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RAYTHEON

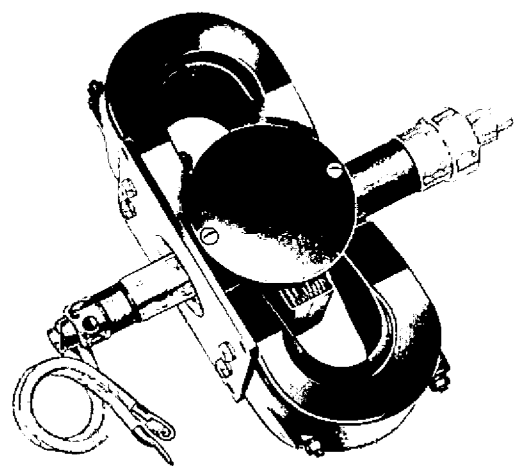
TECHNICAL INFORMATION

Excellence in Electronics

TUNABLE PULSED-TYPE MAGNETRON

TYPE RK6344/ QK-235

The RK6344/QK-235 is a mechanically tunable magnetron designed for pulsed operation in the frequency range of 5450 to 5825 megacycles. It is an integral magnet type tube rated for a minimum peak power of 175 kilowatts. It requires forced air cooling over fins integral with the anode block and is designed for coupling to standard 1 x 2 inch waveguide. Tuner construction facilitates rapid hand or motor tuning to any desired frequency within the specified range.



GENERAL PRECAUTIONS

Reliable operation and maximum magnetron life can be achieved if the overall radar transmitter is designed with the magnetron characteristics and peculiarities clearly in mind. This technical data, prepared by the Applications Group of Raytheon Manufacturing Company, rather than the MIL-E-1B Government purchase specifications, should be used as a guide to equipment designers. As is the case with other electrical components, if magnetrons are operated continuously at their maximum ratings, some deterioration in life will result. There are many problems peculiar to magnetrons in general that must be given special consideration in system design such as RF radiation, pulse shaping, VSWR and length of transmission line to the antenna. These problems are discussed in detail on the following pages. If for any reason it is desired to operate the QK-235 under conditions other than those recommended in this technical data sheet, the Magnetron Application Group must be consulted; and in some cases additional life test must be run.

GENERAL CHARACTERISTICS

ELECTRICAL

Heater Characteristics

Heater voltage — preheat	11 V
Heater current @ 11 volts	10-12 A
Minimum preheat time	3 minutes

Maximum Ratings

Heater voltage	12.5 V
Peak anode current	30 a
Peak anode voltage	24 kv
Average anode power input	720 W
Peak anode power input	720 kw
Max. freq. pulling at VSWR = 1.5/1	15 Mc
Max. anode temp. at point specified on outline drawing	120° C
Maximum pulse duration	3.0 us
Maximum duty cycle	.001
Max. voltage pulse rise time	0.2 us
Min. voltage pulse rise time	0.1 us
Max. freq. change per degree change of temp.	.25Mc/°C

The values specified above are based on the absolute system and must not be exceeded under any service condition. Operation above these limiting values may affect tube life and serviceability adversely. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

Typical Operation

Peak current	22 a
Current pulse duration	1.35 us
Duty cycle	.00085
Voltage pulse rise time	0.1 us min.
Heater voltage start	11.0 V
Heater voltage operate	10.5 V
VSWR	1.5/1 (max)
Frequency	5450-5825 Mc
Peak anode voltage	21.5 kv
Peak power output	260 kw
Average power output	221 W

MECHANICAL

Mounting	Cathode vertical
Overall dimensions	See drawing
Net weight	25 lbs.
Tuner torque required	30 inch ounces
Pressurization	30 inch Hg
Output coupling	UG 148B/U Choke

DETAILED ELECTRICAL INFORMATION

HEATER

The cathode must be preheated at Ef = 11 volts for a period of at least three minutes prior to the application of anode high voltage. Immediately subsequent to the application of anode high voltage, heater voltage must be reduced to 10 volts. For combinations of pulse widths and duty cycles different from those shown under typical operation, the manufacturer must be consulted for optimum heater schedules. Provisions must be made to keep heater current surges below 30 amps. Surges in excess of 30 amps may open the heater circuit and render the tube worthless. Any interruption of tube operation requires that the heater schedule be repeated.

