The Attractive Fixed-Frame Bridge Over St. Clair Avenue, Toronto

Unusual Concrete Bridges are Built on the Canadian National

Marked departures from conventional design result in long and shallow spans—Fixed-frame construction and elimination of track ballast are features

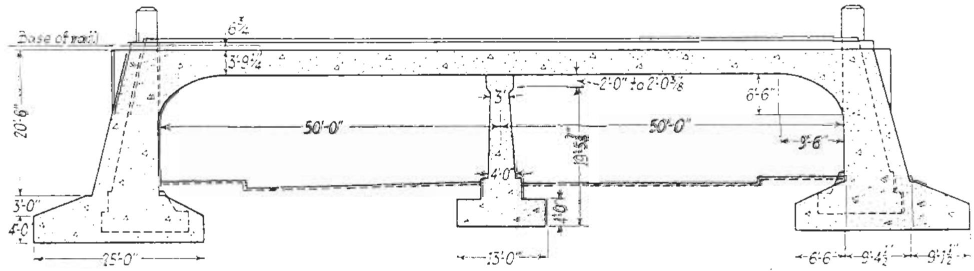
WITH many grade crossing elimination projects confronting it, the Central region of the Canadian National has given much study and thought to reinforced concrete railroad bridge design, with the idea of introducing into this type of construction certain structural economies which would adapt it to a wider range of conditions. As a result, a number of unusual reinforced concrete railroad bridges have been constructed on the Central region during the last three years, which incorporate features considered somewhat impractical only a few years ago, and which, in certain cases, will not yet be fully accepted without extended service tests.

Outstanding among the features involved in several of the bridges are unusually long spans with relatively shallow slabs; the adaptation of the rigid frame type of construction to one of the bridges; and radical departures from the usual type of ballasted deck structure, including the use of reinforced concrete ties directly on the deck slab, without ballast, and in one case, the anchoring of the rails directly to the deck slab, with no cushion other than hardwood filler strips. These latter features of track design were incorporated primarily to minimize the distance from base of rail to the underside of the deck slab. That success has attended the efforts in this direction is seen in the fact that in the case of one bridge, which has a clear span of 49 ft. each side of a center pier, the depth of the deck structure, from base of rail to underclearance, is only 4 ft. 3¼ in. Other interesting features of the bridges are the unusually high strength concretes secured in their construction, and the pleasing finish given to all exposed surfaces, making the structures unusually attractive.

Fixed-Frame Construction Offers Advantages

Of the dozen or more interesting new bridges on the Central region, which range from relatively simple appearing structures carrying a single track to quite extensive structures on severe skews and carrying as many as 13 tracks, one of the most interesting is the double-track structure carrying the main lines of the Newmarket subdivision over St. Clair avenue in Toronto. This bridge, which is of reinforced concrete construction throughout, is of the fixed or rigid-frame type, with a track structure of reinforced concrete ties resting directly upon the deck slab.

While the rigid frame is used quite generally in

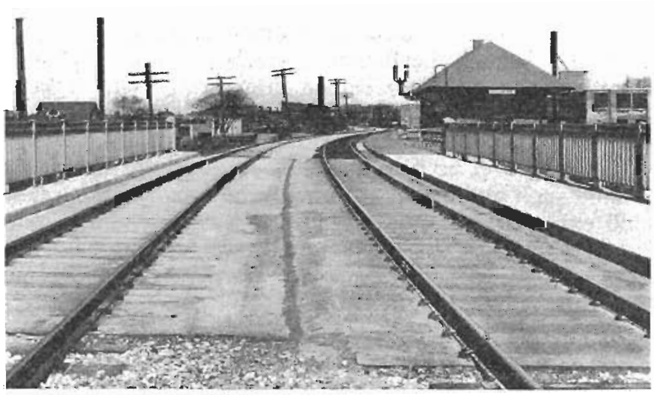


Longitudinal Section Through the St. Clair Avenue Bridge, Showing Arrangement and Principal Dimensions highway bridge construction in certain sections of the country, its application in bridges for railroad loadings is rather uncommon. In this type of construction, as will be noted in one of the illustrations, the abutments and deck slab are cast monolithic. The ends of the slab are designed to take negative moment which is carried into the abutment by the rigid connection of the former to the latter. The resultant decrease in the positive moment at the center of the span permits of an appreciable reduction in the effective depth of the slab compared with a simple-span slab. Excessive stresses at the re-entrant angle where the slab joins the abutment are avoided by the introduction of a fillet which is given a curved outline that adds greatly to the general appearance of the structure.

