



TECHNICAL INFORMATION

PULSED-TYPE
MAGNETRON
OSCILLATOR

TENTATIVE DATA

Excellence in Electronics

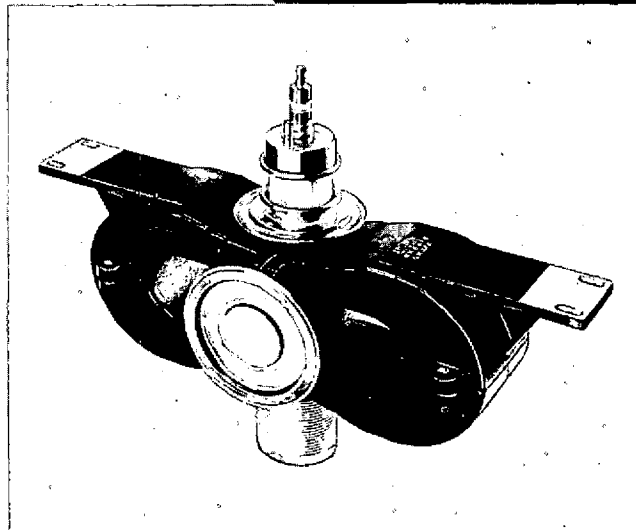
TYPE
RK6410/
QK338

The RK6410/QK338 magnetron is a fixed-frequency pulsed-type oscillator operating in the frequency region of 2750 to 2860 megacycles with a nominal peak-power output of 5.0 megawatts. It is an integral-magnet, wave-guide-output type tube requiring forced liquid cooling and is designed for coupling to standard 1.5" x 3" wave-guide.

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-1B Government purchase specifications.

There are many problems peculiar to magnetrons in general which must be given special consideration in system design. These problems are discussed in detail on the following pages. If for any reason it is desired to operate the RK6410/QK338 under conditions other than those recommended in this technical data sheet, the company's Magnetron Application Engineering Group should be consulted.



GENERAL CHARACTERISTICS

ELECTRICAL

Heater Characteristics

Heater Current Preheat	85 A
Heater Voltage @ 85A	7.3 — 9.3 V
Minimum Preheat Time	3 minutes
Cold Heater Resistance	0.0087 ± 1% ohms

Maximum Ratings

Heater Current	88 A
Peak Anode Voltage	76 kv
Peak Anode Current	135 a
Average Power Input	7000 W
Pulse Duration	2.2 usec
Voltage Pulse Rise Time.	0.5 usec
Duty Cycle	.001
VSWR	1.5/1
Anode Temperature	100°C
Bushing Temperature	150°C
Output Pressurization	55 psia
Coolant Pressure	55 psia

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The values specified above must not be exceeded under any service condition. The ratings are limiting values above which the serviceability of any individual tube may be impaired. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

MECHANICAL

Over-all Dimensions	21.5" x 7.5" x 16"
Net Weight	58 lbs.
Mounting	Cathode Vertical
Output Coupling	1.5" x 3" Choke Flange
Output Pressure	35 psia
Cooling	Forced Liquid
Cathode Bushing	Immersed in Oil
Vibration (nonoperating)	50 cycles @ 10 G
Magnet Protection	12"

Typical Operation

Heater Current Preheat	85A $\pm$ 3.5%
Heater Current—Operate	82A $\pm$ 3.5%
Pulse Duration	2.0 usec $\pm$ 10%
Duty Cycle	.00072
Peak Anode Voltage	71 kv
Peak Anode Current	130 a
Average Anode Current	93.5 mAdc
Peak Power Output	4.8 Mw
Average Power Output	3450 W
Useful Range of Peak Current	90 — 135 a
VSWR	1.1/1
Frequency Region	2750 — 2860 Mc
RF Bandwidth	0.7 Mc @ (—6db level)