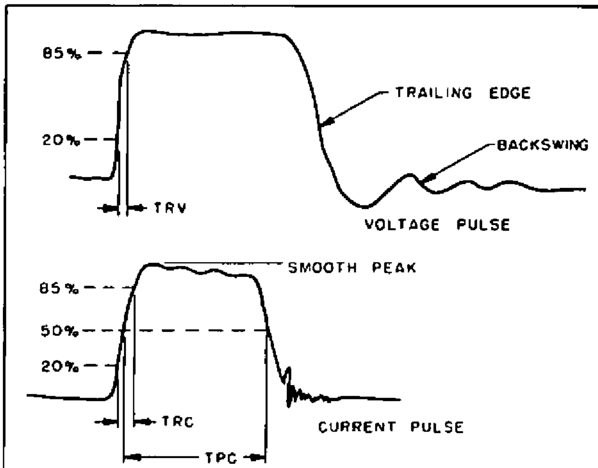


FIG. I

PULSE CHARACTERISTICS

The smooth peak is the maximum value of a smooth curve through the average of the fluctuation over the top portion of the pulse. The pulse width is the time interval between the two points on the current pulse at which instantaneous current is 50 percent of the smooth peak. The rise time is the time interval between points of 20 and 85 percent of the smooth peak. Figure 1 shows graphically the definitions mentioned.

The voltage rise time must not be less than .10 usec for .4 usec pulse to realize good tube performance. Too fast a rise time will lead to moding or arcing. It is necessary to form the pulse so that the current pulse shows no sign of jitter and no large spikes on the leading edge as these conditions also may cause moding or arcing. The ripple on the top of the current pulse must be kept at a minimum to avoid pushing effects which will tend to widen the spectrum. Excessive backswing may cause noise. The backswing should not exceed 20% of the applied pulse.

Many magnetrons draw a certain amount of leakage or diode current at anode voltages as low as 100 volts. For this reason it is not only advisable to keep the time duration of the voltage pulse trailing edge as short as possible; but also to prevent the positive voltage backswing from becoming negative again. This diode current can amount to several milliamperes at an average current of 30 milliamperes. Except for giving falsely exaggerated indication as to the actual peak current at which the magnetron is operating, diode current is not harmful, unless it becomes excessive.

For optimum pulse shaping, the magnetron, pulse transformer, and pulse line must be treated as a unit. We advise building up an experimental pulse line and hand tailoring it for optimum magnetron current and voltage pulse shape when used in conjunction with the pulse transformer and the QK-235.

It is impossible to design a pulse transformer to give optimum results on both long and short pulses. It is, therefore, necessary to decide which pulse is the more important and optimize the pulse transformer for the desired operation.

OPERATION

The operating characteristics of an average QK-235 are described in the following paragraphs and illustrated in Figures 2, 3. All measurements were made under conditions of typical performance. Variation of these characteristics can be expected from tube to tube or from use of the same tube in different systems. A 1 x 2 inch waveguide was used for all tests involving a magnetron load.

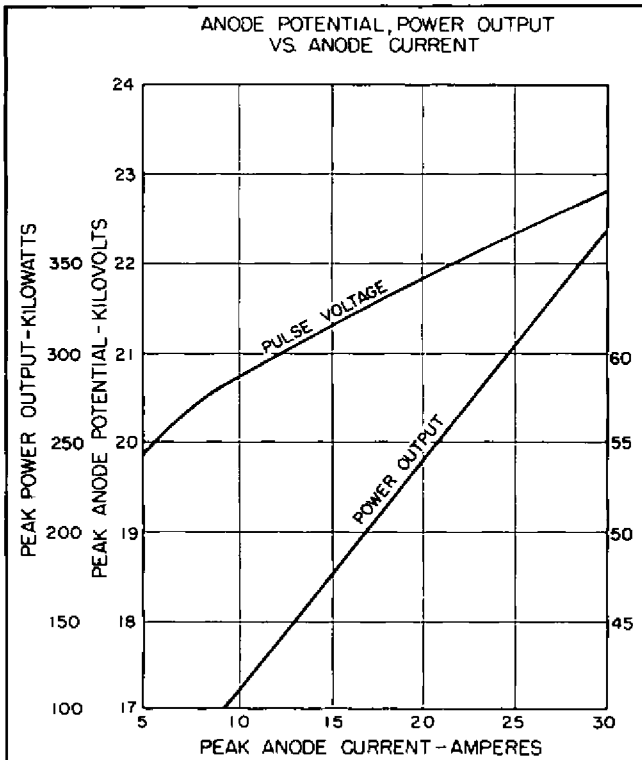


FIG. 2 -PERFORMANCE CHARACTERISTICS OF TYPICAL QK 235 MAGNETRON 5825 Mc.-1.0/1 VSWR.

