

INSTRUCTION BOOK FOR

BIRD

MODEL 694
TERMALINE[®]
WATTMETER

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MODELS COVERED IN THIS INSTRUCTION BOOK

I N S T R U C T I O N B O O K
F O R

M O D E L 6 9 4

BIRD

Electronic Corporation

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SAFETY PRECAUTIONS

The following are general safety precautions that are not necessarily related to any specific part or procedure and do not necessarily appear elsewhere in this publication.

Keep away from live circuits.

Operating personnel must at all times observe normal safety regulations. Do not attempt to replace parts or disconnect an RF transmission or any other high voltage line while power is applied. When working with high voltage always have someone present who is capable of rendering aid if necessary. Personnel working with or near high voltage should be familiar with modern methods of resuscitation.

Warning: Warning notes call attention to a procedure, which if not correctly performed could result in personal injury.

Caution: Caution notes call attention to a procedure, which if not correctly performed could result in damage to the instrument.

The following will appear in the text of this publication and are shown here for emphasis.

```
*****  
*                               W A R N I N G                               *  
*                               *                                           *  
* Before applying RF power to the wattmeter be sure to *  
* remove the shipping plug, located on the top rear of *  
* the coolant tank. Replace the shipping plug with the *  
* supplied breather vent plug. This is important as *  
* internal pressure build-up, caused by expansion of the *  
* heated dielectric coolant, could cause damage to the *  
* equipment and injury to the operator. *  
*                               pg 1 *  
*****
```

```
*****  
*                               C A U T I O N                               *  
*                               *                                           *  
* No parts in the voltmeter may be replaced without *  
* affecting the calibration. *  
*                               pg 3 *  
*****
```

Continued

* W A R N I N G *
* *
* Never attempt to disconnect any RF equipment from the *
* transmission line while RF power is being applied. *
* Leaking RF energy is a potential health hazard. *
* pg 5 *

* C A U T I O N *
* *
* Do not operate this equipment over the rated 1000 watts *
* continuously. Damage to the resistive element will *
* result. *
* pg 5 *

* W A R N I N G *
* *
* Using this load in the upper end of its power *
* dissipation range will cause the housing to become hot! *
* Care should be exercised in touching it. *
* pg 5 *

* W A R N I N G *
* *
* When using dry cleaning solvents, provide adequate *
* ventilation and observe normal safety precautions. *
* Many dry cleaning agents emit toxic fumes that may be *
* harmful to your health, if inhaled. *
* pg 6 *

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MODEL 694 TERMALINE® WATTMETER

INTRODUCTION

DESCRIPTION

The Model 694 is a direct reading instrument for absorbing and measuring RF power in 50 ohm coaxial line systems through the range of 2 to 30 MHz. This portable instrument is used for field or laboratory testing of RF transmitters under nonradiating conditions. Its intended use is for CW, AM, SSB, and TV modulation envelopes. This model utilizes the unique Bird RF input receptacle, designed to accept any of the Bird Quick-Change RF connectors.

PERFORMANCE CHARACTERISTICS AND CAPABILITIES

The termination wattmeter will display and absorb RF power over a range of 0 to 1000 watts for the frequency band of 2 to 30 MHz. The power measurements are made with an error that does not exceed ± 5 percent of full scale. The power reflected by the load section will not cause the VSWR to rise above 1.1 to 1.0.

Among other uses, the Model 694 can be used for:

1. Checking the RF output of transmitter.
2. Routine and troubleshooting maintenance.
3. Production and acceptance tests.
4. Transmitting tests.
5. Loss measurements of RF transmission lines.
6. As an accurate RF line termination, substantially independent of frequency and line length.

DIMENSIONS AND WEIGHT

The dimensions of the meter and load combined are 20-19/32 inches long by 5-15/16 inches wide by 8-3/4 inches high (523 x 151 x 222 mm). The net weight is 29 pounds (13 kg) and the shipping weight is 34 pounds (15.4 kg).

POWER AND UTILITY REQUIREMENTS

The Model 694 is a passive device and therefore does not require an external source of power for operation other than the RF input. This unit does not require water or other external supplements for cooling.

ENVIRONMENTAL REQUIREMENTS

The ambient temperature must remain within the range of minus 20 to plus 40 degrees celsius (-4F to +104F) for proper operation. It would be preferable to locate the wattmeter in as dust and vibration-free an environment as possible. Approximately one foot of clear space should surround the equipment to provide adequate convection for the cooling process of the load portion.

