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RAYTHEON

TECHNICAL INFORMATION

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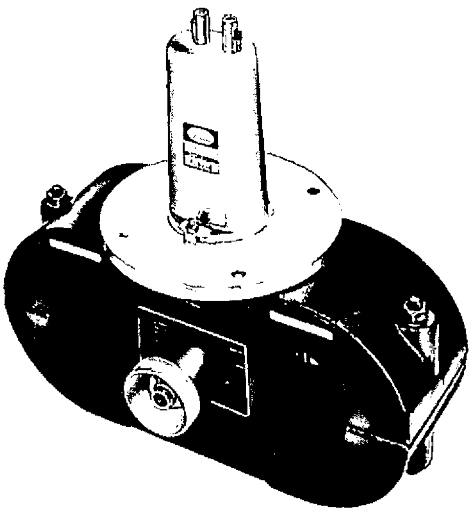
PULSED-TYPE MAGNETRON OSCILLATOR

# TYPE RK6518/QK254

The RK6518/QK254 is a fixed frequency pulsed-type oscillator operating in the frequency region of 2860 to 2900 megacycles with a nominal peak power output of 2 megawatts. It is an integral magnet coaxial output type tube requiring forced air cooling and designed for coupling to standard 1⅝", 50 ohm, coaxial line.



## 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 RK6518/QK254 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

| | |
|---|---|
| Heater Voltage Preheat | 13.0 V ±4.5% |
| Heater Current @ 13 V | 36 — 44 A |
| Minimum Preheat Time | 3 minutes |

#### Maximum Ratings

| | |
|---|---|
| Heater Voltage | 13.6 V |
| Peak Anode Voltage | 48 kv |
| Peak Anode Current | 92 a |
| Average Power Input | 3000 W |
| Pulse Duration | 2.2 μsec |
| Voltage Pulse Rise Time | 0.3 μsec |
| Duty Cycle | .0007 |
| VSWR | 1.5/1 |
| Pulling @ VSWR = 1.5/1 | 16 Mc |
| Anode Temperature | 100° C |
| Input Bushing Pressure | 45 psia |
| Output Pressurization | 45 psia |

The values specified above must not be exceeded under any service condition. The ratings are limiting value 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.

## Typical Operation

| | |
|---|---|
| Heater Voltage Operate | 13.0 V ±4.5% |
| Pulse Duration | 2.0 μsec ±10% |
| Duty Cycle | 0.0006 |
| Peak Anode Voltage | 41 kv |
| Peak Anode Current | 87.5 a |
| Average Anode Current | 52.5 mAdc |
| Peak Power Output | 2.1 Mw |
| Average Power Output | 1260 W |
| Useful Range of Peak Current | 65 — 92 a |
| VSWR | 1.1/1 |
| Frequency Region | 2860 — 2900 Mc |
| RF Bandwidth | 0.7 Mc (@ —6db level) |

## MECHANICAL

| | |
|---|---|
| Over-all Dimensions | 16.4" x 8.5" x 16.3" |
| Net Weight | 82 lbs. |
| Mounting | Cathode Vertical |
| Output Coupling | 1⅝" coax |
| Output Pressure | 35 psia |
| Cooling | Forced Air |
| Cathode Bushing | Pressurized |
| Vibration (nonoperating) | 50 cycles @ 10 G |
| Shock (nonoperating) | 15 G |
| Magnet Protection | 12" |

# DETAILED ELECTRICAL INFORMATION

## HEATER

The cathode must be preheated at Ef = 13.0 V ±4.5% for a period of at least 3 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 voltage within the ±4.5% tolerance. Heater current surges in excess of 200 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 Fig. 1 for heater characteristics.

