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DIFFUSION TECHNIQUES IN WAVEGUIDE FABRICATION

M. V. Hoover
Radio Corporation of America

These few remarks were inspired by the conversations I had about fabrication techniques on vessels, both at Yale and Los Alamos. Perhaps we in the tube industry are already pretty close to the process under discussion. (to POLK) When rolling out the copper clad steel, some material is used to prevent diffusion between the two pieces of copper. What is it?

POLK: It's chromic oxide, I believe.

HOOVER: I'm just going to speculate on that. The pieces for 800 Mc/sec waveguides would be two pieces of copper tubing, with another piece, the iris to be tucked in between. So, suppose we have a disk that needs to be joined to two pieces of copper pipe. One of the usual techniques, of course, would be to braze it. Then you are faced with two problems. One is, that you have to be concerned about solder control, so that it doesn't run all over everything when you braze it. The second is that of crystalline changes, in which copper becomes dead soft during brazing. This led to the discussion on diffusion techniques which we have used in a number of our tubes for several years. As far as I know, the diffusion technique is not used too widely, but as I

listened to the description of the copper cladding process I suspected that this is actually what is going on between the copper and the steel. (to POLK) Do they call it a diffusion technique?

POLK: No, because in addition to diffusion, they use pressure.

HOOVER: The two go together, and we also use pressure to augment diffusion. At what sort of temperature does this go on?

POLK: This is quite hot, because you must roll steel. It is at a temperature of perhaps 1600 to 1700°F.

HOOVER: They're not going over about 850°C, are they?

POLK: No, they're not, but I do think they get pretty close to 850°C.

HOOVER: Normal silver brazing goes on at about 850°C, so they're probably near that. In any event, the properties of diffusion seals (including the fact that these seals are also vacuum tight) were brought home to us from our experience in the development of the 5831 tube.

Vacuum seals were made in four places on this tube with highly polished steel flanges, and copper ring gaskets, of the order of 0.020 in. thick. We pulled the seals together with bolts, and baked it out at temperatures of the order of 450°C. Then, if for any reason, we had to repair the tube, we took out the bolts, and found that the copper gaskets would very frequently be stuck to the steel flanges tight as a drum, and we'd have to use jackscrews to get the tube apart without wrecking it. Then, on checking some of these tubes with the bolts

removed, we found that they were still vacuum tight. That prompted us to think that eventually one might be able to use this technique for closuring.

We are using the technique in another area. Many of you have seen the pantographs that we use for filament springing. The pantograph is made by stacking laminae of copper which are some 0.003 in. thick. Alternate laminae are gold plated near their ends. We stack these laminae and squeeze them under pressure, and then place them in a furnace for about one hour at 500°C, demount them, and then we have, for all practical purposes, a solid piece at either end. This is one of the applications of diffusion, and there are about half a dozen others that we've used in tubes. In fact, we have found that they are also vacuum tight, in a few services.

To fabricate a waveguide, one might plate gold on the ends of the copper pipe and put a clamp around the outside of the iris, stick the whole thing in a furnace and run it at 500°C for an hour. I suspect you would have a nice vacuum-tight joint, at which there is no running of solder and an excellent rf joint at the corner where the current is carried.

WHEELER: What is the relative strength of this, compared to hard solder?

HOOVER: When we try to tear these seals apart and also when we cross-sectionally sample them, they appear to be solid, so I think that if one picked materials which like to diffuse together that this would work. For instance, copper and gold are quite fond of each other, and copper and silver are another such pair.