INSTRUCTION MANUAL

MODEL 1600A-MOD88

AUTOBALANCE TRUE RMS AC/DC TRANSFER STANDARD

APPLICABLE TO SERIAL PREFIX 020- & 040-

(BACKDATING INFORMATION IS AVAILABLE IN SECTION 6)

Ballantine Laboratories, Inc. • P. O. Box 97 • Boonton, New Jersey 07005 U.S.A.
Telephone: 201-335-0900 • TWX: 710-987-8380

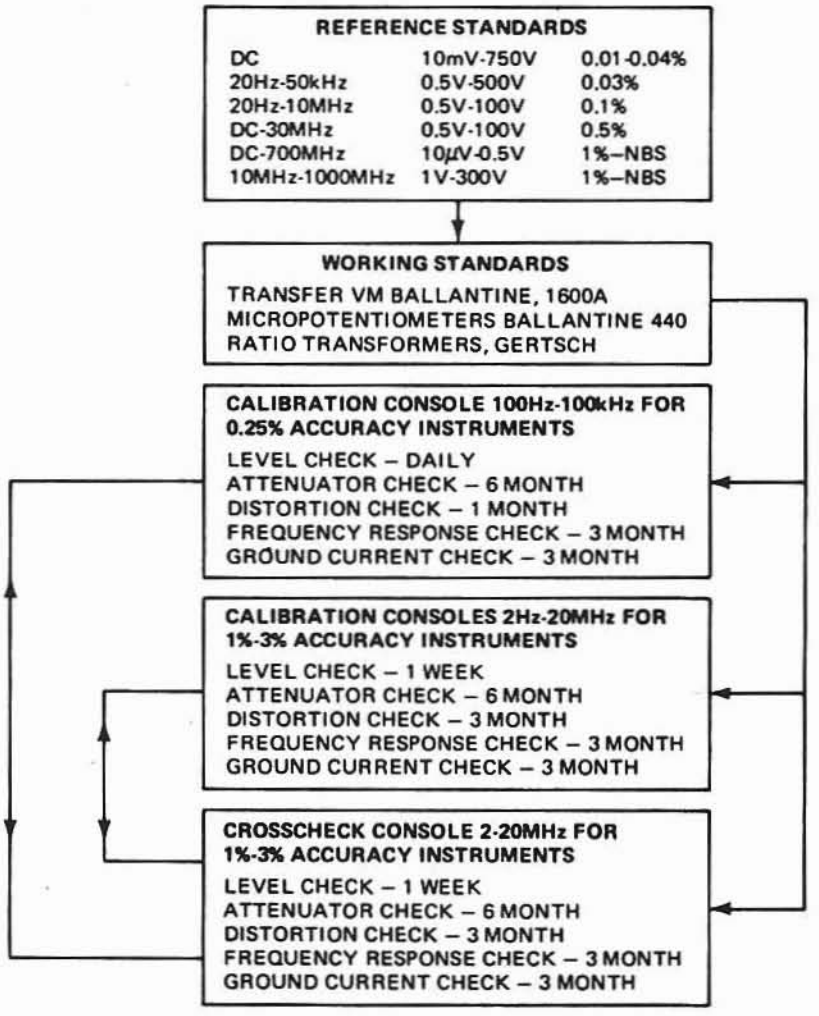
901003318 MAY 1984

WARRANTY

This Ballantine Laboratories, Inc. product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except for batteries, electron tubes, vacuum thermocouples, and certain other components, if any, listed in this manual. Ballantine Laboratories, Inc. will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Ballantine Laboratories, Inc. prepaid, and provided the proper preventive maintenance and calibration procedures as listed in this manual have been followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. BALLANTINE LABORATORIES, INC. IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

CERTIFICATION

Ballantine Laboratories, Inc. certifies that this equipment meets all applicable Ballantine specifications at time of shipment from the factory as determined by thorough testing and inspection. Ballantine further certifies that its measurements are traceable to the United States National Bureau of Standards. All instruments used in calibrating Ballantine products are standardized by systematic reference to NBS-traceable standards as described in the validation procedures shown below.



Ballantine's Quality Assurance program satisfied the requirements of MIL-I-45208

TABLE OF CONTENTS

Paragraph *Page*

SECTION 1. INTRODUCTION

1-1. General 1-1
1-4. Purpose and Use of the Equipment 1-1
1-6. General Description 1-2
1-12. Accessories 1-2
1-14. Equipment Specifications 1-2

SECTION 2. OPERATION

2-1. General 2-1
2-3. Installation 2-1
2-4. Unpacking 2-1
2-5. Inspection 2-1
2-6. Mounting (Benchtop and Rack) 2-1
2-11. Operation 2-3
2-12. Operating Controls, Indicators and Connectors Connectors 2-3
2-13. General Information 2-3
2-23. Manual Balance Operation 2-9
2-24. Reverse Manual Balance Operation 2-10
2-25. Automatic Balance Operation 2-10
2-26. Manual Transfer Operation 2-11
2-27. Automatic Balance Operation from a Remote Location 2-12
2-28. Independent Operation of Transfer Assembly A1 2-12
2-30. External Thermal Converter 2-14
2-31. External Programming Output for Transfer Readout DVM Range 2-14
2-32. Remote Range Programming of the 11600A Transfer Assembly (Option MOD-03) 2-14

2-29. Packaging Instructions 2-16
2-30. Short Term Storage 2-16
2-31. Long Term Storage or Shipment 2-16

SECTION 3. THEORY OF OPERATION

3-1. General 3-1
3-3. Simplified Block Diagram Analysis 3-1
3-7. Manual Balance Operation 3-1
3-8. Auto Operation 3-1

Paragraph *Page*

3-9. Manual Transfer Mode 3-1
3-10. Detailed Theory of Operation 3-1
3-11. Transfer Assembly A1 3-1
3-18. Manual Balance Mode 3-4
3-23. Auto Mode 3-6
3-35. Manual Transfer Mode 3-11
3-36. Amplifier Circuit Boards 3-11
3-42. Power Supplies 3-13
3-50. Auto Re-cycle 3-14

SECTION 4. MAINTENANCE

4-1. General 4-1
4-3. Test Equpment Required 4-1
4-5. Minimum Performance Standards Checks 4-1
4-8. Overload Protection for Thermocouple 4-1
4-9. Functional Checks with DC/DC Transfer Operation 4-1
4-10. DC/DC Transfer Accuracy – All Ranges 4-4
4-11. DC Output Ripple and Noise (Optional) 4-4
4-12. AC/DC Transfer Accuracy 4-4
4-13. Component Locations 4-9
4-15. Power Supply Checks 4-9
4-17. Locating Trouble Within Power Supplies 4-9
4-19. Setting ±15 Volt Supplies 4-17
4-22. AC Calibration 4-17
4-24. AC Calibration MOD 88 4-18
4-25. CHOPPER DRIVER (MOD-08 and MOD-88) . . 4-18
4-26. Trouble Localization 4-18
4-28. Thermoelement Replacement 4-18
4-30. Overload Protection Board A1A1 Calibration . . 4-19
4-32. Voltage Measurements 4-19

SECTION 5. PARTS LIST & CIRCUIT DIAGRAMS

SECTION 6. BACKDATING INFORMATION

LIST OF ILLUSTRATIONS

Figure		Page
1-1.	Model 1600A Auto-Balance AC-DC Transfer Standard	1-1
1-2.	Model 1160OA Transfer Assembly	1-2
2-1.	Installation Outline Drawing	2-2
2-2.	Operating Controls, Indicators and Connectors	2-3
2-3.	Equipment Interconnection Diagram	2-11
2-4.	Typical Remote Control Box	2-13
2-5.	Equipment Interconnection for Remote Operation	2-13
2-6.	Interconnection Diagram for Independent Operation of Transfer Assembly	2-15
2-7.	External Thermo Converter Block Diagram	2-15
2-8.	Packaging Diagram	2-17
3-1.	Simplified Block Diagram	3-0
3-2.	Block Diagram	3-3
3-3.	Low Voltage Attenuator, 1600A Detailed Block Diagram	3-5
3-3A.	Low Voltage Attenuator, 1600A MOD-88, Detailed Block Diagram	3-5A
3-4.	High Voltage Attenuator, Detailed Block Diagrm	3-7
3-5.	Detailed Block Diagram	3-9
3-6.	± 15 Volt Power Distribution	3-10
3-7.	+3.6 and +3.9 Volt Power Distribution	3-12
4-1.	Overload Test Equipment Setup	4-3
4-2.	DC/DC Transfer Operation Setup	4-3
4-3.	DC/DC Accuracy Test Setup	4-5
4-4.	DC Output Ripple and Noise Test Setup	4-5
4-5.	AC Calibration Test Setup	4-10
4-6.	1600A Top View	4-11
4-7.	1600A Bottom View	4-12
4-8.	Transfer Assembly A1, Top View	4-13
4-9.	Transfer Assembly A1, Bottom View	4-14
5-1.	Model 1600A-MOD88, Interconnect Schematic Diagram	5-5
5-2.	Model 1600A-MOD88, Transfer Assembly, (A1) Schematic Diagram	5-7
5-2A.	Model 1600A-MOD88, LO Volt Attenuator Assembly, Schematic Diagram	5-9
5-3.	Model 1600A-MOD88, Overload Protection Infrared Assembly (A1A1), Schematic Diagram	5-11
5-4.	Model 1600A-MOD88, Chopper Amplifier Assembly (A2), Schematic Diagram	5-13
5-5.	Model 1600A-MOD88, DC Amplifier Assembly (A3), Schematic Diagram	5-15
5-6.	Model 1600A-MOD88, LO Voltage Amplifier Assembly (A4), Schematic Diagram	5-17
5-7.	Model 1600A-MOD88, Ladder and Buffer Amplifier Assembly (A5), Schematic Diagram	5-19
5-8.	Model 1600A-MOD88, Counter Assemblies (A6 & A7), Schematic Diagram	5-21
5-9.	Model 1600A-MOD88, Clock Oscillator Assembly (A8), Schematic Diagram	5-23
5-10.	Model 1600A-MOD88, 15 Volt Power Supply Assemblies (A9 & A10), Schematic Diagram	5-25
5-11.	Model 1600A-MOD88, LO Voltage Power Supply Assembly (A11), Schematic Diagram	5-27
5-12.	Model 1600A-MOD88, HI Voltage Amplifier Assembly No. 1 (A12), Schematic Diagram	5-29
5-13.	Model 1600A-MOD88, HI Voltage Amplifier Assembly No. 2 (A13), Schematic Diagram	5-31
5-14.	Model 1600A-MOD88, Auto Transfer Cycle Assembly (A14), Schematic Diagram	5-33
5-15.	Model 1600A-MOD88-03, Remote Programming, Schematic Diagram	5-35
6-1.	Interconnecting Cabling Diagram	6-11
6-2.	Transfer Assembly A1, 1600A, Schematic Diagram	6-12
6-2A.	Transfer Assembly A1, 1600A-MOD88, Schematic Diagram	6-13
6-3.	Overload Protection Board A1A1, Schematic Diagram	6-15
6-4.	Chopper Amplifier A2, Schematic Diagram	6-17
6-5.	DC Amplifier A3, Schematic Diagram	6-19
6-6.	Low Voltage Amplifier A4, Schematic Diagram	6-21
6-7.	Ladder and Buffer Amplifier A5, Schematic Diagram	6-23
6-8.	Counters A6 and A7, Schematic Diagram	6-25
6-9.	Clock Oscillator A8, Schematic Diagram	6-27
6-10.	15 Volt Supplies A9 and A10, Schematic Diagram	6-29
6-11.	Low Voltage Supply A11, Schematic Diagram	6-31
6-12.	High Voltage Amplifier A12, Schematic Diagram	6-33
6-13.	High Voltage Amplifier A13, Schematic Diagram	6-35
6-14.	Auto Transfer Cycle A14, Schematic Diagram	6-37
6-15.	Chopper Drive Assembly A15 (MOD-08 only)	6-39

LIST OF TABLES

Table		*Page*
1-1.	Optional Accessories	1-3
1-2.	Specifications	1-4
1-3.	Available Performance Options	1-7
2-1.	Operating Controls, Indicators, and Connectors	2-4
2-2.	Connector Pin Identification	2-8
3-1.	Low Voltage Attenuator Operation	3-8
3-2.	High Voltage Attenuator Operation	3-8
4-1.	Required Test Equipment	4-2
	Form 4-1. Calibration Test Record Noise and Output Current	4-6
	Form 4-2. Calibration Test Record DC/DC Accuracy with Function.	4-7
	Form 4-3. Calibration Test Reocrd Standard 1600A Frequency Response	4-8
4-3.	Power Supply Check	4-15
4-4.	Power Supply Trouble Localization Procedure	4-15
4-5.	Trouble Localization	4-19
4-6.	Voltage Measurements, Overload Protection Board A1A1	4-20
4-7.	Voltage Measurements, Chopper Amplifier A2	4-20
4-8.	Voltage Measurements DC Amplifier and Filter A3	4-20
4-9.	Voltage Measurements, Low Voltage Amplifier A4	4-21
4-10.	Voltage Measurements, Ladder and Buffer Amplifier A5	4-21
4-11.	Voltage Measurements, Clock and Gating Board A8	4-21
4-12.	Voltage Measurements +15-Volt Supply A9	4-22
4-13.	Voltage Measurements, −15 Volt Supply A10	4-22
4-14.	Voltage Measurements, Low Voltage Supply A11	4-22
4-15.	Voltage Measurements, High Voltage Amplifier A12	4-23
4-16.	Voltage Measurements, High Voltage Amplifier A13	4-23
4-17.	Voltage Measurements, Chassis Assembly	4-23
	Form 4-5. Calibration Test Record, (1600A MOD 88 ONLY) Performance at 50 kHz	4-24
	Form 4-6. Calibration Test Record, (1600A MOD-88 ONLY) Performance at 100 kHz	4-24
	Form 4-7. Calibration Test Record (1600A MOD-88 ONLY) Performance at 1 MHz	4-25
	Form 4-8. Calibration Test Record (1600A MOD-88 ONLY) Performance at 10 MHz	4-25
	Form 4-9. Calibration Test Record (1600A MOD-88 ONLY) Performance at 30 MHz	4-26
	Form 4-10. Calibration Test Record (1600A MOD-88 ONLY) Performance at 100 MHz	4-26

CAUTION

INPUT CURRENTS EXCEEDING 6.5mA ± dc or ac rms will destroy dc reversal error performance of the high precision dual bottle thermal element. Never exceed 6.5mA input current.

