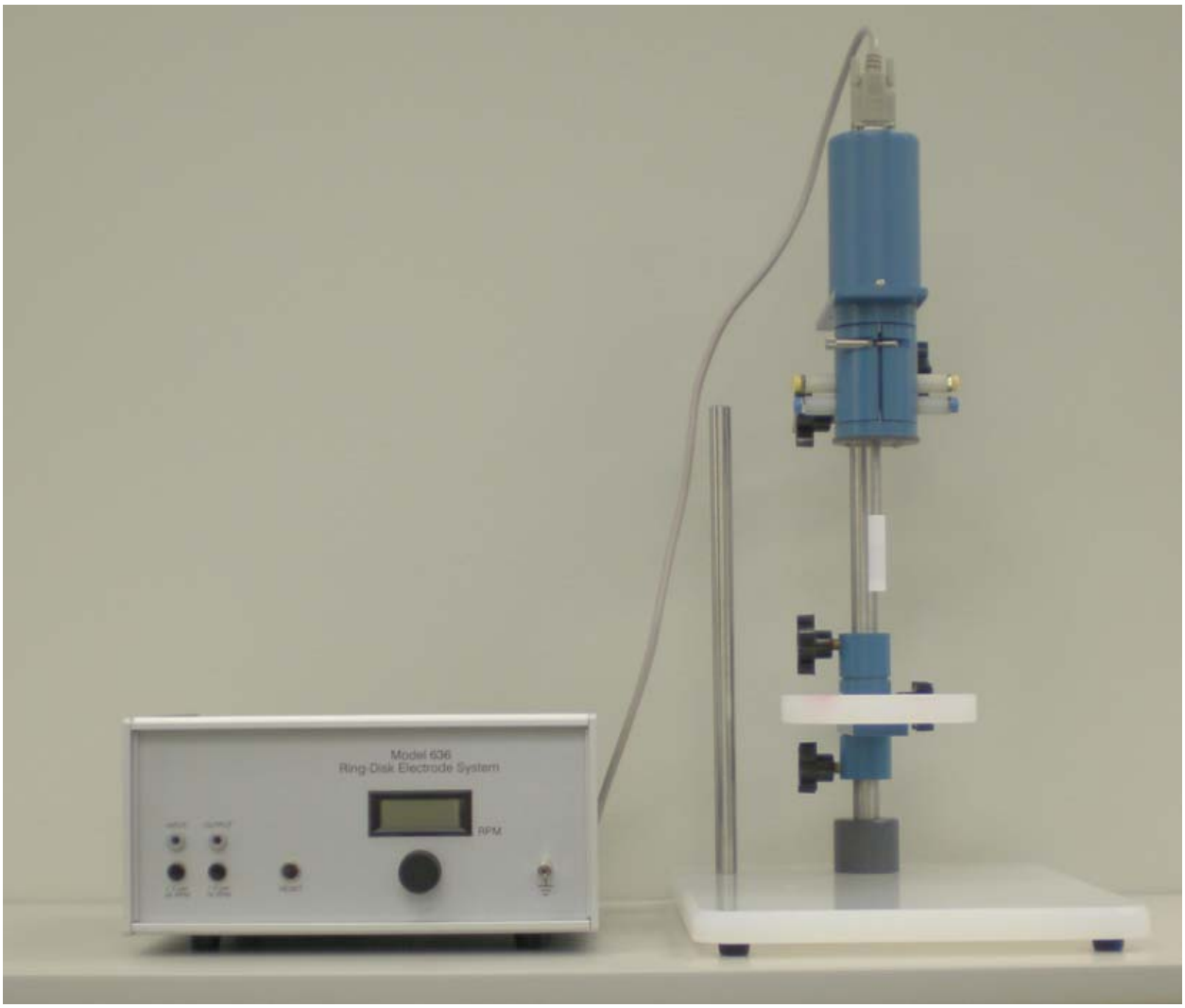
Model 636
Electrode Rotator

Hardware User's Manual

Manual Part Number 220892, Rev. E



Model 636 Electrode Rotator shown with RDE0027 Arbor and RDE0008 Glassy Carbon Disk

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1.0 GENERAL

1.1 Brief Description

Princeton Applied Research's Model 636 Rotating Disk Electrode is a solid-state-controlled servo-system designed to rotate an electrode in an electrochemical cell at a constant speed or at a speed that is modulated by a sine, square or other type waveform. The outstanding acceleration characteristics of the system allow the electrode speed to follow the input signal with little error. This feature is particularly desirable for use in hydro dynamically modulated applications.