DETAILED ELECTRICAL INFORMATION

HEATER

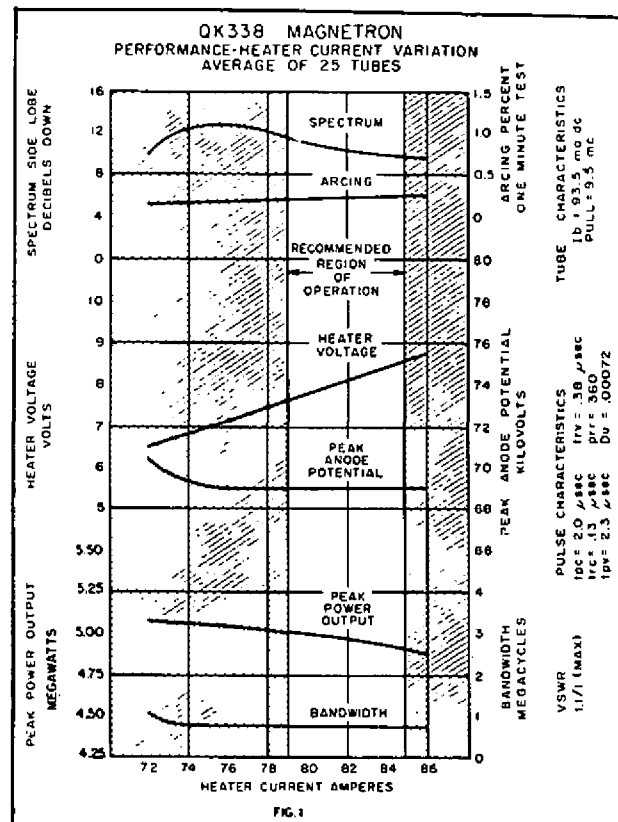
The cathode must be preheated at 85A for a period of at least 3 minutes prior to the application of anode high voltage. Heater current surges in excess of 100 amperes cannot be tolerated. Optimum operation and maximum tube life will be realized only if provisions are made to hold the specified heater current within the $\pm$ 3.5% tolerance.

Even though operation at heater currents higher or lower than specified may not be attended by immediate malfunctioning of the tube, some deterioration of life and performance is likely to result.

Excessive cycling or extended standby operation is detrimental to heater life. Therefore, once a heater is energized, it should remain energized insofar as is practicable; i.e., except in cases where repair or maintenance require shutdown or when standby operation is going to exceed 48 hours.

Figure 1 shows the influence of heater current variations on various operating parameters for the operating conditions tabulated on the graph.

Operation at preheat or standby without forced



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liquid cooling may damage the tube and cannot be tolerated.

STARTING NEW MAGNETRON

New magnetrons, or those which have not been operated for some time, may contain small quantities of gas. The presence of this gas may give rise to arcing when initially running the tube up to its rated current. If the arcing is sporadic with arc bursts of less than 1 or 2 seconds duration, the tube may be run up to rated current without hesitation. If, however, the arcing is severe — i.e., with arc bursts of about 5 seconds duration occurring frequently — it is essential that the following aging or gas clean-up procedure be employed:

1. Raise the average current level to a value just below that which produces sustained arcing. Allow the magnetron current to remain at this level until the arcing begins to decrease.
2. Repeat the above step for successively higher levels of magnetron current until the desired operating point is reached.

NOTE: If difficulty is encountered in achieving stable operation at rated current, it is recommended that the tube be operated 2 or 3 mAdc above the rated current for a period of about 10 minutes. Stable operation will usually be attained in 5 to 15 minutes, although a considerably longer aging time may be required depending on the tube's condition and the experience of the operator.

NOTE: In equipments employing a runback or reverse current circuit, provisions must be made to allow desensitization of the device during the aging process. The runback circuit must be insensitive to arc bursts up to 5 seconds duration during aging, and insensitive to arc bursts up to 2 seconds duration after aging.

PULSE LENGTH AND DUTY CYCLE

The RK6410/QK338 magnetron has been designed and tested for operation at the following

pulse conditions: See Figure 2.

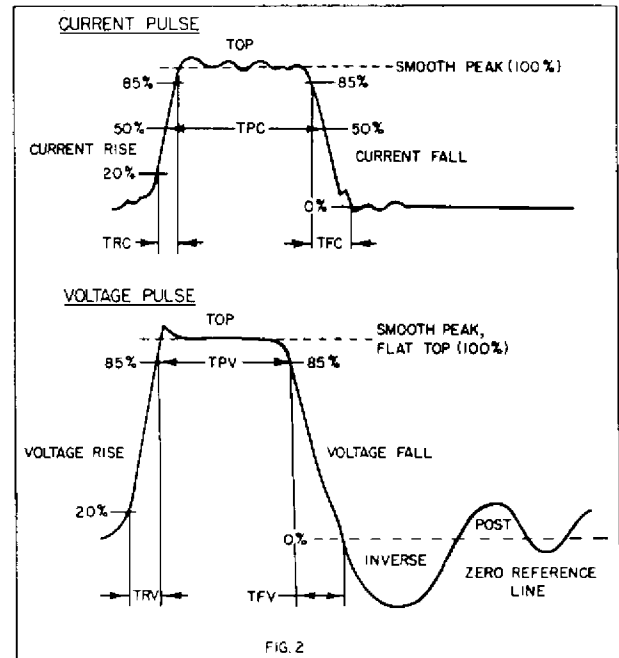
$tpc = 2.0 \pm 10\% \text{ usec @ } DU = .00072$