Take special care to keep input current from exceeding 6.5mA when adjusting the overload protection trip adjustment A1A1R16.

Input overloads greater than 6.5mA rms will destroy the dc reversal error performance but will not burn out the heater in the thermal element which is protected against catastrophic burn out by the overload protection circuit.

SECTION I
INTRODUCTION

1-1. GENERAL

1-2. This instruction manual provides operating and maintenance instructions for the Ballantine Model 1600A Auto-Balance AC-DC Transfer Standard (hereafter referred to as the ATS). Included in this manual are a general description of the ATS, operating instructions, theory of operation, maintenance instructions, schematic diagrams and a repair parts list. The 1600A is illustrated in Figure 1-1.

1-3. The information contained in this manual refers to the standard version of the ATS and is current only to the date of publication. Differences in equipment components, specifications and performance resulting from Ballantine Laboratories continuous product improvement program or customer design and application requirements are described in addendum sheets. The 1600A frequency range extends to 30MHz. The 1600A MOD 88 frequency range extends beyond 100 MHz. Both units are covered in the main body of this manual.

1-4. PURPOSE AND USE OF THE EQUIPMENT

1-5. The ATS is designed to permit a semi-skilled operator to make rapid and precise true rms measurements of a-c voltages with a minimum of operator participation, thereby eliminating the possibility of operator error. The ATS also has the ability to provide manual transfer and balancing measurements (i.e., orthodox AC-DC transfer standard operation). The applied signal under measurement is attenuated and applied to a thermoelement which produces a d-c

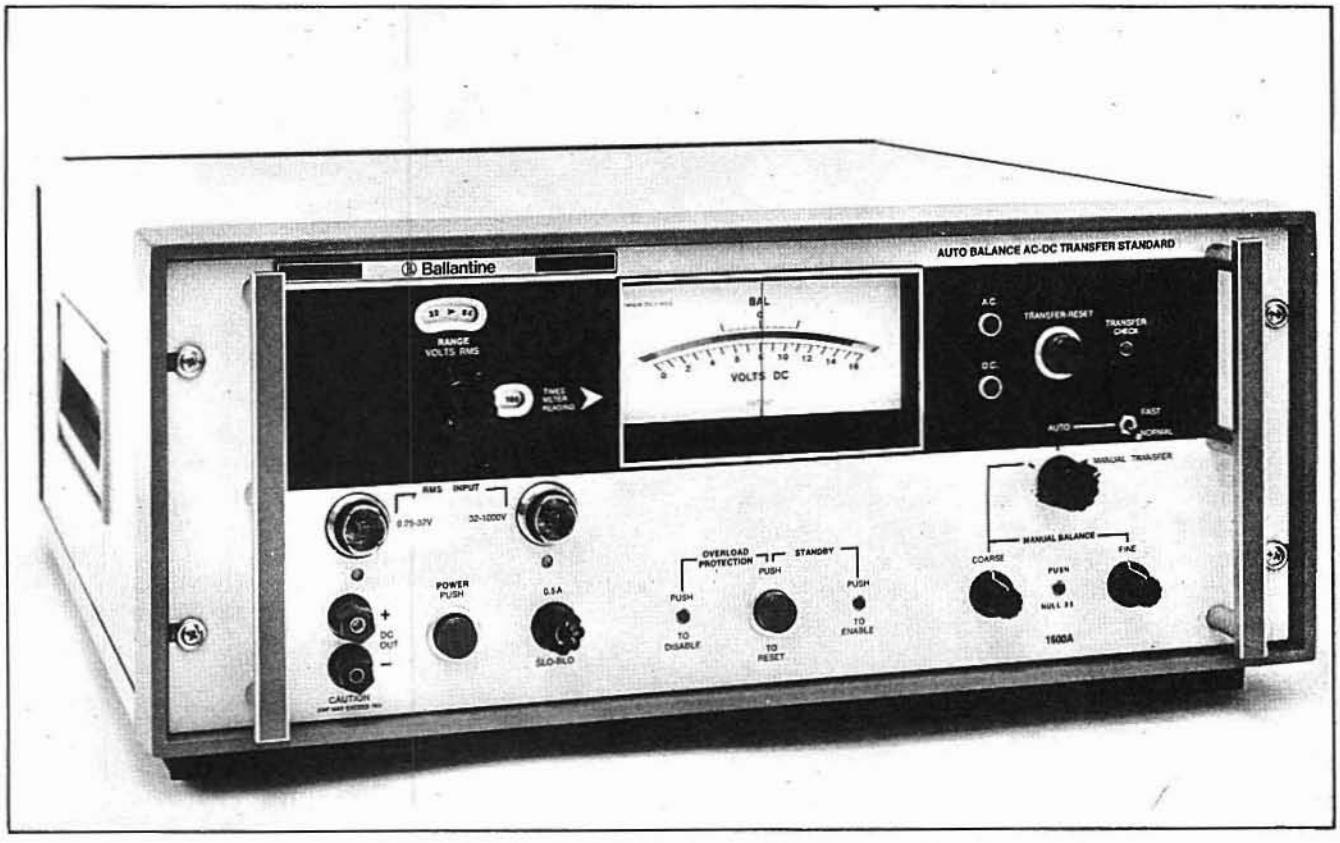


Figure 1-1. Model 1600A Auto-Balance AC-DC Transfer Standard

voltage proportional to the heating (rms) value of the signal. An internally generated d-c voltage having the same heating value is then substituted for the applied signal and this d-c voltage is coupled to auxiliary readout instrumentation to provide a true rms equivalent of the applied signal. The manual transfer mode of operation allows the operator to initiate the point in time at which the AC to DC transfer occurs and, in some instances, allows more accurate measurements than is possible in the automatic mode. The manual balance mode requires the operator to manually blance the unit and, while being somewhat more time-consuming, it is still a rapid operation and permits highest accuracy measurements down to 2 Hz.

1-6. GENERAL DESCRIPTION

1-7. The ATS is a semi-automatic AC-DC transfer standard which provides a d-c output voltage equal to the true rms value of complex (i.e., pulsed, squarewave, triangular-wave and other non-sinusoidal signals having a crest factor of up to 10:1) or sinusoidal signals. The d-c output voltage generated is applied to an auxiliary readout instrument, such as a d-c differential or d-c digital voltmeter, which indicates the d-c rms equivalent of the applied input voltage.

1-8. The ATS employs the same thermoelement and coaxial attenuators for sensing both the applied a-c signal and the internally-developed balancing voltage, thereby eliminating problems due to mismatch. Both the attenuators and the thermally-lagged thermoelement are housed in compartments of an easily removable transfer assembly (Model 11600A – see Figure 1-2). Removal of the transfer assembly permits its use as a conventional AC-DC transfer standard and also permits its shipment to NBS for reports on AC-DC differences with an uncertainty of less than 0.005% (to 20 kHz) and 0.01% (up to 50 kHz).

1-9. The ATS employs a positive-action peak-sensing overload system that does not clip the input signal. This feature eliminates the possibility of erroneous measurements due to undetected clipping or shunting of the applied signal. A non-locking pushbutton switch is provided to permit removal of the overload protection capability when measuring signals having a crest factor greater than 2:1 and to optimize accuracy when measuring signals above 100 KHz.

1-10. A 12-position range selector switch, in conjunction with the internal attenuators, enables the measurement of input voltage levels from 0.25 to 1000 volts. Since the thermoelement has a squarelaw response, the range selection technique employed ensures that the equipment will not balance when the thermoelement driving current

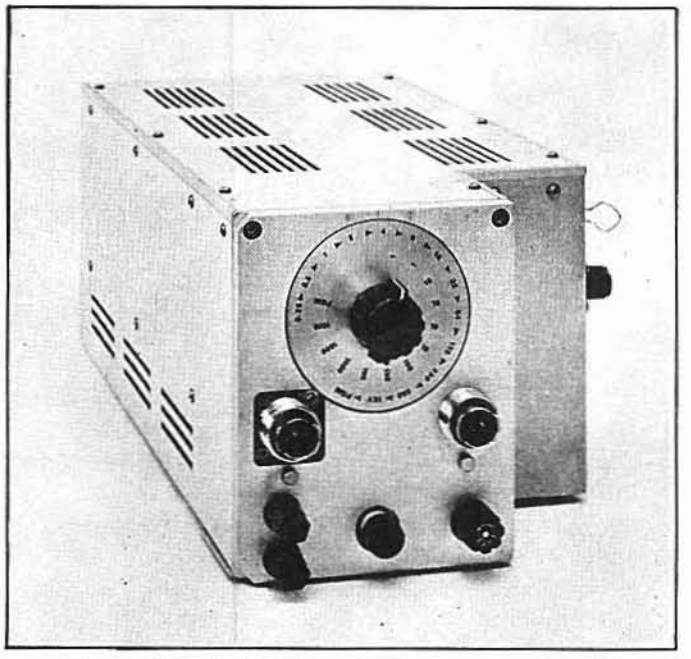


Figure 1-2. Model 11600A Transfer Assembly

falls below approximately one-half the rated level of 5 milliamperes. This design consideration assures good signal-to-noise ratios for all measurements. A thirteenth switch position provides selection of External Remote Range Programing.

1-11. When the ATS is operating in the automatic transfer mode, special circuitry prevents automatic transfer until the thermoelement emf output rate of change is 0.002%/second or less. This ensures against inaccurate measurements resulting from the thermoelement's not having reached equilibrium. A normal transfer is accomplished in typically 10 seconds; however, when there is a large change in heater current, the time required for the thermoelement to reach a stable blance is extended resulting in a somewhat longer measurement time. When the ATS is operated in the manual transfer mode, the instant of transfer is manually determined. In manually-balanced operation, the operator adjusts the level of the internal balancing voltage until a null indication is obtained and then achieves transfer by manual switching.

1-12. ACCESSORIES

1-13. The supplied and optionally available accessories are listed in Table 1-1.

1-14. EQUIPMENT SPECIFICATIONS.

1-15. Refer to Table 1-2.

TABLE 1-1. OPTIONAL ACCESSORIES

Accessory	Ballantine Part No.	Function
Rack Mount Slides	1600A MOD-15	Enables 1600A to be slide-mounted in standard 19-inch rack
Rack Mount Dust Covers	51100151L	Rack Mount Dust Covers, 2 required
Extender, Card	89100011A	Service aid
Power Cable	33100000A	6 foot power cable
CONNECTING CABLES		
50 Pin to 50 Pin	12253A	External program cable, 6 foot
24 Pin to 24 Pin	12254A	Cable used when 11600A is operated out of main frame, 6 foot.
Cable Assembly, DVM	89-10129-1F	Used when 1600A is operated with Ballantine 3600A DVM (J16 to DVM)
Cable Assemblies, External Thermocouple	89-10126-1F	Used when 1600A is operated with external thermal converter with 3-Pin receptacle 1394A and 1396A series.
	89-10128-1F	Used when 1600A is operated with external thermocouple. Supplies dc transfer voltage to external converter GR connector.
Cable, Test and Calibration	89-102371F	AC Calibration Test Cable (for P15)
ADAPTERS AND CONNECTORS		
7-Pin Connector (Plug) P14 MS-3106A-16S-1P	31100390A	Used to connect external transfer programming cable to ATS.
(clamp)	31100860A	Cable clamp, AN3057-8
50-Pin Connector (Plug) P15/P300 Amphenol Blue Ribbon 57-30500	31100500A	Used when 11600A Transfer Assembly is operated independently of main frame. Also used with Remote program command outputs (J16) and Remote Ranging Program Input (J300).
24-Pin Connector (Plug) P3 Amphenol Blue Ribbon 57-30240	31100370A	Used when 11600A transfer assembly is operated independently of the main frame.
10-Pin Connector (Plug) P15 MS3106A-18-1P	31100650A	External thermocouple output connector and/or jumper plug.
(clamp)	31100660A	Cable clamp AN3057-10
3-Pin Connector (female) J MS-3106A-10SL-3S	31100020A	Used for thermocouple output when 11600A Transfer Assembly is operated Independently of main frame.
(clamp)	31100100A	Cable clamp AN3057-4
"T" Connector (GR874 Series)	10186A	Permits monitoring of applied signal by auxiliary equipment.
Adapter, GR874 to BNC	12620A	Adapter GR to female BNC, for input connection.
Adapter, double banana to BNC female	12616A	Shielded adapter for DC output voltage.

TABLE 1-2. SPECIFICATIONS

INPUT

Frequency Range: DC, 5 Hz to 30 MHz usable 2 Hz beyond 100 MHz with internal attenuators. Operation to 1 GHz possible with external thermal converters.

Voltage Range: 12 ranges and Remote Program (Option 03)

All voltages DC and RC rms

0.25 to 0.5 Volts	DC, 5 Hz to 30 MHz usable beyond 100 MHz
0.5 to 1 Volt	DC, 5 Hz to 30 MHz usable beyond 100 MHz
1 to 2 Volts	DC, 5 Hz to 30 MHz usable beyond 100 MHz
2 to 4 Volts	DC, 5 Hz to 30 MHz usable beyond 100 MHz
4 to 8 Volts	DC, 5 Hz to 30 MHz usable beyond 100 MHz
8 to 16 Volts	DC, 5 Hz to 1 MHz usable beyond 30 MHz
16 to 32 Volts	DC, 5 Hz to 100 kHz usable beyond 5 MHz
32 to 64 Volts	DC, 5 Hz to 100 kHz usable beyond 2 MHz
64 to 125 Volts	DC, 5 Hz to 100 kHz usable beyond 1 MHz
125 to 250 Volts	DC, 5 Hz to 100 kHz usable beyond 1 MHz
250 to 500 Volts	DC, 5 Hz to 50 kHz usable beyond 350 kHz
500 to 1000 Volts	DC, to 50 kHz usable beyond 250 kHz

Under Range: −10% of low end of Voltage Range

Over Range: +10% of high end of Voltage Range

Resistance: Nominally 200 Ω per Volt [5 mA (dc) full range]

Overload: Protected to 125% of full range rms for sine wave signals and to 175% peak to 10 MHz.

