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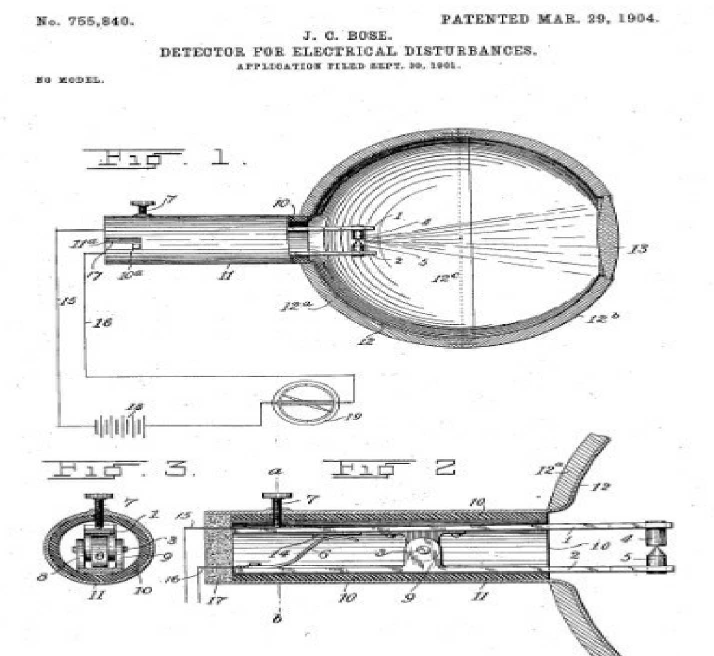
michel ALAS

GALENA TRANSMITTER

While galena receivers are well known to the general public, the same cannot be said for galena transmitters. As we will see, although this property has been known for over a century, it is still not easy to create a reliable setup even today.

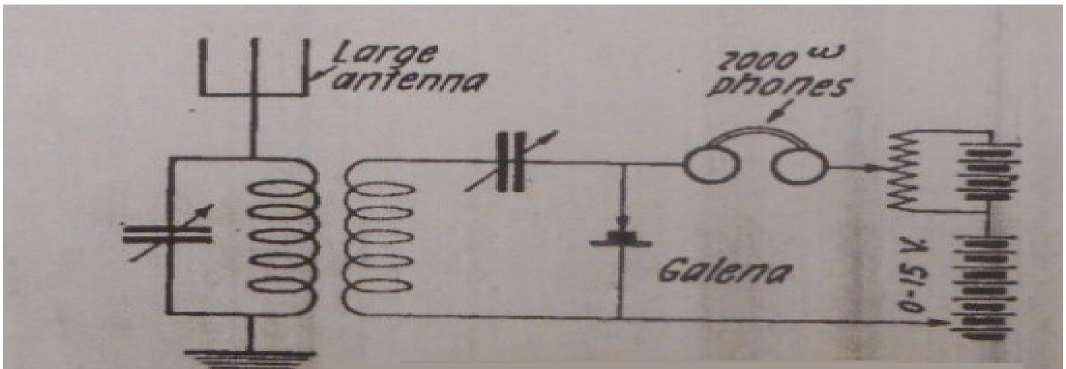
SOME REMINDERS ABOUT GALENA

Galena is lead sulfide (chemical formula PbS) and is one of the main lead ores. The first person to discover its unique electrical conduction properties was a young German physicist, Karl Ferdinand Braun, in 1874, 12 years before Heinrich Hertz demonstrated the existence of electromagnetic waves. The first person to use galena as a radio wave detector was the Indian physicist Jagadish Chandra Bose. In 1901, he obtained a patent for this purpose (US Patent 755,840).



Galena detector J.C. Bose (1901) Figure 1

He used it in a particular way to detect short-wavelength radio waves, with the direct current flowing through the point/crystal assembly varying according to the intensity of the radiofrequency field. This detector allowed him to confirm that very short-wavelength radio waves followed the laws of classical optics. Shortly afterward, galena was used to detect longer-wavelength waves, and it was discovered that many other minerals possessed equivalent properties. It was precisely on this occasion that William Henry Eccles highlighted the possibility of generating periodic waves using the classic setup of that time for receiving radio waves (Figure 2).

