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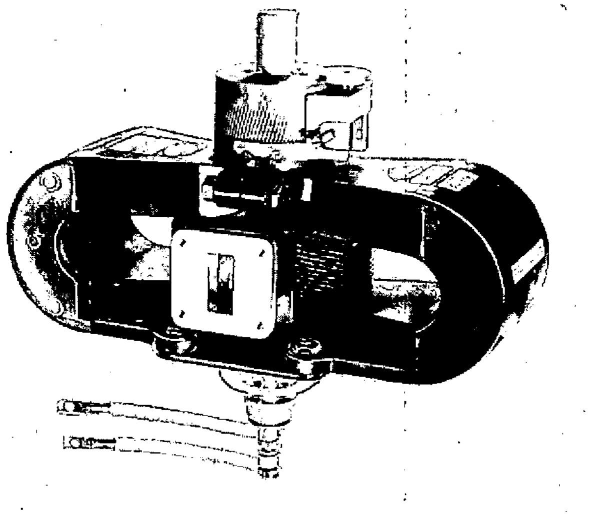
RAYTHEON TECHNICAL INFORMATION

Excellence in Electronics

TYPE RK-6249A

GENERAL DESCRIPTION

The RK6249A magnetron is a mechanically tunable pulsed-type oscillator with a nominal peak power output of 240 kilowatts. This magnetron is capable of either rapid hand or motor tuning to any desired frequency in the 8500 to 9600 megacycle range. It is an integral magnet type, requiring forced air cooling, and is designed for coupling to a standard ⅝″ x 1¼″ pressurized waveguide.



TUNABLE PULSED-TYPE OSCILLATOR

GENERAL PRECAUTIONS

As is the case with other electrical components, if magnetrons are operated continuously at their maximum ratings, some deterioration in life will result. There are many problems peculiar to magnetrons in general which must be given special consideration in system design, such as r.f. radiation, pulse shaping, VSWR, and length of transmission line to the antenna. These problems are discussed in detail in the following pages. If for any reason it is desired to operate the RK6249A 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.

Reliable operation and maximum magnetron life can be achieved only if the overall radar transmitter is designed with the magnetron characteristics and peculiarities clearly in mind. This technical data sheet rather than the MIL-E-1C Government Purchase Specification should be used as a guide to equipment designers.

GENERAL CHARACTERISTICS

ELECTRICAL

Heater Characteristics

Heater Voltage — Preheat	9.0 Volts
Heater Current @ 9.0 Volts	12.8-15.6 Amperes
Minimum Preheating Time	3 minutes

Maximum Ratings

Heater Voltage	10.0 Volts
Peak Current	32.0 Amperes
Peak Power Input	1000 Kilowatts
Duty Cycle	.0013
Minimum Pulse Voltage Rise Time	.1 us.
Maximum VSWR	1.5
Anode Temperature	125°C.

The values specified above are based on the "absolute system," and are not to be exceeded under any service conditions. The ratings are limiting values above which serviceability of any individual tube can be impaired. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

Typical Operation

	Oscillation (1)	Oscillation (2)
Pulse Recurrence Frequency	2000	400
Pulse Duration	.5	2.5 us.
Peak Anode Voltage	28.0	28.0 kv
Peak Anode Current	25.0	25.0 a
Average Anode Current	25.0	25.0 mAdc

MECHANICAL

Mounting Position	Any
Detailed Dimensions	See Outline Drawing (Fig. 9)
Net Weight	16 lbs., 4 oz. (Approx.)
Cooling	Forced Air
Pressurization	45 p.s.i. Absolute
Output Coupling Flange	UG 52/U
Tuner Torque	6″ lbs. Maximum

DETAILED ELECTRICAL INFORMATION

HEATER

The RK6249A should be preheated at 9.0 volts for a minimum time of 3 (three) minutes. For a .001 duty cycle on both the .5 and 2.5 usec pulse, the heater voltage should be reduced to 6.0 volts. If, however, the tube is to operate at a .0005 duty cycle, the operating heater voltage should be at 8.0 volts. Heater voltage must be kept at ±10% of the specified values at all times. Heater surge current must not exceed 2½ times the maximum rated current. Excessive heater surge current will cause the heater in the magnetron to fail.

See Figure 1 for heater voltage vs. input power curve.