$trc = 0.25 \text{ usec max. measured 20\% to 85\%}$

$tfc = 0.60 \text{ usec max. measured 0\% to 85\%}$

$trv = 0.50 \text{ usec max. measured 20\% to 85\%}$

$tfv = 2.5 \text{ usec max. measured 0\% to 85\%}$



No spike or ripple should exceed $\pm 7\%$ of the average peak value of voltage or current. Inverse voltage should not exceed 20% of the forward voltage. Post voltages should be held to a minimum as they may cause post-pulse noise or oscillation and increased leakage current.

If operation at pulse conditions different from those given above is anticipated, the manufacturer should be consulted for further information.

Optimum tube performance will be realized only if proper consideration is given to pulse shaping. Voltage rise times slower than specified will result in moding and/or arcing and cannot be tolerated. Excessive ripple on 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 usec, and



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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 to prevent leakage. It is also advisable to prevent the positive voltage backswing from becoming negative again. Inverse and post-pulse voltages may result in undesirable noise radiation and should be damped. Judicious matching of the pulse-forming network and pulse transformer will, in most cases, reduce post and inverse voltage amplitudes sufficiently to eliminate noise difficulties. For short range radar applications where noise due to inverse and post voltages is most troublesome, it is recommended that a diode clipper be placed across the primary of the pulse transformer.

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.

COOLING

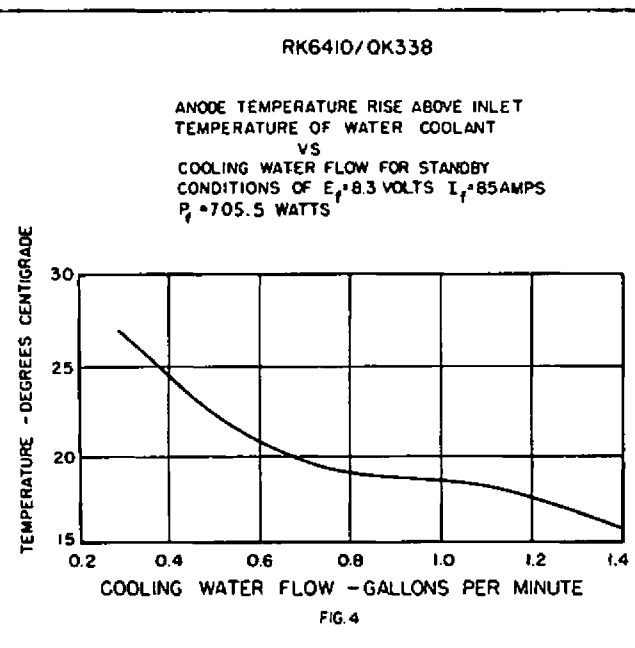
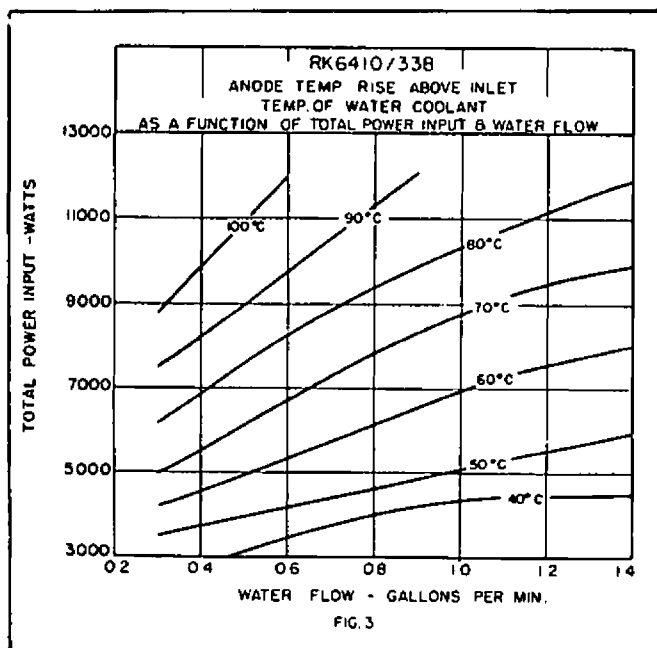
The RK6410/QK338 magnetron is a forced-