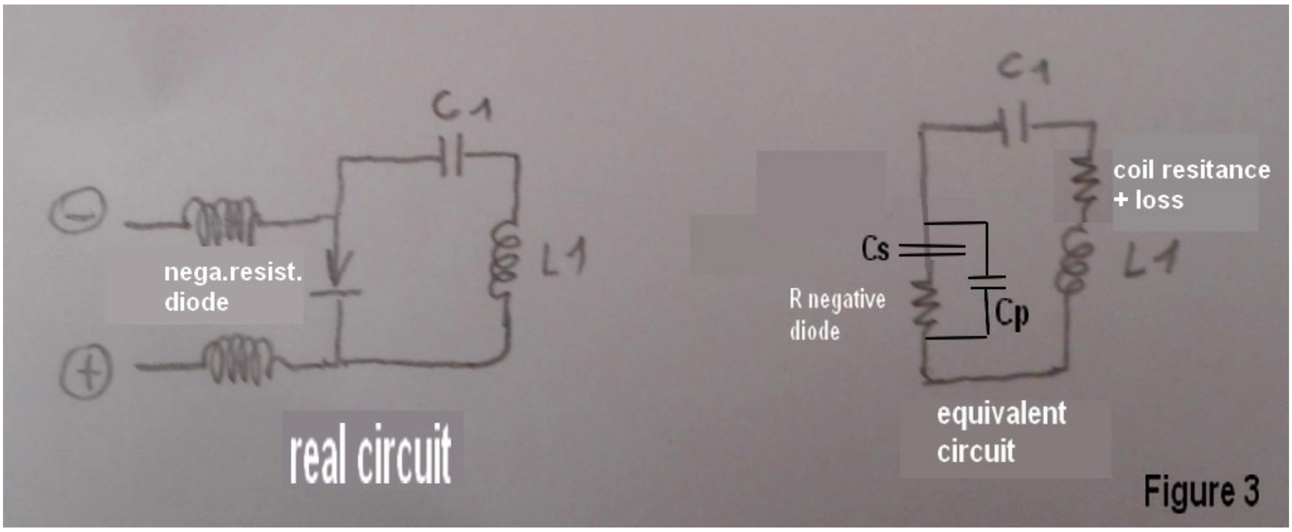


Montage W.H.Eccles 1910 Figure 2

The setup was later adopted by many others, especially by Pickard (see Radio News, January 1925). At that time, the oscillation of galena and other materials (such as zincite) seemed to be in vogue, and numerous authors delved into it. More recently, on YouTube, one can find videos showcasing transmitters with galena following this principle, but their authenticity is questionable (not reproducible). Why not embark on the adventure ourselves? That's exactly what we did, and we're about to see the results

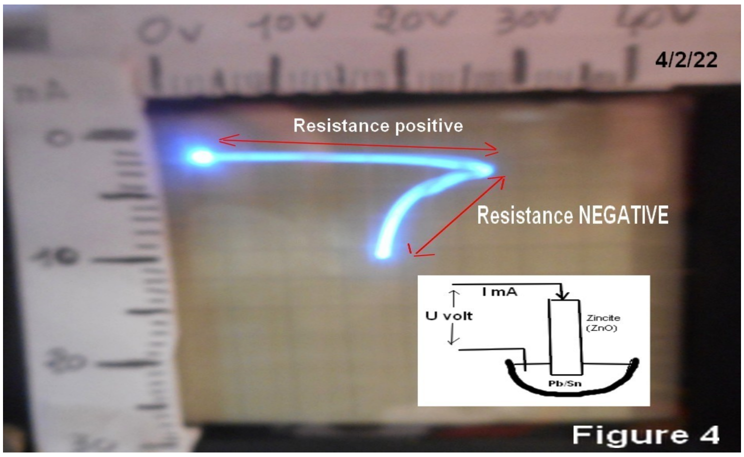
OSCILLATION AND NEGATIVE RESISTANCE

The ability of the circuit in Figure 2 to oscillate may seem mysterious. By employing the concept of negative resistance, everything becomes clearer, as this idea of negative resistance is something observable and measurable with very few resources. The circuit in Figure 2 can be schematically represented by that in Figure 3, where a diode is powered by a direct current and has in parallel a circuit consisting of L1 and C1.



