FORMATION OF STANDING WAVES ON LECHER WIRES*

BY
AIJAZ MOHAMMED AND S. R. KANTEBET
(Communication Engineering Laboratories, Indian Institute of Science, Bangalore, India.)

***Summary**—With a short review of the work on the Lecher wire method of wavelength measurement, this paper describes in detail the wave form of current distribution along wires under a variety of terminal conditions of length and impedances.*

THE problem of precision determination of radio frequencies and keeping radio stations at their assigned places in the frequency spectrum is becoming more and more important owing to the increasing demand for channels both for domestic and international communications. In the case of long waves, several methods of direct comparison either by stroboscopic or spark photography systems are available. Higher frequencies are estimated by comparison with the harmonics obtainable from low-frequency sources such as the valve maintained tuning fork or the piezo-electric crystal oscillator in conjunction with multivibrator systems.

Several measurements of classical interest have been made based entirely on the principle of standing waves. In 1888 Lodge estimated frequencies of the order of several millions with a pair of wires. Lecher in 1890 and Blondlot in 1893 perfected the technique of this method, now well known as the Lecher wire method of wavelength determination. The speed of propagation of electromagnetic disturbances has also been estimated by this method. Its value is considered to be in the neighborhood of 2.998×10^{10} cm per second.

It was soon discovered that the decrement of the wires used tended to reduce the speed of propagation along wires as compared with propagation in free-ether. The distributions of current and potential along the wires were also noticed to be not sinusoidal. This resulted in the observed length of wave being somewhat lower than the true wavelength in ether.

A correction factor of the form $\lambda_0 = 2L(1+\Delta)$ was worked out by A. Hund.[1]

Here λ_0 = true wavelength in ether,
L = distance between two consecutive antinodes,
Δ = correction factor depending on the decrement of wires.

Dunmore and Engel described "A method of measuring short radio

* Decimal classification: R116. Original manuscript received by the Institute March 30, 1931.

[1] *Bureau of Standards Scientific Papers*, No. 491.

wavelengths and their use in frequency standardization[2]." Presumably the distribution of current observed was sinusoidal. However, Takagishi[3] while working on similar measurements, noticed the normal current antinode being split into a trough with a double hump. One of the present writers too while on 6-meter work, noticed similar double hump formation in place of a single resonance peak. It was then reported[4] as having been due to the presence of a strong third harmonic

