M Report - 155

December 11, 1959

MEMO ON AMPLITRONS

By

K. Brown

This is an attempt to summarize the present status of the S-band amplitrons which have been under development at the Raytheon Laboratories in Burlington and Waltham, Massachusetts. The basic specifications for the tubes are given in the ad which is enclosed with this report, (Microwave Journal, November, 1959) and in the article by W. A. Smith and F. Zawada, the latter article appearing in the October issue, 1959, of the Microwave Journal.

There are two S-band tubes which have been developed, the QK-622, covering the frequency range 2800-3100 megacycles and the QK-783, covering the range of 2700-2900 megacycles. Beyond the information given in the ad and in the article by Smith and Zawada, the data quoted here were obtained from the following people at Raytheon: E. J. Shelton and Bert Ryland of the Spencer Laboratories, Burlington, Mass., and from W. C. Brown during his visit here at Stanford Dec. 4, 1959, of the Waltham Laboratories. At the Spencer Laboratories there have been a total of 4 tubes produced since the initial work of W. C. Brown at the Waltham Labs. At the Spencer Labs. the three megawatt tubes have been operated at power levels momentarily as high as 3.8 megawatts and have been operated continuously for several hours at levels up to 3.5 megawatts at an average power of 20 - 20 1/2 kilowatts. This is to be compared with the rated output of the tube of 3 megawatts, 15 kilowatts average power. Of prime importance is the total experience which has been gained to date with these tubes. Conversations with Shelton indicated that at the 3 megawatt level or higher, a total accumulated experience of approximately 2300-2500 hours had been established. Note that this is with 4 tubes, not with a single tube. However, an additional

three thousand hours experience has been accumulated at the power level of 600 kilowatt with the tube being used as a driver for the 3 megawatt tubes. As can be seen from the pictures enclosed in both the advertisement and article, the amplitrons are all metal ceramic construction, as one would expect. They are baked at 500° C and use a slanted ceramic input and output window. One point of interest is the quoted efficiency of these tubes and, in particular, the definition of efficiency. It should be noted that the efficiency is defined in a somewhat different way than with klystrons in that the power which is used to drive the tube feeds on through into the output. Therefore, if one has several tubes in cascade, the efficiency of all these tubes is still approximately 75 per cent, rather than being the multiplication of the efficiencies of the individual tubes.

As reported by W. C. Brown, during his visit here on December 4, 1959, Raytheon has plans for developing a CW amplitron with high average power output capabilities. To summarize their thinking in the matter, the following data were presented by W. C. Brown here, either privately or in a talk which he gave in MTL. Their initial objective was to determine what maximum power dissipation could be handled by these tubes. In order to perform this experiment, they used an X-band tube rather than an S-band tube where the power levels would be within the capabilities of their present modulators. They built a 5 kilowatt X-band tube and, using forced water anode cooling, were able to operate it between 6 and 8 kilowatts per square centimeter anode dissipation. On this basis, Brown estimates that they should be able to conservatively design a tube using 3 kilowatts per square centimeter anode dissipation. Extrapolating to S-band, he concludes that, in principle, a tube of 65 kilowatt anode dissipation is feasible and with an 80 per cent efficiency this would correspond to an rf output of around 260 kilowatts. This, however, is a developmental item and has not been pursued very far at Raytheon. His estimate on the price of such a tube is $10 per

kilowatt or $3,000 - $3,000 per tube. He also estimates that the anode temperature would be somewhere between 200° and 300°, operating under these conditions. The question was raised as to what he intended to use for a window on such a tube and his answer was that their intention was to try to use quartz with forced air cooling, but that they certainly had not solved this problem and are not even sure that they can. So, in summary, it would appear that people at Stanford, and, in particular, Project M should certainly look into the present 3 megawatt S-band amplitron thoroughly to see where, if at all, it has applications to Project M.

It should be emphasized that although high average power operation of the S-band amplitron shows promise that there is as yet no concrete information indicating the feasibility of peak power operation at the 20 mw level.

John Lebacqz and I intend to follow this up with a letter to Raytheon to see what their suggestions are in this direction.

K. Brown

KB/jg