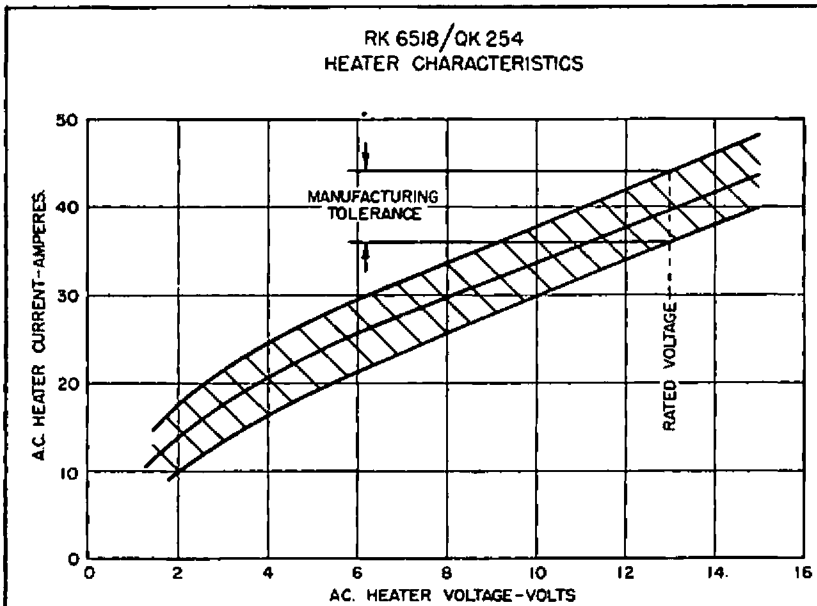



Figure 1

## STARTING NEW MAGNETRON

In starting a new magnetron or one that has not been operated for some time, sparking and some instability may occur. Sporadic arcing will not harm the magnetron, but if the tube tends to arc continuously, the following seasoning procedure is recommended:

1. Preheat magnetron for 15 minutes.
2. Gradually raise the magnetron current to a level just below that which produces continuous arcing. Allow the magnetron current to remain at this level for a few minutes until the arcing begins to decrease.
3. Repeat the above process for succeedingly higher levels of magnetron current until the desired operating point is reached.

It is usually possible to attain the desired operating point within 15 minutes.

NOTE:—Once a tube has been aged in at the specified operating level, it is recommended that the tube be operated throughout its life as close to this level as is feasible. Operation at plate currents lower than the aged in level results in the cathode conditioning itself to this new lower level, and attempts to resume operation at the specified level may be attended by excessive arcing and require the aging process to be repeated.

## PULSE LENGTH AND DUTY CYCLE

The RK6518/QK254 magnetron has been designed and tested for operation at the following pulse conditions: See Fig. 2.

tpc = 2.0 ±10% μsec @ DU = .0006

trc = 0.25 μsec max. measured 20% to 85%

tfc = 0.60 μsec max. measured 0% to 85%

trv = 0.15 — 0.30 μsec max. measured 20% to 85%

tfv = 2.5 μsec max. measured 0% to 85%

No spike or ripple shall exceed ±5% of the average peak value of voltage or current. Inverse voltage should not exceed 10% of the forward voltage. Post voltages should be held to a minimum as they may cause post pulse noise or oscillation.

Optimum tube performance will be realized only if proper consideration is given to pulse shaping. Voltage rise times greater than maximum 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 μsec, 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 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.

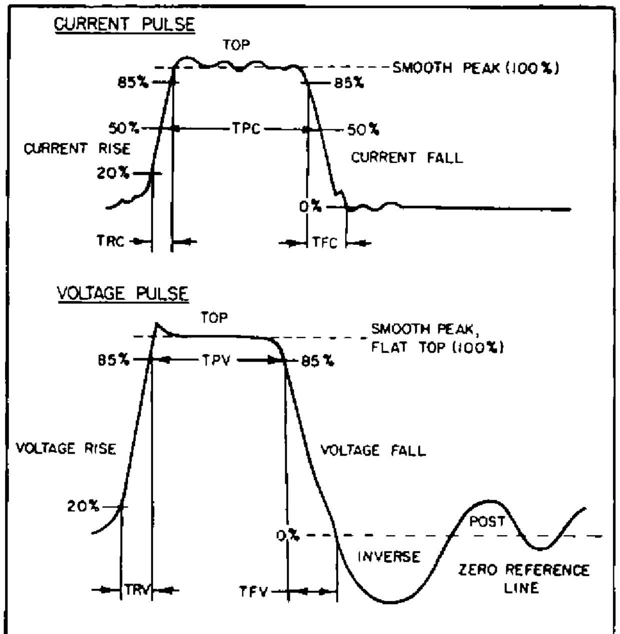



Figure 2

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. For operation at pulse conditions different than above, the manufacturer should be consulted.

