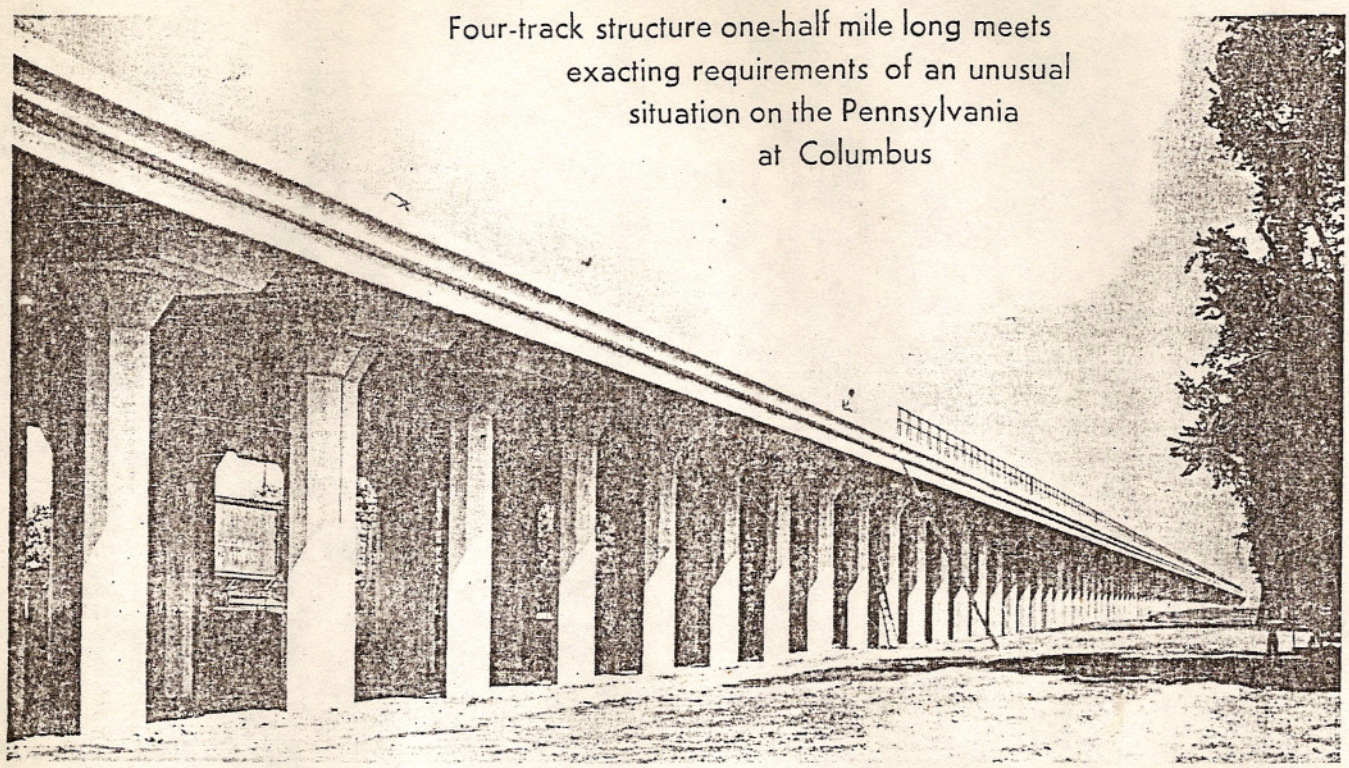
Flat Slab Viaduct Solves Right-of-Way Problem

Four-track structure one-half mile long meets exacting requirements of an unusual situation on the Pennsylvania at Columbus



The Viaduct Is an Impressive Structure

IN ORDER to extend its Grogan yard at Columbus, Ohio, effect street grade separations and secure a ruling grade of 0.3 per cent, the Pennsylvania was confronted with the necessity of relocating one of its lines entering the city, and met the rather unusual requirements that were imposed in the acquisition of needed right-of-way by the construction of one-half mile of reinforced-concrete flat-slab viaduct. This structure, which was built to accommodate four tracks and covers a ground area of nearly 3½ acres, required the placing of 22,000 cu. yd. of concrete containing 2,250 tons of reinforcing steel, and is in many ways an unusual railway structure. It forms a part of a railway terminal project at Columbus that involved an expenditure of approximately three million dollars.