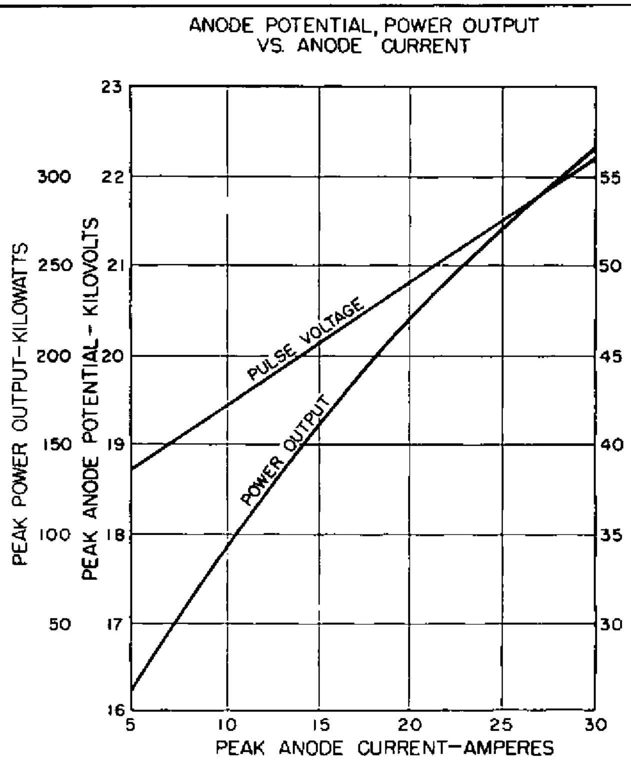


FIG. 3-PERFORMANCE CHARACTERISTICS OF TYPICAL QK 235 MAGNETRON 5450Mc.-1.0/1 VSWR.

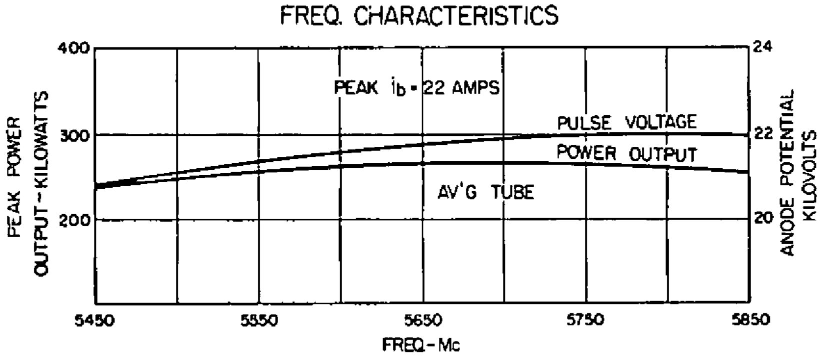


FIG. 4

FREQUENCY CHARACTERISTICS

The manner in which anode voltage and power output, vary with frequency is revealed in Figure 4.

LOAD DIAGRAMS

Figure 5 is a load diagram of a typical QK-235 magnetron operating at frequencies of 5500, 5700 and 5800 megacycles respectively. The contours of constant power output and frequency change are related to voltage standing wave ratios introduced by mismatched loads at various phase positions. Values of VSWR as high as 3.5/1 are plotted but ratios greater than 1.5/1 are not recommended.