ITEMS FURNISHED

The Model 694 is furnished complete and with no separate items other than this instruction book.

ITEMS REQUIRED

The only additional item needed is a coaxial cable equipped with the appropriate mating RF plug to mate with the "QC" connector supplied on the wattmeter.

TOOLS AND TEST EQUIPMENT

Only simple tools such as a screwdriver and adjustable wrench are needed for disassembly. A resistance bridge or an ohmmeter with an accuracy of one percent or better at 50 ohms is recommended for checking the condition of the load resistor.

SPECIFICATIONS FOR 694 TERMALINE® WATTMETER

Impedance	50 ohms nominal
VSWR	Less than 1.1 to 1 in specified frequency
Connectors	Bird Quick-Change type. Female N normally supplied
Power Range	0-1000 watts
Frequency Range	2-30 MHz
Accuracy	±5% of full scale
Dimensions	20-19/32"L x 5-15/16"W x 8-3/4"H (523 x 151 x 222 mm)
Ambient Temperature	-20°C to +40°C (-4F to +104F)
Cooling Method	Oil dielectric & natural convection currents
Weight	29 lb (13 kg)
Operating Position	Horizontal only
Finish	Light navy gray baked enamel per MIL-E-15090

SECTION I - INSTALLATION

1-1. PORTABILITY

1-2. The Model 694 TERMALINE® RF Wattmeter is essentially a portable test equipment instrument. It should be placed as close as possible to the equipment of which the power output is to be measured. A retractable handle is placed in the center of the top face of the radiator for ease of carrying the unit.

1-3. OPTIONAL FIXED MOUNTING

1-4. The wattmeter may be fastened to an operating table, test bench, etc. For this purpose, the four rubber bumpers held on by acorn nuts may be unscrewed from the flanged feet at the bottom of the radiator, and the four 9/32 diameter holes used to mount the wattmeter. Use standard 1/4 inch hardware.

1-5. If the wattmeter is to be mounted on rigid benches, or work surfaces which are not shock mounted, use shock mounts under the wattmeter to replace the shock protection afforded by the rubber feet. The central bushings of suitable small shock mounts may be attached with 1/4-20 machine bolts through the holes in the radiator feet, and the flanges of the mounts screwed to the mounting surface or to an auxiliary metal plate.

1-6. LOCATION

1-7. Free circulation of air around the wattmeter is necessary if operated above 300 watts for more than a few minutes. Avoid mounting it on or along side of heated surfaces. Operate only in the normal position with feet resting on a horizontal surface. Allow at least one foot of clearance on all sides. Space above the wattmeter should be kept as unobstructed as possible for good ventilation.

```
*****  
*                               W A R N I N G                               *  
*                                                                                   *  
* Before applying RF power to the wattmeter be sure to                       *  
* remove the shipping plug, located on the top rear of                         *  
* the coolant tank. Replace the shipping plug with the                         *  
* supplied breather vent plug. This is important as                           *  
* internal pressure build-up, caused by expansion of the                       *  
* heated dielectric coolant, could cause damage to the                       *  
* equipment and injury to the operator.                                         *  
*****
```

SECTION II - THEORY OF OPERATION

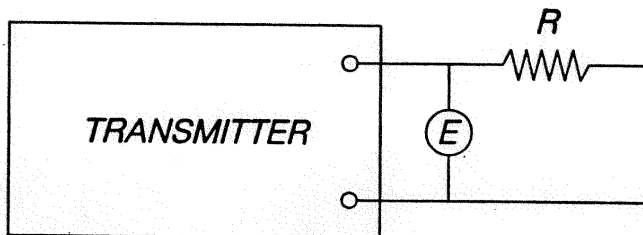
2-1. INTRODUCTION

2-2. There is very little lumped-constant, conventional circuitry in this instrument. Circuit elements are of the distributed constant type, machined and fabricated, as in microwave components.

2-3. BASIC PRINCIPLES

2-4. The method of power determination used in the Model 694 TERMALINE® Wattmeter may be expressed as $W = E^2/R$, where E is the voltage across the resistor R , and W is the power in watts. Figure 2-1 illustrates the E^2/R power measurement similar to that used in the Model 694. RF energy flows from the transmitter through the resistor R , producing a voltage drop across this resistor. The RF voltage is rectified by a crystal diode and voltmeter E displays the drop. It is important that the output impedance of the transmitter be equal to the resistance R , and that the voltmeter is accurate at the operating frequency.

