cosine of the angle between the receiver current and the generator voltage can be expressed by formulas (7) and (8).

The current at the generator is the vectorial sum of the receiver current and the charging current. The charging current may be split into two components $i_o \sin \theta$ in phase with $I_r$, and $i_o \cos \theta$ in quadrature with $I_r$. We may, therefore, express the generator current by formula (9).

For the purpose of calculating the energy loss of the line, we will assume that the difference between the current at the receiver and generator ends follows a straight line law. This is not strictly true, but is close enough for present purposes. In Fig. 2 it is assumed that the receiver current is greater than the current at the generator. The current I at any point distant $l$ from the generator end will be $I = I_g + a$ where a is a constant.

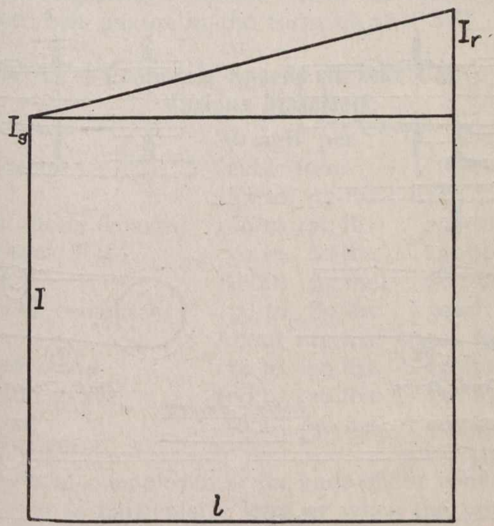


**Fig. 2.**

The mean square value of current can be obtained as follows:—

$$\frac{1}{l}\int_0^l I_g^2\, dl = \frac{1}{l}\int_0^l (I_g^2 + 2I_g\, al + a^2 l^2)\, dl$$

$$= \frac{I_g^2 l + I_g\, al^2 + \tfrac{1}{3} a^2 l^3}{l}$$

$$= I_g^2 + I_g\, al + \tfrac{1}{3} a^2 l^2$$

But $a = I_r - I_g$ so we have

$$I_g^2 + I_g (I_r - I_g) + \tfrac{1}{3} (I_r - I_g)^2$$

This is the mean square value of the current and when multiplied by $R\sqrt{3}$ is the line loss as in formula 12b. If the current at the generator end is larger than that at the receiver end of the line the expression for energy loss takes the form given in formula 12a.

---

Twenty-four railway lines radiate from Winnipeg. The Canadian Pacific Railway, Canadian Northern Railway and Grand Trunk Pacific shops are all located there, employing over 5,000 hands; with 130 miles switch siding facilities for manufacturers. Water transportation on Red and Assiniboine Rivers; vessels drawing nine feet of water ply between Winnipeg and Lake Winnipeg, a body of fresh water, in area, 9,414 square miles. The Winnipeg electric railway carried three million people in 1900 and 35 million in 1912, operating over 300 cars on over 72 miles of city tracks and 45 miles of suburban lines.

## BELT CONVEYERS.

By Reginald Trautschold, M.E.

OBVIOUSLY, the easiest way—so far as consumption of power is concerned—of transporting material from one place to another is to carry or convey it on a moving body rather than to attempt to drag it along a trough, as in the case of flight conveyers; or to push it, as in the case of screw conveyers. Obviously, also, the simplest kind of conveyer carrying its load on moving parts consists of an endless belt running over end pulleys and supported throughout its length by occasional supporting idlers, or carriers, on the carrying stretch of the belt and by less frequent supporting idlers on the return or lower run of belt. Such apparatus, belt conveyers, have now been brought to such a high state of perfection that they are almost indispensible in the handling of materials in bulk and are also used to great extent in carrying packages, boxes, bales, etc. This latter application of belt conveyers usually requires a flat carrying surface (belt) running between guides to prevent the load from leaving the belt. Material in bulk, such as ores, coal, cement, paper pulp, wood chips, etc., etc., on the other hand, are most frequently carried on troughed belts, belts having their edges turned up and inclined to the plane of the conveyer so as to form a trough in which the material is carried, thus materially increasing the carrying capacity. Troughed belt conveyers being more generally and widely used, they will be chiefly considered in this discussion.

The original troughing idler, or belt carrier, consisted of a spool-shaped pulley or series of individual pulleys mounted so as to form a spool. Following this form came the "dish pan" idler, consisting of one or more centre pulleys of the same diameter between concentrating end pulleys of "dish pan" shape which turned up the edges of the carrying belt. These simple types of carrying idlers had the desired effect of troughing the belt, but they possess one very undesirable feature, the circumferential speed of the pulley or pulleys varying with their diameter while the speed of the belt passing over them is constant from edge to edge; the result being that either the belt was travelling faster than the circumference of a particular pulley, or else the belt lagged behind certain circumferential of the troughing idler, causing much unnecessary wear on the belt due to the scouring action between the contact surfaces of belt and troughing idler. Relatively, the belt is the most expensive part of a belt conveyer and the main improvements have necessarily been in the troughing idler to obviate slippage between it and the belt. Troughing idlers are now almost invariably constructed of several individual pulleys of the same diameter mounted so that the end pulleys are inclined to the horizontal and cause the carrying belt to form a trough conforming more or less to an arc of a circle. These individual pulleys constituting a troughing idler may be mounted all in one plane, the end pulleys in a plane in advance or behind that of the centre pulley, may be mounted on hollow shafts in which grease for lubrication is stored and which is supplied to the bearings through small holes in the hollow shafts, mounted on solid shafts with either grease or oil lubrication, or on ball bearings that require only occasional lubrication, depending upon the construction and patent rights of the manufacturer. The latest construction consists of complete individual units of one pulley each which may be mounted on a board so that the pulleys all lie in one plane and may be