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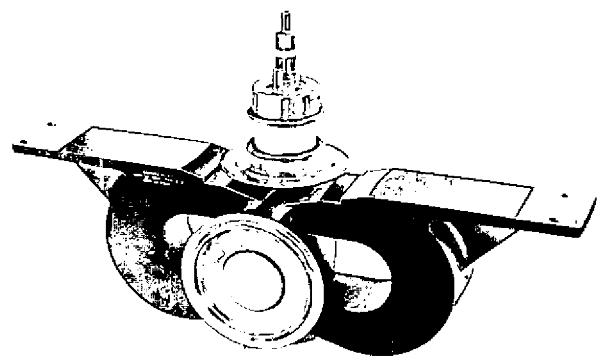
TECHNICAL INFORMATION

Excellence in Electronics

PULSED-TYPE MAGNETRON OSCILLATOR

TYPE RK6406/ QK428

The RK6406/QK428 magnetron is a fixed frequency pulsed type oscillator operating in the frequency region of 2850 to 2910 megacycles with a nominal peak power output of 2 megawatts. It is an integral magnet, waveguide output type tube requiring forced liquid cooling and is designed for coupling to standard 1.5" x 3" 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 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 RK6406/QK428 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	56 kv
Peak Anode Current	95 a
Average Power Input	3200 W
Pulse Duration	2.2 usec
Voltage Pulse Rise Time	0.6 usec
Duty Cycle	0.0006
VSWR	1.5/1
Pulling @ VSWR = 1.5/1	10 Mc
Anode Temperature	100° C
Bushing Temperature	150° C
Output Pressurization	55 psia
Coolant Pressure	55 psia

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.

Typical Operation

Heater Current-Operate	85 A
Pulse Duration	2.0 usec ± 10%
Duty Cycle	0.0006
Peak Anode Voltage	52 kv
Peak Anode Current	85 A
Average Anode Current	51 mAdc
Peak Power Output	2 Mw
Average Power Output	1200 W
Useful Range of Peak Current	75 — 95 A
VSWR	1.1/1
Frequency Region	2850 — 2910 Mc
RF Bandwidth	0.7 Mc (@ -6db level)

MECHANICAL

Over-all Dimensions	21.5" x 7.5" x 16"
Net Weight	40 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
Shock (nonoperating)	15 G
Magnet Protection	12"

DETAILED ELECTRICAL INFORMATION

HEATER

The cathode must be preheated at $I_f = 85A \pm 3.5\%$ 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 current within the ± 3.5% tolerance. Heater current surges in excess of 100 amps cannot be tolerated. Operation of the tube at standby or preheat without forced liquid cooling may result in damage to the tube and is not permissible. See Fig. 1 for heater characteristics.

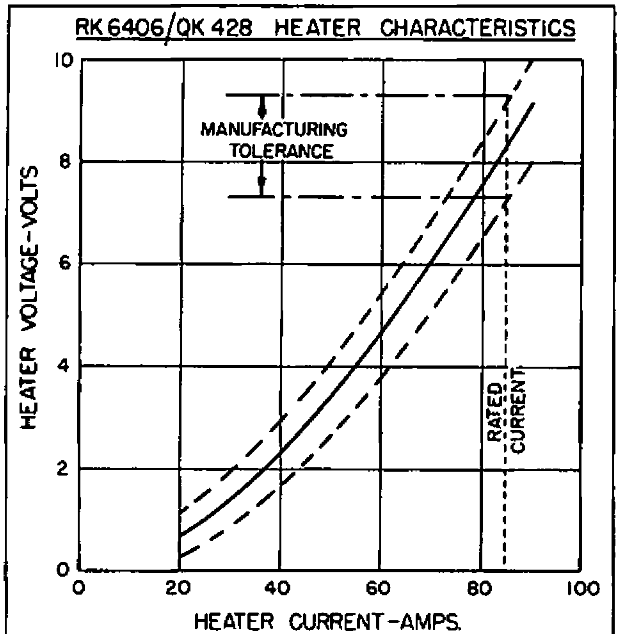


FIG. 1

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.