The bridge over St. Clair avenue, which is on an angle of about 32 deg. with the center line of the street, is 100 ft. long from face to face of abutments, and is divided into two clear spans of 49 ft. by a pier in the middle of the street. These spans are made up of a slab 27 ft. 6 in. wide that is continuous over the pier and monolithic with the abutments, but without a fixed connection between the slab and the pier. The slab therefore acts as a continuous beam over two spans with fixed or partially fixed ends. The curved fillets at the junction with the abutments do not encroach on the clearance requirements over the sidewalks in the street below. Through this means it was possible to develop a thoroughly practical design of slab having a total depth of only 3 ft. 9¼ in.

A further item of interest in connection with the deck slab is the walkways that were cast integral with the slab on both sides. These walkways, one of which extends 2½ ft. and the other 7½ ft. from the slab, consist of thin slabs supported on series of cantilever brackets which are spaced on 8-ft. centers and have a maximum thickness of 11 in. The outer edges of both walkways are provided with ornamental iron railings which extend between concrete posts located directly above and in line with the walk-supporting brackets.

The bridge abutments do not differ essentially from the usual type of reinforced concrete abutments except for the modified shape involved in making them integral with the deck slab and for that part of the reinforcing

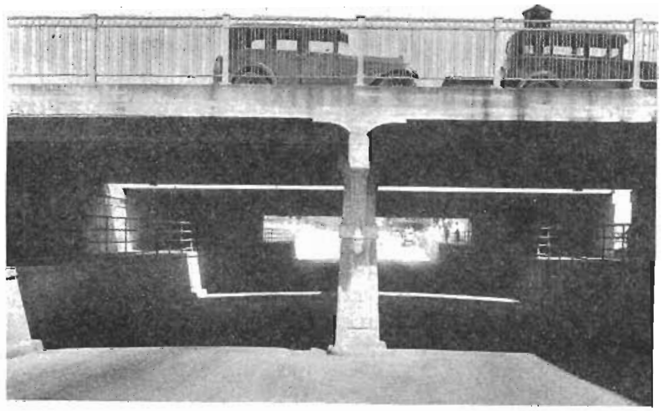


View Showing Deck and Track Construction on the St. Clair Avenue Bridge

which is common with that of the slab. The abutments are of mass design with spread footings 31 ft. 6 in. long and 25 ft. 7⅝ in. in width, that were necessary because of the character of the supporting soil and the heavy loads imposed by the long spans.

Concrete Ties—No Ballast

The type of track structure provided on the bridge is equally as interesting as the bridge proper. This consists essentially of reinforced concrete ties resting directly upon the deck slab. The ties, which are of a type designed on the Canadian National, are manufactured from 3,000-lb. concrete and are 10 ft. 6 in. long. To afford suitable superelevation in the tracks over the bridge, which are on a 2-deg. 30-min. curve, the ties are tapered, ranging from 12 in. by 7⅞ in. in section at one end to 12 in. by 6¼ in. at the other end. Reinforcing in the ties consists of five ¾-in. square



Looking Through the Richmond Street Subway, Under 15 Tracks and a Roadway, in London, Ont.

bars, placed longitudinally, and a series of seven ¼-in. stirrups. In no case do the bars come closer than 1⅜ in. to the faces of the ties.

The track rails rest on hardwood cushion strips, which, in turn, are seated in grooves 5¾ in. wide and ⅞ in. deep, provided in the upper faces of the ties. The rail cushion strips are essentially planks equal in width to the base of the rail, but tapered in section from a thickness of about 1⅛ in. on one side to ⅞ in. on the other, to provide the desired cant in the rails.