Until the completion of the improvements here described, Grogan yard had a length of about 3,000 ft., its east end being fixed by the grade crossing with the Pennsylvania line to Cleveland and its west end by the sharp curve that was introduced where the line to Sandusky turns off to the north. One of its important functions is the interchange with the Norfolk & Western for which purpose it has a direct connection with the large Norfolk & Western yard just east of the Cleveland line crossing.

Yard Had to be Extended

The principal business handled over the Sandusky line is lake coal received from the connecting lines at Columbus and delivered to coal docks at Sandusky, and as much of this is received in solid trains and forwarded without breakup, the limited length of the Grogan yard comprised a serious handicap in the handling of this traffic. However, to extend the yard at the west end by following the direction of the Sandusky line on the sharp curve to the north would have introduced highly objectionable operating conditions, and the fact that the Pennsylvania already owned trackage, used primarily as industrial leads, extending due west from the yard for a distance of about 2,600 feet to the main line of the Big Four, led to the idea of expanding Grogan yard by extending the tracks to the west.

To carry out this plan, it was necessary to develop a scheme that would provide a connection for the Sandusky line at the proposed extended location of the west throat of the yard, and this gave rise to the plan of abandoning the old location for some distance north of the yard in favor of a new location just east of the Big Four right-of-way, and joining the old line a short distance south of Hudson street. The total length of this relocation is 9,630 ft.

The location adjacent to the Big Four involves crossings of only two streets, Eleventh avenue and Seventeenth avenue, over which the Big Four tracks are carried on steel bridges. But the property abutting on the east side of the Big Four right-of-way between these two streets comprises a part of the Ohio State Fair Grounds and the State Fair commissioners were not only reluctant to dispose of any of their property, but also insisted on maintaining the frontage on the Big Four

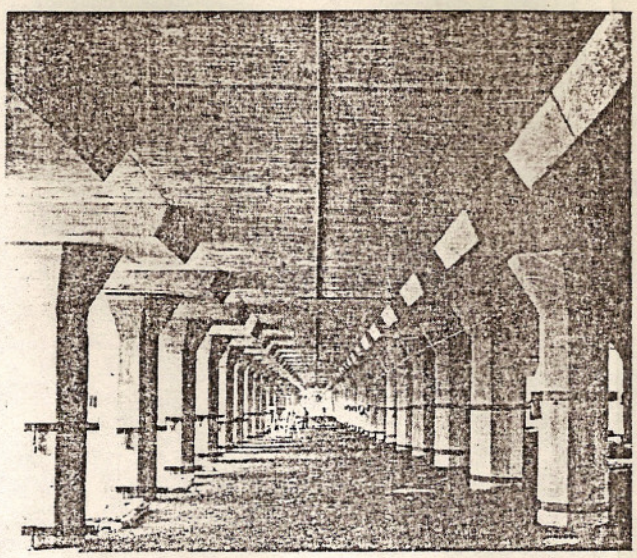
right-of-way. Studies designed to meet these objections led to a plan whereby the Pennsylania acquired an easement on a strip of the fair grounds adjacent to the Big Four for the construction of a viaduct of sufficient width for four tracks, under the terms of which the State Fair authorities retained the use of the ground under the viaduct.

This new line embodies a complete separation of grades with the city streets, as was also the case with the extension of Grogan yard, the plans for which provided for subways for Fields, Essex and Cleveland avenues. The rerouting of the Sandusky line thus provided a new line entirely free from grade crossings to replace the old line that crossed five streets at grade. As a consequence the City of Columbus contributed toward the construction of the new line a sum approximating 35 per cent of the estimated cost of eliminating grade crossings on the old line between Cleveland and Seventeenth avenues inclusive, which portion of the old line was abandoned by the Pennsylvania.

Advantages of Flat-Slab Design

The selection of the type of structure best suited to the requirements of the fair-ground location embraced an interesting study. While the primary reason for the demand for a bridge structure was to afford access to the Big Four tracks for the loading and unloading of exhibits, principally livestock, the dimensions of the new viaduct, 2,462 ft. long by 60 ft. wide, suggested the use of the ground area it covers for stock pens and other purposes. The selection of the design was influenced by the relative adaptability of various types of structures to such use, and a reinforced concrete flat-slab viaduct proved far more attractive from this standpoint than a structure of the bent-and-span type in either steel or reinforced concrete. It proved also to be decidedly more attractive from a cost standpoint.