Standby Operation: Standby push button switch opens input in AC Mode until overload switch is reset. This permits interchange of input signals without loading source or damaging thermocouple. Overload protection may be disabled by front panel momentary push button for crest factors to 10 to one of full range. This feature permits transfer measurements in strict accordance with NBS practice. Duty factor of input pulse train must not be more than the inverse of 10 times the crest factor nor may rms range limits be exceeded.

Overload Protection: Peak sensing circuit opens input and protects each range to 1000% or 1500 Volts peak whichever is less. Protection derates by approximately 5% per MHz above 10 MHz. Illuminated reset push button restores operation. Overloads greater than 10:1 must not last longer than 1 ms.

Crest Factor: 1.75 to one at full range; 3.5 to one at bottom range; Greater than 10 to one with overload circuit disabled. Overloads must not exceed 10:1 for > 1 ms at a duty factor of 10%.

ACCURACY OF AC TO DC TRANSFER

Internal attenuator in 11600A

Manual Mode: (See Table) (all specs in table are to be considered ± indicated tolerance)

Measurement uncertainty referenced by NBS certification.

DC, 5 Hz to 20 Hz	±0.12%
DC, 20 Hz to 20 kHz	±0.02%
DC, 20 kHz to 50 kHz	±0.03%
DC, 50 kHz to 1 MHz	±0.06%
DC, 1 MHz to 10 MHz	±0.12%
DC, 10 MHz to 30 MHz	±0.25%
DC, 30 MHz to 60 MHz	±0.75%
DC, 60 MHz to 100 MHz	±1.5%

EXTERNAL THERMAL CONVERTER MODE

External thermal converters having unique characteristics may be connected to the 1600A and used in Auto Balance and Manual Precision measurements to 1 GHz and 250 V are possible with external converters. AC/DC balance is automatic but connections to external standard are transferred manually. Accuracies of the external thermal converters (such as Ballantine 1394A, 1395A and 1396A) apply.

AUTO AND MANUAL TRANSFER MODES

±0.005% of range additional to manual mode accuracy

DC REVERSAL ERROR

±0.0075% nominal at full range (5 mA); Derated typically to ±0.015% at 2.5 mA thermo element current. Optionally available thermoelement provide reversal errors of less than ±0.005%

(Optional MOD 88 provides 0.005% reversal error thermoelements.)

TABLE 1-2. SPECIFICATIONS (Continued)

AC/DC Transfer Accuracy AC/DC Difference as a % of Reading
with Reference to NBS Certified Standard at Ballantine

STANDARD 1600A

Voltage Range	DC	5 Hz to 20 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 1 MHz	1 MHz to 10 MHz	10 MHz to 30 MHz
0.25-0.5 V	.005%	0.01%	0.01%	0.05%	0.05%	0.75%	5%
0.5-1 V	.005%	0.01%	0.01%	0.05%	0.05%	0.75%	5%
1-2 V	.005%	0.01%	0.01%	0.05%	0.05%	0.75%	5%
2-4 V	.005%	0.01%	0.01%	0.05%	0.05%	1%	5%
4-8 V	.005%	0.01%	0.01%	0.05%	0.05%	1%	5%
8-16 V	.005%	0.01%	0.01%	0.05%	0.05%	-	-
16-32 V	.005%	0.01%	0.01%	0.05%	-	-	-
32-64 V	.005%	0.01%	0.01%	0.05%	-	-	-
64-125 V	.005%	0.01%	0.01%	0.05%	-	-	-
125-250 V	.005%	0.01%	0.01%	0.05%	-	-	-
250-500 V	.005%	0.015%	0.015%	0.065%	-	-	-
500-1000 V	.005%	0.035%	0.055%	0.075%	-	-	-

1600A-MOD88

Voltage Range	>5 Hz to 20 kHz	>20 kHz to 50 kHz	>50 kHz to 100 kHz	>100 kHz to 1 MHz	>1 MHz to 10 MHz	>10 MHz to 30 MHz	>100 MHz
0.25-0.05	0.01%	0.01%	0.03%	0.05%	0.45%	1%	3%
0.5-1	0.01%	0.009%	0.03%	0.05%	0.30%	1%	5%
1-2	0.01%	0.008%	0.025%	0.05%	0.30%	1%	5%
2-4	0.01%	0.007%	0.02%	0.04%	0.30%	1%	3%
4-8	0.01%	0.007%	0.02%	0.04%	0.30%	1%	-
8-16	0.01%	0.008%	0.02%	0.04%	0.50%	1.5%	-
16-32	0.01%	0.008%	0.02%	0.1%	-	-	-
32-64	0.01%	0.01%	0.03%	0.1%	-	-	-
64-125	0.01%	0.01%	0.03%	-	-	-	-
125-250	0.01%	0.01%	0.04%	-	-	-	-
250-500	0.01%	0.01%	0.05%	-	-	-	-
500-1000	0.02%	0.03%	0.065%	-	-	-	-

NOTE

Although not indicated in the 1600A-MOD88 Table above, the transfer accuracy of this Model at "DC" is the same as on the Model 1600A.

DC OUTPUT

Voltage: Equal to rms value of input voltage (0.25 to 1 kV to 2 mA max.)

Resistance: < 12 Ω to 8 Volt range
< 25 Ω to 125 Volt range
< 60 Ω to 1 kV range

MOD 88: < 0.1 Ω to 10 V
< 1 Ω to 100 V
< 10 Ω to 1 kV

Stability: (after thermoelement achieves equilibrium)

0.002% for 15 seconds for 0.5 to 32 Volt ranges
0.008% for 15 seconds for 32 to 125 Volt ranges
0.01% for 15 seconds for 125 to 500 Volt ranges
0.02% for 15 seconds for 1 kV range

After complete stabilization (4 to 6 hours) and with constant temperature and line voltage.

Automatic trigger 15 seconds after transfer to DC for triggering DVM and automatic recycle to AC in Auto Mode assures best transfer reading accuracy.

Ripple and Noise (rms): 90 dB below full scale or 100 μV whichever is greater. Noise is measured over bandwidth from 20 Hz to 100 kHz with true rms voltmeter.

TABLE 1-2. SPECIFICATIONS (Continued)

DC SEARCH METER ACCURACY

±5% of full range; 0 to 1.6, mirror backed scale with front panel range multiplier indicator.

NULL RESOLUTION

0.005% minimum per minor scale division for 5 divisions either side of zero. Resolution decreases thereafter. A 5 x null expansion momentary push button switch provides 0.001% (10 ppm) null resolution.

REMOTE OPERATION

Output Signals:

a) One of 12 lines closed to floating line for program outputs and remote identification of range setting and command switches for external DC DVM ranging.

b) Trigger of > 3 Volt negative from > 1 kΩ . source. Trigger is < 200 μs wide and occurs nominally 3 seconds (Fast) or 10 seconds (Normal) after transfer to dc mode.

c) Contact closure to ground during AC Mode interval.

d) Contact closure to ground during DC Mode interval.

Input Programming Commands:

a) Contact closure to remotely reset to AC Mode in Auto Balance Mode. This contact closure can be used to override Auto Recycling after ac transfer voltage is read and thereby speed up measurement cycles. Remote contacts must switch 5 amps at 28 Volts dc.

b) Standby – Contact closure to ground for > 10 mS will open input attenuator in AC mode. Requires Manual Reset from front panel.

c) Remote operation of the range attenuator by selecting one of 12 ranges in decimal code is available as **Option 03.** All input lines are DTL and TTL compatible with negative true logic. Saturated transistors or contact closure to ground must stay locked during entire AC/DC transfer cycle. Opening all lines provides standby operation with input disconnected.

AC BALANCE TIME

Auto Balance and Manual Transfer Modes:

Normal – For rated precision ten to 25 seconds typical (contingent on thermo element time constant and amplitude stability of input signal which must have < 0.002% drift per second).

Fast – For signals with noise and amplitude instability. Input signals may have drift < 0.005% per second for Auto Transfer. Total "Fast" measuring time typically 2 to 8 seconds.

DC READOUT TIME:

Auto Balance Mode:

DVM trigger pulse after transfer gives delay for time constant of thermocouple in DC Mode.

Normal – 10 to 15 seconds for rated precision

Fast – 4 to 10 seconds at lesser precision

Reset – 45 seconds (typical) after DC transfer ATS reverts to AC input measuring mode. Automatic reset may be switched off by switch located on rear panel. All timing periods may be varied to suit other requirements.

Manual Mode, Manual Transfer Mode: Manually controlled by the operator. DVM Read Command Trigger Pulse available as in Auto Balance mode.

WARM-UP TIME

Negligible: 2 minutes for average use; 30 minutes for rated accuracy; 4 to 6 hours for optimum stability.

TEMPERATURE

Storage: −40°C to +75°C (Option MOD 88: −55°C to +60°C Storage, +21°C to +25°C Operating)
Operating: +10°C to 40°C (usable 0°C to 50°C)

HUMIDITY

Operating: 20 to 80% RH (usable 0 to 95% RH)

ALTITUDE

Storage: to 15 km (50,000 feet)
Operating: to 500 V; 3 km (10,000 feet)
to 1 kV; 1500 m (5,000 feet)

TABLE 1-2. SPECIFICATIONS (Continued)

MAINTENANCE INTERVAL
90 to 180 days in normal use.

RECERTIFICATION INTERVAL
Recertification to NBS calibration standards. Six months after delivery and each 12 months thereafter in laboratory use.

POWER: 115 or 230 Volts ± 10%, 50 and 60 Hz (MOD-08 and MOD-88, 50 to 400 Hz)
Nominally 60 VA at 115 Volts, 60 Hz

SIZE
Cabinet: 216 mm (8-1/2in.)H x 500 mm (19-5/8in.)W x 572 mm (22-1/2in.)D
Rack Mount: 176 m (6-15/16in.)H x 480 mm (18-7/8in.)W x 546 mm (21-1/2in.)D
Behind Panel: 505 mm (19-7/8in.)

WEIGHT
In cabinet (total): 27.3 kg (60) lbs.
Rack Mount configuration (without cabinet): 18.2 kg (40) lbs.
Model 11600A Transfer Assembly only: 8.2 kg (18) lbs.
Shipping weight (total): 34 kg (76) lbs.

NOTES:
Accuracies of the 1600A are referenced to the midpoint of a General Radio 874 "T" connector, and a Ballantine 11600A transfer assembly or Ballantine 1394A Series thermal converter working standard certified by NBS.

Ballantine warrants that each 1600A is ready for NBS certification and NBS supplied correction data. Ballantine can arrange for this service at cost plus a small handling charge, but recommends that the customer uses the instrument for six months to fully stabilize all components prior to the expense of NBS certification

TABLE 1-3. AVAILABLE PERFORMANCE OPTIONS

1600A MOD-03	Remote programming of 11600A range attenuators. See Table 1-2 above.
1600A MOD-08	50 to 400 Hz power line frequency range.
1600A MOD-15	Rack slide kit for installation in 19 inch rack.
1600A MOD-88	Extended frequency range and certification to 100 MHz. See Table 1-2 above. Also includes MOD-08 for 50 to 400 Hz power line frequency range and dust covers P/N 51100151L. and Extender Card 89100011 and Test Cable 89102371F as supplied accessories.

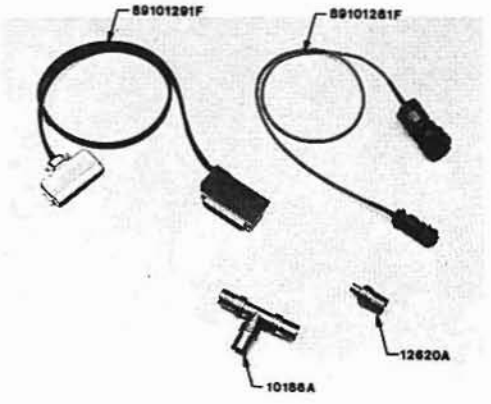


Figure 1-3 ,Some Optional Accessories

SECTION II
OPERATION

2-1. GENERAL

2-2. This section contains instructions for the installation and operation of the ATS. It is strongly recommended that the operator become thoroughly familiar with the material in this section before attempting to operate the equipment. Failure to do so may compromise the accuracy that has been engineered into the ATS.

2-3. INSTALLATION

2-4. UNPACKING. Unpacking and handling of the ATS requires that the normal precautions and procedures applicable to the handling of sensitive electronic equipment be followed. The contents of all shipping containers should be checked against the packing slip to ascertain that the shipment is complete.

2-5. INSPECTION. After the ATS has been removed from its shipping container, visually inspect the equipment for indications of any damage that may have occurred during shipment. Remove any shipping blocks or retainers. Check the front panel controls for freedom of movement, full travel and positive-detent locking. Note any evidence (such as broken glass, dents, etc.) indicating that the equipment has sustained a severe mechanical shock. To check that the ATS is operating properly, perform the Minimum Performance Standards Checks detailed in Section IV.

2-6. MOUNTING. The ATS is normally furnished for benchtop use. Optionally available accessories permit the equipment to be modified for rack mounting. (See figure 2-1 for equipment dimensions.)

2-7. Benchtop Mounting.
The 1600A ATS is normally furnished with a sturdy "Optima" case and requires no special installation procedures. Simple rack slides permit the ATS to be withdrawn from its case after the removal of front panel retaining screws.

The equipment has four plastic feet that will not mar the work surface. A tilt-bar is provided on the underside of the equipment which, when extended provides a convenient angle for front panel viewing.

2-8. The 115V-230V slide switch at the rear of transfer assembly A1 should be set to the position corresponding to the available a-c line voltage. This switch is accessible from the rear panel of the ATS and can best be reached using a small-bladed screwdriver. When the switch is set to the left, the ATS is set for operation from a 115-volt line. Conversely, when the switch is set to the right, the equipment is set for 230-volt line operation. Once the switch has been properly set, couple the ATS to line power. 50/60 Hz. MOD-08 or MOD-88 permit operation 50 to 400 Hz.
The 0.5 Ampere slo-blo 3AG fuse is applicable to either 115 or 230 volt operation.

2-9. **Rack Mounting.** The 1600A AUTO-BALANCE transfer standard may be mounted in a standard 19 inch relay rack. It will occupy seven inches of panel height.

To mount the unit in a rack remove it from the bench mount cabinet. Simply remove the retaining screws at the sides of the front panel and withdraw the unit from the cabinet.