The rails are secured to the ties by means of clips, held in place by ¾-in. square-head bolts, 4 in. long, which pass through the clips and into internally-threaded pipe sleeves embedded in the concrete of the ties. Four holding sleeves are provided at each rail seat, the individual sleeves being 4¾ in. long and anchored in the concrete by means of a steel pin passed horizontally through them below the lowest possible travel of the rail-fastening bolt. Spring washers are used on top of the rigid rail clips and, whereas only two holding bolts are used at each end of the tie, the spare sleeves are sealed with cast iron plugs to exclude water or moisture. Each tie contains approximately 100.8 lb. of reinforcing steel and 0.229 cu. yd. of concrete, and weighs approximately 1,030 lb.

In constructing the track structure, the ties were lined up on the deck for both tracks, about two feet center to center, and the rails were then bolted in place. After the tracks had been lined carefully, the surface taking care of itself automatically, the entire area of the deck between the ties of both tracks was poured with concrete, flush with the tops of the ties, to anchor them in place permanently.

Natural drainage of the bridge deck and track structure is afforded through the fact that the deck slopes toward one end on a 0.5 per cent grade, discharging the water over the back face of the lower abutment where a suitable drainage system is provided to carry it off. In view of the favorable deck drainage and the density of the concrete provided in construction, the bridge deck was not waterproofed with any form of coating.

In many respects, the fixed frame type of bridge for grade separation project is considered an ideal structure by those who designed and built the bridge over St. Clair avenue. They point out its unusually pleasing appearance; the appreciable saving in headroom through the thin slab possible; and the fact that it is economical to construct. They point out also that it can be constructed rapidly, and in evidence of this fact that the entire superstructure of the St. Clair avenue bridge, from the bottoms of the foundations of both abutments, was concreted in 72 hours, and that had early high-strength concrete been used, the bridge could have been put in service within two weeks of the placing of the concrete. Furthermore, they call attention to the minimum of maintenance which such a structure will require, both the superstructure and the track structure without the usual ballast and timber ties, and also to the fact that this type of bridge, if for more than one track, can be built under traffic by constructing only sufficient width at a time to carry one track, and then moving traffic to the finished portions as completed. This factor was not taken advantage of in the case of the St. Clair Avenue bridge since it was found more advantages to keep traffic at the street level during construction and to complete the full width of the bridge without any interference to traffic by the work, or to the work by traffic.

Same Track Construction Used on Other Bridges

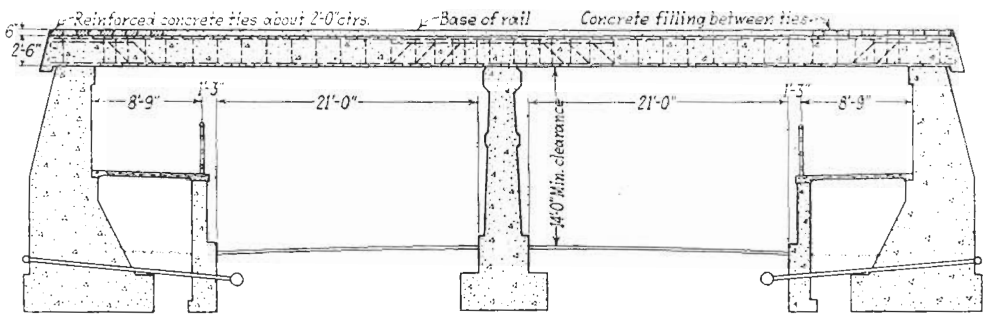
The same type of rigid track structure used on the St. Clair Avenue bridge was also used on several other reinforced concrete railroad bridges built on the Canadian National in connection with grade separation projects, including a 13-track structure over Richmond street, London, Ont., with a slab deck continuous over two spans, and bridges over La Canardiere road, Limoilou, Que., and Simcoe street, Oshawa, Ont., both of which have decks constructed of precast concrete slabs.