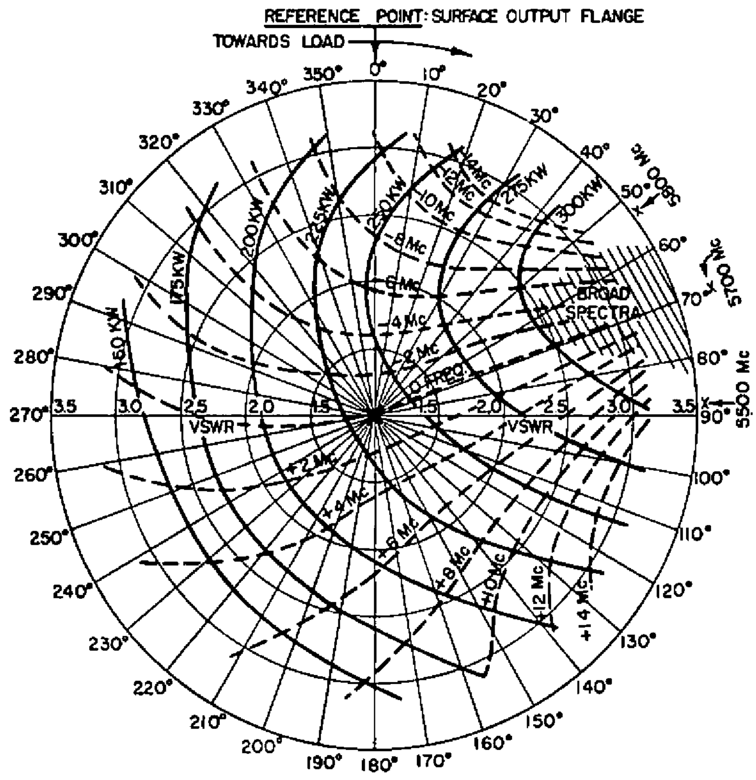


FIG 5—LOAD DIAGRAM OF TYPICAL QK235 MAGNETRON—5700 Mc.

FREQUENCY DRIFT CHARACTERISTICS

After operation of the QK-235 is initiated, its temperature rises with time until thermal equilibrium is reached. During this transient period the geometry of the tube changes slightly and is attended by a slight frequency change or drift.

Frequency drift and anode temperature are plotted as a function of time in Figure 6.

If the tube temperature is changed after thermal equilibrium has been established, the operating frequency will also change until thermal equilibrium is again attained and tube geometry stabilizes.