If the negative resistance of the diode is at least equal in absolute value to the resistances of the oscillating circuit L1/C1, the system can oscillate at a frequency dependent on L1, C1, and also on the "parasitic" capacitances Cs and Cp. The energy is supplied by the direct current power source.

Many diodes exhibit negative resistances. This is the case for the galena/steel contact, but also for many others. Measuring the negative resistance of a galena/steel diode is not experimentally easy for many reasons (instability of the contact, highly variable purity from one crystal to another, natural oxidation of galena in the air, etc.). However, it is much easier with a zinc oxide diode consisting of a zincite crystal and a steel tip. Zincite is indeed purer than galena and, more importantly, remains perfectly stable over time, making the measurement easy and reproducible.



As seen in Figure 4, where the current-voltage characteristic of the steel tip/zincite crystal system is plotted, initially, as the voltage increases, the current also increases (positive resistance region). Then, from around 25 volts, the opposite occurs: the current increases, but the voltage across the crystal decreases. This is the region with negative resistance. The value of the negative resistance can be measured; it is the slope of the voltage-current curve. As can be observed, it is far from constant (it is not a straight line).

TEST SETUP

It consists of 3 modules:

Power Supply Module

Test Module

Visualization Module

The power supply module, created with available resources, allows obtaining a variable voltage between 0 and approximately 300 volts with a current of several tens of milliamps. It can output either a continuous voltage, a pulsed DC at 50 Hz, or an alternating current at 50 Hz (see Figure 5).

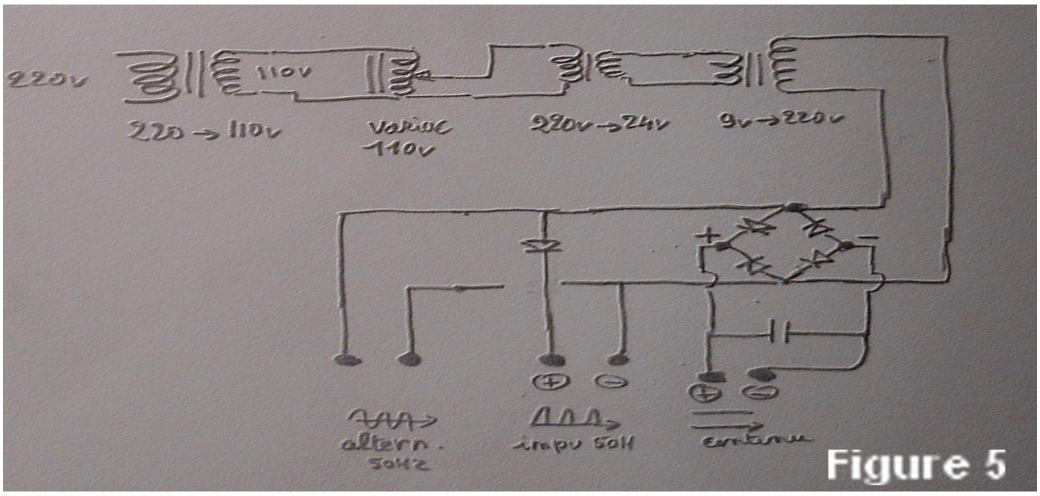


Figure 5

The test module is structured around an X/Y oscilloscope, which allows for a straightforward plotting of the current-voltage characteristic of the crystal (see Figure 6). An inductor-capacitor circuit is connected in parallel with the tested galena.

