Communications & Power Industries

microwave power products division

OPERATING INSTRUCTIONS

COUPLED-CAVITY TRAVELING-WAVE TUBES

INTRODUCTION

These Operating Instructions provide basic information for installing and operating CPI coupled-cavity traveling-wave tubes (CCTWTs). Supplemental information is given in the Test Performance Sheet (TPS) and the individual product specification. The Test Performance Sheet, which is shipped with the product, contains test results at specific frequencies for each individual unit. Inquiries for additional information and requests for copies of these publications should be made to:

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For more detailed product operating procedures in specific equipment, consult the applicable equipment manuals and equipment performance standards. In case of conflict, equipment manuals and performance standards shall govern, except for the absolute maximum ratings on the device. Additional information may be obtained from the equipment manufacturer. Some operational details specified by the equipment manufacturer may vary from those given in individual product specifications.

WARNING

SERIOUS HAZARDS EXIST IN THE OPERATION OF MICROWAVE DEVICES. BEFORE ATTEMPTING ANY PRODUCT OPERATION, CAREFULLY READ AND UNDERSTAND THE “OPERATING HAZARDS” SECTION FOLLOWING THESE OPERATING INSTRUCTIONS, AS WELL AS THESE INSTALLATION AND OPERATING INSTRUCTIONS.

COUPLED-CAVITY TWTs — SPECIFIC HAZARDS

CPI as a component supplier can assume no responsibility for any damage or injury resulting from operation of CPI microwave devices. The transmitter connected with this device must be designed to protect personnel against all operating hazards. Installation and operating precautions should be observed, and ratings given in the Test Performance Sheet must not be exceeded.

High Voltage — Normal operating voltages are deadly. The equipment must be designed so the operator cannot come into contact with high voltages. High-voltage circuits and terminals must be enclosed, and interlocking switch circuits must be maintained so they open the primary circuits of the power supply and discharge high-voltage capacitors when access is required.

RF Radiation — Exposure to rf radiation generated by this device during operation may cause serious bodily injury, possibly resulting in blindness or death. Cardiac pacemakers may be affected. Exposure of the human body to microwave radiation in excess of 10 milliwatts per square centimeter can be harmful. For this reason, rf energy must be contained by the waveguides and shielding. If voltages are to be applied when the device is not connected into a waveguide system, the rf input and output flanges should be closed tightly with shielded terminations.

X-radiation — Coupled-cavity TWTs produce dangerous x-radiation during operation. Harmful levels of exposure can be reached without personnel being aware, and serious personal injury or death may occur as a consequence at some later date. The equipment in which the device is used must provide adequate lead shielding around the device for the protection of personnel. Radiation levels must be checked periodically to ensure safe operating conditions. Never apply beam voltage without having X-ray shielding in place.

Beryllium Oxide (BeO_2) — Some coupled-cavity TWTs use beryllium-oxide ceramics. The dust and fumes from beryllium oxide are highly toxic and can cause serious injury or death.

Implosion Hazard— Ceramic windows in microwave devices can shatter on impact or crack in use, possibly resulting in injury from flying particles.

Elevated Temperatures — Portions of this device will attain elevated temperatures during operation. Avoid physical contact for a sufficient period after operation is terminated to permit adequate cooling. In liquid-cooled CCTWTs, the liquid coolant used to cool the collector reaches scalding temperatures. Touching or rupture of the cooling system can cause serious burns.

These hazards are specifically described in the Operating Hazards section immediately following these operating

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instructions. Equipment using these devices must be designed to minimize risk to personnel from these hazards. Equipment manufacturers and users must develop and institute procedures suitable for the particular equipment and specific use to guard against all hazards not eliminated through equipment design.

HANDLING

Unpacking — The product is shipped in an approved package that will protect it from moderate handling abuse. If the outer container shows evidence of being dropped or is punctured, open the package and inspect the unit for damage.

Weight — Many CPI coupled-cavity TWTs exceed the weight that can be easily lifted by one or more persons. These devices will have eyebolts to permit the use of a hoist or other appropriate lifting devices. Many lower-weight units are provided with handles. Always lift the device by the eyebolts or handles, whichever is provided.