RK6249A HEATER VOLTAGE VS. INPUT POWER

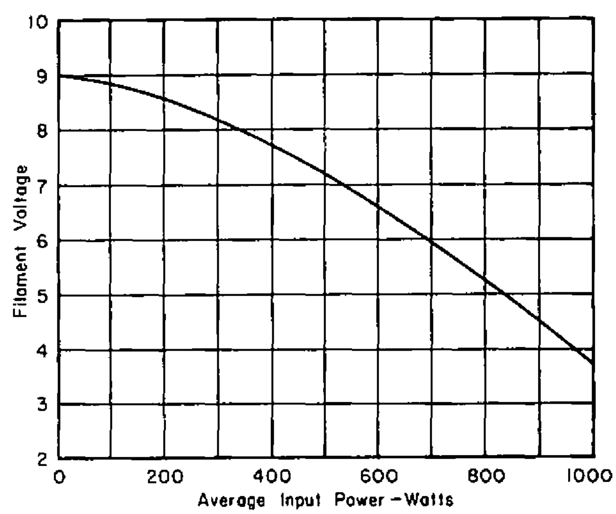


Figure 1

PULSE LENGTH AND DUTY CYCLE

The RK6249A has been utilized in systems which operate the tube at pulse lengths from 0.25 to 3.2 microseconds, and at duty cycles up to .001. Operation at pulse durations and duty cycles within these limits is entirely satisfactory. Consultation with the Applications Engineering Department is recommended before finalizing the operating conditions of any contemplated equipment design. The RK6249A is normally tested in the factory at a .001 duty cycle and 0.5 and 2.5 microseconds.

PULSE CHARACTERISTICS

The smooth peak is the maximum value of a smooth curve through the average of the fluctuation over the top portion of the pulse. The pulse width is the time interval between the two points on the current pulse at which the instantaneous current is 50 per cent of the smooth peak. The rise time is the time interval between points of 20 and 85 per cent of the smooth peak. Figure 2 shows

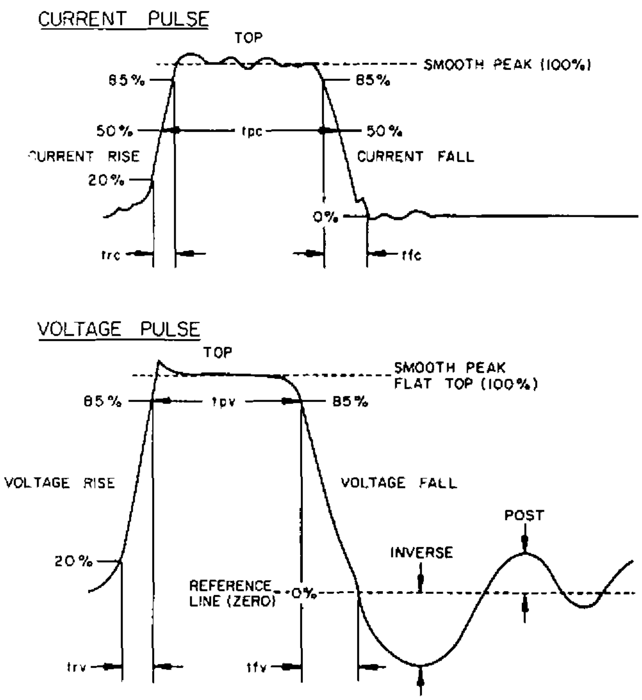


Figure 2

graphically the definitions mentioned. The voltage rise time must not be less than .10 usec for both the .5 and 2.5 usec pulse widths to realize good tube performance. Too fast a rise time may lead to instability. It is necessary to form the pulse so that the current pulse shows no sign of jitter and no large spikes on the leading edge, as these conditions also may cause instability. The ripple on the top of the current pulse must be kept at a minimum to avoid pushing effects which will tend to widen the spectrum. The trailing edge or decay time of the voltage pulse must be as short as possible to obtain optimum performance and high operating efficiencies.

Many magnetrons draw a certain amount of leakage or diode current at anode voltages as low as 100 volts. For this reason, it is not only advisable to keep the time duration of the voltage pulse trailing edge as short as possible; but also to prevent the positive voltage backswing from becoming negative again. The diode current can amount to several milliamperes at an average current of 25 milliamperes. Except for giving falsely exaggerated indications as to the actual peak current at which the magnetron is operating, diode current is not harmful unless it becomes excessive.

For optimum pulse shaping, the magnetron, pulse transformer, and pulse line must be treated as a unit. It is advisable to build up an experimental pulse line and hand tailoring it for optimum magnetron current and voltage pulse shape when used in conjunction with the pulse transformer and the RK6249A.

"Close in returns" or "false echoes" have frequently been related to the generation of r.f. noise from magnetrons during the duration of pulse backswing when voltage is present across the tube but of insufficient value to cause normal oscillation. There has been no experience of this sort with the RK6249A. If this is encountered more information regarding this phenomenon in general may be obtained from the Applications Engineering Department.

