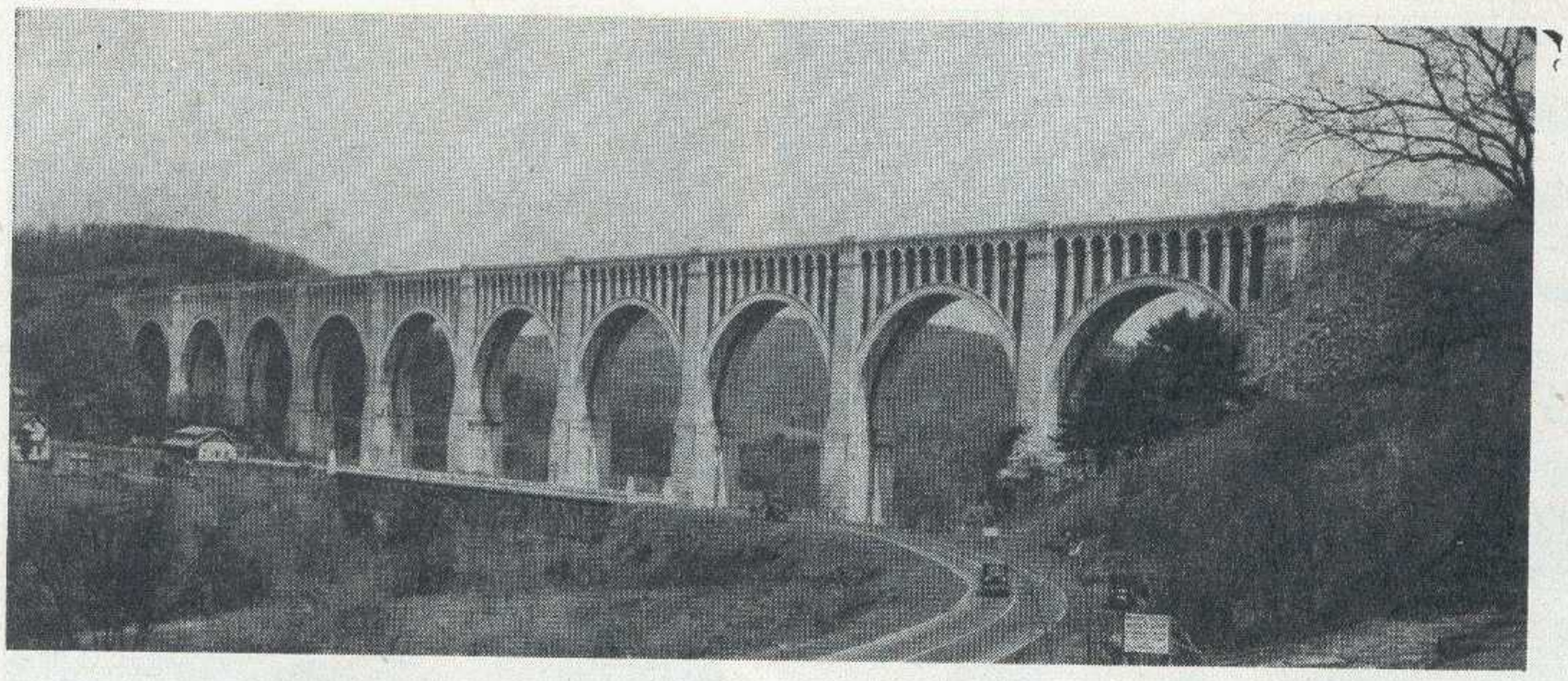
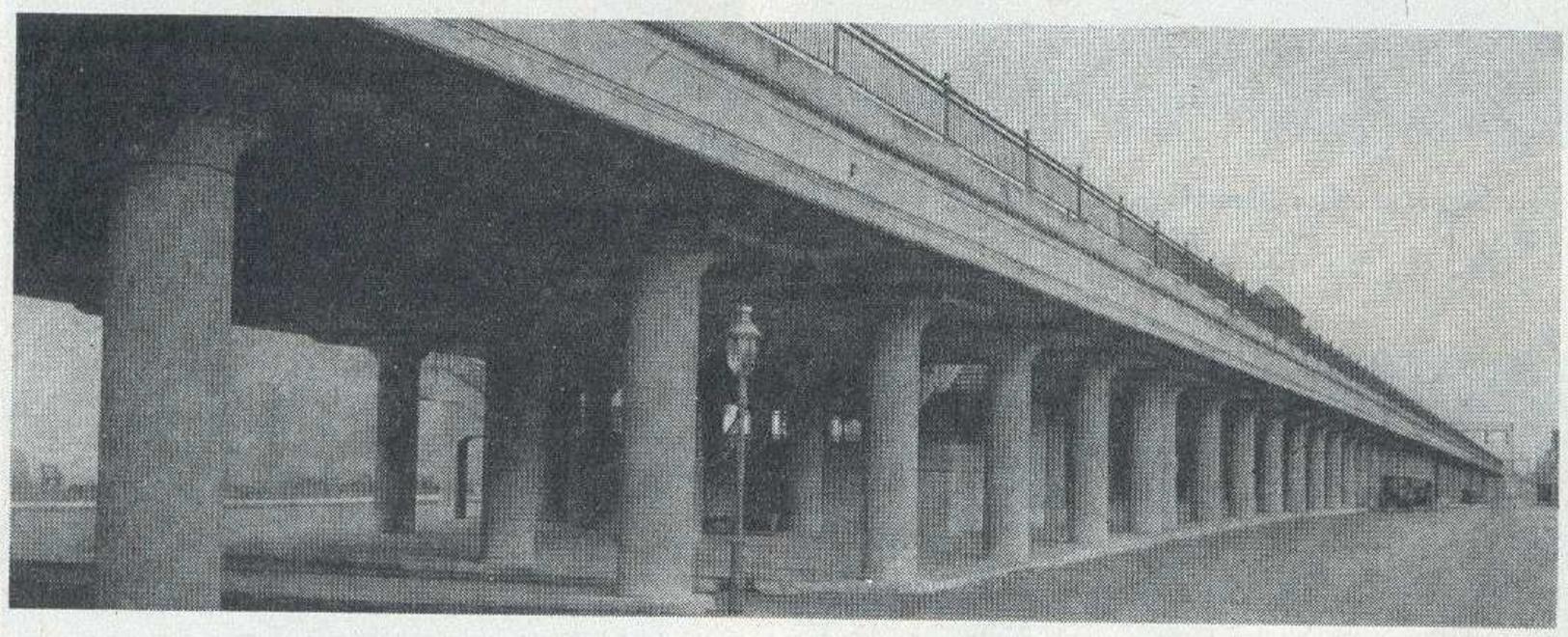