CAUTION

TO MINIMIZE THE RISK OF SERIOUS DAMAGE WHEN MOVING THE DEVICE, DO NOT ALLOW ANY OBJECT TO STRIKE OR APPLY STRESS TO THE DEVICE, ESPECIALLY THE WAVEGUIDES, THE VACION® PUMP, OR THE ELECTRON GUN. **NEVER** *LIFT THE DEVICE BY ANY OF THESE COMPONENTS.*

PROTECTIVE MEASURES

This device must be used in equipment that provides automatic protection as described below. In addition, installation and operating precautions must be observed, and ratings shown within the Test Performance Sheet must not be exceeded. Failure to comply fully with the foregoing may result in product failure, damage, or decreased operating life. Any product damage or failure resulting from noncompliance with these requirements or which, in CPI's opinion, could have been avoided by compliance with these requirements will void the CPI warranty.

Heater Warm-up Time — Heater voltage must be applied for at least the specified warm-up time before attempting to draw beam current from the cathode. Heater surge current must be limited to twice the specified maximum steady-state value or as specified in the product specification.

Beam Voltage — For gridded or modulating-anode CCTWTs, protective circuitry must be provided to inhibit the drawing of beam current unless the beam voltage is within ±2 percent of the nameplate (NP) beam voltage or as given in the product specification. Cathode-pulsed or CW CCTWTs without a beam-control electrode must also be inhibited from operation except for the brief (millisecond) period required for beam-voltage run-up. In general, a voltage *higher* than NP will tilt the gain response, causing it to be higher at low frequencies; a voltage lower than NP will tilt the gain response, causing it to be lower at the low frequencies. Upon initial operation of the device, if the shape of the gain response does not correspond to the data on the Test Performance Sheet, it is acceptable to adjust the beam voltage within the specified beam-voltage range around the NP value to achieve a response similar to that given on the TPS. Any changes in beam voltage outside of the specified limits must be avoided to prevent this gain-response condition or the occurrence of other problems.

Beam-Control Electrode — Coupled-cavity TWTs from CPI utilize several methods of beam control, including grids, beam-control or modulating anodes, and diode (cathode-pulsed) guns; refer to the product specification and Test Performance Sheets for the specific type of beam control used. The control-element voltage, current ratings, and values for the particular unit are given in these documents. Operating instructions provided for the system or power supply should also be consulted in determining proper sequencing for turn-on, turn-off, and protection of the device. For gridded CCTWTs, the grid must be operated at the NP value within approximately plus or minus 1 percent. At least the minimum value of grid-bias voltage must be maintained when the beam voltage is applied to the device; consult the product specification for the safe grid-pulse-voltage range. The beam-control electrode should be operated in conformance with the voltages specified in the Test Performance Sheet. With diode guns, the beam is turned on as the cathode voltage is applied.

Product Protection — Coupled-cavity traveling-wave tubes typically operate at high average power output. The internal structure of the device may be damaged if it is operated outside of its absolute ratings. Product protection requires that the beam power be removed quickly if a fault occurs. The maximum time allowed and the method of turn-off for various fault conditions are specified in the product specifications. The time sequencing for the power supply as it is turned off by various fault inputs should be tested periodically to ensure that turn-off can be accomplished within the maximum times specified.

The method and maximum time of turn-off in case of a fault depends upon the fault experienced, the type of coupled-cavity TWT, and the design of the power supply. The amount of stored energy in the power supply and the amount of time required to disconnect the power supply from the power source are important factors in determining the proper means of CCTWT turn-off. The type of fault, the type of beam-control electrode, the method of cooling, and the average power capability of the CCTWT structure all contribute to the protection requirements. Product operation should be inhibited under the following fault conditions (see the product specification for specified values):

1. Cathode warm-up less than the specified minimum.

2. Beam voltage out of the specified range around the NP value.

3. Collector voltage outside of the specified range around the NP value.

4. Lower than specified coolant flow or higher than specified coolant temperature.

5. Beam-control electrode voltages and currents outside of the specified range around the NP value.

6. Beam or body currents greater than the specified maxima.

7. For solenoid-focused CCTWTs, solenoid current out of the specified range around the NP value. The solenoid current should also be inhibited for solenoid coolant flow less than the specified minimum value, but not until after the device's high voltage is turned off. (To protect the unit, activation of the protection for solenoid undercurrent should occur before turn-off caused by low solenoid coolant flow.)