INITIAL OPERATION

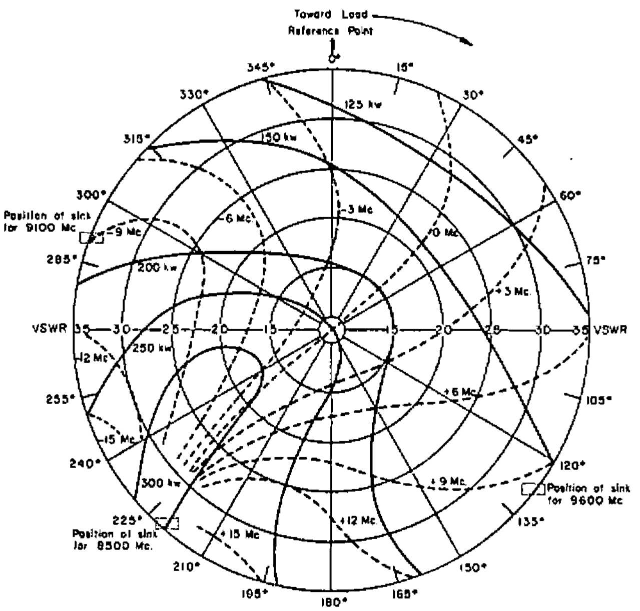
No unusual precautions should be taken when first operating a new tube or one that has been in storage for some time. If any instability of the RK6249A is observed, however, it is usually very short term and its manifestation is related to the sensitivity of the modulator overload circuit and the pulse duration. Seldom is any initial instability encountered with magnetrons at pulse durations of less than one microsecond unless there is a basic problem (i.e., rise time) with the design of the modulator pulse shape. For pulse lengths greater than one microsecond, initial instability may occur. Every RK6249A is tested for "starting stability" at the factory at a 2.5 microsecond pulse width. The criteria for acceptance is a 1% maximum allowable number of "missing r.f. pulses" during the initial test interval immediately following the application of high voltage. This is a standard MIL-E-1C test procedure.

The sensitivity of the overload circuit and the operational requirements of a system are items which should be thoroughly discussed with the Applications Engineering Department.

LOAD DIAGRAM

Figure 3 is a load diagram of a typical RK6249A magnetron. 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 VSWR as high as 3.5/1.0 are plotted, but operation at ratios greater than 1.5/1.0 is not recommended.

TYPICAL RK6249A LOAD DIAGRAM



Reference Point: Surface on output flange.

Ib 25mA — Du 001 — Ipc 0.45 usec

Figure 3

POWER INPUT

The impedance of the RK6249A is initially established at the factory by adjustment of the magnetic field. At a frequency of 9000 Mc (3.0 on the tuning dial) and at a peak anode current of approximately 25 amperes, the peak voltage is within the range of 27 to 29 kilovolts, corresponding to an impedance of 1080 to 1160 ohms. The impedance of the magnetron varies as its frequency is tuned. The change in voltage required to maintain a constant current from 8500 to 9600 Mc is 2.75 kilovolts.

If the RK6249A is used in a circuit which requires tunability without regulation of anode current, the power input to the tube will be determined by the load line characteristic of the modulator. If such is the case, and a conventional line type modulator is used, it is recommended that the power input be initially adjusted for the nominal anode current when the tuning gear is set at 3.0 on the dial. The power output may then be lower or higher than the published data, depending upon the anode current deviations from the rated value as the tube is tuned. If a hard tube modulator is used, regulation of anode current is mandatory.

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 the 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 the skip. This skip condition occurs when the tube is changing frequency (thermal drift) and causes breaks in the tube's ordinarily smooth drift curve.

PRESSURIZATION

The waveguide output section must be pressurized with 15 p.s.i.a. of clean dry air or equivalent means to prevent electrical breakdown.

The input bushing is capable of operation without pressurization up to an altitude of 10,000 ft.