The largest bridge of its kind in the world, the Lackawanna's Tunkhannock viaduct, built more than 35 years ago, was a daring application of reinforced concrete to the construction of a bridge carrying railroad loadings



Taken in 1925, shortly after the structure was completed, and before electrification, this picture shows a section of concrete viaduct at East Orange, N. J., which the Lackawanna built to carry its tracks over many intersecting streets

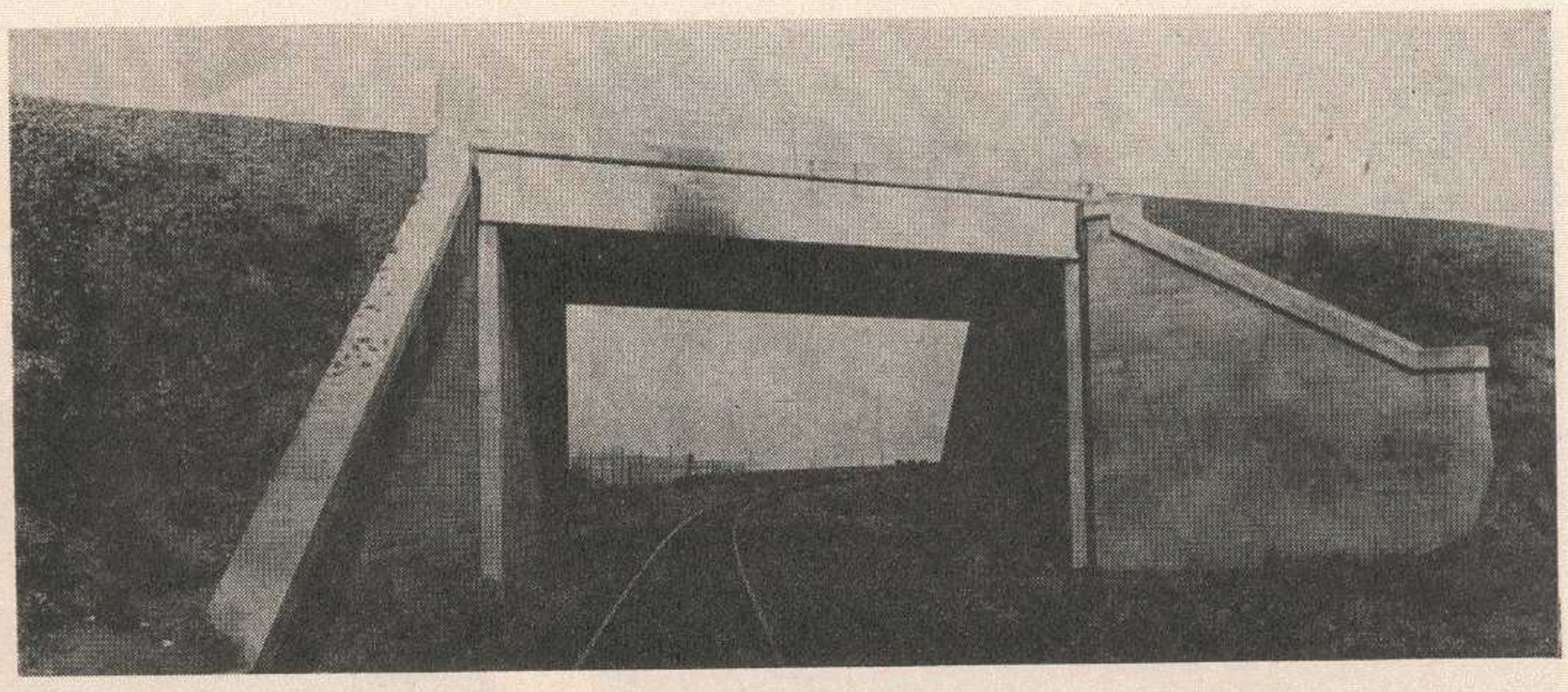
Bold Enterprise Shapes

Engineering Policies on the Lackawanna

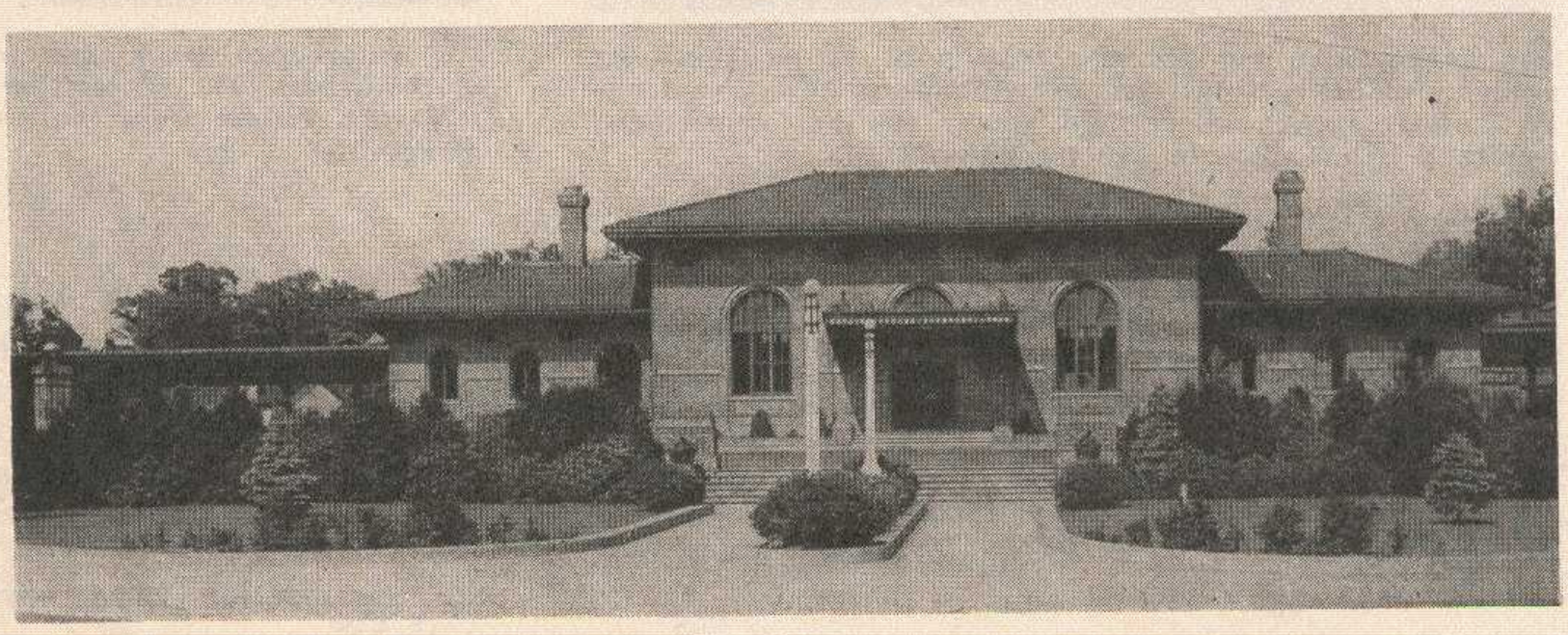
Road has pioneered in design and use of reinforced concrete structures, in construction of attractive stations, and in use of "detour" system and other advanced maintenance practices