liquid cooled tube. The ambient temperature will dictate the type of coolant and flow rate necessary to maintain anode temperature below the specified maximum (100°C). Figure 3 is a plot of anode temperature rise above inlet water coolant temperature as a function of total power input and rate of water flow. Figure 4 is a plot of anode temperature rise above inlet water coolant temperature vs. waterflow for standby conditions.

Sufficient cooling of the cathode insulating oil must also be provided to maintain the cathode bushing temperature below the maximum specified 150°C. If the insulating oil used has insulating properties which deteriorate above the normal operating temperatures, it is of course necessary to maintain the oil temperature at a value below the deterioration level. It is recommended that Esso Univolt 35 or its equivalent be used.

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





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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 5 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 RK6410/QK338 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 5, 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.

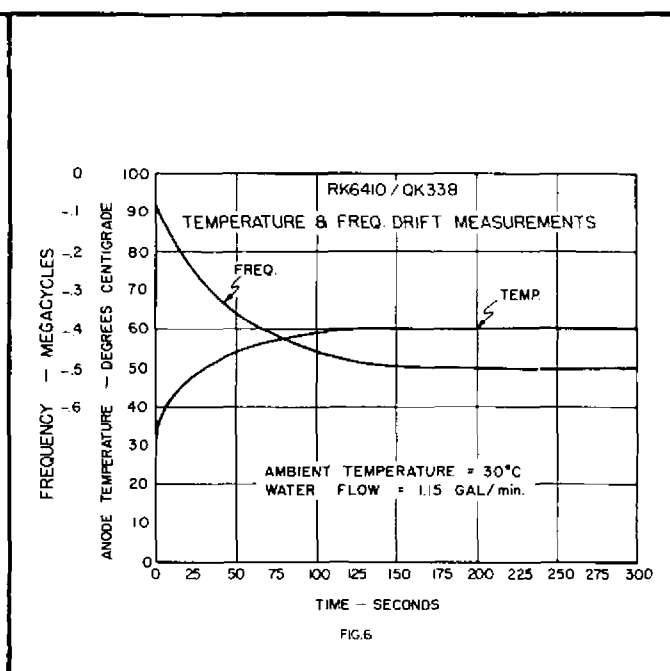
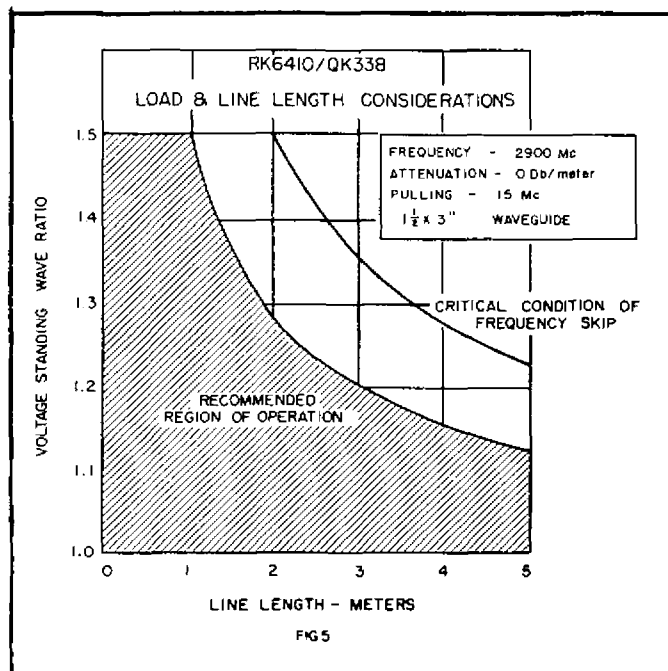
FREQUENCY DRIFT

After operation of the RK6410/QK338 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. It might also be noted at this point, that there is some frequency drift during life due to erosion of internal tube parts.