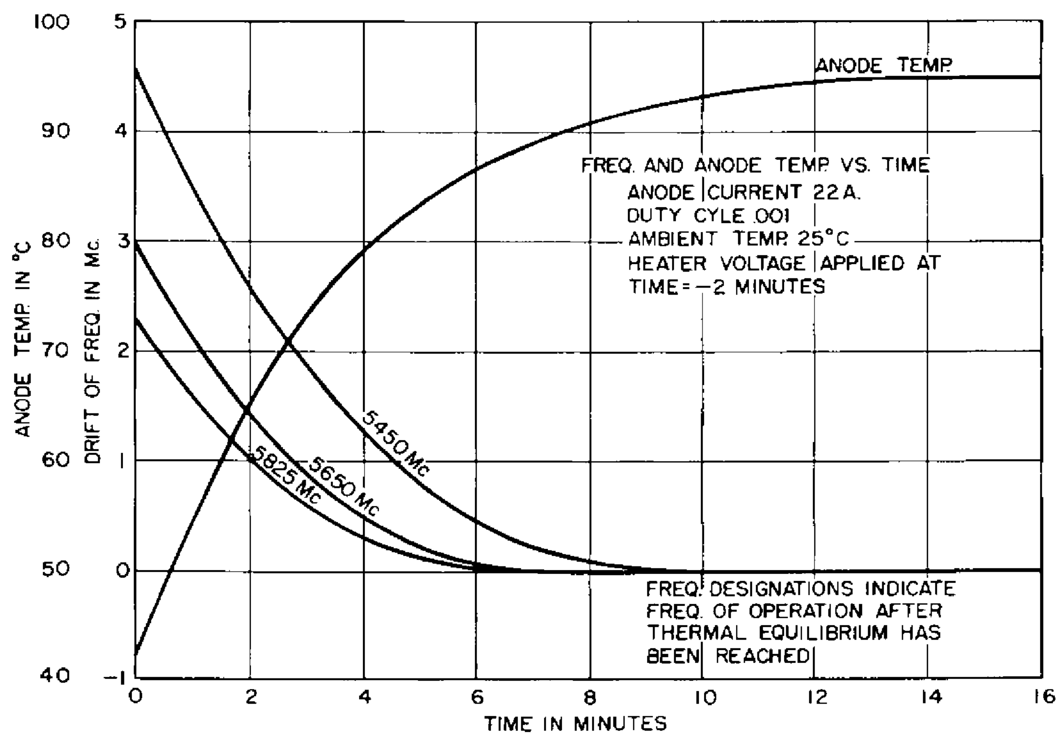


FIG. 6—FREQ. DRIFT CHARACTERISTICS FROM COLD START OF TYPICAL QK 235 MAGNETRON

LOAD AND LINE LENGTH CONSIDERATIONS

Operation of the QK-235 into a line exceeding some critical length and terminated in an impedance different from the line or a short line terminated in a severe mismatch gives rise to undesirable phenomena collectively termed long line effects. Tuner curve discontinuities, spectrum broadening and intolerable attenuation are some of the associated phenomena. Figure 7 shows the line length and VSWR recommended for use with the QK-235. Although the curves apply specifically to an operating frequency of 5650 Mc, they do not change significantly at other frequencies in the tuning range. The critical conditions of frequency skip, where breaks in the tuning curve first appear depend somewhat on the pulling figure of individual tubes. However, operation within the recommended region indicated on the figure will yield satisfactory operation of all QK-235 magnetrons. An extensive treatment of long line effects is beyond the scope of this publication; however, additional information may be obtained on request from the Sales Department, Microwave & Power Tube Operations, Raytheon Mfg. Company.

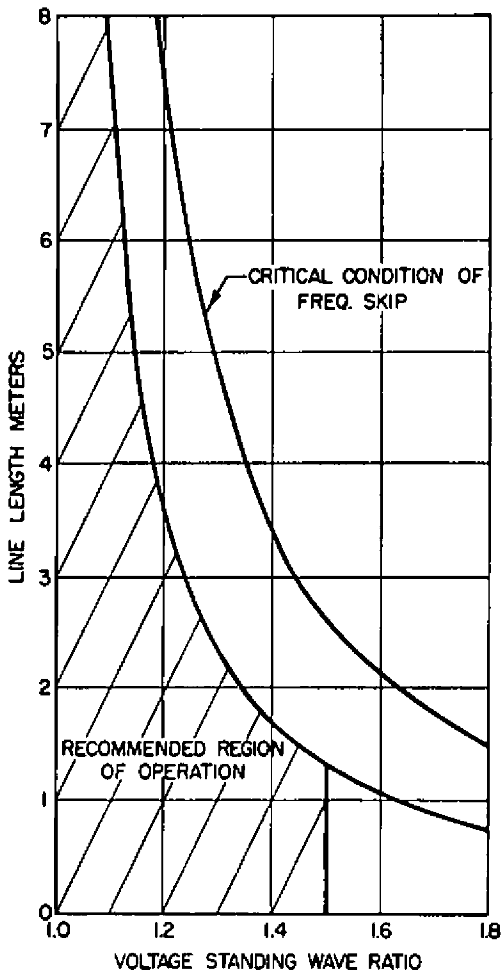


FIG. 7—QK 235 LOAD AND LINE LENGTH CONSIDERATIONS 1"x2" WAVE GUIDE

COOLING

The cooling air stream for the QK-235 should be directed to the air inlet of the radiator through a close fitting duct. Operating anode temperatures below 90°C are recommended although temperatures as high as 120°C can be tolerated.

Figure 8 reveals the relationship between air flow (ft^3/min.) and back pressure (inches H_2O). Figure 9 shows anode temperature as a function of rate of air flow over the radiator at four values of power input. Tests were made at 30 in. Hg and an ambient temperature of 25°C. Higher ambient temperatures will result in correspondingly higher anode temperatures.

Use of a close fitting duct can be avoided if a compensating increase in rate of air flow is made.

