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Dicke R H. The measurement of thermal radiation at microwave frequencies.
Rev. Sci. Instr. **17**:268-75, 1946. [Radiation Lab., Mass. Inst. Technol., Cambridge, MA]

Present day radio telescopes operating at 1-30 cm wavelengths employ a type of receiver invented in 1944, during World War II, at the MIT Radiation Laboratory. This paper describes this 'switched' radiometer and its theory of operation. [The *SCI*® indicates that this paper has been cited over 160 times since 1961.]

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"As in the case of many an invention, a substantial amount of serendipity was involved. It suddenly occurred to me one day in 1944 that the performance of a standard microwave radar receiver as a detector of incoherent thermal radiation was extremely poor at centimeter wavelengths, and that it could be vastly improved by rapidly switching the receiver input back and forth between the antenna and a dummy antenna, a second source of thermal radiation.

"I was led to this idea through research on radar antenna patterns for which I had developed a new type of amplifier, the 'lock-in' amplifier. (The lock-in amplifier was first commercially developed almost 20 years later by the Princeton Applied Research Corp., a small company that I helped organize. But that is another story.) The lock-in amplifier used the same switching principle used in the radiometer.

"After the first crude 'bread-board' model of the microwave radiometer had been built and tried, the claimed sensitivity of the receiver was so great that a well-known physicist, who happened also to be the head of my division, decided to see for himself. He was smoking a big cigar. He held it in front of the antenna and the output meter banged off-scale.

"The first useful piece of research with the bread-board model of the radiometer was carried out on the roof of an MIT laboratory in the fall of 1944. It was shown that the absorption of 1.25 cm waves by water vapor in the atmosphere was much greater than had been expected. This explained the poor performance of the early K-band radars.

"The experiment was repeated in April 1945 in Florida by Beringer, Kuhl, Vane, and me at 3 wavelengths using more substantial versions of the radiometer.[1] The technique is still used for atmospheric studies.

"The first astronomical observations using the technique were carried out at MIT during 1945. These included: (a) the first detection of microwaves from the moon, (b) a microwave temperature measurement of the sun which showed that, owing to the hot upper solar atmosphere, the apparent temperature of the sun was high, ~10,000° C, (c) an observation of a partial solar eclipse, and (d) a determination of an upper limit to the intensity and to the isotropy of the microwave background radiation. The observation of the isotropy yielded an upper limit of 1° C at 1.25 cm wavelength in the uniformity of the background radiation from space.

"At the time of this measurement we were not thinking of the 'big bang' radiation but only of a possible glow emitted by the most distant galaxies in the universe. The connection with 'big bang' radiation came some 19 years later when several of us at Princeton, principally D.T. Wilkinson and PC. Roll, designed and built a radiometer to look for the radiation.[2] Before the radiometer could be completed, Penzias and Wilson accidentally found the radiation while attempting to systematically study the various sources of noise in a Bell Laboratory satellite receiver system."[3]

1. **Dicke R H, Beringer R, Kuhl R L & Vane A B.** Atmospheric absorption measurements with a microwave radiometer. *Phys. Rev.* **70**:340-8, 1946.
2. **Dicke R H, Peebles P J E, Roll P G & Wilkinson D T.** Cosmic black-body radiation. *Astrophysical J.* **142**:414-19, 1965.
3. **Penzias A A & Wilson R W.** A measurement of excess antenna temperature at 4080 Mc/s. *Astrophysical J.* **142**:419-24, 1965.