DYNAMIC PUSHING

Figure 7 displays the dynamic pushing characteristics of the RK6410/QK338 magnetron for anode current excursions of $\pm 16.8\%$. Examination of the curve reveals that minimum pushing (K_c/a) occurs at rated plate current.



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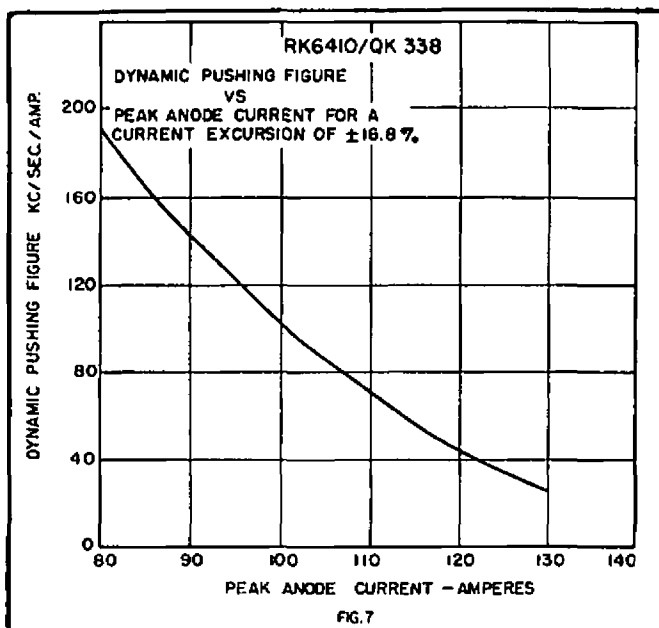
RF RADIATION FROM CATHODE

The RK6410/QK338 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; in particularly critical environment, shielding of the cathode bushing may be necessary to avoid radiation difficulties.

CATHODE BUSHING PROTECTION

It is recommended that the RK6410/QK338 ceramic cathode bushing be immersed in a fluid insulating medium of "Univolt 35" transformer oil or equivalent. A minimum distance of 1½ inches must be maintained through the oil from high voltage to ground, with design considerations to avoid sharp edged objects in the vicinity of the ceramic cathode bushing.

For cases where it is necessary to mount the RK6410/QK338 magnetron such that the ceramic cathode bushing is situated vertically downward, extreme care should be exercised to remove all entrained air from the magnetron oil flange area. Any air trapped beneath this oil flange can impose a dangerous possibility of high voltage breakdown in oil resulting in ultimate puncture of the ceramic cathode bushing.



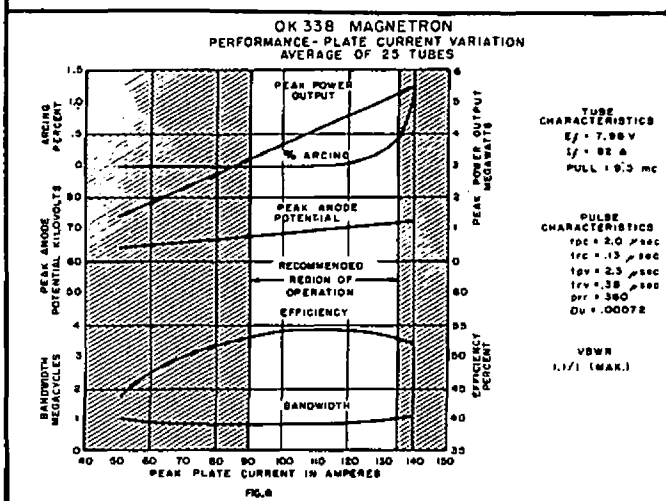
OPERATING CHARACTERISTICS

Figure 8 is a plot of peak power output, anode voltage, arc stability, bandwidth and efficiency as a function of peak anode current.

INSTALLATION AND HANDLING PRECAUTIONS

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

1. Leave the magnetron in its shipping crate until it is ready to be used.
2. Remove the neoprene guard covers from the RF output window and cathode bushing just before installing the tube in the equipment.
3. Avoid setting up mechanical strains in the output window or cathode bushing when handling or mounting.
4. Avoid unnecessary jarring or rough handling.
5. Do not let the magnetron rest on any of its parts normally protected by the shipping crate.
6. If the magnetron has been operated with water as a coolant, be sure to drain the water from the cooling jacket before storing the tube in a freezing environment.