2-10. Remove the two slide bars on the side of the 1600A by removing their retaining screws. If desired, the slide bars in the cabinet may be removed and installed in the relay rack. The slide bars on the side of the 1600A can then remain mounted and used to fit the 1600A into the rack.

Ballantine can supply a standard set of rack mount slides and these can be attached at the factory. Please consult factory for information on factory installed Rack Mount option MOD-15.

Ballantine also recommends installation of optional top and bottom covers (Part Number 51-10015-1L; 2 each required) when the unit is used without the bench cabinet.

If the rack installation is subject to shock and vibration, rear mechanical supports for the 1600A are recommended.

Observe grounding precautions to avoid measurement errors.

NOTE

The 1600A is a precise thermally sensitive instrument. **DO NOT** mount next to high temperature equipment or in strong magnetic or RF fields. **DO NOT** exceed the specified temperature range and avoid temperature change rates exceeding 5°C per hour when the 1600A is used to make operating precision measurements. Avoid forced air cycled ventilation system to optimize measuring accuracy. **DO NOT** mount the ATS in strong AC magnetic fields or subject it to excessive radiated or conducted EMI. Provide accessibility to rear connectors and switches when the 1600A is rack mounted.

CAUTION

INPUT CURRENTS EXCEEDING 6.5mA ± dc or ac rms will destroy dc reversal error performance of the high precision dual bottle thermal element. Never exceed 6.5mA input current.

Take special care to keep input current from exceeding 6.5mA when adjusting the overload protection trip adjustment A1A1R16.

Input overloads greater than 6.5mA rms will destroy the dc reversal error performance but will not burn out the heater in the thermal element which is protected against catastrophic burn out by the overload protection circuit.

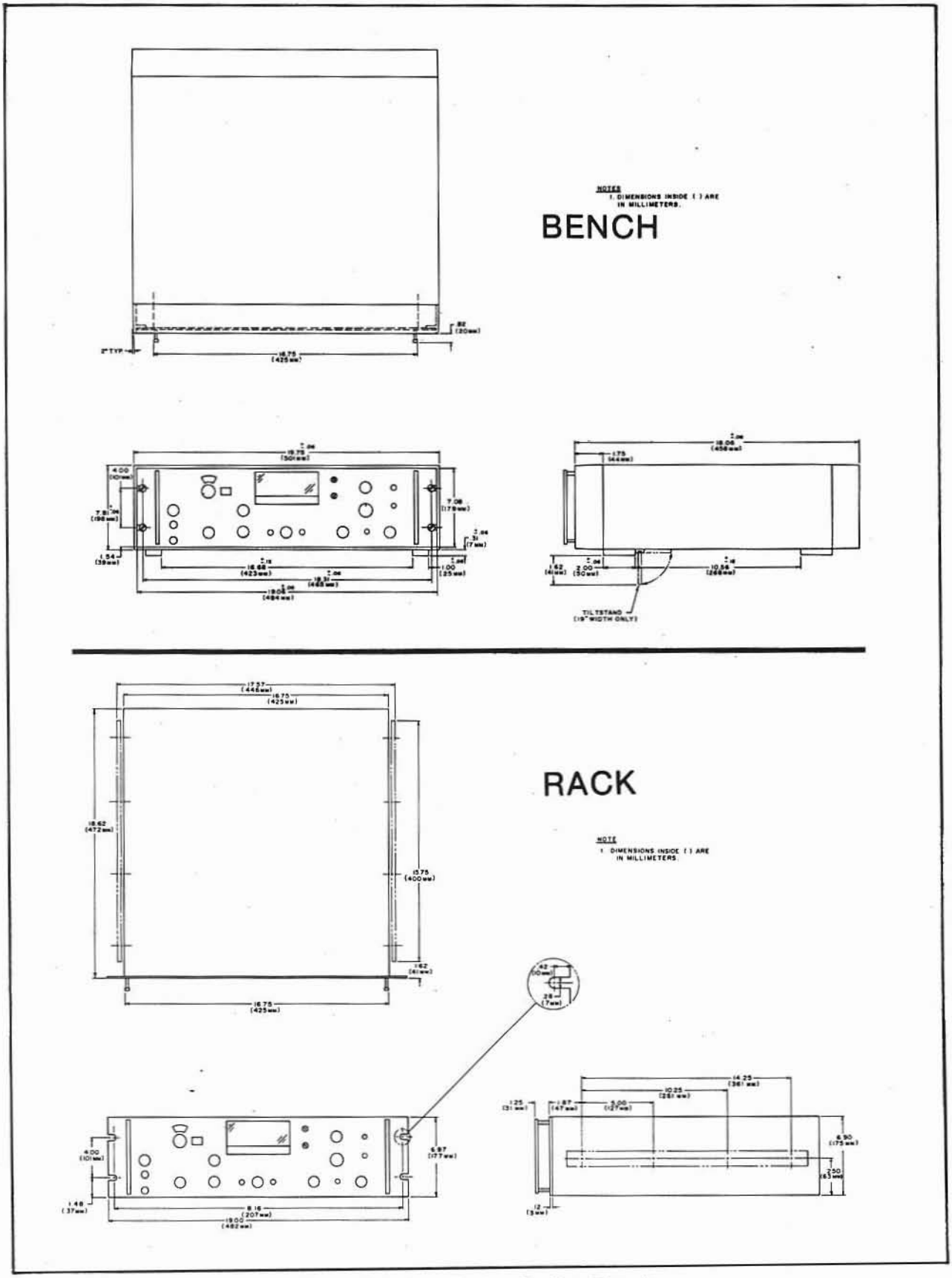


Figure 2-1. Installation Outline Drawing

2-11. OPERATION

2-12. OPERATING CONTROLS, INDICATORS AND CONNECTORS. The controls, indicators and connectors required for operation of the ATS are illustrated in figure 2-2; their functions are described in table 2-1.

2-13. GENERAL INFORMATION. Although the ATS is a relatively simple instrument to use, the operator should read paragraphs 2-14 through 2-21 for the background material required to obtain maximum service from the equipment.

2-14. Setting RANGE VOLTS Switch. If the voltage range of the applied signal is known, the operator need only set the RANGE VOLTS switch to the appropriate psoition and couple the voltage to be measured to either the AC INPUT 0.25-32V or AC INPUT 32-1000V connector, as required. Should the signal be of unknown level, employ the conventional voltmeter technique of setting the RANGE VOLTS switch to the highest voltage range (500 TO 1000) and couple the signal to be measured to the AC INPUT 32-1000V connector. If balance cannot be achieved, the operator should increase the sensitivity of the ATS, switching input connectors when required, until a balance is achieved.

2-15. Signal Stability. The ATS is designed to measure the rms value of stable a-c voltages. Should the AC indicator light remain illuminated and/or the front panel meter continuously "hunts" or "slews" when the ATS is operated in either the AUTOmatic or MANUAL TRANSFER mode, it is likely that the applied signal is unstable. To judge the stability of the applied signal, the operator should switch to the manual balance mode and attempt to null the meter using the MANUAL BALANCE COARSE and/or FINE controls. If a balance condition cannot be maintained, the applied signal is fluctuating too rapidly to permit a measurement of specified accuracy to be made. Under these conditions the measurement should be made in the manual balance mode and the reduced accuracy (due to the fluctuation of the signal) should be noted. In AUTO Transfer use FAST mode for input signals drifting $< 0.005\%$/sec.

2-16. Sources of Error. Various sources of error may be present when employing the ATS. These sources are detailed below so that the user may be familiar with them and allow for them to obtain maximum accuracy.

a. **Loading effects.** The input impedance of the ATS, particularly on the low voltage ranges, is relatively low (due to the current required for the thermoelement heater and the shunt input capacity presented by the relay controlled range attenuator) and will therefore have a loading effect when connected to the voltage source under test. Voltage sources having a non-zero output impedance and/or poor regulation characteristics will therefore develop two different

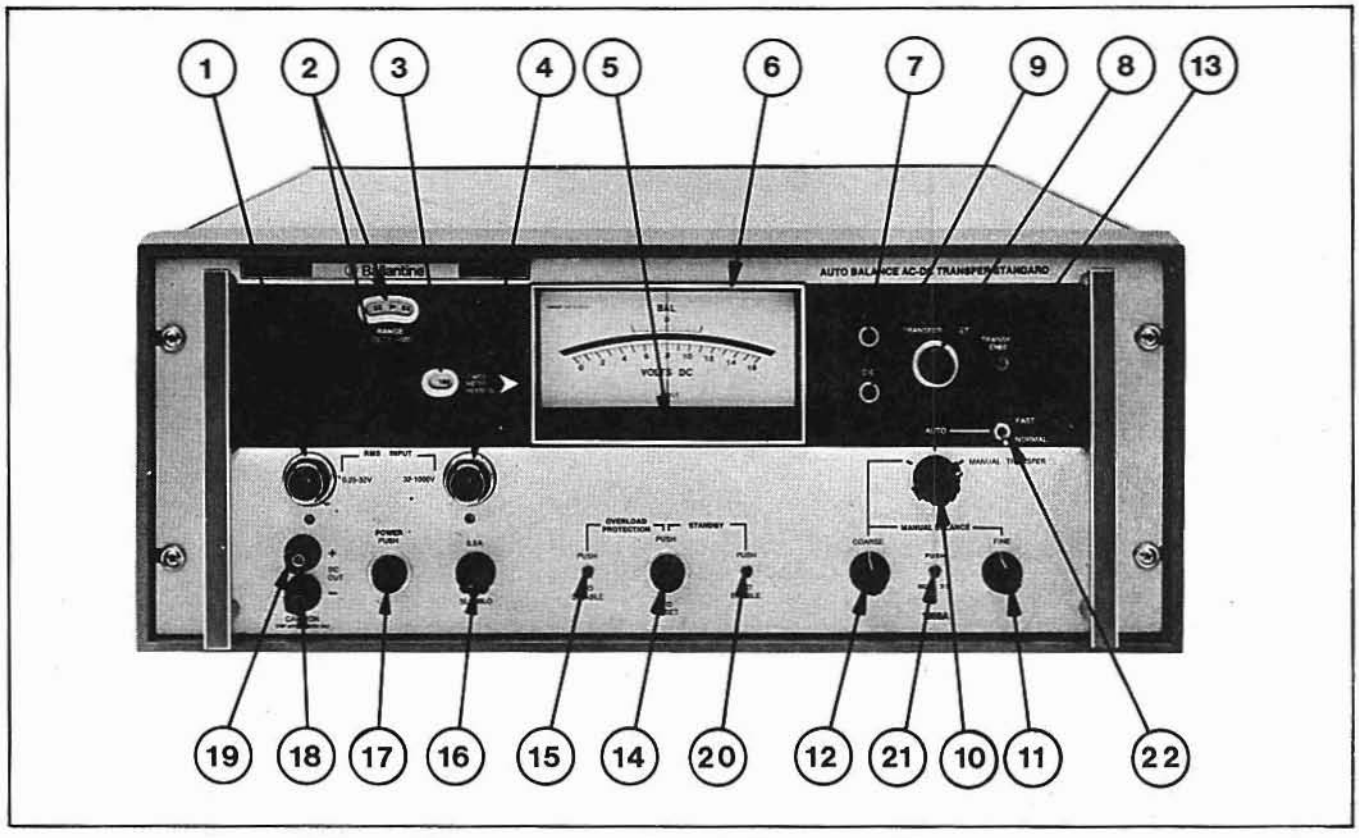


Figure 2-2. Operating Controls, Indicators and Connectors

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Figure 2-2 Index No.	Control, Indicator or Connector	Function
1	AC INPUT 0.25-32V connector A1J5	Connector employed when RANGE VOLTS switch is set to measure applied voltages between 0.25 and 32 volts rms. Connector is General Radio 874 series.
2	RANGE VOLTS switch A1S3 and dial (13 position rotary switch)	Permits operator to select any one of 12 voltage measurement ranges as indicated on dial 0.25 to 0.5 volts 0.5 to 1.0 volts 1 to 2 volts 2 to 4 volts 4 to 8 volts 8 to 16 volts 16 to 32 volts 32 to 64 volts 64 to 125 volts 125 to 250 volts 250 to 500 volts 500 to 1000 volts A 13th range enables remote range programming. (PGM)
3	TIMES METER READING dial	Provides factor which, when multiplied by the front panel meter DC OUTPUT VOLTAGE scale indication, enables the operator to determine (within 5%) the rms value of the applied signal after AC to DC transfer.
4	AC INPUT 32-1000V connector A1J6	Connector employed when RANGE VOLTS switch is set to measure applied voltages between 32 and 1000 volts rms. Connector is General Radio 874 series.
5	Mechanical zero adjustment screw	Permits mechanical zero-setting of meter pointer at BAL center line when power is disconnected.
6	Meter M1	Indicates proximity to null condition (0 on BAL scale) when AC indicator is illuminated and mode switch is set to MANUAL BALANCE, AUTO or MANUAL TRANSFER; indicates d-c output voltage (on DC OUTPUT VOLTAGE scale) within 5% when DC indicator is illuminated.
7	AC Indicator DS1	Illuminates when ATS is in a-c balancing state (i.e., applied signal being automatically or manually nulled).
8	TRANSFER RESET switch S4 (Pushbutton)	When mode switch is set to MANUAL BALANCE or MANUAL TRANSFER, permits the operator to switch between a-c balancing and d-c output states; when mode switch is set to AUTO, permits operator to recycle ATS for another measurement.
9	DC indicator DS2	Illuminates when ATS is in d-c output state (i.e., d-c equivalent of applied signal rms voltage is being furnished at DC OUTPUT binding posts).

