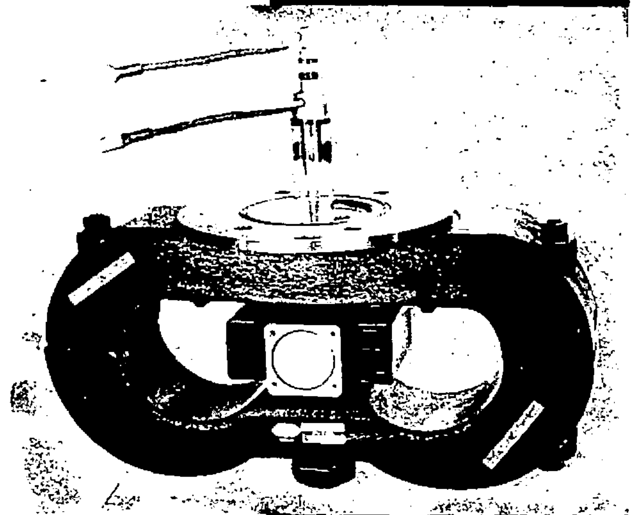
TECHNICAL INFORMATION

Excellence in Electronics

TYPE RK6959/ QK172

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 5/8″ x 1¼″ waveguide.



PULSED-TYPE MAGNETRON OSCILLATOR

GENERAL PRECAUTIONS

Reliable operation and maximum magnetron life can be achieved only if the over-all 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 consideratic system design. These problems are discussed in d 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

Heater current @ 6.0 V	27 — 33 A
Minimum preheat time	5 minutes
Cold heater resistance	.025 ohms

Typical Operation

Heater voltage preheat	6.0 V	
Heater voltage operate	3.0 V	6.5 V
Pulse duration	3.2 μsec ± 10%	0.5 μsec ±10%
Duty cycle	.00105	.0003
Peak anode voltage	33 kv	33 kv
Peak anode current	38 a	67 a
Average anode current	40 mAdc	20 mAdc
Peak power output	500 kw	800 kw
Average power output	525 W	240 W
VSWR	1.5/1	1.5/1
Frequency region	9330 — 9420 Mc	9330 — 9420 Mc
RF bandwidth	1.1 Mc @ —6 db level	4.0 Mc @ —6 db level

Printed in U.S.A.

MICROWAVE AND POWER TUBE DIVISION

RAYTHEON COMPANY

FOUNDRY AVE., WALTHAM 54, MASS.

9-58

from JEDEC release #3478, Nov. 6, 1961

MECHANICAL

Over-all dimensions	15″ x 13″ x 4.5″
Net weight	45 lbs.
Mounting	Cathode vertical
Output coupling	⅝″ x 1¼″ Choke Flange
Output pressure	45 psia
Cooling	Forced air
Vibration (non-operating)	50 cycles @ 10 G
Magnet protection	6″

DETAILED ELECTRICAL INFORMATION

HEATER

The cathode must be preheated at Ef = 6.0 V ± 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.

RK6959/QK172 HEATER CHARACTERISTICS

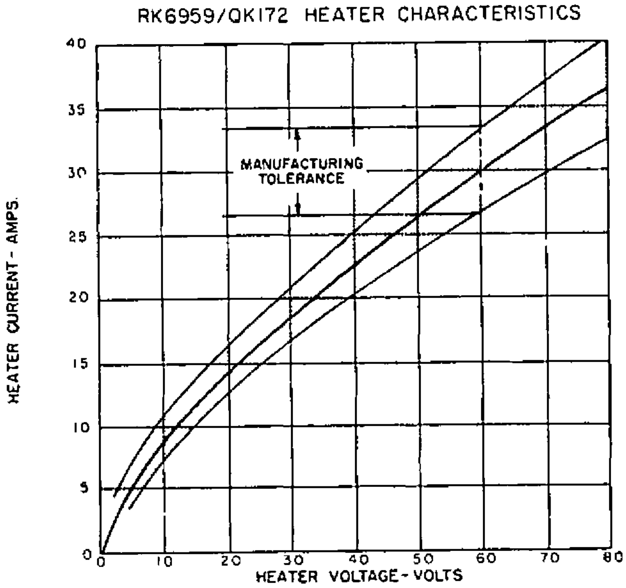


Figure 1

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.

