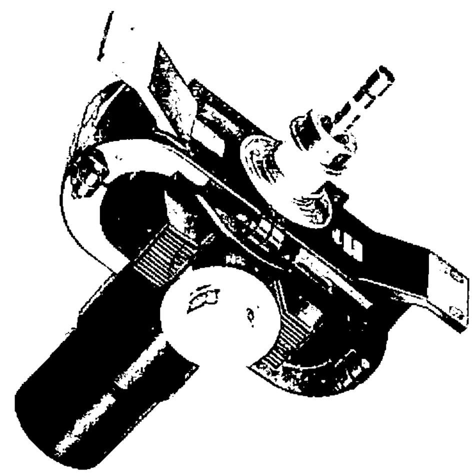
MAGNETRON OSCILLATOR

RAYTHEON

Excellence in Electronics

TYPE RK6517/QK358

The RK 6517/QK 358 magnetron is a mechanically tunable pulsed type oscillator with a nominal peak power output of 1.3 megawatts and capable of rapid hand or motor tuning to any desired frequency in the 1250 to 1350 megacycle region. It is an integral magnet type requiring forced air cooling and is designed for coupling to a standard 3″ x 6″ waveguide.



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 Government technical specification sheet.

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 RK 6517/QK 358 under conditions other than those recommended in this technical data sheet, the manufacturer should be consulted.

GENERAL CHARACTERISTICS

ELECTRICAL

Heater Characteristics

Heater current preheat	75 A
Heater voltage @ 75 A	2.6 — 3.0 V
Minimum preheat time	10 minutes
Cold heater resistance	.00752 ohms (approx.)

Maximum Ratings

Heater current	90 A
Peak anode voltage	70 Kv
Peak anode current	60 a
Average power input	4300 W
Peak power input	3.5 Mw
VSWR	1.5/1
Frequency pulling at VSWR — 1.5/1	5 Mc
Pulse duration	3.3 μsec
Duty Cycle	.0013
Voltage pulse rise time	.8 μsec
Anode temperature	100° C
Bushing temperature	150° C
Output pressurization	45 psia

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

Printed in U.S.A.

MICROWAVE AND POWER TUBE DIVISION

RAYTHEON COMPANY

FOUNDRY AVE., WALTHAM 54, MASS.

12-56

from JEDEC release #3478, Nov. 6, 1961

Typical Operation

Heater current-preheat	75 A ± 3.5%
Heater current-operate	75 A ± 3.5%
Pulse duration	3.0 μsec
Duty cycle	0.00125
Peak anode voltage	54 kv
Peak anode current	50 a
Average anode current	62.5 mAdc
Peak power output	1.3 Mw
Average power output	1630 W
Useful range of peak current	35 — 55 a
VSWR	1.1/1
Frequency region	1250 — 1350 Mc
RF Bandwidth	0.45 Mc (—6 db level)

MECHANICAL

Overall dimensions	22.2″ x 12.1″ x 18.4″
Net weight	90 lbs. (approx.)
Mounting	Cathode vertical
Output coupling	Round Flange, 4½″ diameter
Output pressure	15 psia (normally)
Cooling	Forced air
Cathode bushing	Immersed in oil
Vibration (non-operating)	25 cps @ 2.5 G
Magnet protection	12″

DETAILED ELECTRICAL INFORMATION

HEATER

The cathode must be preheated at 75 amperes for a period of at least ten minutes prior to the application of pulse 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 ± 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.

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

Operation at preheat or standby without forced air cooling may damage the tube and cannot be tolerated.

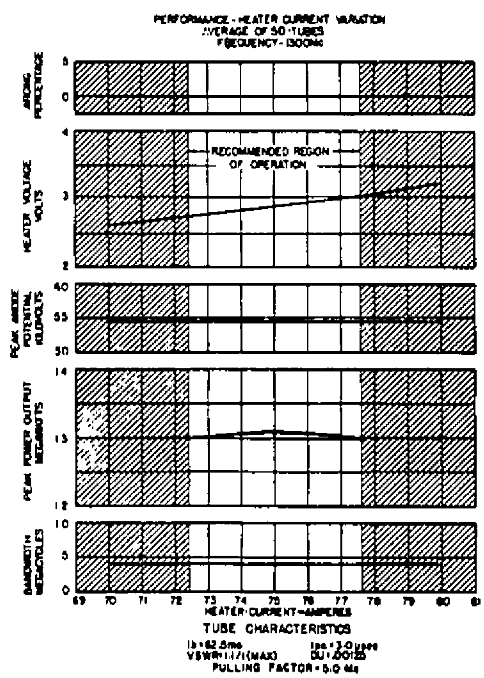


FIG. 1

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 succeedingly 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 skill of the operator.

