DSE 4A CLASS

Lecture-1

22/04/2021

"An instrument may be defined as a machine or system which is designed to maintain functional relationship between prescribed properties of physical variables & could include means of communication to human observer."

"The device used for comparing the unknown quantity with the unit of measurement or standard quantity is called a Measuring Instrument."

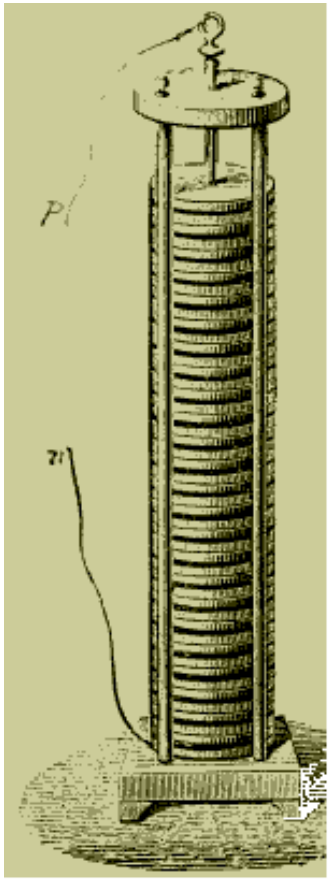
History of Electrical Instruments

Throughout the XVIIIth century, various devices with straw, wire, gold leaf etc were made to estimate tension or electrical charge. They were considered as "electroscopes" rather than "electrometres"

1800 The electric age begins with Volta's battery which sparks many inventors and scientists around the world to start to experiment with electricity. There are no standards of measurement or meters to measure this force.

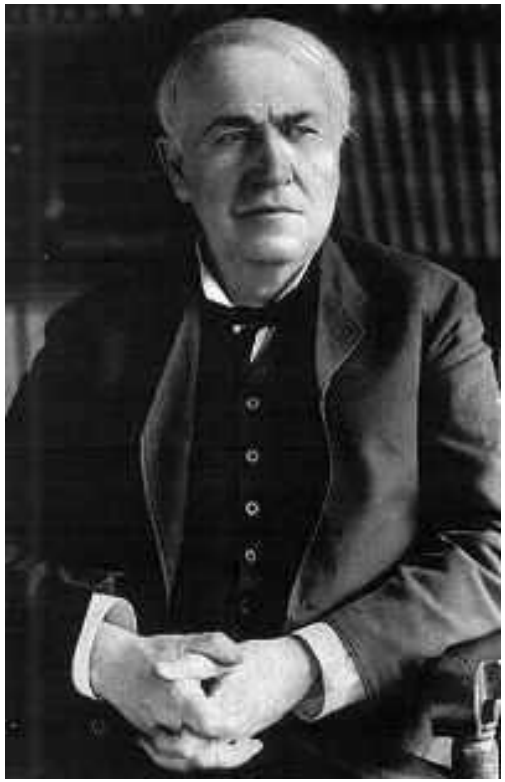
Conte Alessandro Giuseppe Antonio Anastasio Volta, Italian physicist

Volta's battery consisted of alternating disks of zinc and silver separated by paper or cloth soaked either in salt water or sodium hydroxide.



Original illustration of the Voltaic pile.

1879 Thomas Edison invented an electric light bulb. In 1878, Joseph Wilson Swan, an English scientist, also invented an electric light bulb. These two scientists decided to join forces and founded Edison and Swan Electric Lighting Company.

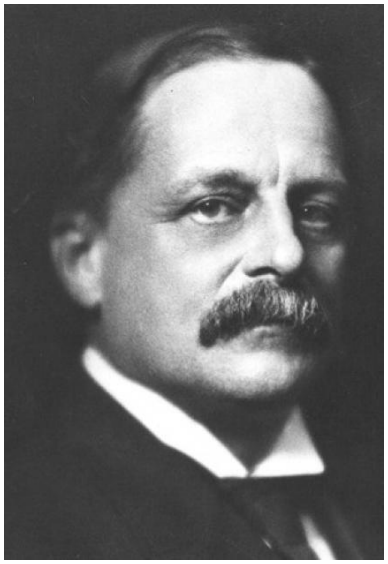


Thomas Alva Edison, an American inventor and businessman

He developed a chemical meter with two rods of copper in copper sulphate solution.

