INSTRUCTION MANUAL

MODEL 1620A

TRANS–
CONDUCTANCE
AMPLIFIER

APPLICABLE TO UNITS WITH SERIAL PREFIX 024–

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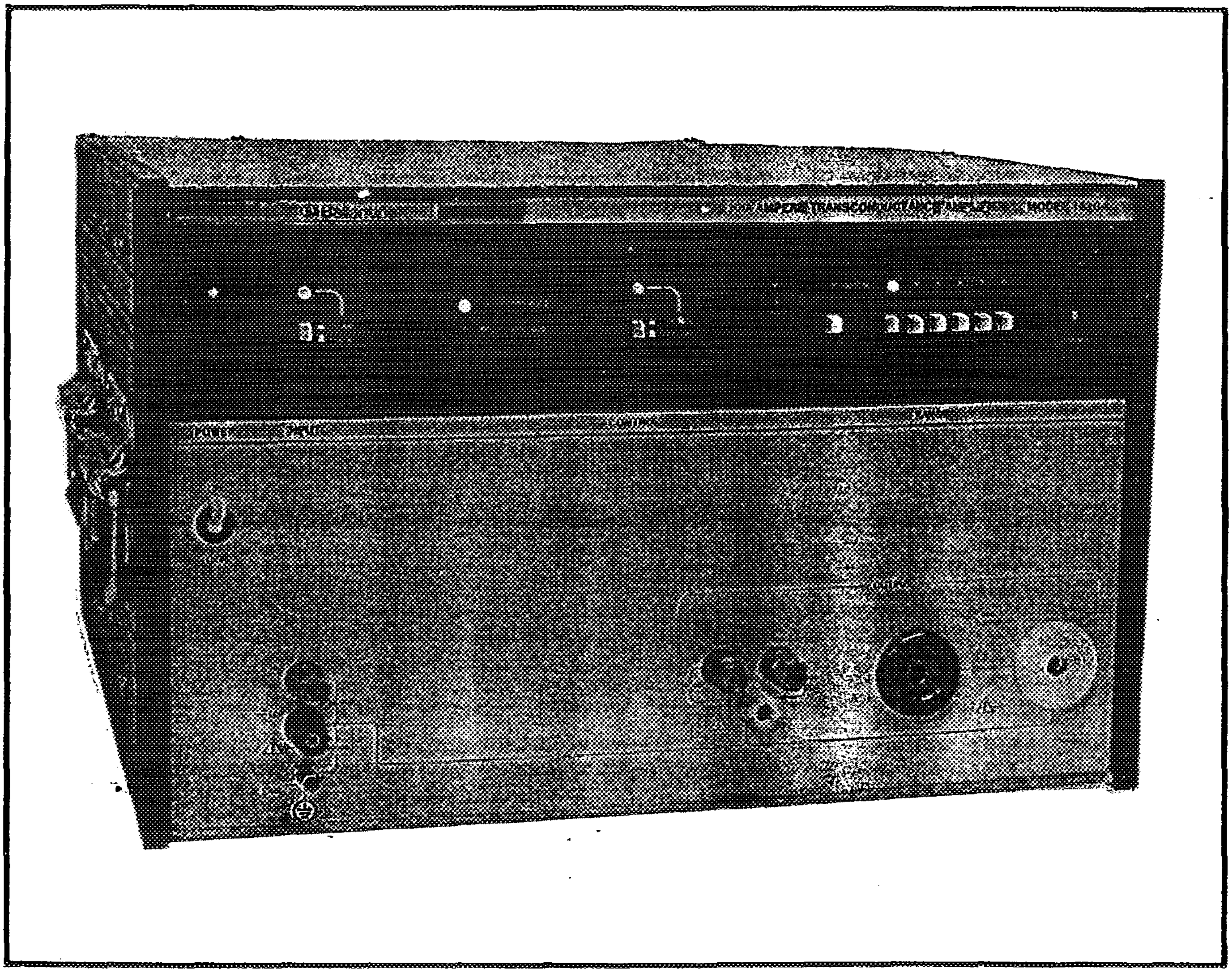


Figure 1-1. Model 1620A Transconductance Amplifier

SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. The Ballantine Model 1620A Transconductance Amplifier is a wide range DC-AC voltage to current converter. The 1620A converts a precision input voltage to a proportional output current. The instrument is intended for use as a precision current source for calibrating ammeters, current transformers and shunts. It may also be used as a high current power supply and as a power source in welding and bonding applications.

1-3. Dc input voltages provide the same polarity output current and output current is proportional to the input magnitude. For AC input voltages the output current has the same frequency and phase of the input voltage. Output current is proportional to the input voltage. The 1620A is DC coupled throughout and will faithfully convert into comparable output currents and input voltages of diverse waveshape, unbalanced symmetry and with dc offset potentials. The signals for the 1620A may be operated ± 100 volts with respect to the enclosure which must be earth grounded.

1-4. The 1620A incorporates seven switch selectable current ranges of:

100A	at	100 Siemens Transconductance
20A	at	10 Siemens Transconductance
2A	at	1 Siemens Transconductance
200m	at	100 milliSiemens Transconductance
20m	at	10 milliSiemens Transconductance
2m	at	1 milliSiemens Transconductance
200u	at	100 microSiemens Transconductance

All current ranges are rated ± dc, ac sinusoidal and ac rms with a crest factor equal to or less than 1.45.

1-5. Convenient front panel output connectors are provided to simplify testing of current ranges on conventional multimeters and ammeters. All currents to 2A are accessible from a single set of binding posts to avoid having to transfer connecting cables. The 20A RANGE and the 100A RANGE are each available on separate output connectors to purposely require switching of cables on these ranges where high current may damage low current ranges of the instrument being provided with the current input.

NOTE

Never connect more than one set of current output terminals at a time and be certain zero has been adjusted before using on each range. On high currents above 10A check zero after unit has been operated to warmup.

1-6. STANDBY and FRONT/REAR INPUT switching are provided along with complete optional remote IEEE-488 control of all RANGES, STANDBY, and FRONT/REAR INPUT. RANGE indicator lamps and REMOTE indication lamps are provided. Option 60 provides IEEE-488 bus operation.

1-7. OOVERCOMPLIANCE and INPUT OVERDRIVE voltage indicator lamps are provided on the front panel to show when the output voltage is excessive due to too high a load impedance for the current being supplied and when the input voltage is beyond the specified limits.

1-8. The Model 1620A is forced air ventilated with cold air drawn into the instrument and discharged from the instrument at its rear panel. Over-temperature output protection is provided.

1-9. The Model 1620A is housed in a rugged aluminum enclosure and is in conformance with RETMA 19 inch rack mount dimension. Rack mount hardware and slides are field installable. Option 15 provides slides and rack mount accessories.

1-10. The Model 1620A may be operated from conventional 100, 120, 220 and 240 volt ac mains with current capacity of 20 amperes.

1-11. SPECIFICATIONS

1-12. Table 1-1 lists the specifications for the Model 1620A.

TABLE 1-1.

PERFORMANCE SPECIFICATIONS

AC OPERATION

RANGES:

0 to 100A rms	Transconductance:	100 Siemens
0 to 20A rms	Transconductance:	10 Siemens
0 to 2A rms	Transconductance:	1 Siemens
0 to 200m rms	Transconductance:	100 milliSiemens
0 to 20m rms	Transconductance:	10 milliSiemens
0 to 2m rms	Transconductance:	1 milliSiemens
0 to 200u rms	Transconductance:	100 microSiemens

Ratio of input voltage to output current. All ranges: 2 Volt input/full range current output except 100A RANGE which has 1 volt for 100A rms output current. AC rms is rated for sinusoidal inputs with a maximum crest factor of 1.45.

RESOLUTION:

(Referred to input voltage)
0.01% of range on the 2m to 20A RANGES.
10mA on the 100A RANGE.
1uA on the 200u RANGE.

COMPLIANCE VOLTAGE:

100A RANGE: 3 V rms sinusoidal (± 4.25 V peak) maximum to meet stated specifications.

20A RANGE: 4 V rms sinusoidal (± 5.6 V peak) maximum to meet stated specifications.

All other RANGES: 5.5 V rms sinusoidal (± 7.7 V peak) maximum to meet stated specifications.

OPEN CIRCUIT COMPLIANCE VOLTAGE:

Not greater that ± 15 V peak.

ACCURACY OF OUTPUT CURRENT:

Allowable deviation of range output current from input voltage:
± (0.15% of output current + 0.1% of range)

BANDWIDTH (SINUSOIDAL INPUT):

100A RANGE: DC to 45 Hz to 100 Amps peak
45 Hz to 1 kHz to 100 Amps rms

20A RANGE: DC to 1 kHz

2A RANGE: DC to 5 kHz

All other RANGES: DC to > 10 kHz

LOAD REGULATION/TRANSIENT RECOVERY TIME:

Any change in load on any range will have an output current settled within ± 0.01% of initial current in 5 seconds or less.

TOTAL HARMONIC DISTORTION:

< 0.1% of the fundamental at 100A rms and 1 kHz sinewave.

LOAD REQUIREMENTS:

The current output will supply resistive and capacitive loads as well as inductive loads to 2 millihenries at full specified currents and frequencies which permit operation within the rated compliance voltage.

DC OPERATION

RANGES AND TRANSCONDUCTANCES:

0 to ± 100A at ± 100 Siemens
0 to ± 20A at ± 10 Siemens
0 to ± 2A at ± 1 Siemens
0 to ± 200m at ± 100 milliSiemens
0 to ± 20m at ± 10 milliSiemens
0 to ± 2m at ± 1 milliSiemens
0 to ± 200u at ± 100 microSiemens

RATIO OF INPUT VOLTAGE TO OUTPUT CURRENT:

All ranges ± 2 Volts input for ± full range current output;
except 100A RANGE which is ± 1 volt for ± 100A output current.

RESOLUTION:

(Referred to input voltage)

± 0.01% of range from ± 2m to ± 20A RANGES.

± 10mA on the ± 100A RANGE.

± 1uA on the ± 200u RANGE.

COMPLIANCE VOLTAGE:

± 4 volts maximum to meet stated specifications on the 20A and 100A RANGES.

± 7.5 volts maximum to meet stated specifications on all other RANGES.

OPEN CIRCUIT COMPLIANCE VOLTAGE:

Not greater than ± 15 V peak.

ACCURACY OF OUTPUT CURRENT:

Allowable deviation of output current from input voltage on 2A, 20A, 100A RANGES:
± (0.02% of output current + 0.02% of range).

On 200m to 200u RANGES:
± (0.12% of output current +.03% of range).

Option 04 provides ± (0.02% of output current +0.02% of range) on all ranges.

TRANSIENT RECOVERY:

0.01% of final output current value within 5 seconds of change in load or input voltage.

GENERAL

INPUT TERMINALS AND IMPEDANCE:

Gold plated universal binding posts.
95K Ohms input resistance.

OUTPUT TERMINALS:

Gold plated, universal binding posts on all ranges except 100A RANGE which uses Superior Model RS 100G high current female terminals.

REAR INPUT:

FRONT or REAR INPUT selectable by front panel switch.

TABLE 1-1. PERFORMANCE SPECIFICATIONS - Cont'd

GENERAL - CONT'D

OFF GROUND OPERATION:

Instrument is capable of operating INPUT LO and OUTPUT LO to ± 100V dc with respect to CASE ground input. LO to CASE resistance: 0.5 Megohms.

ISOLATION:

Input voltage LO may be separated by ± 10 volts common mode voltage with respect to output current HI and LO terminals.

ENVIRONMENTAL CHARACTERISTICS:

Temperature:

Storage:	-40 to +75°C
Operation:	0 to 50°C (Full Accuracy)

Humidity:

Full Accuracy:	20% to 80% RH to 40°C; to 65% RH to 50°C
Usable:	10% to 100% RH without condensation

Altitude:

Storage:	0 to 50,000 feet
Operating:	0 to 10,000 feet

CONTROLS:

ON - OFF POWER Switch
STANDBY Switch - Disables output current drive
FRONT-REAR INPUT Switch - Selects front or rear panel input voltage terminals

PROTECTION:

Input Protection:	to ± 15 volts and open or short circuit.
Output Protection:	Open circuit or short circuit protection and output compliance voltage limited to ± 15 volts peak across current output terminals.

Sensitive components protected by high temperature cut out with STANDBY indicator.

