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Kathryn Jantzen
Grinnell College

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Striations in Stationary Electric Waves

By KATHRYN JANTZEN

The measurement of wave lengths of standing electrical waves in Lecher wires is a standard method of determining the frequency of high frequency oscillators. A common method of discovering the positions of the nodes is by shorting the wires with a small bulb, such as a flashlight bulb. However, we have found another way to determine the positions of the nodes and an interesting phenomenon which occurs in connection with this method. This, as far as we know, has never been reported before.

If fluorescent tubes are placed between the wires when standing waves are set up, the tubes glow at every point along their length except at the position of the potential nodes. By turning the oscillator or changing the length of the wires this dark area can be brought to a minimum width. At this point, also, the tubes fluoresce more brightly. Incidentally, this position, at which the tube is dark, is the only position at which the small bulb, used in the standard method, glows. The phenomenon with which most of this report will deal, however, is one which does not occur when the tube is brightest or the dark area a minimum. This phenomenon is a pattern of striations consisting of light and dark bands. Fig. 1 is a photograph of these striations.

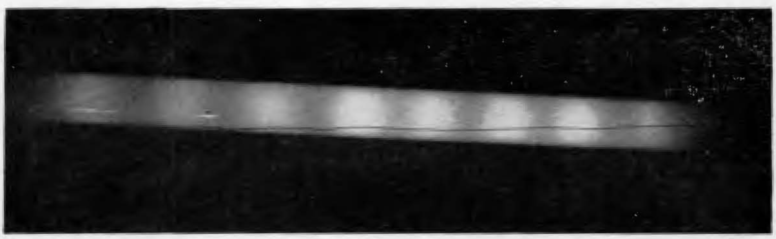

Figure 1. This is a photograph of a striation pattern in a 2-foot fluorescent tube. Although the ends are not visible the pattern extends the entire length of the tube. The black line crossing the pattern is a portion of one of the Lecher wires.

It was possible to obtain fluorescence and striations in each of the tubes used; the tubes were 2 feet, 4 feet and 8 feet in length. When the oscillator is turned so that the node is sharpest, the only way to obtain the striation pattern is to move the tubes away from the wires or to change the coupling between the oscillator and wires. Another method of obtaining striations is by changing the frequency of the oscillator. It appears, then, that the striations form only when the effect of the electric waves is somewhat less than it is at the point of resonance. In accord with this is the fact that when striations do form, they do not extend the entire length of the wires, large portions of the tubes being dark. Nothing quantitative can be said about the length or position of a series of striations, for the conditions (position of tubes, coupling, frequency and length of wires) are so critical that it was never possible to duplicate any one set. Another difficulty is that before striations can form the tube must be fully illuminated, and the conditions where striations exist are close to those at which the illumination ceases. Possibly the only limitation on the maximum length of the tubes which could contain striations is the size of the dark area at the node.

As for the striations themselves, they are poorly defined bands of dark and light, each band being approximately 3 cm. in width. In most cases the striations are not stationary. In a long series all the striations move in the same direction, or else they originate or move toward some position within the series. In the two latter cases, the striations do not move with constant velocity, but in pulses almost stopping between each pulse. This is also noticed at the points where the striations originate or to which they approach, for the striations form or disappear in pulses. The frequency of the pulses and the speed of the motion also seem to depend upon the above mentioned conditions of position, frequency of oscillation, and coupling. By changing any one of these conditions the motion can be made to speed up or slow down. It quite often happens that when the striations are moving in one portion of the tube, they are stationary in another. In this case the two portions are usually separated by a dark band. It is difficult to "stop" the motion of even one series of striations, to say nothing of stopping all of them at once. Fig. 1 shows a good example of a stationary series. It is unusual in that it extends the entire length of a 2-foot tube.

The difficulty of measuring the band width can be seen from the photograph. At the right end the dark bands are more predominant, while at the left end the opposite is true. Also the distance between consecutive light or dark bands becomes smaller at the left end. For the range of frequency of the oscillator it was impossible to tell whether or not the band width changed with wave length. Just to give an idea of magnitudes, however, for a wave length of 375 cm. the distance between consecutive light bands is 5 or 6 cm.