1.2 Highlights

- Accurate speed control
- High performance system: rapid acceleration
- Speed may be modulated from an external source (square wave, sine wave, etc)
- Bi-polar power supply improves dynamic performance
- Chemical resistant base and cell shelf
- Cell shelf position is easily adjusted
- Use with Disk or Ring-Disk type electrodes
- Silver carbon contact brushes for low resistance and long life
- Voltage output proportional to rotational speed
- Speed range to 10,000 RPM
- Ideal for use in hydro dynamically modulated systems
- Low cost, high quality, highly reliable system
- Popular banana-type jacks used for input and outputs

1.3 Detailed Description

Princeton Applied Research's Model 636 Rotating Disk Electrode is a solid-state-controlled servo-system, capable of rotating an electrode at speeds from 5 to 10,000 RPM. The rotational speed may be precisely set via a 10 turn pot located on the front panel, and indicated on a 4 ½ digit display.

The jack marked INPUT allows the operator to apply an external signal to the rotator and causes l000 RPM of the electrode per volt applied. A positive voltage applied at the input jack produces counter-clockwise rotation at the electrode end of the rotator.

The jack marked OUTPUT gives a voltage indication of the electrode rotational speed with a calibrated value of 1.00 volt per 1000 RPM.

An outstanding feature of the Model 636 is its ability to accelerate and decelerate very rapidly, making possible the application of any waveform the operator desires. The inputs from the pot and the input jack are added electronically in the control box, and the sum is the electrode rotational speed. This feature permits the operator to modulate the electrode speed around a set speed or to simply control the speed from an external source.

The outstanding dynamic performance of the Model 636 RDE system is due to the use of a high speed, low inertia, permanent magnet DC motor and a high voltage, bi-polar power supply. The positive power supply voltage is approximately 25% greater than the motor's rating.

The body of the rotator may be easily raised or lowered; a cell shelf is provided whose height is easily adjusted. These features facilitate introduction and removal of the cell. The base is made of a chemically resistant material.

The Model 636 has been designed to accommodate both Disk and Ring-Disk type electrodes. Electrical connections are made to the electrode by silver carbon brushes - two each for the disk and ring - to provide consistent, reliable contact.

1.4 Specifications

Power: 100 - 240 VAC, +/-10%; 50/60 Hz; 2 amps

Weight: Electronic Control Unit (ECU) - 6.5 lbs Body-Motor Assembly - 23 lbs

Operating Temp: 10 deg C to 40 deg C

Dimensions: ECU: 11 3/8" W x 10 1/8" D x 5 3/4" H. Base: 11" x 15" x 3/4"

Motor: 1/50 HP permanent magnet DC

Motor Power Supply: +30 VDC, - 24 VDC

Speed Control: Closed loop servo-system; temperature compensated tach-generator is mounted on the motor shaft and provides rotational speed information

Speed Range: 50 to 10,000 RPM (Note: One should not exceed the recommended maximum rotation speed of the electrode itself which may be less than the maximum speed capability of the rotator. See the electrode package for recommended maximum rotation speed).

WARNING! Use of the 636 should be in an enclosed chamber or surrounded by a shielding device to prevent bodily harm in the event that an electrode or arbor becomes unstable, loose and is thrown from the system.