Ventilation:	Forced air ventilation is provided whenever interior temperature rises above 50°C.	
Size:	Height:	267 mm (10½")
	Width:	19" standard EIA rack mount configuration
	Depth:	416 mm (16 3/8") behind panel 457 mm (18 inches) overall
	Weight:	45.5 kg (100 lbs.) 68 kg (150 lbs.) shipping

POWER REQUIREMENTS:

100V or 120V or 220V or 240V ± 10%, Single phase, 50 to 60 Hz
2000 Volt Amperes fully protected with magnetic 20A circuit breaker.

ACCESSORIES PROVIDED:

P/N: 31-10338-0	100 Ampere plug connector; red
P/N: 31-10339-0	100 Ampere plug connector; white
P/N: 90-10296-5	Instruction Manual

1-13. ACCESSORIES

1-14. The Model 1620A is provided with the standard accessories listed in table 1-1.

1-15. Optional accessories and instrumentation for the Model 1620A are listed in table 1-2.

1-16. OPTIONS

1-17. Several options are available for the Model 1620A. These options are listed in table 1-3. Desired options may be specified at time of purchase. Contact Ballantine for options which may be available on a special order basis or may have been added since this manual was prepared. Table 1-4 defines option compatibility. Refer to Section 7 for specifications and operating information for all options.

1-18. INSTRUMENT AND MANUAL IDENTIFICATION

1-19. These Ballantine instruments are identified by a two section serial number. The first three-digits section of this number identifies the configuration code. This code number appears on the front page of the manual and must coincide with the first three digits of the serial number of your instrument. Addendum sheets supplied with the manual will define technical corrections or differences between your instrument and the unit described in this manual. If applicable, back dating information is located at the end of this manual. This back dating information pertains to instruments with serial prefixes listed on the front page.

TABLE 1-2.

AVAILABLE ACCESSORIES

MODEL OR PART NUMBER	DESCRIPTION
12250D	Cable, Coax RG58/U BNC to Alligator Clips; 4 feet
12623A	Adapter; Double Banana to BNC male
31-10338-0	100 Ampere Plug; Red
31-10339-0	100 Ampere Pluge; White
88-10120-1	Cable; 2 meter, #2 gauge, 100 Ampere Plug; White and Spring Clip
88-10121-1	Cable; 2 meter, #2 gauge, 100 Ampere Male Plug; Red and Spring Clip
88-10122-1	Cable; 1 meter, #2 gauge, 100 Ampere Red Male Plug at Each End
88-10123-1	Cable; 1 meter, #2 gauge, 100 Ampere White Male Plug at Each End
1625A	Current Shunt: Ranges: 100A/10A/1A/100mA/10mA/1mA/10uA (100% overrange capability all RANGES except 100A) Accuracy: DC ± 0.01% AC ± 0.015% (to 1 kHz 100A and 10A RANGES to 5 kHz 1A RANGE to 10 kHz all other RANGES)

TABLE 1-3.

OPTIONS

OPTION	DESCRIPTION	FACTORY INSTALLED	FIELD INSTALLED
04	High Accuracy 200mA - 200uA	Yes	Yes
15	Rack Mount with Slides	Yes	Yes
60	IEEE-488 Bus Control	Yes	No
90	Accessory Cable Kit Consists of: 1 each P/N: 88-10120-1 1 each P/N: 88-10121-1	Yes	Yes

TABLE 1-4.

OPTION COMPATIBILITY

OPTION	04	15	60	90
04	---	Yes	Yes	Yes
15	Yes	---	Yes	Yes
60	Yes	Yes	---	Yes
90	Yes	Yes	Yes	---

SECTION 2

INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 1620A Transconductance Amplifier. Details are provided for initial inspection, power connection, grounding safety requirements, installation information and repacking instructions for storage or shipment.

2-3. UNPACKING AND INITIAL INSPECTION

2-4. Unpacking and handling of the Transconductance Amplifier requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

CAUTION

This instrument weighs 100 lbs. and should always be transported with care and handled by two people who are aware of its weight.

2-5. PERFORMANCE CHECKS

2-6. This instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for damage in transit and perform the electrical performance verification procedure outlined in paragraph 5-6. If there is indication of damage or deficiency, see the warranty in this manual and notify your local Ballantine field engineering representative or the factory.

CAUTION

It is recommended that the operator be fully familiar with the specifications and all sections of this manual. Failure to do so may compromise the warranty and the accuracy which Ballantine has engineered into your instrument.

2-7. POWER REQUIREMENTS

2-8. The instrument may be operated from any one of the following ac sources:

a. 90 to 110 volts (100 volts nominal)

b. 108 to 132 volts (120 volts nominal)

c. 198 to 242 volts (220 volts nominal)

d. 216 to 264 volts (240 volts nominal)

e. All instruments operate over the power frequency range of 48 to 62 Hz. Always verify that the operating line voltage is the same as that specified in figure 3-3.

CAUTION

Failure to connect the instrument to match the operating line voltage will damage the instrument and may void the warranty.

f. The instrument should be operated from a power source with its neutral at or near ground (earth) potential. The instrument is not intended for operation from two phases of a multiphase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at -10%/+8% of the nominal rms mains voltage. Use a true rms responding voltmeter, such as the Ballantine Model 3620A, to measure the ac mains power voltage.

2-9. GROUNDING REQUIREMENTS

2-10. To insure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. All Ballantine instruments are provided with an Underwriters Laboratories (U.L. and C.S.A.) listed three-conductor power cable, which when plugged into an appropriate power receptacle, grounds the instrument. The long offset pin on the male end of the power cable carries the ground wire to the enclosure of the instrument.

2-11. To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an "earth" ground.

2-12. It is recommended that a separate 20A mains circuit be used only for this instrument. This mains circuit should have its own fuses or circuit breaker.

2-13. INSTALLATION AND MOUNTING

2-14. The instrument is fully solid state and dissipates considerable power. Forced air cooling is incorporated. However, the instrument should not be operated where the ambient temperature exceeds 50°C (122°F), when the relative humidity exceeds 95% or condensation appears anywhere on the instrument.

2-15. BENCH MOUNTING

2-16. The instrument is shipped with plastic feet in place and ready for use as a bench instrument. See outline drawing figure 2-1 for dimensions.

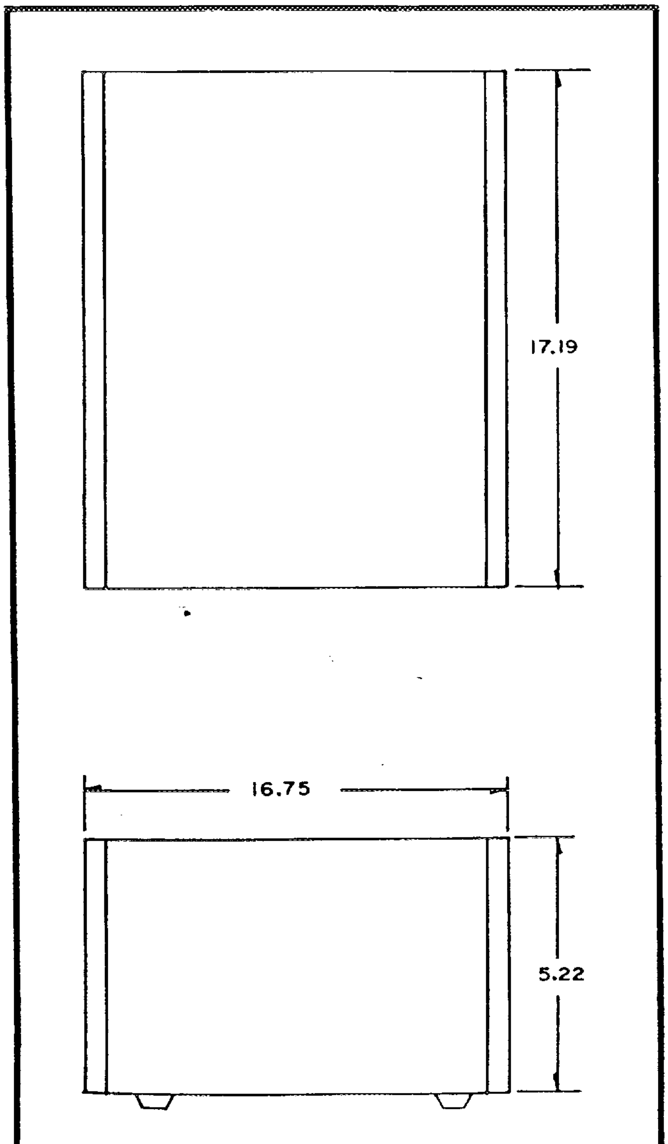


Figure 2-1. Outline Dimensions

2-17. RACK MOUNTING

2-18. The instrument may be rack mounted in a standard 19 inch EIA rack. Order Option 15 which provides rack ears and sturdy slides. See figure 2-2 for outline dimensions. Remove plastic feet from bottom cover before mounting in rack adapter. Always provide adequate ventilation and clearance around the instrument. Allow adequate air movement and unobstructed rear panel ventilation openings.

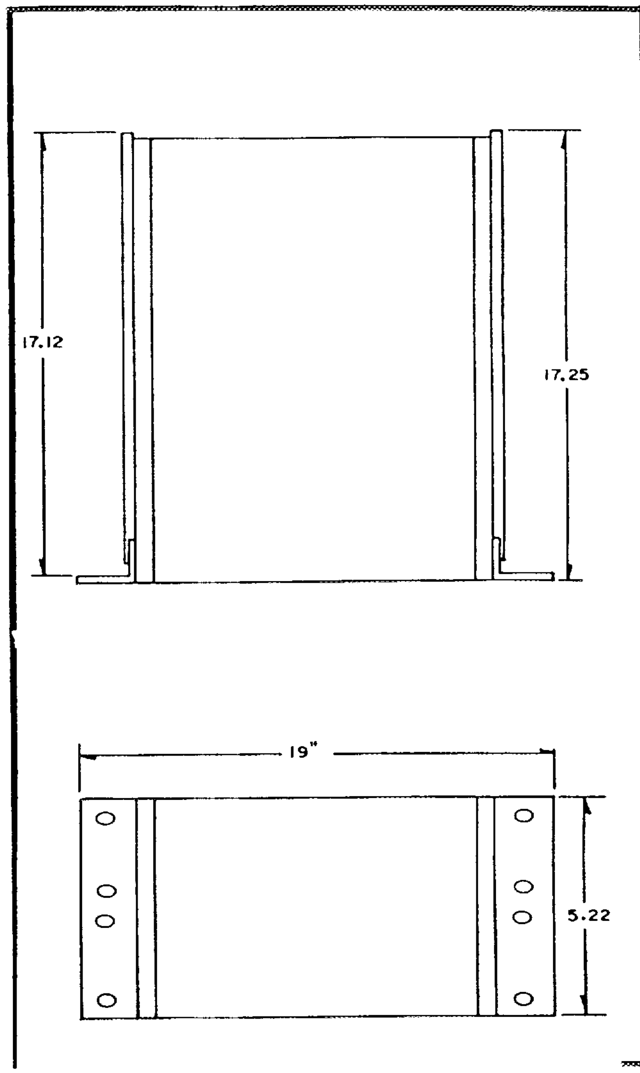


Figure 2-2. Rack Mount, Outline Dimensions

2-19. SHORT TERM STORAGE

2-20. If the instrument is to be stored for a short period of time (less than three months) place cardboard over the panel, and cover the instrument with suitable protective covering such as a plastic bag or strong kraft paper. Place accessories with the instrument. Store the covered unit in a clean dry area that is not subject to extreme temperature variations or conditions which may cause moisture to condense on the instrument.

2-21. LONG TERM STORAGE OR REPACKAGING FOR SHIPMENTS

2-22. If the instrument is to be stored for a long period or shipped, proceed as directed below. If you have any questions, contact your local Ballantine field engineering representative or the Ballantine Service Department at the factory.