The bridge forming the Richmond Street subway, which includes a 13-track section and a separate 2-track section, in addition to a 24-ft. vehicle roadway, consists essentially of mass type abutments, a center pier, a steel and concrete roadway deck, and track slabs of reinforced concrete, cast in place, continuous over the center pier. The length of the bridge between abutment faces is 66 ft., which provides clear spans of 31½ ft. on both sides of the center pier. The full length of the undercrossing, including the roadway deck, is approximately 268 ft.

Sidewalks, nine feet wide, were provided along the sides of the lowered street, but for several reasons these were constructed at a level about five feet above the street pavement and were separated from the roadway by means of curb walls and pipe railings. Through this expedient, in combination with short 10 per cent ramps leading to the lowered walks, grading for the walkways was materially reduced, and, directly beneath the bridge structure, the effective width for the roadway and walks was materially increased. In this latter regard, the placing of the walks at the higher level, opposite the vertical faces of the abutments, enabled the bases of the abutments to be spread forward under the walks, instead of toward the rear, thus saving in the amount of excavation required, without at the same time reducing the effective width of underpass.

The railroad deck slab, which was poured in sections with expansion joints at intervals of from about 30 to 40 ft., is unusual in that at both ends it extends over and several inches beyond the full top width of the abutments, excluding all possibility of deck drainage water accumulating on the slab seats or reaching the face of the abutment. The deck drainage carried over the backs of the abutments is taken care of adequately through dry packing and subdrainage pipes which have connection with city sewers.

The thickness of the deck slab, which is reinforced for compression as well as tension, is only 2 ft. 6 in., and, in combination with the use of reinforced concrete ties laid directly on top of the slab, as in the case of the St. Clair Avenue bridge, the total thickness of the deck structure from base of rail to the under side of the deck slab is only 3 ft. The practical advantage of the relatively thin deck structure in the case of this bridge is seen in the fact that the street was lowered as far as was possible without interfering with a large brick sewer longitudinally beneath it, and, therefore, required that all headroom above the lowest practical pavement level be provided through raising the tracks. While such alterations of tracks are usually undesirable and expensive, they would have been particularly so in connection with the Richmond Street crossing because 13 tracks were involved and the normal track gradients were not conducive to elevation.



Longitudinal Section Through Richmond Street Bridge Showing General Details of Construction Employed

Concrete Ties Used on Precast Deck Slabs

In the cases of the bridges over La Canardiere road at Limoilou, and over Simcoe street at Oshawa, where the same type of track construction was used as at Richmond street, London, and St. Clair avenue, Toronto, the main difference in design is in the deck slab. In these cases, where it was necessary to construct the bridges under traffic, precast slab units were used. These bridges are more or less similar in design and size, having center piers, with an opening of 61 ft. between abutment faces at La Canardiere road, and of 60 ft. at Simcoe street.

In both bridges the decks are of reinforced concrete units from 4 ft. 7 in. to 5 ft. 3 in. wide by 3 ft. 4 in. deep, and from about 30 ft. 6 in. to 37 ft. 6 in. long, and are designed to interlock longitudinally with each other. The lifting weight of the slab units ranged from 51 to 57 tons. All joints between the units were filled with asphalt mastic, making them watertight and insuring that all deck drainage will be carried to the rear of the abutment walls.

With the full depth of the deck slabs only 3 ft. 4 in. in the case of these bridges and with 6-in. reinforced concrete ties directly on top of the slabs, the total depth of the deck structure, from base of rail to bottom of the slabs was held down to 3 ft. 10 in. Furthermore, by using precast units in these bridges, set in place by derricks, it was possible to construct the bridges progressively, always maintaining a part of them in service.

Other bridges of this type have been built on the Canadian National, including a two-track structure 69 ft. 7 in. long near Paris, Ont., and a 12-track structure at Toronto. The latter bridge, which is made up of 42 slabs, each weighing 85 tons, was built under traffic and the entire deck was set in place by derricks in 16 working days, without interruption to train service. Both bridges have track structures similar to those on the bridges at La Canardiere road and Simcoe street.

Bridge Has Neither Ties Nor Ballast

While a number of other interesting grade crossing elimination bridges have been constructed on the Canadian National in recent years, one at Breslau, Ont., while only a single-track structure, is of special interest because of its design and the manner in which it was erected. This bridge, which is approximately 118 ft. long and on a skew of 25 deg. 30 min. with the center line of the street, is a half-through plate girder structure with a steel and concrete deck, supported on two abutments and a center pier.