tpc = 3.2 ± 10% μsec @ Du = .00105	tpc = 0.5 ± 10% μsec @ Du = .003
tfc = 1.0 μsec Max.	tfc = 0.2 μsec Max.
rrv = 75 to 150 KV/μsec	rrv = 150 to 270 KV/-μsec
tfv = 2.5 μsec Max.	tfv = 0.5 μsec 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

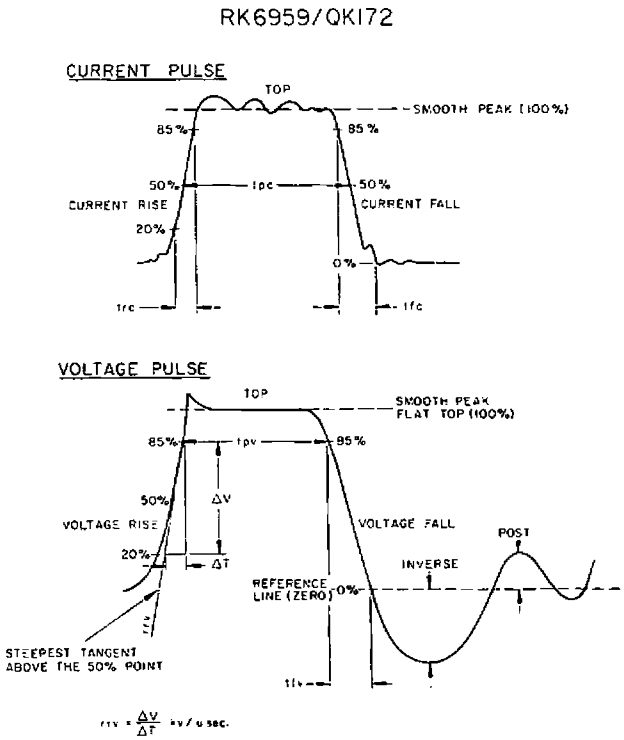


Figure 2

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.

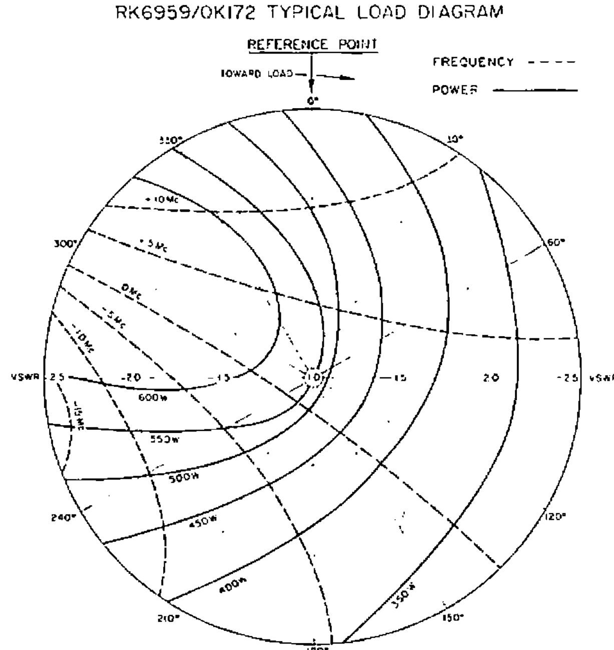
POST PULSE NOISE

It is possible that some RK6959/QK172 magnetrons may exhibit RF noise output unless the post pulse 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/QK172 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.

RK6959/QK172 TYPICAL LOAD DIAGRAM



REFERENCE POINT SURFACE ON OUTPUT FLANGE

fo = 9410 Mc
Ep = 33.5 kv
prr = 350 pps
Ip = 40 mA
tp = 30 us
Du = 0.0105
Ef = 6.0 V
If = 29.0 A

Figure 3

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.

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LOAD AND LINE LENGTH CONSIDERATIONS

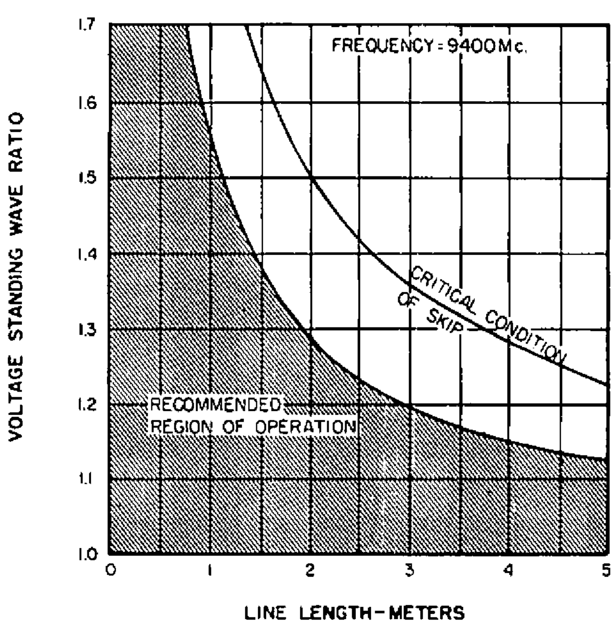


Figure 4

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.

