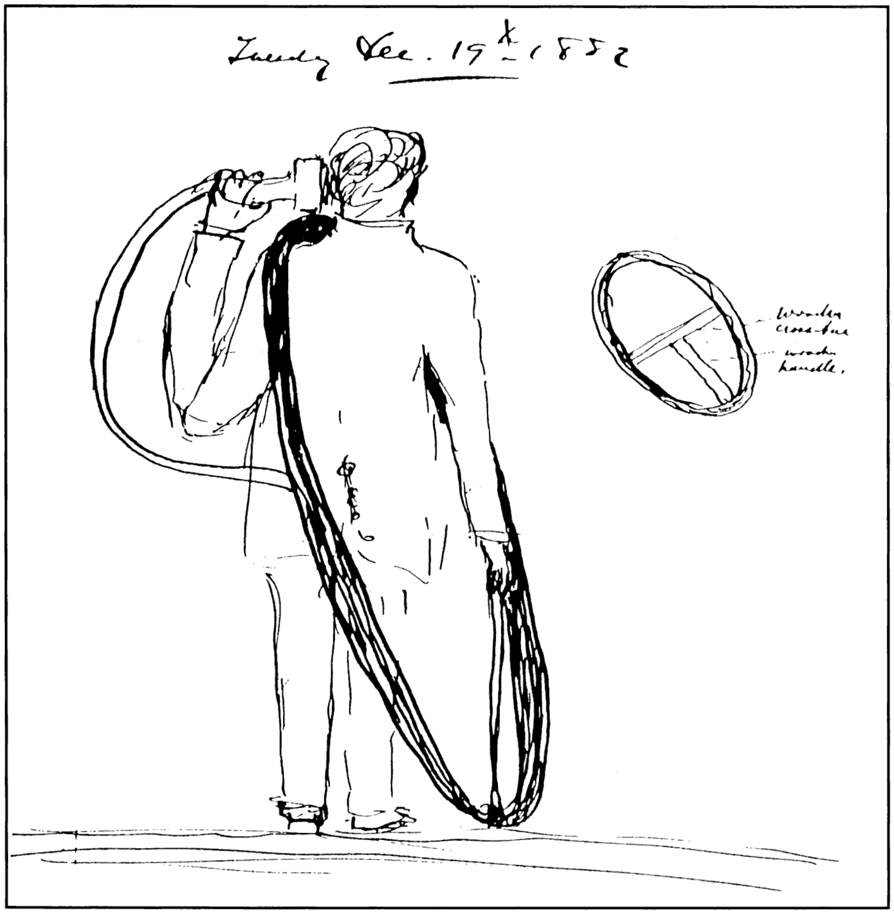


Bell's sketch of his coil for metallic veins and underground telegraph wires, December 19th, 1882.

The History Of Metal Detectors

By Roy T. Roberts

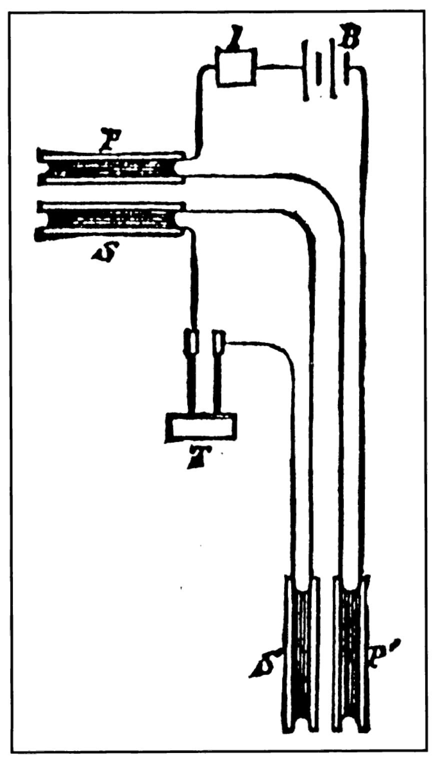
The theory of electromagnetism was first demonstrated by American Joseph Henry, and independently by Michael Faraday of England in 1831. Henry soon successfully experimented with electromagnetic induction and self-induction, the basic foundation for the telegraph, telephone, and radio. He enhanced his experiments upon induction by the use of flat spirals of insulated wire — the first coil.

