

ing of incompetent hands, at low wages, in positions which they are not qualified to fill. Employers are also responsible for the existence of considerable ill-feeling, by not properly appreciating the value of long experience in certain branches of the service. A larger proportion of the spirit of humanity infused into those years of toil would, beyond question, materially increase the profits of nearly every branch of business."

In re-reading the above under the light of later experience, and in view of to-day's discussion, I will merely add that I take pleasure in admitting the advantages and satisfaction to be derived from a classical education, supplemented as far as possible with a knowledge of modern language, in which I should certainly include French, German and Spanish. My experience teaches me that the student should pursue his studies as early as possible, for unless he denies himself the opportunities offered for recreation and social intercourse, he will find that owing to the demands upon his energy required in his regular employment, he will find less and less opportunity to study. My early telegraphic work, followed by years of editorial experience, and accompanied at all times with reading of the best English literature, has forced upon me what little knowledge of our language I possess, and at the same time taught me that a more thorough general education would have established a more satisfactory foundation, which I would urgently advise young men to obtain, and the neglect of which is to-day inexcusable.

MR. RAYMOND:—I think the paper has had an injustice done it. These gentlemen apparently assume that as soon as men graduate from college that all study ceases. I propose to drop during the college course those studies that will be taken up by the students themselves later, such as literature and history. A man can read history without a trained professor to assist him. One who has come out of college and has studied for four years is not going to stop as soon as he graduates. It would undoubtedly be interesting to study astronomy during the college course, but we must agree there is no time to take it up. Many of us since leaving college, may, however, have studied it quite thoroughly. I repeat, why not drop the studies that can easily be taken up after graduation and concentrate on those most urgently needed in our profession and in a large number of cases not properly taken up during the college course.

[COMMUNICATED AFTER ADJOURNMENT BY B. A. BEHREND IN DISCUSSION OF PAPER BY M. LEBLANC.]

The result of M. Leblanc's paper can be obtained in a very simple way by directly considering the case of a transmission line having no ohmic resistance but only distributed capacity and self-induction. I will briefly outline how to obtain this result, leaving to a special paper the highly interesting subject of the phenomena of long transmission lines treated in an elementary way.

The differential equation for a long transmission line having distributed capacity and distributed self-induction is readily obtained from our figure. Let c be the mutual capacity per unit length, and L the inductance per unit length of the two wires, then the charging current per unit length is

$$i = 2 \pi n C v \quad (1)$$

where v is the potential between the wires. Setting $2 \pi n C = a$, for the sake of simplicity, we have

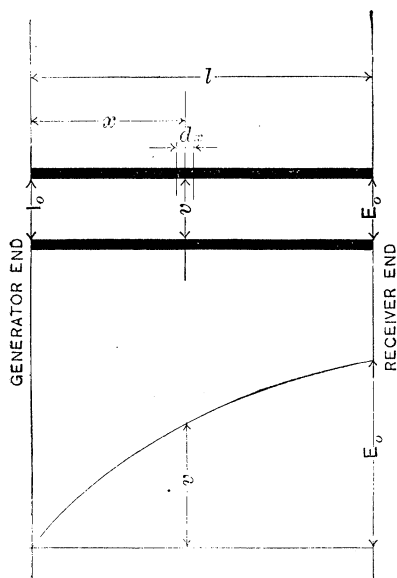


FIG. 1.

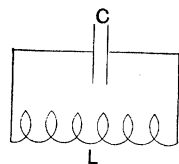


FIG. 2.

$$i = a v \quad (2)$$

The e.m.f. of self-induction is equal to

$$e = 2 \pi n L i \quad (3)$$

Again, setting $2 \pi n L = b$, we obtain

$$e = b i \quad (4)$$

Let us investigate the distribution of potential along the line on the supposition that the potential at the generating end is

zero, then the distribution of potential thus obtained will be identical with the distribution for the fundamental of the natural vibration of the line.