The superstructure, which is divided into two spans by the pier, consists essentially of two lines of steel girders, 7 ft. ½ in. deep, back to back of flange angles, and spaced 17 ft. 6 in. center to center, but instead of any one of the usual types of steel floor systems, the deck consists of 30-in. steel floorbeams, 7 ft. center to center, which are encased in concrete integral with a 12-in. reinforced concrete floor slab. Instead of stringers, there is a reinforced concrete T-beam with a stem about 20 in. square in section under each line of track rails. The over-all depth of the floor system is 2 ft. 10 in., and the distance from the top of the deck to the lowest point of the girders is 3 ft. 4¼ in.

These same dimensions hold true when referring to the track and deck structure as a whole, because neither ties nor ballast are used on this bridge, the rails being supported directly on hardwood cushion strips laid in longitudinal grooves provided in the top faces of the floor slabs. The method of seating the rails and of holding them in place is practically identical with that employed in connection with the use of concrete ties on the bridges already mentioned, including the use of rail clips and ¾-in. bolts which are turned down into internally-threaded pipe sleeves embedded in the concrete. In other words, the base of rail is practically on a level with the top of the concrete deck, saving the six inches in depth of the concrete ties, in addition to reducing the dead weight of the floor system through the elimination of the ties and the concrete filler poured between them, neither of which adds structural strength to the deck system, unless it be in distributing the live loading.

The two units of the Breslau bridge, one for each side of the center pier, were constructed as a whole on falsework immediately alongside their final positions, without any interference with rail traffic. After their completion they were moved laterally into place on the new abutments and pier on a system of rollers within a period of about four hours between trains.

The Bridge Over La Canardiere Road, Which Has Precast Deck Slabs From 30½ Ft. to 37½ Ft. Long

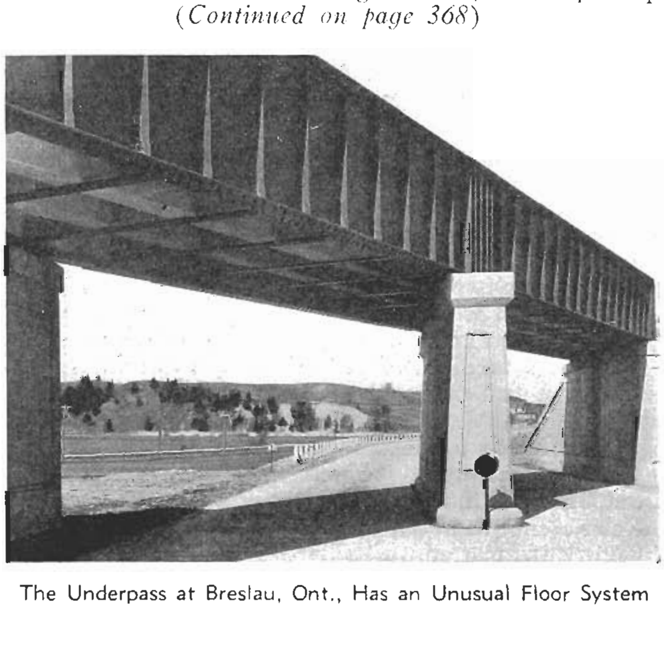
High Grade Concrete Secured

All of the bridges described were designed for Cooper's E-60 loading using the impact formula $\frac{L^2}{L + D}$. The live loading on each track was assumed to be confined to a width of 13 ft., but actual deflectometer tests after the completion of the bridges showed the load distribution to be much greater.

