increased or decreased when the grades on the next division make this advisable. If the road has necessarily to pass over a summit between two points and the natural grade is very high it may be advisable to use pusher engines on this high grade, a lower rate can then be used for the ruling grade.

On most roads the ruling grades affect only the heavier class of freight trains, the lighter freight and passenger trains being usually well under the maximum tonnage capacity of their locomotives. The cost of operating is dependent on the number of trains and not on their tonnage, and an extra train means an extra locomotive, train crew, etc., and this extra engine and train will also increase the maintenance of way charges due to the additional wear and tear of the track.

A small saving is made by having fewer cars per train due to the lighter work on the engines, when hauling over the minor grades and level sections. The following table gives an idea of the effect on different items of operating (n + 1) trains on heavy ruling grades compared with the cost of operating "n" trains on light grades, the tonnage being the same in both cases:

TABLE VIII.

Item.	Normal average.	Cost per mile per cent.
Maintenance of way	20.09	7.45
Maintenance of equipment	22.74	5.88
Traffic expenses	3.08	0.00
Transportation	50.44	28.30
General expenses	3.65	0.00
	100.00	41.63

In estimating the probable train mileage of a new road the estimated tonnage, ruling grades and the type of engine to be used must all be taken into account. It is possible to get an approximation of the hauling capacity of any type of locomotive over the ruling grades. In practice the engine is not loaded up to capacity, the reduction being dependent upon the rate of grade and its length. In general, this reduction will be as follows:

Grades of 0.3% to 0.6%, reduction 25% to 16%
Grades of 0.7% to 1.0%, reduction 14% to 10%

Dividing the estimated tonnage by the hauling capacity of the engine and multiplying by the length of the line will give the train mileage. Multiplying this by the cost per train mile will give the yearly cost of operating. The saving resulting from adopting a lower ruling grade or using pusher engines in isolated cases of heavy grades may thus be determined.

The last of the 92 leaves for the miter gates of the Panama Canal locks was lowered into place on its hinge pintle on Thursday, October 30th. This was the side wall leaf of the lower operating gate in the east flight at Miraflores Locks. The lower operating gates at Miraflores are the largest in the Canal construction, each of the lower leaves being 82 feet high and weighing over 700 tons. The swinging of a leaf means the completion of its erection, sheathing, and most of the riveting and reaming, but it is a step toward final adjustment. The work of lining up and babbiting the nickel steel bearing plates at both ends of a leaf can be completed only after the leaf is swinging in operating position, and the leaves are yet to be tested, painted inside and out, and fitted with foot-walk and handrail.

ELECTRIC LOCOMOTIVES FOR MOUNT ROYAL TUNNEL.

VARIOUS features of the tunnelling of Mount Royal, by the Canadian Northern Railway, in order to reach a terminal in the centre of the city of Montreal, have been described in *The Canadian Engineer* during the past year. Attention is directed to Jan. 16th issue, outlining the essential engineering aspects of the scheme; to Feb. 6th issue for an article descriptive of the early operations and the plant equipment; to Feb. 27th issue dealing with the precise survey work in connection with its location, and to the issue of June 12th, where mention was made of the remarkable speed with which operations were progressing. In Oct. 9th issue the announcement was made of the contract for the electrification of the tunnel having been let, as, in the design, considerations of cleanliness and health pointed to the use of electricity as the motive power. The present article contains a few points of interest with respect to the design of the locomotives selected.

The equipment for the electrification of the tunnel and terminals, for which the Canadian General Electric Company, Limited, has the contract, includes 6 electric locomotives designed for an operating potential of 2,400 volts with overhead trolley construction. Two of these locomotives, operated and controlled as a single unit, will have ample capacity and suitable speed requirements for handling the heavy transcontinental passenger trains—1,130 tons trailing load—within the Montreal terminal zone. A single locomotive will successfully handle the freight trains—1,000 tons trailing load—and the local passenger service—500 tons trailing load.

Locomotives.—The general type of the locomotive proposed is that known as the box cab, articulated running gear type of locomotive. Its estimated weight is 83.0 tons. The locomotive has four axles with all of the weight upon the eight driving wheels, thus securing the maximum adhesive weight on drivers. The running gear consists of two 4-wheel trucks, articulated together by a heavy hinge. The equalization of the trucks is accomplished by a heavy locomotive type semi-elliptic leaf spring over each journal box, connected through spring hangers to the frame and to the equalizer bars. Practically a 3-point suspension is thus supplied through the side equalization of one of the trucks and both side and cross equalization of the other truck. With the Miner friction draft gear mounted in the end frame casting of the truck, this type of construction restricts the hauling and buffing stresses of the truck side frames and articulated joint, instead of through the cab centre plate. This relieves the cab and apparatus from the effect of severe shocks.

Both the box cab and platform are built of plates, sheets, angles and heavy channels, and are thoroughly reinforced throughout. The box cab is divided into three compartments: the apparatus compartment in the centre and the two operators' compartments at the ends. Each operator's compartment has a full complement of apparatus, consisting of controller, control switches, meter, air brake control apparatus, air gauges, pantagraph control and heaters, thus providing the locomotive with a complete double-end control. All apparatus subject to 2,400-volt potential is located in the centre apparatus compartment and properly screened to protect against accidental contact. The location and general arrange-