In dealing with the design, construction and maintenance of its fixed properties, a railroad has one of two general lines of approach open to it; it can either "drift with the current," adopting new policies only after they have proved their worth in actual practice on other railroads, or it can strike out boldly on its own, blazing a trail for other railroads to follow. Disdaining the "me too" role the Lackawanna has, particularly during the second half-century of its existence, exhibited a spirit of bold enterprise in developing and putting into effect advanced forms of structural design as well as in discarding traditional maintenance practices in favor of new methods and equipment that have frequently been adopted on this railroad first and later taken up by other lines.

One of the fields of engineering in which the Lackawanna has pioneered is the use of reinforced concrete in bridges and buildings. The road's inclination to use this material became apparent early in the twentieth century. The first large-scale use of reinforced concrete in buildings was in the roof and floor of the locomotive shops at Kingsland, N. J. Somewhat later, in 1906-08, similar construction was used in the shops at Scranton, Pa. The Lackawanna also pioneered in the use of reinforced concrete in construction of low umbrella-type train sheds with openings over the tracks to carry off smoke and steam from locomotives. Known as the Bush-type train shed, the first of these was built at Hoboken, N. J., and others were later constructed at Scranton and Buffalo. The Lackawanna also was one of the first railroads to use concrete walls in the construction of docks at tidewater. In these structures the walls rest on timber



Lackawanna engineers pioneered in the design and construction of pre-cast reinforced-concrete slab bridges. A substantial reduction in the floor thickness was effected by using steel reinforcement in compression



That the Lackawanna has long believed in building attractive passenger stations in landscaped settings is shown by this photograph of the station at Morristown, in the North Jersey suburban territory. The picture was taken in 1923

piling and grillages that do not extend above the low-water level, and the spaces between the walls are filled in.

As a pioneer in the use of reinforced concrete, the Lackawanna is most widely known, however, for its concrete bridges and viaducts. Reinforced concrete was first used for this purpose on a large scale in 1908-11 in the construction of the New Jersey cutoff, which incorporates two large viaducts, one over Paulins Kill and the other over the Delaware river.