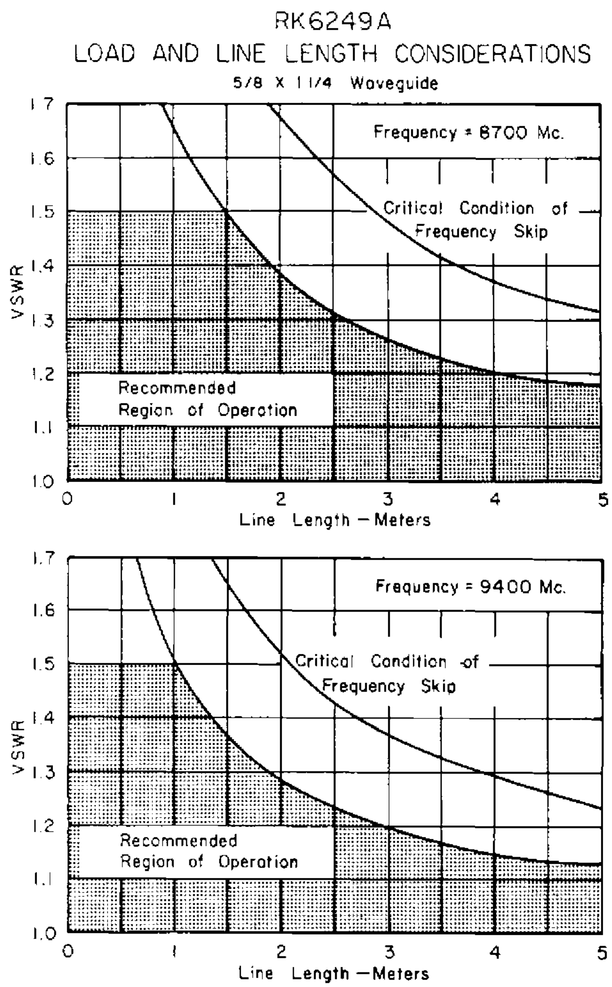


Figure 4

WAVEGUIDE BREAKDOWN

If an arc occurs anywhere in the waveguide run, it may immediately be reflected back to the magnetron output window. The arc effectively short circuits the magnetron output, heats the window, resulting in implosion of the glass.

The minimum power specification for the tube is 200kw at an average current of 25mAdc; however, an average tube can yield 240kw into a matched load, 300kw into a VSWR of 1.5/1.0 at 25mA, and 375kw into a VSWR of 1.5/1.0 at an average current of 28mAdc. For this reason, a large size "X" band waveguide is recommended, and *all* waveguide components should be capable of withstanding 400kw.

COOLING

The air stream for cooling the RK6249A should be directed to the air inlet of the radiator through a close fitting duct. Anode temperatures of 100°C or lower are recommended, although temperatures as high as 125°C can be tolerated. Sufficient circulating air or equivalent cooling must be supplied around the input bushing so that the bushing temperature will never exceed 270°C. See Figure 5 for cooling characteristics.

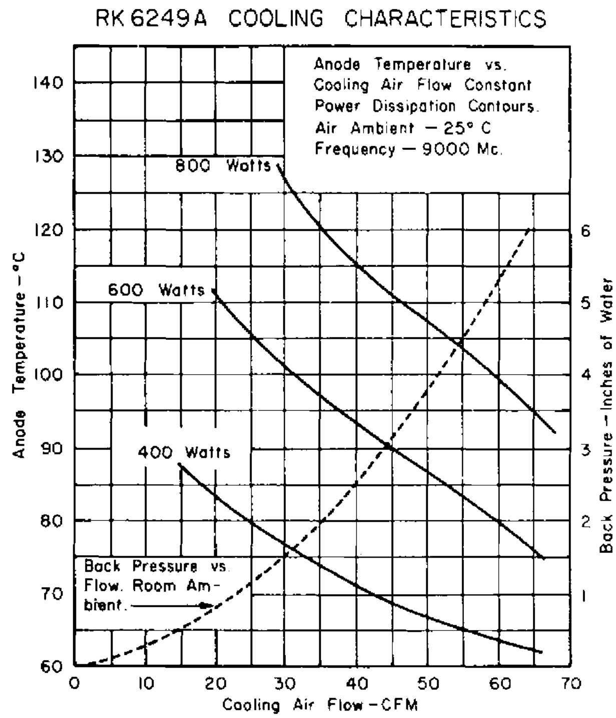


Figure 5

FREQUENCY DRIFT

After operation of the RK6249A is initiated, the tube's temperature increases with time until thermal equilibrium is reached. During this period, the dimensions of the tube change slightly and consequently the operating frequency changes or drifts. The average frequency drift characteristics of the RK6249A after starting at room temperature is presented in Figure 6. If the tube temperature is changed after thermal equilibrium has been established, such as will be the case with changes in ambient temperature or changing duty cycles, the operating frequency will also change until the new equilibrium is reached. The resulting frequency change in this case will be less than .25 megacycles per centigrade degree.