## LOAD DIAGRAM

Fig. 3 is a load diagram for a typical RK6518/QK254 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 2.2/1 have been plotted, but operation at ratios greater than 1.5/1 is not recommended.

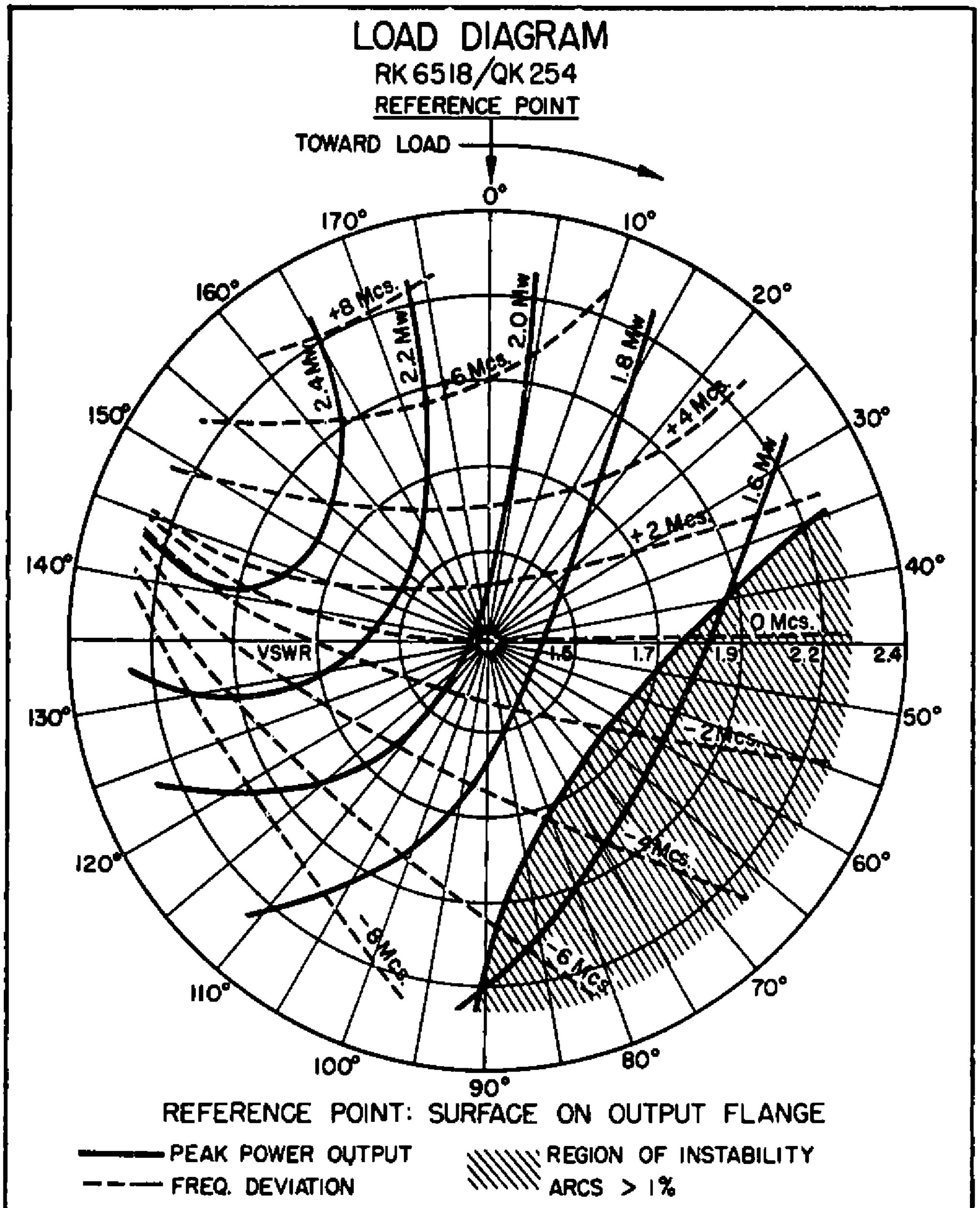



Figure 3

## COOLING

The RK6518/QK254 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). Fig. 4 is a plot of anode temperature rise above ambient as a function of total power input and rate of air flow. Fig. 5 is a plot of back pressure as a function of rate of air flow (Cfm).