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Figure 2-2 Index No.	Control, Indicator or Connector	Function
10	Mode switch S1 (3 position Rotary switch)	Permits operator to select operating mode: MANUAL BALANCE – operator must manually balance null meter before manually transferring to d-c output state; AUTO – ATS automatically nulls and switches to d-c output state; MANUAL TRANSFER – ATS automatically nulls but operator must manually switch to d-c output state.
11	MANUAL BALANCE FINE control R2 (10 Turn Control)	Permits vernier adjustment of nulling voltage, when operating in manual balance mode.
12	MANUAL BALANCE COARSE control R1 (10 Turn Control)	Permits coarse adjustment of nulling voltage when operating in manual balance mode.
13	TRANSFER CHECK switch S5 (Mom. Pushbutton)	Provides a quick check for the nulling circuitry when ATS is in the d-c output state (i.e., DC indicator illuminated). Depression of the switch should cause the front panel meter to indicate nearness to null when in the d-c output state.
14	OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator S2/DS3 (pushbutton)	Illuminates when an overload has occurred. Momentary depression of the switch resets the overload protection circuitry. Note that if the overload remains or the indicator lamp within the switch fails, the circuitry cannot be reset.
15	OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch S3 (Momentary pushbutton)	When held depressed, disables the overload protection capability. This feature permits the measurement of a-c signals having a crest factor of up to 10:1 and optimizes accuracy above 100 KHz.
16	0.5A fuseholder A1XF1	Line fuse. 0.5A 3AG Slo-Blo
17	POWER PUSH pushbutton switch/ indicator A1S1/A1DS1	Controls application of line power to ATS. When equipment is coupled to line power and switch is depressed, indicator will illuminate.
18	–DC OUTPUT binding post A1J2	Common (ground) d-c output terminal.
19	+DC OUTPUT binding post A1J1	Positive d-c output terminal.
20	STANDBY switch S6 (Momentary pushbutton)	Disconnects input by opening attenuator thru overload circuit activation. Operates only in AC mode.
21	NULL X5 switch S9 (momentary pushbutton)	Increases Null resolution by factor of five to 10 ppm (0.001%).
22	FAST/NORMAL switch S7 (Double throw toggle switch)	Operates in Auto Balance modes to provide NORMAL high accuracy transfer on steady signals or FAST transfer when signals have amplitude drift $< 0.005\%$ per second.

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Control, Indicator or Connector	Function
REAR PANEL CONNECTORS AND SWITCHES NOT SHOWN IN FIGURE 2-2	
115V-230V switch A1S2 on 11601A Transfer Assembly	Enables ATS to operate from either a 115-volt or 230-volt a-c line.
Line Power Receptacle on 11601A Transfer Assembly	Receptacle for 3 wire power cable 33100000A.
Remote programming connector J14 (7 Pin MS Connector)	Permits operation of the ATS (in AUTOmatic mode) from a remote location. Requires jumper connecting pins per Table 2-2 in local operation.
AUTO RECYCLE switch S8 (2 position slide switch)	Provides for automatic reset to AC in AUTO mode after 45 second waiting period after transfer from AC to DC. Also provides for manual reset operation from front panel or remote programmer.
Remote thermo converter connector J15 (10 Pin MS Connector)	Permits operation of external thermal converter from ATS. Also provides access to thermo element couple output emf during calibration. Requires jumper connecting pins per Table 2-2 in local operation.
Remote DVM range command and trigger output Connector J16. (50 pin Blue Ribbon)	Permits range tracking of remote dc readout DVM with ATS range switch A1S3. Also provides DVM "read" trigger 10 seconds after ATS transfer to DC.
Remote ATS Range Programming Input connector J300. (Option 03) (50 pin Blue Ribbon)	With option 03 permits remote ranging of ATS range switch A1S3 when latter is in PGM position.

output levels: one while the ATS is in the a-c balancing state (loading the source) and a second when the ATS is in the d-c transfer state (voltage source removed from ATS input attenuator). The output voltage of the ATS, as indicated on the readout instrument, will be the voltage of the loaded source.

b. **Losses in interconnecting wiring.** Since the ATS has an input impedance of approximately 200 ohms/volt, the voltage drop in the wiring interconnecting the voltage source and the ATS may introduce a measurement error, particularly when the low voltage ranges are employed. It is recommended that short heavy leads be employed when interconnecting the equipment.

c. **Thermal emfs in d-c output system.** Non-similar conductors employed to couple the DC OUTPUT binding posts to the readout instrument will introduce thermal emfs. it is recommended that conductors of the same material (copper) be employed.

d. **Settling time.** When the ATS transfers from the a-c balancing state to the d-c output state in the AUTO mode, the internal d-c substitution voltage builds up to balance that voltage stored in the digital memory circuit. The operator should allow approximately 15 seconds to elapse before reading the d-c output voltage.

e. **Stability.** Due to inherent temperature-dependent drift in the thermoelement output (≈0.01%/minute after a 10-minute warmup), the ATS output voltage should be measured as soon as the instrument has "settled" in the d-c output mode. If a potentiometer system or differential voltmeter is employed as the readout instrument, balance the readout instrument as closely as possible after the ATS has transferred to the d-c output state. Repeat the measurement cycle a second time and then null the readout instrument. Note that, for maximum d-c output stability, the ATS should be allowed to warm up for at least 4 hours before measurements are made.

f. **Auto-Zero.** The 1600A Auto Balance ac/dc Transfer Standard incorporates circuitry which automatically transfers from the signal input ac measuring mode to the dc output read mode. The ideal dc read time occurs some 15 seconds after transfer since then the same thermal conditions occur in the dc transfer system as existed at the ac measuring point at which transfer was initiated.

Making a dc reading too early does not provide the dc transfer voltage loop time to reach stable equilibrium required for repeatable 100 ppm measurements. Waiting too long (>20 seconds) causes changes in the thermal equilibrium and thermal drifts which will cause additive errors to accrue to the transfer dc reading.

It is advisable to read the dc transfer voltage on the 15 sec. basis. Although the thermocouple is suitably "thermally lagged" and low temperature coefficient metal film multiplier resistors are used, it must be remembered that the thermal transfer standard is basically a "thermal" sensing instrument. The extreme sensitivity of the 1600A can resolve ambient changes of as little as 20 millidegrees Celsius and the transfer dc output reading should be made within the time constraints indicated above to assure specified transfer accuracy. These read-out timing conditions apply equally to the AUTO, MANUAL BALANCE, and MANUAL TRANSFER operating modes.

The 1600A is thermally lagged to provide precise, accurate, and repeatable transfer measurements within the timing constraints indicated. To certify readings, it is recommended that three to four transfer readings are made. Delete the first reading and average the remaining readings for best results. It is recommended that the AUTO operating mode be used in re-cycle mode to make continuous ac/dc/ac transfer measurements.

Slide switch S8 is located on the rear panel of the 1600A. When set to OFF position, the front panel RESET pushbutton initiates switch to ac Mode. When S8 is set to ON, the reset from dc to ac is automatically recycled approximately 30 seconds after transfer from ac to dc mode. This continuous recycle adds an Auto-Zero feature to the Auto Balance Mode which avoids transfer errors caused by long term thermal variations.

It is recommended that AUTO mode is *always* used with Switch S8 in Auto-Zero recycle mode.

Should dc readout be accomplished with a manually balanced potentiometer which requires more time to read than a DVM, then attention must still be given to the above precautions. The 1600A must be continually recycled to remove thermal drift "zero" errors. Make a number of transfer readings at frequent or auto-recycled intervals while bringing the potentiometer to finite balance. If absolutely necessary, resistor A14R14 may be increased to lengthen the automatic recycle time interval.

The ideal time for reading the dc transfer voltage is at the same equilibrium point where ac to dc transfer was initiated. See paragraph for a full discussion of the DVM "read trigger" program output provided at approximately 15 seconds after transfer to dc.

g. **Attenuator heating.** When measuring voltages between 250 and 1000 volts, the power dissipated by the input attenuators will produce a slight change in resistance. It is recommended that the MANUAL TRANSFER mode be employed when measuring such voltages and that transfer be made after the signal under measurement has been applied for approximately two minutes (thereby allowing the input attenuator resistance to stabilize).

h. **Repeatability.** Lack of perfect repeatability is due to internal noise, finite digital memory resolution, contact resistance in switches and relays, thermal effects on attenuators, etc. Since these error sources are random in nature, several measurements should be made and the results averaged to obtain ultimate accuracy.

i. Push OVERLOAD DISABLE on second measurement of ac signals having components above 100 KHz.

2-17. **Mode Selection.** The ATS has three modes of operation, each selected by the setting of the front panel switch. When the switch is set to MANUAL BALANCE, the operator manually adjusts the MANUAL BALANCE COARSE and/or FINE controls until a null (0 on the meter BAL scale) is attained. After transfer, the voltage at the DC OUTPUT binding posts will be equal to the rms value of the applied a-c signal. While this mode of operation provides the greatest measurement accuracy (due to the finite resolution of the digital memory circuitry in the AUTO mode), it is slightly more time consuming – although substantially faster than conventional AC-DC transfer standard measurements.

2-18. When the mode switch is set to AUTO or MANUAL TRANSFER, the ATS balances automatically. In the AUTO mode, AC to DC transfer is performed automatically while in the MANUAL TRANSFER mode the AC to DC transfer point is determined by the operator. Manual transfer mode is used for moderately unstable input signals.

2-19. **Voltmeter Operation.** The ATS can be employed as a voltmeter to provide a relatively coarse indication of applied signal levels. When the instrument is operated in either the automatic or manual transfer mode, the d-c equivalent of the applied a-c signal rms level can be read by multiplying the meter DC OUTPUT VOLTAGE scale indication by the factor specified on the TIMES METER READING dial after transfer has been achieved. The voltage thus obtained will be within ±5% of the true rms level of the input signal.

2-20. **Overload Protection.** An overload protection capability is provided which will automatically remove the applied signal from the attenuator/thermoelement circuitry whenever the peak value of the applied signal exceeds 175% of the selected range high voltage peak. Thus, if the RANGE VOLTS switch is set to 125 to 250 and the peak value of the applied signal is in excess of 437 volts (although its rms value is between 125 and 250 volts), the overload protection circuitry will be triggered. The OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator will illuminate to indicate that an overload condition was and/or is present. The ATS will not be capable of measurement until the overload condition has been corrected (i.e., setting the RANGE VOLTS switch to a higher range and depressing the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator).

TABLE 2-2. CONNECTOR PIN IDENTIFICATION

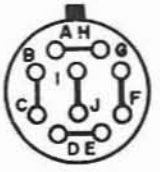
Remote DVM Commands Output Connector J16 *(mates to Amphenol 57-30500)*

Pin	Function
1	PGM
2	500 – 1 kV Range
3	250 – 500 V Range
4	125 – 250 V Range
5	64 – 125 V Range
6	32 – 64 V Range
7	16 – 32 V Range
8	8 – 16 V Range
9	4 – 8 V Range
10	2 – 4 V Range
11	1 – 2 V Range
12	.5 – 1 V Range
13	.25 – .5 V Range
14	Read pulse
15	Shield
16	Not Used
17	Not Used
18	Not Used
19	Not Used
20	Not Used
21	Not Used
22	Not Used
23	Not Used
24	Not Used
25	Program Ground
26-49	Not Used
50	Case Ground

Remote Thermalconverter Connector J15 *(mates to MS-3106A-18-1P connector with MS-3057-10 clamp)*

Pin	Function
A	DC High Voltage Interconnect
B	TC pos. OUT
C	TC pos. IN
D	DC Low Voltage Interconnect
E	DC Low Voltage Interconnect
F	Shield IN
G	Shield OUT
H	DC High Voltage Interconnect
I	TC neg. OUT
J	TC neg. IN

Dummy plug used when remote thermocouple not required.



Connector MS-3106A-18-P and 9760-16 cap with bead chain removed.

NOTES:

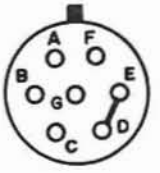
1) The High Voltage cut off jumper (pins H-A on P15/J15) and the low voltage cut off jumper (pins E-D on P15/J15) must be removed when using External Thermal connectors. This applies dc transfer voltage to the external thermal converter and disconnects the internal attenuator which would otherwise parallel the external converter.

2) Jumpers H-A and E-D must ALWAYS be installed when using the 1600A in its normally intended internal attenuator operation. Failure to install these jumpers will render the internal attenuator dc mode inoperative.

Remote Reset Connector J14 *(mates to MS-3106A-16S-1P connector with AN-3057-8 clamp)*

Pin	Function
A	Remote DC Mode Indicator
B	Remote Indicator Common
C	Remote AC Mode Indicator
D	External Reset line*
E	External Reset line*
F	Chassis Ground
G	No Connection

*Normally closed together:
a) Jumper for normal operation
b) NC momentary push button for remote reset.



Remote Range Programming Input Connector J300 *(mates to Amphenol 57-30500)*

Pin	Function
1	Not Used
2	500 to 1 kV Range Select
3	250 to 500 V Range Select
4	125 to 250 V Range Select
5	64 to 125 V Range Select
6	32 to 64 V Range Select
7	16 to 32 V Range Select
8	8 to 16 V Range Select
9	4 to 8 V Range Select
10	2 to 4 V Range Select
11	1 to 2 V Range Select
12	.5 to 1 V Range Select
13	.25 to .5 V Range Select
14-24	Not Used
25	Common
26-49	Not Used
50	Case Ground

2-21. The overload protection circuitry is normally not intentionally disabled unless signals having a high crest factor (greater than 2:1) are being measured. When such signals are applied to the ATS, the overload protection circuitry (if not disabled) would remove the input when the signal peak value is greater than 175% of the selected range rms high limit. When the rms level of the applied signal will not damage either the attenuator or thermoelement, the overload protection circuitry may be disabled by holding the OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch depressed for the duration of the measurement. Observe overload derating above 10 MHz and for short (< 1 mS) transients).

EXAMPLE

Assume that the a-c signal to be measured has a peak value of 150 volts and a crest factor of 3:1. When the operator sets the RANGE VOLTS switch to 125 TO 230, the ATS will not be capable of providing a meter indication of 0 on the BAL scale since the rms value of the applied signal (50 volts) is below the selected measurement range.
When the operator switches to the next lower position of the RANGE VOLTS switch (i.e., 64 TO 125), the ATS will still not balance because the rms value of the applied signal is still below the selected measurement range. Note that the peak value of the applied signal is less than 175% of the selected range high voltage limit of 125 volts. 125 x 175% = 219V Therefore the overload protection circuitry will not be triggered.

Since a null was not obtained, the operator now sets the RANGE VOLTS switch to 32 to 64. The peak value of the applied signal is now in excess of 175% of the selected range high voltage limit, causing the overload protection circuitry to trigger and remove the applied signal from attenuator network. The OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator will illuminate to indicate that an overload condition exists.

To measure the rms value of the applied signal, the operator should depress the OVERLOAD PROTECTION PUSH TO DISABLE switch and, while holding this switch depressed, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION PUSH TO RESET indicator will no longer be illuminated and the operator can perform the selected measurement. After transfer has been achieved, the operator should set the RANGE VOLTS switch to the next higher range and then release the OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch.