NOTE: In equipments employing a reverse current and high voltage run down 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 1 second duration after aging.

PULSE LENGTH AND DUTY CYCLE

The RK 6517/QK 358 magnetron has been designed and tested for operation at the following pulse conditions: (See figure 2)

tpc = 3.0 μsec (measured at 50%)
trc = 0.25 μsec (measured 20 to 85%)
tfc = 1.5 μsec (measured 0 to 85%)
trv = 0.70 μsec (measured 20 to 85%)
tfv = 3.0 μsec (measured 0 to 85%)

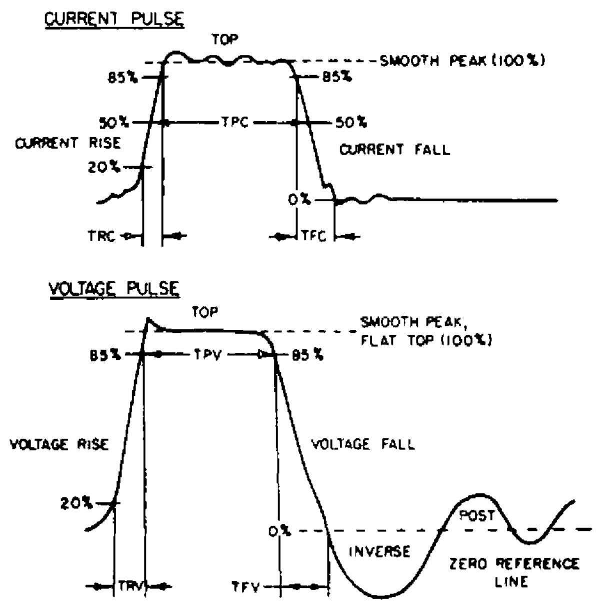


Figure 2

No spike or ripple should exceed ± 5% of the average peak value of voltage or current. Inverse voltage should not exceed 12% of the forward voltage. Post voltages should be held to a minimum as they may cause post-pulse noise or oscillation.

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 less than 0.6 μsec 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 specified, and at a given duty cycle the calculated peak current will be in error.

It is therefore advisable that the equipment design effect as rapid a decay time as possible. Inverse and post-pulse voltages may result in undesirable noise radiation and should be damped. Judicious matching of the pulse forming network and the 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.

LOAD AND LINE LENGTH CONSIDERATIONS

If an oscillator is loaded by an electrically long transmission line which is terminated by an impedance differing 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 electrically long transmission lines, 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 the oscillator, as well as the degree of mismatch.

Figure 3 shows the relation between the VSWR and the line length with respect to the critical condition at which frequency skipping will occur. The frequency skips will be noticed as the tube is mechanically tuned. It may also prove troublesome as the frequency changes due to thermal drift with breaks appearing in the ordinarily smooth drift curve. Even more serious consequences of "long line effect" may be the broadening deterioration of spectra. In some cases spectra of two frequencies may appear simultaneously. Operation into loads specified in the recommended region of figure 3 should eliminate the above difficulties, although the VSWR of the load should be kept as low as possible if minimum bandwidth is important.

More detailed information on "long line effects" is available upon request.