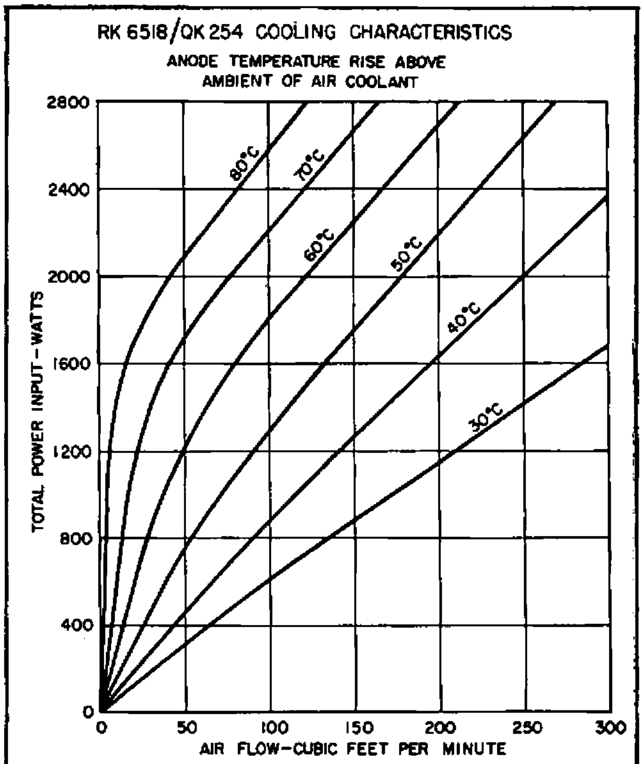



Figure 4

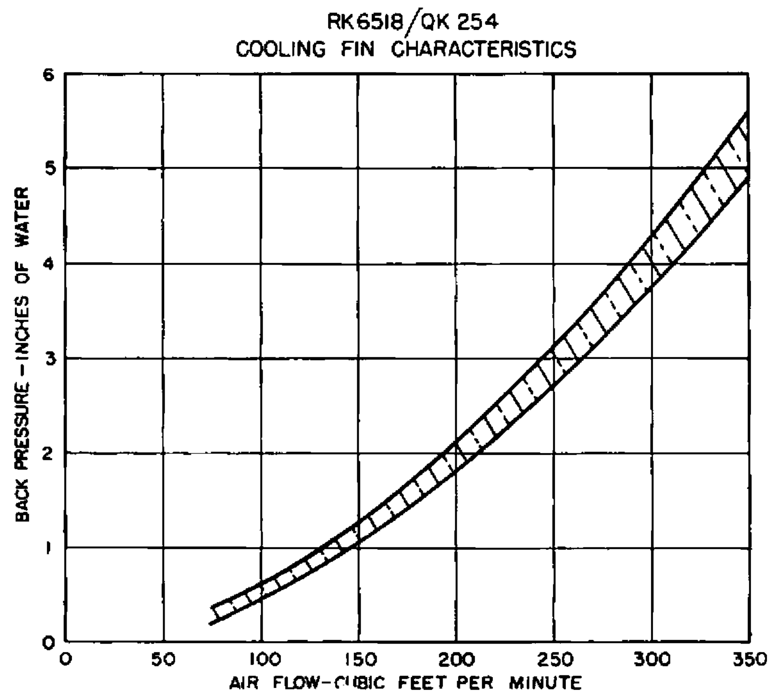



Figure 5

## 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. Fig. 6 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 RK6518/QK254 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 Fig. 6, 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 are available upon request.

