Operation of New RF Drivers for the Bevatron Local Injector *

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Abstract

A new 200 Mhz power amplifier system has been used operationally on the Bevatron Local Injector 20 MEV LINAC with two different power tetrodes: an EIMAC 4CW100,000E and a Thomson-Houston TH-535. The same basic anode and grid structures were used with both tubes. The system has provided increased power output over the 4616 tetrode previously used. Maximum operational gradients were achieved with both tubes. System testing, tube interchangeability, and high power operating data will be presented.

I. INTRODUCTION

After satisfactory high power testing of the prototype version of the amplifier with the EIMAC 4CW100K tube, described in Reference [1], mechanical design of the final version of the cavity and the output paddle was completed. The final version of the amplifier was installed as the driver to the TH-516 final amplifier for Tank 2 of the Bevatron Local Injector LINAC in place of the existing 4616 tetrode. Operational tests of the amplifier cart with the EIMAC tube installed proved very successful, reaching a higher gradient than had ever been achieved in this tank. Concurrently, neutralization tests were begun on the TH-535 in the prototype cavity. After neutralization of the TH-535 was completed, it was installed in the amplifier cart for high power testing; as expected, its power output was lower than that of the EIMAC tube, but it also proved capable of exceeding all required operational gradients.

II. FINAL CAVITY CONSTRUCTION

The prototype had been constructed with a copper-lined plywood box as the anode cavity. The final version of the cavity (shown in figure 1) was made with half-inch aluminum plates for the top and bottom, supported by brass pipes in the four corners. The sides were made of sheet aluminum panels set into a frame of aluminum extrusions of the type used to build standard electronic equipment cabinets. The bottom plate was machined to accommodate the Thomson tube socket directly (shown in figure 2.) and the EIMAC socket with an adapter ring. A high voltage interface assembly, constructed of large diameter, heavy walled aluminum tubing, was bolted to the top plate of the anode enclosure from the inside, and the entire structure was designed so that no access is possible without opening interlocks in the anode high voltage chain.

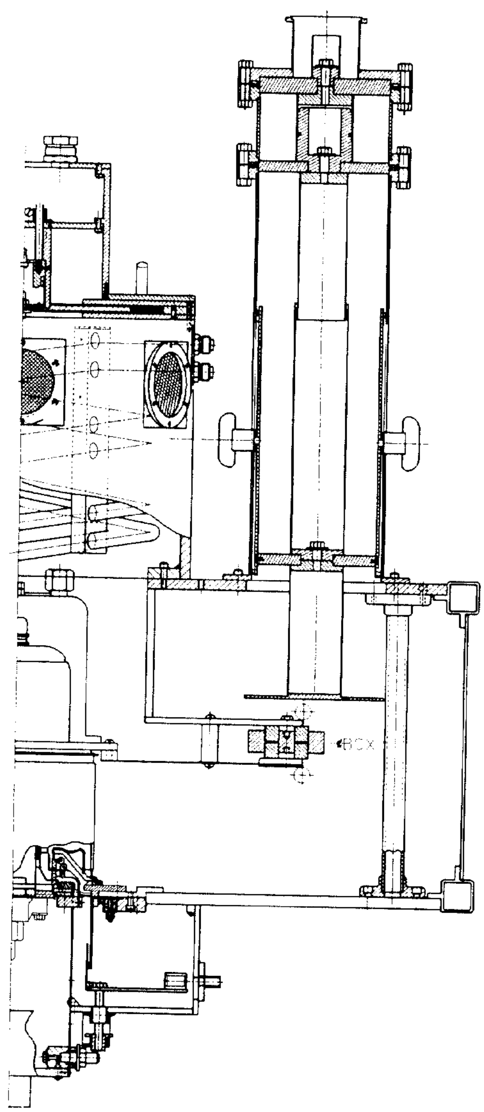

Figure 1. Scale drawing of the final cavity with the EIMAC 4CW25K tube installed.