PULSE LENGTH AND DUTY CYCLE

The RK6406/QK428 magnetron has been designed and tested for operation at the following pulse conditions: See Fig. 2.

tpc = 2.0 ± 10% usec @ DU = .0006
trc = 0.2 usec max. measured 20% to 85%
tfc = 0.5 usec max. measured 0% to 85%
trv = 0.6 usec max. measured 20% to 85%
tfv = 2.5 usec max. measured 0% to 85%

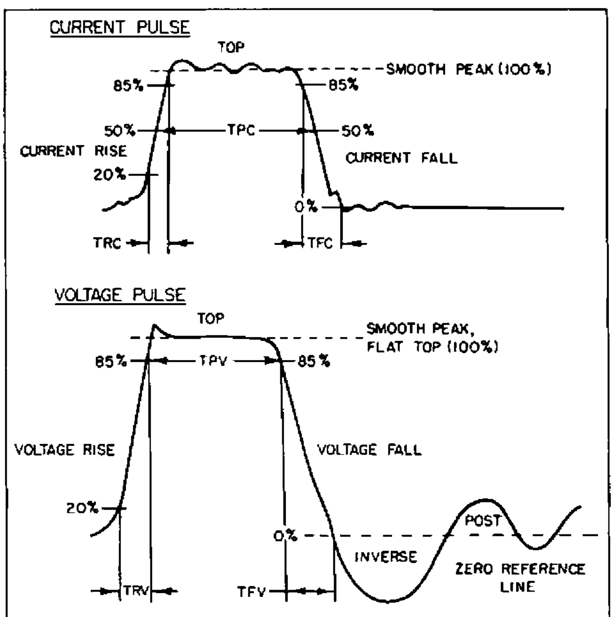


FIG. 2

No spike or ripple shall exceed ± 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.

Short pulse operation is currently under investigation and the preliminary results indicate that operation at the following pulse widths and duty cycles is feasible:

tpc — 0.6 usec @ Du = 0.0002
tpc — 0.6 usec @ Du = 0.0006

If operation at either of these short pulse conditions 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 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 usec, 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.

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 DIAGRAM

Fig. 3 is a load diagram for a typical RK6406/-QK428 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 2.5/1 have been plotted, but operation at ratios greater than 1.5/1 is not recommended. The RK6406/QK428 is capable of operation at a VSWR of 1.5/1 phased opposite the sink with virtually no arcing, and therefore readily lends itself for operation in systems requiring extremely stable performance.

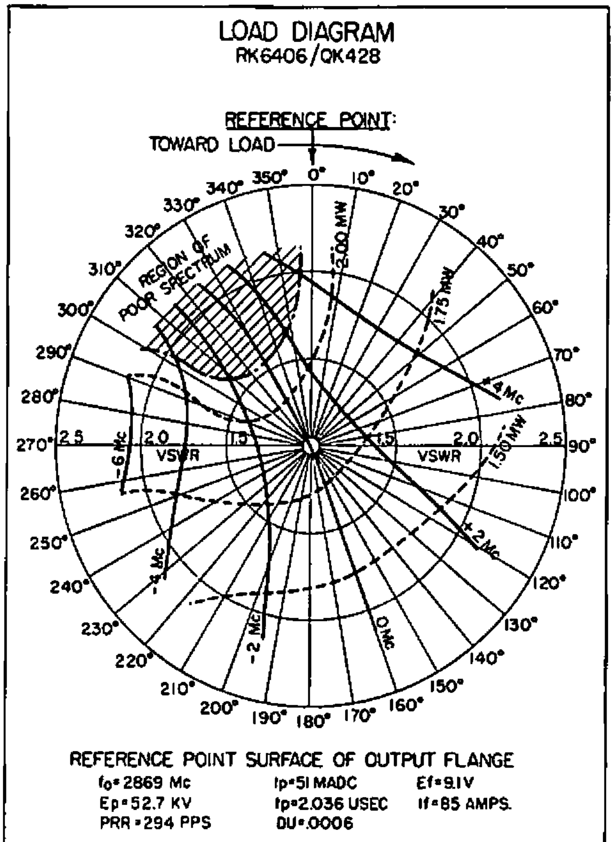


FIG. 3

COOLING

The RK6406/QK428 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). Fig. 4 is a plot of anode temperature rise above ambient as a function of total power input and rate of water flow.

Sufficient cooling of the cathode insulating oil must also be provided to maintain the cathode bushing temperature below the maximum specified 150°C. If an insulating oil is used whose insulating properties deteriorate above 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.