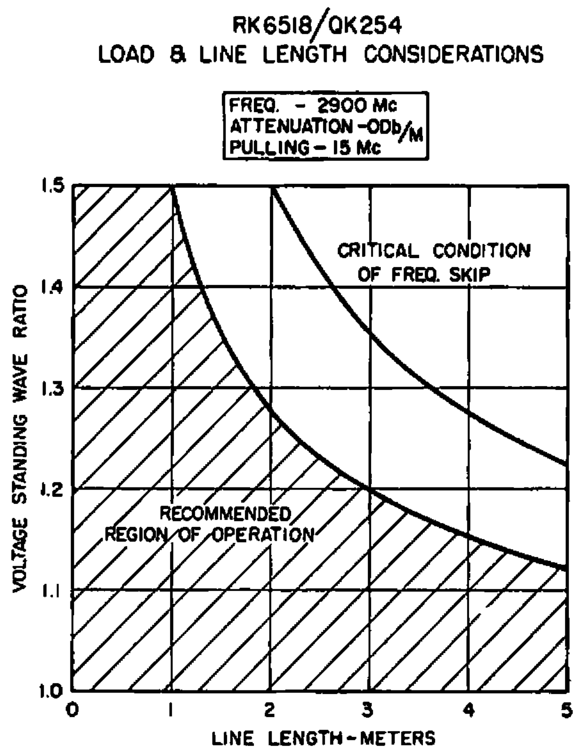



Figure 6

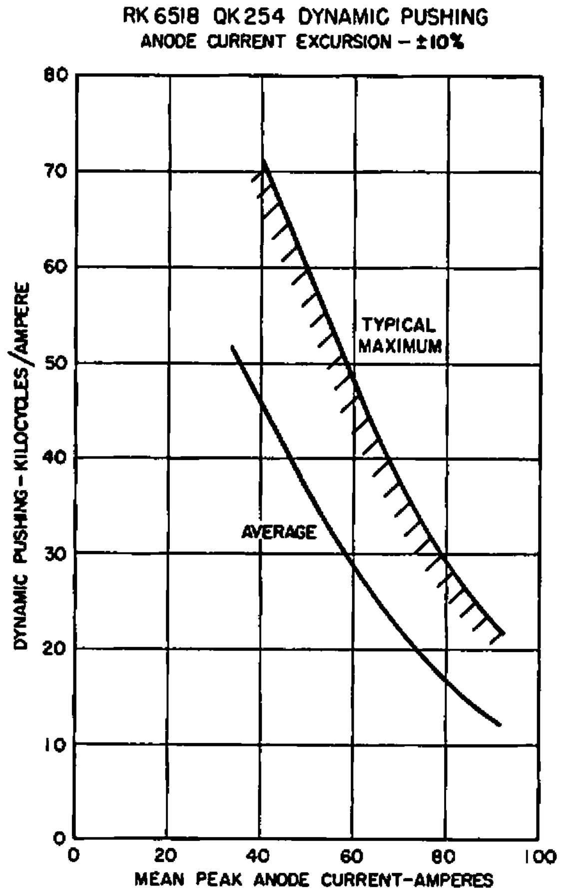



Figure 7

## FREQUENCY DRIFT

After operation of the RK6518/QK254 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.

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.

## DYNAMIC PUSHING

Fig. 7 displays the dynamic pushing characteristics of the RK6518/QK254 magnetron for anode current excursions of ±10%. Examination of the curve reveals that minimum pushing (Kc/a) occurs at rated plate current.

## RF RADIATION FROM CATHODE

The RK6518/QK254 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 particularly critical environments shielding of the cathode bushing may be necessary to avoid radiation difficulties.