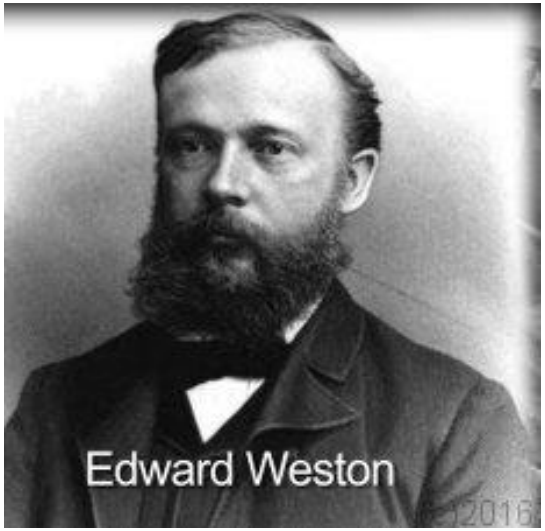
His ‘electric meter’ patented in 1881 used the electrochemical effect of current.

1880s Elihu Thomson develops a chemical meter similar to Edison's except it used zinc sulphate bath which worked much better. Edison's companies immediately started using Thomson's meter.



1880s Thomson builds one of the first reliable wattmeters. He used solid silver bars and brushes with an aluminum disk with a small motor. Edison used Thomson's meter as a standard.

1886 Edward Weston develops a moving coil galvanometer type meter with stable permanent magnet which becomes the basis of Amp, Volt and Watt meters



In **1887** Oliver_Shallenberger develops the first accurate voltmeter at Westinghouse with Philip Lange

In1888 it was Oliver Shallenberger who developed the first practical modern Watt hour meter, based on invention of Weston and Thomson's moving coil galvanometer instruments.

Throughout the XIXth century, engines, generators, lighting devices, were developed on an industrial scale.
Then came demand for common standards.
Instruments of measure were conceived and at the same time units were discussed.
Initiatives were, at first, dispersed until harmonization was felt necessary.

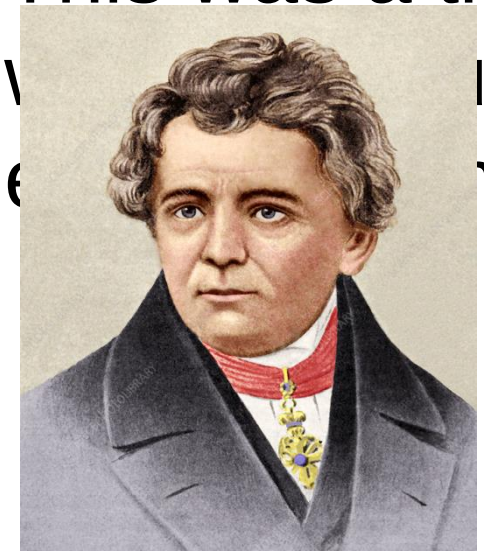
Since 1863 the British Association for the advancement of science had established a unit system that was partially accepted internationally under the name : "**System of the British Association**".

They took Mechanic Science as model.
So Electrical units were defined from the three basic units in mechanics :
the metre, the gramme, the second.

In 1873, William Thomson (later known as Lord Kelvin) suggested that the metre be replaced by the centimetre more suited for measuring volumic masses.

The system was then known as

Beside the theoretical CGS system, the British Association defined a system of practical unit in which the unit of resistance was called "ohm", the unit of electromotive force "volt" and the unit of intensity "weber". This was a tribute paid to three scientists



Georg Simon Ohm

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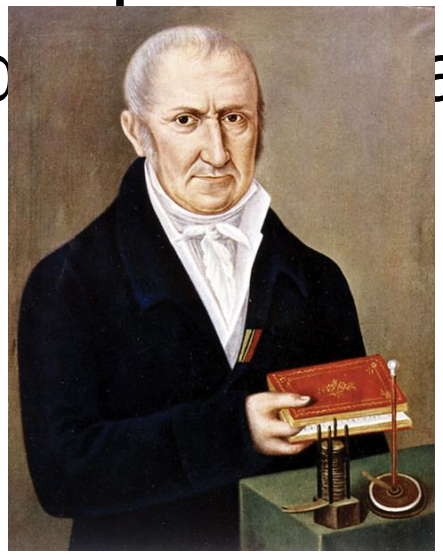


Conte Alessandro Volta,

Wilhelm Eduard Weber, German physicist.

These three units were linked by the formula "I = E/R " which translated the relation established by Ohm between the tension of the resistance terminals and the intensity of the current passing through it.
One weber is, consequently, the intensity of the current that circulates in a resistance of one ohm under the action of an electromotive force of one volt.