RK-6517/QK358
LOAD AND LINE LENGTH
CONSIDERATIONS

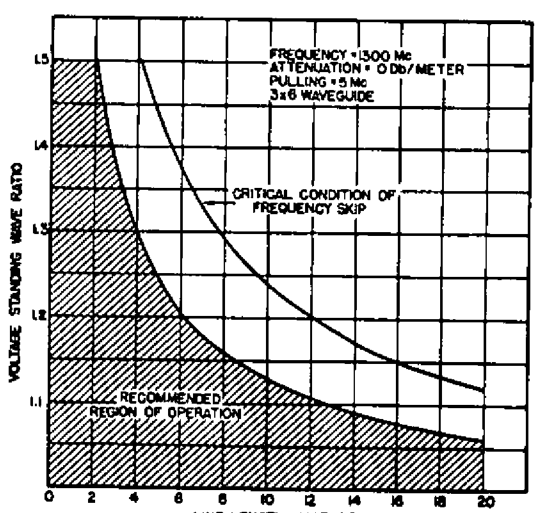
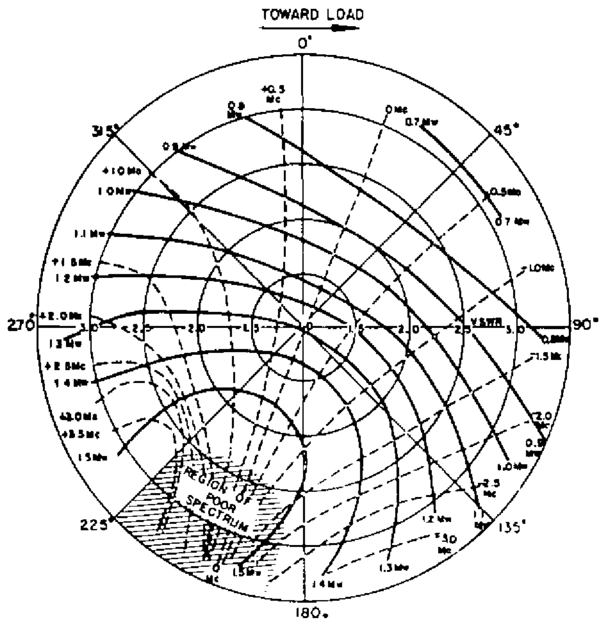


FIG. 3

LOAD DIAGRAMS

Figures 4, 5, and 6 are load diagrams of a typical RK 6517/QK 358 operating at frequencies of 1250, 1300, and 1350 megacycles. The contours of constant power output and frequency change are related to the voltage standing wave ratios introduced by mismatched loads at various phase positions. Values of VSWRs as high as 3.0/1 are plotted but operation at ratios greater than 1.5/1 is not recommended.

RK 6517/QK358 RIEKE DIAGRAM



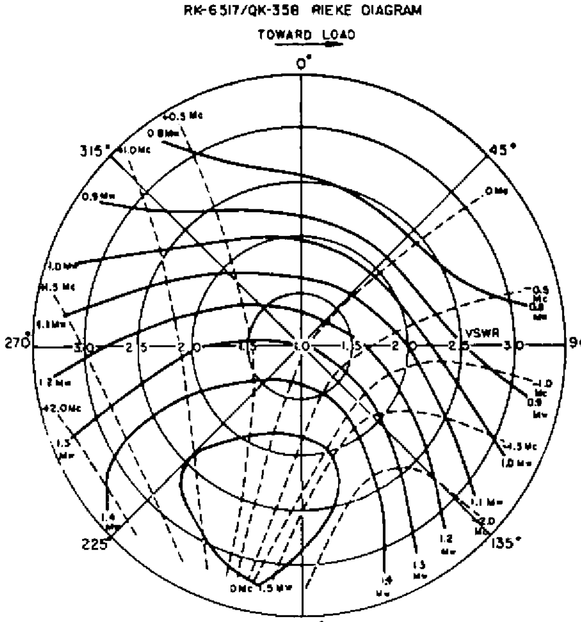
tpc - 3.2
prf - 391
DU - .00125
Ib - 62.5 mAdC
ib - 50a