Accuracy: Within 1% of reading

Controls: Rear Panel On-Off switch; 10-turn pot, with 4 ½ digit display sets speed

Front Panel Connections:

Input Jack: for controlling the speed via an external source.
Output Jack: provides a voltage proportional to the rotational speed: 1 V/1000 RPM +/- 1%
Common Jack: DC common, isolated from the case.
Ground Terminal: connected to the ground lead of the power cord and to the case of the unit

Max Slew Rate of Motor: Approximately 300,000 RPM/sec (no load)

Bandwidth: @1000 RPM peak to peak modulation, 2000 RPM base speed:
>50 HZ,-1db

Motor Protection: 2.0 amp thermal-type circuit breaker; current limited power Supplies

1.5 Acceleration and Modulation Performance

Tests were run to determine the performance which may be expected of the Model 636. Note that these figures are given as general information, and are not necessarily exact specifications for all conditions under which the rotator may be operated.

NOTE: It is suggested that the operator determine the performance under his/her operating conditions.

The tests were performed with an electrode inserted, and four brushes in contact with the electrode shaft.

Response to a step input applied at the input jack:

Start Speed	End Speed	Rise Time
0 RPM	1K RPM	4 msec
0 RPM	5K RPM	10 msec
0 RPM	10K RPM	30 msec

Frequency response to a sine wave signal of 1 volt peak to peak (1000 RPM peak to peak) applied to the unit running at a base speed of 2000 RPM: -3db point at 100 HZ.

2.0 OPERATION

CAUTION – Disconnect all power before servicing

WARNING – Risk of Electric Shock

CAUTION – Disconnection of the Protective Earth Conductor may impair the protection provided by the System

WARNING- Use of the 636 should be in an enclosed chamber or surrounded by a shielding device to prevent bodily harm in the event that an electrode or arbor becomes unstable, loose and is thrown from the system.

2.1 Initial Inspection

Inspect the packing case and rotator for any damage; notify the carrier and Princeton Applied Research in case of any apparent damage.

Check the shipment against the packing list. Included with the rotator system should be:

1 Electronic Control Unit (ECU)
1 Body-Motor Assembly
1 Communications Cable
1 BNC-Double Banana Cable
1 Power Cord
1 Instruction Manual

2.2 System Set-Up/Installation

The system should be placed on a flat bench or a desk and there should be access to appropriate AC voltage outlets. Additionally, the area for system placement should be large enough to accommodate the rotator components and any additional instruments required for performing the desired experiments (e.g. computers, monitors, function generators, potentiostats, etc.).

The Body-Motor Assembly should be placed on a level area that is easily accessible to facilitate electrode/cell set-up and operation. Place the Electronic Control Unit (ECU) close to the Body-Motor Assembly so that the supplied cable may be connected to each of the assemblies.

Plug the “D” style cable end into the appropriate “D” style connector on the rear panel of the ECU, and then tighten the two screws to secure the connection. Be certain that the connector is fully inserted.

Plug the other end of the cable into the “D” style connector located on the top of the Body-

Motor Assembly and tighten the two screws to secure the connection. Be certain that the connector is fully inserted.

Plug the power cord into the appropriate connector on the rear panel of the ECU. It is suggested that the power switch located on the rear panel of the ECU is in the “OFF” position before connecting the power cord to the appropriate AC voltage source. Plug the power cord into an AC power outlet of the appropriate voltage. This outlet should have a good quality earth ground.

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The rotator is now electrically set-up and ready for the operator to introduce the electrode and the chemical cell into the system.

2.3 Electrode Coupling Instructions

Princeton Applied Research’s Model 636 rotator is manufactured with a precision electrode coupling. In order to obtain maximum performance from the rotator, proper mounting of the electrode to the rotator is critical.

1) Open the “clam-shell” by loosening the small knurled knob on the front of the rotator body.

2) Loosen each of the screws (2) on the electrode coupling inside the rotator body.

3) Carefully insert the electrode through the bottom bearing fully into the coupling.

4) Hold the electrode in the coupling while lightly tightening one screw. Rotate coupling (still holding electrode) and firmly tighten second screw. Rotate coupling and firmly tighten first screw.

CAUTION: To avoid damage to the electrode be certain that it is securely clamped in the rotator before releasing it.

5) If an interchangeable tip electrode arbor has been employed, the electrode tip is attached by sliding it onto the end of the arbor with the set screw in the tip in line with the machined flat on the arbor. Tighten set screw lightly with a 1/16" hex wrench. (Do not over tighten.)