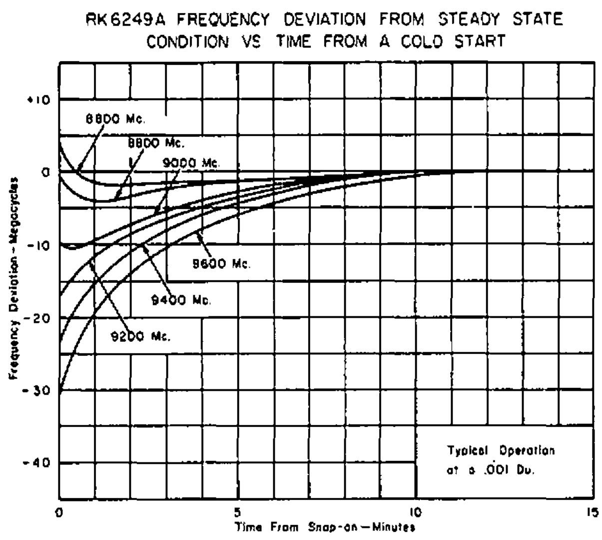


Figure 6

FILAMENT SUPPLY FREQUENCY

The RK6249A has a large alnico magnet which supplies the field energy. Interaction between the magnetic field and the AC field of the filament coil may excite electro-mechanical resonances of the filament structure. For this reason, variable frequency supplies must be avoided. Frequencies of 60, 400, or 1600 cycles should be used, as these regions have been investigated, and have been found to contain no resonances.

It may be necessary in MTI applications to use a DC source in order to avoid heater modulation.

R. F. SPECTRUM BANDWIDTH

The r.f. spectrum is related directly, but not exclusively to the shape of the input pulse. The property of the tube which contributes to the spectrum shape is called "pushing." Pushing is related to electron density within the interaction space. Electron density in turn is related to pulse width and current. As the pulse width increases the deviation of the spectrum from its direct relationship to the input pulse may be more pronounced.

With pulse widths shorter than 1 microsecond, a theoretical spectrum should not be expected until the magnetron current pulse shape has attained comparable properties, particularly a fast fall time. With pulse widths greater than 2 usec, the spectrum may deviate from the ideal at discrete currents usually above 9,000 mcs. Ordinarily this phenomenon of spectrum broadening is only apparent over very narrow phase changes in the reflections of loads having a high VSWR.

Factory specifications allow a maximum bandwidth of 1.5 Mcs. measured at the —6db point on the power spectrum. The test is performed at a pulsewidth of 2.5 usec. with an r.f. load having a 1.5 minimum VSWR phased for maximum bandwidth.

It is recommended in applications where VSWR's in excess of 1.3 are unavoidable that a ferrite type r.f. load isolator be used in conjunction with the magnetron.

POWER OUTPUT

At the nominal anode current of 25 amperes, the minimum power output from the RK6249A is 200 kilowatts. The actual distribution of power is greater, however, with the average minimum being 240 kilowatts. If the anode current is maintained constant as the magnetron is tuned, the power output is greater at each frequency extreme than at the minimum power frequency which occurs in the middle of the band.

The power output is directly related to the power input with the value being directly proportional to the anode current. The effect of load VSWR can result in a further variation as great as ±20% with a VSWR of 1.5.

In a typical system, under extreme conditions of line voltage, load VSWR, and frequency, the RK6249A may deliver 375 kilowatts of peak power.

During the operational life of the tube, power output may vary. Military specifications for any magnetron consider a tube acceptable in this regard as long as the power output does not decrease by more than 20%. Such a decrease in power output rarely occurs in practice.

Absolute power measurements should only be made with a calorimetric standard.

R. F. RADIATION FROM CATHODE

All magnetrons radiate r.f. energy or noise from the input bushing. Proper shielding should be provided to prevent this energy from affecting sensitive circuits. This is normally accomplished if the magnetron is mounted in a compartment of a pulse transformer assembly.

X-RADIATION

Radiation from the internal anode structure of the RK6249A during oscillation emanates in a conical pattern through the glass of the input bushing and from the waveguide output window.

Exposure to this radiation, although not considered harmful, should be avoided inasmuch as the national trend is toward minimization of unnecessary exposure.

In normal mounting of the tube in a completed system where the input bushing is immersed in a compartment of oil and the waveguide output is connected to the r.f. plumbing, there is sufficient attenuation to absorb or shield the radiation. As a further precaution, the inside of the housing which the bushing fits into may be coated with a lead paint. The Applications Engineering Department can supply the details for procurement of this material.

In laboratory setups, care should be taken to shield these areas or by appropriate mounting to direct the input bushing away from personnel. Observation of the cathode in an oscillating tube by viewing through the output window should be avoided unless lead glass is used.