Measurement
Units and Standards

Measurement *is the act, or the result, of a quantitative comparison between a given quantity and a quantity of the same kind chosen as a* ***unit****.*

A ***unit*** *is realized by reference to an arbitrary material standard or to natural phenomena including physical and atomic constants.*

A standard of measurement is a physical representation of a unit of measurement.

The international standards are defined by international agreement.
They represent certain units of measurement to the closest possible accuracy that production and measurement technology allow.
International standards are periodically checked and evaluated by absolute measurements in terms of the fundamental units.

In 1860, the British Association for the Advancement of Science appointed a committee comprising Clerk Maxwell, Lord Kelvin, Joule and others to consider the proposals and questions on units. They laid the basis for present absolute systems of electrical and magnetic units.

The primary standards are maintained by national standards laboratories in different places of the world.

The ***National Bureau of Standards (NBS)*** in Washington is responsible for maintenance of the primary standards in North America.

Other national laboratories include the ***National Physical Laboratory (NPL)*** in Great Britain and the oldest in the world, the ***Physikalisch Technische Reichsanstalt*** in Germany.

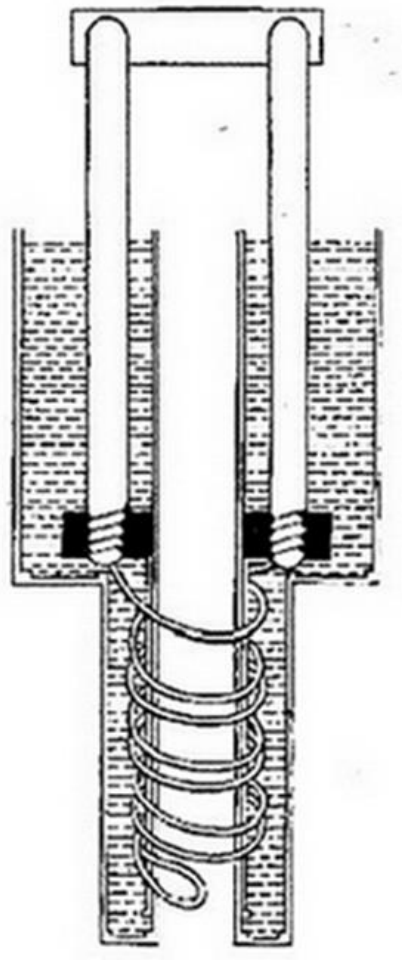
Units of resistance.

The theoretical unit :The value of the CGS theorical unit (cm/s) corresponded to a very low resistance.

The practical unit : The British Association, therefore, selected a practical unit more convenient to measure ordinary resistances. It corresponded to 10 million metres per second (10^9 CGS units). It was then called ohm.
It is to be remembered that 10 million metres correspond to a quarter of the length of the earth meridian, the universal value which is used to define the metre.