RK6959/QK172

COOLING FIN CHARACTERISTICS

Back Pressure vs. Air Flow

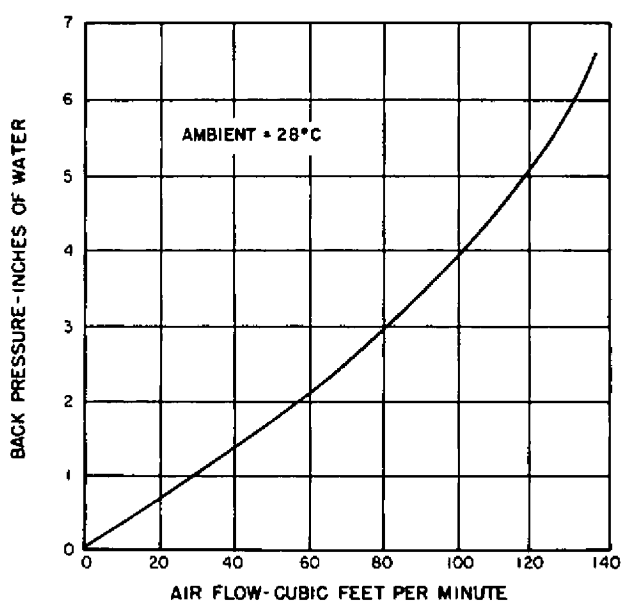


Figure 5

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.

RK6959/QK172

COOLING CHARACTERISTICS

Temperature vs. Power Input and Air Flow

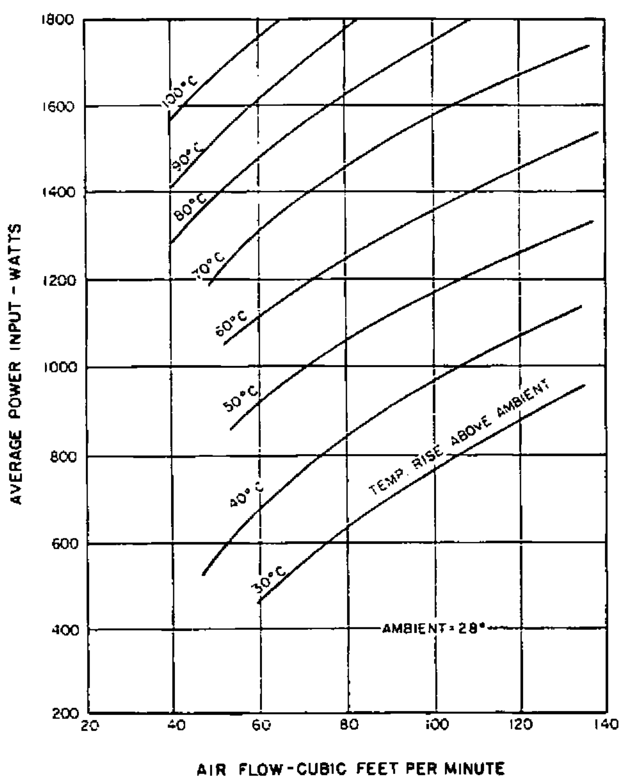


Figure 6

Sufficient circulating air, or equivalent cooling, must be supplied around the cathode bushing so that the cathode bushing temperature will never exceed 270° C. The exact point at which this temperature is measured is indicated on the electron tube drawing, Figure 9.

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.