The influence exercised upon induction by metallic masses formed the subject of numerous experiments by various investigators, as was the principle of balancing the effects of induction on one portion of a circuit by equal and opposite effects produced upon another portion. The earliest form of induction balance for this purpose appears to have been devised in Germany by Professor Dove about 1841. About the same time, a similar apparatus was independently devised in America by Professor Henry Rowland.

In 1876, Professor Alexander Graham Bell's attention was directed to the balancing of induction by the disturbing noises produced in the telephone by the operation of telegraphic instruments on lines running near the telephone conductor. The difficulty was remedied by using two conductors instead of one, so that the currents induced in one conductor was exactly equal and opposite to those induced in the other; thus an induction balance was produced, and a quiet circuit was secured.

This method was patented in England by Bell in 1877, and during the winter of 1877-78 he was engaged in London with experiments relating to the subject. He found that when a position of silence was established, a piece of metal brought within the field of induction caused the telephone (receiver) to sound. When a silver coin the size of a half crown or florin was passed across the face of the two paralleled coils, the silence of the telephone was broken three times.

An English acquaintance of Bell, music professor Daniel Hughes, experimented with induction balance in 1878 and demonstrated in July 1879 a most promising arrangement for induction balance, using four coils, with



Induction Balance circa 1879.

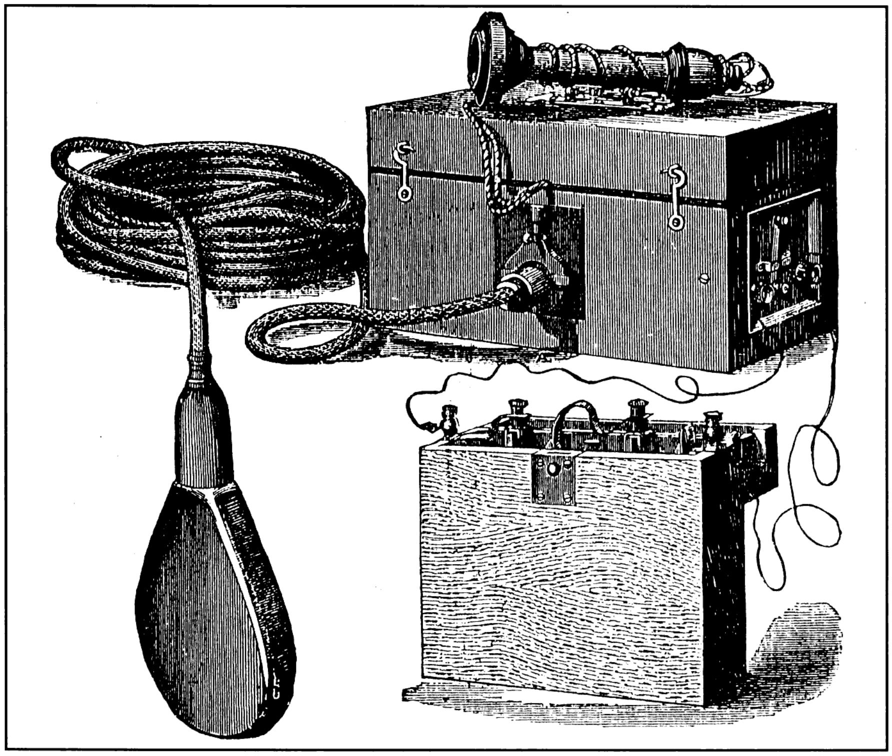
the help of his newly patented electric microphone and the ticking of a clock, to create an electrical disturbance in a circuit containing two primary coils and two corresponding coils connected to a telephone earpiece. When a piece of metal was brought near one pair of the coils, the balance was disturbed, and the ticking of the clock was audible in the telephone.

