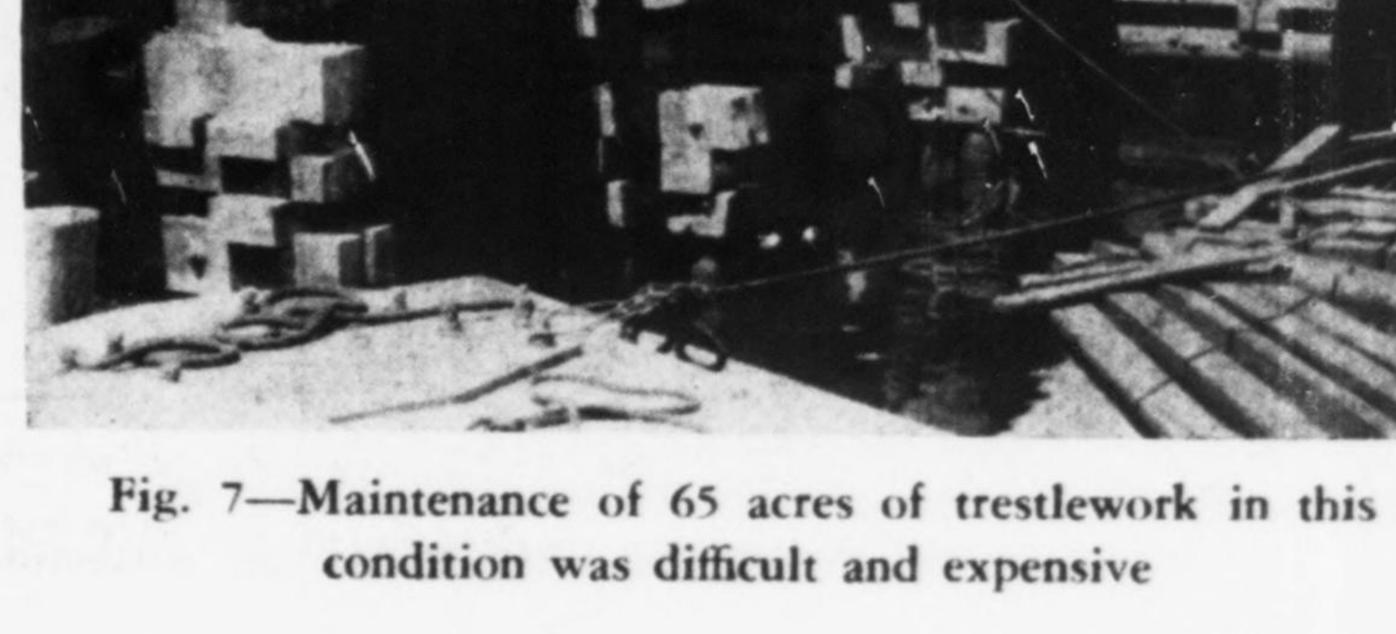


Fig. 7—Maintenance of 65 acres of trestlework in this condition was difficult and expensive

bascule bridges were designed by Keller & Harrington, Chicago.

Contractors—All channel dredging was done by the Bay State Dredging Co. The Phoenix Bridge Co., Phoenixville, Pa., furnished and erected the bascule spans, under the supervision of W. C. Bearce. The contracts for the Millers River conduits, the new bridge substructures and concrete seawalls, and new pile trestles were held by T. Stuart & Sons Co., Boston, with F. H. Stuart in charge.