FIGURE 2-1. E^2/R METHOD OF POWER MEASUREMENT



2-5. CRYSTAL VOLTAGE LEVEL

2-6. The crystal operates at 1.2 volts and 100 microamps rectified dc for full scale deflection. This value is conservative with respect to overload damage. It has been determined that four times full scale power can be applied momentarily without appreciable change in crystal characteristics or calibration. Since the crystal voltmeter is connected across the load resistor, substantial power is required for voltage overload.

2-7. The stability realized from the application of crystal diodes in calibrated direct-reading voltage or power measuring instruments is surprising. From a long program of measurements in the laboratory and from field experience with many similar instruments in industrial use, it has been found that the calibration will be stable and hold well. There is no indication of long-term aging and calibration may be expected to hold within 2 percent for variations chargeable to the crystals.

2-8. COOLING SYSTEM

2-9. Heat Transmission - To assure full power rating, the cylindrical film resistor is immersed in coolant which carries heat by convection to the inside wall of the enclosing cylinder through openings in the coaxial metal shell. From there, heat is conducted to the radiator fins and carried away

by natural air convection. It will handle the rated power (1000 watts) at an ambient temperature of up to +40°C (+104F) without damage.

2-10. ELECTRICAL SIGNIFICANCE OF COOLANT

2-11. The unit must be reasonably full of the proper dielectric coolant, approximately 1.1 gallon, (4.2 l) or the RF input impedance and calibration may be seriously impaired. The dielectric constant of the coolant is an important factor in determining the input impedance. Careful attention has been given to obtaining a design which is leak-proof under service conditions. In order to get both high quality RF connections and a leak-proof assembly, Teflon insulators are compressed as gaskets for the RF connections and O-Ring seals of synthetic high temperature resistant rubber are used.

```
*****
*                               C A U T I O N                               *
*                               *                                           *
* No parts in the voltmeter may be replaced without                       *
* affecting the calibration.                                               *
*****
```

SECTION III - OPERATING INSTRUCTIONS

3-1. USE AND FUNCTION OF CONTROLS

3-2. There are no operating controls, the read-out meter is the only functional part of the Model 694 TERMALINE® Wattmeter that the operator uses. The meter is labeled in 200 watt major divisions from 0 to 1000 W and subdivided into 20 watt increments. The power absorbed by the load portion is indicated in watts by the meter. A hinged metal lid can be swung down to cover the meter.

3-3. INITIAL ADJUSTMENTS AND CONTROL SETTINGS

3-4. Check the meter to be sure that it reads zero under a no-load condition. If the meter needle does not rest on zero, use a small screwdriver to turn the adjustment screw on the lower center face of the meter movement to bring the needle back to zero.

3-5. START-UP

3-6. It is only necessary to attach the coaxial cable from the RF source to the "QC" connector on the front panel of the wattmeter and then activate the transmitter to apply RF power. There are no ON/OFF controls on the Model 694 or other adjustments to make. See para 3-7 Normal Operation following.

3-7. NORMAL OPERATION

3-8. Place the wattmeter where a short patch cord, preferably not over five feet long, will connect the transmitter to the wattmeter and where the meter is conveniently seen while adjusting the transmitter.

3-9. With the TRANSMITTER OFF (see Warning in para 3-13), disconnect the antenna line and connect the wattmeter. For this use a patch cord of 50 ohm cable, such as RG-213/U or RG-214/U equipped with type N plugs such as UG-21D/U.

3-10. Turn the TRANSMITTER ON. The wattmeter will directly indicate the RF power being absorbed.

3-11. If an adjustment to the transmitter is necessary, follow the instruction book pertaining to transmitter tune-up.

3-12. When the desired output has been obtained, NOTE THE READINGS of the wattmeter and of the meters provided on the transmitter, particularly the plate current and voltage meters on the final stage, and of the antenna line monitor. These readings bear a direct relationship to power output, and are useful in relating the transmitter output to its antenna and to its output into the wattmeter.