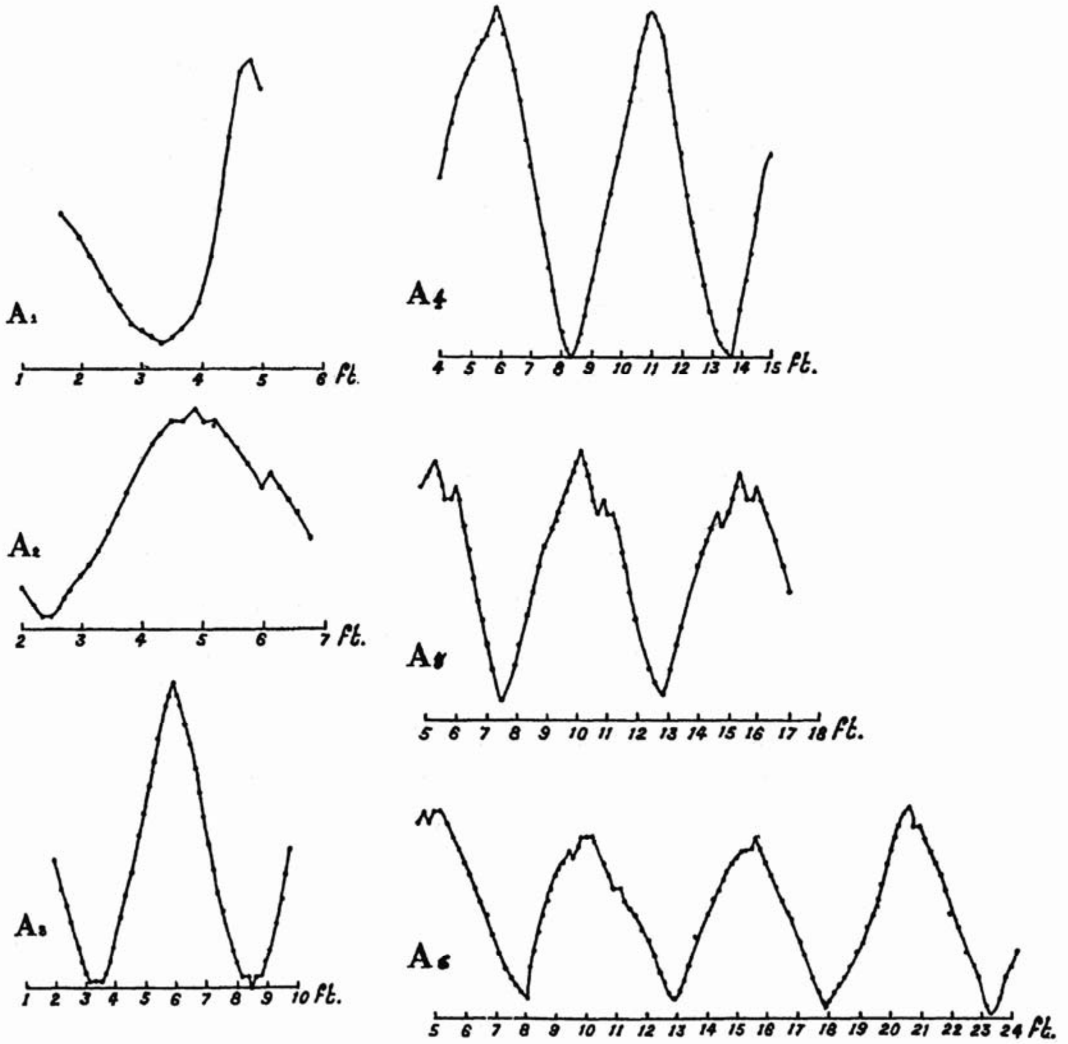

Fig. 1

in the generated wave, rather than to close coupling as suggested by Dunmore and Engel. Takagishi[5] has just given a mathematical proof in explanation of this double hump formation under certain conditions of line and bridge impedances.

The present investigation was undertaken in these laboratories to study the actual wave form of current distribution along wires under the following conditions:

[2] Proc. I.R.E., 11, 1923.
[3] Proc. I.R.E., 13, 1925.
[4] Discussion between Kantebet and Dunmore, Proc. I.R.E., October, 1925.
[5] Proc. I.R.E., March, 1930.

(1) Constant generated frequency.

(2) Tight and loose coupled Lecher wires, both open- and short-circuited at far end.

(3) Length of wires varying from a fraction of a wavelength to 2 wavelengths.

The indicator used was a galvanometer having a range of 600 micro-amperes, with a crystal rectifier with contacts rigidly held in place. The assembly was hung up by a pair of short, stout copper rods, and shifted from place to place along the wires. Corresponding galvanometer deflections were noted.

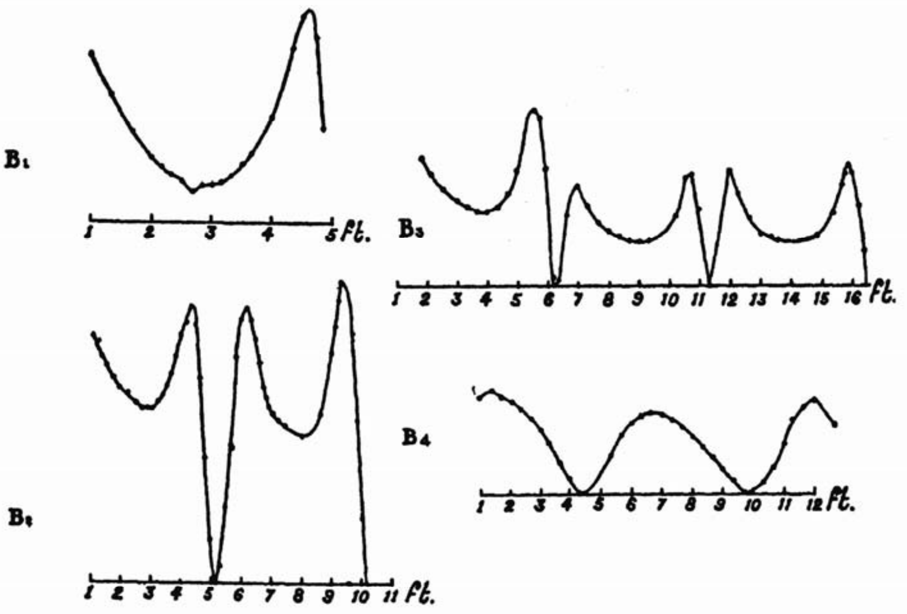

Fig. 2

The results are submitted in the shape of three groups of curves as follow:

Fig. 1, group A_1 to A_6—Length of wires 24 feet and coupling constant, the wires being bridged at various distances from far end, coupling loose, the distribution being mostly due to radiation field.