CAUTION

To prevent damage to the thermoelement, follow the above example whenever high crest factor signals are to be measured (i.e., null cannot be obtained on initial setting of the RANGE VOLTS switch).

It should be stressed that the overload protection circuitry is not designed to serve as a range indicator and that continuous overloading of the ATS may result in the eventual degradation of the thermoelement.
The thermoelement is not covered by the warranty.

2-22. **Standby.** A standby mode is provided to eliminate the possibility of damaging the thermoelement when changing input cables or switching signal levels. Standby switch S6 is provided to activate the overload protection circuit and thus disconnect the input from the attenuator. S6 is activated by depressing a momentary pushbutton switch on the front panel. It functions only when the ATS is in the AC mode.

The overload lamp DS3 lights to show standby operation.

When ready to resume normal operation the overload protection reset switch S2 is pushed to reconnect the input connectors to the attenuator.

2-23. **MANUAL BALANCE OPERATION.** To operate the ATS in the manual balance mode, process directed in the following steps.

a. Couple the ATS to line power and momentarily press the POWER PUSH pushbutton switch; the indicator portion of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the mode switch to MANUAL BALANCE.

c. Set the RANGE VOLTS switch to obtain a dial indication of 500 to 1000. Push the STANDBY pushbutton and note that the overload lamp is illuminated.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector. Set input voltage and RANGE VOLTS switch into range.

e. Note which indicator (AC or DC) is illuminated. If the DC indicator is illuminated, momentarily press the TRANSFER-RESET pushbutton switch AC indicator will become illuminated and the DC indicator will become extinguished.

f. Note if the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch. The indicator should become extinguished.

g. Adjust the MANUAL BALANCE COARSE and/or FINE controls to obtain a meter indication of 0 on the BAL scale. When this indication is obtained, the ATS is ready to be set to the d-c output state. To increase

resolution at balance push NULL X5 pushbutton. This gives maximum resolution of 10ppm per minor scale division.

NOTE

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and −DC OUTPUT binding posts when the DC indicator is illuminated. The −DC post is chassis ground.

h. Momentarily depress the TRANSFER-RESET pushbutton switch to place the ATS in the d-c output state; the DC indicator should illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement can be obtained from the indication of the digital VM or potentiometer connected between the +DC OUTPUT and −DC OUTPUT binding posts. Note that a less accurate reading can be obtained by noting the meter DC OUTPUT VOLTAGE scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial.

i. To perform another measurement, repeat steps e through h.

2-24. **REVERSE MANUAL BALANCE OPERATION.** To operate the ATS in the reverse manual balance mode (i.e., using the ATS to provide a reference output level and then setting the rms value of the applied signal to equal this voltage), proceed as follows.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator portion of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. set the mode switch to MANUAL BALANCE.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and −DC OUTPUT binding posts when the DC indicator is illuminated.

c. Set the RANGE VOLTS switch to obtain the desired voltage and note which indicator (AC or DC) is illuminated. If the AC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch; the AC indicator will become extinguished and the DC indicator will be illuminated.

d. With the voltage source set for minimum output level, interconnect the equipment as illustrated in figure 2-3.

e. Adjust the MANUAL BALANCE COARSE and/or FINE controls until the desired rms voltage level (as indicated on the d-c digital voltmeter or potentiometer null is obtained.

f. Without further adjustment of either the MANUAL BALANCE COARSE and/or FINE control, momentarily depress the TRANSFER-RESET pushbutton switch; the DC indicator will become extinguished and the AC indication will be illuminated.

g. Carefully adjust the output level of the voltage source until the pointer of the ATS meter deflects to an indication of 0 on the BAL scale. When this occurs, the voltage source output level has been set to the desired value.

2-25. **AUTOMATIC BALANCE OPERATION.** To operate the ATS in the automatic balance mode, proceed as directed in the following steps.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator section of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes. Set the Auto Recycle slide switch S8 on the rear panel to "OFF".

b. Set the mode switch to AUTO; the AC indicator will become illuminated. Set the NORMAL/FAST toggle switch to NORMAL.

c. Set the RANGE VOLTS switch to obtain a dial indication of 500 TO 1000. Push the STANDBY pushbutton and note that the overload lamp is illuminated.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector. Set input voltage and RANGE VOLTS switch into range.

e. Note that the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch. The indicator should become extinguished.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and −DC OUTPUT binding posts when the DC indicator is illuminated.

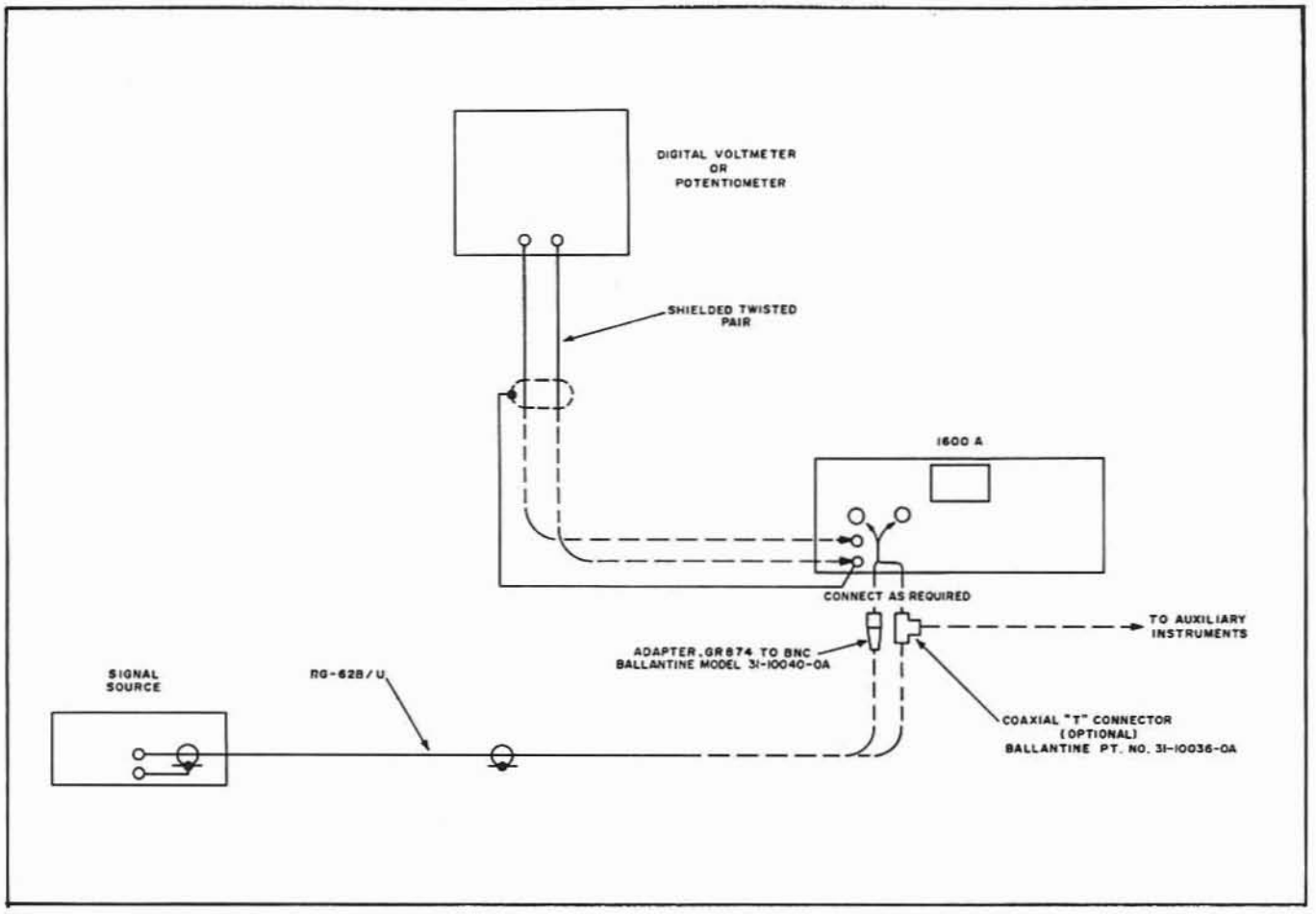


Figure 2-3. Equipment Interconnection Diagram

f. After approximately 15 seconds, the meter pointer will deflect to an indication of 0 on the BAL scale. At this time the AC indicator will be extinguished and the DC indicator will illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement can be obtained from the indication of the d-c digital voltmeter or other readout instrument connected between the +DC OUTPUT and −DC OUTPUT binding posts. Note that a less accurate reading can be obtained by noting the meter DC OUTPUT VOLTAGE scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial.

NOTES

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

i. To perform another measurement, momentarily depress the TRANSFER-RESET pushbutton switch.

To obtain the advantage of Auto Zero operation set rear panel Auto Recycle switch S8 to ON. The ATS will make a new reading approximately 45 seconds after transfer from AC to DC. There is no further need to manually push the RESET switch.

2-26. **MANUAL TRANSFER OPERATION.** To operate the ATS in the manual transfer mode, proceed as directed in the following steps.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator section of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the RANGE VOLTS switch to 500 TO 1000.

c. Set the mode switch to MANUAL TRANSFER and note which indicator (AC or DC) is illuminated. If the DC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch; the DC indicator will be extinguished and the AC indicator will illuminate.

Push the STANDBY pushbutton and note that the overload lamp is illuminated.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector. Set input voltage and RANGE VOLTS switch into range.

e. Note that the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch; the indicator section of the switch should be extinguished.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and −DC OUTPUT binding posts when the DC indicator is illuminated.

f. After approximately 15 seconds, the meter pointer will deflect to an indication of 0 on the BAL scale. When the pointer comes to rest within one-half division of 0, momentarily depress the TRANSFER-RESET pushbutton switch. At this time the AC indicator will be extinguished and the DC indicator will illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement is available at the DC OUTPUT binding posts and can be read by means of the d-c digital voltmeter or potentiometer. Note that an approximate reading may be obtained by noting the meter DC OUTPUT scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial; this feature permits presetting of differential voltmeter or potentiometer controls.

NOTES

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

g. To perform another measurement, repeat steps c through f.

2-27. **AUTOMATIC BALANCE OPERATION FROM A REMOTE LOCATION.** To operate the ATS in the automatic balance mode from a remote location, proceed as directed in the following steps.

NOTE

This procedure assumes that the voltage under measurement does not require resetting of the RANGE VOLTS switch.

a. With the ATS removed from line power, remove 7 pin plug P14 from J14 on the rear panel.

b. Remove the jumper between contacts D and E from plug P14. Also see Table 2-2.

c. Fabricate a remote control box (see figure 2-4) and interconnect the ATS and remote control box as illustrated in figure 2-5.

d. Couple both the ATS and the remote control box to line power and energize the equipment.

e. Set the ATS mode switch to AUTO and the RANGE VOLTS switch to that range compatible with the signal to be measured.

f. Operate the ATS as in the standard AUTOmatic balance mode (refer to paragraph 2-26), using the pushbutton switch on the remote control box to switch between a-c balance and d-c output states. Note that range switching and resetting of the overload protection circuitry cannot be accomplished at the remote control box. Range programming may be accomplished when option 03 is installed in the ATS.

2-28. **INDEPENDENT OPERATION OF TRANSFER ASSEMBLY A1.** At times it may be required that the transfer assembly (11601A) be operated independently of the remainder of the ATS system. Such instances occur when the transfer assembly is sent to the National Bureau of Standards for a test report on AC-DC difference. The wiring for independent operation of the transfer assembly is illustrated in figure 2-6. Note that the circuitry shown by heavy lines are the minimum required for independent operation. Plus and -15 volt supplies are required only to operate the overload protection circuits.

CAUTION

If the transfer assembly is to be operated without the operation of the overload protection capability, care must be taken to ascertain that the voltage range setting of the RANGE VOLTS switch is compatible with the a-c voltage to be measured.

2-29. To remove the transfer assembly from the equipment frame, proceed as directed in the following steps:

a. With the ATS unenergized remove the unit from its bench mount case or from the rack.

b. If the ATS contains top and bottom chassis dust covers P/N 51-10015-1L remove these two covers.

c. Disconnect the 3 high voltage BNC connectors, the 50 pin Blue Ribbon and the 24 pin Blue Ribbon connector from the mating receptacles in the 11600A transfer Assembly. Remove the front panel collet knob by first removing the knob cover to gain access to the collet lock nut.

d. Place the 1600A ATS on its left side (with the 11600A at the bottom).