2-23. If the original Ballantine supplied packing is to be used proceed as follows:

a. If the original wrappings, packing material and container have been saved, repack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Ballantine Service Department at the factory.

b. Be sure that the carton is well sealed with strong tape or metal straps.

c. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

2-24. If the original container is not available, proceed as follows: (See figure 2-3.)

a. Before packing the unit, place all accessories into a plastic bag and seal the bag.

b. For extended storage or long distance shipping only, use U.S. Government packaging method II C and tape a two-unit bag of desiccant (per MIL-D-3464) on the rear cover.

c. Place a 41 cm (16 inch) by 273 cm (10.5 inch) piece of sturdy cardboard over the front panel for protection.

d. Place the instrument into a plastic bag and seal the bag.

e. Wrap the bagged instrument and accessories in one inch thick flexible cellular plastic film cushioning material (per PPP-C-795) and place in a barrier bag (per MIL-B-131). Extract air from bag and heat seal.

f. Place bagged instrument and accessories into a 510 mm (20 inch) x 510 mm (20 inch) x 375 mm (14 inch) fiber board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps. If the unit is to be shipped by surface transport or trans-shipped frequently, it is recommended that the packed unit be palletized or enclosed in a wooden shipping crate.

g. Mark container "DELICATE INSTRUMENT", "FRAGILE", etc. Mark instrument model and serial number and date of packaging. Affix shipping lables as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Ballantine for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment.

2-25. Always contact factory for authorization and a control number BEFORE shipping to Ballantine.

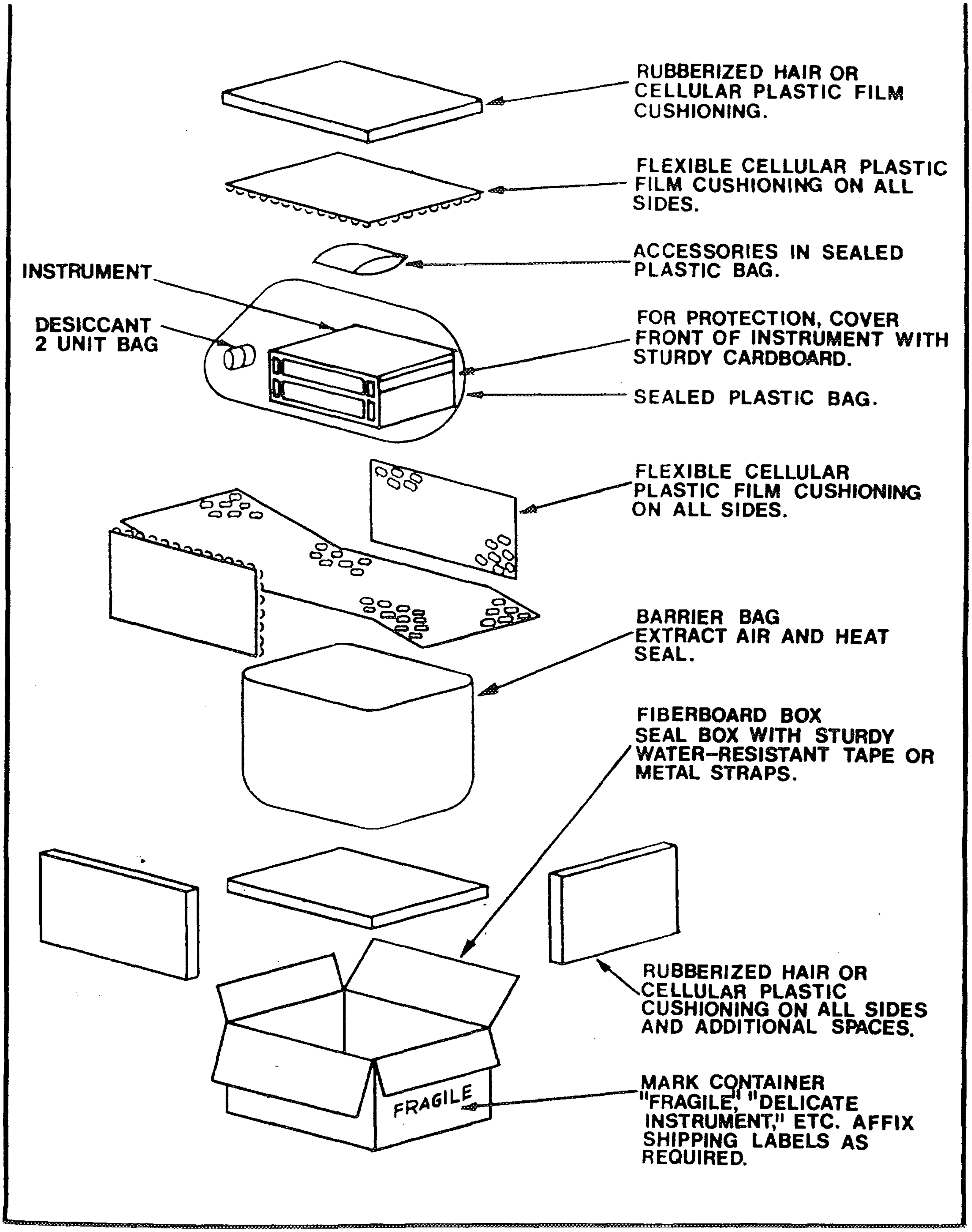


Figure 2-3. Packing Diagram

TABLE 2-1.

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Ballantine Laboratories assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to Ballantine Laboratories Service Department for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

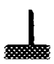
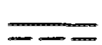
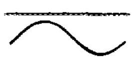
WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

TABLE 2-2.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

	Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.
	Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).
 OR 	Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.
	Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.
 OR 	Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.
	Alternating current (power line).
	Direct current (power line).
	Alternating or direct current (power line).
WARNING	The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.
CAUTION	The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.
NOTE	The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION 3

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

3-2. This section contains instructions and information required for the operation of the Ballantine 1620A Transconductance Amplifier. Included are identification of controls, connectors, options and indicators as well as turn on procedures and operating instructions.

3-3. CONTROLS, INDICATORS, AND CONNECTORS

3-4. The instrument controls, indicators, and connectors are identified in figure 3-1 and 3-2 and described in table 3-1.

TABLE 3-1.

CONTROLS, INDICATORS, AND CONNECTORS

INDEX NO.	CONTROL, INDICATOR, OR CONNECTOR	REFERENCE DESIG.	FUNCTION
1	Mains POWER Indicator	DS200	POWER ON indicator
2	FRONT/REAR INPUT Indicator	DS7	Light for REAR INPUT
3	FRONT/REAR Selector Switch	S3	FRONT/REAR INPUT selector
4	OVERCOMPLIANCE Indicator - Yellow	DS9	Lights when load compliance voltage is exceeded
5	INPUT OVERDRIVE Indicator - Red	DS10	Lights when input drive voltage limits are exceeded
6	OPERATE Mode Indicator	DS6	Lights when output drive is active
7	OPERATE/STANDBY Selector Switch	S2	Push to deactivate current output
8	LOCAL LOCKOUT Indicator	DS100	Lights when REMOTE bus interface deactivates all front panel controls except POWER
9	REMOTE Indicator	DS101	Lights when REMOTE operation is selected
10	LOCAL Selector Switch	S4	Push for LOCAL request when Opt. 60 is installed
11	RANGE Selector Switches and Indicators	S1 DS1, DS2, DS3, DS4, DS5, DS8	Push one switch to select output current range. Indicator lights to show range selected either manual or by REMOTE bus interface
12	ZERO ADJ	R26	Screwdriver adjust for zero current output with zero input drive

TABLE 3-1. CONTROLS, INDICATORS, AND CONNECTORS - Cont'd

INDEX NO.	CONTROL, INDICATOR, OR CONNECTOR	REFERENCE DESIG.	FUNCTION
13	100A LO OUTPUT Connector	J9	100A LO OUTPUT
14	100A HI OUTPUT Connector	J10	100A HI OUTPUT
15	20A HI OUTPUT Connector	J7	20A HI OUTPUT
16	LO Connector	J8	LO connector for all RANGES except 100A
17	$\leq$ 2A HI OUTPUT Connector	J6	HI output connector for all RANGES except 20A and 100A
18	Front CASE Connector	J5	Allows for connection of 1620A CASE to external equipment
19	INPUT Voltage LO Connector	J4	INPUT voltage LO (neg) connector
20	INPUT Voltage HI Connector	J3	INPUT voltage HI (pos) connector
21	Mains POWER ON/OFF Switch	CB300	POWER ON/OFF switch and overload reset circuit breaker

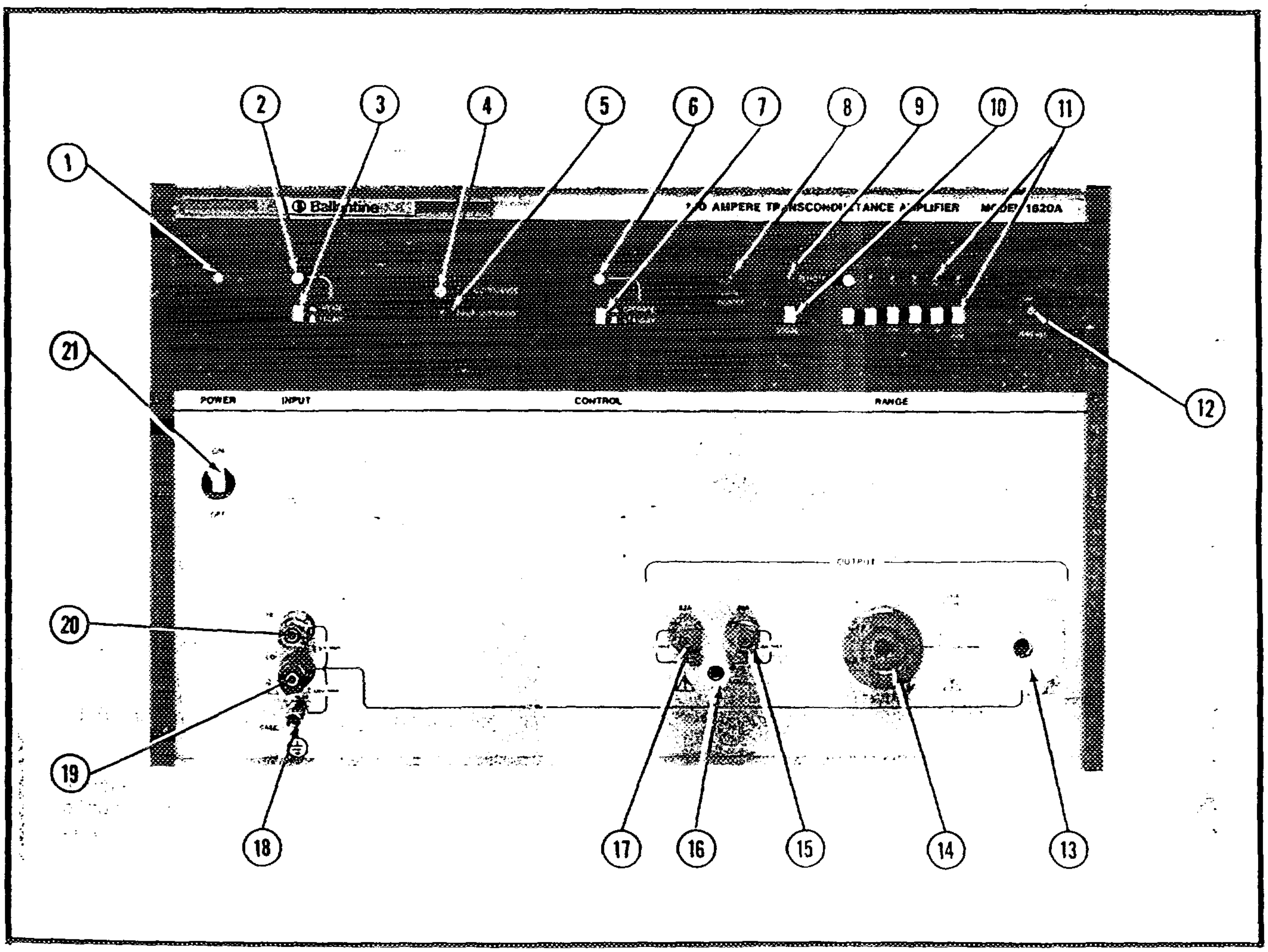


Figure 3-1. Model 1620A Front Panel Controls, Indicators, and Connectors

TABLE 3-1. CONTROLS, INDICATORS, AND CONNECTORS - Cont'd

INDEX NO.	CONTROL, INDICATOR, OR CONNECTOR	REFERENCE DESIG.	FUNCTION
22	IEEE Interface Address Switch	U3	Sets bus address when Opt. 60 is installed
23	IEEE Interface Connector	J1	Connector for IEEE-488 Bus Interface for REMOTE connector when Opt. 60 is installed
24	FUSE	F300	Fuse for cooling fans
25	Mains Power Cable	J200	Connects ac mains Power to instrument
26	Rear CASE Connector	J304	Allows for connection of 1620A CASE to external equipment
27	Rear INPUT LO	J303	Connects input voltages when REAR INPUT is selected
28	Rear INPUT HI	J302	Connects input voltage HI when REAR INPUT is selected
29	I/O REMOTE EXPANSION Connector	J305	Allows for additional REMOTE control capabilites when used in conjunction with the IEEE-488 Bus Interface