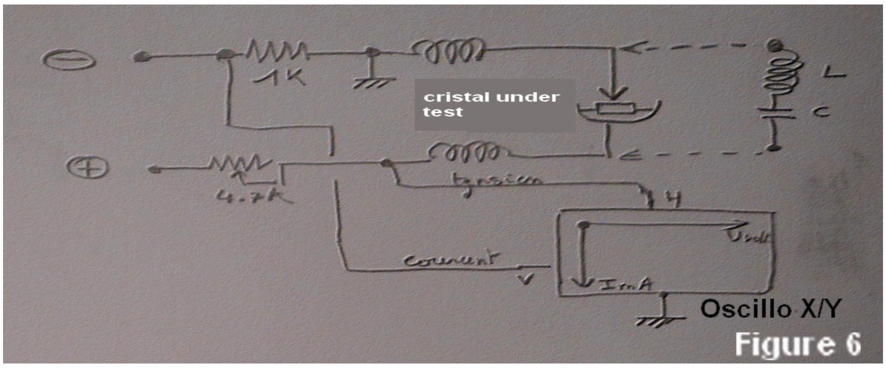


Figure 6

The coil L is a transformer retrieved from a switching power supply (ohmic resistance 1 ohm). A few coupling turns have been added to recover the signal analyzed by the spectrum analyzer. The coil is in series with a capacitor of 860 pF, the combination resonating at 90 kHz. The crystal to be tested is embedded in a Lead/Tin alloy placed in a small crucible lined with a copper sheet. This part is connected to the positive pole of the power supply. The negative pole is connected to a steel tip (sewing needle in Figure 7).

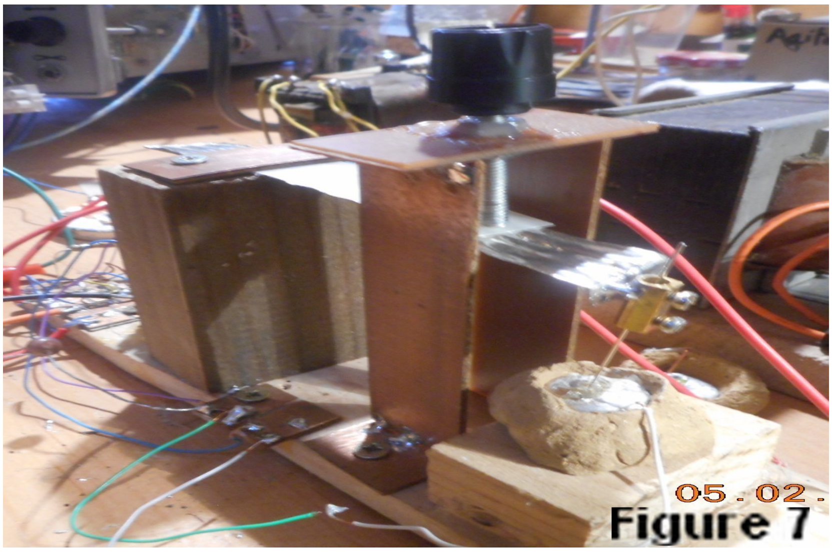
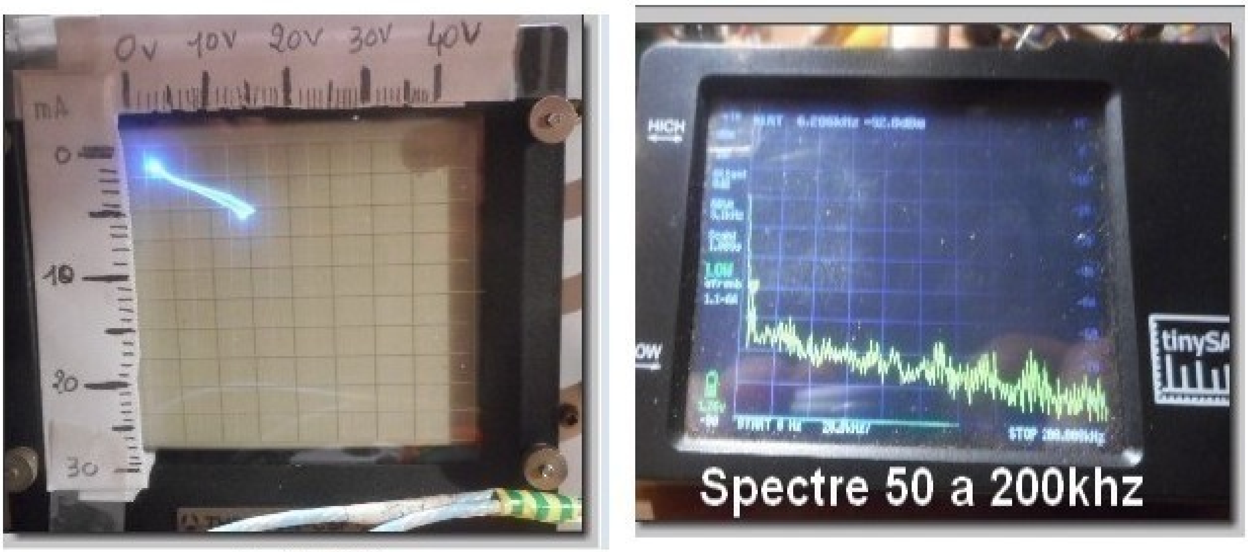