NOTE: It is recommended that a small amount of silicon grease be applied to the arbor tip to prevent the electrode tip from seizing.

2.4 Control and Signal Electrical Connections

There are many configurations in which the Model 636 Rotator may be employed. This section will describe the connections for a simple potentiostat based system that utilizes the rotator, a ring/disk electrode and a bi-potentiostat.

The potentiostat should be set-up per the manufacturer's instructions.

If the speed of the rotator is NOT to be externally controlled or monitored, no connections need to be made to the jacks on the rotator's front panel.

If the speed of the rotator is to be externally controlled, then the rotator's DC Common (black jack on the front panel) should be connected to the common jack on the controlling device, which could be a function generator, certain potentiostats, programmable voltage source, computer based DAC system, etc.). The output of the controlling device should be connected to the jack on the rotator's front panel marked "INPUT". A positive voltage applied to the "INPUT" jack causes CCW rotation at the electrode end of the rotator.

If the speed of the rotator is to be externally monitored, then the rotator's DC Common (black jack on the front panel) should be connected to the common jack on the monitoring device, which could be an oscilloscope, certain potentiostats, DMM, computer based A/D system, etc.). The input of the monitoring device should be connected to the jack on the rotator's front panel marked "OUTPUT".

For a Princeton Applied Research supplied electrode, the connection to the disk section of the electrode is via either or both of the two yellow jacks located on the "clam-shell" style section of the rotator's Body-Motor Assembly; the potentiostat's "WE" or first working electrode connection is normally made to these jacks (NOTE: the use of both of these jacks reduces electrical noise as compared to the use of a single jack).

For a Princeton Applied Research supplied electrode, the connection to the ring section of the electrode is via either or both of the two blue jacks located on the "clam-shell" style section of the rotator's Body-Motor Assembly; the potentiostat's "WE2" or second working electrode connection is normally made to these jacks (NOTE: the use of both of these jacks reduces electrical noise as compared to the use of a single jack).

This completes the electrical signal connections to the rotator. There are other connections that must be made to the cell system, generally including the counter electrode and the reference electrode. Please see your potentiostat manual for connection instructions.

2.5 Chemical Cell Introduction

Once the unit has been set-up as described above, and the electrode has been properly mounted into the rotator coupling, the chemical cell may be introduced into the system.

The rotator has an adjustable cell shelf that facilitates introduction of the electrode into the chemicals. The height of the shelf and/or the rotator body may be easily raised or lowered as follows:

- Rotate the appropriate knob (located on the rear of the item near the vertical shaft) CCW with one hand, while securely holding the item with the other hand
- Gently move the shelf (or body assembly) up or down
- When the item is positioned as desired, rotate the knob CW to tighten
- CAUTION: be careful so that the item does not rapidly “fall” when the tension of the knob is loosened

2.6 Operation

The unit may now be operated. Adjust the round speed control knob on the front panel to the full CCW position. This is done so that the rotational speed will be zero or very low when power is applied. Apply AC power to the unit by pressing the top of the ON/OFF rocker switch located on the rear panel of the ECU. The 4 ½ digit display should come “ON” and display a low number, such as “0000” +/- 10 counts. Adjust the round speed control knob CW to increase the speed of rotation of the electrode; CCW to decrease the speed of rotation.

The electrode rotates in a CCW direction when driven by the internal source and viewed from the electrode end of the rotator.

2.7 Description of Components of the Unit

Electronic Control Unit: The control unit contains the drive circuitry, power supply, and control circuitry:

AC Power Cord: Connect to a 3-prong AC outlet of proper voltage with a good quality earth ground

Power Switch: Controls the AC power to the control box

Speed Adjust: 10 turn Pot with 4 ½ digit display of speed

Common Jack: Connected to DC common; used as common for measuring the rotator speed output and applying an external input (see below)

Output Jack: A voltage output appears at this point which is an indication of the rotator speed: 1 volt per 1000 RPM. The output impedance is about 600 ohms