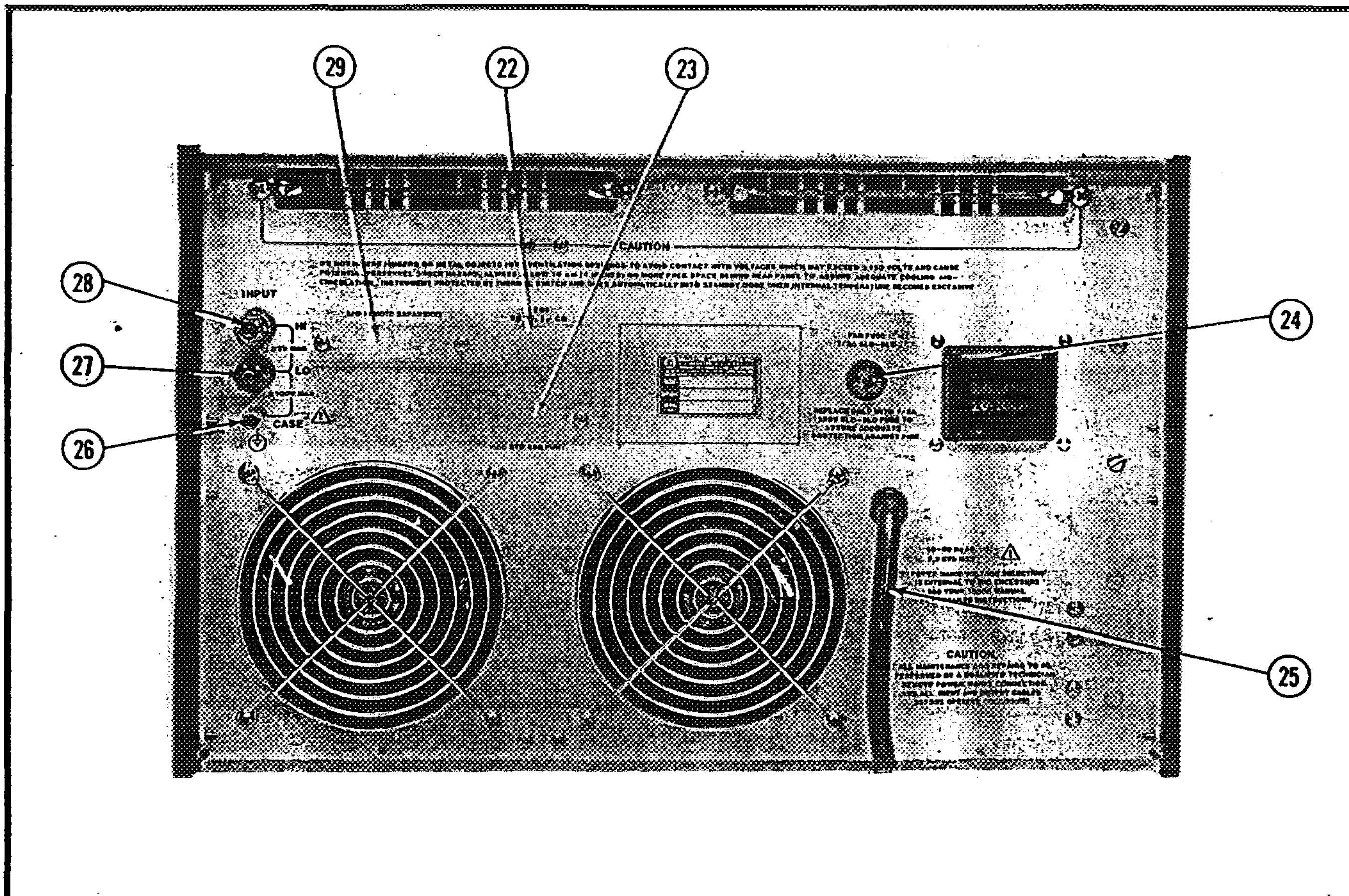


Figure 3-2. Model 1620A Rear Panel Controls, Indicators, and Connectors

a. AC LINE VOLTAGE POWER. Be sure that the mains voltage used is within the limits defined in figure 3-3 (ac mains wiring). Other mains voltages may be used after rewiring the instrument internally.

CAUTION

Failure to have the 1620A wired for the mains voltage in use can cause serious damage to your instrument and may void the warranty.

the 1620A.

c. Turn the POWER toggle switch to ON and note that the pilot lamp lights.

WARNING

Be sure to connect the case of the instrument to earth ground through the power cable or faulty measurements and possible shock hazard may result.

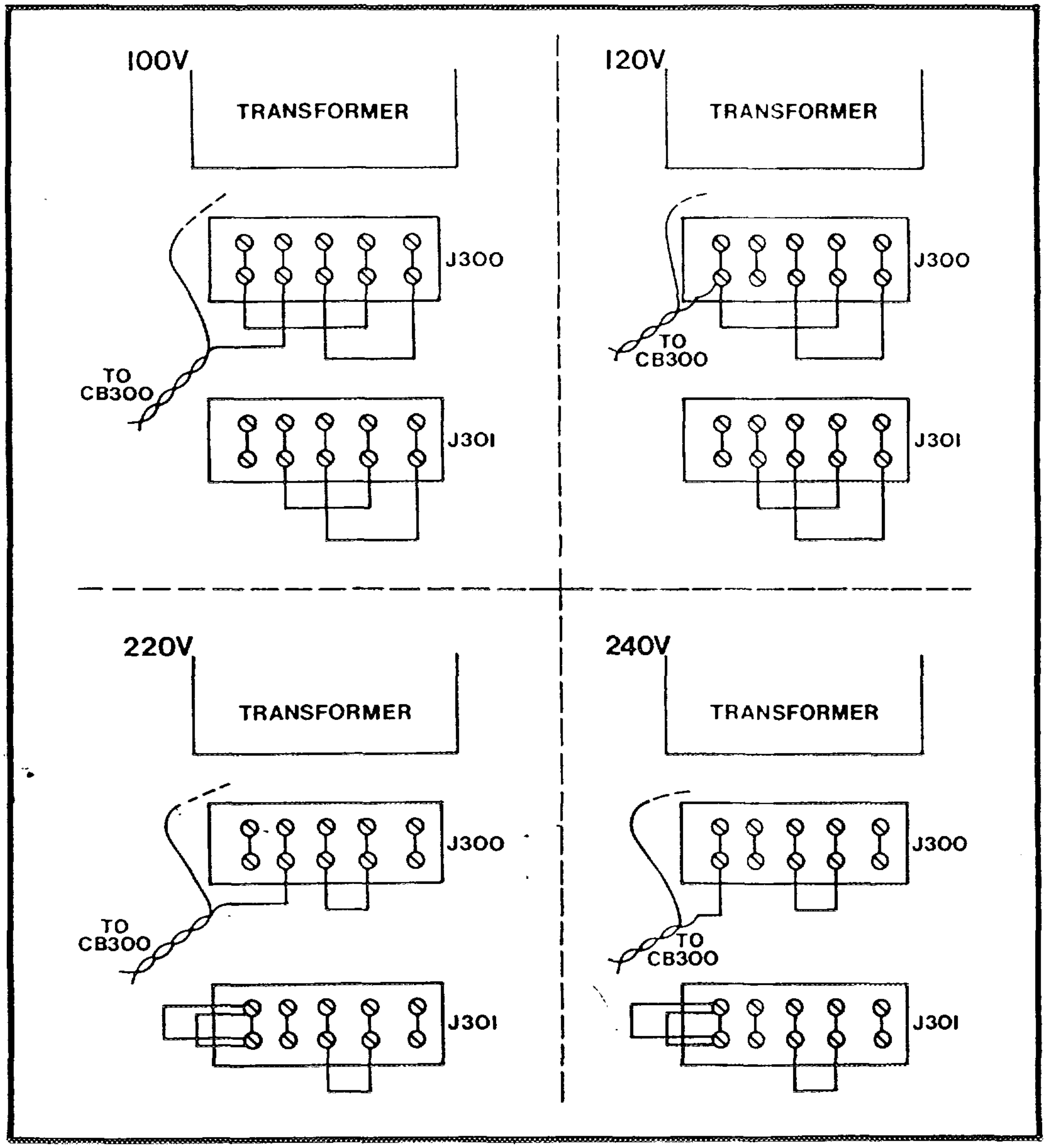


Figure 3-3. AC Mains Wiring

3-6. INPUT VOLTAGE

3-7. A precision DC or AC voltage source is normally used to drive the transconductance amplifier. The amplitude and polarity of the input voltage determines the magnitude and polarity of the output current.

3-8. It is good practice to set the transconductance amplifier to STANDBY and to connect an output load before applying an input voltage.

3-9. For precision applications always connect the input connectors together to assure zero drive and check the amplifier zero adjustment by setting the loaded system to OPERATE and proper range. A voltmeter connected across the output load or an ammeter in series with the output load should indicate nominally zero. If necessary, adjust the ZERO ADJ screwdriver control on the front panel until a minimum output reading is obtained.

3-10. The input circuit of the 1620A is balanced to ground through 1 megohm resistors while the total input impedance is 95,000 ohms. When making precision measurements always use a low output impedance source to drive the 1620A. The input voltage generator should have a source impedance of less than 10 ohms to assure better than 0.01% precision. Always use a 4 wire sensed and shielded input system. Sense directly at the input terminals of the 1620A.

The error source formed by the source impedance of the input voltage source forms a resistive divider with the 100k ohm input resistance of the 1620A. See figure 3-4. R_S is the source resistance and R_A is the input resistance of the 1620A.

To maintain an error ratio caused by input impedance division at less than 0.01% the ratio of:

$$\frac{R_A}{R_S} \leq 10{,}000$$

Since R_A is 100k ohms the maximum allowable voltage source impedance must be less than 10 ohms.

3-11. The input of the 1620A is dc coupled and the maximum input voltage is ± 2 V dc or ac sinusoidal rms. The maximum peak input voltage for ac input signals must not exceed ± 2.9 V peak. These amplitudes apply to all RANGES except the 100A RANGE which is limited to ± 1 V dc or ac sinusoidal rms with a maximum ac of ± 1.45 V peak. Input voltages in excess of ≈ 1.3 V RMS on the 100A RANGE will be detected and will switch the unit to the STANDBY state until the input is lowered to less than ≈ 1.01 V RMS. This restricts the output drive to less than 130 amps.

3-12. The output current of the 1620A is directly proportional to the input voltage. When the input voltage is increased, the output current will increase linearly within the range selected. As an example, when the 2A RANGE is selected and 1.000 volts is applied, an output current of 1A is produced. When the input voltage is increased to 1.400 volts, the output current increases to 1.4A.

3-13. Input common mode signals should be kept at a minimum to optimize precision measurements. If possible, ground the INPUT LO connector to earth ground. Do not exceed ± 100 volts peak off ground operation.

3-14. RANGE SELECTION

3-15. RANGE selection is performed by pushing one of the six RANGE pushbuttons on the front panel. The 20A and 100A RANGES are selected by a single pushbutton switch. RANGE selection may also be commanded remotely through the IEEE-488 Interface Bus when Option 60 is installed.

3-16. Always operate in the upper 80% of the full scale output current of the RANGE selected. Switch to a lower current range when output current is 20% or less of full scale.