FREQUENCY 1250Mc

——— POWER
-------- FREQ

FIG. 4

RK-6517/QK-358 RIEKE DIAGRAM



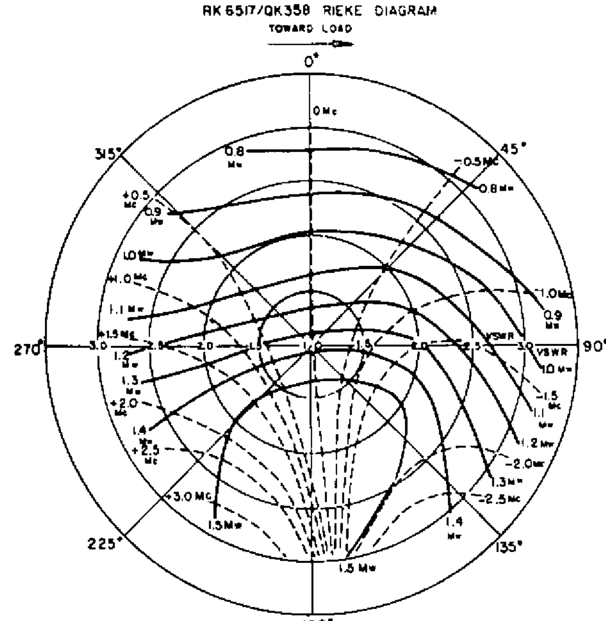
tpc-3.2
Prf-391
DU-.00125
Ib - 62.5 mAdC
ib -50a

FREQUENCY 1300Mc

——— POWER
-------- FREQ.

FIG. 5

RK 6517/QK358 RIEKE DIAGRAM



tpc - 3.2
prf - 391
DU - .00125
Ib - 62.5mAdc
ib - 50a

FREQUENCY 1350Mc

——— POWER
- - - - FREQ.

FIG. 6

FREQUENCY CHARACTERISTICS

The manner in which anode voltage and power output vary with frequency is revealed in Figure 7.

RK 6517/QK358 FREQUENCY CHARACTERISTICS

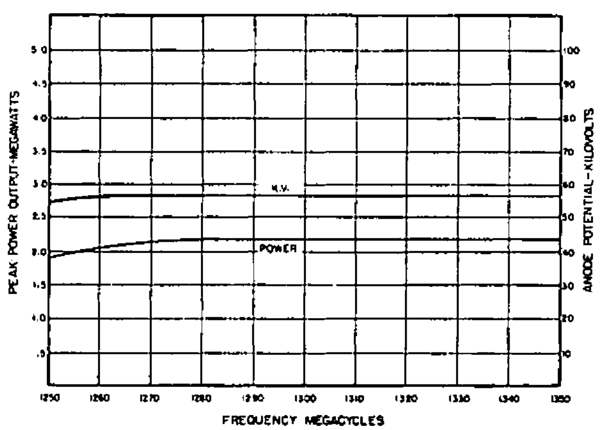


FIG. 7

FREQUENCY DRIFT

After operation of the RK 6517/QK 358 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 is plotted as a function of time in Figure 8. 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. Because of cavity dimensions and the mass of metal involved in a magnetron at these low frequencies, thermal equilibrium from a cold start will naturally take considerable time.

RK-6517/QK358 FREQUENCY DRIFT CHARACTERISTICS

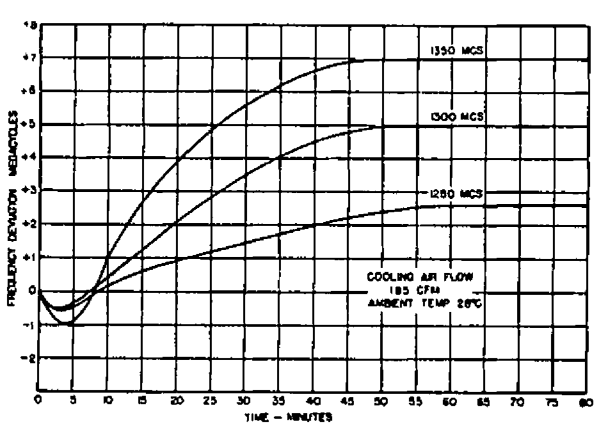
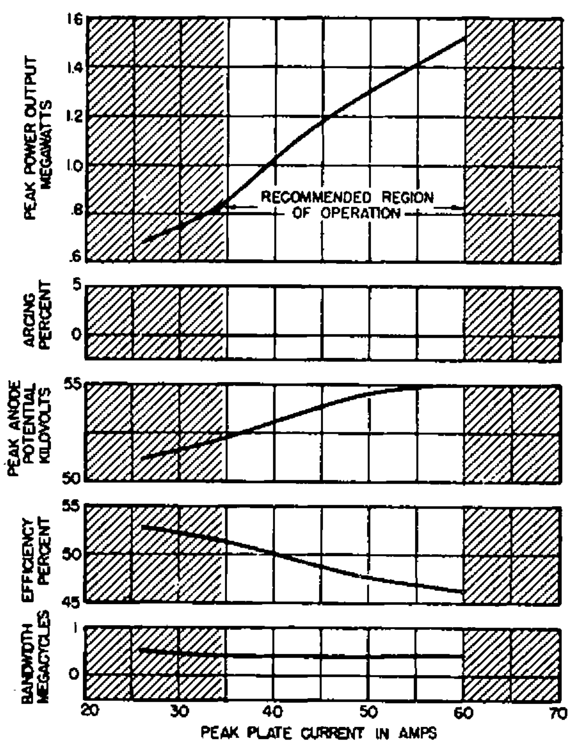