## OPERATING CHARACTERISTICS

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

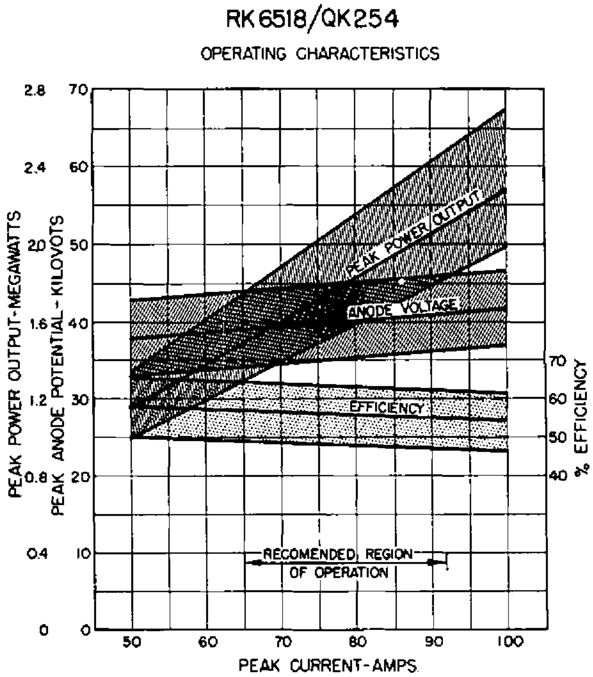



Figure 8

# INSTALLATION AND HANDLING PRECAUTIONS

Although magnetrons give the appearance of great structural strength, they are in reality quite fragile and may be easily 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 guard cover from the RF output pipe before installing tube in equipment.
3. Avoid setting up mechanical strains in R.F. output pipe 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. It is essential that the bullet be properly aligned in the receptacle to avoid setting up mechanical strains in the glass to metal seal of the coaxial center conductor of the R.F. output.
7. If a magnetron has been stored in a freezing environment, examine it closely for traces of frost or moisture on the RF output pipe or base tube insulator and wipe dry before application of high voltage.

8. Do not place tube in closer proximity to magnetic materials than is indicated on tube magnet.

## MOUNTING

The tube is mounted within the equipment by four bolts passed through the clearance holes of the circular mounting plate with the longitudinal axis of the cathode high voltage bushing vertical. 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.

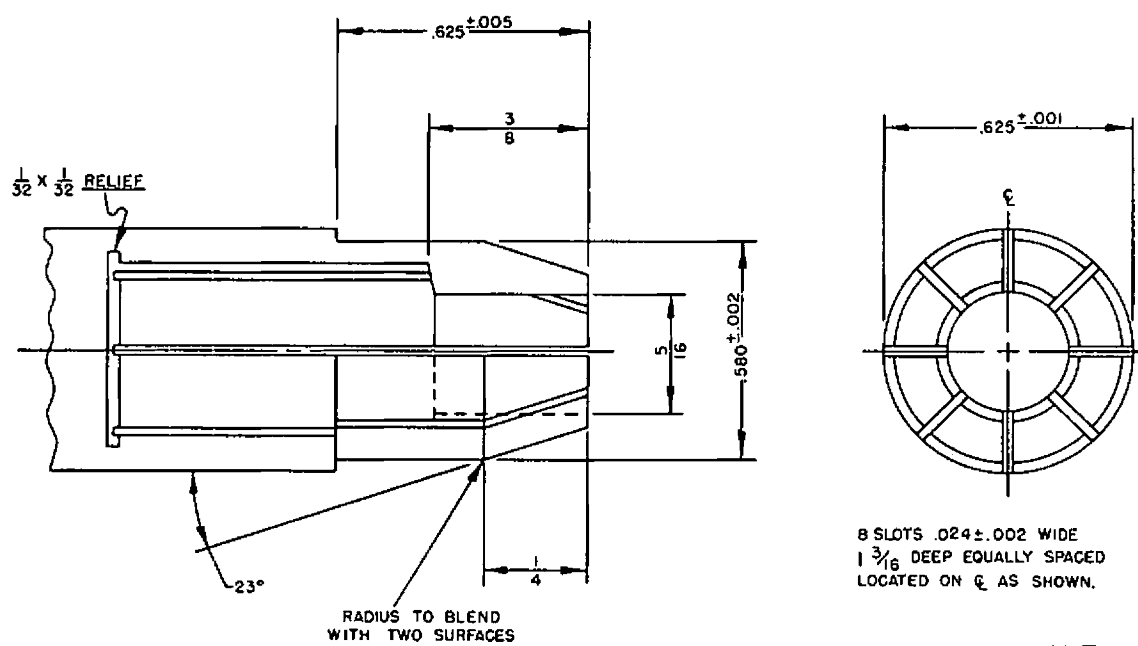
## ELECTRICAL CONNECTIONS

The positive high voltage should be grounded at the mounting surfaces. Heater and cathode connections are made to the terminals on the base tube insulator (see note 17 of tube outline drawing). Heater connectors should be designed to minimize contact resistance and lateral forces on the heater terminals.