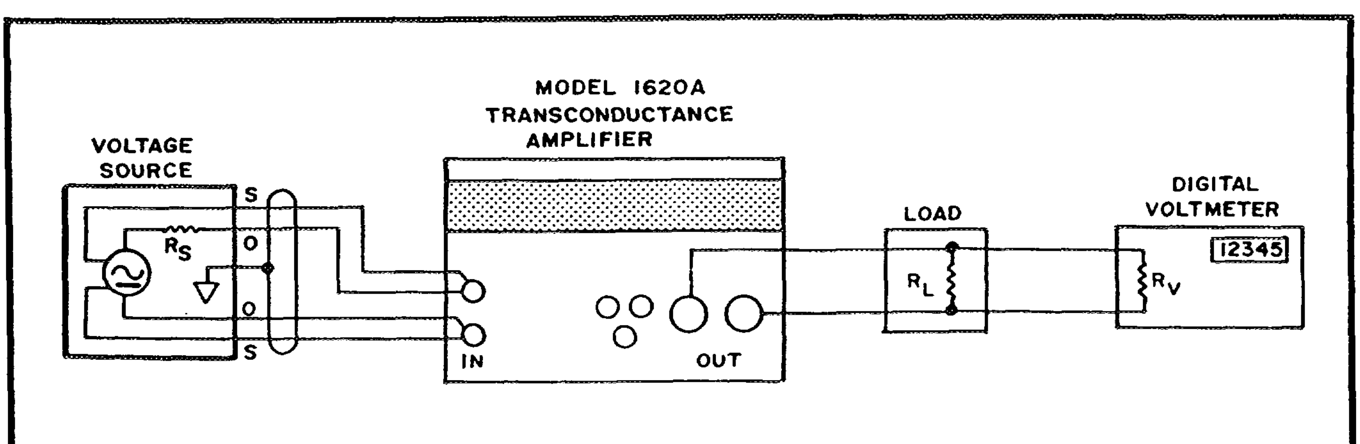


Figure 3-4. Input Connectors and Error Sources

3-17. OUTPUT CURRENT CONNECTIONS

3-18. Output current is provided from a single set of universal binding posts for the 200u, 2m, 20m, 200m, and 2A RANGES. A second set of universal binding posts provides access to the 20A RANGE and a set of two high current jacks supplies 100A connections.

NOTE

To achieve specified accuracy, adjust the front panel ZERO adjustment for zero output current with the input shorted after the 1620A temperature has stabilized. Repeat this procedure whenever the range is changed or for output currents above 10A even though the range may not change.

3-19. Welding cable is recommended for use with the high current plugs which connect to the 100A jacks. Wire gauge #2 should be used to minimize the voltage drop in the connecting leads when using the 100A RANGE.

3-20. OUTPUT CURRENT AND LOAD CONSIDERATION

3-21. In the Model 1620A Transconductance Amplifier, the effective output impedance is very high and may be considered to approach infinity within the compliance voltage limits. Therefore, the output current generating circuit of the 1620A will attempt to deliver the requested current into any load impedance applied to the output terminals. A 100mA current output impressed on a 10 ohm load will produce 1 volt across the load. A 100mA output current impressed on a 50 ohm load will produce 5 volts across the load. When the output voltage reaches ± 7 volts dc or peak ac (approximately 5 volts ac rms sinusoidal), the rated compliance level of the transconductance amplifier is reached. Exceeding the maximum compliance voltage will decrease the output impedance. This distorts the waveform and the 1620A will not deliver the requested current into a load which is too high and causes the maximum compliance voltage to be exceeded. See table 1-1 for compliance voltage limits on the various output current ranges.

3-22. LIMIT INDICATORS

3-23. Two illuminated RANGE limit indicators are provided on the front panel of the instrument.

3-24. The INPUT OVERDRIVE (RED) indicator illuminates when the input voltage exceeds ± 2 V dc or ac peak to alert the operator that the input drive voltage must be decreased to keep the 1620A within its specifications. The input system is designed to accept signals with a crest factor of 1.45 so that the permissible maximum input for ac voltages is ± 2.9 V peak. The INPUT OVERDRIVE warning indicator may, therefore, illuminate just before the ac peak limit is exceeded.

3-25. The OVERCOMPLIANCE (YELLOW) indicator illuminates when the output voltage exceeds the compliance voltage limits of ± 5 volts dc and ac rms. Since the compliance voltage allows for a crest factor of 1.45 on ac waveforms, the OVERCOMPLIANCE warning indicator may illuminate just before the ac peak compliance voltage limit is reached.

The OVERCOMPLIANCE indicator always illuminates when the output of the transconductance amplifier has no load connected or the load is too high in impedance for the requested output current.

3-26. STANDBY - OPERATE

3-27. A push switch on the front panel of the instrument places the instrument into STANDBY condition when pushed IN towards the panel. STANDBY internally disconnects the input drive voltage and prevents the 1620A from delivering output current. Note that a small output current (and potential) may still exist in STANDBY since the current output circuit is disabled but not disconnected.

To set the 1620A to OPERATE, push the switch and release it to its out position. The STANDBY-OPERATE lamp will illuminate in OPERATE mode.

3-28. ERROR SOURCES AND APPLICATION LIMITS

3-29. A number of sources for measurement error exist when using the transconductance amplifier. A few of these are listed below.

a. Always keep the off ground potential of the input voltage and output current to a minimum. Do not exceed ± 100 volts to maintain the 1620A within specifications. Whenever possible, connect INPUT LO to "earth" ground.

b. Always keep the voltage between INPUT LO and OUTPUT LO at a minimum. Do not exceed ± 15 volts dc or ac peak.

c. Keep the source impedance (R_S) of the input voltage much lower than the input resistance (R_A) of the 1620A. This avoids dividing the input voltage. See paragraph 3-10 and figure 3-4 for full details. Use sense leads to connect the voltage source to the input terminals of the 1620A to minimize cable and source impedance errors. Always sense directly at the input voltage terminals of the 1620A.

d. A potential error exists when the load current is diverted by any parallel impedance. As an example, a voltmeter used to measure the voltage across the load may divert sufficient current to uncalibrate the system. See figure 3-4 and note load resistance R_L and voltmeter resis-

... to maintain the error caused by the voltmeter load (R_V) at 0.01% or less then:

$$\frac{R_V}{R_L} \text{ must be greater than } 10{,}000$$

For conventional digital voltmeters with input resistance (R_V) of 10 megohms the load resistance (R_L) must be less than 1000 ohms.

e. Excessively long leads carrying the output current may also cause excessive voltage drop and cause errors due to exceeding the compliance voltage.

f. Always use output cables made of copper. Avoid aluminum cables and never use one copper and one aluminum cable to minimize the effects of thermal voltage potentials.

g. An inductance in series with the load resistor may also cause measurement errors when providing ac currents. See figure 3-5. If the load resistance is 10 millohms (0.01 ohm) and the series inductance is only 50 nanohenries, the effective load impedance at 1 kHz will be:

$$Z_L = \sqrt{R_L^{\,2} + (2\pi FL)^2}$$

$$= \sqrt{(0.01)^2 + (6.28 \times 10^3 \times 50 \times 10^{-9})^2}$$

$$= \sqrt{0.0001 + 0.0000098} = \sqrt{0.0001098}$$

$$= \sqrt{0.0104785} = 10.4785 \text{ milliohms}$$

Excessively inductive loads and even carelessly coiled output leads may cause sizeable measurement errors and exceed the compliance voltage limit of the transconductance amplifier.

h. High load inductance may also store energy and cause large voltages to be developed when the current is decreased quickly. Excess voltages applied to the output connectors of the 1620A may damage the instrument.

i. Although the 1620A can drive capacitive loads, they should be avoided. A capacitance in parallel with a resistive load will assume some of the load current giving rise to measurement errors for current intended for the resistive load.

Never use the 1620A to drive a resonant load.

Minimize wiring capacitance and load shunt capacitors especially on high resistance loads driven at a frequency that will cause appreciable current to be shunted through the capacitance. The capacitance reactance may be expressed as:

$$X_c = \frac{1}{2\pi FC}$$

Capacitive load currents can substantially affect the low current ranges and where higher compliance voltages are required.

j. Always shut the system down by slowly decreasing the input voltage or by using the STANDBY mode.

3-30. Do not apply voltage to the current output connectors to avoid damage to the instrument.

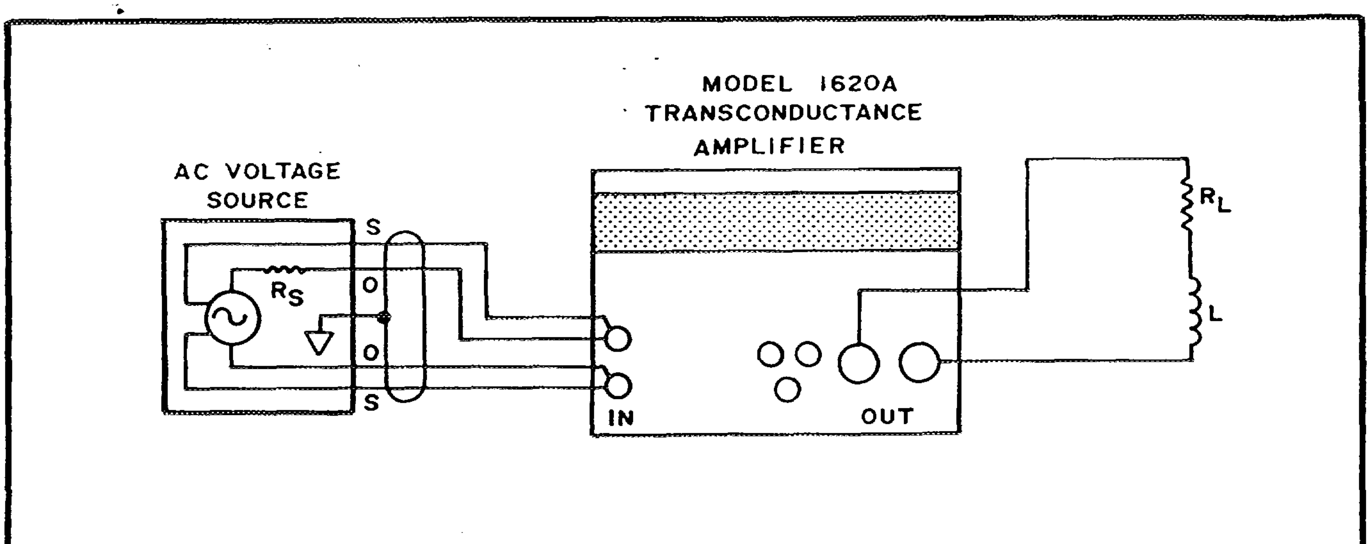


Figure 3-5. AC Error Sources

SECTION 4

PRINCIPLES OF OPERATION

4-1. GENERAL

4-2. The 1620A Transconductance Amplifier is shown in the simplified schematic diagram in figure 4-1. The following discussion details the principles of operation of the instrument. For location of reference designators which identify specific components, refer to the schematic diagram figure 6-1.

4-3. The INPUT AMPLIFIER U2 is a monolithic instrumentation amplifier. It has two high impedance inputs and provides a low output impedance. U2 has an internally fixed gain of 10 and the input divider consisting of R8, R9, and R10 which provides a balanced division of the input signal by a factor of 3. The entire input stage, therefore, has a gain of approximately 3.3 from the input terminals to the output of U2.

4-4. U2 has exceedingly high common mode rejection of approximately 25,000 to one. It, therefore, rejects the effects of the current output common mode voltage on the input voltage and gain of the input amplifier.

4-5. R10 is gain adjustment used to set the overall calibration of the instrument. Since the shunts on the four lowest current ranges are precision fixed resistors, R103 is adjusted to conform to these shunts. R103 is adjusted on the 2m RANGE to avoid affects of leakage currents.

4-6. The TRANSCONDUCTANCE AMPLIFIER is a voltage to current converter. It consists of an operation amplifier which has in its closed loop a high gain amplifier U4, unity gain buffer amplifier U5, the metering shunt resistors RN1, R302, R303, R304, and the transistorized power amplifier Q1 thru Q4, and Q400 thru Q423.

4-7. The shunt resistors are based on circuit ground. The load current is supplied by the power amplifier. Once the load current is returned from the load, it passes through the appropriate shunt and develops a voltage of approximately 200 mV full scale for the 200 mA through the 20 A range, and 100 mV on the 100 A range. This shunt voltage is sent to the unity gain buffer amplifier U5 and then to the summing junction of high gain amplifier U4. At the summing junction of U101 appear the input voltage, the shunt voltage, and the zero adj. voltage. The loop gain of this Transconductance Amplifier is very high and its frequency flat over the rated ac accuracy of the instrument. There are no frequency compensating adjustments, since flat bandwidth is inherant in the design of the instrument.

4-8. The Transconductance Amplifier has extremely high loop gain so that the output resistance of the power amplifier is extremely high. It, therefore, is an ideal current source for the applied load. It will supply precise current to any load impedance whose compliance voltage is within the output voltage limits of the power amplifier. Once these compliance voltage limits are exceeded, the power amplifier limits the output voltage and, thereby, reduces the Transconductance Amplifier loop gain. The load impedance or range and shunt resistor should then be switched to keep the instrument operating within its design limits. In this manner, the 1620A provides a precision input voltage to output current conversion.