TUNER TORQUE

Not less than 10″ ounces nor more than 6″ pounds should be applied to the drive shaft of the tuner.

TUNING

Tuning is accomplished by rotating the double ended worm shaft driving the tuning dial gear. Counter clockwise rotation of the tuning gear increases the operating frequency of the tube.

155 ±15 turns of the tuning shaft (worm gear) covers the entire 1100 mc tuning range. The turns ratio of the worm gear to the dial gear is 25 to 1. Under the factory test conditions, dial readings corresponding to the following frequencies are stamped on the magnet of each tube.

Dial Reading	*Approximate Frequency*
A	8750 Mc
B	9250 Mc
C	9375 Mc

In addition, the dial gear is adjusted so that at a reading of 3.0 the frequency is approximately 9,000 Mc. Tuning linearity is a consistent characteristic of the RK6249A. The variation of any tube from the average tuning curve is within ±25 Mc. Refer to Figure 7.

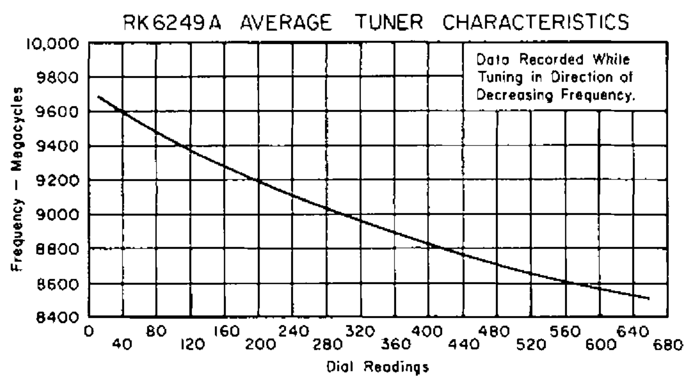


Figure 7

The RK6249A has been designed for rapid tunability. No appreciable wear, backlash, or changes in characteristics will occur for at least 5,000 cycles at tuning speeds of the drive shaft as high as 1500 rpm. Even higher speeds are feasible.

The tuning mechanism requires a maximum torque of 12 inch oz. under the most extreme conditions of temperature, minus 55°C. The stop mechanism is designed to withstand not more than 6 in. lbs. without damage.