Blotting Paint With Sawdust Cuts Striping Costs

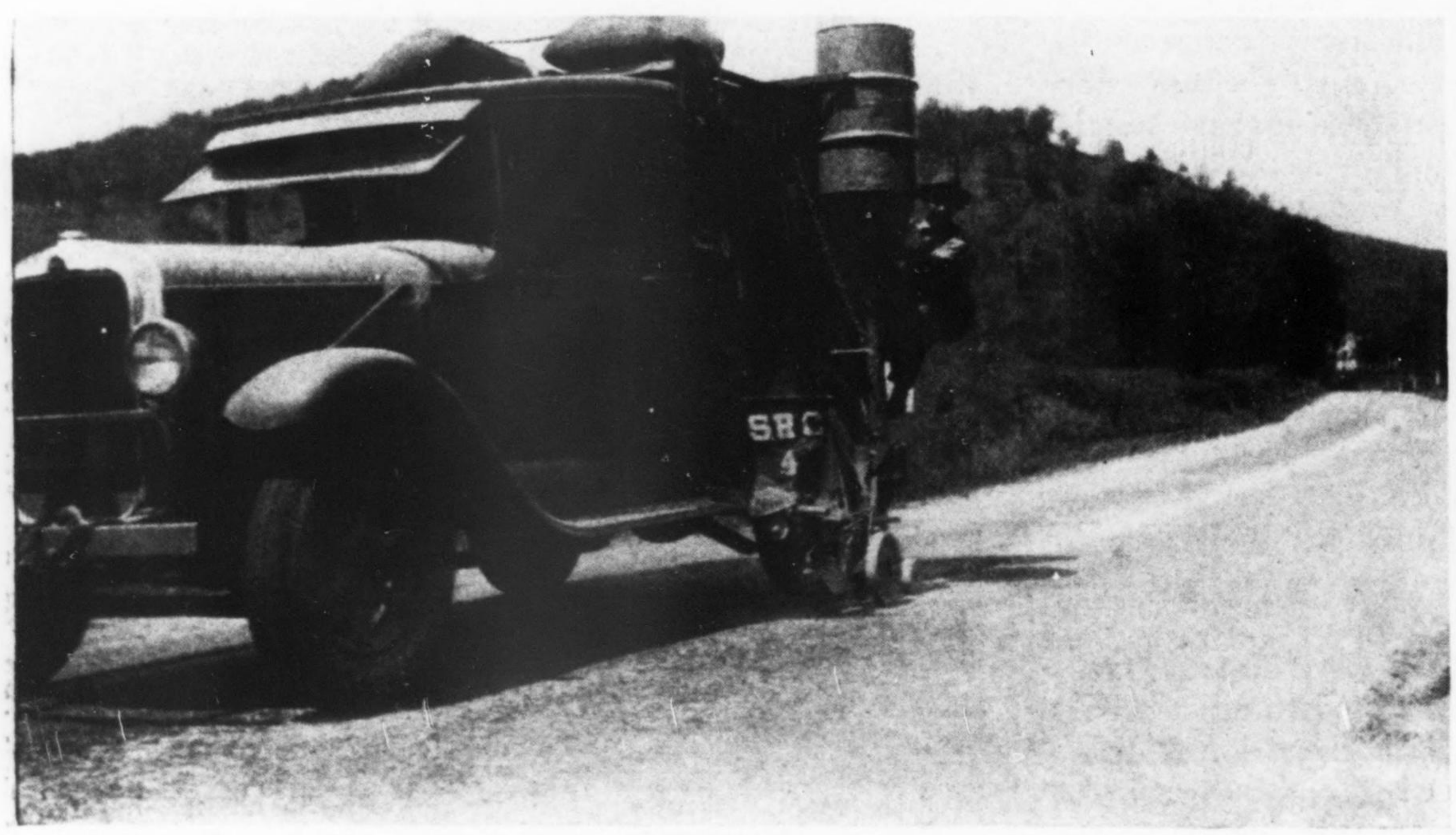
New device sprinkles sawdust behind sprayer nozzle—Counter measures length of stripe painted

By A. K. ERB
Senior Assistant Engineer, District Four, State Road Commission, Clarksburg, W. Va.