8. Higher than specified VSWR of the rf source or output lines.

9. Waveguide arcing.

10. Higher than specified rf input drive power.

Heater Voltage — Heater voltage is provided to heat the cathode to the proper temperature to produce space-charge-limited emission current. In the space-charge operating condition, little additional beam current is obtained as the heater power is increased. The increased temperature with increased heater power may change the gun electrode spacings and produce a slight emission change compared with that obtained at lower cathode temperatures. The onset temperature for space-charge-limited operation moves higher with operating life because of barium evaporation from the cathode surface and the subsequent depletion of barium from the cathode matrix. The evaporation rate is increased at higher cathode temperatures; hence, cathode life is a function of the cathode operating temperature. The NP value for heater voltage is set from emission measurements and product operating requirements, such as warm-up, emission life, and power-supply-heater voltage variations. Operating at excessive heater power will result in shortened cathode life and may cause high-voltage breakdown problems and heater failure. The heater voltage should be set at the nameplate value supplied with the unit’s test performance data.

Collector Voltage — The collectors on all CPI coupled-cavity TWTs are designed to operate over a limited voltage range and at a maximum amount of power dissipation. In general, the higher the cathode-to-collector voltage, the easier it is to collect a major percentage of the electrons and thereby to lower the body current. The collector is often operated depressed (from ground potential) to improve CCTWT efficiency. In some applications, the increase in body current that occurs with increasing amounts of collector depression is undesirable, so the collector is operated undepressed. In cases where the device is pulsed by pulsing the cathode voltage, the collector also is typically operated undepressed. The specified collector voltage range and the NP value of collector voltage are given in the Test Performance Sheet. Operation outside of this voltage range should be avoided.

Solenoid Operation — CPI coupled-cavity TWTs are either period-permanent-magnet (PPM) focused or solenoid focused. In either case, the electron beam is focused by the magnetic field generated either by current flowing in the solenoid or by permanent magnets placed along the length of the beam. In solenoid-focused CCTWTs, the magnetic field generated is dependent upon the amount of current flowing in the solenoid; therefore, device protection should ensure that the CCTWT is shut down if the solenoid current drops below the minimum specified value for the unit. (Consult the product specification for this value of solenoid current; the NP value is found in the Test Performance Sheet.) Turn-on must be accomplished only with the solenoid current at the NP value. During turn-off or with a power failure, the solenoid current must decay at a slower rate than the beam and collector power supplies.

For those CCTWTs with permanent-magnet focusing, the TWT and magnet are held together by bolts that should never be loosened. The magnet field strength is very high and must be maintained to ensure proper operation of the device. Disturbance of the magnetic field from external sources may seriously affect product performance and, in extreme cases, may destroy the device. All wrenches and screwdrivers used to mount and align the unit must be nonmagnetic. Magnetic materials should be kept at least 6 inches from the magnet, and other magnets should be at least 12 inches away, or serious damage to the device may result.

Cooling — CPI coupled-cavity TWTs are either conduction, forced-air, or liquid cooled. The cooling method used depends on the average power generated, with conduction cooling appropriate for the lowest and liquid cooling the highest power capability.

The conduction method requires the simplest cooling configuration of the three types. The device need only be bolted to the cooled base plate and the base plate held at or below the specified maximum temperature. A thin layer of thermal conductive grease is typically spread over the CCTWT base plate to enhance heat conduction from the device. The CCTWT and system base plates should be free of old thermal grease and other elements such as dirt and metal chips before applying the new layer of thermal grease.

The product specification states flow rate, direction of air flow, and maximum air temperature for forced-air cooling. The air should be filtered to eliminate deposits on the cooling surfaces. Some CCTWTs expose the collector insulator to the cooling air stream, and leakage currents may occur if the air is unfiltered. Some liquid-cooled units also required forced-air cooling to be circulated over the gun end of the device. This provides additional cooling for the gun elements, such as the focus electrode or control grid, to eliminate electron emission from these elements. Excessive gas generation may also occur within the device if the gun cooling air is not provided as specified.