Input Jack: A voltage may be applied to this point from an external source to cause the rotator to turn at a rate of 4000 RPM per volt applied. The voltage applied at this point is summed with the pot setting. The input impedance is 50K ohms. Do not exceed +/- 2.5 VDC applied

Ground Jack: Connected to the ECU/Body Assembly frame and to ground through the protective earth conductor of the power cord

Circuit Breaker: A 2.0 amp thermal- type circuit breaker is connected in series with the motor to protect the motor from overload

Body and Motor-Tach Assembly: This assembly contains the rotating components, frame, and base:

Motor-Tach: DC motor and DC tachometer are an integral unit

Frame: Supports the motor-tach, bearings, etc. Cell holder and motor tach section may be adjusted up and down on the column

Base: Chemical resistant material; supports the frame

Electrode Coupling: Holds the electrode in place

Electrode Bearing Assembly: Supports the electrode at two places

Pick-up Brushes: Contact the electrode for electrical pick-up

3.0 MAINTENANCE

CAUTION – Disconnect all power before servicing

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CAUTION – Disconnection of the Protective Earth Conductor may impair the protection provided by the System

3.1 General

The Model 636 Rotator is covered by a six month warranty. Attempts to recalibrate or modify the instrument by an unauthorized person may void the warranty. It is suggested that the factory be advised on all matters of improper operation.

3.2 Normal Maintenance and Cleaning

Normal regular maintenance of the rotator primarily consists of keeping the external surfaces of the system clean by wiping with a towel moistened with a mild, non-abrasive cleaner.

After many hours of operation, the electrode brushes may deposit silver-carbon “dust” in the areas near the brushes. This material may be simply wiped off with a slightly moistened, clean rag. It is not recommended to spray down the brush area with a solvent, as the solvent may remove the lubrication from the bearings.

The electrode brushes are field replaceable items. Please contact the factory for replacements and instructions.

The motor/tach is sealed and no maintenance is possible, or normally required. Faulty bearings in the motor/tach require replacement of the entire motor/tach unit.

The bearings that support the electrode (spindle bearings) last for many years under normal operating conditions. However, under certain operating conditions including such conditions as long-term high speeds or exposure to harsh chemical fumes, their life may be shortened. These bearings may be replaced in the field; contact the factory for replacements and instructions.

3.3 Technical Assistance

Princeton Applied Research
801 S. Illinois Ave.
Oak Ridge, TN 37830
865-425-1289

3.4 Trouble Shooting

CAUTION – Disconnect all power before servicing

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This section provides some suggestions for an operator to follow in the event of problems.

Problem	Cause and/or Action
Motor fails to rotate	Check the motor shaft and spindle for freedom of rotation
	Confirm that the unit is connected to a live outlet of the proper voltage, that the power switch is "on" and the digital meter display is “ON”
	Check the connection from the ECU to the motor-tach assembly: push connection on and tighten appropriate screws fully
	Check the circuit breaker: reset if tripped
	The pot should not be set to full CCW position; rotate clockwise to increase the speed
	Remove the top cover and insure that the printed circuit board is fully inserted into the connector
	Faulty connection or wire – contact the factory
	Faulty circuitry or motor – contact the factory
Motor runs at high speed at any Pot setting	Faulty connection or wire – contact the factory
	Faulty circuitry – contact the factory
Excessive audible noise	Spindle bearings are worn – contact the factory
	Motor bearings are worn – contact the factory

Excessive electrical noise	Connect DC Common to the Ground Jack; use only one point in the system as the common; eliminate ground loops CAUTION: Care must be taken when making connections to ground. This should be done only on a "floating" system. Contact the factory for more information.
	Use shielded cables as connections to the brushes
	Clean the surface where the brushes contact the rotating rings
The breaker trips	The breaker is a thermal type, sized to limit the average motor current to within the motor specification. Running the motor at a high modulation rate, or great amplitude changes, or a combination of the two, may cause tripping. It may be necessary to reduce the modulation rate and/or amplitude to prevent tripping of the breaker

4.0 ELECTRODES

4.1 General

A variety of electrodes are available for the Model 636. The user can choose from Platinum (Pt), Gold (Au), and glassy carbon (GC) for disk electrodes. A choice of Pt and glassy carbon for the disk and Pt and Au for the ring is available for ring-disk work.