We have for the charging current in the element dx .

$$di = a v dx \quad (5)$$

The inductive drop in the line is

$$dv = -b i dx \quad (6)$$

Hence, by differentiating (6) and substituting in (5) we obtain,

$$\frac{d^2 v}{dx^2} = -ab v \quad (7)$$

The solution of this equation is

$v = A \sin \kappa x + B \cos \kappa x$, for by differentiating

$$\frac{dv}{dx} = \kappa A \cos \kappa x - \kappa B \sin \kappa x$$

$$\frac{d^2 v}{dx^2} = -\kappa^2 A \sin \kappa x - \kappa^2 B \cos \kappa x$$

$$\frac{d^2 v}{dx^2} = -\kappa^2 v$$

Therefore, $\kappa^2 = ab$, and $\kappa = \sqrt{ab}$ (8)

For $x = 0, v = 0$, by our assumption, hence

$$A \sin \kappa x = -B \cos \kappa x$$

$$B = 0$$

Therefore,

$$v = A \sin \kappa x$$

For $x = l, v = E_0$, hence

$$E_0 = A$$

The potential at different points of the line is thus given by the equation,

$$v = E_0 \sin \kappa x \quad (8)$$

We obtain the maximum value of v for

$$\sin \kappa x = 1,$$

and, therefore, the most dangerous case exists for a line whose length is such that

$$\kappa l = \frac{\pi}{2}$$

or, substituting for κ its value $\sqrt{ab} = 2\pi n \sqrt{LC}$, we obtain

$$l = \frac{1}{4n\sqrt{LC}} \quad (9)$$

Now, let us see what relation the length of the line thus determined has to the wave-length. It can easily be proved that the velocity of an electro-magnetic disturbance is given by

$$V = \frac{1}{\sqrt{LC}} \quad (10)$$

L and C being the inductance and capacity per unit length of the line in electro-magnetic measure.

Let λ be the wave-length, then we have

$$\lambda = \frac{V}{n} = \frac{1}{n\sqrt{LC}} \quad (11)$$

and substituting in (9)

$$l = \frac{\lambda}{4} \quad (12)$$

which is M. Leblanc's result arrived at in a strictly correct but simple manner.

I need hardly remark that from equation (8) follows that if κl is equal to $3\pi/2$, $5\pi/2$, $7\pi/2$, etc., a dangerous state is obtained.

From (9) follows that the fundamental of the natural frequency of the line oscillation is

$$n = \frac{1}{4l\sqrt{LC}} \quad (13)$$

It is interesting to compare this result with that of a condenser and an inductance connected in series. The natural frequency of such a system (Fig. 2) can easily be obtained by the consideration that the potential difference between the condenser plates must be equal and opposite to that at the terminals of the inductance, hence

$$2\pi n L i = \frac{i}{2\pi n C}$$

From this follows:

$$n = \frac{1}{2\pi \sqrt{LC}} \quad (14)$$

The discharge frequency of a long line with distributed capacity and self-induction is therefore greater than if the capacity and self-induction were concentrated as in Fig. 2.

The subject is treated by Dr. Bedell and Dr. Crehore, and by Mr. Steinmetz, and my remarks are made with the sole purpose of showing a short cut to the known results.

NORWOOD, O., July 1, 1902.

[COMMUNICATED AFTER ADJOURNMENT BY B. A. BEHREND IN DISCUSSION OF MR. STEINMETZ'S PAPER ON THE "THEORY OF THE SYNCHRONOUS MOTOR."

Mr. Steinmetz calls the quantity $\frac{1}{2} m v^2$ by the name of "mechanical momentum," but since the time of Newton the term "momentum" has been used to designate the product $m v$, and we speak of the "conservation of momentum," and of the "conservation of angular momentum," meaning thereby the conservation of the product $m v$, as, for instance, in the case of impact. Since the formulation of the principle of the "conservation of energy," we have been accustomed to call the quantity $\frac{1}{2} m v^2$ the "kinetic energy" of the body in motion, and we should like to ask why Mr. Steinmetz deems it necessary to change, without explanation, a nomenclature which has been used by Helmholtz, Kelvin, Maxwell, Rayleigh and others.

NORWOOD, O., July 1, 1902.

[COMMUNICATED AFTER ADJOURNMENT BY MR. CALVERT TOWNLEY IN DISCUSSION OF MR. A. H. ARMSTRONG'S PAPER, PAGE 809.]

I have read with much interest Mr. Armstrong's account of his various investigations, which involve and represent an enormous mass of painstaking mathematical calculations. His graphic representations of the results obtained are clear and concise, and will furnish material for much contemplation and study to any one interested in following out the possibilities involved by changing the numerous railway motor variables between widely separated limits.

His individual conclusions given as interpreting the various curves plotted are clear and well stated, but there is one general conclusion not deduced directly from the calculations which does not seem to me proved, and with which I am unable to entirely agree. Mr. Armstrong states:

"As a result of considerable investigation along these lines, the writer has not arrived at any commercial rating of a railway motor which serves its purpose better than the one-hour test now universally used. Admitting that such a test does not give the comparative size of different motors, it does serve the