FIG. 8

OPERATING CHARACTERISTICS

Figure 9 is a plot of efficiency, arc stability, bandwidth, anode voltage, and peak power output as a function of peak anode current.

RK-6517/QK358
PERFORMANCE - PLATE CURRENT VARIATION
AVERAGE OF 50 TUBES
FREQUENCY - 1300Mc



TUBE CHARACTERISTICS
If = 80A
PULL = 5Mc
tpc = 3.0 sec
Du = .00125
VSWR = 1.1/1 (MAX)

FIG. 9

RF RADIATION FROM CATHODE

The RK 6517/QK 358 magnetron 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 particuarly critical environments, shielding of the cathode bushing may be necessary to avoid radiation difficulties.

INSTALLATION & 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 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.
7. Do not place the tube in closer proximity to magnetic materials than indicated on the tube magnet.

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 high voltage cathode bushing vertical. The tube should be operated in this position although small angular deviations (± 15°) 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 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.

COUPLING AND PRESSURIZATION

The magnetron output flange is designed to couple to standard 3" x 6" waveguide. Mechanical details of the recommended flange to mate to the magnetron are illustrated in the outline drawing. See figure 12

Waveguide pressurization is not required at altitudes up to 10,000 feet. 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.

COOLING

The RK 6517/QK 358 magnetron is a forced air cooled tube. The ambient temperature will dictate the flow rate necessary to maintain anode temperature below the specified maximum (100° C). Figure 10 is a plot of anode temperature rise above ambient as a function of cooling fin air flow and anode power dissipation. It is also a plot of back pressure as a function of rate of air flow. (c.f.m.)

Sufficient cooling of the cathode insulating oil must 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.

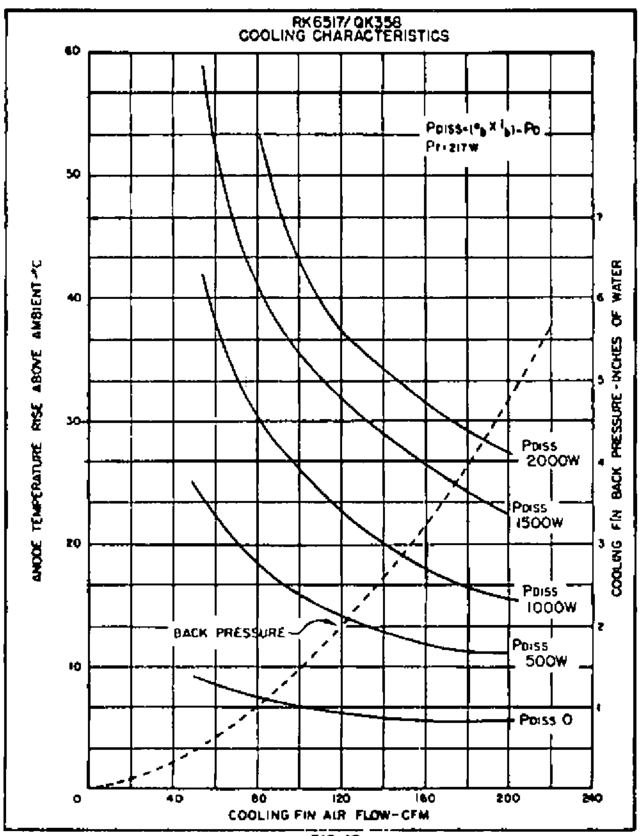


FIG. 10

CATHODE BUSHING PROTECTION

It is recommended that the RK 6517/QK 358 ceramic cathode bushing be immersed in a fluid insulating medium of "Univolt 35" transformer oil or equivalent. A minimum distance of 1½" 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.