RK6249A AVERAGE PERFORMANCE CHARACTERISTICS

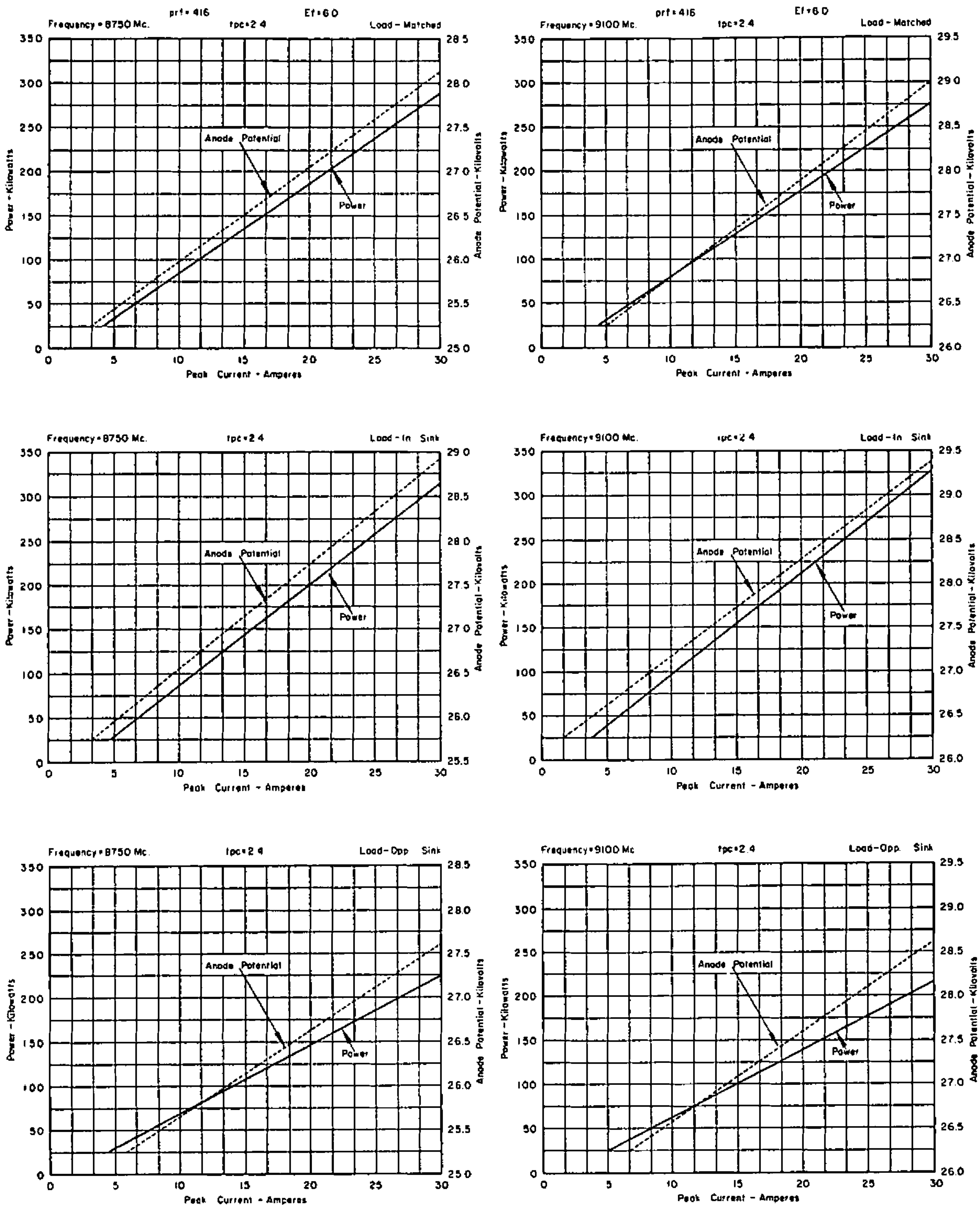


Figure 8

RK6249A AVERAGE PERFORMANCE CHARACTERISTICS

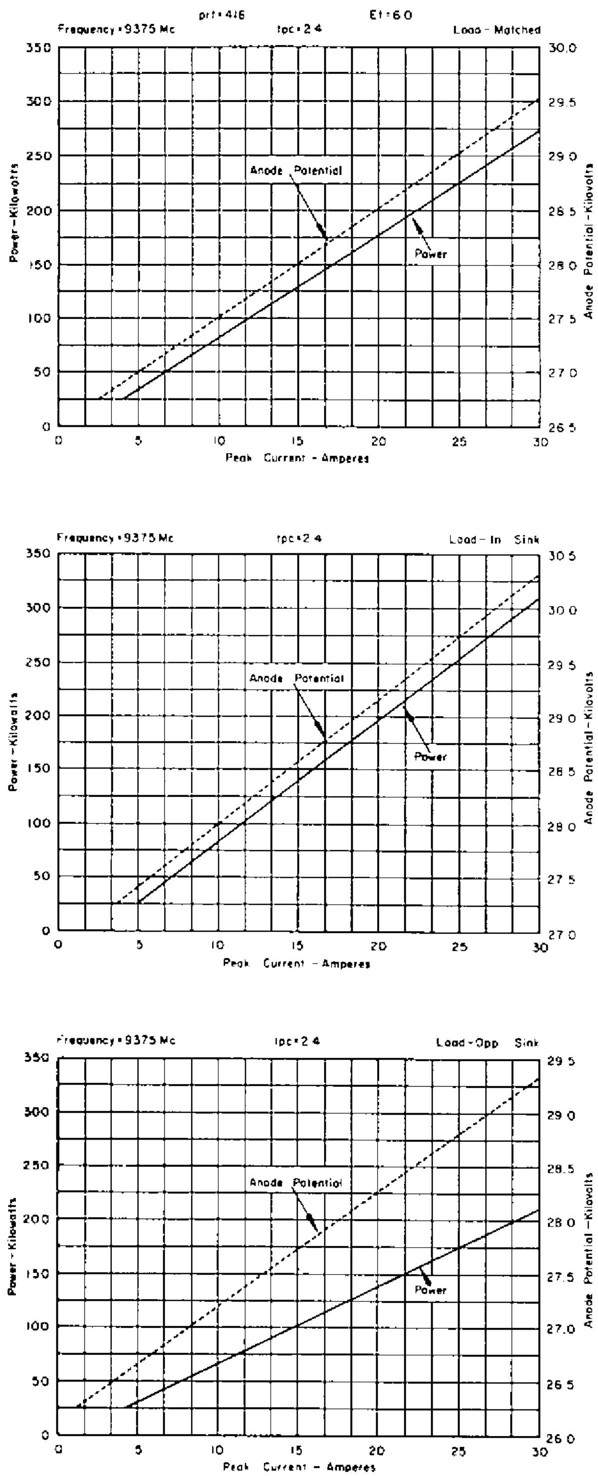


Figure 8

DETAILED MECHANICAL INFORMATION

INSTALLATION AND HANDLING PRECAUTIONS

The high voltage bushing and the output window are protected by guard covers during shipment. These covers must be removed before the tube is installed in its associated equipment. No mechanical strain should be applied to the bushing or the output window in handling or mounting the magnetron.