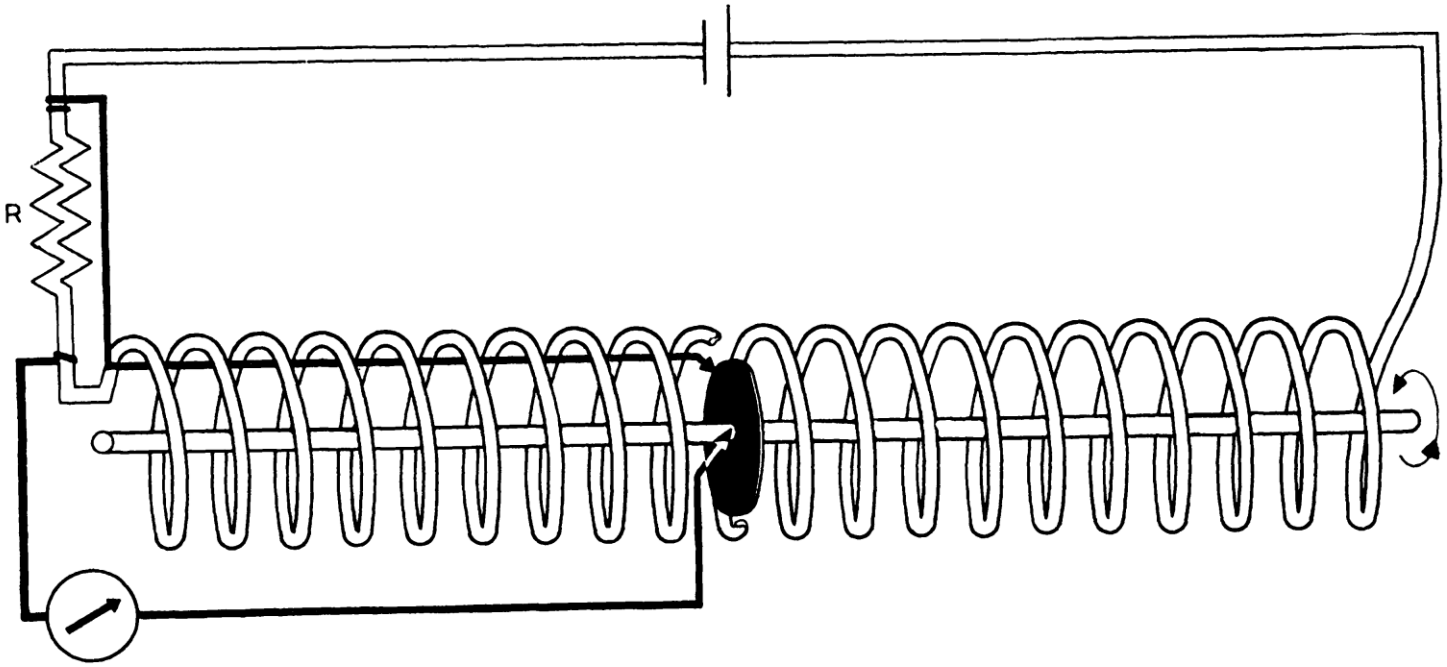
The standards :

Once this practical unit was defined, standards had to be made.
Maxwell, was tasked to determine these standards.



It was made of an alloy of two parts of silver and one of platinum in the form of wires from 5 millimetres to 8 millimetres
diameter, and from one two metres in length.
These wires were soldered with copper electrodes.