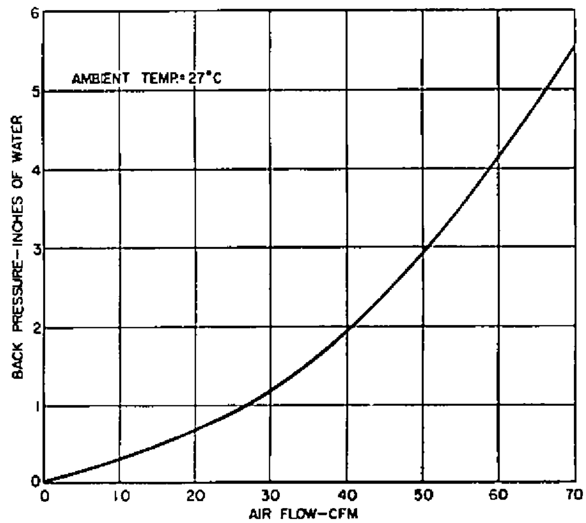


FIG. 8—COOLING FIN CHARACTERISTICS OF TYPICAL QK235 MAGNETRON

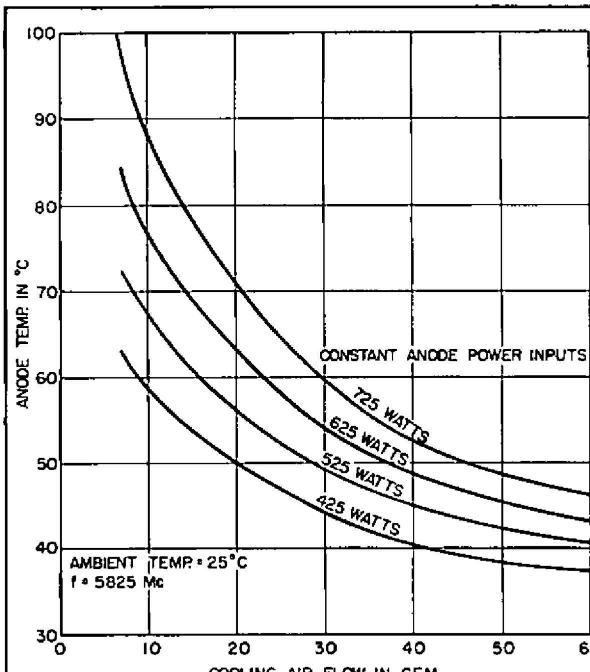
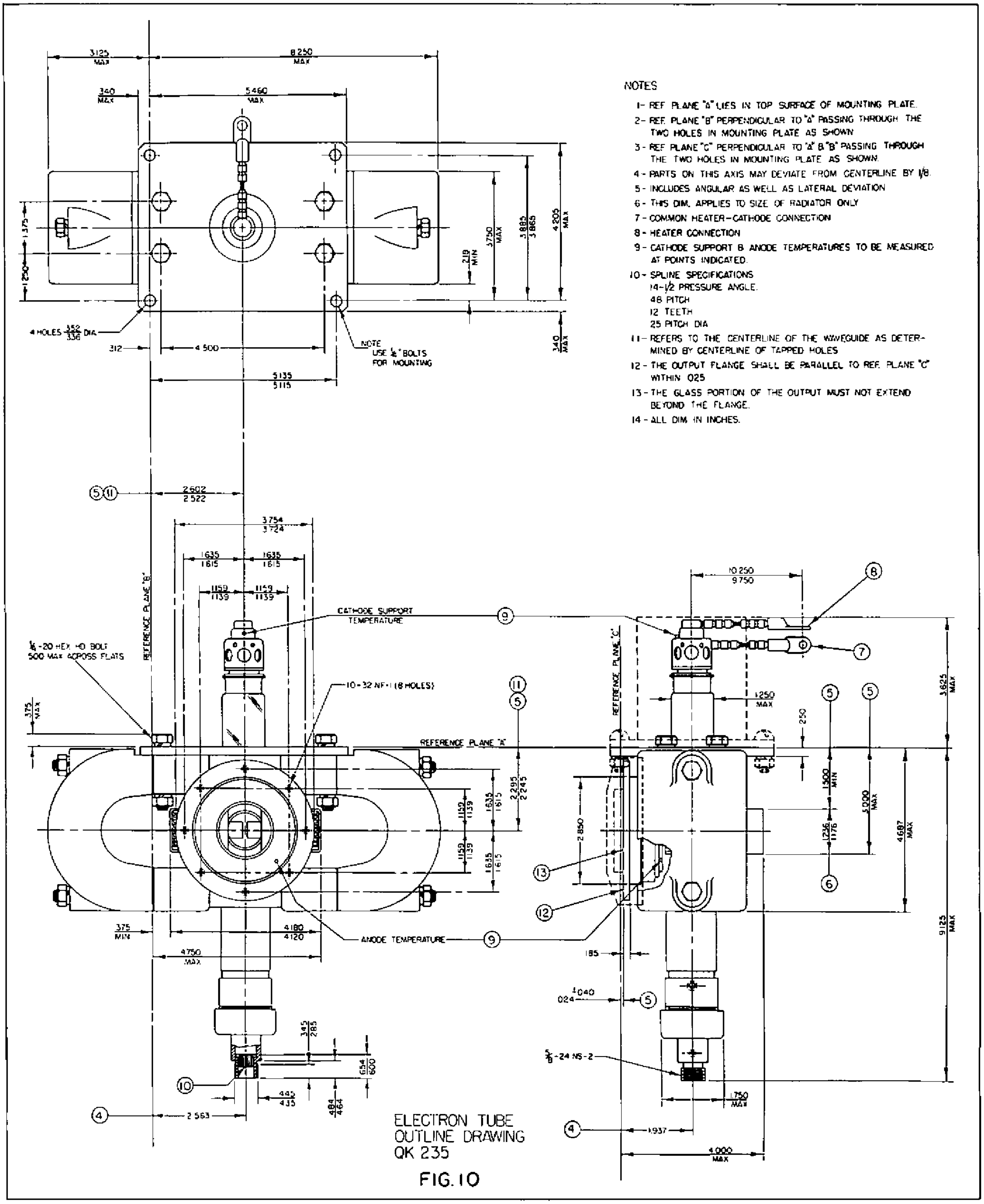