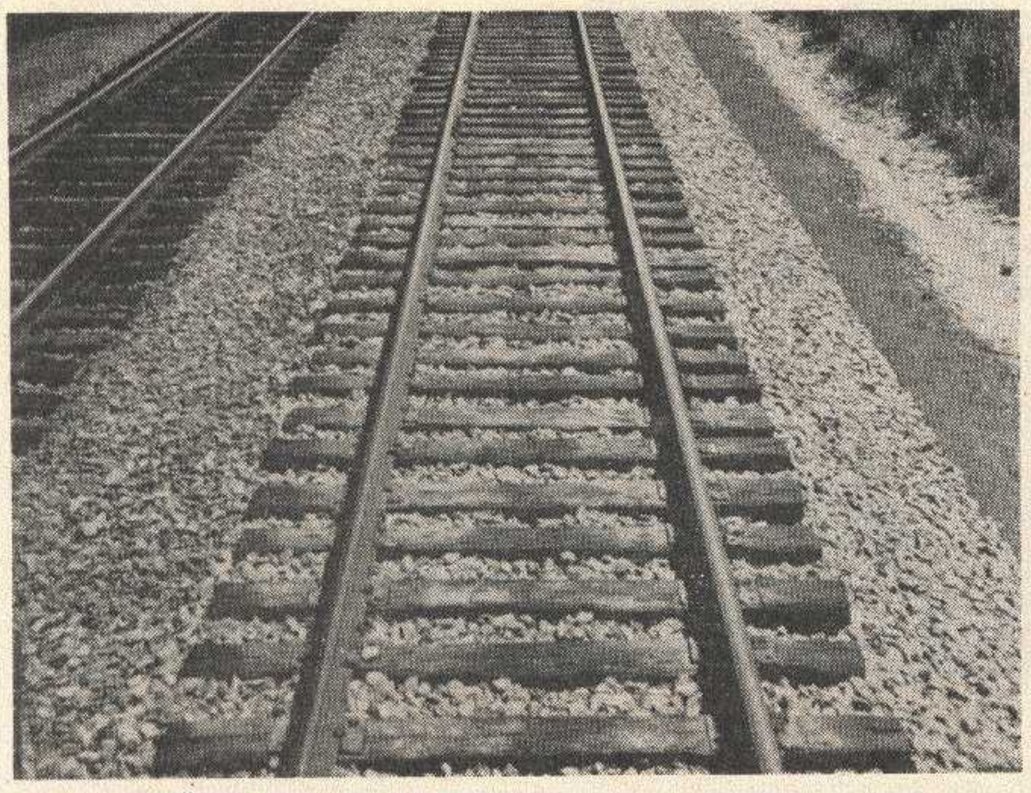
A few years later, in 1912-15, the world's largest concrete viaduct was built by the Lackawanna, namely, the Tunkhannock viaduct, which carries the double-track main line across Tunkhannock creek near Nicholson, Pa. Famous the world over for its size and symmetrical beauty, Tunkhannock viaduct is 2,375 ft. long and rises 240 ft. above the water level. It consists of ten 180-ft. arches and two 100-ft. arches. Each of the arches is surmounted by small superimposed arches upon which the concrete deck of the viaduct is carried. The foundations of the viaduct are carried down to bedrock, approximately 80 ft. below the surface of the ground.

Early uses of reinforced concrete on the Lackawanna included many bridges where the railroad was carried over or under intersecting highways. One of the larger projects of this type was the elimination of grade crossings through the Oranges in New Jersey, where the tracks were elevated on a reinforced-concrete viaduct. In the beginning, the use of reinforced concrete for individual grade-separation structures was limited to situations where the spans were relatively short. To adapt the use of the material to structures where longer spans were necessary, but at the same time keeping the floor depth of the bridges to a minimum, the Lackawanna introduced the flat-slab type of construction. Such use involved two new conceptions in reinforced-concrete design. One was the use of reinforcing steel to overcome compressive stresses in excess of those concrete is capable of sustaining, and the second was the use of a single slab continuous over two spans. Another innovation was precasting these slabs to facilitate and expedite the work of installing them in bridges on existing alinements.