Figure 7

The visualization setup consists of an X/Y oscilloscope and an affordable Tiny Spectrum Analyzer covering an adjustable frequency range. During tests, a sweep is performed between 50 kHz and 200 kHz or beyond. This process takes a few seconds, which is a limitation when dealing with variable frequency signals.

The main advantage of this device is the ability to quickly identify crystal points with the desired properties, namely negative resistance (on the X/Y oscilloscope) and circuit oscillation (on the Spectrum Analyzer).



Oscillo X/Y

spectrum.analyzer

Figure 8

The setup is tested with a zincite crystal. A highly pronounced and stable negative resistance is observed over time for several needle positions on the crystal (Figure 4). When the oscillating circuit is connected, circuit oscillation is clearly observed, whether powered continuously or in pulsed 50 Hz continuous mode. When powered continuously without pulsing, stable oscillation is noted, with the frequency varying as the current in the steel tip/crystal assembly is adjusted. In the latter case, the spectrum recorded on the spectrum analyzer is complex because the signal is strongly frequency-modulated (the spectrum analyzer takes several seconds to sweep the exploration zone).

EXPERIMENT WITH NATURAL GALENA

The tested sample is an agglomeration of crystals (originating from Bulgaria). By breaking apart the agglomeration, crystals were obtained and tested in the same way as with the zincite crystal. It was impossible to observe any zone with negative resistance or oscillation. At best, a difference in conduction depending on the direction of the current could be verified (Figure 8b).

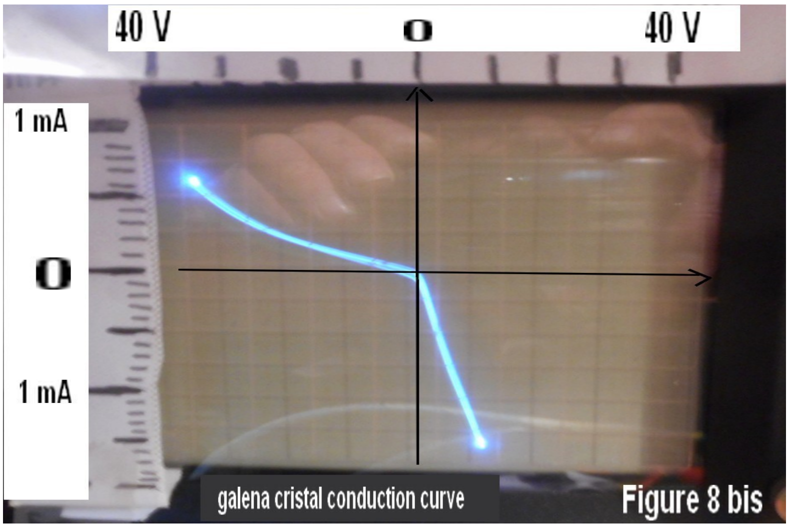


Figure 8 bis

EXPERIMENT WITH SULFUR-TREATED GALENA

It is well known that it is possible to revitalize a failing galena crystal. Chemically, lead sulfide oxidizes in humid air, producing substances that do not possess the semiconductor properties of galena. The most commonly employed technique involves treating galena with sulfur. Its implementation is straightforward; a mini furnace is set up (Figure 9).