While many users are interested in the behavior of a species in solution at an inert electrode, the corrosion scientist is concerned about the behavior of many different active electrodes. The needs of this group have been answered by the use of our Quick-Change electrode assemblies. An investigator can choose a disk geometry or a cylinder geometry and have the electrode machined out of the metal of interest. The rotator is designed to accept different arbors to accommodate these two options.

4.2 Accessories

The Model 636 can be used either as a simple rotating disk electrode (like the Model 616), or as a rotating ring-disk. Reflecting the 636's dual nature, there are two different sets of accessories, according to the intended use. Note that the Model 636, as supplied, comes with without an arbor, electrode, or accessories.

The available electrodes (part number and description) and accessories are listed below.

Used as a Simple Rotating Disk Electrode:

Arbor: RDE0027 Disk Arbor

Permanent Disk Electrodes (5.0mm diameter):
RDE0004 Platinum
RDE0005 Gold
RDE0008 Glassy Carbon

Customer-Made Disk Electrodes: (Disk Electrodes 11.3 mm diameter, 1 cm2 surface area. The material adjacent to the electrode surface is Teflon. The electrode body is Kel-F. 17.0 mm od shroud.)
RDE0001 Disk Electrode Assembly (with a 430 SS sample)
RDE0002 Disk Installation Tools

Customer-Made Cylinder Electrodes: (Cylinder electrodes 12.0 mm diameter, 12.4 cm height, 3.0 cm2 surface area. The material adjacent to the electrode surface is Teflon. The electrode body is Kel-F. 12.0 mm od shroud.) The Cylinder Electrode Assembly can be ordered either with or without a sample:

RDE0011 Cylinder Electrode Assembly and Tool (with a 430 SS sample)
RDE0012 Cylinder Electrode Assembly and Tool (without a sample)

Used as a Ring-Disk Electrode:

Arbor: RDE0070 Disk Arbor

Disk Non Changeable: (Requires RDE0070 Ring-Disk Arbor)
RDE0071 Pt Disk; Pt Ring
RDE0072 GC Disk; Au Ring
RDE0073 GC Disk; Pt Ring

NOTE: For custom electrodes not listed above, please contact your representative for a custom availability and quotation.

4.3 Additional Supplies for 636 (&616)

RDE0018 Analytical Cell Kit. Includes:

K0060 Cell Bottom (glass, 5-50 ml)
K0066 Top Assembly (not used in rotating electrode applications)
RDE0010 Top Assy (five holes). The center hole is 1.6 mm to accept the working electrode arbor. The other four are 1.4 mm standard taper ports to accept reference and counter electrodes, purge tube, etc.)
RDE0019 Purge Tube
RDE0020 Reference Electrode Tube Assembly
RDE0021 Pt Counter Electrode Wire (6 in)
RDE0022 AgCl-KCl Filling solution
RDE0023 Counter Electrode Bridge Tube
RDE0024 Reference Electrode Cap
RDE0025 Counter Electrode Cap & Screw
1601-0077-09 Cell Collar
2811-0205-0 Counter Electrode Screw

These items can also be ordered separately.
G0028 Purge Tube (Incorporates T14/20 standard taper joing to fit K0066 or RDE0010 Cell Top. Two-way Teflon stopcock directs inert gas stream through analyte solution for displacement of disolved oxygen, or over solution to form inert gas blanket. Only flexible Teflon tubing contacts solution.)
G0100 Vycor Frits, 4 mm (pkg of 5)
K0015 Polishing Kit
K0062 Low-Volume Cell Bottom (glass, 2-50 ml)
K0064 Jacketed Cell Bottom (a water jacketed version of the K0060 Cell Bottom suitable for connection to constant-temperature circulators)
RDE0026 Reference Bridge Tube

4.4 Electrode Care

Electrodes designed for use with the Model 636 are precision research tools. Each is tested and guaranteed to be leak free before shipment. The test was conducted at an ambient temperature of about 23 degrees Celsius in a solution of 0.2M H_2SO_4 .

