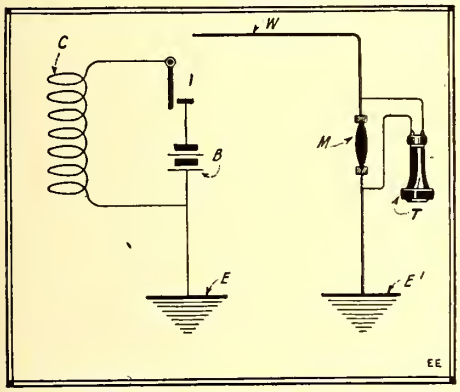
How I Invented the Crystal Detector

By GREENLEAF WHITTIER PICKARD

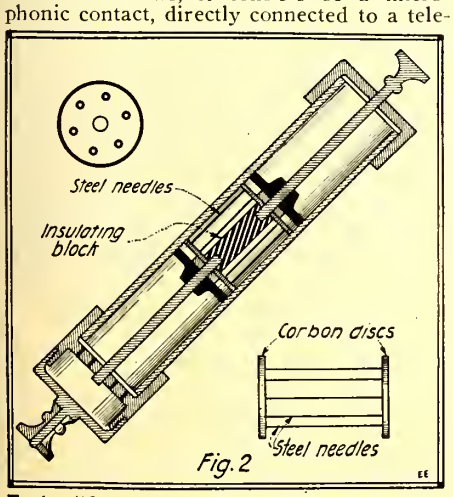
SPECIALLY WRITTEN FOR THE "ELECTRICAL EXPERIMENTER"

IN 1874 Prof. Ferdinand Braun discovered *unilateral conductivity* in a number of the natural metallic sulfids, such as pyrite, galena and chalcopyrite His observations were limited to the application of battery current to metallic contacts on the minerals, and he noted that a materially larger current would flow in one direction than in the other. Five years later, in 1879, Prof. D. E. Hughes, while experimenting with a carbon microphone, discovered that it was affected by a distant spark discharge, altho there was no wire connection between the circuits. Altho Prof. Hughes did not publish an account of his experiments until 1899, he exhibited his apparatus in operation, over distances as great as 1,500 feet, to many of the prominent English physicists, including Preece, Crookes, Stokes and Dewar. A glance at the circuit employed by Prof. Hughes in 1879 will show that he had the principal elements of the



Hughes 1879 Detector System. B Is the Transmitting Battery, C an Inductance Coil, 1 a Mechanically Operated Interrupter and E a Ground Connection. W is the Receiving Aerial, M a Carbon Microphone, T a Telephone Receiver and E¹ a Ground Connection. Hughes Discovered that the Carbon Microphone Was Affected by a Distant Spark Discharge. Fig. 1.

system re-discovered by Marconi in 1895. Undoubtedly, if Prof. Hughes had had proper encouragement at the time, he would not only have anticipated Hertz in the discovery of electric waves, but also Marconi, in their wonderful application to Radio-telegraphy, and so have altered considerably the course of scientific history. Our immediate interest in Prof. Hughes' work is, however, his detector. As my illustration shows, it consists of a microphonic contact, directly connected to a telephone receiver, and without local battery. It is the germ of the crystal detector.



Early "Carbon-Steel" Microphone Detector Used by the Author in 1902 at the Cape May, N. J., Wireless Station.

Dr. Greenleaf Whittier Pickard, Inventor of the Crystal Rectifying Detector. He is Well-known as an Electrical, Telephone, and Radio Engineer and Has Taken Out Numerous Wireless and Other Patents. He Has Tested 31,250 Crystal Detector Combinations.

The Coherer

In 1898, when my work in Radio-communication began, there was but one detector—the coherer. To the early workers in this field, the coherer was the *bête noir* of radio-telegraphy; the principal obstacle to assured and speedy communication without wires. Despite its unpleasant idiosyncrasies, the coherer had our deep respect, first because it was the only thing then known which worked, and second because of its *supposed* extreme sensitiveness to electrical oscillations. In the absence of any quantitative measurements, it was generally assumed that the received energy in radio-communication was so infinitesimal as to absolutely preclude its measurement or even detection by ordinary means, such as galvanometers or telephones, even if by some means it could be converted into a form suitable for these instruments. Altho in some of the early laboratory work with electrical waves various forms of thermo-couples and bolometers were used, the practical workers never considered these as possibilities in actual radio-telegraphy, because of the supposed extremely minute character of the received currents, to which such a device as the coherer could alone respond. In common with the other workers at that time, I held the same view of radio reception, and spent much time in attempts to improve the coherer as to regularity of action.