When Bell returned to America, he published "Upon New Methods of Exploring the Field of Induction of Flat Spirals" in August 1879, at the request of Gardner Hubbard, who saw it as a possible way to detect valuable metallic deposits in the earth.

On July 2, 1881 President Garfield was shot in the back by an assassin. In the hours and days that followed, the whole world waited in hope and fear, as no one could venture to predict the end so long as the position of the bullet remained unknown. Bell, who was in Washington, D.C. at that time, offered his assistance in the matter. He quickly made some preliminary experiments.

On July11, 1881, George Hopkins of *Scientific American* Magazine published his results using improved methods of Hughes' induction balance in the New York *Tribune.* Bell, assisted by Sumner Tainter, contacted Hopkins and, together with Hughes, Rowland, and John Trowbridge of Harvard, set up a network to help build a device to detect the bullet. They experimented with different sizes of balances, lengths and diameters of coils, and batteries, and finally added a condenser to the circuit, until a similar lead bullet was detected about 2" in a clenched hand.

On July 26 Bell brought his apparatus to the White House. After setting up, he heard a sputtering sound and discovered that the range seemed impaired. The device failed to detect the bullet. It was later found out that the condenser had been connected to only one of the two primary coils. Bell returned in August and heard a feeble sound over a considerable area of Garfield's body. The next day he found out that the president's mattress was supported by steel springs. The president later died on September 19. The autopsy showed that the bullet was too deep to detect with Bell's apparatus.



Captain McEvoy's underwater metal detector, circa 1905.

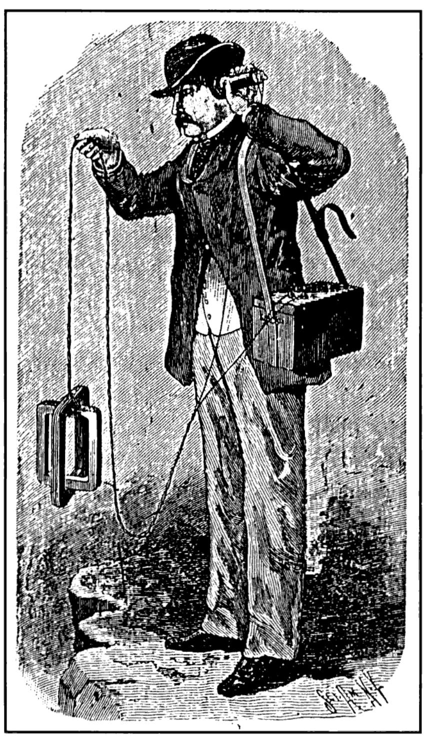
On October 24, 1881, Bell was in Paris, where he successfully demonstrated induction balance and published "A Successful Form of Induction Balance for the Painless Detection of Metallic Masses in the Human Body." His apparatus could detect a bullet at 2-1/2", 5" when flattened, and 1" flattened on edge. In conclusion, he stated that the depth at which an object lies beneath the surface cannot be determined unless the shape and angle of projection are known. Bell's attention was drawn to other work until December 1882, when he experimented with a coil for the detection of metallic veins in the earth of the discovery of underground telegraph wires.

In February 1887, Dr. John Girdner of New York, who had heard Bell's speech five years earlier, published the results of his experimentation with locating metallic masses in the human body. His apparatus consisted of a bichromic battery with six cells, an ordinary interrupter with interruptions being about 600/second. The exploring coils were put in a wooden frame which he called "the explorer," and the other coils were called the "adjusting coils." A bullet could be detected at 6" in the human body, but less in the ground.