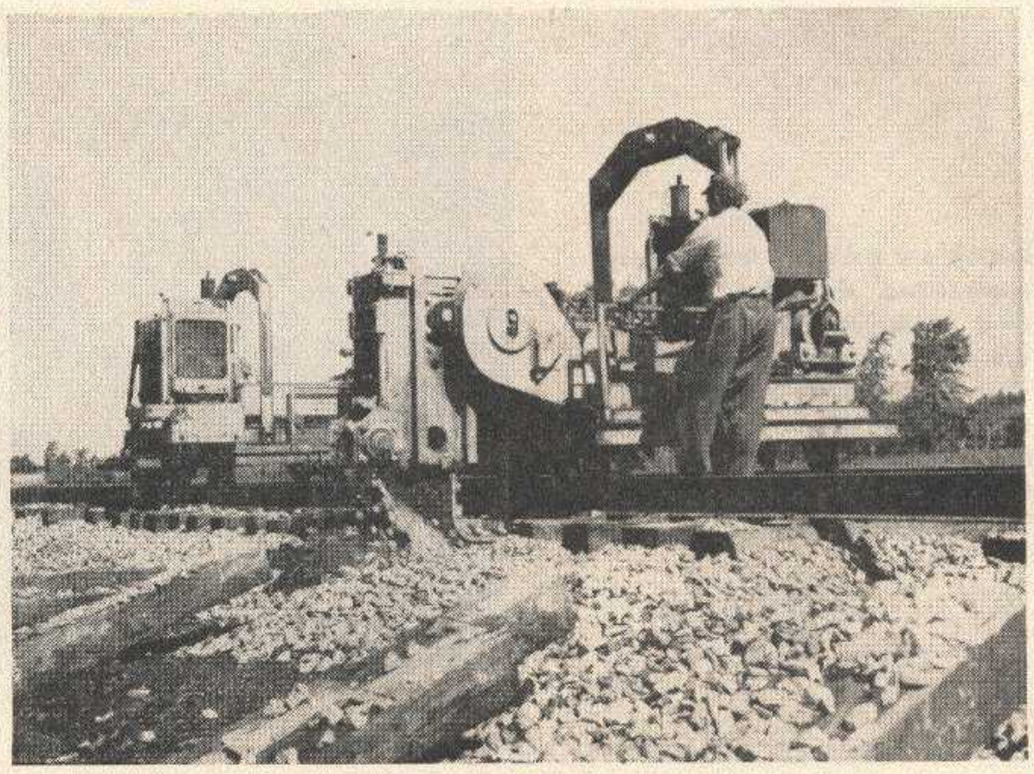
Passenger stations on the Lackawanna have been noted for their beauty and variety of architecture and the permanence of their construction. Especially attractive are many of the stations in suburban territory in New Jersey. Of brick and masonry construction, these structures appear to have been designed to harmonize with their picturesque settings, usually including wooded hills. As part of the scheme to promote the attractiveness of the stations, the property immediately adjacent to each normally consists of well-kept lawns and shrubbery, planned to provide an appropriate setting for the station.

Heavy-Duty Track, Plus . . .

Regarding the character, durability and design of its fixed properties in general, including the track, the Lackawanna has at least kept up with other progressive railroads, and in some instances has adopted practices that are considered in some quarters to be far in advance of the times. With respect to the weight of the rail section, the nature of the ballast and ties, and other parts of the track, the Lackawanna's standard construction



The Lackawanna management was quick to recognize the economy of heavy-duty track construction, with a free-draining ballast section of crushed stone, and has consistently employed it on all main line trackage



All out-of-face track maintenance operations are highly mechanized. This illustration shows two Cribex machines removing ballast from the track to facilitate the insertion of new ties

conforms to the present-day conception of heavy-duty track. Typical heavy-duty main-line track construction on this road consists of 132-lb. rail, six-hole headfree joint bars, double-shoulder "waffle bottom" tie plates, 24 creosoted crossties per 39-ft. panel (the road first started using creosoted ties in 1910) and crushed limestone or trap-rock ballast. Adequate anchorage is provided to maintain the joint gaps in the rails.

The Lackawanna was one of the first railroads to give adequate recognition to the necessity for keeping ballast clean and in a free-draining condition as a means of promoting economy in track maintenance. For many years the road has conducted ballast-cleaning programs every year, the object of which is to clean the ballast in the shoulders and intertrack spaces on the average of once every three years. Distribution of ballast is carried out by means of special ballast-handling cars designed to economize on labor and the use of work train service for this operation.

The Lackawanna also was one of the first railroads to recognize the wisdom of lengthening track sections, and at the same time taking heavy maintenance work out of the hands of section forces and doing it with large specialized gangs. The lengthening of its track sections took place about 20 years ago. Before this was done the road had approximately 263 track sections. The extent to which they were lengthened is indicated by the fact that today it has only 69 sections. Sections in double-track main-line territory at the present time each consist of about 15 miles of road, or, in other words, about 30 miles of main-line track.