The column spacing decided on is 21 ft. center to center (three rows) transversely and 21 ft. 2¾ in. longitudinally. The design of this structure comprised an adaptation of the general method employed in flat-slab concrete building construction, with such modifications as were necessary to meet the special conditions imposed by railroading loading. The criterion for live loading used in the design was a uniform-load equivalent to the driver-axle concentrations of the standard locomotive loading of the Pennsylvania, assumed as distributed uniformly over a longitudinal strip 14 ft. wide (the track spacing on the structure). For positive moment the load was assumed as applied to one panel only, while for negative moment and for column loads the same uniform load was assumed as covering two panels, which implies a greater number of axle concentrations than the five embodied in the Pennsylvania standard locomotive live load. For the type of structure involved, the additional cost imposed by such loading is inconsiderable and it was felt that advantage should be taken of this condition to provide for a possible future increase in length of driver base and weight of engines.

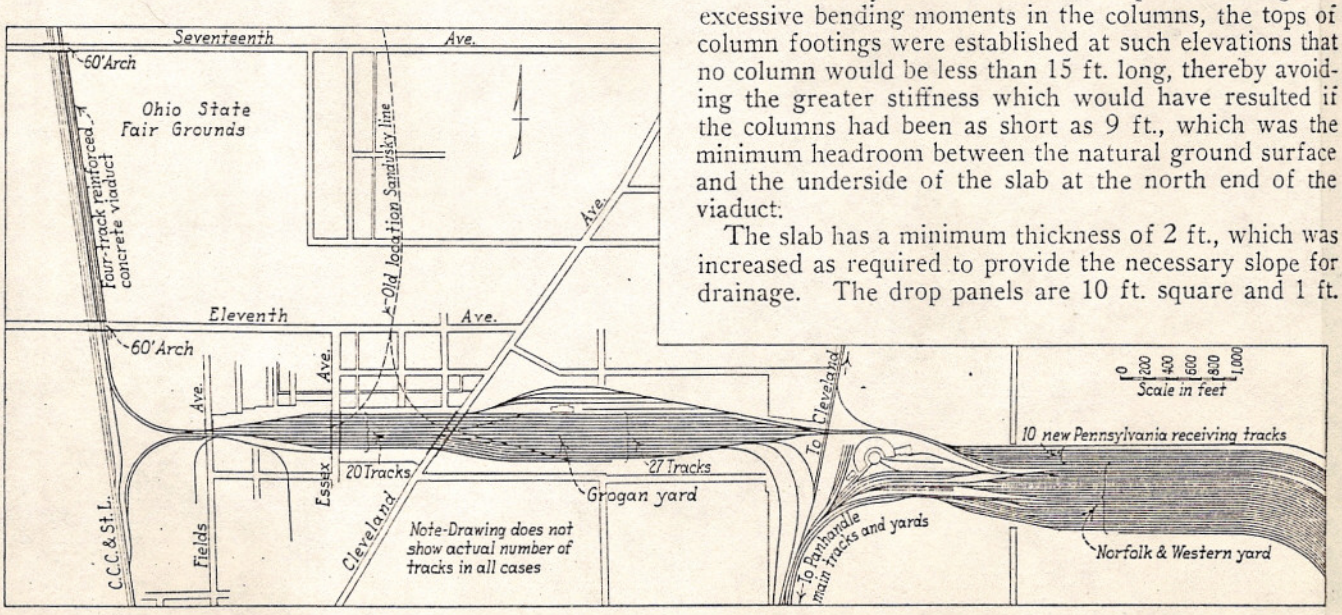


Fencing Attached to the Bands on the Columns Makes it Possible to Use Space Under the Viaduct for Stock Pens

Expansion Joints

For the proportioning of the columns, the design was tested as a stiff frame and adequate allowance was made for bending moment carried into the columns. To guard against the possibility of excessive bending in the columns by reason of temperature changes, the viaduct was divided into longitudinal units 127 ft. 4½ in. long (six panels) separated by 2-in. expansion joints. Double columns supported on a common foundation were provided at these joints. As a further precaution against excessive bending moments in the columns, the tops of column footings were established at such elevations that no column would be less than 15 ft. long, thereby avoiding the greater stiffness which would have resulted if the columns had been as short as 9 ft., which was the minimum headroom between the natural ground surface and the underside of the slab at the north end of the viaduct.