RK6959/QK172

FREQUENCY DRIFT CHARACTERISTICS

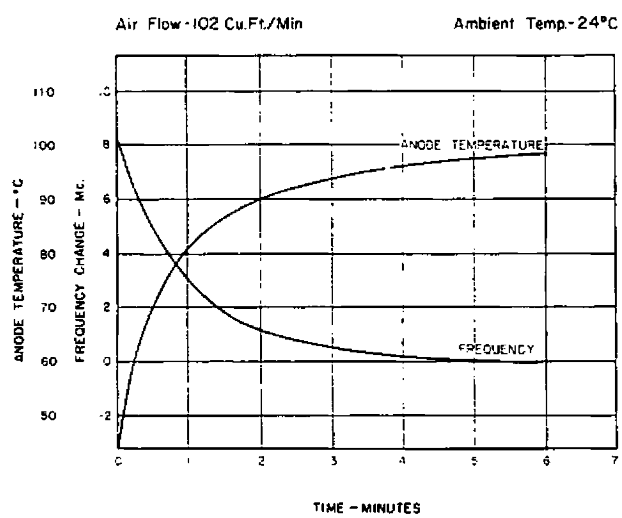


Figure 7

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.

RK6959/QK172 OPERATING CHARACTERISTICS

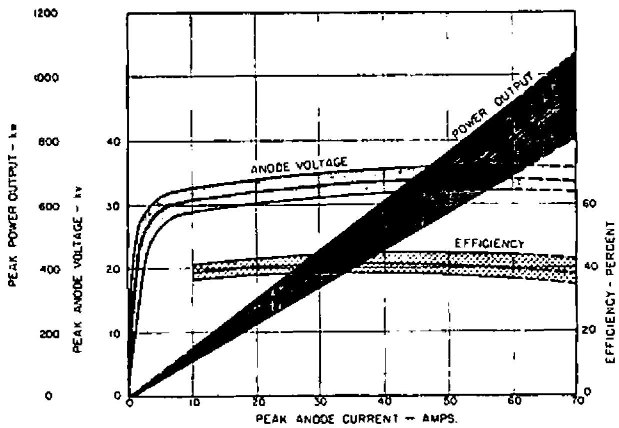


Figure 8

ELECTRICAL CONNECTIONS

Electrical connections are made to the frame of the tube and to the two terminals on the high voltage cathode bushing. The positive high voltage should be grounded at the mounting surfaces. Heater and cathode connections are made to the terminals on the cathode bushing (see note 11 of tube outline drawing).

RF RADIATION FROM CATHODE

The RK6959/QK172 is designed to minimize radiation from the cathode bushing which will in general be negligible. It is not possible, however, to guarantee it as being negligible, and in particular critical environment shielding of the cathode bushing may be necessary to avoid radiation difficulties.

COUPLING AND PRESSURIZATION

The magnetron output flange is designed to couple to standard ⅝ x 1¼ waveguides. Mechanical details of the recommended choke flange to mate to the magnetron are illustrated in the outline drawing. See Figure 9.