4-9. The POWER AMPLIFIER is a totem pole configuration. On the positive output side, a four level Darlington type emitter follower is used. Individual emitter followers are cascaded for current gain until the final power stage of eight NPN transistors. Q400 thru Q409 are arranged in parallel to provide 100 Amps dc and 145 Amps ac peak. Emitter resistors R402 thru R423 are used to divide the load current equally between the output power transistors. Negative currents are provided in a similar fashion by PNP transistors. Q416 to Q419 provide the negative output current. For configuration code 021 and above, four additional power transistors (Q420 thru Q423) and four emitter resistors (R424 thru R427) are added.

4-10. Diodes CR1 to CR7 provide a bias to Q1 and Q3, the input emitter followers of the power amplifier. The nominal 2.4 volt bias on these emitter followers mains a "just on" current condition in the power output transistors Q400 thru Q419 to assure minimum waveform distortion without excess idling current.

4-11. RANGE SELECTION for the seven current ranges is made by using the proven output terminals for the 100A and 20A RANGES. The five other decade RANGES from 2A to 200u are selected by relays which are operated from the front panel switches or remotely from the IEEE-488 Interface Bus when Option 60 is installed. These five RANGES have a convenient single set of output terminals for which the range relays select the appropriate shunt resistor.

4-12. The OVERCOMPLIANCE indicator lamp is driven by a bipolar voltage level detector U1. This level detector senses the voltage at the output of U4. The LED lights whenever the output level of U1 exceeds approximately ± 5 V.

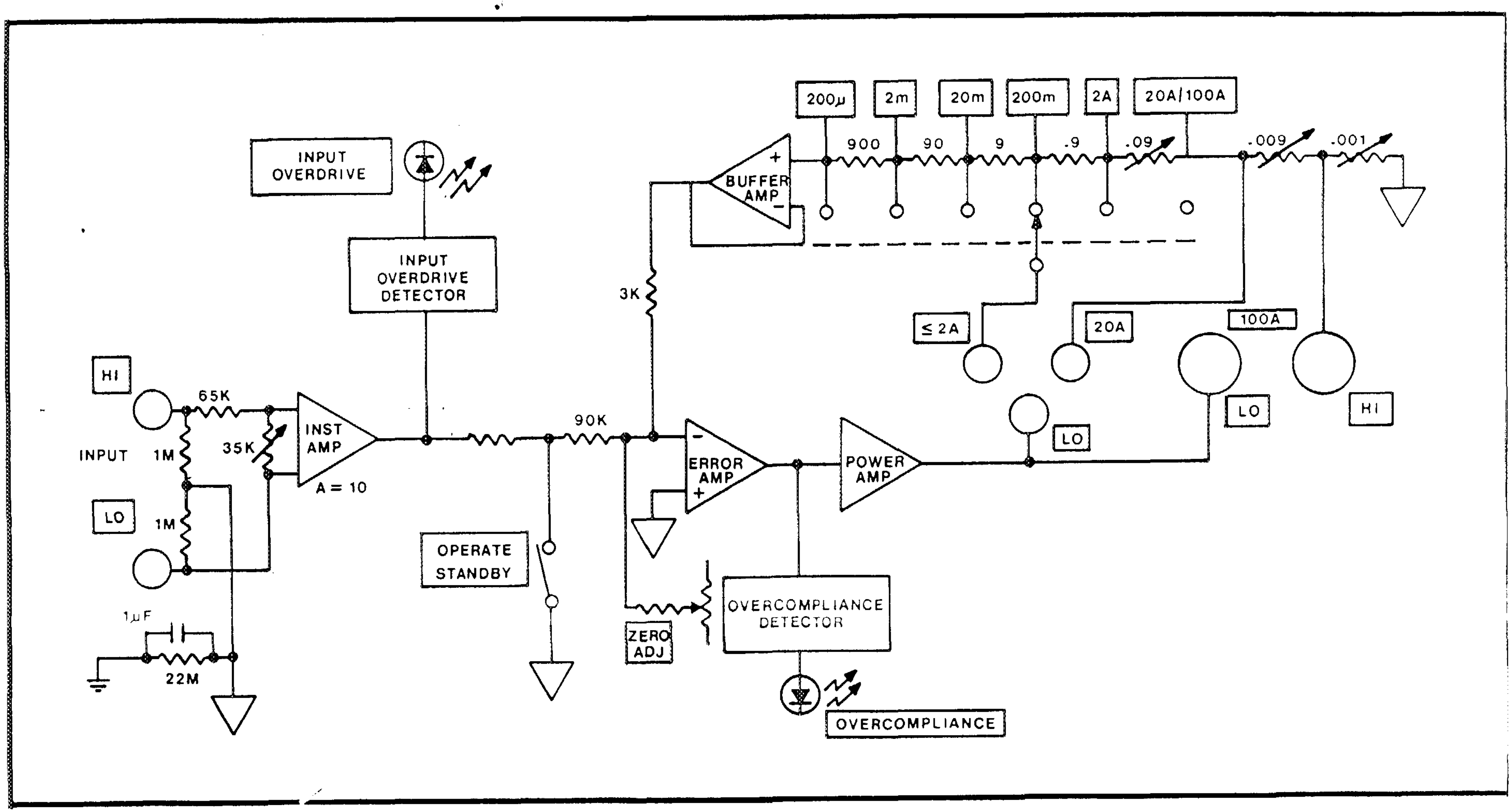


Figure 4-1. Model 1620A Simplified Schematic Diagram

4-13. The STANDBY circuit is operated from the front panel STANDBY-OPERATE switch and relay K6. STANDBY may be operated remotely and always overridden by the front panel switch. The STANDBY mode disables the output current by removing the input drive voltage through a grounding of the output of input amplifier U2. R15 protects U2 from excessive current demand in the STANDBY condition.

4-14. The INPUT OVERDRIVE indicator is operated from bipolar level detector U3. This level detector senses the voltage at the output of input amplifier U2 and the red LED lights whenever the output voltage of U2 exceeds aproximately ± 2 V.

4-15. The POWER SUPPLIES for the 1620A consist of very high current ± 10 volt supply, a +15 volt, -15 volt and a +5 volt supply.

4-16. The ± 10 volt high current supply is provided by T2 through a full wave rectifier consisting of CR300 to CR303. The voltage of this supply is 9 to 15 volts depending on mains voltage and load current.

4-17. The +15 volt supply is provided by T1 through CR201 and regulated by monolithic regulator U201. The output voltage is within the limits of +13.8 to +16.5 volts.

4-18. The -15 volt supply is provided by T1 through CR202 and monolithic negative regulator U202. The output voltage is within the limits of -13.8 to -16.5 volts.

4-19. The +10, -10, +15 and -15 V supplies are all referenced to circuit ground which may be floated with respect to enclosure earth ground by ± 100 volts dc or ac peak.

4-20. The +5 volt supply is provided by T1 through CR200. It is regulated by monolithic regulator U200. The output voltage is within the limits of +4.6 to +5.5 volts. The common of this supply is connected to enclosure earth ground so as to serve the digital interface, the relays, and the remote control circuits.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

CAUTION

Semi-conductor devices using metal oxide junctions are liable to suffer destructive damage from electrostatic discharges. Such devices appear with several names, such as MOS, MCMOS, CMOS, MOSFET, IGET, detector diode, etc. Whenever these devices or assemblies including such devices are handled, the operator must be grounded, and only grounded soldering irons can be used safely. To facilitate identification of assemblies containing metal oxide devices, Ballantine pc boards containing such devices are marked with this symbol:

MAINTENANCE AND CALIBRATION

5-1. INTRODUCTION

5-2. This section contains information required to maintain the 1620A Transconductance Amplifier within specifications. The following paragraphs detail:

a. Performance Assurance Checks

b. Calibration Procedure

c. Fault Finding (Troubleshooting) Details

d. Preventive Maintenance

5-3. The 1620A Transconductance Amplifier is designed with premium components and, like other Ballantine instruments, will provide many years of satisfactory service. Ballantine recommends that performance assurance checks and preventive maintenance procedures be performed periodically. Full NBS Traceable Calibration should be performed once a year. If required, Ballantine Laboratories will gladly provide this calibration service at our Boonton, NJ, plant for a nominal charge.

5-4. REQUIRED TEST EQUIPMENT

5-5. Table 5-1 provides a list of required test equipment needed to properly check, calibrate, and maintain the 1620A. Equivalent test equipment meeting all requirements may be substituted if the recommended items are not available.

5-6. PERFORMANCE VERIFICATION CHECKS

5-7. The performance assurance checks are "in cabinet" tests with covers on that compare the 1620A with the applicable specifications. A test record form is provided for these instruments. The form included in this manual as Form 5-1 may be duplicated to provide a permanent record of incoming inspection or of periodic performance assurance checks. These checks should be conducted in their entirety and in the order listed before any attempt is made to calibrate the instrument.

5-8. CALIBRATION ACCURACY VERIFICATION

5-9. DC CALIBRATION CHECK

5-10. Connect the test set-up for DC Current Calibration as shown in figure 5-1. Connect ac mains voltage to nominal voltage 100, 120, 220, 240 as specified in figure 3-3.

5-11. ZERO ADJUST

5-12. Set the OPERATE/STANDBY switch to STANDBY. Select the 2m RANGE. Connect the 1k ohm load resistor to the 1620A. Connect the 5½ Digit DC Voltmeter across the 1k ohm load.

5-13. Connect the 1620A input terminals together. Set to OPERATE.

a. Center front panel zero.

b. Set to STANDBY. Note reading.

c. Set 1620A to OPERATE and adjust R10, Zero Offset Adj., to obtain the same reading as in step b.

d. Use front panel zero adjustment to zero 1620A output. Put unit into STANDBY and note that the 1620A output is zero ± 200 uV.

5-14. Adjust the front panel ZERO ADJ screwdriver control for minimum indication on the DC Voltmeter. Set for zero ± 200 microvolts and note the reading.

5-15. Set to STANDBY and note that the dc output goes to a nominal zero. Note: This is not a critical value.

5-16. DC CURRENT CHECKS

5-17. Temporarily connect the DC Voltmeter across the 1620A input connectors. Adjust the DC Standard to produce a voltmeter reading of 1.90000 volts. Reconnect the voltmeter across the 1k Ohm load resistor.

5-18. To verify 2m RANGE, apply the approximate + 1.900 volts dc established in para. 5-17 to the 1620A. Set to OPERATE.

5-19. The DC Voltmeter should read 1.89921 volts to 1.90079 volts ± the zero offset noted in paragraph 5-14.

5-20. Follow the choice of load resistance and ranges and perform the tests shown in table 5-2.

