

DISCUSSION

G. Breit (by letter): Professor Morecroft considers my calculations on the distributed capacity of coils and finds them inapplicable in his work. In particular under "Effect of Moisture, Shellac, Spool, and so on, Upon Resistance and Capacity of Coils," just after Figure 12 we find the paragraph: "All of these internal capacities are much larger than theory (by Breit) would indicate, and evidently end connections, shellac, spool, thickness of insulation, and so on, have appreciable effects on the internal capacity, making it generally about twice as much as the theoretical value. In . . . coil. In this case the measured internal capacity was $2.55 \mu\mu\text{f}$, whereas the theoretical value was $2.4 \mu\mu\text{f}$."

I quite agree with Professor Morecroft that the leads have an appreciable effect, and that the other influences cited may be also marked. The most essential factors, however, have been investigated in previous work, as I shall proceed to show.

The effect of the dielectric constant of the spool or insulation is considered in my formulas (22), (27). The capacity according to these formulas is proportional to the dielectric constant— K . If K is not a constant, a mean value must be used. This value becomes unity only if the space occupied by the spool and insulation is negligible. This effect has been demonstrated by Drude (See P. Drude, "Annalen der Physik, 9, 1902, pages 293-339). On pages 302-307, we find the verification of the effect of the core, and on pages 308-310, the effect of the insulation is discussed.

The effect of the leads is mentioned in my paper on page 669, line 1. ("The formulas . . . are . . . in agreement with experiment if capacity of leads is taken into account and the effect of condenser shields is made negligible.") The leads may be considered a part of the condenser with as much right as a part of the coil. For this reason I preferred treating the leads separately.

As a matter of nomenclature, it does not appear to me correct to call the capacity of the leads and clips as part of the *internal* capacity as Professor Morecroft does.

The lead effects discussed in the paragraph just preceding Professor Morecroft's Figure 12 are of the same kind as the effects of condenser shields which have been warned against on my page 669, line 21. In my measurements I avoided bringing the leads close to any part of the coil except the part to which the particular lead is connected.

Professor Morecroft's experiment demonstrating the effect of shellac is open to criticism because paper tubes warp when coated with shellac and wires are frequently shifted in the act of coating. Granting the absence of these errors, the change from 49 meters to 51 meters would amount to 8.2 per cent in the capacity, which is not very much for a capacity of $2.5 \mu\mu f$. If a larger coil were painted with a coat of shellac of the same thickness, the percentage of the effect would be smaller.

So far as the effect of length on the capacity of multi-layer coils is concerned, it is of interest to recall the results of Pietz (W. Pietz—"Ueber die Kapazität von Spulen," "Annalen der Physik," 41, page 543, 1913. Especially pages 559 and 566). It appears that Pietz found an increase in the capacity with length instead of a decrease as Professor Morecroft does.

Professor Morecroft's experiments as to the relative advantages of stranded and solid wire are in agreement with the measurements of Lindemann and the considerations of M. Wien, cited by Lindemann. (See R. Lindemann, "Berichte der Deutschen Physikalischen Gesellschaft," 1909, page 682 and, in particular, page 696 and Figure 4) as well as the theoretical work of Butterworth ("Phil. Trans. Roy. Soc.," A596, volume 222, pages 57-100), and Howe ("Roy. Soc. Proc.," A, volume 93, page 468, 1917), which explains the general effects observed.

The displacement currents between strands which are considered by Professor Morecroft could not be pronounced in the experiments of Lindemann, for if they were, the increase in resistance would not be proportional to the square of the frequency.

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J. H. Morecroft (by letter): I am in agreement with Mr. Breit in practically all his comments on my paper on "The Resistance and Capacity of Coils at Radio Frequencies." The paper pretends to be but a slight contribution of experimental results to a field which is extremely bare; the fact that the only references given by Breit are to German periodicals is sufficient evidence on this point, and he must remember that such matter is not available to the average American engineer.

Instead of endeavoring to disprove Breit's formula, as one might judge from his comments, I really did my best to prove it, and my results show that his formula is correct (within the experimental error of my work) when the extraneous effects are eliminated. The shellaced coil, to which he makes allusion, was meas-

ured for inductance before and after coating with the shellac, and as no appreciable change was observable, it is reasonable to assume that no displacements, such as he infers, occurred. The fact that my results show internal capacity decreasing with length of coil, that Howe assumes the internal capacity independent of length, and that one of Breit's references found it to increase with length, is further evidence that there is still room for the publication of accurate experimental results in this field; this fact was further evidenced by the discussion which followed the presentation of the paper.