FEW inventions in radio have been made which proved of such tremendous importance to the young art than the Crystal Detector, invented by Dr. Greenleaf Whittier Pickard. In the olden days of the coherer, when we were still groping in the dark, only comparatively small distances could be bridged. The invention of the Crystal Detector may be said to have opened up an entirely new era in radio, for with the coming of this detector great distances were easily bridged and almost perfect communication was possible at all times. "Wireless" had arrived.

But you will want to read the story of how Dr. Pickard invented the Crystal Detector yourself. It is a historical classic. We promise you twenty minutes of most unusual as well as instructive reading.—EDITOR.

The Microphone Detector.

Much of the trouble in coherer working arose from the adjustments of the coherer adjuncts, the relay-tapper-recorder trio. Realizing this, in the latter part of 1899 I began experiments with a *single contact coherer,* in series with a battery and telephone receiver. I soon found, as several others did at about the same time, that a simple carbon steel microphone consisting of a sewing needle resting lightly against a carbon block, in series with a cell or two of dry battery and a telephone receiver, formed a most effective detector, exceeding the coherer in sensitiveness, speed of working and reliability. And, best of all, I found that this combination permitted a considerable degree of discrimination between Morse signals and static, which was not possest at all by the coherer-relay-tapper-recorder combination. All was fish that came to the coherer net, and the recorder wrote down dot and dash combinations quite impartially for legitimate signals, static disturbances, a slipping trolley several blocks away and even the turning on and off of electric lights in the building. Translation of the tape frequently required a brilliant "imagination!"

Altho the *microphone detector* was a

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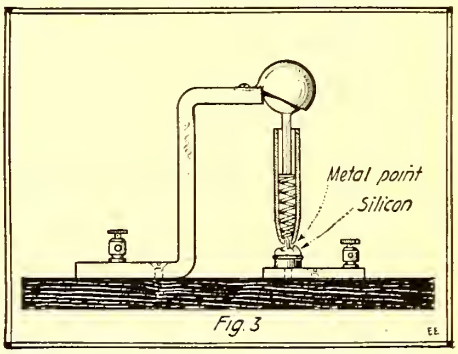
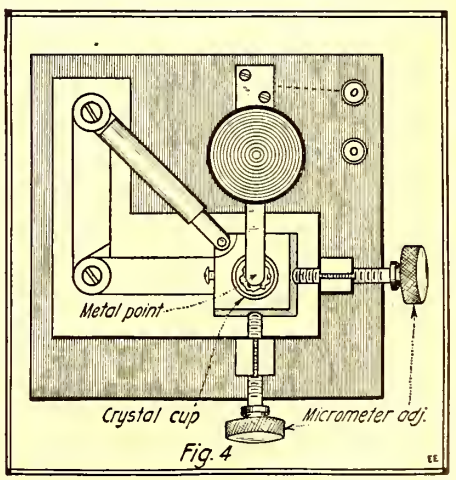


The "Silicon" Detector—A Good Old Standby of All Radio Operators. Invented by Dr. Pickard at an Early Date. It Involved a Sharp Metal Point in Spring Contact With a Piece of Fused Silicon.



Dr. Pickard's "Micrometer Adjustment" Detector. Can be Used With Any Crystal and the Cup Adjusted With Precision in Any Direction While in Use.

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By Dr. G. W. PICKARD

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great improvement over the coherer, I soon found that it, also, had defects. Severe static or nearby sending would usually cause a partial or complete paralysis of the contact, curable only by the hit-or-miss process of repeatedly jarring the detector so that new contact points were formed, or the old ones unwelded. Even in the absence of severe electrical disturbances, the contacts gradually became, as it were, fatigued, and the signals weakened toward inaudibility, unless periodically restored by jars. Then, also, the microphone detector lived up to its name by acting as a microphone, picking up any slight sound or vibration in a most annoying way. Finally, even if the detector was screened from sounds and jars, it was prone to develop a hissing or frying sound, which overlaid faint signals to their obliteration.

The Contact Detector Is Invented.