In cases where it is necessary to mount the RK 6517/QK 358 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.

DYNAMIC PUSHING

Dynamic pushing is the change in frequency with a given change of anode peak current. With a peak current variation between 45 amperes and 55 amperes, RK6517/QK358 pushing has been found to be less than 26 KC/ampere.

TUNER CHARACTERISTICS

Approximately 34 turns of the tuner spline at an applied torque of 70 inch-ounces are required to tune the tube through its frequency range.

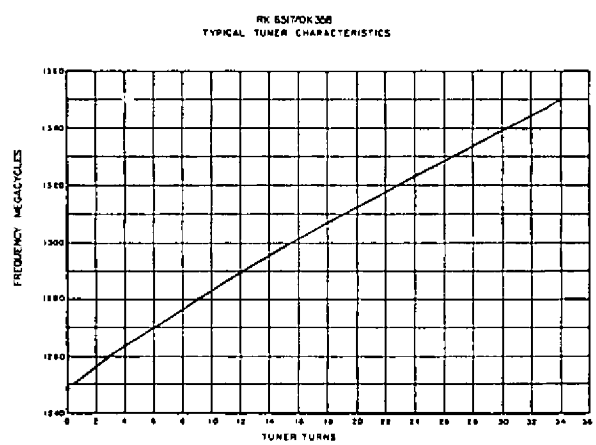
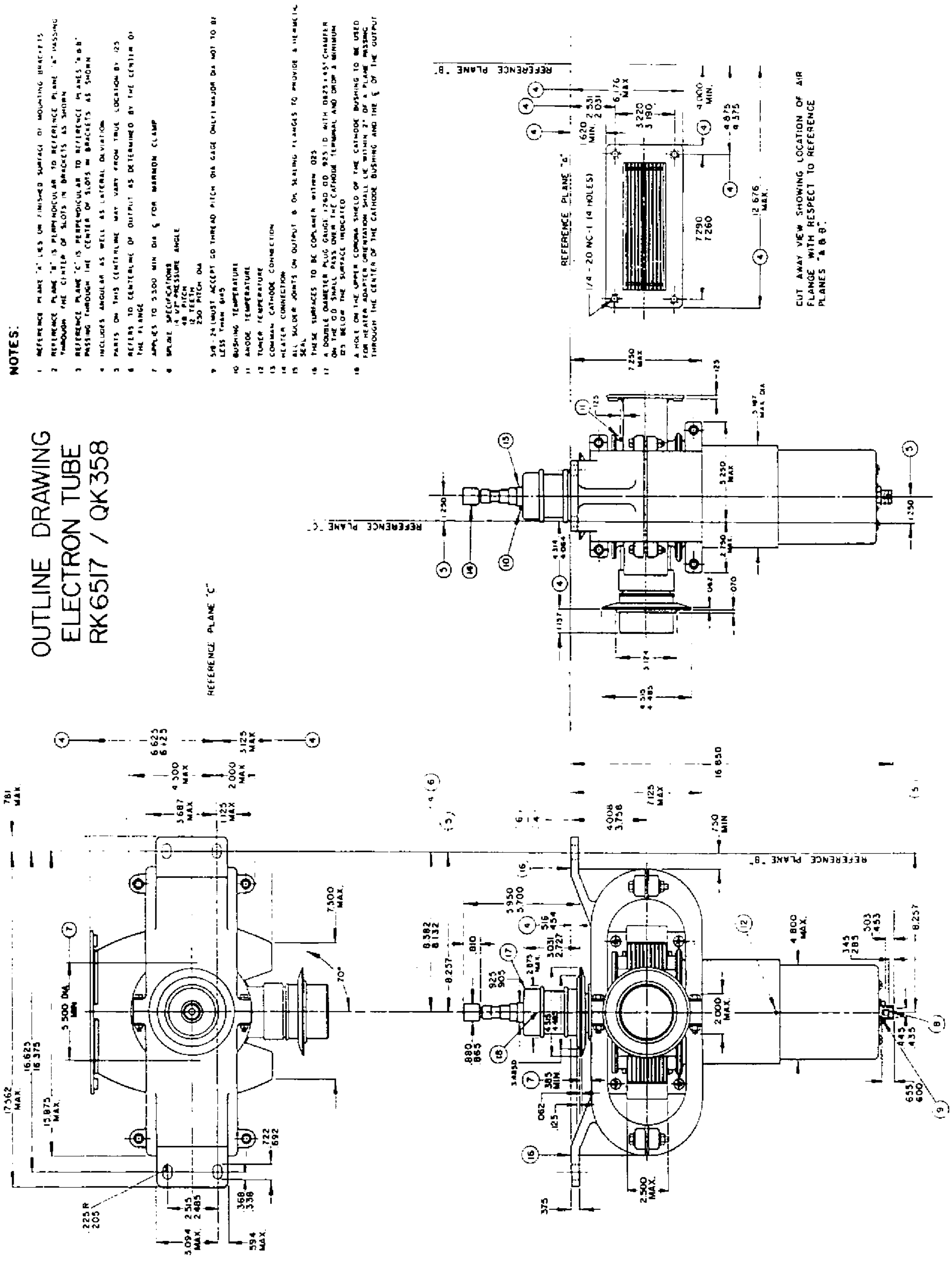
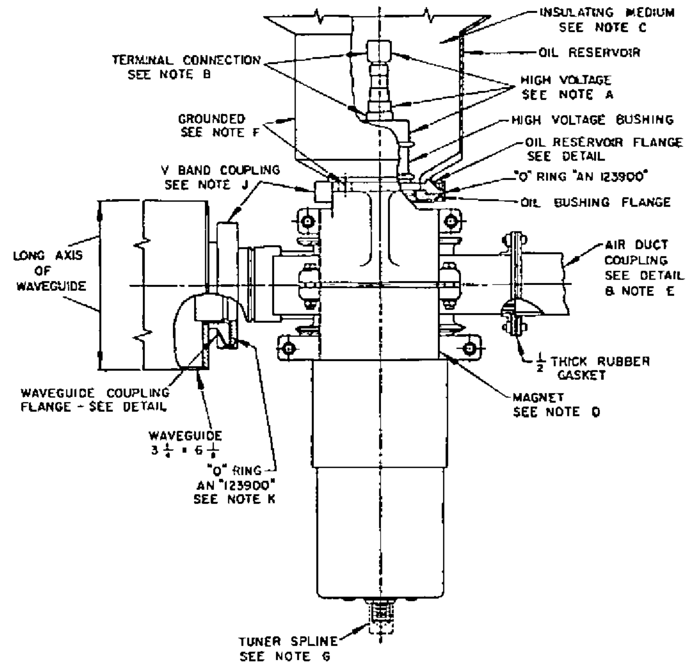
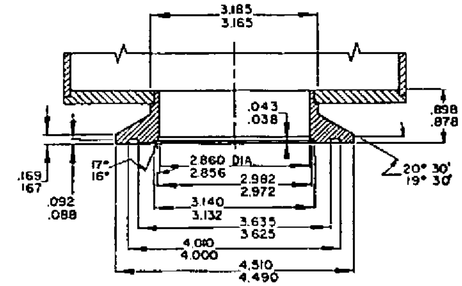


