Zoltán Bay and the Moon radar experiment

„I saw the Moon walking behind the tower and I asked the adults: If I walk to the top, could I touch the Moon?"

These words were said by Zoltán Bay at his childhood, when he looked up to our heavenly companion devoutly, although he was just a few years old. Maybe this childlike curiosity led to the point, when after four decades, with his successful radar experiment in 1946, though by just radio-signs, but he had reached the surface of the Moon.

Zoltán Bay enriches the team of those Hungarian scientists, whose work has sunk into oblivion. Like his many contemporaries, he composed and lived overseas, but his main discoveries and experiments were accomplished here, in Hungary. His life could have been turned into a totally different way, because before he had chosen his profession he could not decide whether he should choose to be an artist, a sociologist or a natural-scientist. Luckily his ideal, Loránd Eötvös, directed his life towards physics. If it had not happened so, maybe we would remind him as an average painter or as a fallen sociologist. Instead of this, they mention him as the father of radio-astronomy. Though, the way was really long to gain this appreciated rank.

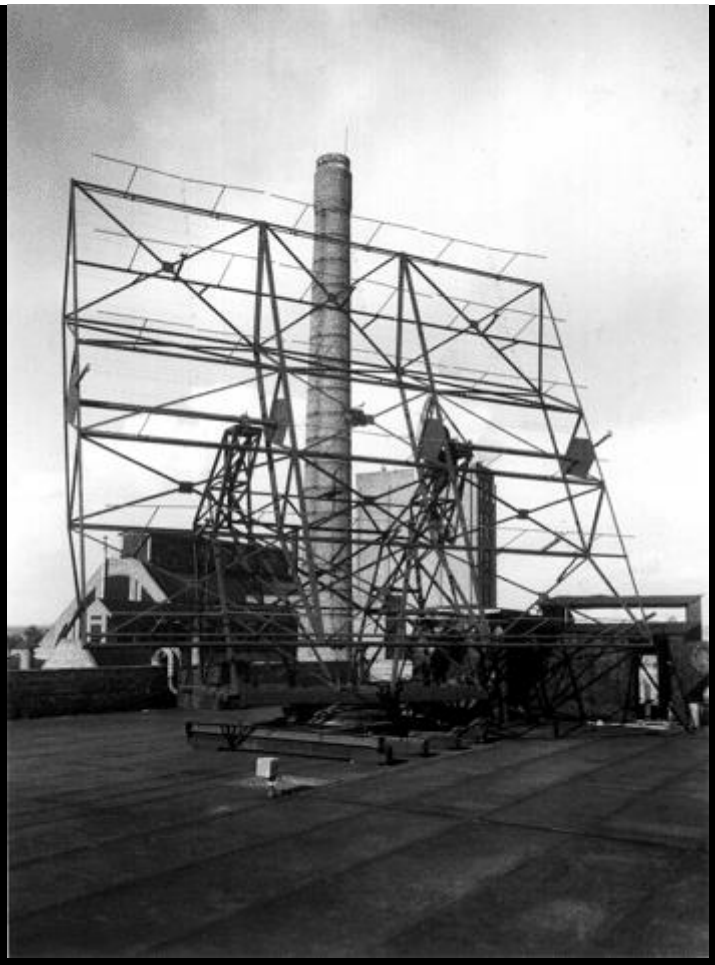
Zoltán Bay

After he had taken his diploma he got a job in Berlin as a researcher, where he carried out experiments connected to the Moon-radar. Back from Germany he continued his work at the Budapest University of Technology and Economics, in the Tungsram Laboratory. Not just the radar experiments can be connected to his name, like an important result in physics, but he had many patent: development of high voltage gas pipes, fluorescent light, vacuum tubes, patent concerning electro-luminescence, development of radio-receiver circuits and decimetre radio wave technique.

Like many of the significant discoveries, the success of the Moon-radar experiments can be thanked to the war, and to the improvements in military technique. The entry of Hungary into the Second World War involved the possibility that the territory of the country is going to be bombed. In every country, both in the enemy and in the alliance side, the scientists were thinking about the question: how is it possible to recognise the entering hostile planes in the shortest time? These researches were kept in secret by every country, so the Hungarian Army should have developed its own technology. In 1942 the so-called Bay-team was established, which task was to perform micro-wave experiments, like improve radar and introduce the micro-waved telecommunication. Among the team members were many famous scientist, like Károly Simonyi Sr (the father of Charles Simonyi).