CAUTION: R.F. arcing and melting of the metal to kovar seal of the center conductor of the coaxial output will result, if the bullet connector does not make positive contact and is not properly seated.

## COUPLING AND PRESSURIZATION

The output pipe is designed for coupling to standard 1⅝", 50 ohm coaxial line. A coaxial to standard 1½" x 3" waveguide transition may be effected by use of a suitable doorknob coupler. Pressurization of the RF transmission system to 35 psia is required. Pressurization lower than 35 psia may result in arcing in the system. If sustained arcing in the coaxial output section occurs, failure of the metal to kovar seal of the coaxial center conductor is likely. To minimize the possibility of arcing in the RF transmission system and to achieve optimum tube performance, the VSWR should be kept as low as possible; VSWR values greater than 1.5/1 are not recommended. See outline dwg. for mechanical details of RF output coupling.




MATING BULLET DETAIL OUTLINE DRAWING

NOTES:

1 - REF. PLANE "A" IS DEFINED AS A PLANE PASSING ALONG THE FACE OF THE MOUNTING PLATE.

2 - REF. PLANE "B" IS DEFINED AS A PLANE PERPENDICULAR TO PLANE "A" PASSING THRU THE CENTER OF HOLES AS SHOWN.

3 - REF. PLANE "C" IS DEFINED AS A PLANE MUTUALLY PEPENDICULAR TO PLANE "A" & "B" PASSING THRU THE CENTER OF HOLES AS SHOWN.

4 - THIS DIM. INCLUDES ANGULAR AS WELL AS LATERAL DEVIATIONS.

6 - REFERS TO THE CENTER LINE OF THE GUARD PIPE.

7 - THE CENTER LINE OF THE JACK HOLES SHALL BE WITHIN A RADIUS OF .100 OF LOCATION SPECIFEID BUT SHALL BE SPACED 1.054 $\pm$.015 WITH RESPECT TO EACH OTHER.

8 - BANANA PIN JACK .281 $\pm$.005 HOLE DIA. 25/32 MIN. DEEP.

9 - THIS SURFACE TO BE FLAT WITHIN .015.

10 - LEADS SHALL BE FLEXIBLE AND SLACK.

11 - PYREX GLASS OR EQUIVALENT.

12 - NO SHARP EDGES ON OUTSIDE DIA. AT END OF INNER CONDUCTOR.

13 - APPLIES TO STRAIGHT PORTION OF INNER CONDUCTOR WALL.

14 - APPLIES TO INNER CONDUCTOR INSERT ONLY ℄ OF INNER CONDUCTOR INSERT SHALL BE CONCENTRIC WITH ℄ OF GUARD PIPE TO WITHIN .025.

15 - ℄ OF MAX. DIA. SHALL BE CONCENTRIC WITH ℄ OF GUARD PIPE TO WITHIN .040.

17 - COMMON CATHODE CONNECTION MARKED WITH LETTER C.