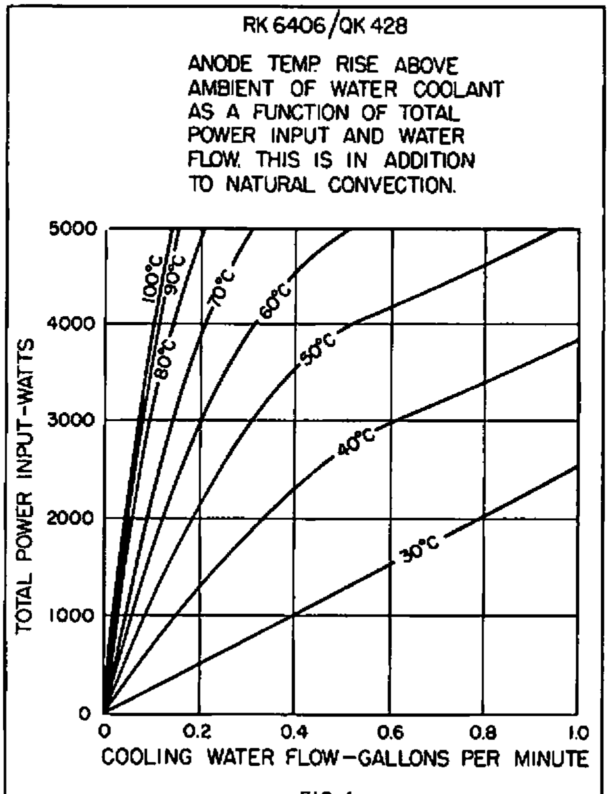


FIG. 4

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. 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 RK6406/QK428 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. 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 are available upon request.

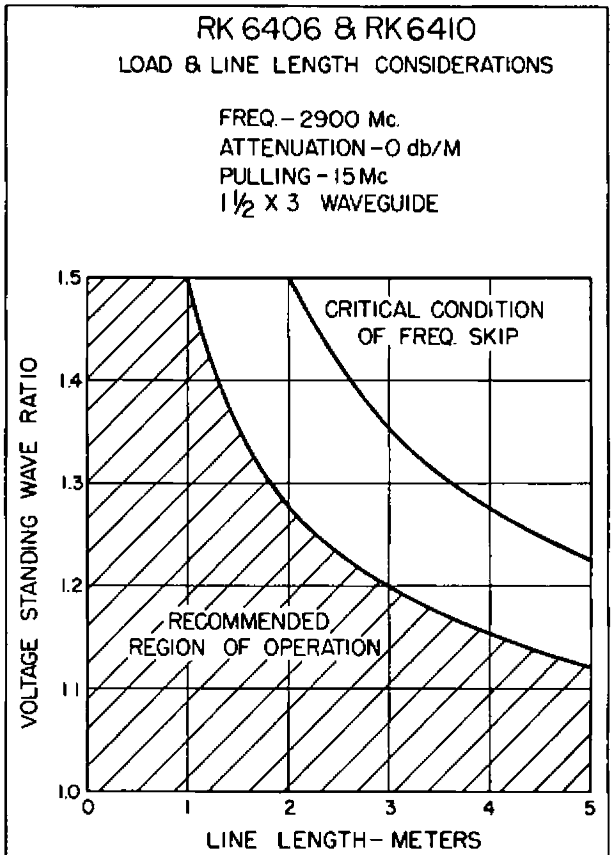


FIG. 5

FREQUENCY DRIFT

After operation of the RK6406/QK428 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 Fig. 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. The frequency change will not exceed 0.15 Mc/C° between 40° and 70°C anode temperature.

