February 23, 1945
212 W. Seminary Ave.
Wheaton, Illinois

Mr. G. C. Southworth
Bell Telephone Laboratories
Box 107
Red Bank, New Jersey

Dear Mr. Southworth:

The place one comes out in most academic discussions is entirely determined by the premises one starts with, the various steps in logic being only way stations along the route. It seems to me we are both embarking from the same place and arriving at the same destination but getting there via different routes. Perhaps my ideas can be more clearly expressed by some arithmetic on the apparatus most familiar to me.

(1) Lets assume the receiver has a band width of one megacycle so that it samples equal increments of the continuous spectrum at all frequencies in question.

(2) Have the receiver end in some square law device so that the output meter is calibrated linearly in power. Further, the receiver is to have a constant and uniform power sensitivity such that the output meter reads 3.46×10^{-14} watts full scale (see below) at all frequencies in question.

(3) For the sake of discussion assume that Cosmic Static follows my 1942 idea with a constant amount of power per unit band width at all frequencies in question.

(4) Connect our direct reading wattmeter of (2) to a collector device and point at the center of the disturbance in Sagittarius where a large area in the sky has an approximately uniform radiation intensity of $I = 10 \times 10^{-22}$ watt/sq.cm.,cir.deg.,mc.bd.

(5) the power collected by the collector and delivered to the input of our wattmeter will be

$$P = A \times I \times \psi \times B \text{ watts}$$

where A = area of collector in sq. cm.
I = intensity of source in watts/sq.cm.,cir.deg.,mc.bd.
ψ = solid angle of acceptance cone of collector in cir.deg.
B = incremental frequency band width in mc.

(6) First, lets use my collector with an area of 7.2×10^5 sq.cm. and set the frequency at 160mc such that $\psi = 48$ circular degrees. Under these circumstances $P = 3.46 \times 10^{-14}$ watts and the output meter will read full scale.

(7) Now with the same collector shift the frequency to 480mc. Immediately the angular resolving power trebles and $\psi = 5.33$ circular degrees. Now $P = .385 \times 10^{-14}$ watt and the output meter moves up only to one ninth scale.

(8) At this point lets use your collector and the figures I deduced in my last letter. Now $A = 8.8 \times 10^3$ sq.cm., $\psi = 2.0$ cir.deg. and $P = .00176 \times 10^{-14}$ watt. Obviously the wattmeter will not even wiggle its needle. From last paragraph page 6, figures 2&4 of your paper I estimate the minimum energy your machine is able to detect as about 10^{-19} watt/cm.sq.,mc.bd. Multiplying this by 8.8×10^3 sq.cm. gives $.088 \times 10^{-14}$ watt as the minimum perceptable power your wattmeter is capable of showing. If your wattmeter could have its sensitivity increased fifty times then, on the basis of the above estimates, a barely perceptable indication of Cosmic Static would show when the apparatus pointed at Sagittarius.

(9) Comparing (6) and (7) shows that the price paid for a three to one increase in resolving power is the demand for a wattmeter with nine times the absolute sensitivity to give the same apparent sensitivity. This is the direction I am heading with my new 480mc apparatus altho the desired improvement will probably not be achieved in full.

(10) If due to technical difficulties (2) cannot be realized and the wattmeter becomes more insensitive with frequency; or because of the general cussedness of nature (3) does not hold and it turns out something like my 1940 ideas on intensity vs frequency prevail, then the problem of measuring Cosmic Static at high frequency becomes still more formidable. In any case its still worth giving a whirl, so I'll be pleased to hear what your results are with improved apparatus.

Replying more directly to your letter of the 19th, I am in agreement with contents of second paragraph and first sentence of third paragraph. However, as I have tried to point out above, the next sentence should be qualified by power sensitivity of receiver and size of collector. To me the concept of temperature in these discussions is a bit artificial and rather difficult for me to think in terms of. In my 1942 paper I made some attempt at calculating the effective temperature of the antenna radiation resistance; however its not a very satisfactory concept to me as nowhere in the apparatus can this resistance be visualized much less inspected or measured for temperature. Forinstance at your highest frequency the suns disk nearly covers the acceptance

cone of your antenna so the radiation resistance of your antenna should be in thermal equilibrium with the sun at that frequency or have a temperature of 6000°abs. To me, this requires considerable imagination to grasp. Personally I would rather work with watts and let the temperature fall where it may. The relation under (5) is quite general and if A, I, ψ or B vary with frequency such alteration may be easily incorporated.

While I'm writing this I have been wondering what the future holds for this embryonic science. Before the war my friends at Yerkes Observatory (part of University of Chicago) and I were considering ways and means of conducting bigger and better experiments at a more desirable location. We had made overtures to various foundations for support and while not accorded great enthusiasm we were received with an open ear. The University has good connections with the State of Texas where it operates the McDonald Observatory. Thru these connections it appears we could obtain practically any desired amount of land for a good all weather site at a lower latitude. Unfortunately all this has been halted by the war. It has occurred to me that if the Bell Tel. Labs. are interested in this type of work perhaps somekind of a mutual benefit organization could be set up with the Laboratories as co-sponsor. What,if any, scientific or financial interest the Labs. may have in this work is better known to you than to me. In any case I'd appreciate it if you would give the matter some consideration and if it appears reasonable, perhaps you can broach it to your superiors at an opportune moment.

Now I had better get back to fighting the war so that the day when such schemes can be achieved will arrive sooner.

Very truly yours,

Grote Reber

Grote Reber

Date

$P = 7.2 \cdot 10^{5} \times 10 \times 10^{-22} \times 48 = 3.46 \cdot 10^{-14}$

$P = 3.46 \cdot 10^{-14} / 9 = .385 \cdot 10^{-14}$

$P = 8.8 \cdot 10^{3} \times 10 \cdot 10^{-22} .2 = .00176 \cdot 10^{-14}$

H.F. solar intensity = $2.32 \cdot 10^{-18}$ watt/cm^2 MC bd.
sensitivity limit = 10 DB down,
= $2.32 \cdot 10^{-19}$ watt/cm^2 MC bd.

M.F. solar intensity = $2.89 \cdot 10^{-19}$ watt/cm^2 MC bd.
sensitivity limit = 8 DB down
= $4.57 \cdot 10^{-19}$ watt/cm^2 MC bd

L.F. solar intensity = $3.14 \cdot 10^{-19}$ watt/cm^2 MC bd.
sensitivity limit = 5 DB down
= $1.0 \cdot 10^{-19}$ watt/cm^2 MC bd.

Average of HF, M.F, L.F = $2.63 \cdot 10^{-19}$ watt/cm^2 MC bd.