The slab has a minimum thickness of 2 ft., which was increased as required to provide the necessary slope for drainage. The drop panels are 10 ft. square and 1 ft.



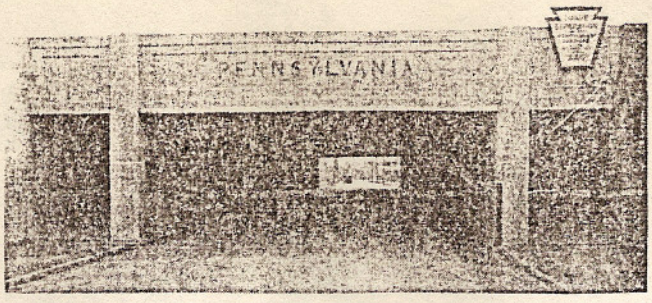
The Fairground Viaduct in its Relation to Grogan Yard and Other Terminal Facilities

thick. The intermediate columns are octagonal—2 ft. 10 in. on the short diameter, while the double columns at the expansion joints, which together form an elongated octagon, have a short diameter of 2 ft. 6 in. The deck is covered with a membrane waterproofing carried over the expansion joints on lead flashing and conforming to the slope of the surface so as to carry the water to two drain outlets in each 127-ft. unit of the viaduct. The unique feature of this drainage plan is that the water is discharged through 4 in. cast iron down-spouts that are carried down inside the columns and then out on an incline to catch basins alongside the column footings.

The viaduct terminates at each end in a handsome three-centered arch of 60 ft. span over the full width of Eleventh avenue and Seventeenth avenue, respectively. Arches were practicable at these two locations owing to the fact that these streets had previously been depressed a sufficient amount to permit of subways under the Big Four tracks. Consequently, the higher elevation of the Pennsylvania tracks afforded ample headroom for arch structures.

Foundations

An interesting study was imposed in the foundation design because of the imperative necessity for insurance against settlement in a structure of the type adopted. The soil at the surface and extending down to a depth of

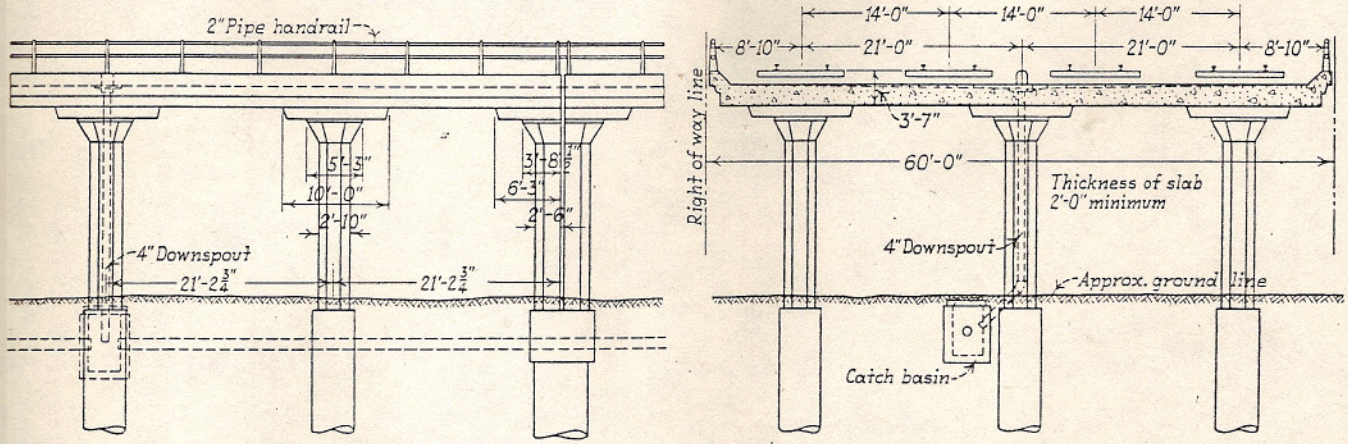


The Subway at Essex Avenue Passes Under 22 Tracks

feet in diameter and belled out at the bottom to reduce the bearing pressure to four tons per square foot. The excavation was done by hand, using tripod supported niggerhead winches operated in groups for hoisting the muck buckets.