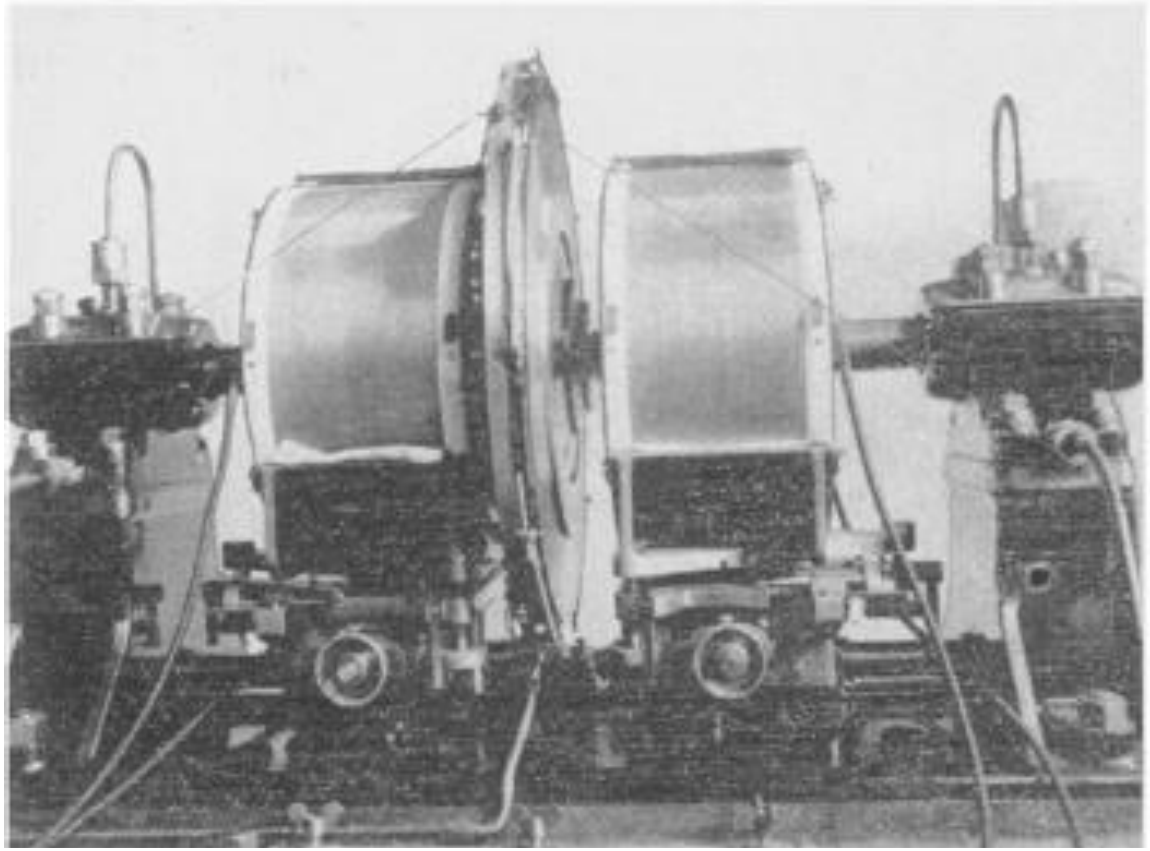
Lorentz Method



B	MAGNETIC INDUCTION
H	MAGNETIC INTENSITY
I	CURRENT IN HELIX
p	PITCH OF HELIX
E	INDUCED ELECTROMOTIVE FORCE IN DISC
r	RADIUS OF DISK
n	NUMBER OF REVOLUTIONS PER SECOND
R	RESISTANCE

FORMULAS

$$B = H = 4\pi I / p$$
$$E = \pi r^2 n B$$
$$E = RI = 4\pi^2 r^2 n I / p$$
$$R = 4\pi^2 r^2 n / p$$



Apparatus developed at British National Physical Laboratory
by Modification of Lorentz method

In the 1920s, Dr. James L. Thomas had taken up the task of improving the long-term stability of wire-wound resistors.

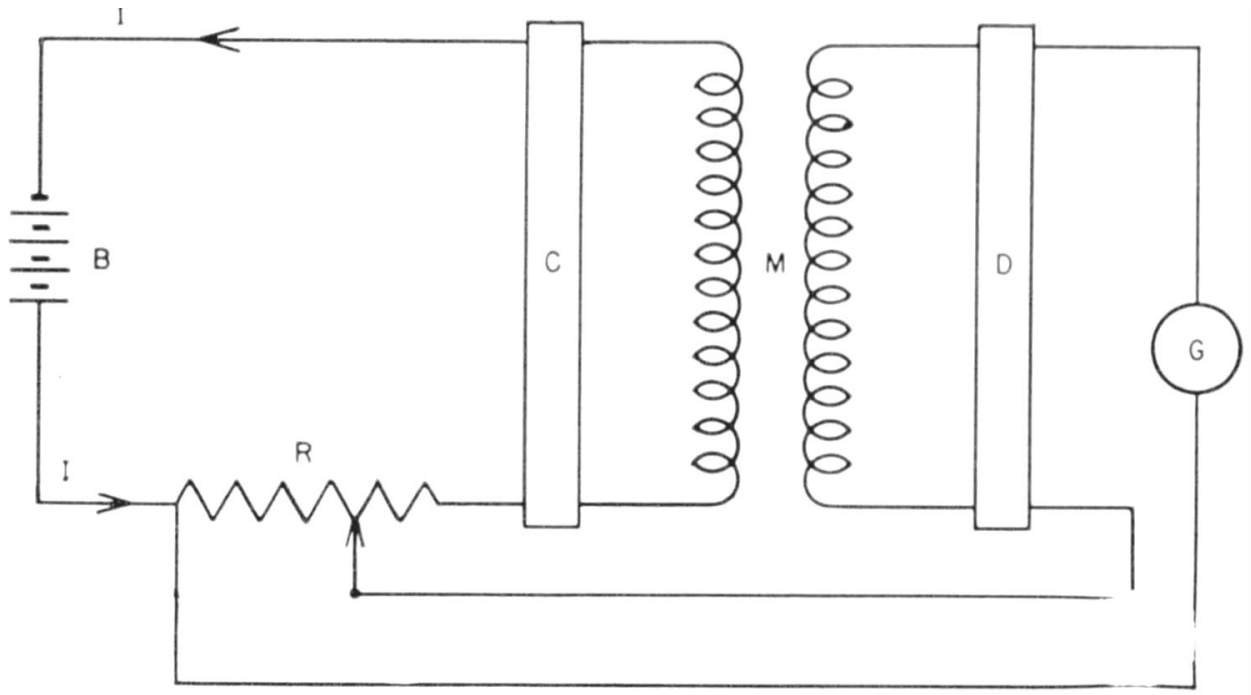
Heat-treated manganin wire resistors developed by Thomas incorporated hermetically-sealed, double-walled enclosures, with the resistance element in thermal contact with the inner wall of the container to improve heat dissipation.

