GENERAL DESCRIPTION

The RK6959/QK172 magnetron is a fixed frequency pulsed type oscillator operating in the frequency region of 9330 to 9420 megacycles with a nominal peak power output of 500 kilowatts. It is an integral magnet type tube requiring forced air cooling and is designed for coupling to standard \( \frac{5}{8}'' \times \frac{1}{4}'' \) waveguide.

GENERAL PRECAUTIONS

Reliable operation and maximum magnetron life can be achieved only if the overall radar transmitter is designed with the magnetron characteristics and peculiarities clearly in mind. This technical data should be used as a guide for equipment designers rather than the MIL-E-1C Government purchase specifications. There are many problems peculiar to magnetrons in general which must be given special considerate system design. These problems are discussed in detail on the following pages. If for any reason it is desired to operate the RK6959/QK172 under conditions other than those recommended in this technical data sheet, the Applications Group at Raytheon must be consulted. In some special cases, additional evaluation and life test will be necessary.

GENERAL CHARACTERISTICS

ELECTRICAL

Heater Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater current @ 6.0 V</td>
<td>27 — 33 A</td>
</tr>
<tr>
<td>Minimum preheat time</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Cold heater resistance</td>
<td>.025 ohms</td>
</tr>
</tbody>
</table>

Typical Operation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater voltage preheat</td>
<td>6.0 V</td>
</tr>
<tr>
<td>Heater voltage operate</td>
<td>3.0 V</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>3.2 ( \mu )sec ( \pm 10% )</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>.0003</td>
</tr>
<tr>
<td>Peak anode voltage</td>
<td>33 kv</td>
</tr>
<tr>
<td>Peak anode current</td>
<td>38 ( \alpha )</td>
</tr>
<tr>
<td>Average anode current</td>
<td>40 mAdc</td>
</tr>
<tr>
<td>Peak power output</td>
<td>500 kw</td>
</tr>
<tr>
<td>Average power output</td>
<td>525 W</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.5/1</td>
</tr>
<tr>
<td>Frequency region</td>
<td>9330 — 9420 Mc</td>
</tr>
<tr>
<td>RF bandwidth</td>
<td>1.1 Mc @ —6 db level</td>
</tr>
</tbody>
</table>

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MICROWAVE AND POWER TUBE DIVISION

RAYTHEON COMPANY

FOUNDRY AVE., WALTHAM 54, MASS.

from JEDEC release #3478, Nov. 6, 1961
MECHANICAL

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over-all dimensions</td>
<td>15&quot; x 13&quot; x 4.5&quot;</td>
</tr>
<tr>
<td>Net weight</td>
<td>45 lbs.</td>
</tr>
<tr>
<td>Mounting</td>
<td>Cathode vertical</td>
</tr>
<tr>
<td>Output coupling</td>
<td>3/8&quot; x 1 1/4&quot; Choke Flange</td>
</tr>
<tr>
<td>Output pressure</td>
<td>45 psia</td>
</tr>
<tr>
<td>Cooling</td>
<td>Forced air</td>
</tr>
<tr>
<td>Vibration (non-operating)</td>
<td>50 cycles (at 10 G)</td>
</tr>
<tr>
<td>Magnet protection</td>
<td>6&quot;</td>
</tr>
</tbody>
</table>

DETAILED ELECTRICAL INFORMATION

HEATER

The cathode must be preheated at $E_f = 6.0\, \text{V} \pm 5.0\%$ for a period of at least 5 minutes prior to the application of anode voltage. Optimum operation and maximum tube life will be realized only if provisions are made to maintain the specified heater current within the ± 5.0% tolerance. Heater current surges in excess of 55 amps cannot be tolerated. Operation of the tube at standby or preheat without forced air cooling may result in damage to the tube and is not permissible. See Figure 1 for heater characteristics.

For .001 duty cycle at peak current over 25 amperes the heater voltage should be reduced to 3.0 volts. For other duty cycles the manufacturer should be consulted for the optimum heater schedule.

If the tube has been running at reduced heater voltage and high voltage is temporarily removed, it will be necessary to preheat the tube again at 6.0 volts to resume normal operation.

PULSE CHARACTERISTICS

The RK6959/QK172 Magnetron has been designed and tested for operation at the following pulse conditions. See Figure 2.

- $t_{pc} = 3.2 \pm 10\% \, \mu\text{sec}$
- $t_{pc} = 0.5 \pm 10\% \, \mu\text{sec}$
- $\Delta t_{Du} = .00105$
- $\Delta t_{Du} = .003$
- $t_{fc} = 1.0 \, \mu\text{sec Max.}$
- $t_{fc} = 0.2 \, \mu\text{sec Max.}$
- $t_{rv} = 75 \, \text{to} \, 150 \, \text{KV/\musec}$
- $t_{rv} = 150 \, \text{to} \, 270 \, \text{KV/\musec}$
- $t_{fv} = 2.5 \, \mu\text{sec Max.}$
- $t_{fv} = 0.5 \, \mu\text{sec Max.}$

If operation at pulse conditions different from those given above is anticipated, the manufacturer should be consulted for further information. No spike or ripple should exceed ± 7% of the average peak value of voltage or current. Inverse voltage should not exceed 20% of the forward voltage.

