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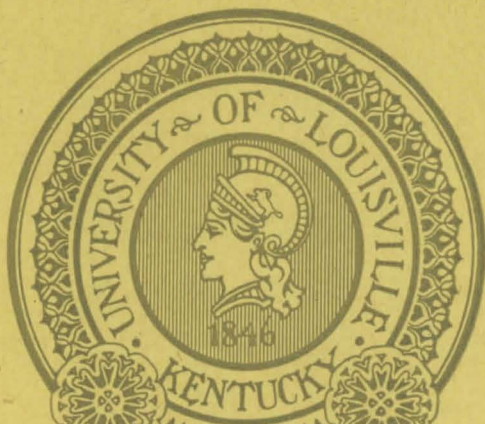
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THE MEASUREMENT OF THE SPECIFIC INDUC-
TIVE CAPACITIES OF VARIOUS LIQUID
DIELECTRICS

OBE BROMFIELD ELLIS

JUNE 1924

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THE MEASUREMENT OF THE SPECIFIC INDUC-
TIVE CAPACITIES OF VARIOUS LIQUID
DIELECTRICS

A THESIS

SUBMITTED TO THE FACULTY OF THE
GRADUATE SCHOOL OF ARTS AND SCIENCES
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DEPARTMENT OF PHYSICS

OBE BROMFIELD ELLIS
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16 May 27
S.D.

THE MEASUREMENT OF THE SPECIFIC INDUCTIVE CAPACITIES OF VARIOUS LIQUID DIELECTRICS

The name inductivity, or dielectric capacity, or specific inductive capacity is given to the ratio between the capacities of two condensers of the same size and shape, one of them filled with the specified dielectric, and the other an air condenser. The inductive capacity of dry air at standard conditions is usually taken as the standard. Therefore, the measurement of the specific inductive capacity of any given dielectric resolves itself into the measurement of the capacity of a condenser with the given material as dielectric.

The capacity of a condenser may be measured by comparing it with the capacity of a standard condenser. There are numerous methods of comparing these capacities, the more important of which are outlined below.

(a) The Electrometer Method. The condenser of unknown capacity is charged to a certain potential. It is then made to share its charge with a condenser of known capacity, and the potential to which the charge sinks is then measured. The original capacity is calculated since it will bear the same ratio to the joint capacity of the two as the final potential bears to the original potential. If **C** represents the unknown capacity, **c** the known capacity, **P** the original potential, and **p** the final potential, then

$$\frac{C}{C + c} = \frac{p}{P}$$

or

$$C = \frac{c P}{P - p}$$

(b) The Wheatstone Bridge Method. Two condensers of capacity C and c are connected in the two arms of a Wheatstone bridge, and the two resistances, R and r , are adjusted so that there is no deflection of the galvanometer either on charge or on discharge. Then the larger capacity acts as the smaller resistance, and the following relation holds

$$C : c = r : R$$

(c) Leakage Through a High Resistance Method. The condenser is charged and is allowed to discharge through a high resistance of the order of twenty megohms and upwards for a known time, t . If C is the capacity of the condenser, r the high resistance, Q the value of the original charge, and q the value of the final charge after leakage, then

$$C = \frac{t}{r \log_e \frac{Q}{q}}$$

(d) The Ballistic Galvanometer Method. An air condenser of unknown capacity or known capacity is charged to a known potential, and is then discharged through a ballistic galvanometer, and the deflection is observed. The same condenser is filled with a dielectric whose specific inductive capacity is to be measured, is charged to the same potential and is then discharged through the ballistic galvanometer, the deflection being noted. Then the ratio of the deflection with the condenser filled with the dielectric whose specific inductive capacity is to be measured to the deflection of the air condenser will be the inductive capacity of the dielectric.

The latter method was used for this work. Three parallel plate condensers of the type commonly used in wireless telegraphy were connected in parallel. This condenser was then placed in a glass vessel, sealed, and dried for twenty-four hours with calcium chloride. It was

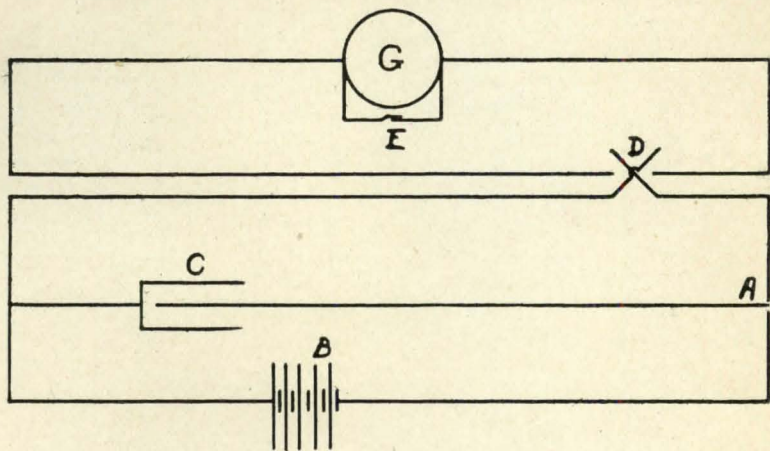
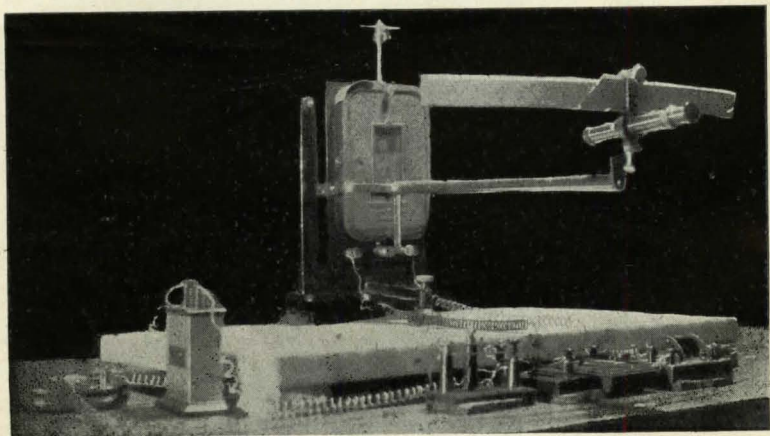
then charged to a potential of 38.8 volts, discharged through the ballistic galvanometer and the deflections very carefully measured. The average of thirty readings, fifteen on each side of the zero, was taken as the most probable value of the deflection. The glass vessel was then filled with the various dielectrics, liquids being used entirely, and the deflections were again measured as before.