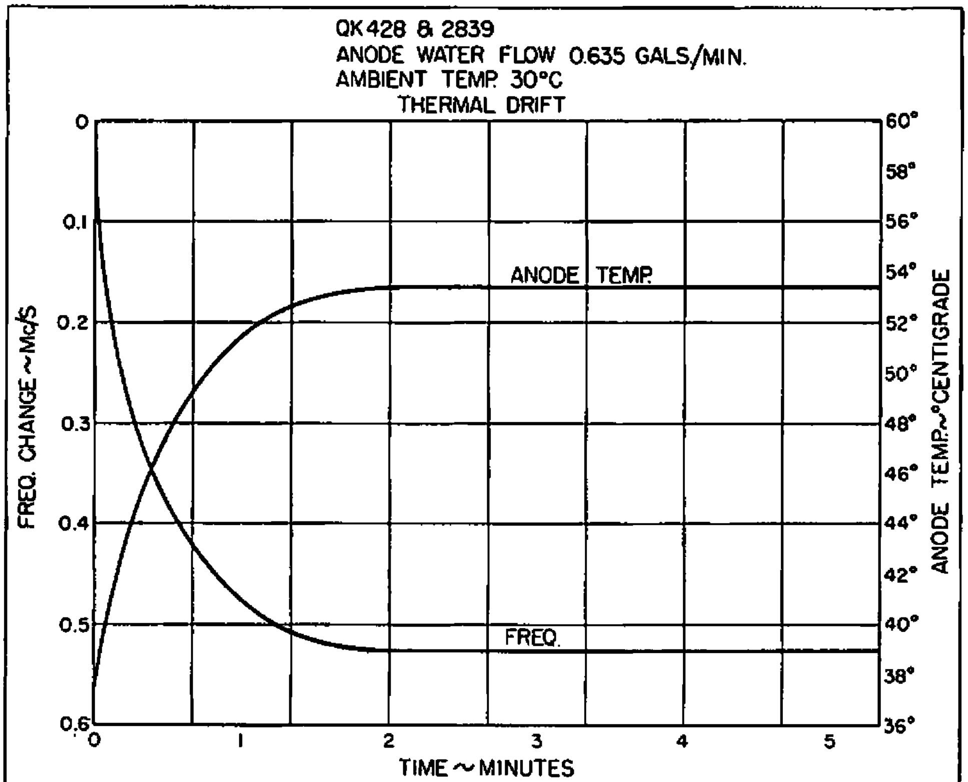


FIG. 6

RF RADIATION FROM CATHODE

The RK6406/QK428 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. 7 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.

RK 6406/QK 428 OPERATING CHARACTERISTICS

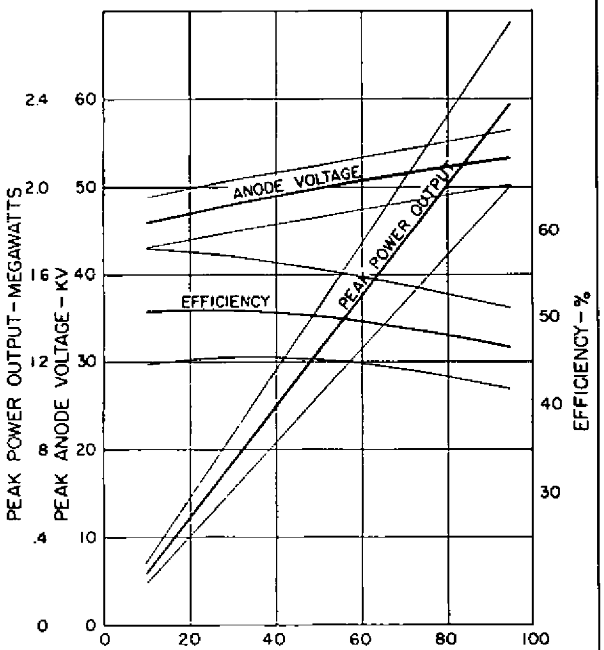


FIG. 7

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 neoprene guard covers from the RF output window and 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 magnetron has been operated with water as a coolant, be sure to drain water from the cooling jacket before storing 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 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 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.

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 9 of tube outline drawing). 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.