Protection for overtemperature or less than specified air flow rates should be provided for all forced-air-cooled CCTWTs. Overtemperature sensing, if specified in the product specification, will be provided as a product component in the form of an overtemperature interlock switch. If it is not provided, air underflow protection should be used.

Liquid cooling is typically accomplished with water, a water/ethylene glycol mixture, or a dielectric fluid. Airborne devices typically use a dielectric fluid, which also may isolate the gun and collector insulators. Because the designs of water- and water/glycol-cooled CCTWTs are generally quite different from those of devices that use dielectric coolant, one coolant should not be substituted for another. Coolant type, flow rates, and maximum temperatures and pressure drops are provided in the product specification and/or the Test Performance Sheet supplied with each unit.

Each coolant should be handled and used with special care. Consult the manufacturer's publication before using dielectric coolants. Water and water/glycol coolant systems also require special design and maintenance; scaling and corrosion in the cooling system should be minimized to realize optimum product performance and life. Metals used in the cooling system should be close to copper in the galvanic series, and zinc-bearing alloys should be avoided. Coolant resistivity should be greater than 100K ohm-centimeters or as stated in the product specification. Distilled water cools most efficiently, but the coolant should never be permitted to freeze in the device. If the coolant is to be subjected to subfreezing environments, the use of coolant heaters or a mixture of water and ethylene-glycol up to 50 percent is recommended. Precautions should be taken to maintain the cleanliness of the cooling system, to keep the dissolved oxygen content of the coolant below 1.25 ppm, and to operate at the lowest inlet coolant temperature consistent with the operating temperature environment. Contaminants such as soaps, foaming detergents, water-soluble oils, and particulate matter larger than 50 microns are not allowed in the coolant; all sources of oils or grease should be eliminated. A coolant purification loop and/or coolant filtering may be desirable adjuncts. The system should be drained, cleaned, and refilled with fresh fluids at least annually. Protective flow rate interlock circuits should be provided. If coolant is allowed at any time to drip down the device and over the surface of the cathode ceramic, the resulting arcing with high voltage on is capable of destroying the device by inducing a ceramic puncture.

All liquid-cooled CCTWTs are tested with coolant passages subjected to static pressure in order to determine that no liquid leaks occur under pressure. The static pressure maximum should not be exceeded, as damage to the product may result.

Water and water/glycol coolants must be removed from the unit under shipment or storage conditions. Corrosion of the coolant channels is sometimes accelerated under stagnant coolant conditions. Water coolant in the unit may freeze during storage or shipment, and this may irreparably damage the device and void the warranty. Consult the CPI Marketing Department if questions arise.

Waveguide Arcs and Reflected Power — All coupled-cavity TWTs require strict control on the source and load VSWRs to ensure proper product operation. If the load and source reflections are high in band, excessive gain and phase ripple will occur. If the source and load VSWRs become excessive, the device may oscillate. In general, the source and load reflection coefficients need to be controlled over a greater bandwidth than the specified operation frequency band. The product specification for each individual product type should be consulted for requirements.

Coupled-cavity TWTs typically operate at power levels high enough to potentially induce waveguide arcing. Waveguide pressurization may be required, especially if the peak power level is high or if the air pressure is reduced from sea level atmospheric pressure. Waveguide arcing will send power back into the device and may cause breakage of the output window if the arc occurs at the window face. Waveguide arcs will travel to the source of the power; therefore, the system may require waveguide arc protection to guard against window breakage. Waveguide arc protection is typically provided by a light-source detector placed in the output waveguide and directed toward the CCTWT window. Detection of a waveguide arc must initiate TWT shutdown or attenuation of the rf drive to the device. Shutdown can involve complete turn-off of the CCTWT voltages or the beam current. Consult the product specification for the period of time allowed before the CCTWT or rf must be shut down and the method of shutdown recommended.