Fig. 2, group B_1 to B_4—Length of wire altered in steps of $\lambda/2$, the extra lengths being coiled up and wires bridged at bottom of coils.

Fig. 3, group A to 20—Constant coupling, line length decreased in steps from one wavelength to less than $\lambda/2$.

The A group of experiments would appear to show that so long as the far ends are open, the increase in the distance between the bridge and the far ends has little effect on the distribution, and with loose coupling current distribution is normal. Curve $A1$, however shows some peculiarities. The same has been plotted after repeated experiments. For this curve the distance between the node and the antinode is 15 inches corresponding to λ/8 rather than to λ/4. Experimental conditions were the same as with the other curves of the group.

The *B* group all show a double hump formation. It was suspected that the coupling might be the cause of the double humps. Observations corresponding to *B*2, with a length of 12 feet, were repeated with

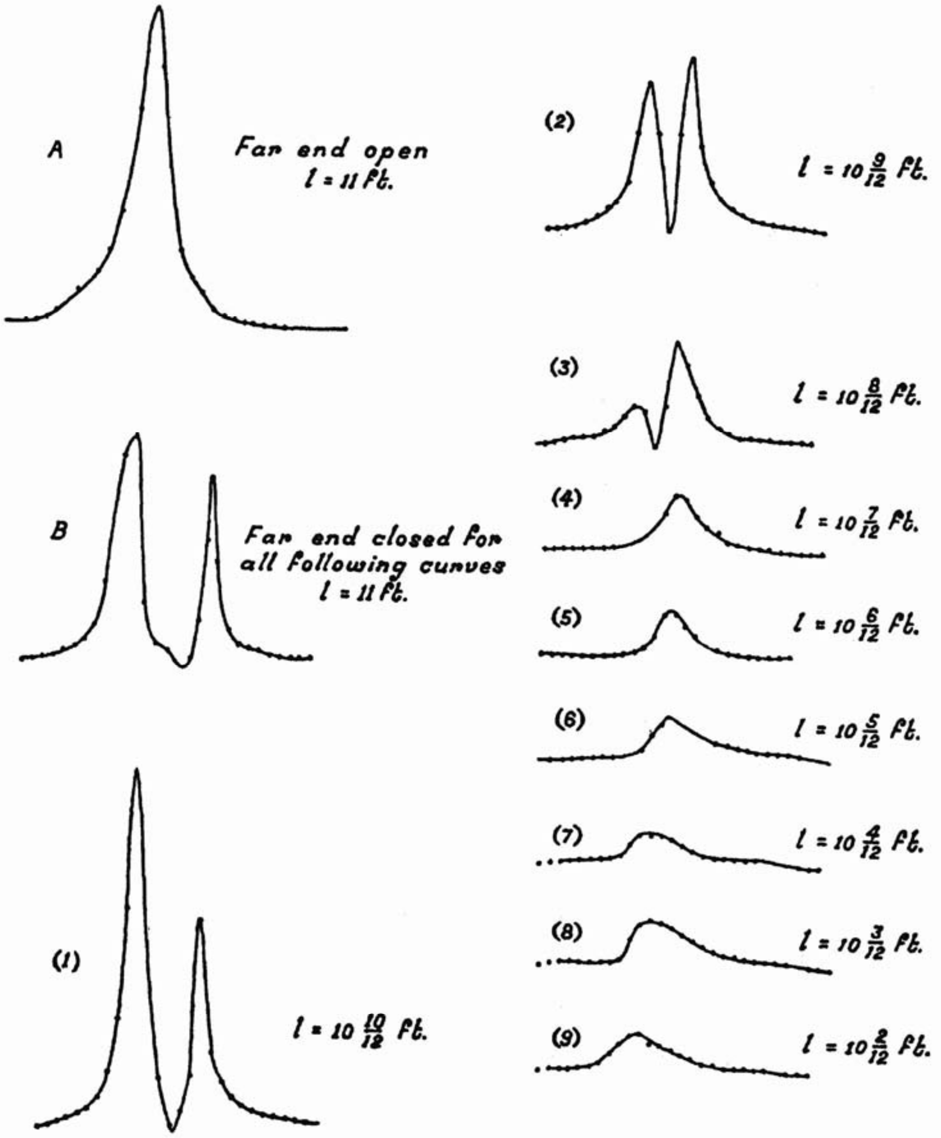

Fig. 3.—Group *A* to 9.

the short-circuiting bridge removed. The double hump disappeared giving the distribution of *B*4. From this set of experiments the peculiar distribution seems to be due to the low impedance bridge at the ends of the wires. Curve *B*1 corresponds to *A*1 giving a spacing of λ/8 and not λ/4 between the node and the antinode.