The Bay-group completed their task in two years. They solved the problems of microwave communications and by 1944 a radar that was able to detect hostile airplanes at a distance of 60 km (38 miles) was installed. This made it possible to detect bombers heading to Székesfehérvár (place of a major industrial area) while flying only above Budapest. Bay then stood before his colleagues and said: *"We will send radar signals to the Moon!"* And it wasn't just the researchers who became excited from the new challenge: the experiment was authorized by the military too. It took only two years to perform the extraordinary experiment successfully and it was only a matter of weeks that the research group did not become the first in the world to accomplish this not everyday feat. Despite that the war itself was the reason behind the inception of the group, it's adversities caused continuous setbacks in the work. The group had to change premises and move their equipment several times, depending on the field situations.

Experiments were conducted at first, without any meaningful results, in Nógrádverőce (a village north of Budapest, today known as Verőce). This wasn't really surprising since conditions were far from ideal: even the power supply wasn't adequate. Soon, as the front line approached, they were moved back to the United Incandescent factory in Újpest (district of Budapest). Sufferings continued nevertheless, the group lost it's legitimacy after the the Arrow Cross Party's rise to power (the Hungarian pro-Nazi party), members were enlisted to the army and everybody with Jew origins were at lethal danger – Bay risked his own life to save many of them. But things did not improve after the war as well: the Soviets occupied and sacked the factory and took everything, including the radar experiment equipment. Nevertheless, none of these could have hold Bay back from continuing the work and his attempts finally succeeded on the 6th February 1946. Only by that time did the group learn that American researchers successfully received radar echo from the Moon a few weeks earlier, but still the technique Bay employed was unique. So let's look into the details of our fellow countryman's achievements.



The Moon radar

Since the term radio-astronomy was non-existent back then, researchers had to start from scratch and create the basis of the field on their own. Many problems that could decide between success or failure of the experiment had to be solved. The most intriguing questions were: could the microwaves even reach space; how reflective the surface of the Moon actually is; how do the signals propagate through space and could it be detected here at the Earth? Bay's group gave theoretical answers for all of them, but the last question of the experimental proof remained. Signals with 1 m (3 ft) wavelength were thought to propagate through the ionosphere unhampered and loss-less. Since the reflectivity of the surface of the Earth is about 10 per cent, similar value was considered for the Moon and homogeneous dispersion was assumed for the echoed signal in the theory. The detection of the Earth-bound signal gave the group the greatest headache. Don't forget that the Moon is incredibly far in terrestrial terms, more than 380 000 km (240 000 miles) away. As the signal strength decreases with distance, covering such width was no easy task. The signal-to-noise ratio was estimated from the calculations to be 1/10, which was too low. Bay suggested an ingenious idea that was a novelty for the Americans, who worked with much better equipment, as well: send repeated signals and sum up the detections. Microwaves need 2.5 seconds to travel the Earth-Moon-Earth distance. The scientists calculated a 50-minute duty cycle to send and store the signals. The 50-minute value comes from the way the method worked: transmitting 1000 signals, an amount thought to be suffice, at every 3 seconds takes that long.

But since there were no computers or other machines back then to store and summarize the signals, the method faced a great challenge. The solution came from Andor Budincsevics and his co-worker Emil Várbíró who developed a device called hydrogen coulometer to store the signal. The signal-to-noise ratio improved 30-fold with this device. For the first trials a 3m (10ft) parabolic dish and half-meter (1.7ft) wavelength was used, without success. Wartime adversities and the confiscation of the dish by the Soviets halted the experiments. After the

restart of the group's work in 1945, an ex-army reconnaissance radar was used. That too wasn't perfect: it had a 2.5 m (8.3ft) wavelength so the dish surface had to be enlarged. Beside the actual Moon radar experiment, blind tests had to be conducted as well in order to get reference measurements to estimate the noise. At last, on the 6thFebruary 1946, the accumulating coulometer showed a signal of 4 per cent above noise level. Bay and his colleagues considered this high enough to call it a success. They also calculated the reflectivity of the Moon on the spot from the results. Bay's unique technique, the signal-accumulation is used in radio-astronomy ever since. Bay also planned to develop a huge radio telescope by digging a cauldron-like hole into the ground and covering it with metal. It never came into existence though. After learning about the technological improvements in the field by the US, Bay thought he couldn't possibly compete with the Americans, despite that many people persuaded him, some even promised to support the project. But the idea was not forgotten, the largest single-dish radio telescope in Arecibo (Puerto Rico) was built in the same way that Bay envisioned.

Arecibo Observatory

Despite the success and international recognition, he emigrated to the States and continued his work there when the political situation in Hungary changed for the worse. Yet, as the following quote confirms it, he never forgot his roots:

“I've come to visit Hungary many times. I've never denied that I am Hungarian. I will be as long as I walk the Earth.”

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