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INVESTIGATION OF HIGH-POWER KLYSTRONS

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STATUS REPORT

1 June, 1953 to 31 August, 1953

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Prepared by: The Staff of the
Microwave Laboratory

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1 June, 1953 - 31 August, 1953

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TECHNICIANS - MONTHS TOTAL FOR PERIOD

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Drafting	1/2

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I. INTRODUCTION AND SUMMARY

The period covered by the present report is 1 June to 31 August, 1953. The progress of the major projects is summarized in this section; the details are described in subsequent sections.

1. ACCELERATOR KLYSTRONS. Window failure has accounted for only one of the six tube failures which occurred during the quarter. Eight of the tubes have been added to the accelerator installation.

2. BASIC STUDIES. The special klystron has been equipped with a new collector. Two discrete values of magnetic field intensity appear to focus the beam equally well, in the absence of r-f drive; with the drive present, the higher value yields greater output, but the lower value gives greater r-f gain.

Modifications in the hollow-beam gun and the associated beam tester are being made following the initial tests.

The klystron with a high-efficiency collector has been successfully operated, and quantitative performance data are beginning to be assembled.

The gradient-focusing project has been completed, and a report will be prepared.

3. TRAVELING-WAVE KLYSTRONS. Measurements of output power and bunching parameter in the gridless t-w klystron have been made. The output power is smaller than predicted, probably as a result of imperfect gun design, which will be improved.

The gridded duplex t-w klystron has undergone preliminary tests, which will be continued after the installation of a modified heater arrangement.

4. PULSED TRAVELING-WAVE TUBE. The tube has been taken off the pump for the purpose of making several improvements, notably in the design of the electron gun and of the magnetic focusing coils.

II. ACCELERATOR KLYSTRONS (Staff: J. H. Jasberg)

Six tubes failed on the Mark III accelerator during this quarter and eight have been added. Only one tube was lost due to cathode poisoning by window failure. Of the others, two had seal punctures; two, heater shorts; and one, a broken input window. The reasons for seal failure are not known definitely, although some of the seals have a rather thin bead at the feather edge. The heaters which failed were of the old type. There have been no failures of the new structure (described in a previous report, M. L. Report No. 196), which is used on all repaired tubes. However, there are still not enough data to indicate whether this design modification is completely successful.

(III. BASIC STUDIES)

Some of the output windows have failed during this period due to the solder fillet between the ceramic and the copper tube to which it is brazed. It is hoped that this trouble will be eliminated by a modification which eliminates the fillet entirely. The life of windows in which this fillet is small has been satisfactory.

III. BASIC STUDIES

A. SPECIAL KLYSTRON, K-14 (Staff: J. H. Jasberg)

A new collector was constructed for this tube and the tube was retested this quarter, with most of the results the same as given in the last report. It has also been found that, as on unmodified tubes, there are two optimum adjustments of the focusing fields. The lower adjustment gives transmission of 85 to 93 per cent as the beam voltage is raised from 180 to 365 kv (the maximum voltage at which the tube has been operated). The higher value of magnetic field gives almost a constant 93-percent transmission. These figures are all without r-f drive. As the drive is increased, the collector current steadily drops until it is equal to only 50 per cent of the beam current. A major part of the intercepted current appears as heat in the output-cavity region. Because the insulated collector decreases the cooling in the catcher region, it was necessary to add jury-rigged cooling before tests could continue at high power inputs. This addition was made without loss of vacuum in the tube, which was then run for several days at levels up to 30 Mw output without overheating. The output from the tube is about 10 per cent greater with the high value of focusing field, but requires about 3.5 times the drive power for maximum output.

Without drive, the tube still oscillates weakly at some values of the focusing field. However, no oscillations have been observed with the drive on, neither with wavemeters nor with filters on the thermistor bridge plumbing.

The tube was removed and stored on an unused accelerator station to allow processing of accelerator klystrons. Both tube and window were in good condition when removed. The tube will be tested further when the processing station is again available. A vacuum water calorimeter should be finished by that time, so that the thermistor power measurements can be checked. We would also like to get more complete data on the effect of load impedance on output and on the nature of the residual 5-cm oscillation which still exists. Moreover, the tube will be eventually pushed to the maximum 400-kv beam voltage.

(IV. TRAVELING-WAVE KLYSTRONS)

B. HOLLOW-BEAM STUDIES (Staff: M. Chodorow, C. Süsskind)

The beam tester has been disassembled and is being transferred to another vacuum-pump installation. Several improvements in the assembly of the hollow-beam electron gun are also being made, notably the replacement of ceramic wafers (used in the demountable gun for spacing, etc.) by quartz washers specially manufactured for this purpose.

C. REDUCED-VOLTAGE COLLECTOR (Staff: R. H. Winkler)

A two-cavity klystron with a special collector designed to recapture some fraction of the beam power following the r-f section of the tube is now in operation.