FIG. 9—COOLING CHARACTERISTICS OF TYPICAL QK235 MAGNETRON



ELECTRON TUBE OUTLINE DRAWING QK 235

FIG. 10

DETAILED MECHANICAL INFORMATION

OUTLINE DRAWING

The detailed mechanical dimensions are given in Figure 10. These dimensions should be used in designing a mechanical layout for an equipment rather than the dimensions of a sample tube.

INSTALLATION & HANDLING PRECAUTIONS

The high voltage bushing and output window are protected by guard covers during shipment. These covers must be removed before the tube is installed in its associated equipment. The bushing or output window must not be subjected to any mechanical strain in the handling or mounting of the magnetron.

Care should be taken to keep magnetic material 12 inches away from the magnets, since deterioration of the magnetic field results in low power and instability.

Unnecessary jarring of the tube must be avoided. Although a packaged magnetron lends the appearance of great structural strength, it is in reality quite fragile and the resulting shock of careless handling may easily exceed its maximum allowable vibration or shock rating.

MOUNTING

The tube is mounted within the equipment by four ¼ inch bolts passed through the four clearance holes of the mounting plate. The tube must be mounted with the longitudinal axis of the cathode high voltage bushing vertical. The tube should be operated in this position although small angular deviations can be tolerated for short intervals as long as the mean position of the above axis remains vertical during the period of operation. If the mean position differs from that described, the heater may become short-circuited.

ELECTRICAL CONNECTIONS

Electrical input connections are made to the frame of the tube and to two flexible leads terminated in lugs with clearance holes for #10-32 screws. Positive high voltage is grounded to the frame, preferably the mounting plate. Both flexible leads project radially from the cathode high voltage bushing. The lead at the extreme end of the bushing is connected to the heater power supply; the other, identified by a brown band, serves as a common lead for the remaining heater connection and the negative high voltage cathode terminal.

COUPLING & PRESSURIZATION

The load is attached to the QK-235 output system through standard 1 x 2 inch waveguide connected to the tube output flange by a UG148B/U choke flange. The eight tapped holes of the choke flange should be drilled to provide clearance for #10-32 screws. The output section of the magnetron should not be used to support either the weight of the tube or that of the load.

The QK-235 magnetron is intended for operation at barometric pressure common to sea level. Electrical breakdown across the cathode high voltage bushing may occur at appreciably lower pressures. Also, if sustained arcing in the waveguide occurs, it will generally move along the guide towards the output window of the tube, and may result in failure of the window. To minimize the possibility of arcing in the guide and to achieve optimum tube performance, the VSWR in the guide should be kept as low as possible; VSWR values greater than 1.5/1 are not recommended.