The radial line for the anode resonator is end loaded with eighteen capacitors which also provide mechanical support for the line. The dielectric for these capacitors was machined

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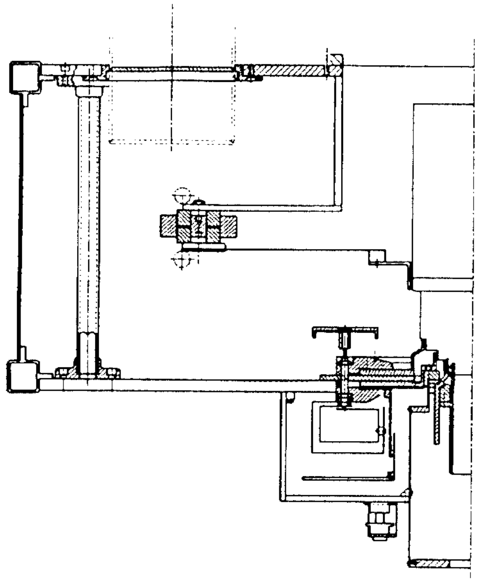

Figure 2. Scale drawing of the final cavity with the Thomson TH-535 tube installed.

at LBL from Teflon rod in an annular re-entrant shape which was chosen to provide mechanical strength and a long leakage path for the anode voltage present on the lower plate of the line, as well as the necessary capacity. The capacitor "plates" are machined aluminum rings. These locally manufactured capacitors were also lower in cost than commercially available ones.

Energy was coupled out of the prototype cavity with a loop which was not readily adjustable to vary the amplifier loading. In the final version, this arrangement was changed to a circular capacitive coupling paddle which is easily adjusted.

The output flange is designed to be fitted with either a standard 6-1/8 inch EIA flange or a pressure tested 6-1/8 to 3-1/8 inch adapter. This adapter will allow for greater than four atmospheres of air pressure in the 3-1/8 inch line. In the tests described below, a 3-1/8 inch line pressurized to 20 psi was used.

III. AMPLIFIER CART COOLING

Both tubes require water cooling for their anodes and air cooling for their bases. In addition, the various power supplies located in the double rack enclosure described in Reference [1] require air cooling. The air cooling requirements were met by providing two air sources: a high pressure centrifugal blower and a low pressure axial fan.

The high pressure centrifugal blower feeds air through a manifold to the base in the case of the TH-535 and to the grid cavity in the case of the 4CW100K. The manifold also supplies air to the 4CW25K stage tube base and grid cavity. When the 4CW100K is installed, an additional centrifugal blower is mounted on the tube socket to blow air directly on the filament connections. Both of these blowers are interlocked to the filament power supply.

Air for general cooling of the electronics cabinet is taken in by the ten-inch axial fan. This air is passed from the cabinet into the anode cavity through screened ports in the four corners of the cavity baseplate. It then passes through the anode radial line and is exhausted through ports in the high voltage interface assembly. This path prevents ionized air from standing in the anode cavity and causing arc-over problems.

Low conductivity water is circulated through the 4CW100K anode through fittings on the high voltage interface assembly; the anode voltage is isolated from ground with coils of insulating tubing. The anode of the 4CW25K stage is cooled in similar fashion. Tests on the prototype showed that some heat from the filaments was transferred to the supporting structure despite the air cooling of the tube bases, therefore supplementary parallel water cooling loops were provided for the bases in the final version.

IV. TH-535 NEUTRALIZATION

It had been planned to neutralize the TH-535 with a screen grid to control grid resonator in the manner described in Reference [1] for the 4CW25K stage. However, succeeding tests proved that a resonator much larger than the space available was required. We then opted for the more conventional method of using a shielded rotating inductive coupling loop in the grid cavity connected to a capacitive pickup disc in the anode cavity . As tested in the prototype, this neutralizing circuit provided more than 45 DB of isolation.

V. HIGH POWER OPERATION

The amplifier cart was installed adjacent to the TH-516 final amplifier stand for Tank 2 in order to minimize the required length of pressurized output line. It was first tested with the 4CW100K tube, then with the TH-535. Operating results are presented in Table 1.

