Jim Garland (AND FRED JOHNSON) Guidance on 30S-1 Cooling and the 4CX1500B

(October 23, 2020 email from Jim to the CCA reflector)

I can contribute a little to the 30S1 cooling debate. Back in 1998, I posted here about the pros and cons of swapping a 4CX1500B for the stock 4CX1000a. I pointed out that the fins of the 4CX1500B provided an additional impedance to the air flow that reduced the allowable plate dissipation in the 30S1 to below the 1000W that the amplifier expected.

Thus I was agreeing that 750W maximum dissipation with the original low-speed blower was probably correct. In my post, I gave an argument that drew an electrical analogy to RF circuits. I wasn't surprised that to many my conclusion seemed a violation of common sense.

Shortly after my post appeared I got a phone call from *<u>Fred W. Johnson, a retired Collins mechanical engineer who had led the team that designed the cooling system for the 30S1</u>*.

Fred wasn't a ham (though he authored several articles in Electric Radio in the 90s), but he was vitally interested in and proud of the mechanical design of the 30S1. We had a long phone chat, which he followed up with a lengthy letter and a copy of his 1998 publication "Airflow Measurement" which he had authored for the company.

Fred liked my electrical analogy to the cooling system. He wrote, "When I received the current copy of The Collins Journal (CCA Signal sic), I was at once surprised and pleased that you had written up your different approach to the same anode cooling problem, but arriving at essentially the same answer: "it depends!". You are right!" He added, "I'm experienced with individuals who desire a simple answer that cannot exist unless quantitative answers are made. That's true here in spades. At Collins ... I've lived with this impatience forever. My EE cohorts at Collins almost always wanted the simple answer right away. Maybe today some Ham with sufficient interest could equip himself to make necessary measurements for the 4CX1500B question."

In other words, Fred strongly believed that an accurate comparison of the plate dissipation of the two tubes could not be predicted unless one actually performed quantitative measurements of the dissipation under controlled conditions. His publication, "Airflow Measurement," described how to do this. The reason this result can't be obtained without comparison measurements is because the airflow through the tube fins is very complicated. *<u>In our phone call, Fred made several points:</u>*

<u>(1) The cooling system in the 30S1 is designed specifically for the airflow characteristics of the 4CX1000A, the goal being to obtain 1000W of plate dissipation with the minimum possible noise. Fred told me that tests done at Collins determined that a laminar air flow was more effective at transferring heat out of the tube than the turbulent air flow created by faster, more powerful blowers. What this means is that replacing the original low speed blower with a larger, higher speed blower will - in most cases - actually reduce the plate dissipation.</u>

Similarly, swapping the 4CX1000A with the 4CX1500B also reduces the plate dissipation, because the fin design of the new tube is an impediment to laminar air flow. Fred was quite insistent on this conclusion, despite that it seems non-intuitive.

(2) There are several reasons the cooling in the tube is difficult to understand. One is that tube cooling is highly non-linear and even non-reproducible. Fred wrote that "You double the pressure but the air flow increases by 62%. On the next apparently similar measurement the flow increases by 71%. Duh??"

(3) The reason the cooling is so complicated is mostly because of Boyle's law, which states that for most gases, the Pressure x Volume is proportional to Temperature. For an external anode tube, the air molecules enter the anode cooling fins at the back pressure of the blower and are at room temperature. When the molecules exit the tube, their temperature is much higher, the pressure has decreased to atmospheric pressure (not a huge percentage change) and the volume has greatly increased. The actual number of molecules hasn't changed, of course, since air isn't being created or destroyed.

Figuring out the precise airflow inside the fins is a near-impossible task. The air molecules are bouncing off each other and off the fin walls, mostly traveling in random directions. Thus, the question is best answered by making quantitative measurements, which to my knowledge have never been done. Thus we can speculate all we want about this topic, but the best we can do is make very general conclusions.

73,

Jim W8ZR

Note added from Bill Carns, K0CXX/N7OTQ

It should be added here that, from what I remember of discussions with Gene Senti and Warren Bruene, the airflow of the original blower design in the 30S-1 was also somewhat compromised – the design team "knowing at the time" that the FCC regulations limited Amateur Radio TOTAL Plate Input dissipation (including drive) to 1000 watts, hence the tube would NEVER see 1000 watts dissipation.

Of course, this has changed now and it is possible the see 1000 watts total dissipation in 30S-1 operation.

But, one has to seriously ask why the design goals set in 1959 by Gene, Fred and Warren (when they were obviously driven by lowering noise) would have included getting full dissipation out of the 4CX1000.

As I said above, it is my understanding that the blower airflow of the original design was also compromised – as allowed by the then limit of 1000 watts total input power for Amateur Radio use. This flies in the face of one of the comments in the Fred Johnson/Jim Garland email and only good airflow data will ever resolve this question.

One thing is for sure though. We have to be very careful – as both Fred and Warren allude to – when we press the 30S-1 up against its limits – whatever those really are! WE ALSO KNOW IS THAT IT IS SUPER IMPORTANT that owners vacuum out the air inlet paths leading up though the handle recesses to the blower inlet. Dust plugging those inlet holes further reduce the airflow.