It is quite possible that the phenomenon of striations is a function of the fluorescent tubes. In one experiment two tubes of different length were side by side. In one the striations moved and in the other they did not. The conclusion cannot be drawn that the tube length caused the difference, for it is just as likely that the difference in positions of the tubes was the deciding factor. The same differences in motion are sometimes noticed when tubes are placed end to end and striation patterns are close to the end in each tube. This might likewise be explained by a slight difference in angles that the tubes make with the wires.

It is perhaps of some value at this point to mention some other phenomena which seem to be in some cases parallel to the one under discussion. A Crookes discharge tube exhibits a striation pattern. As far as appearances are concerned, there does not seem to be very much similarity. In the Crookes tube the striations are well defined and much closer together. It is impossible to say whether or not the two have similar causes. However no explanation has been offered for the striation pattern in the discharge tube. In a recent paper[1] Donahue and Dieke made the following statement concerning striations in a discharge tube: ". . . it was not possible to set forth a satisfactory explanation for the moving striations. As a result they have never really acquired a stature beyond that of a mere curiosity, a manifestation perhaps of a somewhat abnormal situation."

Another case to which a few analogies can be drawn is the striation pattern formed by cork dust in a Kundt tube. The dust forms in well-defined ridges, which are close together, so that they, too, appear quite different from the striations in a fluorescent tube.

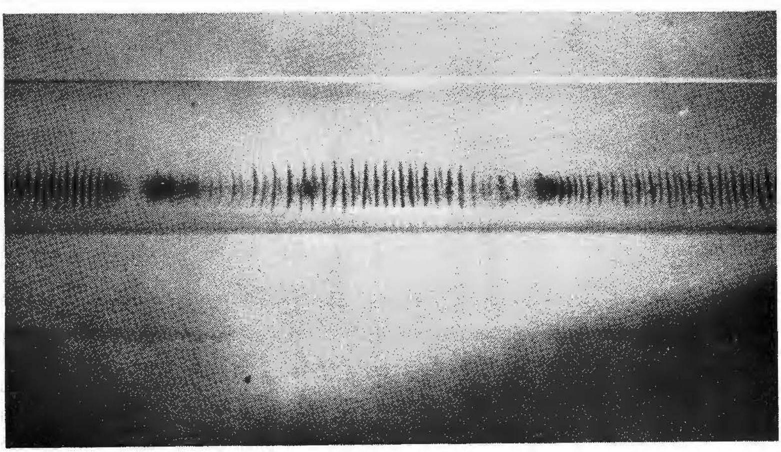

Figure 2. This shows a portion of a cork dust pattern in a Kundt tube. The photograph was taken after the source of sound had been turned off. The ridges do not appear as sharp and straight as they actually do when the sound is turned on.

[1]Donahue, T. & Dieke, G. H., "Oscillatory Phenomena in Direct Current Glow Discharges," Phys. Rev., 81, p. 248, 1951.

These differences can be seen by comparing Fig. 1 and 2. However, the situations under which the striations occur are somewhat similar. In the Kundt tube the pattern forms when standing sound waves are set up. Also, well-defined ridges are not formed under all conditions, but only when the frequency of oscillation is slightly different from resonance or when the intensity is lowered. Nor are the ridges always stationary, as they sometimes move in a direction toward the nodes. The most widely accepted explanation for the pattern in a Kundt tube was given by Andrade.[2] He explained that the dust forms in ridges because of a vortex motion of the air. Even if this is a valid explanation of the phenomenon in stationary sound waves, it is of little use in drawing analogies with stationary electric waves.

Since there has been so much difficulty in arriving at satisfactory explanations for these two phenomena, which have been known for quite some time, it is perhaps safe to say that finding a complete and satisfactory explanation of striations in stationary electric waves will be a long and difficult task.

GRINNELL COLLEGE
GRINNELL, IOWA
604 S. 16 STREET
QUINCY, ILL.

[2]Andrade, Edward Neville da Costa, "On the Groupings and General Behavior of Solid Particles Under the Influence of Air Vibrations in Tubes," Phil. Trans. Roy. Soc. A230 p. 413-445, 1932.