7. 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 them dry before application of high voltage.
8. Do not place the tube in closer proximity to magnetic materials than is indicated on the tube magnet.

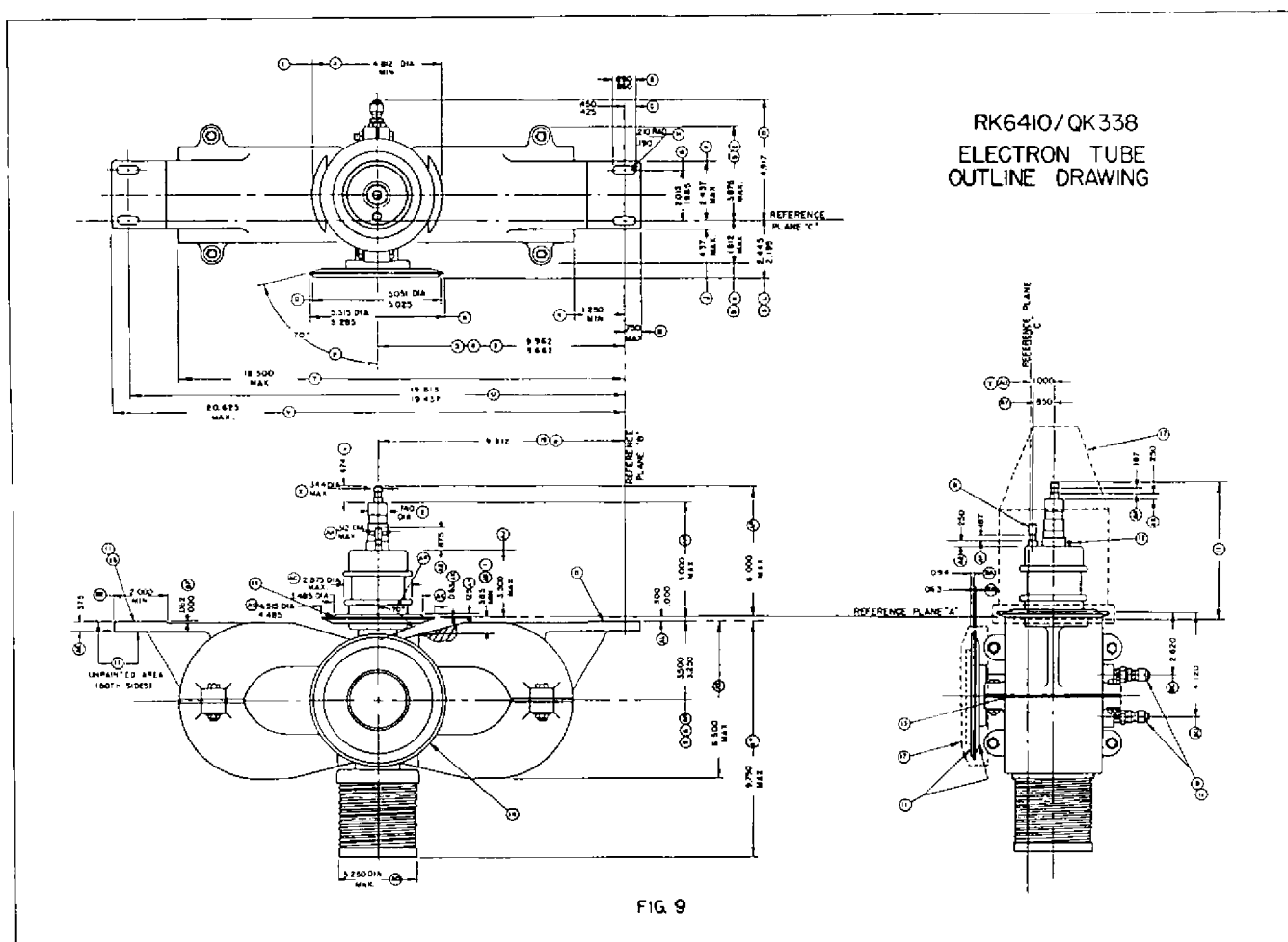
intervals as long as the mean position of the above axis remains vertical during the period of operation. If the mean position differs from that described, the heater may become short-circuited.

ELECTRICAL CONNECTIONS

Electrical 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. Heater connectors should be designed to minimize contact resistance and lateral forces on the heater terminals. Drawings of suitable heater cathode connecting devices are available on request.