Optimum tube performance will be realized only if proper consideration is given to pulse shaping. Rate of voltage rise faster than specified will result...
PULSED-TYPE MAGNETRON OSCILLATOR

RK6959/OK172

CURRENT PULSE

TOP

SMOOTH PEAK (100%)

85%  1%  95%

50%  20%

current rise

current fall

100µsec

VOLTAGE PULSE

TOP

SMOOTH PEAK

85%  1%  95%

50%  20%

voltage rise

voltage fall

REFERENCE LINE (ZERO)

STEEPEST TANGENT

ABOVE THE 50% POINT

100µsec

Figure 2

backswing is controlled very closely. A backswing in the negative direction of several hundred volts may be enough to cause an RF output in the order of a microwatt. If this low level energy is fed directly to the receiver, noise or false targets will appear on the radar indicators. By judicious matching of the pulse line, pulse transformer and magnetron, and by the use of a clipper tube across the primary of the pulse transformer, the voltage backswing can be controlled so that its magnitude is quite small; and more important, that the backswing is completely damped out within a very short interval after the pulse.

LOAD DIAGRAM

Figure 3 is a load diagram for a typical RK6959/OK172 magnetron. 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 have been plotted, but operation at ratios greater than 1.5/1 is not recommended.

in moding and/or arcing and cannot be tolerated. Excessive ripple at the top of the current pulse causes frequency pushing and broadening of the spectrum. Most magnetrons draw a small amount of leakage or diode current at anode voltages as low as 100 volts. This leakage current may amount to several milliamperes if the voltage fall time is greater than 2.5 µsec, and at a given duty cycle the calculated peak current will be in error. It is therefore advisable that equipment design effect as rapid a decay as possible.

Optimum pulse shaping can best be achieved by treating the magnetron, pulse transformer, and pulse line as a unit; hand-tailoring the line and transformer for magnetron compatibility is recommended.

If operation at both long and short pulses is anticipated, the pulse transformer should be designed to optimize the more important pulse.

POST PULSE NOISE

It is possible that some RK6959/OK172 magnetrons may exhibit RF noise output unless the post pulse
LOAD AND LINE LENGTH CONSIDERATIONS

If an oscillator is loaded by an electrically long transmission line which is terminated by an impedance different from that of the line, the impedance of the load will be a periodic function of frequency. Operation of the oscillator under these conditions gives rise to phenomena collectively termed "long-line effects". Although these phenomena are usually associated with an electrically long transmission line, they can also be exhibited by a short line terminated by a sufficiently mismatched impedance. In any case the extent to which the long-line effect is exhibited depends on the amount of coupling between the load and oscillator as well as the degree of mismatch in the line. Figure 4 shows the relation between the VSWR and the line length with respect to the critical condition of skip. This skip condition occurs when the tube is changing frequency (thermal drift) and causes breaks in the ordinarily smooth drift curve. This condition is not critical in the RK6959/QK172 because the tube is not tunable. Of far more serious consequence, however, is the broadening and deterioration of the spectrum caused by this phenomena. It may in some cases permit spectra of two frequencies to appear simultaneously. By operating into loads specified under the region of recommended operation in Figure 4, satisfactory operation should be obtained. In this region no significant broadening of the spectrum will take place, although for close control of bandwidth the VSWR should be kept as low as possible.

More detailed information on the theories and remedies of long-line effects is available upon request.

COOLING

The air stream for cooling the RK6959/QK172 should be directed to the air inlet of the radiator through a close fitting duct. During tube operation an anode temperature below 100° C is recommended, although temperatures as high as 130° C can be tolerated. Figure 5 shows the relation between air flow in cubic feet per minute and back pressure in inches of water at the entrance to the RK6959/QK172 cooling fin structure.
Figure 6 shows the anode temperature as a function of forced air flow through the cooling fins at different values of anode input power (exclusive of heater power). These measurements were made at an ambient temperature of 28 degrees centigrade and normal atmospheric pressure. Higher ambient temperatures will result in correspondingly higher anode temperatures.

**FREQUENCY DRIFT**

After operation of the RK6959/QK172 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 7.

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. The frequency change will not exceed ±0.40 Mc/C° of anode temperature.

**OPERATING CHARACTERISTICS**

Figure 8 is a plot of power output, anode voltage and efficiency as a function of peak anode current, showing the deviation from the average.
MOUNTING

The tube is mounted within the equipment by four bolts passed through the clearance holes of the mounting brackets. 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 (15 degrees) 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.

INSTALLATION AND HANDLING PRECAUTIONS

Although magnetrons give appearance of great structural strength, they are in reality quite fragile and may easily be damaged in handling or installation. Damage to the magnetron will be avoided if the following installation and handling precautions are carefully observed.

1. Leave magnetron in its shipping crate until ready to be used.
2. Remove neoprene guard covers from the RF output window or cathode bushing before installing tube in equipment.
3. Avoid setting up mechanical strains in output window or cathode bushing when handling or mounting.
4. Avoid unnecessary jarring or rough handling.
5. Do not let magnetron rest on any of its parts normally protected by the shipping crate.
6. If a magnetron has been stored in a freezing environment, examine it closely for traces of frost or moisture on the RF window or cathode bushing and wipe dry before applying high voltage.
7. Do not place tube in closed proximity to magnetic materials than is indicated on tube magnet.

MICROWAVE AND POWER TUBE DIVISION

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FOUNDRY AVE., WALTHAM 54, MASS.
 RK6959/QK172 ELECTRON TUBE
 OUTLINE DRAWING

Figure 9
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