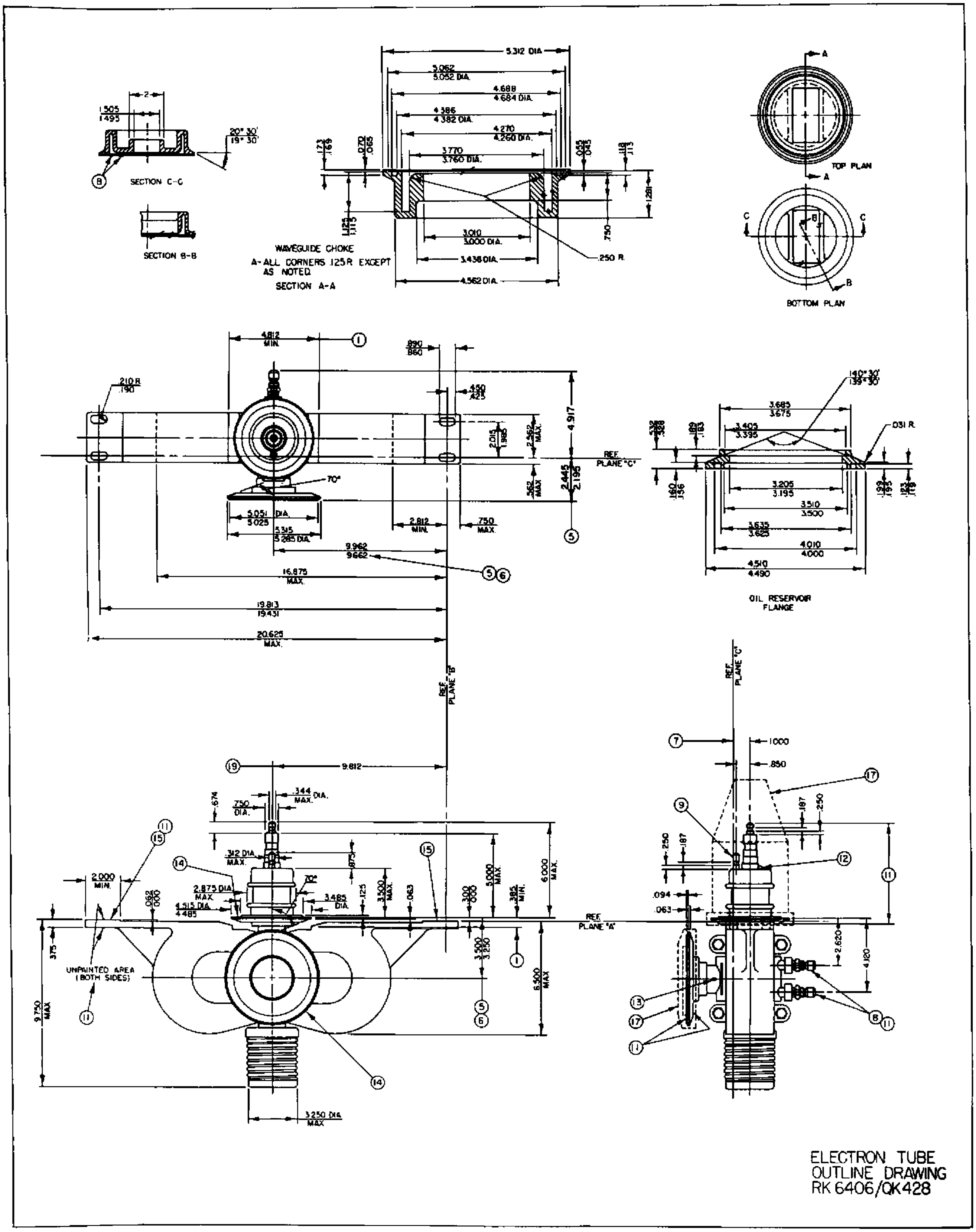
COUPLING AND PRESSURIZATION

The magnetron output flange is designed to couple to standard 1.5" x 3" waveguide. Mechanical details of the recommended choke flange to mate to the magnetron are illustrated in the outline drawing. See Fig. 8.

Waveguide pressurization to 35 psia is required. Pressurization lower than 35 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 a 4.812" minimum.
2. Reference plane "A" lies on the mounting surface of the magnets.
3. Reference plane "B" passes through the center line of the holes in the bracket and is perpendicular to reference planes "A" and "B."
4. Reference plane "C" passes through the center line of the holes in the bracket and is perpendicular to reference planes "A" and "B."
5. Includes angular as well as lateral deviations.
6. Refers to the center line of the waveguide.
7. Parts on this center line may vary from the true location by 0.125".
8. Hansen 33-T20 coupling plug.
9. Common cathode connection.
10. All solder joints on the output section should be soldered to provide a hermetic seal.
11. The following should be free from paint: front and back faces of the oil-sealing sleeve, parts above the flange, front and back faces of the output flange, the exhaust cap, the mounting surface on the magnets, and the coolant plug connectors.
12. The cathode stem temperature is measured at this point.
13. The anode temperature is measured at the right side (facing output) of the output transformer by inserting a tapered thermocouple plug (see installation details in drawing C69659).
14. Equipment flanges mating to the oil-sealing and output flanges should provide compliance by means of a bellows or other flexible union. These flanges cannot be used to support the tube. The entire weight must be held by the magnet brackets.
15. These surfaces must be coplaner within 0.032".
16. WARNING: Maintain a minimum clearance of 8" between the magnets and ferromagnetic materials, except at bracket ends where the minimum clearance can be 3". Maintain a minimum clearance of 12" to the other magnets.
17. Protective cover for shipping purposes only.
18. Coat with black, heat-resistant, noncorrosive paint.
19. Parts on this center line may vary from the true location by 0.188".


SECTION C-C
SECTION B-B
WAVEGUIDE CHOKE
A-ALL CORNERS .125R EXCEPT AS NOTED
SECTION A-A
TOP PLAN
BOTTOM PLAN
OIL RESERVOIR FLANGE
REF. PLANE "C"
REF. PLANE "B"
REF. PLANE "A"
UNPAINTED AREA (BOTH SIDES)
ELECTRON TUBE
OUTLINE DRAWING
RK 6406/QK428