TABLE 5-1. REQUIRED TEST EQUIPMENT

INSTRUMENT TYPE	PURPOSE	RECOMMENDED MODEL	SPECIFICATIONS
DC Voltage Standard	Provide Precision DC Voltages	Fluke 332A	DC output 1 mV to 10 volts Accuracy: ± 0.003%
AC Voltage Standard	Provide Precision AC Voltages	Fluke 5200A	AC Output 1 mV to 10 volts Rms 10Hz to 50 kHz Accuracy: ± 0.05% to 1 kHz ± 0.1% to 10 kHz ± 0.2% to 50 kHz
AC Mains Control Variac	Set Line Voltage	Gen. Rad. W5MT3AW	0 to 135 volts 20 Amps or 0 to 220 volts 15 Amps
True Rms Voltmeter	Set Line Voltage	Ballantine 9635M or 3620A	AC + DC volts, 3 1/2 digits 1 mV to 200 volts Accuracy: ± 0.25% dc to 1 kHz ± 0.75% dc to 50 kHz
DC Voltmeter	Measure Output Compliance Voltage	Ballantine 9635M	DC volts, 5 1/2 digits 10 Megohm input 2 V FS and 20 V FS Accuracy: ± (0.01% + 1 LSD)
Active Shunt Set 100A, 20A, 2A, 200mA, 20mA, 2mA, 200uA Full Scale NBS Traceable	Calibrate AC and DC Output Currents	Ballantine 1625A	<u>100 Amp Range:</u> 0.1 volt output at FS DC ± 0.01% of FS (20A to 100A) AC ± 0.1% to 400 Hz ± 0.2% to 1 kHz <u>20 Amp Range:</u> 0.2 volt output at FS DC ± 0.01% of FS AC ± 0.1 % to 400 Hz ± 0.15% to 1 kHz <u>2 Amp Range:</u> 0.2 volts output at FS DC ± 0.01% of FS AC ± 0.1 % of FS to 5 kHz <u>200 mA Range:</u> 0.2 volts output at FS DC ± 0.01% of FS AC ± 0.1 % of FS to 5 kHz ± 0.15% of FS to 10 kHz <u>20mA, 2mA, and 200uA Ranges:</u> 0.2 volts output at FS DC ± 0.01% of FS AC ± 0.1 % to 5 kHz ± 0.13% to 10 kHz <u>Active output Xvolts X10:</u> Add 0.015% dc to 5 kHz and 0.02% to 10 kHz

TABLE 5-1. REQUIRED TEST EQUIPMENT - Cont'd

INSTRUMENT TYPE	PURPOSE	RECOMMENDED MODEL	SPECIFICATIONS
1k Ohm Standard Resistor	Current Calibration 2 mA and 200 uA Ranges	Cambridge Instrument Co.	1K Ohm ± 0.01% (NBS Traceable) 2 terminals
100 Ohm Standard Resistor	Current Calibration 20 mA Ranges	Leeds and Northrup 100 Ohms ABS	100 Ohm ± 0.01% (NBS Traceable) 4 terminals
10 Ohm Standard Resistor	Current Calibration 200 mA Range	Leeds and Northrup 10 Ohms ABS	10 Ohm ± 0.01% (NBS Traceable) 4 terminals
1 Ohm Standard Resistor	Current Calibration 2 A Range	Leeds and Northrup 1 Ohm ABS	1 Ohm ± 0.01% (NBS Traceable) 4 terminals
AC/DC Autobalance Transfer Standard	AC Current Calibration and frequency response	Ballantine 1605A	.25 to 10 volts rms 100 ppm transfer accuracy with correction. 10 Hz to 50 kHz
Distortion Analyzer	Distortion Adjustment with 1 kHz, 100 amp output	H.P. 333A	Measure distortion levels greater than 66 dB down with a fundamental rms level of 100 mV, 1 kHz
Digital Multimeter	Troubleshooting	Ballantine 3028B-21	3 1/2 digits AC Volts 100 uV to 1 kV DC Volts 100 uV to 1 kV + 0.1% Resistance: 10 M Ohm to 20 M Ohm AC Current: to 10 Amps DC Current: to 10 Amps
Oscilloscope	Troubleshooting	Ballantine 1032A	Dual trace, 20 MHz, 5 mV to 5 volts/div
Micro-ohmmeter	Troubleshooting check high current connections	Ballantine 3205B	3 1/2 digits 1 micro-ohm resolution. Accuracy ± 0.5% continuous and pulsed current measurement modes.

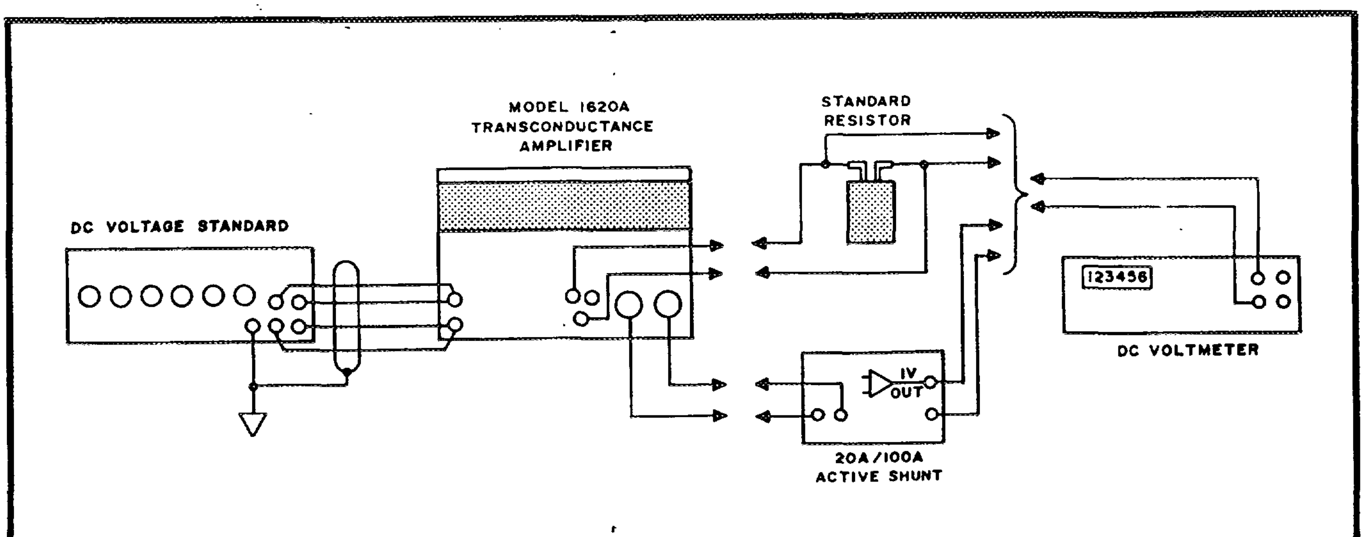


Figure 5-1. DC Current Check, Equipment Test Set-Up

TABLE 5-2a.

DC ACCURACY VERIFICATION

NOMINAL INPUT VOLTAGE	RANGE	LOAD RESISTOR	VOLTMETER LIMITS
+ 1.9 V	2m	1 k Ohm	1.89715 to 1.90285
- 1.9 V	2m	1 k Ohm	-1.89715 to -1.90285
+ 1.9 V	200u	1 k Ohm	0.18971 to 0.19029
+ 1.9 V	20m	100 Ohm	1.89715 to 1.90285
+ 1.9 V	200m	10 Ohm	1.89715 to 1.90285
+ 1.9 V	2A	1 Ohm	1.89921 to 1.90079
+ 1 V	20A	20A Shunt	0.99939 to 1.00061
+ 1 V	100A	100A Shunt	0.99959 to 1.00041

TABLE 5-2b. (Option 04)

DC ACCURACY VERIFICATION

NOMINAL INPUT VOLTAGE	RANGE	LOAD RESISTOR	VOLTMETER LIMITS
+ 1.9 V	2m	1 k Ohm	1.89921 to 1.90079
- 1.9 V	2m	1 k Ohm	-1.89921 to -1.90079
+ 1.9 V	200u	1 k Ohm	0.18990 to 0.19010
+ 1.9 V	20m	100 Ohm	1.89921 to 1.90079
+ 1.9 V	200m	10 Ohm	1.89921 to 1.90079
+ 1.9 V	2A	1 Ohm	1.89921 to 1.90079
+ 1 V	20A	20A Shunt	0.99939 to 1.00061
+ 1 V	100A	100A Shunt	0.99959 to 1.00041

5-21. AC CURRENT CHECKS

5-22. Connect the test set-up of figure 5-2 using the active shunt with 1 volt low source impedance output. Connect the Model 1605A AC/DC Transfer Standard to the output of the active shunt. Set the 1605A to 1 volt range and connect the 5 1/2 Digit DC Voltmeter to the 1605A output. If required, apply shunt calibration correction factors at 100 Hz and 1 kHz.

Follow the steps of table 5-3 to verify AC Current Calibration.

5-23. CHECKING INPUT OVERVOLTAGE INDICATOR

5-24. Set to 200u RANGE and restore the 1k Ohm output resistor to the current output terminals of the 1620A.

5-25. Increase the ac input voltage from 1 volt, 1 kHz to 3 volts, 1 kHz and note that the input overvoltage indicator is not lit at 1 volt and lights when 3 volts are applied. Apply + 4 volts dc and note that the lamp is lit. Apply - 4 volts dc and note that the lamp is lit.

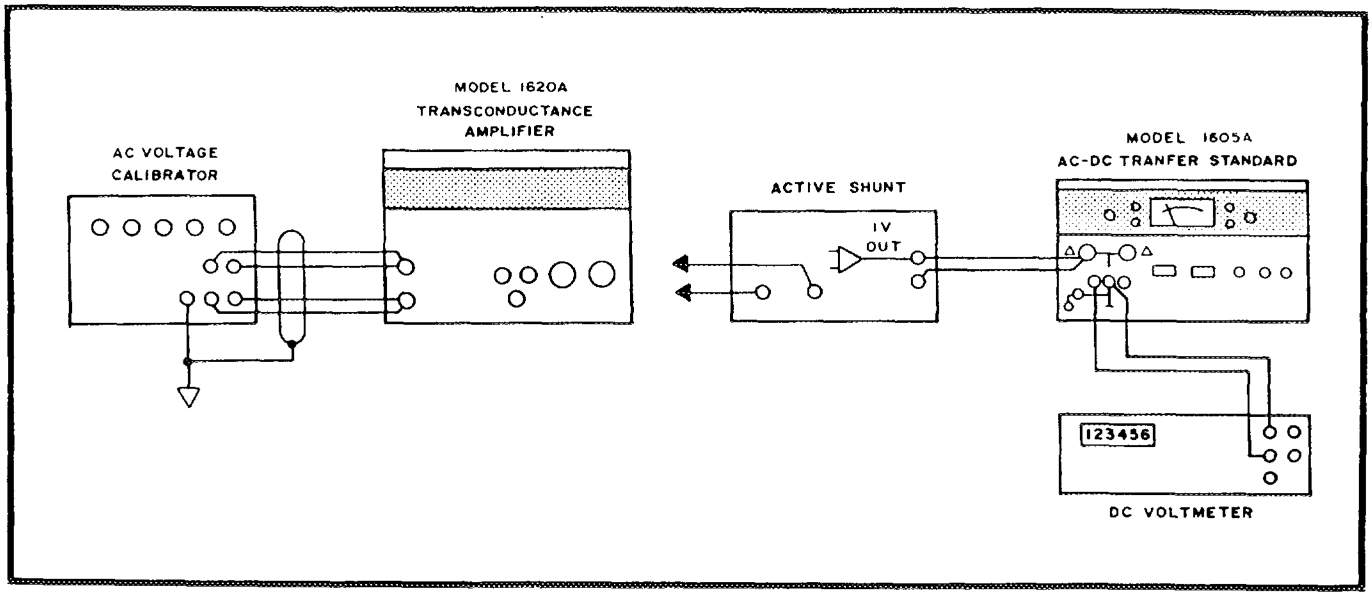


Figure 5-2. AC Current Check, Equipment Test Set-Up

TABLE 5-3.

AC CURRENT VERIFICATION

AC INPUT		1620A		AC/DC TRANSFER VOLTMETER
VOLTS	FREQUENCY	RANGE	SHUNT	LIMITS
1.000	10 kHz	200u	100 uA	0.9964 to 1.0036
1.000	10 kHz	2m	1 mA	0.9964 to 1.0036
1.000	10 kHz	20m	10 mA	0.9964 to 1.0036
1.000	10 kHz	200m	100 mA	0.9964 to 1.0036
1.000	5 kHz	2A	1 A	0.9964 to 1.0036
1.000	1 kHz	20A	10 A	0.9964 to 1.0036
1.000	100 Hz	100A	100 A	0.9974 to 1.0026
1.000	1 kHz	100A	100 A	0.9974 to 1.0026

5-26. CHECKING OVERCOMPLIANCE INDICATOR

5-27. Connect 1 volt, 1 kHz to the input of the 1620A.

5-28. Disconnect the 1k Ohm load and observe that the OVERCOMPLIANCE lamp is lit only when the 1k Ohm is disconnected.

5-29. CHECKING OUTPUT OVERCURRENT PROTECTION

a. Apply 1 volt DC to input. Connect current shunt to 100A output.

b. Step up input voltage to 1.2V DC. UUT should go into STANDBY at 1.2 volts at input. Decrease input voltage to 1.03 volts. UUT should return to OPERATE.

5-30. CONCLUSION OF PERFORMANCE VERIFICATON CHECKS

5-31. When the instrument has passed the above "covers on" Performance Assurance Checks, it has met its specifications as listed in Table 1-1. A calibration certification record may be maintained using Form 5-1. Again, note that all the ac calibration checks are optional and are not required to certify the instrument. They may be performed periodically to check more rigorous applications at the discretion of the user.

