

The History Corner: The Galvanometer

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The mirror galvanometer is one of several instruments used for measuring small amounts of electrical current. Its use in psychological research led to greater understanding of the physiological underpinnings of emotion.

The Archives of the History of American Psychology houses several different galvanometers, which measure electrical current, such as the one pictured to the right. This device is a mirror galvanometer typically called a Deprez–d’Arsonval galvanometer because the design was initiated by Marcel Deprez (1843–1918) and Jacques d’Arsonval (1851–1940) in France in the 1880s. This kind of galvanometer was commonly used to measure small amounts of electrical current for laboratory and classroom demonstrational purposes well into the 1940s when it was replaced by electronic measuring devices.

In this device, a mirror is attached to a coil of wire. The coil is suspended in a strong magnetic field from above by a thin ribbon of wire and held at the bottom by a fine torsion spring. Electrical current is introduced to the coil through the wire ribbon and the torsion spring. A small electric current passing through the coil of wire causes the coil and its attached mirror to be rotated around a vertical axis an amount proportional to current flowing through it. The deflection is measured by viewing the mirror’s reflection of a scale set before the mirror by means of a small telescope. It was also possible to bounce a beam of light off the mirror onto a scale outside of the device, allowing very sensitive measurements of electrical current. The spring returns the coil and attached mirror to its original resting position when voltage is removed from the coil, which was the innovation of this design.

The original mirror galvanometer was devised in 1826 by Johann Christian Poggendorff (1796–1877), who is better known to psychologists for the visual illusion that bears his name. He named his device to honor Luigi Galvani (1737–1798), an Italian physician and physicist who discovered that the muscles of a frog he was dissecting moved when it was stimulated by an electric charge. Galvani would go on to investigate the properties of electricity in animals. However, Galvani had nothing to do with the instrument that bears his name or the electromagnetic principle on which it operates.

The earliest form of the electromagnetic galvanometer was devised in 1820 by Johann Schweigger (1779–1857) at the University of Halle in Germany. Hans Christian Oersted (1777–1851), a physicist at the University of Copenhagen in Denmark, had just discovered electromagnetism in April, 1820, while

preparing a classroom lecture demonstrating the heating of a metal wire when electrical current passed through it. A compass was lying nearby and he saw that the compass needle deflected when the electricity was passed through the wire. He sent an article describing this effect to the *Journal for Chemistry and Physics (Jahrbuch der Physik und Chemie)*, which was edited by Schweigger. Schweigger immediately recognized the possibilities of the phenomenon and devised a simple device to measure the strength of the electromagnetic field in terms of the deflection of a magnetic needle. This type of instrument which used a coil of many turns in a magnetic field also became known as a *multiplikator* (multiplier) because the sensitivity of the device was multiplied as the number of turns of wire in the coil increased. Another early form of the electromagnetic galvanometer was devised by William Cummings in England.

Many versions of the galvanometer appeared throughout the 19th Century and their use extended to many different fields of investigation. One of its most important applications was by Hermann von Helmholtz (1821–1894) in 1850. He used a galvanometer as a chronoscope in his classic experiment on the measurement of the speed of the nervous impulse in the frog. The French physiologist Claude Pouillet (1791–1868) discovered that if a brief electrical pulse with a fixed current was sent through the coil of a galvanometer, the deflection of the needle would indicate the duration of the electrical pulse. This allowed the device to measure extremely short durations, far shorter than any other device of the time. In 1901, Willem Einthoven (1860–1927) devised a very powerful device called a string galvanometer. This version of the galvanometer was so sensitive that it was used to measure the electrical potentials of the heart from outside the body, producing the electrocardiogram.

Not to be left out of the game, psychologists began to investigate the influence of electricity in psychological phenomena.

One such early use of the galvanometer was in research published in 1890 by Jean De Tarchanoff (1857–1927) in Russia entitled “Galvanic Phenomena in the Human Skin in Connection with Irritation of the Sensory Organs and with Various Forms of Psychic Activity.” It related to emotional responses to stress and sensory stimuli recorded as changes in the electrical properties of the skin on a galvanometer. The name Tarchanoff phenomenon was given to the effect.

In 1907, Frederick Peterson and Carl G. Jung published an article in the journal *Brain* based on their research in Zurich. They used the galvanometer with normal and abnormal individuals measuring galvanic skin changes in reaction to word associations. Jung mentioned the research as early as 1906 in his *Studies of Word Analysis*.

Otto Veraguth (1870–1944) in Switzerland also published in 1907 a similar study using the galvanometer in conjunction with word-association tests. He noticed that personally emotive stimuli created larger fluctuations in the galvanometer readings from electrodes on the skin than did neutral ones. This led to Veraguth to use the term “psychogalvanic reflex” for the response.

The possibilities of the use of galvanometers to measure deception grew directly from its ability to measure emotional states. Its use for this purpose was controversial. William Marsten, who is often credited with inventing the lie detector, rejected the use of galvanic skin response (GSR) measurements as early as 1921 for measuring deception. However other researchers held that if the galvanometer were used in conjunction with other measures, such as respiration and blood pressure, the GSR could be a

valuable tool for measuring deception. It became part of the “lie detector” assembly.

From the 1920s through the 1960s, the galvanometer or its replacement, one of several psychogalvanometers and their successors, remained standard instruments in psychological laboratories.

The preceding is just a small sample of the early research conducted with this instrument. The galvanometer has been instrumental in psychology research for over a century now. Although it was phased out by more sophisticated measurement devices when electronics came in, the electromagnetic galvanometer ushered in a new era of research blending psychology and biological electrical responses.
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Suggested Reading

Eva Neumann and Richard Blanton, The early history of electrodermal research, *Psychophysiology*, 6, 1970 pp. 453- 475.