3-13. TURN TRANSMITTER OFF before opening RF connections to the wattmeter.

```

*****
*                               W A R N I N G                               *
*                               *                                           *
* Never attempt to disconnect any RF equipment from the *
* transmission line while RF power is being applied. *
* Leaking RF energy is a potential health hazard. *
*****

```

3-14. RECONNECT THE ANTENNA LINE, TURN TRANSMITTER ON and note its meter readings. If the antenna impedance (VSWR) is correct, the transmitter meters will read as they did with the wattmeter connected. Some allowances should be made for the fact that VSWRs around 2 to 1 are normal at some frequencies in the range of good broadband antennas.

3-15. OPERATION UNDER EMERGENCY, ADVERSE, OR ABNORMAL CONDITIONS

3-16. The Model 694 is designed to dissipate 1000 W of RF power in continuous operation. It will withstand moderate overloads for limited periods of time. The wattmeter portion will not, of course, be able to read these excessive power levels.

```

*****
*                               C A U T I O N                               *
*                               *                                           *
* Do not operate this equipment over the rated 1000 watts *
* continuously. Damage to the resistive element will *
* result. *
*****

```

```

*****
*                               W A R N I N G                               *
*                               *                                           *
* Using this load in the upper end of its power *
* dissipation range will cause the housing to become hot! *
* Care should be exercised in touching it. *
*****

```

3-17. SHUTDOWN

3-18. Since the Model 694 is a passive device, there is no way to turn it off. The only way to prevent RF energy from entering the equipment is to turn off the RF source instead. After de-energizing the equipment, allow time for the load to cool before touching the cooling fins.

3-19. EMERGENCY SHUTDOWN

3-20. As in para 3-17 Shutdown, turn off the RF source.

SECTION IV - MAINTENANCE

4-1. TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
RF power ON; no meter response	Damaged meter	Replace meter, see para 4-11 Calibration.
	Defective meter cable assembly	Check continuity. Replace if defective.
	Burnt out resistor	Replace resistor-voltmeter assembly, see para 4-21 Repairs.
	Defective or broken transmission line	Turn off RF power and inspect transmission line and connectors.
	Open diode	Replace resistor-voltmeter assembly, see para 4-21 Repairs.
Inaccurate readings	Defective meter	Check meter, see para 4-11 Calibration.
	Defective load	Check load, see para 4-21 Repairs.

4-2. CLEANING

```

*****
*                               W A R N I N G                               *
*                               *                                           *
* When using dry cleaning solvents, provide adequate                       *
* ventilation and observe normal safety precautions.                       *
* Many dry cleaning agents emit toxic fumes that may be                 *
* harmful to your health, if inhaled.                                       *
*****

```

4-3. Dust off the unit when necessary, removing any deposit of dirt or grime particularly from the cooling fins. Especially important - keep the jacks and plugs clean.

4-4. Keep the plug on the meter cable firmly in place on the dc jack at the side of the voltmeter block. This excludes dirt and moisture. If this connector has been stationary for a long time, slightly loosen (unscrew) the knurled nut on the plug, rotate its right angled sleeve back and forth a few times to clean the contacts, then retighten securely.

4-5. Protect the power input jack by keeping it plugged or covered when not in use. If the connector parts become dirty, clean carefully with a clean dry cloth. Use a self-drying contact cleaner that leaves no residue on the inaccessible portions. Give special attention to cleaning the exposed faces of the Teflon insulators and also to all of the coaxial surfaces.

4-6. INSPECTION

4-7. A periodic inspection is recommended. The major objective will be to check for the accumulation of dust on the cooling fins which would impede their ability to dissipate load heat into the surrounding air (see para 4-3). Also check for any interference with or blockage of free air circulation over the cooling fins. Inspect the rear O-Ring seal clamp band assembly for signs of possible coolant leakage.

4-8. PREVENTIVE MAINTENANCE

4-9. Cleanliness is the most important preventive maintenance activity (see paras 4-2 Cleaning and 4-6 Inspection). Anything that interferes with proper and rapid heat dissipation by the load could result in overheating and possible damage to the equipment. If any portions of the radiator are corroded or rusted, clean the area carefully with a fine flint sandpaper, and touch up with gray enamel.

4-10. Dropping is the most likely source of damage to the wattmeter. DO NOT DROP IT. The microammeter movement or voltmeter parts might be damaged. Close the meter lid when not in use, particularly when carrying the wattmeter.