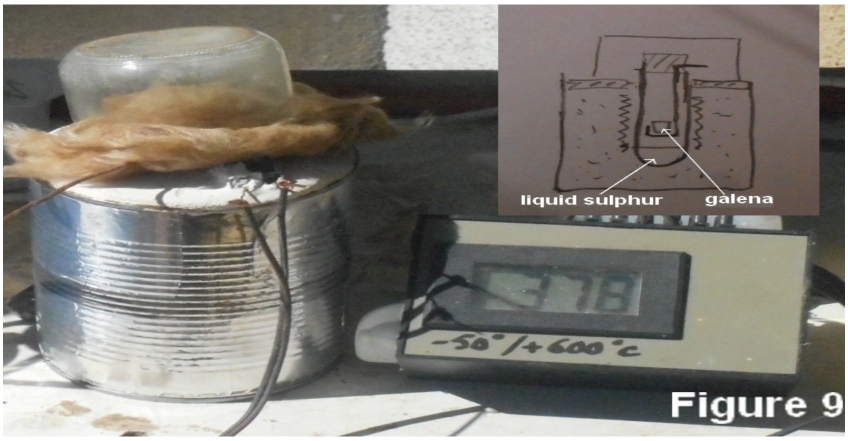
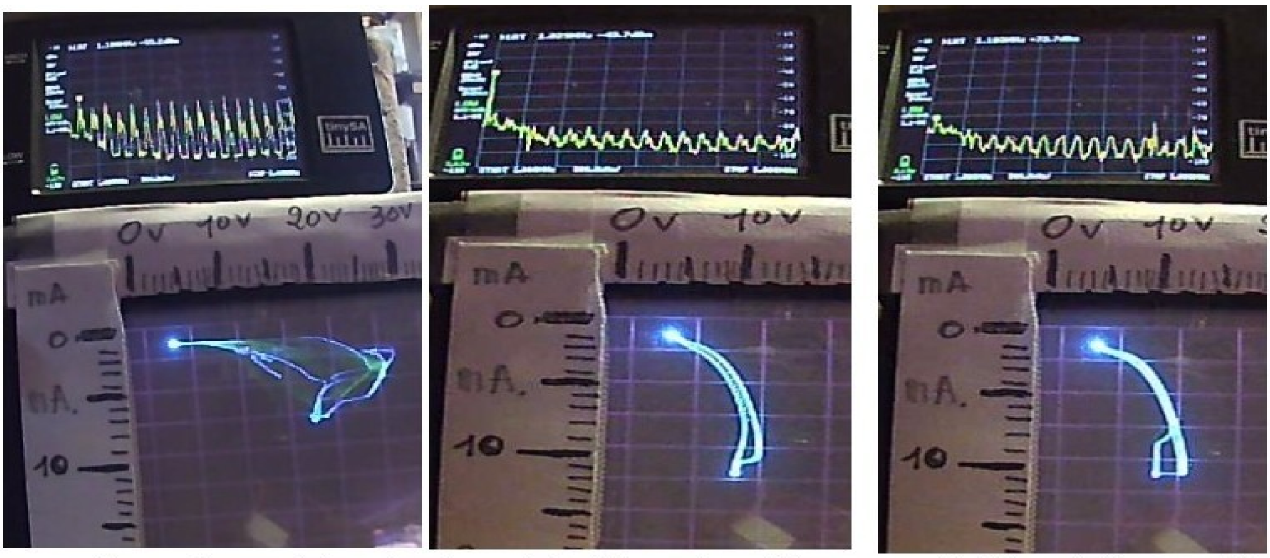


Figure 9

The furnace consists of a 3-ohm metal resistor powered by 12 volts. It can easily reach temperatures up to 600°C. A small amount of sulfur is placed in a glass tube, and the galena crystal is suspended above. The process is conducted at a constant temperature of 370°C, slightly below the boiling point of sulfur, and lasts for an arbitrary duration of 12 hours. After treatment, the crystal is tested in pulsed 50 Hz direct current mode with a parallel L/C circuit (resonance at 90 kHz).

This time, it is easy to find points where negative resistance is observed with oscillations detected by the spectrum analyzer (see Figure 10). However, when powered with continuous current, the system fails to oscillate.