These 1 Ω Thomas-type standards proved to be quite stable with time, and quickly came into favor as the primary reference for maintaining the resistance unit at NBS and at many other national measurement institutes (NMIs).

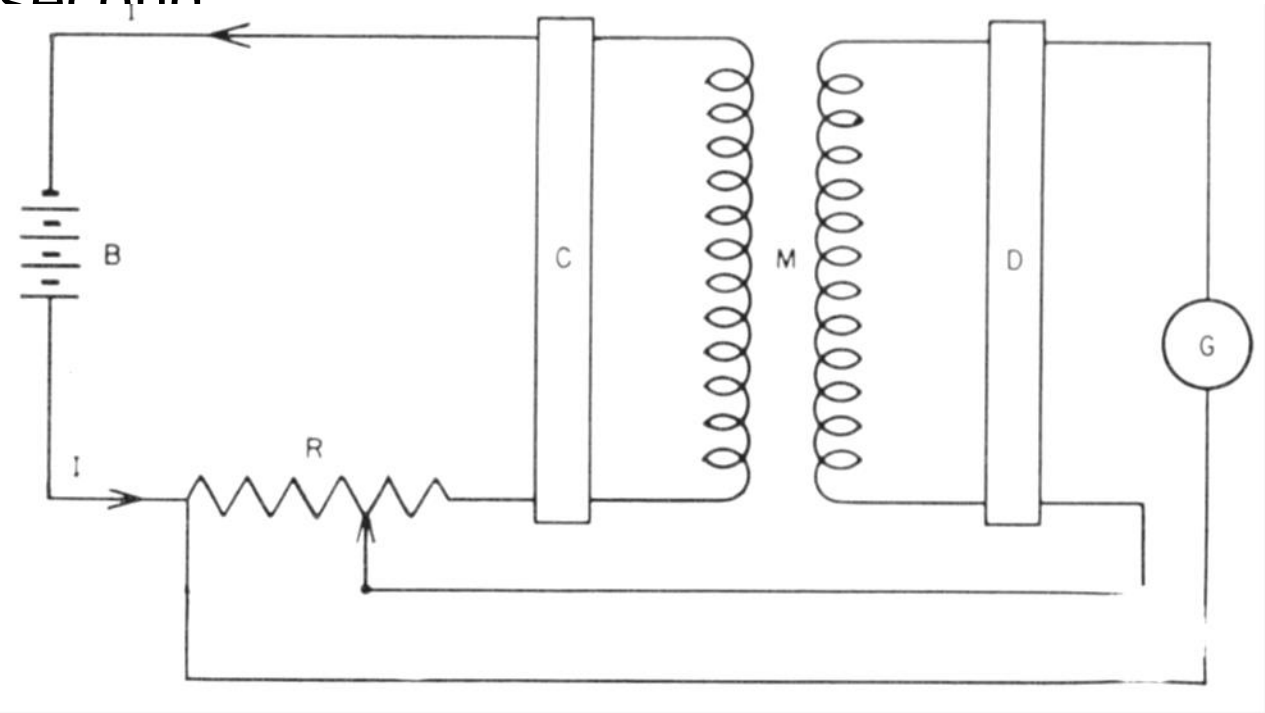

BUREAU OF STANDARDS
ONE OHM No 73

in 1949, J. L. Thomas, C. L. Peterson, I. L. Cooter, and F. R. Kotter published a new measurement of the absolute ohm using an inductor housed in a non-magnetic environment.

Using the Wenner method of measuring a resistance in terms of a mutual inductance and a rate of rotation, the work gave a value of 0.999 994 absolute ohm for the new unit of resistance at NBS.



By means of the storage battery, *B,* a direct current, *I ,* is passed
through the resistor, *R,* and the primary of the mutual inductor, *M.* A rotary switch , C, reverses the connections to the primary but does not reverse the current through *R,* . This switch is driven at constant speed, the current through the primary of the mutual inductor being reversed about 45 times per second



A commutator, *D,* on the same shaft rectifies the alternating emf induced in the secondary.
This rectified emf is connected through a direct-current galvanometer, *G,* to oppose the potential difference across resistor *R* and the galvanometer shows no deflection.

Under this condition $IR=4niM$
I is the average current in the resistor
2n is number of reversals per second,
i is the current in the primary of the mutual inductor

$R=4nM$ (i/I). This current ratio should be constant and be known