Four-Cornered Basis for Efficiency

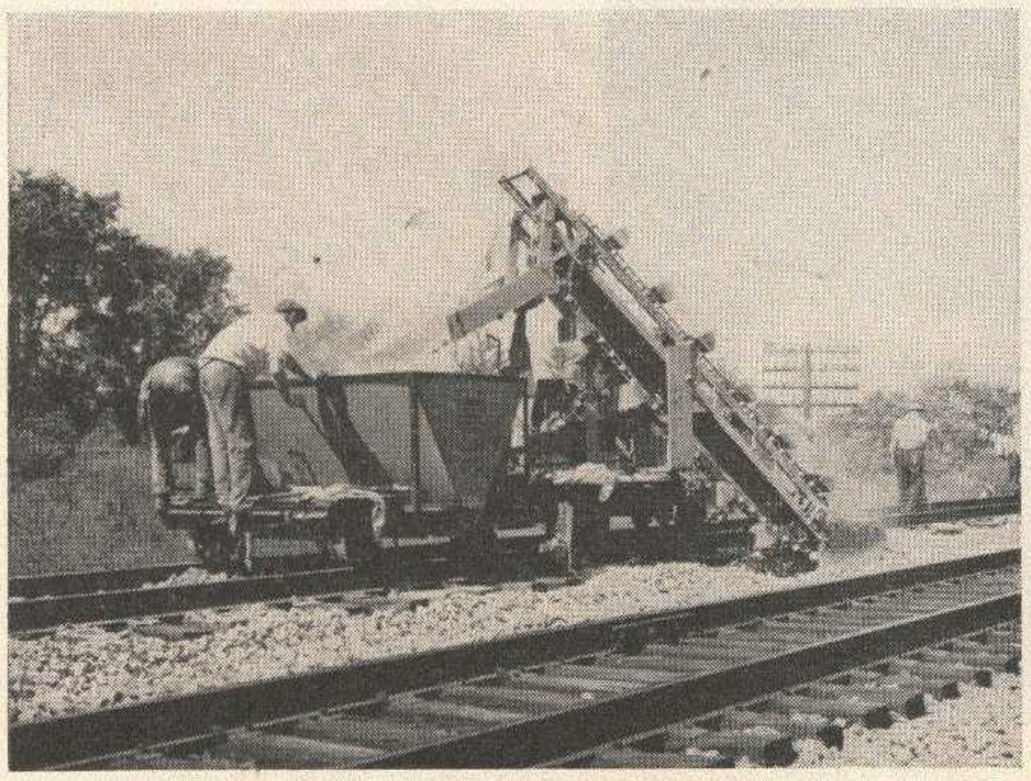
By lengthening its track sections and inaugurating the practice of doing heavy roadway maintenance work by large specialized gangs, the Lackawanna has been able to take advantage of the production-line principle in doing such work. The mass-production methods used are based on a four-cornered foundation, with one corner consisting of a high degree of mechanization, another the extensive use of highway trucks for transportation of track maintenance forces, the third the so-called "detour" system of carrying out heavy maintenance work, and the fourth the detailed programming of all such work on an annual basis.

The conduct of out-of-face maintenance work on the Lackawanna is based on the conception that the only way the work can be done at minimum cost is to make maximum utilization of power equipment. By this is meant not only the use of an optimum amount of such equipment, but also its employment in tightly organized gangs in which each step or operation is integrated with the organization as a whole. The progress that this road has made in mechanizing its track forces is indicated by the fact that, whereas in December 31, 1941, its investment in roadway machines, including highway trucks, was only $581,176, this figure had increased to $1,294,202 at the end of 1950.

So great is the motivating force behind the railroad's program of mechanization of track work that it has taken the initiative in evolving machines for performing operations for which no equipment was available on the market. Among the machines so developed is a unit for extracting from the track old ties that are to be renewed. This was soon followed by the development of a machine for inserting new ties. Another example of the Lackawanna's ingenuity in developing new equipment is a so-called ballast loader-distributor by means of which, in connection with tie-renewal and track-raising work, a windrow of new ballast previously deposited in the intertrack space is picked up and delivered to a hopper from which it is distributed evenly across the track section to provide an adequate amount of properly distributed ballast for the tie-tamping operation.

The shift to highway trucks for transportation of track forces is considered an important factor in assuring that the gangs will spend a maximum amount of the working day in doing productive work. As of December 31, 1941, the maintenance of way and structures department of the railroad had only 16 highway trucks, involving an investment of $16,960. By December 31, 1950, the number of such units had increased to 110, and the investment in them was $267,073.

The third corner of the Lackawanna's production-line methods of doing track work—the detour system—was inaugurated on a large scale on this road more than 10 years ago and is considered to have been more highly perfected by the Lackawanna than by any other line. Simply stated, the system consists of dividing the multiple-track main line of the road into so-called



The Lackawanna has taken the initiative in devising machines for specialized operations. One of these, a ballast loader-distributor, is shown here. Ballast from the intertrack space is distributed evenly across the track section

"detour" sections, five to seven miles in length, and the provision of temporary crossovers at the ends of each section to permit trains to be detoured around the length of track on which work is being carried out, thus permitting the gang to get the maximum of productive time out of the working day. What makes the use of the detour system on the Lackawanna of more than ordinary interest is the fact that the practice has the complete endorsement of the operating department, which recognizes the wisdom of substituting the single-tracking of trains for the slow orders that would be necessary if the maintenance department was required to do its out-of-face track work under traffic.