FIG. 11

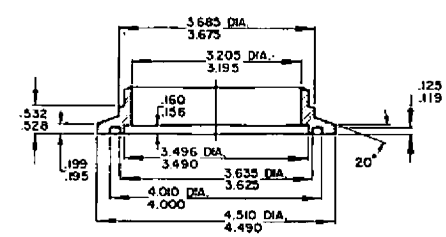

OUTLINE DRAWING
ELECTRON TUBE
RK6517 / QK358
NOTES:
REFERENCE PLANE "B"
REFERENCE PLANE "C"
REFERENCE PLANE "A"
1/4-20 NC-1 (4 HOLES)
CUT AWAY VIEW SHOWING LOCATION OF AIR FLANGE WITH RESPECT TO REFERENCE PLANES "A & B".

RK6517 / QK358
ELECTRON TUBE INSTALLATION DETAILS

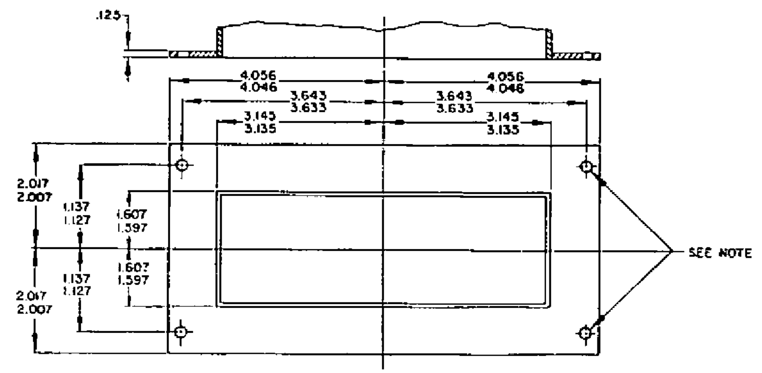




WAVEGUIDE COUPLING FLANGE



OIL RESERVOIR FLANGE



AIR DUCT COUPLING FLANGE

NOTES:

A. MINIMUM DISTANCE FROM HIGH VOLTAGE TO GROUND SHOULD BE 1.500 THROUGH FLUID INSULATING MEDIUM AS SPECIFIED IN NOTES "C" AND 10,000 THROUGH AIR AT ATMOSPHERIC PRESSURE.

B. HEATER TERMINAL CONNECTORS MUST BE LARGE ENOUGH TO CARRY AT LEAST 150 AMPERES RMS.

C. THIS SPACE TO BE FILLED WITH FLUID HAVING INSULATING PROPERTIES AT LEAST EQUIVALENT TO UNIVOLT 35 (ESSO ST'D OIL CO.)

D. MAGNET, FERROMAGNETIC MATERIALS, MUST NOT BE PERMITTED AT ANY TIME CLOSER THAN 8" FROM MAGNET EXCEPT AT THE ENDS WHERE THE CLEARENCE MAY BE 3". ENERGIZED MAGNETS MUST NOT BE PERMITTED AT ANY TIME CLOSER THAN 12" FROM TUBE MAGNET.

E. AIR DUCT COUPLING:
ANODE COOLING INLET FLANGE, DUCT WORK FOR SUPPLYING AIR TO TUBE COOLING SYSTEM MUST BE SUCH AS TO INSURE DELIVERY OF AIR TO ENTIRE CROSS SECTION PROVIDED FOR ADMITTANCE OF COOLANT.

F. ANODE MUST BE THOROUGHLY GROUNDED THROUGH MOUNTING BRACKETS, OUTPUT FLANGE OR HIGH VOLTAGE BUSHING FLANGE.

G. COUNTER CLOCKWISE ROTATION OF TUNER SPLINE INCREASES FREQUENCY.

H. 4 HOLES, CLEARANCE FOR 1/4 SCREW, SIZE OF HOLES AND FREEDOM OF FASTENING SCREWS MUST BE SUCH THAT DISTANCE BETWEEN CENTERLINES OF FASTENING SCREWS CAN DEVIATE ±.020 OUTSIDE LIMITS SHOWN FOR DISTANCE BETWEEN CENTERLINES OF HOLES.

I. INSTALLATION WITH CATHODE TERMINALS AS SHOWN HERE IS FOR TEST PURPOSES ONLY. TUBE MOUNTING IS DESIGNED FOR INSTALLATION IN EQUIPMENT WITH CATHODE TERMINALS DOWN. USE OF BELLOWS IS RECOMMENDED TO ACCOMODATE DIMENSIONAL VARIATIONS BETWEEN PLANE OF MOUTING BRACKETS AND PLANE OF OIL, RESERVOIR FLANGE PROVISIONS MUST BE MADE FOR DISSIPATING HEAT INTRODUCED IN OIL THROUGH CATHODE TERMINALS.

J. V BAND COUPLING MARMON PRODUCT CO. INC. PART # 4369-462 WITH ST. ST. BOLT & NUT OR EQUIVELENT.

K. "O" RING AN123900 AVAILABLE FROM PARKER APPLIANCE CO. PART # AMS 7274.