In addition, directional waveguide couplers are sometimes used to measure reflected power from the load to detect waveguide arcs. In a critical application, this type of waveguide arc protection is not recommended because of the possibility that the arc may be initiated between the CCTWT and the directional coupler and therefore would not be detected. If this type of protection is used, care should be exercised to ensure that the waveguide flanges mate properly and the waveguide is free of burrs and particles, especially between the CCTWT and the directional coupler.

RF Leakage — External leakage should be prevented by making tight rf input and output connections. Under certain tuning conditions, regeneration or oscillation can occur if rf energy from the output line or radiation from the antenna reaches the input cavity because of faulty rf connections, leaky cable, or inadequate shielding. RF is also coupled into the collector and can radiate from the collector insulator. RF radiation is hazardous. See Operating Hazards section.

INSTALLATION

Product Inspection — Inspect the device when it is removed from the container. If any obvious defects appear, a report should be sent to the factory at once. Any damage during shipment should be reported to the carrier.

All ceramic portions of the device should be clean and dry. Check the inside of the input and output waveguides for contaminants as well as the mating system waveguides; there should be no foreign particles of any kind. Do not apply stress to the waveguides.

WARNING

ALL UNITS SHOULD BE CAREFULLY HANDLED TO AVOID DAMAGE TO THE DEVICE AND PREVENT PERSONAL INJURY. TWTS THAT CANNOT BE HANDLED NORMALLY SHOULD BE CAREFULLY CONNECTED TO THE LIFTING DEVICE AND SLOWLY RAISED, PROTECTING THE GUN, WINDOWS, AND OTHER EXTERNAL COMPONENTS FROM STRIKING OR CATCHING ON PROTRUDING SURFACES.

Mounting —

1. Mount the unit in the correct position to align the waveguides and the electron gun.

2. Bolt the unit into the transmitter using the bolts and procedures called out in the system installation procedures.

3. For devices with permanent magnets, mounting screws, washers, and all other materials used within 6 inches of the permanent magnet must be nonmagnetic.

CAUTION

AVOID STRESSING THE DEVICE DURING INSTALLATION OF THE COOLANT CONNECTIONS. BE SURE THAT ANY QUICK-CONNECT FITTINGS HAVE BEEN LOCKED INTO PLACE.

Coolant Connections — For liquid-cooled CCTWTs, connect the coolant lines to the device, ensuring that the direction of flow is as marked on the device. On some units, the connectors are polarized, ensuring that the flow is in the correct direction. If the flow direction is unmarked, no special flow direction is required.

On some liquid-cooled CCTWTs with depressed collectors, the collector coolant channels are also operated depressed, Make sure that the coolant lines are capable of withstanding the depression voltage without arcing or excessive leakage. Ensure that all coolant lines are connected with the specified direction of flow and that coolant flow is at or above the specified minimum values.

For air-cooled devices, connections must be carefully mated to prevent excessive air loss. If the device has a thermal overtemperature switch, it should be connected and working. Systems with flow switches should also be checked for proper flow and operation.

Conduction-cooled devices should be bolted into position on the system base plate. Inspect the system and CCTWT base plates prior to installation to ensure proper mating over the complete base-plate area; thoroughly clean if necessary. A thin new coat of thermal grease placed between the CCTWT and system base plates aids in the transfer of heat to the system base plate. Install the CCTWT and torque mounting bolts to the specified values.

On all CCTWTs requiring air cooling of the gun structure, inspect the cathode-cooling fans or ducts to ensure adequate cooling is provided.

Electrical Connections — All CPI coupled-cavity TWTs utilize an internally connected heater and cathode. It is important that the negative high voltage be connected to the heater-cathode lead and not the separate heater connection to prevent the beam current from passing through the heater. If the heater supply is dc, the heater-cathode leads should be connected to the heater supply with the polarity positive and the separate heater lead negative.

1. Make the heater-cathode and heater lead connections.

2. Connect the beam-control electrode (either grid or modulating anode). Some units have both a grid and an insulated anode; both connections must be properly made.

a. Systems using CCTWTs with grids sometimes have grid-oscillation problems associated with both the device and the grid pulser. Ferrite beads are sometimes supplied with the device and are placed over the grid lead to help suppress these oscillations. Minor differences in a CCTWT and grid pulser may determine whether grid oscillations occur. Lead dress of both grid and cathode leads may also affect the onset of grid oscillations.