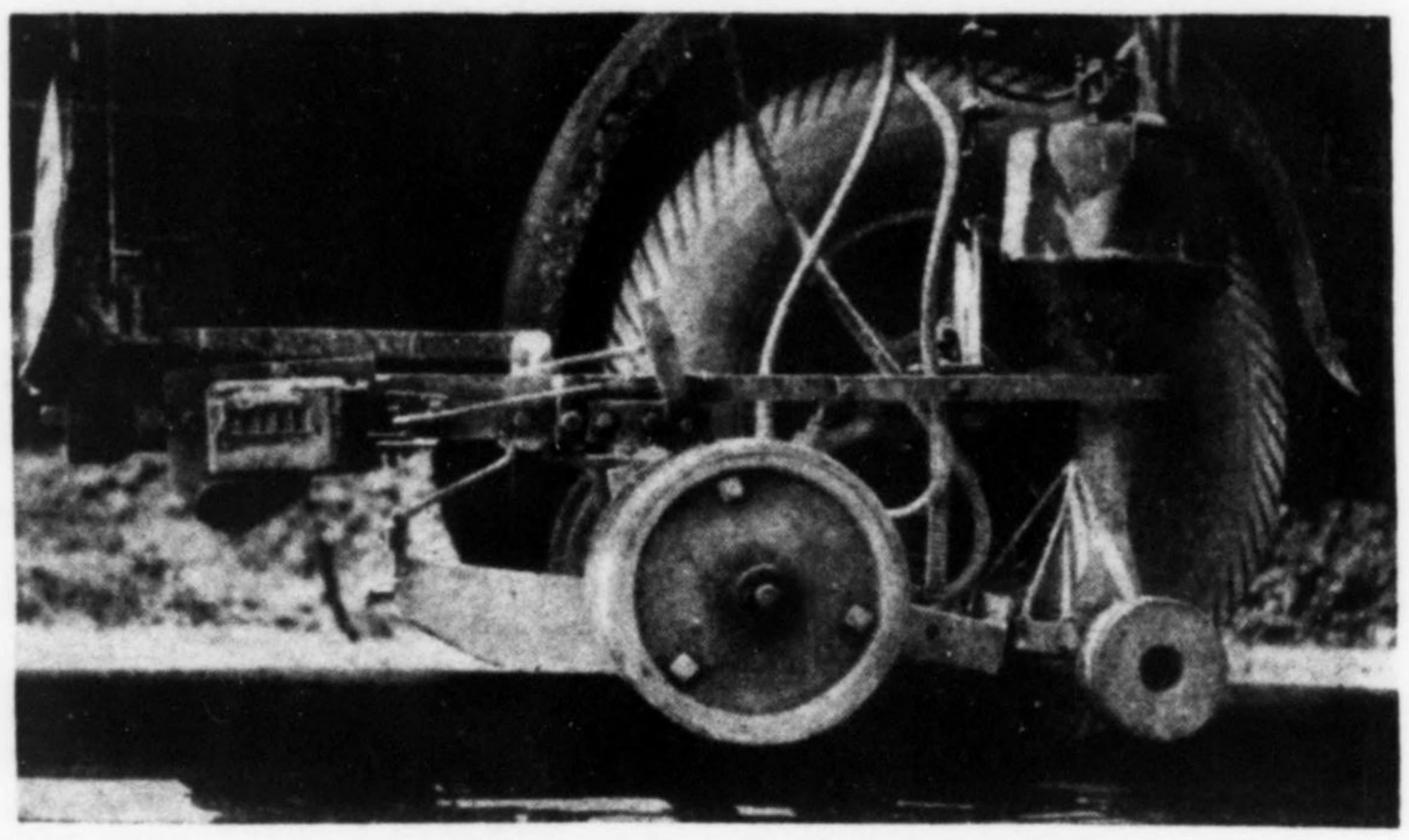
A NOVEL method of highway striping was developed in District 4 of the West Virginia state road commission during the early summer months of this season. The unique features include an automatic device for blotting the stripe with sawdust immediately following the application of the marking paint, and a counter for measuring the linear feet of stripe painted. The method had been to follow the pneumatic striping machine, which is a part of the present equipment, with a light truck and two men placing red flags and blocks to guard the stripe until the paint had dried.

The sawdust blots the paint sufficiently to allow traffic to cross or drive upon the stripe without causing excessive smearing and has little or no detrimental effect upon the visibility of the line. A comparison of the cost and speed of the two methods is shown in the table.

The averages are for a nine-hour day and include delays incident to weather conditions, breakdowns, etc. The cost of sawdust is added to 1931 costs because it is a cost in addition to the 1930 charges. Equipment rentals for 1931 are presumed to be identical with those of 1930, which is sufficiently accurate for the comparison.



Stripe painting truck fitted with sawdust blotter



Working parts of paint spray and sawdust blotter

Further study of the efficiency of the machine, made possible by the attachment to the truck of a recording device that makes an indelible record of the time spent in actual operation, reveals that the possible peak production may be increased to nearly three times the average shown for 1931, this efficiency being possible without appreciable increase in labor and equipment cost. The addition of a mechanical device for stirring the paint and an additional spray gun attached to the striping machine is expected to accomplish the desired result.

COMPARISON OF COST AND SPEED OF TWO METHODS

1930 Organization	
1 1-ton truck and operator	$9.30
1 highway striper and operator	8.25
1 ½-ton truck and operator	6.20
2 laborers	6.30
	$30.05
Average day's work	14,000 lin.ft.
Labor and equipment cost	$0.00214 per ft.
1931 Organization	
1 1-ton truck and operator	$9.30
1 highway striper and operator	8.25
250 lb. sawdust at 0.005	1.25
	$18.80
Average day's work	20,000 lin.ft.
Labor and equipment cost	$0.00094 per ft.

The development of the apparatus for distributing the sawdust required considerable experimenting. Three different types of compressed air-operated nozzles were tried and discarded in favor of a mechanically operated screw-type distributing nozzle and gravity feed to the screw. On account of the relatively small apertures that were found to be necessary to prevent the use of an excessive amount of sawdust, it became obligatory to provide some means of controlling the tendency of the sawdust to clog in the feeding chambers. This difficulty was overcome by an agitator in the small funnel directly above the distributing nozzle. The agitator consists of a short piece of $\frac{5}{8}$-in. No. 8-gage flat iron twisted to form an auger and actuated by a vacuum-type windshield wiper. Compressed air is supplied to the windshield wiper from the supply tank of the spray machine. Commercial screened sawdust No. 16 to No. 18 was used to facilitate control further.