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



**COUPLING AND PRESSURIZATION**

The magnetron output flange is designed to couple to standard 1.5" x 3" waveguide. Mechanical details of the recommended choke flange to mate to the magnetron are illustrated in the outline drawing. See Figure 9.

Waveguide pressurization to 45 psia is required. Pressurization lower than 45 psia may

result in waveguide breakdown. If sustained arcing in the waveguide occurs, failure of the output window may result. To minimize the possibility of the tube arcing in the guide and to achieve optimum tube performance, the VSWR of the waveguide system should be kept as low as possible; VSWR values greater than 1.5/1 are not recommended.

NOTES —

- 1 — THIS DIMENSION APPLIES TO 4.812" MIN DIAMETER.
- 2 — REFERENCE PLANE "A" LIES ON MOUNTING SURFACE OF MAGNETS.
- 3 — REFERENCE PLANE "B" PASSES THROUGH ϕ OF HOLES IN BRACKET AND IS PERPENDICULAR TO REFERENCE PLANE "A".
- 4 — REFERENCE PLANE "C" PASSES THROUGH ϕ OF HOLES IN BRACKET AND IS PERPENDICULAR TO REFERENCE PLANES "A" & "B".
- 5 — INCLUDES ANGULAR AS WELL AS LATERAL DEVIATIONS.
- 6 — REFERS TO ϕ OF WAVEGUIDE.
- 7 — PARTS ON THIS ϕ MAY VARY FROM TRUE LOCATION BY 0.125".
- 8 — HANSEN B3-T20 COUPLING PLUG.
- 9 — COMMON CATHODE CONNECTION.
- 10 — ALL SOLDER JOINTS ON OUTPUT SECTION SHALL BE SOLDERED TO PROVIDE AN HERMETIC SEAL.
- 11 — THE FOLLOWING SHALL BE FREE FROM PAINT: FRONT AND BACK FACES OF OIL SEALING SLEEVE, PARTS ABOVE FLANGE, FRONT AND BACK FACES OF OUTPUT FLANGE, EXHAUST CAP, MOUNTING SURFACE ON MAGNETS AND COOLANT PLUG CONNECTORS.
- 12 — CATHODE STEM TEMPERATURE MEASURED AT THIS POINT.
- 13 — ANODE TEMPERATURE MEASURED AT RIGHT SIDE (FACING OUTPUT) OF OUTPUT TRANSFORMER BY INSERTING TAPERED THERMOCOUPLE PLUG. (SEE INSTALLATION DETAILS DWG.)
- 14 — EQUIPMENT FLANGES MATING TO OIL SEALING FLANGE AND TO OUTPUT FLANGE SHOULD PROVIDE COMPLIANCE AS BY MEANS OF A BELLOWS OR OTHER FLEXIBLE UNION. THESE FLANGES MAY NOT BE USED IN SUPPORTING THE TUBE. ENTIRE WEIGHT IS TO BE HELD BY MAGNET BRACKETS.
- 15 — THESE SURFACES TO BE COPLANER WITHIN 0.032".
- 16 — WARNING: MAINTAIN 8 INCHES MIN. CLEARANCE BETWEEN MAGNETS AND FERROMAGNETIC MATERIALS EXCEPT AT BRACKET ENDS WHERE MIN. CLEARANCE MAY BE 3 INCHES. MAINTAIN 12 INCHES MIN. CLEARANCE TO OTHER CHARGED MAGNETS.
- 17 — PROTECTIVE COVER FOR SHIPPING PURPOSES ONLY.
- 18 — PAINT WITH BLACK HEAT RESISTANT, NON CORROSIVE PAINT.
- 19 — PARTS ON THIS CENTERLINE MAY VARY FROM TRUE LOCATION BY 0.188".

NOTES —

- A — MINIMUM DISTANCE FROM HIGH VOLTAGE TO GROUND SHOULD BE 1.500" THROUGH OIL AND 10.000" THROUGH AIR AT ATMOSPHERIC PRESSURE.
- B — PLUGS INTO HANSEN 3-520 SOCKET.
- C — LEADS MUST BE LARGE ENOUGH TO CARRY AT LEAST 100 AMPERES RMS.
- D — USE "UNIVOLT 35" TRANSFORMER OIL OR EQUIVALENT FOR FLUID INSULATING MEDIUM.
- E — FERROMAGNETIC MATERIALS MUST NOT BE PERMITTED AT ANY TIME CLOSER THAN 8" FROM TUBE MAGNET EXCEPT AT ENDS TO WHICH MOUNTING BRACKETS ARE ATTACHED WHERE CLEARANCE MAY BE 3" MINIMUM. ENERGIZED MAGNETS MUST NOT BE PERMITTED AT ANY TIME CLOSER THAN 12" FROM TUBE MAGNET.