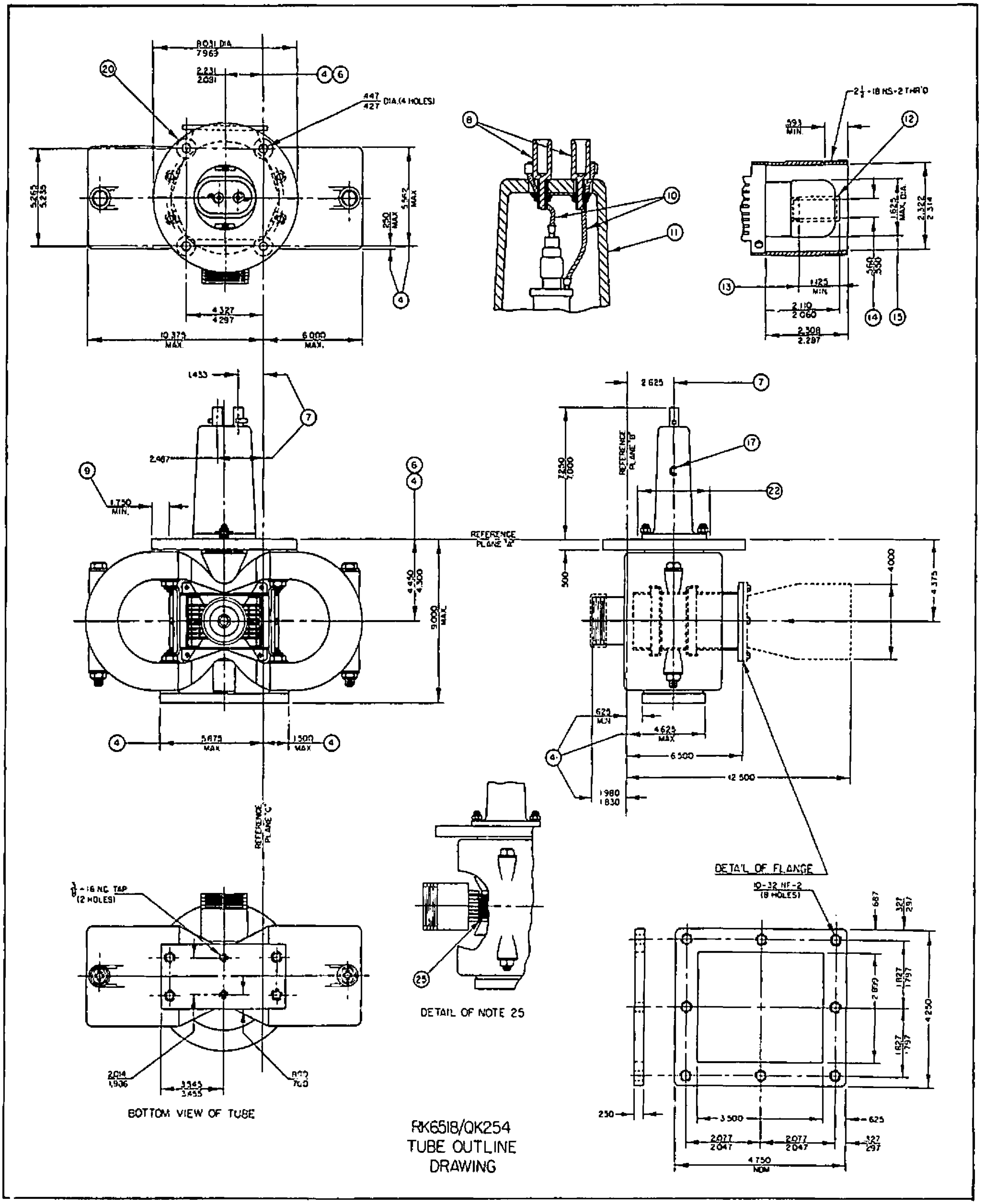
18 - ALL SOLDER JOINTS ON MOUNTING PLATE & GUARD PIPE SHALL BE SOLDERED TO PROVIDE AN HERMETIC SEAL.

19 - PAINT WITH BLACK HEAT-RESISTANT NON-CORROSIVE PAINT. THE FOLLOWING SHALL BE FREE FROM PAINT, TOP SURFACE OF MOUNTING PLATE, PARTS ABOVE MOUNTING PLATE SCREW THR'DS ON GUARD PIPE & ALL SURFACES INSIDE GUARD PIPE, BOTTOM SURFACE OF MAGNET PLATE, & EDGE OF MOUNTING PLATE.

20 - MIN. CLEARANCE BETWEEN AXIS OF PLATE HOLES & SURFACE OF MAGNET TO BE .563.

22 - ANY PORTION OF THE ASSEMBLY EXTENDING ABOVE THIS SURFACE SHALL BE WITHIN 2.125 RADIUS OF THE TRUE CENTER OF THE PLATE.

24 - FERROMAGNETIC MATERIALS SHALL NOT BE BROUGHT WITHIN 12 INCHES OF TUBE MAGNETS.


BOTTOM VIEW OF TUBE
DETAIL OF NOTE 25
DETAIL OF FLANGE
REFERENCE PLANE "A"
REFERENCE PLANE "B"
REFERENCE PLANE "C"
RK6518/QK254
TUBE OUTLINE
DRAWING