MOUNTING

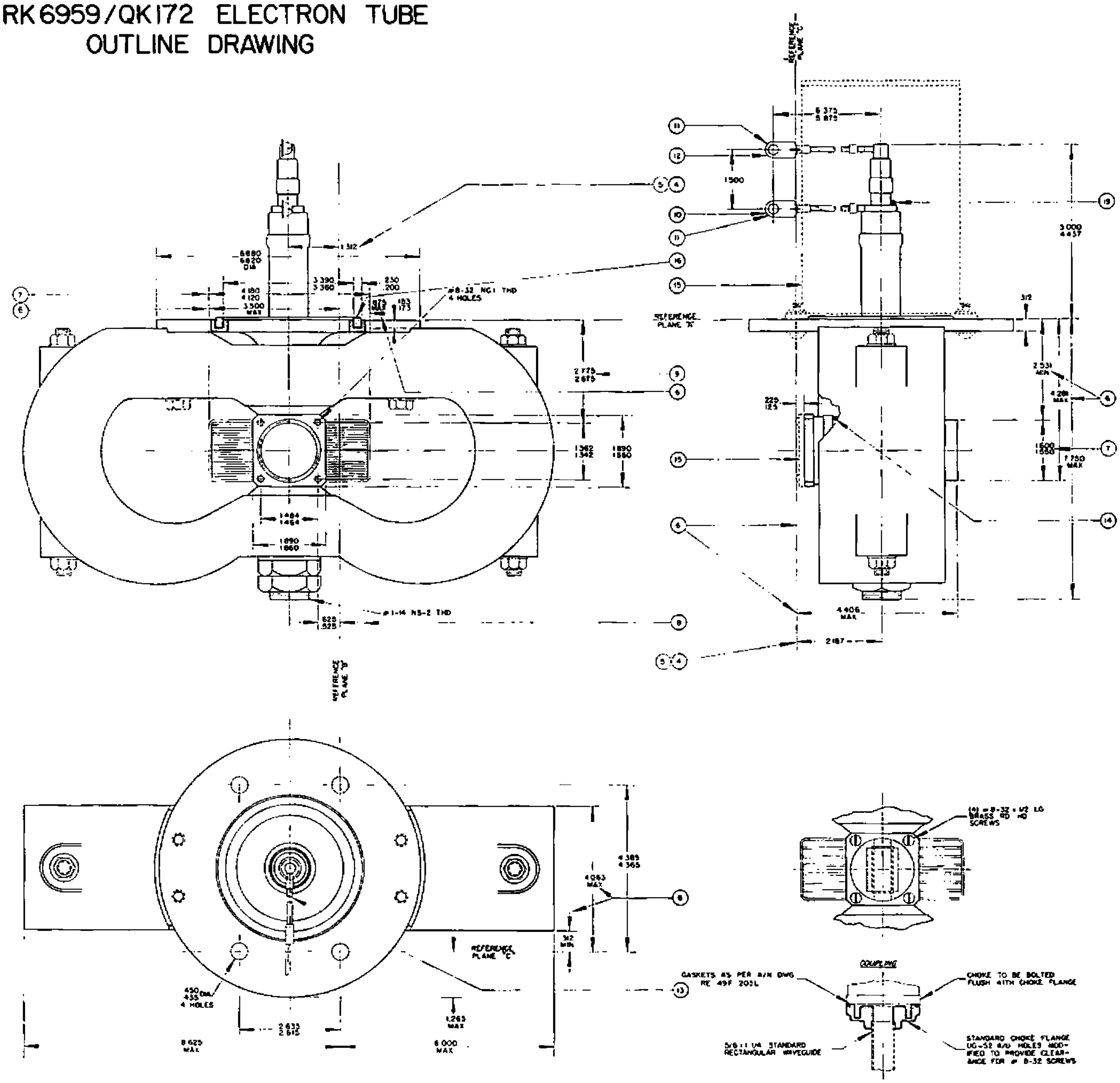
The tube is mounted within the equipment by four bolts passed through the clearance holes of the mounting brackets. The tube must be mounted with the longitudinal axis of the cathode high voltage bushing vertical. The tube should be operated in this position although small angular deviations (15 degrees) 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.

RK6959/QK172 ELECTRON TUBE OUTLINE DRAWING



NOTES

1) REFERENCE PLANE "A" LIES IN TOP SURFACE OF MOUNTING PLATE
2) REFERENCE PLANE "B" IS PERPENDICULAR TO "A" PASSING THROUGH THE TWO HOLES OF MOUNTING PLATE AS SHOWN
3) REFERENCE PLANE "C" IS MUTUALLY PERPENDICULAR TO "A" AND "B" PASSING THROUGH THE TWO HOLES IN MOUNTING PLATE AS SHOWN
4) THIS DIMENSION REFERS TO THE CENTER LINE OF THE TUBE
5) PARTS ON THIS CENTER LINE MAY VARY FROM TRUE LOCATION BY .125
6) THIS DIMENSION INCLUDES ANGULAR AS WELL AS LATERAL DEVIATION
7) THESE DIMENSIONS APPLY TO RADIATOR SIZE ONLY
8) THIS DIMENSION IS TO END OF RADIATOR
9) TAPPED HOLES MUST BE PARALLEL TO REF PLANE WITHIN .030
10) BROWN PAINT TO IDENTIFY COMMON HEATER-CATHODE CONNECTION
11) STANDARD 50 AMP SOLDER LUGS, CLEARANCE FOR 1/4 DIA BOLT
12) HEATER CONNECTION
13) HEATER LEADS TO BE PARALLEL TO REFERENCE PLANE "B" WITHIN 20°
14) ANODE TEMPERATURE TO BE MEASURED AT THIS POINT
15) GUARD FOR SHIPPING PURPOSES ONLY
16) GROOVE FOR PARKER AIRCRAFT O-RING AN-6227B-43
17) PRESSURE TEST WAVEGUIDE FLANGE WITH 35 PSI ABSOLUTE
18) PRESSURE TEST OIL SEAL RING JOINTS AT MOUNTING PLATE WITH 30 PSI ABSOLUTE
19) CATHODE SUPPORT TEMPERATURE

Figure 9