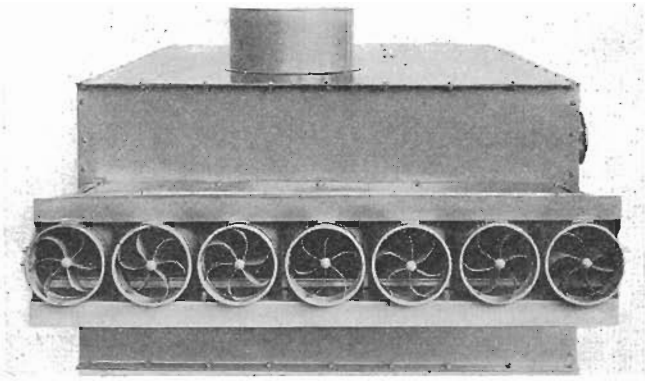
All deck slabs were reinforced for both tension and compression, and, in general, the same concrete specifications obtained for the different bridges. These specifications called for the use of 2,000-lb. or 2,500-lb. concrete in piers and abutments below the seats, and for 3,000-lb. concrete in all deck slabs, seats and other parts subject to intensive loading of flexure stresses. They also provided for the close control of the water in the mix, the use of Celite as an admixture to increase the workability of the concrete, and the addition of calcium chloride in the mixing water where quick setting was desired.

Owing to the care exercised in the preparation of the concrete, actual tests made during construction showed the concrete to run from 6 to 33 per cent stronger at 28 days than called for. The reinforcing steel also tested well above the specified requirements of a minimum ultimate strength of 80,000 lb. per sq.

(*Continued on page 368*)



The Underpass at Breslau, Ont., Has an Unusual Floor System



The Front View of the Airtrol Unit, Showing the Distribution Nozzles with the Direction-Controlling Whirls in Place

each contain vanes which impart a whirling motion to the air as it is discharged from the nozzles. These vanes are also adjustable to control the direction of the discharge from each nozzle.

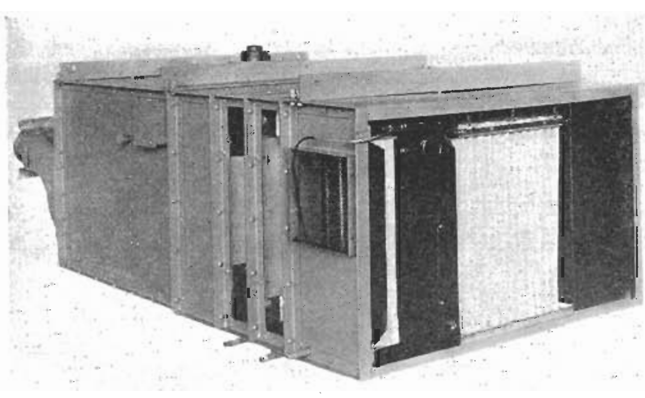
In the New Haven diners the ice-storage bin has a capacity of 1,500 lb., an amount which is determined by local conditions. Cooling water is drawn from the storage bin by a motor-driven centrifugal pump to be circulated through the cooling coils, and thence returned to the storage bin where it is sprayed over the ice. The heat-transfer coils in the Airtrol unit are piped both for cooling and heating. For the heating season a change in the valves disconnects the cooling-water system and connects the steam-heating system to the heat-transfer coils. The humidifier is then placed in operation, the heating system supplying the moisture to textile screen humidifying surfaces through which the fresh and recirculated air passes to the heat-transfer coils and circulating fan in the same manner as for summer cooling.

The directions of the whirling streams of cold air from the seven nozzles are fixed to cover uniformly the entire width of the dining room. The whirling discharge causes a rapid enlargement of the air streams and thus effects a thorough mixture of the cool air with the air contents of the dining room, from which the recirculated air is drawn through the grille in the buffet ceiling at the rear of the unit.