Concreting Methods

The concrete was mixed at a stationary plant located adjacent to the Pennsylvania tracks a short distance south of Eleventh avenue, and was transported to the point of placing along the viaduct in dump buckets delivered on narrow-gage cars hauled by a gasoline locomotive. This narrow-gage track was carried over Eleventh avenue on a temporary trestle and run along

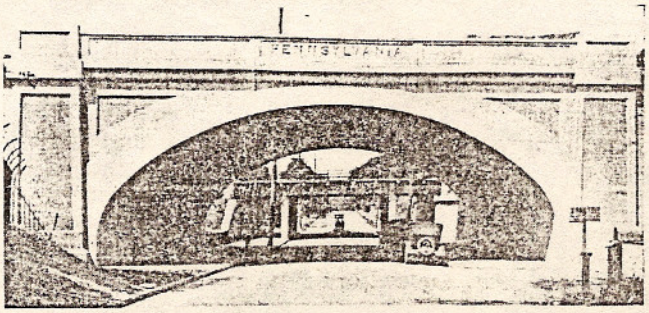


Part Elevation and a Cross-Section of the Viaduct

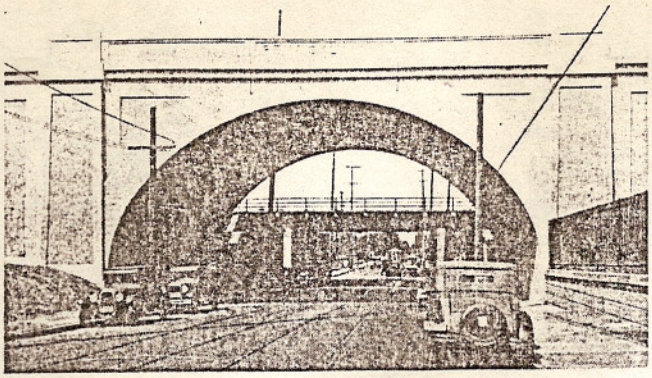
12 to 20 ft. is yellow clay, while under this material there is a considerable depth of hard blue clay or hard pan. The yellow clay, which is fairly stiff at a depth of 10 to 12 ft. is of a character able to support a load of 1½ to 2 tons per square foot, but to obtain this bearing pressure involved a rather large footing area. To meet these conditions a design was developed which embodied a grid of longitudinal and transverse reinforced concrete footing beams, but because this plan entailed the complication of heavy excavation over a large part of the area covered by the structure, this scheme was abandoned in favor of open-caisson or well-type foundations extending to a depth of 25 ft.

This plan entailed far less excavation, disturbed a much smaller area and had the advantage of insuring against the need of underpinning in the event that subsequent building operations adjacent to the site of the viaduct should result in deep excavation. It was felt also that the hard blue clay would develop adequate lateral resistance on the caisson walls to take care of bending moments in the columns. As a matter of fact the soil conditions were especially favorable for this type of foundation as the excavation could be completed without resort to sheeting. The wells were made four

the east side of the viaduct parallel with a standard-gage track which was occupied by a locomotive crane that was employed to lift the buckets to the point of dumping over the caissons, the tops of the columns and the slab. In the placing of the slab concrete, transportation by the crane was supplemented by a belt conveyor to deliver the concrete to the more remote portions. The forms for the slab were supported on a traveling frame which was rolled forward on a multiple-rail track and wedged up in its successive positions. The need



Arch Over Seventeenth Avenue and Big Four Structure in the Background



A 60-Ft. Arch Spans Eleventh Avenue at the South End of the Viaduct

for rodding the concrete in the column forms was avoided by the use of electric vibrators that were clamped to the forms while the concrete was being placed.

All of the concrete was proportioned in accordance with the water-cement ratio for a desired strength of 3000 lb. per sq. in. at 28 days. Tests of specimen cylinders indicated a strength well above that value, while core specimens cut from one of the columns gave values ranging from 4,000 to 4,700 lb. per sq. in. at an age of about 3 months. Surface treatment of the concrete was limited to rubbing facia columns and drop panels with abrasive bricks accompanied by a cement wash, except that certain panels in the spandrels and parapets of the two street arches were bush hammered.

