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# Student Measurement of Capacitance by the Method of Substitution

W. H. Kadesch
*Iowa State Teachers College*

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W. H. KADESCH

The time-honored methods of measuring capacitance are the deflection method, with a ballistic galvanometer, and the bridge method, using a current galvanometer if by D.C., or a pair of earphones if by A.C. In recent years the vacuum tube oscillator, with some type of detector, has made it possible to measure capacitances more accurately and more readily.

An arrangement in which the amplified output of a crystal oscillator beats against the output of a tuned plate-tuned grid oscillator, was used in this experiment. The plate circuit of the tuned oscillator includes an ordinary variable air condenser connected in parallel with a standard that is variable from 50 mmf upward. The standard is graduated in single mmf. divisions. When the tuned oscillator is adjusted to the frequency of the crystal there is no response in the phones, but when the capacitance in the plate circuit of the former is altered slightly in either direction an audible note indicates that the frequency of this oscillator has also been changed. A low-frequency note sets in for a change of about .4 mmf. in either direction from the zero-beat position. Adjustment to zero-beat is readily made to about .1 mmf.

To measure an unknown capacitance the standard is first adjusted to produce in the tuned oscillator the exact frequency of the crystal. The unknown is then connected into the circuit in parallel with the standard. When the capacitance of the standard is reduced by an amount equal to the unknown capacitance the frequency of the tuned oscillator is again equal to that of the crystal.

In table 1 are given the values of capacitance of each of two condensers as measured by several different students. No. 1 was a small variable air condenser set at a maximum capacitance. No. 2 was a fixed mica. The time required for all of the measurements on either capacitance was about 15 minutes.

**Table I**

| *Student* | *Capacitance* | |
|---|---|---|
| | *No. 1* | *No. 2* |
| A | 27.2 mmf | 237.3 mmf |
| B | 27.3 | 238.15 |
| C | 27.2 | 237.55 |
| D | 27.1 | 238.15 |
| E | 27.2 | 237.3 |
| F | 27.2 | 237.39 |
| G | 27.17 | ..... |

Addendum:

Measurements of the dielectric constant of commercial benzol were made by the instructor. The test cell consisted of a single-bearing

variable air condenser placed with axis vertical in a shallow glass cup. The capacitance of this condenser was measured at the 10th and 95th divisions of a 100-division scale, condenser first in air, then in the dielectric. The changes in capacitance from 10 to 95, and the values of K computed from them, are shown in table II.

**Table II**

Delectric Constant of Benzol

| *No. of settings made* | *Capacitance change* | | *K* |
|---|---|---|---|
| | *With Air* | *With benzol* | |
| 6 | 118.235 mmf | 271.618 mmf | 2.297 |
| 8 | 118.369 | 272.218 | 2.299 |
| 9 | 118.271 | 271.844 | 2.298 |
| 8 | 118.045 | 271.407 | 2.299 |

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