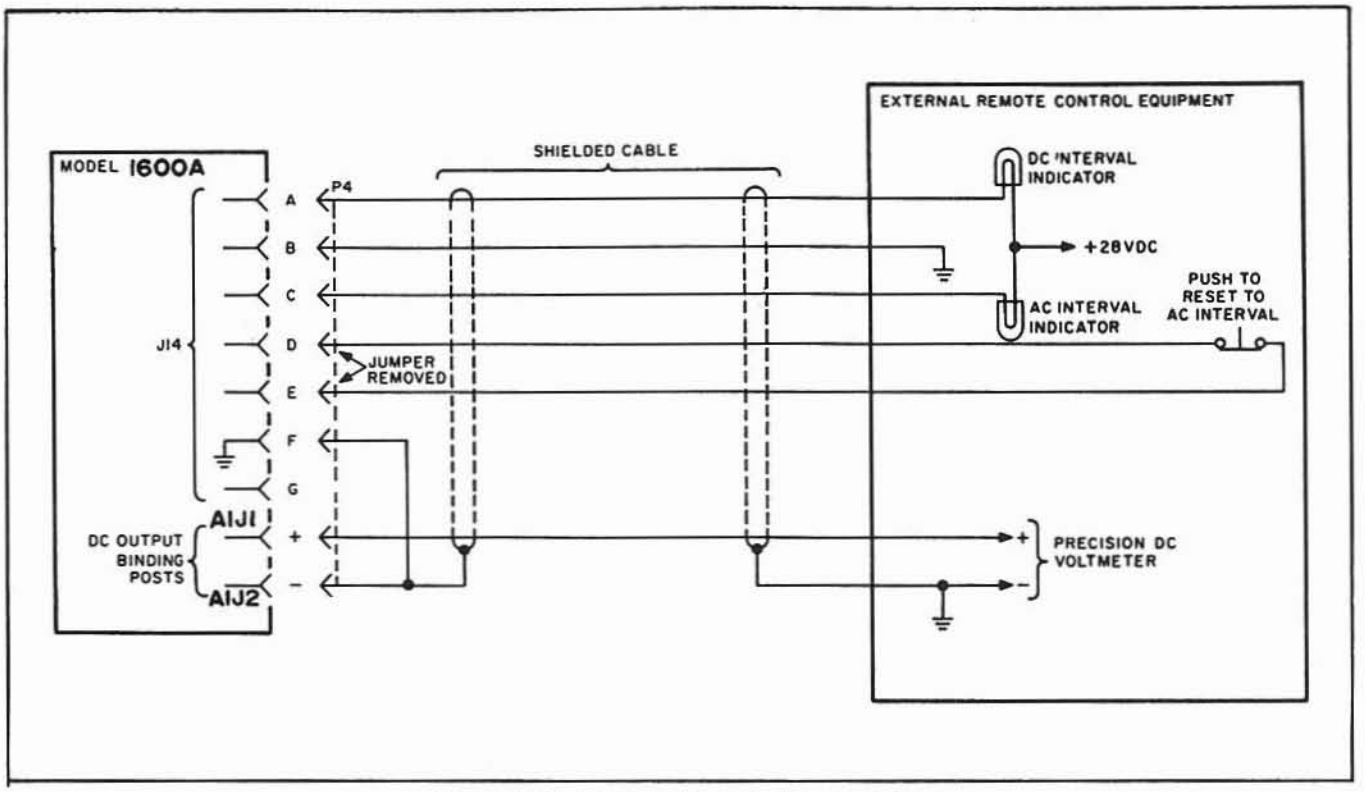


Figure 2-4. Typical Remote Control Box

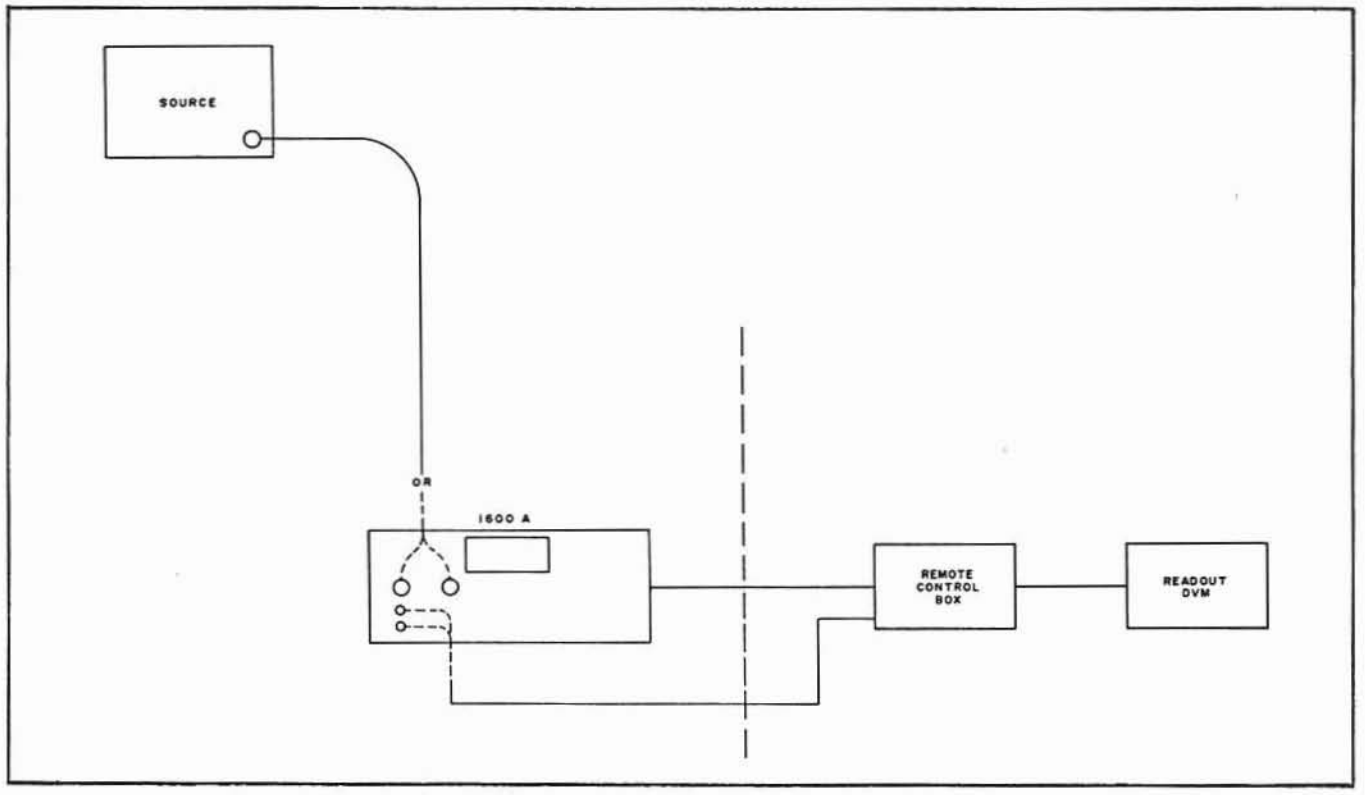


Figure 2-5. Equipment Interconneetion for Remote Operation

e. Remove the four screws that hold the transfer assembly to the struts in the equipment frame.

f. Carefully place the ATS rightside-up.

g. Gently slide the transfer assembly toward the rear of the equipment and, using both hands, carefully lift the transfer assembly out of the equipment.

2-30. EXTERNAL THERMAL CONVERTER. Provision is made for the use of external thermal converters where this may be advantageous. Thermal converters to 1 GHZ operation such as Ballantine Series 1394A and 1396A are recommended. The 1600A is set up for this mode of operation simply by removing P15 from J15 at the rear panel and connecting a suitable cable between J15 and the thermocouple dc output, such as Ballantine part 89-10126-1F for three terminal connectors on thermoconverter outputs. Refer to Table 2-2 and Figure 92-10037-1C. Connect cable Ballantine Part No. 89-10128-1F to the dc output terminals of the 1600A. Disable the Auto-Recycle switch S8 on the rear panel.

To make a transfer reading, connect the unknown ac source being measured to the input of the thermocouple. Balance the ac loop in the usual way, depending on the mode of operation of the 1600A. When the dc transfer has taken place, disconnect the unknown ac source from the thermocouple and quickly connect the free end of dc output cable, part number 89-10128-1F to the thermocouple. Allow 10 to 15 seconds for the dc loop to stabilize and read the dc voltage on the DVM. When high voltages are involved, care must be taken in handling the dc output cable to avoid a severe shock or damage to the equipment.

CAUTION

External thermoconverters are not protected by overload protection. Extreme care must be taken that the input voltage to the thermo converter and the 1600A ATS Voltage Range selection match the maximum anticipated input signal to the thermo converter.

2-31. EXTERNAL PROGRAMMING OUTPUT FOR TRANSFER READOUT DVM RANGE. Manual Range selector switch AIS3G on the 11600A provides selection of one of 13 output points corresponding to each of the 12 attenuator ranges and the PGM external remote program selection range. All thirteen points and the common are available at AIS3G and the rear panel 50 pin connector J16. The interconnecting cable is provided with jumpers to provide range coding for external programable digital voltmeter 3600A when using connecting cable 89-10129-1F.

The Program Output is available from the factory and provides installation of the universal "one of 13" points range output program. J16 is then wired with pin 2 through pin 13 wired sequentially from the 0.25 to 0.5 V attenuator range code on pin 13 and the 500 V to 1 kV range code connected to pin 2. Pin 1 codes the PGM output and pin 25 is the common for this program output system. See Table 2-2.

Switching of voltages to 100 Volt dc is permitted but inductive loads with currents over 10 mA should be diode surge protected. Inductive loads over 20 mA should be avoided. Off ground operation to 200 Volts dc is permissible. Avoid ac signals on these program output lines and if necessary, provide EMI suppression since transfer errors could be caused by stray coupling in the 1600A from unknown or uncontrolled external systems tied to this remote range output programming system.

A trigger output signal is available to program triggerable DVM's to read at the "most precise" thermal point occurring some 15 seconds after the transfer from ac mode to dc mode. This trigger output is a unique "Read" feature and assures best accuracy and optimum repeatability. It minimizes operator error and variables caused by indeterminate timing and thermal time constants.

The "Read" trigger is a 4 Volt negative trigger of 200 usec duration. It is capactively coupled to pin 14 of J16 and is referenced to the 1600A +3.9 V dc supply. Its negative transition source impedance is 0, and positive transition approximately 1 kΩ. Avoid capacitive loads in cables and receiving units with shunt capacity greater than 175 pF and keep resistive load at 50Ω or greater. A 50Ω terminated transmission system is recommended.

When using Ballantine Model 3600A DVM, the 3600A is automatically programmed by the range switch of the 1600A Auto Transfer Standard. Cable assembly Ballantine part number 89-10129-1F is connected between the 3600A and J16 at the rear of the 1600A Auto Transfer Standard.

2-32. REMOTE RANGE PROGRAMMING OF THE 11600A TRANSFER ASSEMBLY. Remote Range Programming MOD-03 is optionally available to permit remotely activating the range attenuator.

When MOD-03 option is installed and the RANGE VOLTS switch on the 11600A is set to PGM position any of the 12 ranges from 0.25V to 1 kV may be remotely selected.

Rear Input Connector J300 is provided for connection of external range programmers to the 1600A. It is a

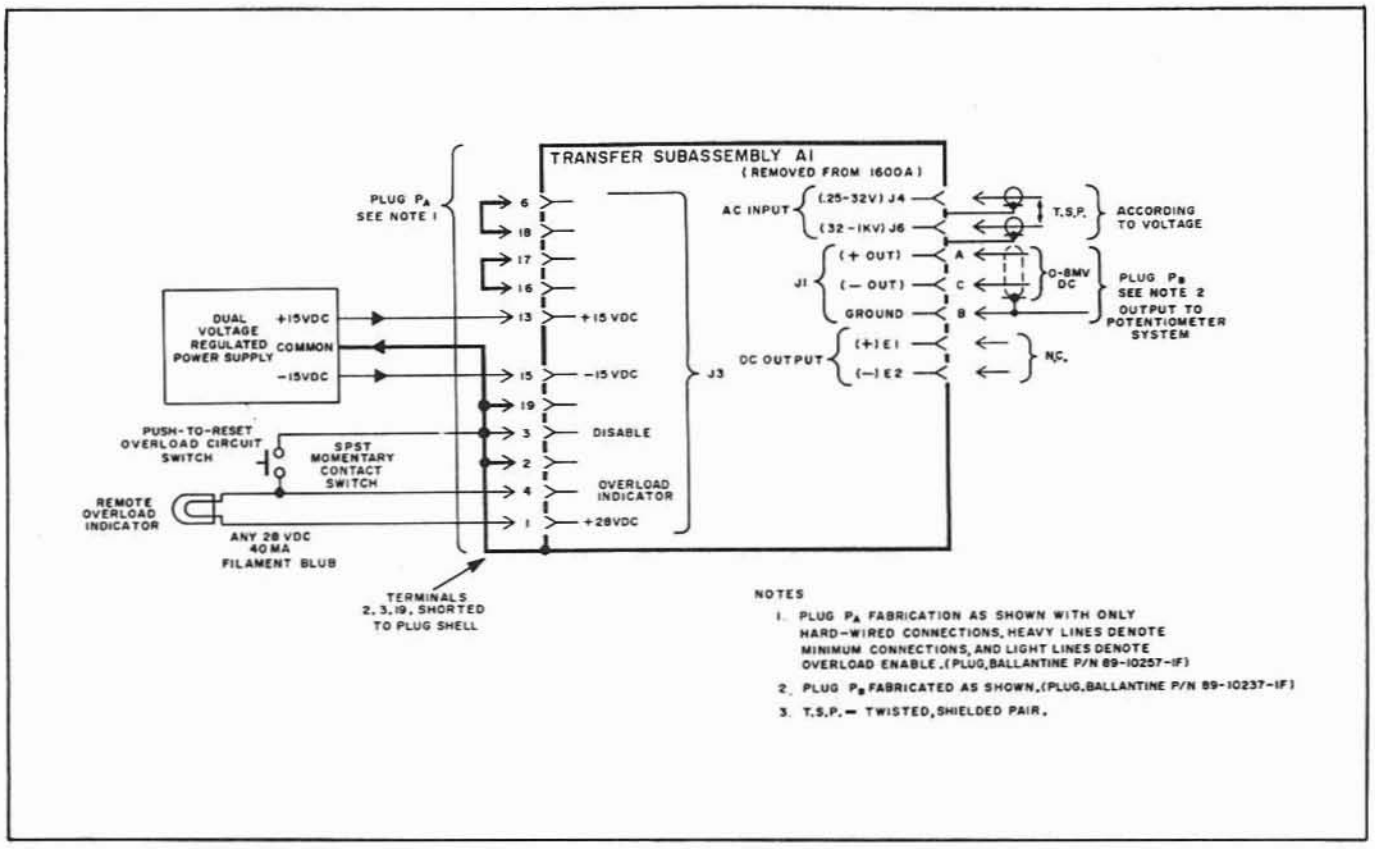


Figure 2-6. Interconnection Diagram for Independent Operation of Transfer Assembly