At the turn of the century, Captain McEvoy, who experimented with Hughes' apparatus, reduced the metal detector to a thoroughly practical form with his electric submarine detector. A portable, wax-sealed case contained the adjusting coils, the interrupter, a two-cell voltaic battery which could be replaced by a small magneto-electric machine producing alternating currents, and a telephone earpiece. An insulated cable carrying the wires connected up the pairs of coils. Rubber washers, ivory screws, and ebonite knobs were used to limit interference with metal parts. When the search head was lowered into the water by the cable and moved about, or dragged over the bottom, the instant it came against a piece of metal such as a torpedo case, a chain, or a submarine cable, it disturbed the balance; and the sound in the telephone receiver, very faint until then, became unmistakably loud and clear. Its only drawback was that a body of metal lying the place of the coil would not affect it.

During this time, George Hopkins, who had continued his studies with metal detection, invented an electrical ore finder using an induction coil, not induction balance, and his setup of perpendicular coils. He noted that the larger the coil, the larger the current, and the greater the depth of penetration. An ordinary 6" or 8" coil could detect minerals lying near the surface at a few inches.

During WWI some attention was given to bomb detection, but no record of an instrument employed for actual field use was found during research for this article. In 1915, M.C. Gutton of France experimented with such a device but was not able to obtain perfect silence. His apparatus consisted of two transformers in the form of 5 coils connected with a Maxwell-bridge circuit. In 1922, the U.S. Bureau of Standards published "Induction Balance for Detecting Metallic Bodies" after experimenting with Gutton's apparatus and an Anderson-bridge circuit.



George Hopkins' electrical ore finder, circa 1904.

Early in 1924, Daniel Chilson of Los Angeles invented and patented his electromagnetic detector, known as a "radio" detector. His apparatus used a new beat-frequency circuit which became known as the Chilson-bridge. The first successful hunt for buried treasure with a "violet ray" or "radio" device that indicated the presence of treasure was reported by James Young of the New York *Times* in 1927. The hunt was engineered by an American and two English adventurers with a four-year government license on the Isthmus of Panama. Finds included gold chains, jewels, and plate from pirate hoards.

Mr. Young went on to report that it had only been a year or two since sunken treasure hulks began to be penetrated with any success. He anticipated an organized search for lost treasure on a large scale. The radio apparatus, he said, had achieved success where men had sought in vain for two centuries or more, and he predicted that further success in applying the new radio treasure-finder would undoubtedly bring about an intensive search of the West Indies, the Florida Keys, and the coast of Mexico.

Apparently, the first metal detecting book was R.J. Santschi's *Modern Divining Rods: Construction and Operation of Electrical Treasure Finders,* printed in 1927. It proved so popular that later editions appeared in 1928, 1931, and 1939.

In 1929, Gerhard Fisher of Hollywood, California, a consulting research engineer for Radiore Corporation (known for its successful geophysical prospecting for mining companies), patented the "Metallascope." It weighed 22 lbs. and was equipped with dry batteries, vacuum tubes, and headphones. It required no special training or skill to operate. The operator stood between the vertical transmitter and a horizontal receiver which were fastened together by wooden handles. A tube voltmeter registered the strength of the disturbance caused by the metal. The depth of an object could not be estimated, but by noting the angle of the transmitter at which maximum readings were reached at different points, and plotting them on paper using trigonometry, a reasonable estimate could be calculated.

The unit, selling for $200, became widely used by public utility companies to locate quickly and accurately old pipe lines, cables, casings, steel rails, and other buried structures, as well as prospecting for near-surface ore veins. Mr. Fisher went so far as to prepare blueprints and instructions and make them available to amateurs using standard radio parts. The "M-Scope," as it became known, soon became used as a "treasure finder" by persons who believed that they knew the approximate location of buried wealth.