1. Precautionary measures should be taken to avoid damage to the electrode. Leave the electrode wrapped when not in use.

2. Do not use teflon shrouded electrodes above 30 degrees C because expansion at higher temperatures may cause the electrode to leak.

3. Keep the protective cover on the electrode when not in use.

4. Mount the electrode securely in the rotator. Do not apply excessive force to the teflon shroud or the electrode because it can cause slipping of the shroud along the metal shaft. Mount the electrolysis cell so that the electrode enters the cell through the electrode port with the end of the electrode submerged approximately 5 mm below the surface of the solution. The electrode should be centered in the electrode port so that the shroud doesn't rub against the cell cover.

5.0 TRANSPORTATION

It is suggested that the packing materials in which the unit was originally shipped be maintained for any future shipping requirements, either back to the factory for repair/modification, or to some other location. These packing materials were designed to provide both protection in shipment and minimum size and weight for efficient shipment. PAR normally employs carriers such as UPS, DHL or FedEx for shipment of these units.

6.0 STORAGE

In the event that the rotator system is not going to be used for a long period of time, it is suggested that it be stored in the original packaging material to prevent damage. In any case the unit should be stored at temperatures between 0 and 100 degrees F, and at humidity levels less than 95% non-condensing.

Advanced Measurement Technology, Inc.

a/k/a Princeton Applied Research, a subsidiary of AMETEK®, Inc.

WARRANTY

Princeton Applied Research* warrants each instrument of its own manufacture to be free of defects in material and workmanship. Obligations under this Warranty shall be limited to replacing, repairing or giving credit for the purchase price, at our option, of any instrument returned, shipment prepaid, to our Service Department for that purpose within ONE year of delivery to the original purchaser, provided prior authorization for such return has been given by an authorized representative of Princeton Applied Research.

This Warranty shall not apply to any instrument, which our inspection shall disclose to our satisfaction, to have become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation, or other causes beyond our control. This Warranty shall not apply to any instrument or component not manufactured by Princeton Applied Research. When products manufactured by others are included in Princeton Applied Research equipment, the original manufacturer's warranty is extended to Princeton Applied Research customers.

Princeton Applied Research reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF. THIS WARRANTY IS IN LIEU OF, AND EXCLUDES ANY AND ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING MERCHANTABILITY AND FITNESS, AS WELL AS ANY AND ALL OTHER OBLIGATIONS OR LIABILITIES OF PRINCETON APPLIED RESEARCH, INCLUDING, BUT NOT LIMITED TO, SPECIAL OR CONSEQUENTIAL DAMAGES. NO PERSON, FIRM OR CORPORATION IS AUTHORIZED TO ASSUME FOR PRINCETON APPLIED RESEARCH ANY ADDITIONAL OBLIGATION OR LIABILITY NOT EXPRESSLY PROVIDED FOR HEREIN EXCEPT IN WRITING DULY EXECUTED BY AN OFFICER OF PRINCETON APPLIED RESEARCH.

SHOULD YOUR EQUIPMENT REQUIRE SERVICE

A. Contact the Customer Service Department (865-482-4411) or your local representative to discuss the problem. In many cases it will be possible to expedite servicing by localizing the problem.

B. If it is necessary to send any equipment back for service, we need the following information.

1. Model number and serial number.
2. Your name (instrument user).
3. Your address.
4. Address to which the instrument should be returned.
5. Your telephone number and extension.
6. Symptoms (in detail, including control settings).
7. Your purchase order number for repair charges (does not apply to repairs in warranty).
8. Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation).

C. U.S. CUSTOMERS — Ship the equipment being returned to:

Advanced Measurement Technology, Inc.
801 S. Illinois Avenue
Oak Ridge, TN 37831
ATTN: Customer Service

PHONE: 865-482-4411
FAX: 865-483-2133

D. CUSTOMERS OUTSIDE OF U.S.A. — To avoid delay in customs clearance of equipment being returned, please contact the factory or the nearest factory distributor for complete shipping information.