4-11. CALIBRATION

4-12. Microammeter (Meter Assembly - Bird P/N 2760-021-2) -

a. Replacement of the microammeter without wattmeter recalibration may alter accuracy (possibly up to 3 percent but normally not more than 2 percent of full scale).

b. These meters can be checked for accuracy. However, this should be attempted only by one familiar with procedures for testing sensitive dc microammeters as they can be readily damaged.

c. USE CARE: Test the meter as a microammeter in series with a low voltage battery, variable resistor, and an accurate external microammeter. Full scale deviation should be 100 microamperes \pm 2 percent.

4-13. Resistor-Voltmeter (RF Section - Bird P/N 6940-003) - The resistor-voltmeter unit is an integral component, not subject to further disassembly by field maintenance. The condition of the load resistor proper may be checked by its dc resistance. A resistance bridge or ohmmeter with an accuracy of 1 percent or better at 50 ohms is required. Use a low resistance lead, preferably a short length RG-213/u coaxial cable with a UG-21D/U plug attached to mate with the female N type input connector. A

change of more than 2 ohms from the value of the resistance stamped on the nameplate may cause wattmeter readings beyond tolerance. It should be noted that even within allowed dc tolerance of the load resistor, a change in this resistance will produce a corresponding apparent change in the wattmeter reading. Be sure that there is a sufficient amount of dielectric coolant. When the load is cool and in a horizontal position, there should be about 1/4 inch of coolant covering the bottom of the storage tank. This will provide enough room for coolant expansion.

4-14. **DISASSEMBLY**

4-15. RF Sections -

a. To remove the RF section from the wattmeter, loosen the two slotted special drum-head screws at the front of the meter case just below the corners of the lid. Unscrew these fasteners until they are free of the studs behind, which project from the radiator face. Pull the meter box off enough to expose the voltmeter block at the side of the nosepiece. Unscrew the knurled nut from the jack on the voltmeter block to disconnect the meter cable. Remove the meter cable and the meter box assembly entirely.

b. Remove the vent plug, P/N 2450-094, on the top of the coolant tank and replace with shipping plug, P/N 2450-049, to avoid spilling out coolant. Stand the wattmeter vertically, with the nose up, and brace the radiator so that it won't tip over. Unscrew the 10-32 clamping screw on the V-band on the top face of the radiator.

c. Remove the V-band and pull the resistor-voltmeter unit (RF section) straight up and out from the radiator tank. Allow sufficient time for coolant drainage before removing the unit from face of tank. Replace the RF section if required.

4-16. Main Radiator Tank Rear Cover and Seal -

a. Before loosening the rear end (if the coolant has not been drained from the tank) the radiator should be stood on end with the connector pointing down. Unscrew the four 10-32 truss head screws at the corners of the guard cover, P/N 2430-078, and remove the guard box. Unscrew the tube nut from the tank nozzle and pull free. Unscrew clamp screw from the bottom of V-band (same type as at front) and remove the V-band clamp. This releases the rear cover, P/N 2430-088, (which includes the attached escape tube with captive nut) and the diaphragm seal, P/N 2430-089. The seal should be soft and pliable. If it shows signs of hardening or surface cracks, replace it.

b. The expansion tank is vented through the breather vent, P/N 2450-094, screwed into the top. The unit unscrews from the socket, but is not itself subject to disassembly. The seat is sealed by the compressed O-Ring, P/N 5-504, which should be included when replacing the breather vent with the shipping plug. The O-Ring should be soft and pliable. If it shows signs of hardening or surface cracks, replace it.

4-17. Radiator Handle - with the meter case removed, the radiator handle may be replaced by use of a suitable screwdriver. Remove the 10-32 truss head retaining screws at the end of the line of holes through top center of the front fins. Push handle forward and pull up.

4-18. "QC" Connectors - The input connector of the Model 694 may be readily changed to other AN standard types. Alternate available types are listed in Section VII, Replacement Parts List, and may be procured from Bird Electronic Corp. To change connectors, simply unscrew the four 8-32 pan head screws on the square base flange, and pull the connector straight out.

4-19. Microammeter - Before replacing the microammeter proceed as in para 4-12 above. If the meter must be replaced, raise the cover on the meter case and remove the three flat head screw and nut assemblies which fasten the meter to the inside of its case. Remove the meter assembly, P/N 2760-021-2, and replace it.