In the first part of the year 1902, the American Wireless Telegraph and Telephone Company erected stations at Atlantic City and Cape May, N. J., about 40 miles apart, and also equipt the schooner *Pleiades* as a floating experimental station. On May 29, 1902, I was in the Cape May station, experimenting with a new system of tuning, and receiving signals from the *Pleiades*, then about two miles off Cape May. The detector I was using consisted of several fine sewing needles, laid lightly across a pair of carbon blocks, and in series with three cells of dry battery and a telephone receiver. Becoming annoyed at the microphonic "fry" of my detector, I attempted to check this by, as I thought, cutting out of circuit two of the three dry cells. The frying ceased, and the signals, tho much weakened, became materially clearer thru being freed of their former background of microphonic noise. Glancing over the circuit, I discovered to my great surprise that instead of cutting out two of the three cells, **I had cut out all three**, so, therefore, the telephone diafram was being operated **solely by the energy of the receiver signals.** A contact detector, operating without local battery, seemed to me so extraordinary, so contrary to all my previous experience, that altho I did not then know the reasons for its operation, I appreciated its possible great value to the art, and resolved at once to thoroly investigate the phenomenon at the earliest possible moment. This entirely accidental discovery was the foundation of my invention of the crystal detector.

Silicon and Other Detectors Invented.

During the summer of 1902, I was concerned with the development of a system of radio-telephony, conducting this work in the Boston laboratory of the American (Bell) Telephone and Telegraph Company. As one of the essential elements of this system was a detector which would respond quantitatively to telephonically modulated electrical waves, I at once began a series of tests, first with the form of the carbon-steel microphone I had used at Cape May, and then with other contact materials. Discovering that such detectors responded quantitatively to musical spark signals up to at least 2000 sparks per second, and were therefore capable of receiving speech, I devoted my energies for the time to the transmitting end of the system, finally discovering, in the fall of 1902, an effective means of telephonically modulating a stream of electrical waves. Returning to the detector development, I found that the Telephone Company had in their laboratory a large quantity of magnetite ($FeO.Fe_2O_3$) crystals, which had been procured as a possible material for loading coil cores. I broke one of these crystals apart, exposing a fresh fracture face, made a small area contact thereon with a brass point, and found that this crystal, like the carbon steel detector, operated well without local battery, but, unlike the carbon-steel contact, did not require a light or microphonic contact for best operation. In the period 1902 to 1906, I tested many different minerals and combinations, including magnetite, pyrite, galena, molybdenite, silicon and zincite. Much development was also required on holders for these minerals. Perhaps one of the greatest early stumbling blocks in such development was the old coherer idea that extremely light pressure contacts were necessary. With the carbon-steel microphone, this was still true, but I can remember my surprise when I found that many of the minerals worked best with quite high pressure contacts.

31,250 Crystal Detectors Invented.

A list of the several thousand materials I have tested would make dry reading. *Suffice it to say that I have found some two hundred and fifty minerals and furnace products which make operative detectors, either against metallic contacts, or in combination with other minerals. The possible combinations of these two hundred and fifty substances, amounting to some* 31,250 *pairs, have all been tested by me, or by my assistants, and many hundred useful pairs have been found.*

Oscillating Crystal Detectors.

The last word on crystal detectors and their uses has yet to be written. **For example, it may be of interest to know that they can be made to OSCILLATE, under proper circuit conditions, and I have found it possible to receive intelligible signals from UNDAMPED wave stations across the Atlantic, on a simple contact between a fragment of galena and a fine wire.**

MOTHER SHIPTON TOLD OF AVIATION IN 1488.

The following, which is known as "Mother Shipton's Prophecy," was first published in 1488, republished in 1641 and again in 1875. It will be noticed that all the events predicted in it except the last two lines have come to pass:

Carriages without horses shall go;
And accidents fill the world with woe.
Around the world thoughts shall fly,
In the twinkling of an eye;
Water shall yet more wonders do;
How strange, yet shall be true.
The world upside down shall be,
And gold be found at root of tree.
Through hills men shall ride,
And no horse or ass be at his side.
Under water men shall walk,
Shall ride, shall sleep, shall talk.
In the air men shall be seen,
In white, in black, in green.
Iron in water shall float
As easy as a wooden boat.
Gold shall be found, and shown
In a land that is not known.
Fire and water shall wonders do,
England shall at last admit a Jew.
The world to an end shall come
In eighteen hundred and eighty-one.

(It is curious to note that only the last two lines—WHICH DO NOT RHYME—have failed to come true. All the others that do rhyme did come about as prophesied!—Editor.)