When drive was first applied, arcing occurred between the radial line corona ring and the output paddle. This problem was corrected by installing a shallow Teflon cup on the paddle. Initial tuning with the 4CW100K installed in the amplifier cart showed that it was closely coupled with the final stage: the TH-516 grid tuning had considerable effect on the anode tuning of the cart. The TH-516 grid tuning was held constant when the TH-535 was installed and it was matched using the cart anode tuning slugs. The tuning range of the slugs proved sufficient to resonate both tubes at the operating frequency of 198.965 Mhz, although with the TH-535 they were almost at the extreme "all in" end of their range.

The power output for the 4CW100K tube given in Table 1 is not the maximum achievable. The screen voltage

Table 1.

	4CW100K		TH-535	
Tank Level 8.2 V = 2.69 Megawatts	Pulse Pk (T=100us)	Pulse End (T=1ms)	Pulse Pk (T=100us)	Pulse End (T=1ms)
E_g (V)	-660	-660	-216	-232
I_g (A)	1	0.8	1.06	0.84
E_{sg} (V)	750	750	1350	1350
I_{sg} (A)	2	1.2	2.2	1.8
E_b (V)	20.4	19.2	21	20
I_b (A)	29.4	24.6	30[1]	25.2
P_{out} (KW)	428.3	342.9	438.8	342.9
P_{ref} (KW)[2]	7.1±1	5.9±0.7	11.2±1.3	8.3±0.9
Gain (DB)	11.4	10.7	13.3	13.3
Eff (%)	58	52	70	68
Driver (EIMAC 4CW25K):				
E_b (KV)	10	10	9	8
I_b (A)	4.3	4	3.4	3
Pout (KW)[3]	24.8	20.8	20.5	16.1
Tank Level 8.4 V = 2.82 Megawatts				
E_g (V)	-660	-660	-216	-236
I_g (A)	1	0.8	1.06	1
E_{sg} (V)	1250	1250	1350	1350
I_{sg} (A)	2.4	1.8	2.2	2
E_b (KV)	20.2	18.5	21	20
I_b (A)	36.6	30.6	30[1]	28.2
P_{out} (KW)	541	372	438.8	372
P_{ref} (KW)	13.8±1.6	8.9±1.1	11.2±1.3	8.9±1.1
Gain (DB)	11.7	11.4	13.3	13.1
Eff (%)	73	66	70	66
Driver (EIMAC 4CW25K):				
E_b (KV)	10	10	9	9
I_b (A)	4.6	4	3.4	3
P_{out} (KW)[3]	36.5	27.1	20.5	18.1

(1) Manufacturer's limit of 25 A plate current was exceeded with their permission for test purposes only.
(2) The reflected power measurement accuracy is determined by the directional coupler directivity, which was measured at approximately 25 DB.
(3) The 25K stage output power was estimated by using the same efficiency as the 100K stage because we did not use a directional coupler between the stages.
(Frequency= 198.965 Mhz, Pulse Width= 1 ms, Pulse Repetion Rate= 2 pps)

was deliberately kept low, limiting the power output in order to avoid excessive x-ray production from the tank and reduce the risk of output line sparking. Power output of the TH-535 was limited by the manufacturer's specified maximum plate current.

VI. CONCLUSION

The simplified operation of the LINAC RF system anticipated in Reference [1] was achieved when the new amplifier cart was installed and operating. Fixed bias was used in the cart for all three tube stages. After the cart had been initially tested in the operating system and proved capable of producing the necessary drive power, the pulsed bias system described in Reference [2] for the TH-516 final amplifier was also replaced with a simple DC bias supply.

The cart was used with the LINAC for ten months (including approximately one month with the TH-535 tube installed), until the end of operations at the BEVALAC. During this time, it proved to be extremely reliable and maintainable.

VII. ACKNOWLEDGMENTS

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VII. REFERENCES

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