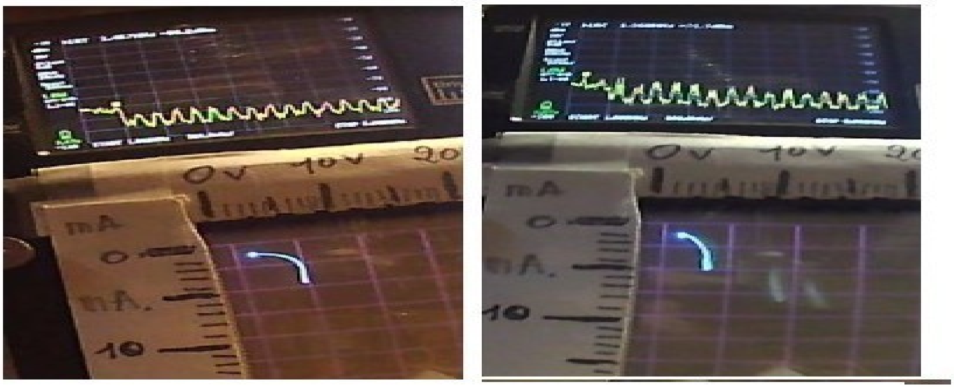
galena after sulphur treatment 3 different position on cristal Figure 10

EXPERIMENT WITH HOMEMADE GALENA

Galena transmitter

It is decided to create galena, also known as lead sulfide, either through the action of sulfur on lead or through the action of sulfur on lead oxide, and to test its properties regarding its ability to oscillate an L/C circuit.

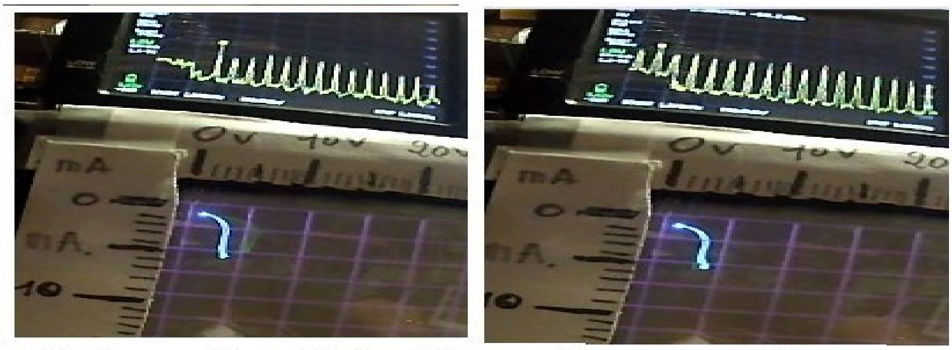
To create galena from lead, a lead strip is suspended in a glass tube containing sulfur at the bottom (similar to Figure 9). The temperature is set at 320°C, not exceeding it to avoid melting the lead. The treatment duration has been arbitrarily set to 24 hours.



Galena ex Pb+Sulphur 24H 320°c Figure 11

When powered with pulsed 50 Hz direct current, numerous points with negative resistance and oscillation are observed (with smaller amplitudes than with natural galena treated with sulfur). However, it is impossible to achieve oscillation (L/C circuit at 90 kHz) when powered with continuous current, regardless of its value.

Let's move on to the slightly more complicated alternative technique. We still start with a lead strip (L=4 cm, l=0.8 cm) that is superficially oxidized into lead oxide (PbO/PbO2), which is an excellent conductor of electricity. This is achieved through anodic oxidation by immersing the strip in a mixture of water and sodium bicarbonate. The strip is connected to the positive pole, and a lead electrode is placed at the negative pole. A current of 180 mA is passed for 40 minutes at 20/30°C. The lead strip at the positive pole is then placed in the furnace containing sulfur and maintained arbitrarily for 5 hours at 320°C.



Pb after anodic oxidation+ 5 hours with sulphur 320°c **Figure 12**

When powered in continuous pulsed 50 Hz mode, numerous points with negative resistance and oscillation of the L/C circuit at 90 kHz are easily found. Unfortunately, it has still been impossible to induce oscillation in continuous non-pulsed mode.

PROVISIONAL CONCLUSION

There are various ways to produce lead sulfide. Interestingly, a review of current scientific literature reveals that lead sulfide has been the subject of numerous studies since 1990, particularly focusing on applications in the infrared detection field due to its semiconductor properties.

As seen, the results for inducing oscillation in a galena crystal, whether natural or artificial, are not very conclusive. However, these few experiments have by no means exhausted the subject. If you are interested in continuing experiments in this direction, please contact me for information exchange.

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