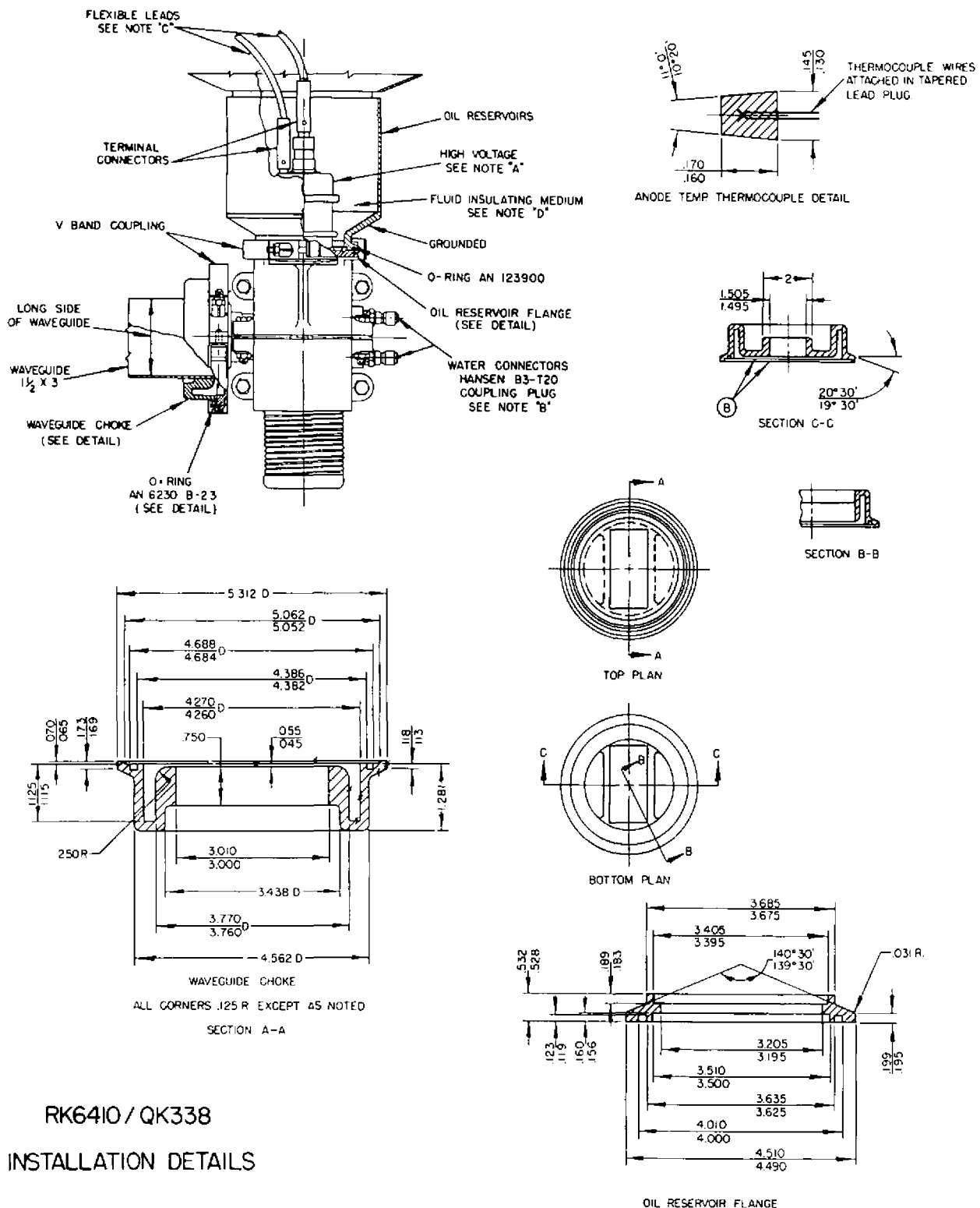
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