4-20. REASSEMBLY

4-21. RF Section - Reverse the procedures given in para 4-15, under Disassembly. The oil seal (O-Ring, P/N 8110-039) for the RF section should be completely clean and correctly placed against the beveled flange all around without twists. Tighten the clamp band securely, and then place the unit horizontal. After a short time, check carefully for possible oil leakage. When attaching the meter case, be sure that the extension sleeves, P/N 2430-077, are placed on the inside over each of the meter housing screws, P/N 6940-030.

4-22. Main Radiator Tank Rear Cover and Seal - Reverse the procedures given in para 4-16, Disassembly.

4-23. Radiator Handle - Reverse the procedures given in para 4-17, Disassembly.

4-24. "QC" Connectors - To attach the connector, reverse the procedure given in para 4-18, Disassembly. Be certain to properly engage the center pin in the contact hole, keeping the alignment true, and fasten the flange securely.

4-25. Microammeter -

a. Reverse the procedures given in para 4-19, Disassembly.

b. When attaching the dc plug to the voltmeter jack, be sure that the contacts are essentially clean and wipe the plug as described in para 4-2, Cleaning.

4-26. REPAIRS

4-27. For repairs beyond those described above, it is generally advisable to return the unit to the Bird Electronic Corp. for repair and recalibration. Specified accuracy of the unit is then assured, and the qualifications of a new instrument are maintained. Consult the factory.

SECTION V - PREPARATION FOR RESHIPMENT

5-1. GENERAL

5-2. Shipping Plug - Remove the vent valve, P/N 2450-094, on top of the coolant tank and replace it with the shipping plug, P/N 4250-049, to avoid the possible loss of coolant in transport. Since these two parts are connected together by a bead chain, the vent valve should be carefully wrapped and taped to the side of the load for protection. Be sure the O-Ring seal, P/N 5-504, is in place.

5-3. RF Connector - Wrap the RF connector with padding and secure it with tape to keep out foreign matter during shipment.

5-4. Meter Cover - Close the meter cover and tape it shut for protection.

5-5. Packing - Enclose the Model 694 suitably braced and padded in a shipping container. For the ultimate protection a sturdy wooden crate is recommended.

SECTION VI - STORAGE

6-1. GENERAL

6-2. No special preparation for storage is required other than to cover the equipment to keep it free of dust and dirt accumulation. Storage in a dry dust-free environment is recommended. The storage temperature should preferably remain within the ambient working temperature range of -20°C to $+40^{\circ}\text{C}$ (-4°F to $+104^{\circ}\text{F}$).

SECTION VII - REPLACEMENT PARTS LIST

7-1. GENERAL

ITEM	QUANTITY REQUIRED	DESCRIPTION	PART NUMBER
1	1	Meter, 0-1000 W, 100 ua, 3000 ohms	2000-011
2	1	Handle	2430-028
3	2	Clamping band assembly	2430-043
4	1	Extension stud	2430-077
5	1	Diaphragm guard cover	2430-078
6	1	Diaphragm cover assembly	2430-088
7	1	Diaphragm cover seal	2430-089
8	1	Radiator assembly	2430-090
9	1	Shipping plug	2450-049
10	1	Meter housing screw (1/4-20 x 1-1/4")	6940-030
11	1	Meter and cable assembly	2760-021-2
12	1	"QC" connector	*See below
13	4	Bumper foot	5-049
14		Coolant, 1.1 gallon (4 l) one gallon container	5-1070-2
15	1	Vent valve O-Ring	5-504
16	1	Vent valve	2450-094
17	1	Meter housing assembly	6940-002
18	1	Resistor-voltmeter assembly (factory calibrated)	6940-003
19	1	Cable assembly connector	7500-076
20	1	RF assembly O-Ring	8110-039
21	4	Acorn type nut 8-32	8110-171
22	1	Cable assembly (meter to voltmeter block)	8180-021-4

*Available QC Type Connectors

**N-Female	4240-062	LT-Female	4240-018
N-Male	4240-063	LT-Male	4240-012
HN-Female	4240-268	C-Female	4240-100
HN-Male	4240-278	C-Male	4240-110
LC-Female	4240-031	UHF-Female (SO-239)	4240-050
LC-Male	4240-025	UHF-Male (PL-259)	4240-179
	7/8" EIA Air Line	4240-002	

**Normally supplied

FIGURE 7-1. OUTLINE DRAWING MODEL 694 RF WATTMETER