3. Make the collector connection(s).

WARNING

IN SOME SYSTEMS WITH DEPRESSED-COLLECTOR OPERATION, THE COLLECTOR BODY AND COOLANT CONNECTIONS WILL BE OPERATED BELOW GROUND POTENTIAL. IT IS IMPORTANT THAT ALL SYSTEMS ARE INTERLOCKED SO THE GUN AREA OF THE CCTWT AND THE COLLECTOR AREA OF THE SYSTEM HAVING EXPOSED DEPRESSED-COLLECTOR CONNECTIONS ARE PROTECTED AGAINST ACCIDENTAL CONTACT WITH VOLTAGES. SEE "OPERATING HAZARDS" SECTION.

4. The body is run at ground potential on all CPI coupled-cavity TWTs. It is important to make a good grounding connection to the CCTWT body and that the positive side of the beam power supply is also grounded through a low-impedance connection.

5. Make the input and output rf connections. Ensure that the waveguides are clean and free of foreign materials. Also make sure the waveguide flanges align properly without inducing excessive strain on the device. Use correctly sized bolts in all of the flange holes provided. The output waveguide may be operated pressurized in some systems. Adherence to these precautions will help prevent waveguide arcs. Consult the individual product specification for the specified value of waveguide pressurization required.

6. A VacIon® pump is supplied as an integral part of most CPI coupled-cavity TWTs. The VacIon pump should be operated at least every 6 months while the unit is in storage to verify that the device still has a vacuum and to pump it to a lower internal pressure; guidance on this procedure can be found in the product specification. Connect a positive 3-kV supply to the insulated terminal of the pump and the negative side to the CCTWT body.

WARNING

THE VACION POWER SUPPLY IS CAPABLE OF DELIVERY OVER 3000 VOLTS UNDER OPEN-CIRCUIT CONDITIONS. DO NOT ALLOW THE CABLE TO BECOME DAMAGED, AND DO NOT HANDLE THE CABLE WITH THE POWER SUPPLY ENERGIZED. MAKE SURE THE NEGATIVE SIDE OF THE PUMP POWER SUPPLY IS CONNECTED TO THE CCTWT BODY.

7. If the device is electromagnetically focused, connect the electromagnet electrical connector to the power supply. Electromagnet polarity is important; check the TWT or electromagnet outline drawing for the correct pin connections. All CPI coupled-cavity TWT electromagnets require forced-air or liquid cooling. Make the proper coolant connections and ensure proper flow before operating the electromagnet.

OPERATION

WARNING

DO NOT ATTEMPT TO OPERATE THIS DEVICE UNTIL IT HAS BEEN DETERMINED THAT ALL PRECAUTIONS HAVE BEEN TAKEN TO PROTECT PERSONNEL FROM ALL HAZARDS. PROTECTIVE DEVICES SUCH AS SHIELDS AND INTERLOCKING SWITCH CIRCUITS MUST BE IN OPERATION. REREAD AND COMPLY WITH ALL PRECAUTIONS AND PROCEDURES SPECIFIED IN THE "OPERATING HAZARDS" SECTION.

WARNING

***X-RAYS** — MOST COUPLED-CAVITY TWTs OPERATE AT VOLTAGES THAT PRODUCE DANGEROUS X-RADIATION DURING OPERATION. THE METALLIC DEVICE ELEMENTS PROVIDE A LIMITED DEGREE OF SHIELDING, BUT X-RADIATION LEVELS SHOULD BE MONITORED AND ADEQUATE X-RAY SHIELDING PROVIDED AROUND THE DEVICE, INCLUDING THE GUN REGION, FOR THE PROTECTION OF PERSONNEL. BOTH DEVICE AND SYSTEM MUST NEVER BE ALTERED IN ANY WAY THAT MIGHT DECREASE SHIELDING. RADIATION LEVELS SHOULD BE CHECKED PERIODICALLY TO ENSURE SAFE OPERATING CONDITIONS AND COMPLIANCE WITH STATUTORY AND REGULATORY REQUIREMENTS.* **NEVER** *APPLY BEAM VOLTAGE WITHOUT HAVING X-RAY SHIELDING IN PLACE. X-RAYS ARE DEADLY AND CANNOT BE DETECTED EXCEPT WITH SPECIAL EQUIPMENT. SERIOUS EXPOSURE MAY OCCUR WITHOUT PERSONNEL BEING AWARE. SERIOUS PERSONAL INJURY OR DEATH MAY OCCUR AT SOME LATER DATE AS A CONSEQUENCE.*