A Leeds and Northrup Type HB D'Arsonval Ballistic Galvanometer was used. This galvanometer had a sensitivity of .0364 microfarads per centimeter with a scale distance of 52.5 centimeters. It was found that if the discharge key A, figure 1, was pressed and held down for any length of time, a deflection was observed which was not due to the discharging of the condenser. The cause of this deflection was looked for and was found to be due to a thermal couple at the key which was caused by the heating of the junction by contact with the hand. This was eliminated by tapping the key and measuring the instantaneous discharge of the condenser through the galvanometer, which gave consistent results.

It was very difficult to obtain samples of the various dielectrics that were pure enough to give consistent results. In addition to those named below, water and linseed oil were tried, but these were conducting to such an extent as to render them useless for this work. The air was dried for twenty-four hours before any readings were taken. The turpentine and sperm oil were of a very good quality, and the results obtained from these are of a reasonable order of accuracy. There were no tables to be found giving results on gasoline, and as the gasoline used was a commercial product of rather low specific gravity the value obtained probably has considerable error. The benzene had an odor more of gasoline than of benzene, and its specific gravity was also too low for the pure substance. The results are tabulated, following.

In conclusion I wish to express my appreciation to Dean Warwick M. Anderson who suggested the problem and to Dr. Leo G. Raub whose kind assistance and criticism during my work has been of great value.

Burt



- A**—Charge and Discharge Key
- B**—Batteries
- C**—Condenser
- D**—Reversing Switch
- E**—Damping Key
- G**—Galvanometer

DRY AIR

Temperature 22° Centigrade

Potential 38.8 volts

Deflections

Right	Left	Average
4.00	4.00	4.000
4.02	4.00	4.010
4.00	4.02	4.010
4.10	4.00	4.050
4.10	4.09	4.095
4.10	4.12	4.110
4.00	4.15	4.075
4.10	4.08	4.090
4.03	4.00	4.015
4.09	4.12	4.115
4.10	4.15	4.125
4.10	4.10	4.100
4.10	4.10	4.100
4.00	4.10	4.050
4.08	4.09	4.085

Average deflection 4.068 centimeters

TURPENTINE

Temperature 21.3° Centigrade Potential 38.8 volts

Deflections

Right	Left	Average
9.20	9.32	9.26
9.26	9.28	9.27
9.30	9.20	9.25
8.60	8.82	8.71
9.16	9.00	9.08
8.80	9.20	9.00
9.08	9.20	9.14
8.80	9.10	8.95
8.90	9.14	9.02
9.12	9.20	9.16
8.92	8.70	8.81
8.92	9.40	9.16
9.10	8.84	8.97
9.00	8.98	8.99
9.00	8.80	8.90

Average deflection 9.045 centimeters
 Specific Inductive Capacity 2.224
 Accepted Value 2.230
 Percentage Error .034

SPERM OIL

Temperature 18° Centigrade Potential 38.8 volts

Deflections

Right	Left	Average
13.10	13.30	13.20
13.10	13.50	13.30
13.40	13.28	13.34
13.10	13.00	13.05
12.94	13.36	13.15
12.86	13.50	13.18
12.90	13.10	13.00
13.20	13.18	13.19
13.40	13.30	13.35
13.30	13.00	13.15
12.80	13.60	13.20
13.30	13.40	13.35
12.90	13.02	12.96
12.80	13.60	13.20
12.90	13.60	13.25

Average Deflection 13.19 Centimeters

Specific Inductive Capacity 3.22

Accepted Value 3.17

Percentage Error .15

GASOLINE

Temperature 20.75° Centigrade Potential 38.8 Volts

Deflections

Right	Left	Average
7.80	7.70	7.75
7.84	7.70	7.77
7.86	7.78	7.82
7.90	7.72	7.81
7.76	7.66	7.71
8.06	7.80	7.93
7.80	7.70	7.75
8.00	8.00	8.00
7.80	7.70	7.75
7.90	7.72	7.86
7.88	7.74	7.81
8.00	7.86	7.93
7.94	7.76	7.85
8.02	7.72	7.87
8.00	7.78	7.89

Average Deflection 7.84 Centimeters
Specific Inductive Capacity 1.93.

BENZENE

Temperature 21.5° Centigrade Potential 38.8 volts

Deflections

Right	Left	Average
8.00	8.32	8.16
8.00	8.22	8.11
8.19	8.17	8.18
8.10	8.20	8.15
8.12	8.34	8.23
8.30	8.10	8.20
8.32	8.24	8.28
8.10	8.36	8.23
8.30	8.48	8.39
8.18	8.10	8.14
8.22	8.40	8.31
8.12	8.30	8.21
8.28	8.30	8.29
8.34	8.20	8.27
8.10	8.10	8.10

Average Deflection 8.218 centimeters

Specific Inductive Capacity	2.022
Accepted Value	2.288
Percentage Error	11.6