The extension of the Grogan yard increased its capacity from 1010 cars to 2324 cars. This increase in capacity was effected by moving the ladder tracks to the west a sufficient distance to provide 22 tracks with a maximum capacity of 118 cars, whereas the original maximum capacity per track was 63 cars. The improvements to the Grogan yard also involved grade separation, subways being provided at Fields, Essex and Cleveland avenues. The Fields avenue subway under the west throat of the yard carries 4 tracks while the other two subways each pass under 22 tracks. These are three-span structures supported on concrete abutments and reinforced concrete bents at the curb lines, the sidewalk spans consisting of reinforced concrete slabs and the long spans between the curb lines involving the use of 30-in. wide-flange I-beams incased in concrete.

Other Improvements Involved

Simultaneous with the enlargement of the Grogan yard and the construction of the viaducts, extensive improvements were made east of the Cleveland line crossing. The Norfolk & Western extended its yard to the east (or south) and the Pennsylvania built a new ten-track yard north of and parallel to the Norfolk & Western yard. A portion of the lake coal handled in interchange between the Norfolk & Western and the Pennsylvania at Columbus, moves in solid trains without breakup at Columbus, and the new 10-track yard was provided for the delivery of these trains to the Pennsylvania and the changing of engines and cabooses and crews.

The project was planned and executed by the construction department of the Pennsylvania, Western region, under the direction of I. W. Geer, chief engineer and E. E. Stetson, assistant to the chief engineer. The structures were designed under the supervision of E. Weidemann, engineer of bridges and buildings, Western region. The John F. Casey Company, Pittsburgh, Pa., was the contractor for the Fair Ground viaduct and the two street arches together with the adjacent retaining walls, while the three subways under Grogan yard were built under contract by the Fritz-Rumer-Cook Company of Columbus. The grading and track work was done under a contract with the Ferguson & Edmondson Company, of Pittsburgh, Pa.

Freight Car Loading

WASHINGTON, D. C.

REVENUE freight car loading in the week ended August 29 amounted to 763,764 cars, which, although it represented an increase of 15,053 cars as compared with the week before, was relatively the lowest total reported since the depression began, when compared with the corresponding weeks of the past two years. It was a reduction of 220,746 cars as compared with the corresponding week of last year, which turned out to be the peak week for 1930, and a reduction of 398,336 cars as compared with 1929, in which year the peak occurred in the last week of September. All classes of commodities except grain and grain products and ore showed increases as compared with the preceding week but grain loading showed a reduction of 4,307 cars and was 19,205 cars less than that for last year. The summary, as compiled by the Car Service Division of the American Railway Association, follows:

Revenue Freight Car Loading

Week Ended Saturday, August 29, 1931.

Districts	1931	1930	1929
Eastern	174,283	218,141	262,570
Allegheny	147,002	197,725	239,620
Pocahontas	49,172	56,571	66,920
Southern	105,059	130,426	153,042
Northwestern	111,564	157,936	184,761
Central Western	117,406	145,533	163,481
Southwestern	59,278	78,178	91,706
Total West. Dists.	288,248	381,647	439,948
Total All Roads	763,764	984,510	1,162,100
Commodities			
Grain and Grain Products	40,453	59,658	53,496
Live Stock	24,248	24,554	26,828
Coal	134,403	168,879	189,700
Coke	4,868	8,483	11,859
Forest Products	28,036	42,824	69,823
Ore	34,927	55,748	75,237
Mdse. L.C.L.	214,627	239,322	266,743
Miscellaneous	282,202	385,042	468,414
August 29	763,764	984,510	1,162,100
August 22	748,711	940,558	1,137,966
August 15	742,736	922,823	1,102,567
August 8	734,780	904,157	1,092,153
August 1	757,293	919,781	1,105,920
Cumulative totals, 35 weeks	25,658,035	31,428,015	35,377,737

The freight car surplus for the week ended August 22 averaged 573,252 cars, a decrease of 1,132 cars as compared with the week before. The total included 296,622 box cars, 211,767 coal cars, 25,376 stock cars and 15,064 refrigerator cars.

Car Loading in Canada

Revenue car loadings at stations in Canada for the week ended August 29 totaled 49,011 cars, an increase over the previous week of 1,518 cars, but a decrease from the same weeks last year of 23,430 cars.

	Total Cars Loaded	Total Cars Rec'd from Connections
Total for Canada		
August 29, 1931	49,011	22,562
August 22, 1931	47,493	21,599
August 15, 1931	47,556	21,544
August 30, 1930	72,441	31,797
Cumulative Totals for Canada		
August 29, 1931	1,678,784	919,666
August 30, 1930	2,085,020	1,182,899
August 31, 1929	2,337,638	1,450,472