The fourth corner of the railroad's foundation for production-line methods in track work—the practice of programming its work on a detailed and precise basis*—has been followed for about 10 years. Briefly, the procedure is to determine early in the year the total amount of money to be spent for roadway maintenance work during the year, after which the amounts of the different types of work to be done are determined and detailed schedules are established for carrying out these operations. Nothing less than major swings in the business cycle or other developments of similar magnitude are permitted to interfere with the maintenance program so established.

An account of ways in which the Lackawanna's spirit of enterprise in the development of engineering practices has manifested itself would not be complete without reference to a number of other practices on this railroad. For instance, when some of the road's suburban lines in New Jersey were electrified more than two decades ago, rectifiers were used for the first time on a large scale on a railroad job of this sort for converting alternating current to direct current. Also, the Lackawanna was a pioneer in the use of Greenheart piling. All of its ferry racks in New York harbor, as well as many of its floatbridge racks, are constructed of this material.

For many years the Lackawanna has carried on extensive programs of building up battered joints by welding, using highly mechanized gangs for this purpose. Truck transportation is used for the gangs, and crawler-type tank carriers greatly reduce manual handling of the gas cylinders. The road commenced heat treating rail ends in track in 1937, and, after keeping cost and performance records over a period, it adopted this practice as standard for all new rail in 1945. About 1940 it started repairing driver burns in rail by welding. Exhaustive tests were made of this practice and the methods were altered as indicated by the results of the tests. As a result, the railroad determined that welding of driver burns is entirely feasible, economical and safe, and as a consequence an "all-out" program along this line was started in 1945.

Considerable emphasis has been placed on this road on the lubrication of the high rails on curves. Consequently, despite the adverse conditions of curvature that prevail, the changing out of rail on curves is usually required because of the crushing of the low rail rather than the wearing of the high rail. To the extent possible, worn and damaged frog and switch points are rebuilt in the field. Manganese frogs are rebuilt by welders equipped with "jeeps" on each of which is mounted a generator, which is driven by a power take-off from the engine. Switch points are rebuilt by the oxyacetylene process.

Since 1934 the road has been using corrugated-bottom tie plates. The experience on the Lackawanna is that tie plates of this type help to maintain the correct gage at smaller expense than flat-bottom tie plates, and that they do not damage the ties. It is now buying the high-eccentricity tie plate for use on the low sides of curves to retard the "bedding" of the tie plates at such locations.

For two or three years the railroad has been experimenting with protective coatings and tie pads to prolong the life of bridge ties. Preliminary results of the tests indicate that the use of preservative coatings for bridge ties will soon be established as a general practice. The use of tie pads is reported to be still in the testing stage. Another field in which the Lackawanna has pioneered is in the use of chemicals for controlling the growth of brush along the right of way. For this purpose the company uses a derivative of 2,4-D which is applied to the foliage by a spray rig specially designed by the railroad for this purpose. Chemical weed killers have been in use on the road for many years.

Toward a Better Subgrade

Extensive programs are being carried out on the Lackawanna for widening and raising the subgrade shoulders of its roadbed to provide better support for the ballast section and at the same time to permit a reduction in the amount of ballast used. Other advantages of this practice are the provision of additional clearance and better drainage in cuts. In many locations the roadbed shoulders are being widened sufficiently to provide a roadway for the use of off-track equipment and trucks to transport men and materials. Where possible the widening of the shoulders is being carried out by means of off-track equipment.

The Lackawanna has, especially in recent years, experienced drastic changes in the character of traffic carried, largely incident to a reduction in the market for anthracite coal. To help the railroad over this difficult period the maintenance and engineering department has done more than its share by effecting economies, largely through the practices described in this article. As a result of the spirit of enterprise exhibited toward the development of economy-producing maintenance practices the Lackawanna has one of the lowest maintenance-of-way ratios of the country's Class I railroads.

*The Lackawanna's practice of programming heavy roadway maintenance operations was described in detail in *Railway Age*, August 20, 1951, along with other advanced maintenance practices in use on this road.