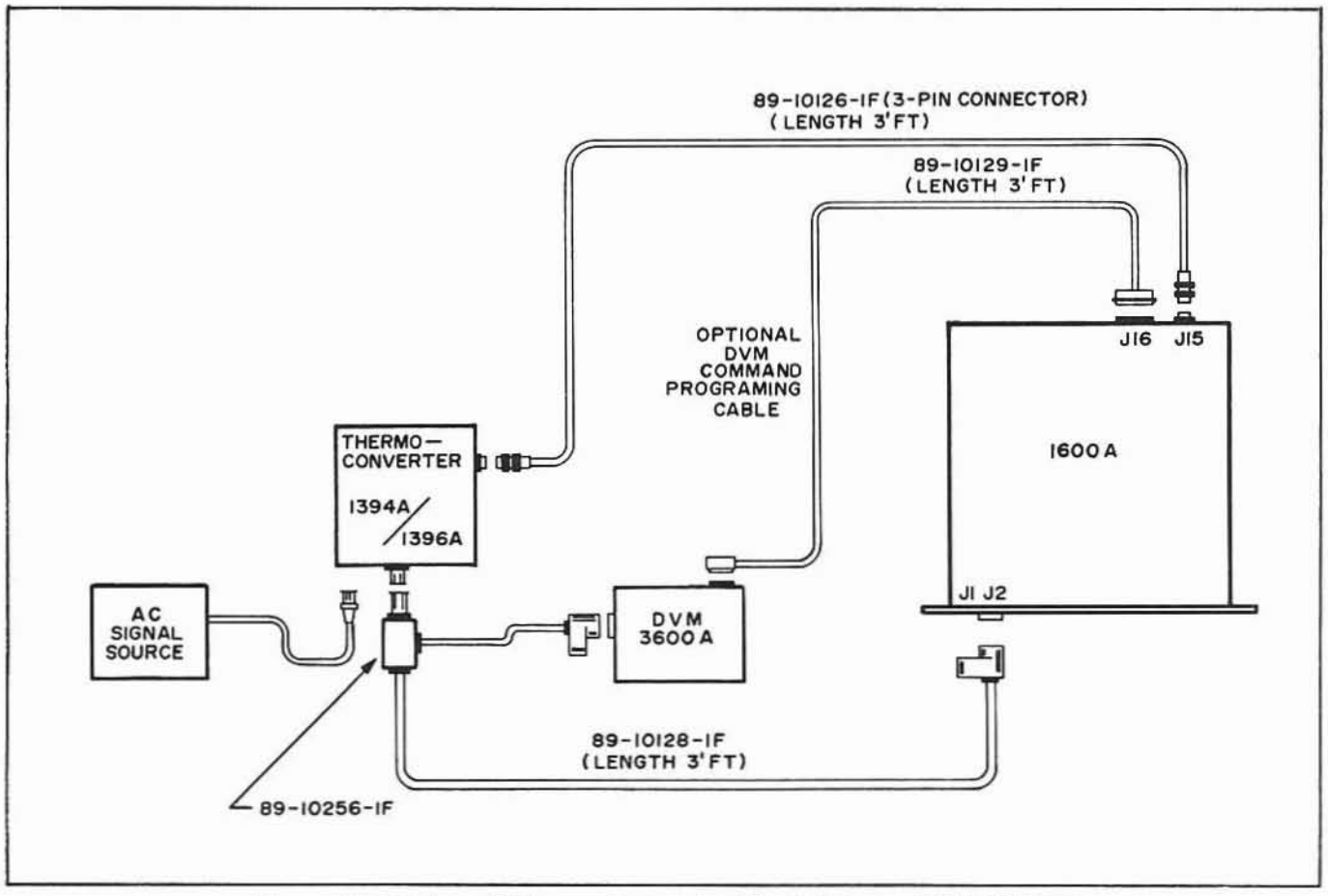


Figure 2-7. External Thermo Converter Block Diagram 92-10037-1C

50 pin Amphenol Blue Ribbon connector (Amphenol 57-40500). Mating connector, Ballantine Part 31-10050-0A (Amphenol 57-30500) is optionally available as is a 6 foot mating program cable, Ballantine Model 12253A which terminates in 50 pin connectors at both ends.

Electrical activation is by 12 lines of TTL compatible signal levels or contact closure to ground. One of twelve lines only must be activated to select one attenuator range. A range is selected by a "low" level of less than +0.3 Volts or a contact closure to ground. Current sinking capability must be greater than 10 mA. This is the "zero" or command level. All other range program lines must be at voltage levels of +5 ±0.5 Volts. The latter is "1" state level and presents a nominally greater than 2,000Ω source impedance to the external programmer.

All range program inputs are decoupled through solid state optical isolators. 5 Volt bias voltage may be supplied from the external programmer or internally from the 1600A. When external +5 V bias is provided, ground currents and noise interference are minimized. Off ground operation of ±200 V dc plus peak ac is permitted.

It is recommended that the programmer is a break before make contacting type to avoid having more than one attenuator range activated simultaneously. Range selection may be randomly sequenced. It is also recommended that range switching be accomplished in dc Mode and at rates slower than one change every 2 seconds to prevent overload trip.

Reset may be remotely programmed and all other 1600A remote features are independently usable with the remote ranging option.

Table 2-2 gives the pin connection for remote ranging J300.

Remote ranging circuits are coupled through solid state optically activiated isolators. These solid state relays, K311 through K322, provide selection of range and operate sealed reed relays K321 through K332. The ranging relays select ranges normally chosen by manual attenuator selector switch S3A and S3B. The reed relays K321 through K332 select internal dc transfer voltage multipliers normally chosen by manual attenuator selector switch S3C and S3D. In addition, K340 is a SPDT reed relay used to provide error feedback to either low or high voltage systems as normally selected by switch S3E. Interconnection is provided by 50 pin blue ribbon connector J310 mounted in the 11601A.

The front panel output voltage indicating meter is not active when remote range PGM is selected, although it still functions as a null indicator in the ac operating mode.

MOD-03 is normally installed at the factory.

2-33. PACKAGING INSTRUCTIONS.

2-34. SHORT TERM STORAGE. If the ATS is to be stored for a short time, cover the equipment with suitable protective covering (such as a sheet of plastic or paper) and store the equipment in a clean and dry area that is not subject to extreme temperature variations.

2-35. LONG TERM STORAGE OR SHIPMENT. If the ATS is to be stored for a long period, or shipped, proceed as directed below.

a. If the original wrappings and carton have been saved, package the equipment as illustrated in figure 2-8.

b. If new packing material is to be employed, first wrap the ATS in a moistureproof barrier such as a plastic bag. Place the equipment in a suitable box or carton and fill all empty spaces with suitable filler material to prevent possible shifting of the equipment. Seal the box or carton. Should conditions warrant rugged packaging, enclose the sealed box in a carton in an outer wooden crate or metal transit case.

c. Always "block" the rack slides and the unit in the bench mount case with shipping blocks made of heavy duty corrugated cardboard to prevent motion of the instrument within the enclosure during shipping shock and vibration.

2-36. If shipment is to the factory:

a. Notify Ballantine in advance and include detailed reasons for return inside the box along with your name, company name, telephone and full mailing address. Also include the purchase order number.

b. Properly label and address box with several typed labels or an indelible pen.

c. Mark the box FRAGILE ELECTRONIC INSTRUMENT – DO NOT DROP OR THROW. It is recommended that the shipment be fully insured against loss or shipping damage.

d. Ship prepaid by truck or Air Freight to:

Ballantine Laboratories
90 Fanny Road
P.O. Box 97
Boonton, N.J. USA 07005

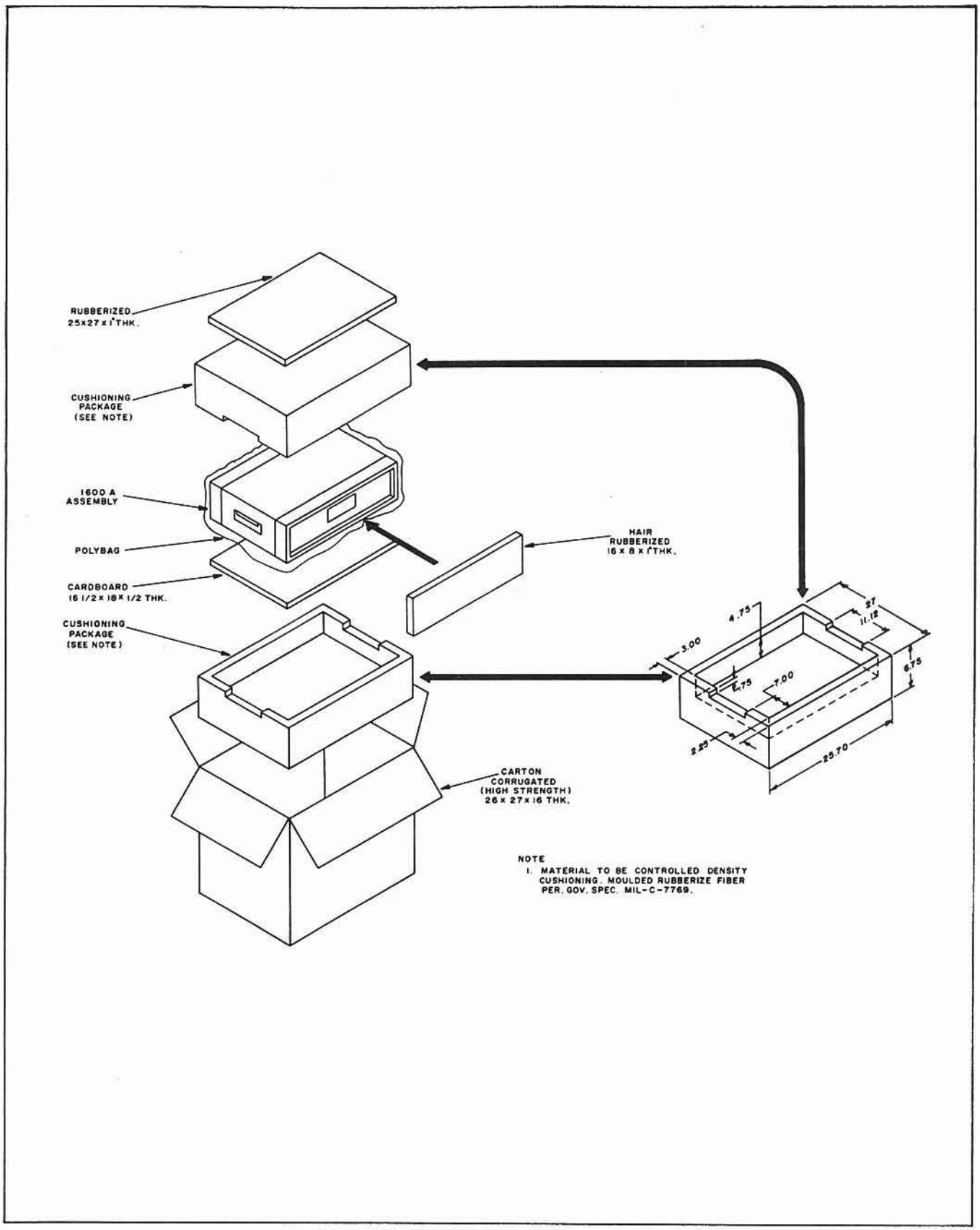


Figure 2-8. Packaging Diagram

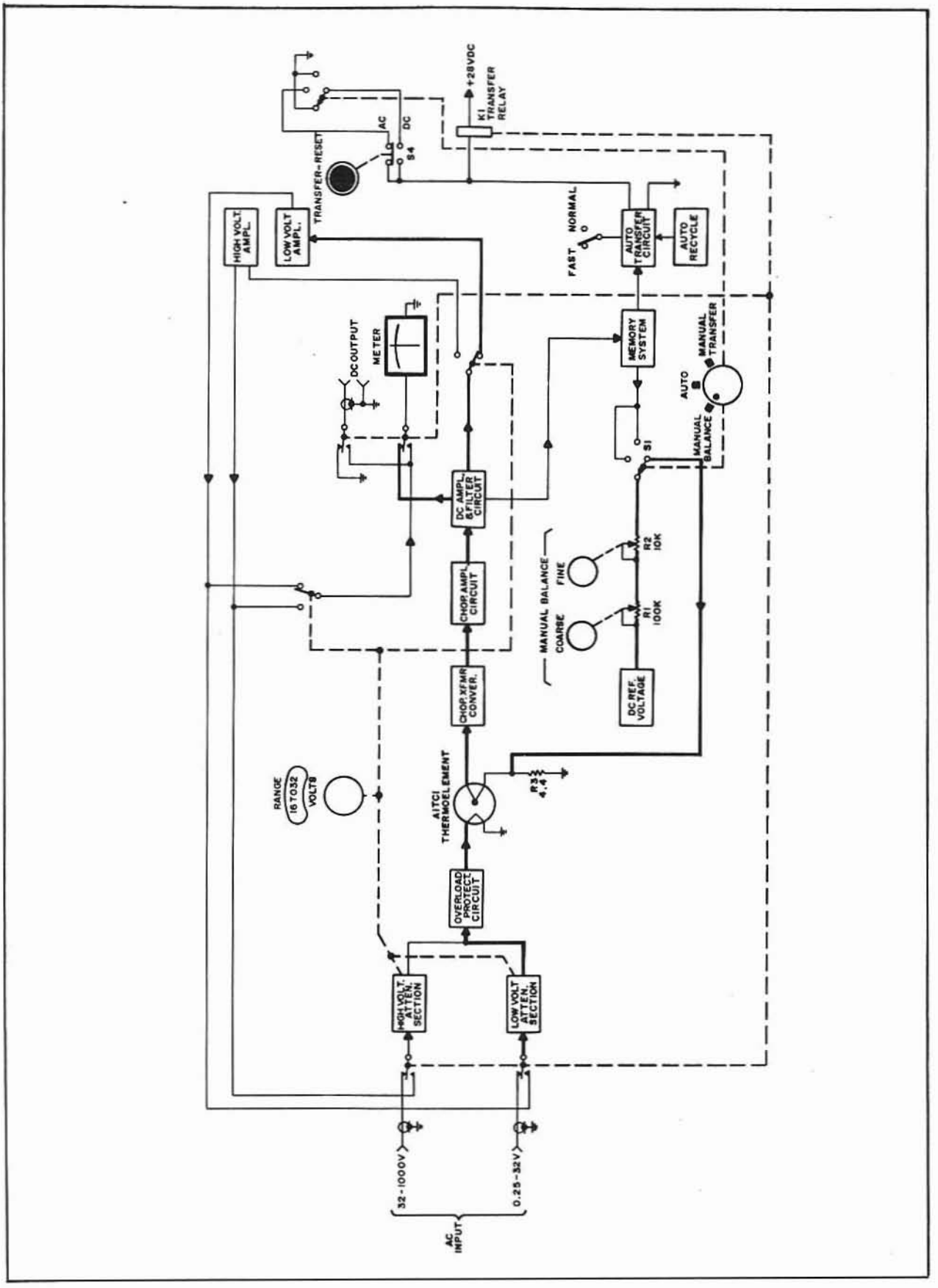


Figure 3-1. Simplified Block Diagram