Care should be taken to keep magnetic materials 4" away and ferro-magnetic materials 12" away from the magnets. The aluminum coating on the magnets minimizes the danger of demagnetization by contact but cannot be guaranteed completely effective. Deterioration of the magnetic field will cause low power and instability.

Unnecessary jarring of the tube must be avoided. While a packaged magnetron may give an appearance of massiveness and great strength, the internal structure is delicate and involves critical alignment of parts. In the event of careless handling, the resulting shock may easily exceed the maximum allowable.

MOUNTING

The tube is mounted from the four holes in the mounting flange which provide clearance for ¼" bolts. The RK6249A may be mounted in any position.

ELECTRICAL CONNECTIONS

Electrical input connections are made to the frame of the tube and to two flexible leads terminated in lugs with clearance holes for #10-32 bolts. The positive high voltage lead should be grounded to the tube, preferably at the mounting surface. The heater lead projects radially from the extreme end of the cathode bushing. The other lead provides a common heater and cathode connection and can be identified by a band of brown paint.

When making connections to the filament, the circuit should be studied and arranged to prevent any portion of the filament supply voltage from being applied between the anode and cathode of the magnetron. The magnetron would rectify this low ac voltage, and the average anode current meter would indicate a few milliamperes. Depending upon the circuit, this false indication of current could be exaggerated if the filament-cathode connections were reversed.

COUPLING

The magnetron output flange is designed to couple to a standard ⅝" x 1¼" pressurized waveguide. A standard X-band flange, type UG-52/U with holes modified to provide clearance for #8-32 bolts, mates with the tube output flange.

NOTES:

1 Reference Plane "A" is defined as a plane passing along the face of the mounting plate.

2 Reference Plane "B" is defined as a plane perpendicular to plane "A," passing through the center of holes as shown.

3 Reference Plane "C" is defined as a plane mutually perpendicular to planes "A" and "B" passing through the center of holes as shown.

4 Includes angular as well as lateral deviation.

5 Center line of tapped holes must be parallel to planes "A" and "B" within .030.

6 Brown paint to identify common cathode connection.

7 Refers to radiator size only.

8 Lug (25 amp).

9 It shall be possible for a sleeve .195 I.D. x .406 O.D. x 1" long to pass ends of shaft to face of worm bracket.

10 Entire surface outside a 1.187 radius from the center of circle through the nominal centers of the four mounting holes shall be flat within .020. The mounting plate shall extend to a radius not less than 1.750 from its center as here defined.

11 ***WARNING!!!*** Maintain min. 4 inches clearance between magnet and magnetic materials (magnets, steel tools, plates, etc.).

12 Refers to opening in cooling fins.

13 All joints in mounting plate must be vacuum tight to provide a hermetic seal at surface "A."

14 All joints in waveguide assembly to be vacuum tight to provide a hermetic seal at surface "B."

15 Anode temperature to be measured at this point on surface of waveguide 1.500" back from face to waveguide flange.

16 Bushing temperature to be measured at this point.

17 Slot in flange to be centered within .005 with respect to 4 tapped holes.

18 All points on cathode stem within 1.250 max. from Ref. Plane "A" shall fall within the circumference of a 2.250 max. dia. cylinder con structed concentric to a circle drawn through the nominal center of the 4 mounting holes, and perpendicular to Ref. Plane "A." All points on cathode stem beyond 1.970 max. from Ref. Plane "A" exclusive of leads must fall within a similarly constructed cylinder of .750 max. dia. and finally all points between 1.250 and 1.970 from Ref. Plane "A" must fall within a similarly constructed conical section of 2.250 major dia. and .750 minor dia. as shown.

19 Refers to projected radius of mounting plates.

20 The frequency increases as the tuner shaft is driven in a counter clockwise direction as viewed in direction indicated by arrow.

21 The complete frequency range is covered by approximately 175 turns of the tuner shaft.

22 Leads must be capable of being bent as shown (detail viewed in direction of arrow).

23 Two No. 6-32 tapped holes with screws inserted are located as shown. The addition of the tapped holes and screws satisfy an Air Force equipment, and the magnetron serviceability will not be impaired with the screws inserted or removed.

24 Clearance between radiator and inside magnet leg.

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