A number of tests conducted on the diner "Dreadnaught" of the New Haven while in regular service during the past summer all indicate a satisfactory uniformity in the air temperatures throughout the dining room while the system is in operation. In one case the car entered service after having stood 2½ hours in the sun on a humid day when the outside temperature in the shade was 85 deg. The temperature on the interior of the car, taken at several points on both sides, stayed at 85 deg., with the temperature 1 ft. below the ceiling at 90 deg. On starting the unit the air at the recirculation intake grille registered 84 deg. Thirty minutes after the unit was started, when the train left the terminal, the temperature had been reduced by 10 deg. on the left side of the car and about 8 deg. on the right (sunny) side of the car. The temperature was 1 deg. higher at the buffet end of the dining room than at the opposite end farthest away from the air discharge nozzles. At the end of 1½ hours the difference in temperature between the two sides of the car had been reduced to 1 deg., the car thermometer on the sunny side registering 76 deg. and on the opposite side 75 deg. The temperature at the buffet end on the sunny side was 77 deg. and on the same side at the opposite end of the dining room, 76 deg. The lowest temperatures on the interior of the dining room at that time were 73 deg. which were registered, respectively, about two-thirds of the way down the left side of the car, and at the center of the car, 1 ft. below the ceiling and 2 in. from the floor. Before the unit was started the relative humidity in the car was 61 per cent. One and one-half hours later this had been reduced to about 47 per cent. The temperature of the cooled air leaving the nozzles varied between 54 and 55 deg., and the temperature of the recirculated air entering the intake grilles was 78 deg.

The single Airtrol unit is sufficient to care for a space up to 4,500 cu. ft. which is sufficient for the dining-room space in the dining car. In cars where air conditioning must be applied to a space larger than 4,500 cu. ft., two units are installed at opposite ends of the space. In such cases a single ice tank services both units, but each unit may be provided with a separate motor-driven water circulating pump.

A single unit requires two ¼-hp. motors. The circulating-fan motor operates at 720 r.p.m., while the centrifugal-pump motor operates at 1,750 r.p.m. The system is rated as the equivalent of four tons of refrigeration. The pump motor is designed to circulate approximately 16 gal. of water per min. at temperatures of 35 deg. in, and from 40 to 42 deg. return. It operates intermittently under thermostatic control. The fan motor operates continuously, delivering a total of 1,200 cu. ft. of air per min., 300 cu. ft. of which is fresh air taken in from the outside and 900 cu. ft. of which is air recirculated from the interior of the car. Two reduced fan-motor speeds are available where conditions require less than the full capacity air circulation. Under full capacity, the air leaves the nozzles at a velocity of approximately 2,000 ft. per min. During the heating season the operation of the humidifier is subject to automatic hygrometer control, and the heating-transfer coil is thermostatically regulated by floor temperature.



Rear End of the Airtrol Railroad Unit, Showing the Interior of the Humidifier

Unusual Concrete Bridges are Built on the Canadian National

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in., this ranging about 15 to 17½ per cent higher, with corresponding increases in the yield point and percentage of elongation, and with satisfactory cold bend tests. No waterproofing was used on the decks which were poured-in-place, reliance against percolation into or through the concrete being placed in the dense concrete used and a suitable drainage pitch in the deck slabs.

On the precast slabs on the other hand, a membrane was used under the concrete ties.

All the structures described were designed in the bridge department of the Canadian National, Toronto, Ont., under the direction of C. P. Disney, bridge engineer; T. T. Irving, chief engineer; and W. A. Kingsland, general manager. B. A. Baldwin was engineer in charge of construction.

N. Y. C. Installs Mercury-Arc Rectifier

By G. R. McDonald*

THE New York Central has installed in its Wakefield, N. Y., substation a 3000-kw., 666-volt mercury-arc rectifier to operate in multiple with the 2000-kw. motor-generator set already in service. The starting and stopping of both of these units is accomplished by remote control. Both machines are provided with automatic control equipment. The generator of the motor-generator set is equipped with a counter e.m.f. voltage regulator which is biased by means of a current coil to give the generator a straight line drooping characteristic from zero load to 150 per cent load. At 150 per cent load a current relay functions to maintain constant current output. The rectifier transformer was designed to provide the rectifier with a characteristic giving the same regulation as the generator. The rectifier, however, is not provided with load-limiting resistors or any other method of limiting the output current, although provision was made for adding a step of load limiting resistance in the future if found necessary. The rectifier and motor-generator set share the load very well through the load range.