WARNING

***RF RADIATION** — THIS DEVICE IS DESIGNED TO PRODUCE HIGH-ENERGY RF RADIATION, ESPECIALLY IN THE MICROWAVE REGION. EVEN LOW LEVELS OF RF RADIATION CAN BE HAZARDOUS TO HUMAN HEALTH. PRECAUTIONS MUST BE TAKEN TO PREVENT EXPOSURE OF PERSONNEL TO THE STRONG RF FIELDS GENERATED BY THIS DEVICE. RF RADIATION DUE TO LEAKAGE AT THE WAVEGUIDE FLANGE SHOULD BE PREVENTED BY MAKING TIGHT RF INLET AND OUTPUT CONNECTIONS.* **NEVER** *OPERATE THIS DEVICE WITHOUT HAVING AN APPROPRIATE ENERGY-ABSORBING LOAD ATTACHED.* **NEVER** *LOOK INTO AN OPEN WAVEGUIDE OR ANTENNA WHILE THIS DEVICE IS ENERGIZED.*

Preliminary Check — Check the following conditions before applying voltages to the device:

1. Heater, cathode, and grid and/or anode leads connected correctly.
2. Collector lead(s) is (are) connected to supply correctly.
3. CCTWT body grounded.
4. Electromagnet (if required) connected correctly.
5. Arc or reflective power protective circuitry and all interlocks operating correctly.
6. RF connections made to the device.
7. Coolant correctly connected and flowing at the specified flow rates and temperature ranges.
8. RF drive at correct frequency range; rf should be turned off when first operating the device.
9. VacIon pump connected correctly and operating.
10. X-ray shielding in place.

WARNING

***HIGH VOLTAGE** — VOLTAGES REQUIRED FOR OPERATION OF THIS DEVICE ARE EXTREMELY DANGEROUS TO LIFE; EQUIPMENT MUST BE DESIGNED WITH PROTECTIVE INTERLOCK CIRCUITS TO MAKE PHYSICAL CONTACT WITH THESE VOLTAGES IMPOSSIBLE. SEE “OPERATING HAZARDS” SECTION.*

Application of Voltages — Recommended operating voltages and currents (nameplate values) are given on the Test Performance Sheet that accompanies each product. The turn-on procedures will be different for each product type and are included in the product specifications. Refer to the specific product specification for the correct method of turn-on.

The following steps are general guidelines for product operation:

1. Turn on the coolant flow, VacIon pump, and solenoid voltages applicable to the product type.
2. After the device has pumped to a few microamperes of pump current, heater voltage can be applied. Heater voltage should be applied such that the maximum heater surge current shown in the specification is not exceeded.
3. If applicable, apply grid-bias voltage or modulating-anode cutoff voltage at the values given on the Test Performance Sheet.
4. Apply voltages to the collector and cathode in accordance with the Test Performance Sheet. No current will be drawn while the grid or modulating anode are at the voltage applied in step 3. If the device has no grid or modulating anode, then full current will be drawn, and the voltage rise time given in the specification must be observed.
5. Apply grid-pulse voltage or modulating-anode voltage to draw beam current where applicable.
6. Turn on rf drive power, and operate within the drive power and frequency range given in the Test Performance Sheet.
7. Verify product performance against the data provided in the Test Performance Sheet.