A simpler set selling for $95, the MT-Scope, offered medium sensitivity and adjustable depth range, using a filament voltmeter. A third Fisher circuit was later developed but never placed on the market commercially. It used only three tubes and one double loop instead of separate loops for the transmitter and receiver. Mr. Fisher is also noted for establishing that the longer an object is buried, the more sensitive (susceptible to detection) it is.

Shortly after the same time the Fisher M-Scope hit the market, plans were published to build a homemade "radio prospector" which could find a silver dollar several inches underground, as indicated by a buzzing noise in the headphones. Twenty-eight inch wooden bicycle rims were used for the coils.

In 1930, Theodore Theodorsen, a physicist for the National Advisory Committee for Aeronautics, reported that a new "Instrument for Detecting Metallic Bodies Buried in the Earth" had been developed at Langley Laboratory for the immediate purpose of locating unexploded bombs known to have been dropped from airplanes during target practice near the site of the new Seaplane Towing Channel at Langley Field, Virginia, then under construction. The new "detector" successfully located a number of bombs buried on or near the site, including a 17 pounder 2' deep.

The detector, known as the N.A.C.A. Bomb Detector, was of simple design and required no skilled operators. The design was based on the work of M.C. Gutton of France. Three coils were wound on a hollow wooden frame 3' in diameter and 1-1/2' high. The coils were suspended from a ladder-like frame and required two men. A large power-supply truck was necessary for field operation of the 110-volt unit.

In 1935 a metal detector was designed for the purpose of locating buried shut-off boxes behind walls on the campus of a leading American state university. The radio exploring device was soon promoted as a sensitive instrument for treasure hunting, and plans were published for the amateur in popular magazines. Like most detectors during this era, it had to be brought within a reasonable distance of the target in order to operate and was unable to distinguish between different metals. Although some detectors could compensate for body and ground interference, others reacted to streaks of wet soil or moist grass roots. Even the best of equipment was useless on an ocean beach that contained much magnetic black sand.

During this era an "Invisible Gun Detector" was developed in prisons for magnetic metal. It indicated the presence of metal by the deflection of a cathode-ray tube beam (pulse) producing remarkable sensitivity but required delicate adjustments.

By 1938 a tuned inductance bridge circuit was developed for detecting metallic bits in cigars during manufacturing. This circuit allowed for high sensitivity and good stability under all conditions of temperature, humidity, dust, and vibration. It also featured simple adjustments and compactness, and was more stable than beat-frequency units.

In 1939, Harry Fore published his plans for an inexpensive treasure finder using the Chilson-bridge circuit of beat-frequency, reportedly without interference from outside forces and adjustable to zero beat or silent operation. It used a single loop and detects by a "clucking" sound in the 4,000 ohm headphones. With good adjusting, it could locate a 3" square of sheet metal at 12", and a dime at a few inches.

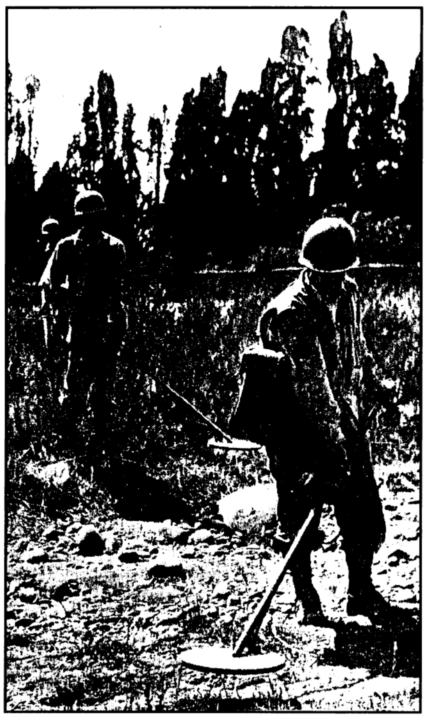
In December 1939, Dr. Lincoln La Paz of Ohio State University presented a paper to the Astronomy Society on meteorite detectors. Three instruments were designed and built, using research from Theodorsen's bomb detector. The first was a large three-coil instrument energized by a portable gas engine-driven 110-volt generator, and was small enough to be mounted in the luggage compartment of a car. The second design was also a three-coil system energized by vacuum-tube oscillators and small enough to be carried in a knapsack. Searchcoils of all sizes could be plugged into the unit as easily as changing a lightbulb. The final design proved the most successful. It consisted of a pickup coil and a power coil, and offered less than half the battery drain of any commercial instrument tested. Weighing less than 15 lbs., it could be used anywhere a man could walk or climb.