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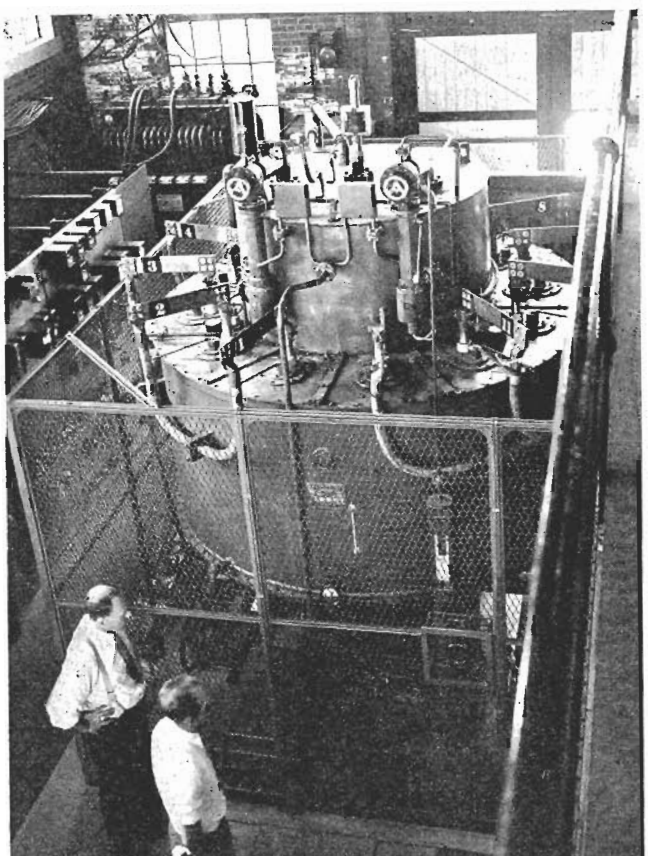

The Rectifier as Seen from the Sub-Station Balcony

The rectifier has fully demonstrated its suitability for this type of service by its ability to operate alone during the peak load period and carry repeated load swings of short duration to 300 per cent of its normal rating.

Cooling of the rectifier is accomplished by means of a heat exchanger. The rectifier cooling water is circulated continuously through one side of the exchanger. Tap cooling water is admitted to the heat exchanger as required. This method of cooling prevents a large temperature gradient through the rectifier.

Discuss Principles and Problems of Railway Supply Work

(Continued from page 362)

roads. It is important that each worker should consider himself not only an employee, but a partner and do all in his power to promote the best interests of the road.

Supply Work in the Future

There is no other purpose of the store department, J. C. Windbigler, store helper on the Missouri-Kansas-Texas at Parsons, Kan., warned, than that of service to the roads through the dollars saved over other methods of distribution of material. The best interests of the railroad must be the first consideration. The supply organizations, he said, are now facing a crisis and the future will determine whether the department will rise to a higher level of service or sink by the relegation of the work to other departments. It is incumbent upon the stores forces, he contended, to leave nothing undone to produce actual and convincing evidence of the usefulness of the department and the extent of the service rendered.

Stationery stores do not receive a great deal of attention, in the opinion of R. C. Stenback, store helper on the Northern Pacific at St. Paul, Minn., but the doorway to economy and increased efficiency is to be found in this branch of service. Among the methods advocated by Mr. Stenback to secure economy were the use of packages of standard sizes, the standardization of forms including the reduction of letter-size paper from 8½ in. by 11 in. to 7½ in. by 9½ in., and conferences of the stationery storekeepers of various railroads to secure the economies of group printing.

Savings in Scrap Handling

Discussing the problem of scrap disposal on railroads, N. J. McDonald, sales clerk in the purchasing office of the Pennsylvania, proposed several ways by which the efforts already being made in collecting, sorting and selling scrap can be augmented to the best interests of the railroad. This should consist, he said, (1) of a survey of the raw material needs of scrap consumers, made by personal visits to plants and by questioning representatives that visit the purchasing agents offices; (2) of efforts to fill the requirements of the railroads with old material; (3) of co-ordinating the buying and selling functions in the purchasing agents' offices, and the ordering and scrap offering functions in the storekeeper's offices to keep users of materials and scrap collecting agencies posted as to the special salvage value in certain materials purchased; and (4) of avoiding the purchase of material where scrap already on hand can be substituted for it.