The device does indeed recapture some of the beam power. Precise measurements of tube efficiency are presently being made to determine the magnitude of improvement of a klystron with such a collecting device over a klystron with the conventional grounded collector.

D. GRADIENT FOCUSING (Staff: M. Chodorow, C. W. Barnes, Jr.)

The experimental tests on focusing a long thin beam by periodic quadripoles have been completed. Although some focusing was obtained, the behavior was very critical to alignment of the quadripoles. The theory also indicates that, at best, such focusing can be used only with very low perveance, and, therefore, would not be useful for most practical cases. A technical report will be prepared.

IV. TRAVELING-WAVE KLYSTRONS

(Staff: E. L. Ginzton, H. J. Shaw, C. L. Hsieh)

A. GRIDLESS TUBE

The r-f power at the output end of the catcher guide has been measured when the beam is bunched by feeding power into the buncher guide. The optimum bunching parameter was found to be close to the theoretical prediction, but the output power delivered by the beam was only about one-sixth of that calculated. Investigations were carried out to find the explanation of this loss of power. Beam-loading tests indicated that there was a considerable amount of beam loss in the drift space between buncher and catcher gaps. Also, when the beam was modulated, a decrease in collector current was observed. It seems quite certain that electron trajectories are not as predicted in the design; either the entrance angle is not correct, or the positive-ion focusing is imperfect. Since the r-f modulation for

(V. PULSED TRAVELING-WAVE TUBE)

gridless gaps is concentrated on the edges of the beam in the form of surface current, a small percentage interception of beam along the edges might cause a great loss of r-f power.

It is intended to do some more work on this tube by using narrower cathodes if time permits.

B. GRIDDED TUBE

The gridded duplex traveling-wave klystron was assembled and has been under test during this period. As this tube was assembled with the help of "Araldite," to allow for the possibility of repairing grids if some of them should fail, considerable time has been spent in tracing the leaks. The tube now holds vacuum at 4×10^{-7} mm Hg.

In cold measurements, power leakage of -27 db from input of buncher guide to output of catcher guide was found. This leakage is due to the finite attenuation of grids and drift space, and cannot be reduced with the present tube. Doubtless this leakage will affect the results of some of the measurements.

So far, three tests have been made with the tube. The first test showed that the heat radiation loss was too great, and the cathode could not be fully converted before the heater became so hot that it melted the ceramic tubing insulating it from the cathode sleeve. A new heat shield was added and a second test was made with a glass plate covering one end, in order to secure information about the power-handling capacity of the grids. In this run, it was found that the beam perveance is very close to the designed value, and that the transmission is excellent. After passing through five rows of grids, 65 per cent. of the beam was collected at the collector without any focusing voltages. At 4 amperes of beam current, the bottom row of grids showed color temperature of about 800° C, while the outer four rows remained colorless. This situation was not improved by adding more water cooling tubing outside the tube.

In the third test, couplers were installed and r-f tests were made with low beam current. The results were found to be in general agreement with theory.

It is intended to run a test with higher current after an insulation-coated heater is installed in the tube.

V. PULSED TRAVELING-WAVE TUBE (Staff: M. Chodorow, E. J. Nalos)

A disk-loaded type of structure has been tested, and the results were submitted in the last status report. The structure has been taken off the pump for various improvements:

(VI. MILLIMETER WAVE GENERATION)

(1) Improved electron gun with variable perveance, using bellows at the ground potential for ease of adjustment during operation of the tube. This gun is about half complete.

(2) The coupler is being broadbanded over a wider portion of the passband. It is also being redesigned for easier construction (electroforming).

(3) The magnetic focusing is being improved by adding auxiliary focusing coils to maintain the field uniform in a region extending closer to the cathode. Only 60-percent transmission at the operating voltage was obtained in initial tests. A preliminary study of the possibility of periodic focusing is also being undertaken.

(4) The importance of proper position and amount of loss in the tube is being investigated. Various types of lossy materials are being investigated, as well as methods of cooling same.

(5) The pulser waveform and trigger circuits are being reworked for greater reliability.

(6) Driver broadband magnetron and associated circuitry are being assembled into a portable setup.

(7) A sweeper circuit for impedance measurements and broadband matching is being contemplated.

It is hoped that the improved version of the tube will be on the pump in about eight weeks. A new tube with similar disk loading, but designed to operate at about 90 kv, is being made and will be ready for electroforming within two weeks. The power output should be proportionately higher.

VI. MILLIMETER WAVE GENERATION

(Staff: H. Motz, W. Thon, R. N. Whitehurst)

During the period under review, this project was transferred from Contract N6onr 225(07) to Contract N6onr 25123.

The buncher section made by the medical accelerator group turned out to be defective. Another section has since been made. It is being used by that group for the time being, and will be available to Task 23 eventually. A straight section is being constructed.

Circuits to sweep the analyzing magnet field have been assembled, and parts have been made for the cascade prebuncher. Gun tests so far have not been entirely satisfactory and further development work on the gun will be necessary.

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