With WWII well underway, there came an immediate demand for mine detectors. The work was carried out by the research branch of Britain's Ministry of Supply. Soon they were working on nine different experimental detectors. The problem was to devise an instrument that could withstand the roughest conditions of active service, yet not weigh more than a reasonable additional load for a soldier in battle equipment. In addition, it had to be foolproof in operation, require only a minimum operating team, and be composed of simple interchangeable parts for quick replacement. A single-tube oscillator, developed by William Osborne in 1928, was finally used.

At the beginning of October 1941, the research team were nearing the final stages when they received particulars of a new model produced independently by two lieutenants in the Polish forces. It embodied no new principles or approach, but its layout suggested advantages in manufacturing and operation. It was obvious at once that the Polish design was very good, so test models were based on this design. Production started in December 1941.

The detector consisted of a flat plate, known as the search probe, and measured 8" x 15". A moveable shaft was fixed into the center of the coil, and there were two control knobs on the handle of the shaft. The remainder of the equipment was contained in a haversack on the operator's back. Initial orders for the detectors were placed with various firms in Britain's radio manufacturing trade. This "modernized" detector became the standard design still in use today.

In 1942 considerable experimental work led to the introduction of a frequency-modulation detector. Known as the F.M. Locator, it proved to be very stable and featured adjustable ground balance.



American-made mine detectors, circa 1943.

In 1943, William Blankmeyer made improvements on the beat-frequency metal locator circuit. The same year, the Wheatstone-bridge was developed for measuring resistance in a mine detector. The unit, which was pushed along the ground like a carpet sweeper, was composed of 250 components involving 29 subassemblies.

Immediately after the war, as war-surplus stores sprang up throughout North America and Europe, thousands of mine detectors were released to the public for $5 to $50. Needless to say, this created a new breed of experimenters and treasure hunters.

In 1946, Harry Fore published plans to build an electro-coupled, zero-beat metal detector based on research from the British Army. His design was intended for the advanced experimenter and, while not as "sharp" as commercial locators, retained all the excellent points of the original Chilson type detector and added many refinements. It could detect a 1' square piece of sheet metal at 12". Detection could be indicated by either an increase or decrease of the "clucking" sound rate.

Wartime research on mine detectors had been a boon to those interested in locating hidden treasure. As these new units with more sensitivity and a modernized form grew in popularity, many small companies began manufacturing and selling detecting and treasure hunting equipment The three main type of detectors became the bridge circuit, the beat frequency, and radio balance. Another technological breakthrough, the transistor, was destined to transform metal detector design and performance even more in the decade ahead.

Today, nearly half a century later, the metal detecting hobby and industry are still growing and prospering. And even though the basic principles underlying them may have been around for quite a while, there have been some amazing innovations in our own generation: discrimination, VLF motion discrimination, notch discrimination, visual target ID and depth indication, pushbutton and automatic tuning, precision manual and automatic ground balance, multi-frequency operation, refined pulse induction designs, computerized and miniaturized high-performance detectors, ergonomic body configurations, and much more. We can only dream what tomorrow will bring!

ROY T. ROBERTS is currently researching the history of metal detecting and treasure hunting, and would like to enlist the help of WE&T readers. His address is 20-609 Dundas Street, London, Ontario, Canada NSW 2Z1.