Trimming CCTWT Performance — The device's performance can be trimmed by minor adjustments of the beam voltage and current. If the power and gain are low at the low-frequency end of the specified operating band. a slightly higher beam voltage will rapidly raise the gain and power at these frequencies. Likewise, higher power and gain can be reduced at the low-frequency end of the band by slightly reducing the beam voltage. Higher gain and power at the high end of the frequency band can be reduced by slightly reducing beam current or increased by increasing beam current. Only adjust beam current by making small changes to the grid-pulse voltage or to the modulating-anode voltage. For devices without grids or insulated anodes, the beam voltage and current cannot be independently adjusted. However, some adjustments can be made for the bandpass characteristics in these TWTs. Raising and lowering the beam voltage will raise or lower the power faster at the low-frequency end of the band than at the high-frequency end. However, the power and gain will generally rise across the band if the beam voltage is raised. Make these adjustments cautiously, and do not adjust the beam voltage or beam current more than 1   percent.

Removal of Voltages — Voltages are typically removed in the reverse order of turn-on or, alternatively, by firing the crowbar or turning off the prime power to the power supply. This last method is to be avoided if possible, but proper sequencing of voltages should be designed into the power supply so that inadvertent loss of prime power does not result in product damage. For prime power failures, the fall time of the voltages must be less than 10 milliseconds. For solenoid-focused devices, the solenoid current should decay slower than the other electrode voltages.

WARNING

PORTIONS OF COUPLED-CAVITY TWTs MAY ATTAIN HIGH TEMPERATURES. IT IS IMPORTANT TO EXERCISE EXTREME CAUTION DURING OPERATION OR IMMEDIATELY AFTER TURNING OFF POWER TO THE DEVICE TO PREVENT PERSONNEL FROM COMING INTO CONTACT WITH THESE HOT SURFACES. WHENEVER POSSIBLE, IT IS RECOMMENDED THAT THE COOLANT REMAIN ON FOR SEVERAL MINUTES AFTER TURNING OFF POWER TO THE DEVICE.

CAUTION

FOR NORMAL OPERATION AND/OR SHUTDOWN OR POWER INTERRUPTION, IT IS IMPORTANT THAT THE MAGNET POWER SUPPLY AND GRID-BIAS POWER SUPPLY, IF USED, DECAY AT A SLOWER RATE THAN OTHER SUPPLY VOLTAGES.

RETURNED PRODUCT FORM

Before any product is returned for repair and/or adjustment, written authorization from CPI for the return and instructions as to how and where the product should be shipped must be obtained. The product type and serial numbers and a full description of the circumstances giving rise to the warranty claim should be included. Such information will help establish the cause of failure and expedite adjustment or repair. For this purpose, a Returned Product Form is shipped with each product.

TRANSPORTATION AND STORAGE

Whenever possible, use the original packing case for both transportation and storage of the product when it is not in service. Drain the water from the unit, and blow out the remaining coolant with warm, dry air or follow the system operating instructions. The device should not be exposed to an icing or salt-spray environment during storage. The protective covers for the rf input connector, output flange, coolant connectors, and high-voltage connectors should be in place whenever the device is not installed.

CAUTION

WATER-COOLED CCTWTS CAN BE SERIOUSLY DAMAGED IF THE WATER IS ALLOWED TO FREEZE IN THE DEVICE'S COOLANT PASSAGES. FREEZING TEMPERATURES ARE GENERALLY ENCOUNTERED IN AIR SHIPMENTS. CORROSION OF THE COOLANT CHANNELS CAN ALSO OCCUR IF THE COOLANT IS NOT DRAINED FROM THE COOLANT CHANNELS DURING STORAGE PERIODS.

For CCTWTs with permanent magnets, storage shelves must be made of nonmagnetic materials and the TWTs must be stored at least 12 inches apart.

If a VacIon pump is an integral part of the device, the gas pressure level can be checked at any time when the TWT has been removed from its electromagnet and placed in storage. The VacIon pump permanent magnet must be in its correct position on the VacIon pump. Whenever the TWT is not in its electromagnet, do not operate the VacIon pump if its permanent magnet is not in place. When replacing the permanent magnet on the VacIon pump, align the holes of the brackets and the magnet, then fasten the magnet securely in place with the two screws originally provided for this purpose. Connect the VacIon pump cable to an appropriate power supply, and put the pump into operation according to the instructions provided for the VacIon pump and its power supply.