TUNER CHARACTERISTICS

Approximately 13 turns of the tuner spline, at an applied torque of 1½ inch lbs., are required to tune the QK-235 through its frequency range. Internal mechanical tuner stops designed to withstand a torque of 200 inch ounces allow a slightly wider tuning range than specified, but operation out of the specified band is not recommended. See Figure 12.

Further information on the operation and capabilities of this and other type magnetrons may be obtained on request from the Applications Engineering Department, Microwave & Power Tube Operations, Raytheon Manufacturing Company, Waltham, Mass.

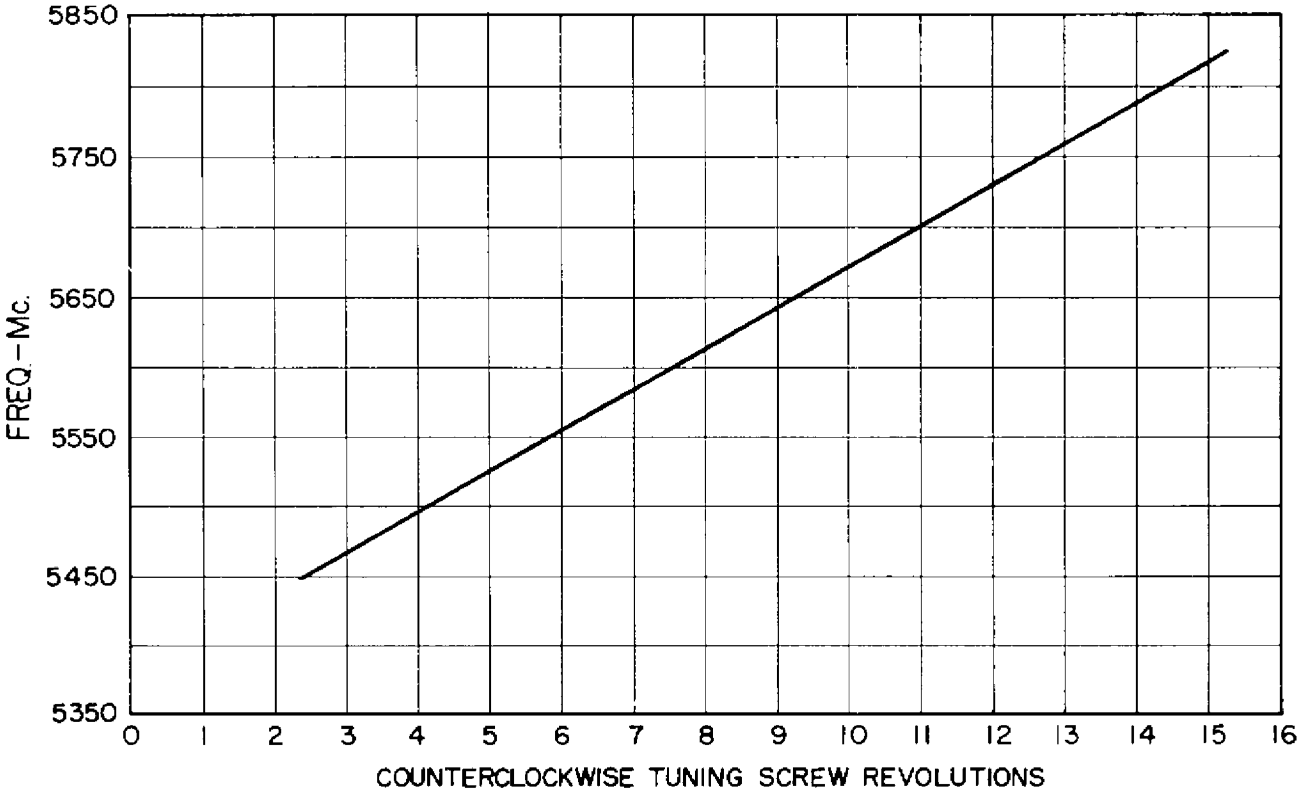


FIG. 11 – TUNING CHARACTERISTICS OF TYPICAL QK 235 MAGNETRON