Finally the shape of a single resonance curve was studied in great detail. With the oscillator working stably at about 3.3 meters, a loose coupled Lecher system was used. The coupling was kept constant and the length of wires gradually reduced inch by inch and the current distribution in the neighborhood of a hump was observed. Curves 10 to 20 of Fig. 3 were thus obtained.

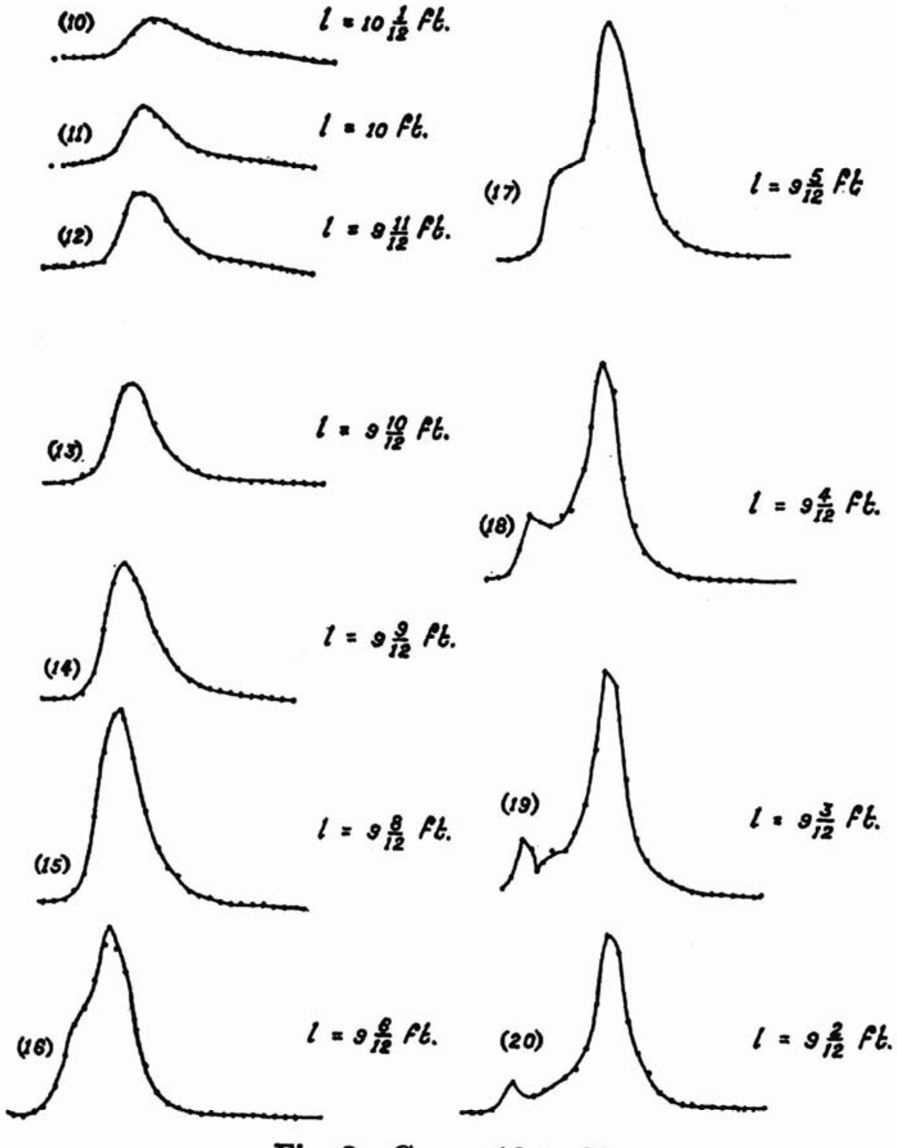

Fig. 3—Group 10 to 20.

In conclusion, the wave form in the Lecher wire method of short-wave measurements is liable to be complex if the lines are exactly a multiple of a half wavelength and the far ends are bridged. Under other conditions the distribution is controlled to a large extent by the dimensions of the system compared with the wavelength.