5-32. CALIBRATION AND ALIGNMENT PROCEDURE

5-33. The alignment and calibration procedures are "covers off" procedures to adjust the 1620A to the performance specifications. If the instrument cannot be properly adjusted, refer to the trouble-shooting and fault finding procedures detailed later in this section.

5-34. REMOVAL OF COVERS

5-35. The top and bottom covers of the 1620A are both retained by simple machine screws. To remove the covers, simply unfasten the screws and grasp the edge of the covers at the rear of the instrument. Gently pull backwards and upward to disengage the cover from the rear panel. Once the cover is free, it can easily be released from the retaining edge of the front panel and removed from the instrument. To replace covers, reverse the above procedure.

5-36. PRELIMINARY INSPECTION

5-37. Always check the instrument for mechanical damage, loose parts, faulty solder joints, burned resistors, etc. Use a low wattage (25 watt grounded soldering iron to make repairs and always replace components with exact equivalents to be certain that all performance specifications can be obtained. Use heat shunts when soldering diodes and semiconductors. Do not overheat circuit board printed wiring and pads. Make certain heat sinks and power transistors are tightly fastened.

5-38. INTERNAL ADJUSTMENTS AND TEST POINTS

5-39. See figure 5-3 for the location of internal adjustments and test points.

5-40. The ZERO ADJ screwdriver adjustment control is located on the front panel.

5-41. All calibration adjustments must be made in the sequence given.

5-42. INITIAL POWER SUPPLY CHECK

a. Short the input voltage connectors and connect a 1k Ohm load to the current output connectors.

b. Connect the ac power line input to the voltmeter thru a line voltage control unit (Variac) and use a true rms voltmeter to measure the input line voltage to the instrument under test. See figure 5-1.

c. Use a digital multimeter such as the Ballantine 3028B to measure internal dc power supply voltage levels. Connect the COMMON lead of the DMM to LO, a circuit ground point on the printed circuit board or the ground at the 100 Amp Shunt. Do not ground the DMM to the enclosure or the front panel connectors.

d. Connect the volts input connector lead of the 3028B DMM to the + 15 volts supply at the output of U102. Set the DMM to DC Volts and the 20 Volt range.

e. Vary the power line voltage from 106 to 130 volts (or equivalent) and observe that the +15 volt supply does not vary more than ± 0.20 volts and is always within the range of +13.8 to +16.2 volts.

f. Move the DMM input lead to U106, the -15 volt regulator and repeat step d observing that the voltage is within -13.8 to -16.2 volts.

g. Move the DMM lead to pin 4 of J400. Vary the power line voltage and observe that the DMM is within the limits of +9.5 to +14 volts.

h. Move the DMM lead to pin 5 of J400. Vary the power line voltage and observe that the DMM is within the limits of -9.5 to -14 volts.

i. Move the DMM input leads to U107, the +5 volt regulator output, and its ground. Vary the power line voltage. Observe that the +5 volt supply does not vary more than ± 0.3 volts and remains within the range of +4.7 to +5.3 volts.

5-43. DC CALIBRATION

All DC Calibrations should be performed prior to making any AC Checks or Calibrations.

NOTE

Calibrate ranges in the following sequence when Option 04 is installed:

200 uA	R18 Fine and R12 Coarse
2 A	R52
200 mA	R73
20 mA	R71
2 mA	R72
100 A	R55
20 A	R51

5-44. FRONT PANEL ZERO ADJ (R26)

5-45. Connect the DC test set-up shown in figure 5-1 with DC Standard at 0 volts and lowest RANGE.

5-46. Connect the 1k Ohm standard resistor as a load to the current output. Set the 1620A RANGE to 2m.

5-47. Connect the DVM across the 1k Ohm standard resistor and adjust the front panel ZERO ADJ for 0.00 ± 10 uV.

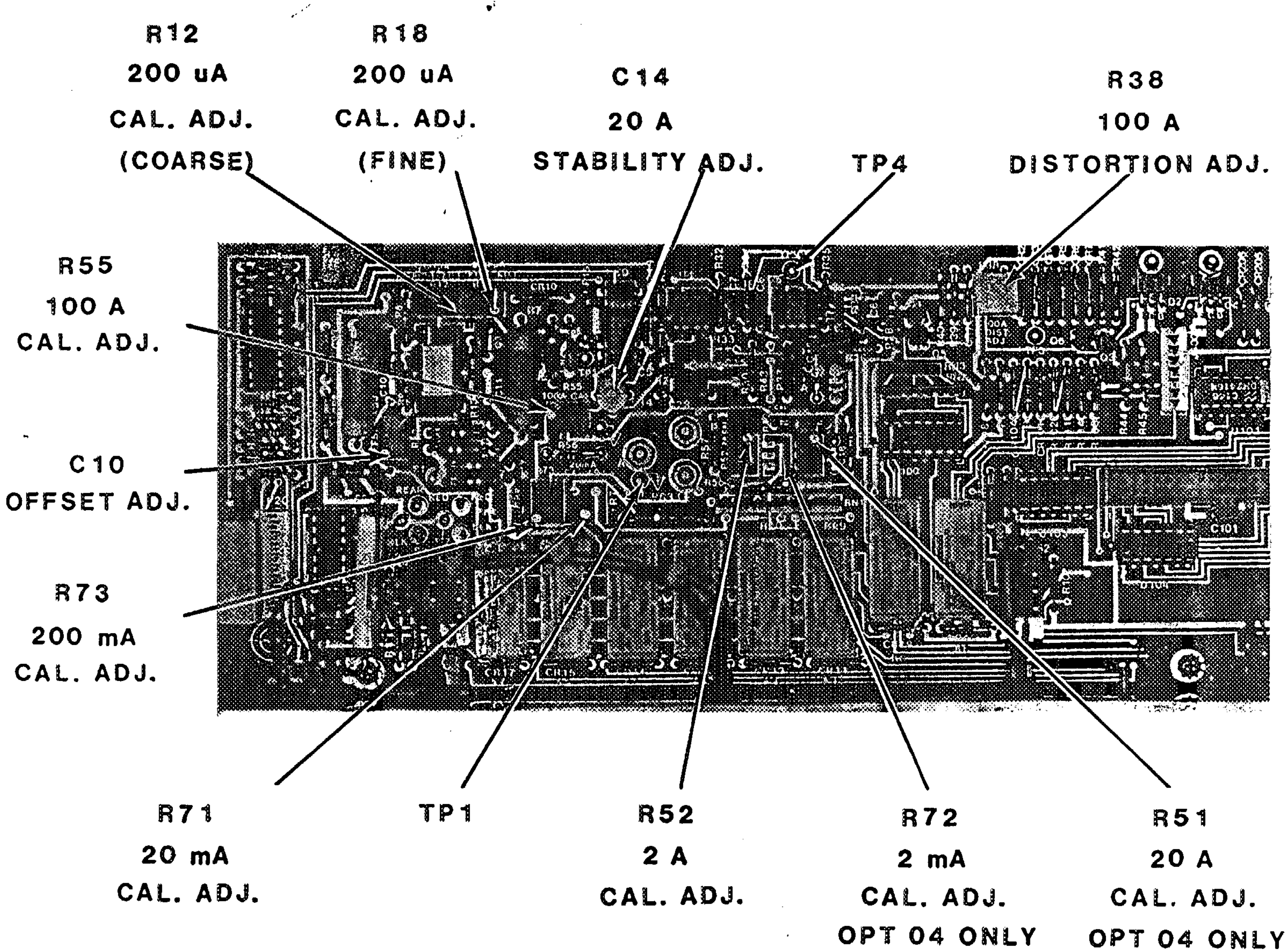


Figure 5-3. Model 1620A, Internal Adjustments and Test Points

5-48. 200u RANGE CALIBRATION (R18)

5-49. Connect the DC test set-up shown in figure 5-1.

5-50. Connect the 10k Ohm standard resistor as a load to the current output. Set the 1620A RANGE to 200u.

NOTE

Always be certain the ZERO ADJ has been made before calibrating. The ZERO ADJ should be made on the particular RANGE being calibrated with the specified standard load resistance for that RANGE.

5-51. Apply +1.9 volt dc to the input of the 1620A.

5-52. Connect the 5 1/2 digit voltmeter across the input and adjust the dc voltage calibrator to provide exactly a +1.90000 reading on the voltmeter.

5-53. Connect the voltmeter across the 10k Ohm load resistor.

5-54. Center R18 200uA FINE ADJ. Adjust R12 for a reading of 1.90000 ± 3 digits. Use R18 to fine tune 200uA RANGE. Allow for temperature effects and repeat this adjustment several times within five minutes. If R18 lacks sufficient range, then set to its adjustment center and adjust R12, 200u Coarse Adjustment, close to +1.90000 V. Make the final adjustment with R18.

5-55. 2A RANGE CALIBRATION (R52)

5-56. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Vpltmeter and DC Voltage Standard are normalized at +1.90000 volts.

5-57. Connect the 1 ohm standard resistor to the current output and set the 1620A RANGE to 2A.

5-58. Apply the nominal +1.9 volts to the input of the 1620A.

5-59. Adjust R52, the 2A CAL. ADJ. control, until the DC Voltmeter connected across the 1 ohm standard resistor reads +1.90000 ± 3 digits. Allow for temperature effects and repeat this adjustment several times within five minutes.

5-60. 200m RANGE CALIBRATION (R73)

5-61. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Voltmeter and DC Voltage Standard are normalized at 1.90000 volts.

5-62. Connect the 10 ohm standard resistor to the current output and set the 1620A RANGE to 200m.

5-63. Apply the nominal +1.9 V to the input of the 1620A.

5-64. Adjust R73, the 200m Cal. Adjust control, until the DC Voltmeter connected across the 10 ohm standard reads +1.90000 ± 3 digits. Allow for temperature effects and repeat this adjustment several times within five minutes.

5-65. HIGH ACCURACY DC (OPTION 04)

5-66. These are steps performed between 2A RANGE calibration and 100A RANGE calibration.

NOTE

Paragraphs 5-67 thru 5-71d for R71 and R72 apply only to instruments equipped with Option 04 for highest accuracy on 200m, 20m, 2m, and 200u RANGES.

5-67. 20m RANGE CALIBRATION (R71)

5-68. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Voltmeter and DC Voltage Standard are normalized at +1.90000 V.

5-69. Connect the 100 ohm standard resistor to the current output and set the 1620A RANGE to 20m.

5-70. Apply the nominal +1.9 V to the input of the 1620A.

5-71. Adjust R71, the 20m Cal. Adj. control, until the DC Voltmeter connected across the 100 ohms standard reads +1.90000 ± 3 digits. Allow for temperature effects and repeat this adjustment several times within five minutes.

5-72. 2m RANGE CALIBRATION (R72)

5-73. Adjust R72, the 2m Range Calibration as follows:

a. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Voltmeter and DC Voltage Standard are normalized at +1.90000 V.

b. Connect 1k ohm standrad resistor to the current output and set the 1620A RANGE to 2m.

c. Apply the nominal +1.9 V to the input of the 1620A.

d. Adjust R72, the 2m Cal Adj. control, until the DC Voltmeter connected across the 100 ohm standard reads +1.90000 ± 3 digits. Allow for temperature effects and repeat this adjustment several times within five minutes.

5-74. 100A RANGE CALIBRATION (R55)

5-75. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Voltmeter and DC Voltage Standard are normalized at +1.00000 volts.

5-76. Connect the 100 Amp active shunt with 1 volt full scale output as a load across the 100A current output connectors. Set the 1620A to the 20A/100A RANGE.

5-77. Connect the 5 1/2 digit DC Voltmeter across the 1620A input terminals and set the DC Voltage Standard until the DC Voltmeter reads +1.00000 volt.

5-78. Connect the 5 1/2 digit DC Voltmeter to the output of the active 100 Amp shunt.

5-79. Adjust R55, the 100A RANGE CAL. ADJ. control, until the DC Voltmeter reads +1.00000 ± 3 digits. Allow for temperature effects and repeat this adjustment within five minutes.

5-80. 20A RANGE CALIBRATION (R51)

5-81. Continue the test set-up of paragraph 5-49 and be certain that the ZERO ADJ is properly set and the DC Voltmeter and DC Voltage Standard are normalized at +1.90000 volts.

5-82. Connect the 10 Amp active shunt with 1 volt full scale output across the 20A current output connectors. Set the 1620A RANGE to 20A/100A.

5-83. Connect the 5 1/2 digit DC Voltmeter across the 1620A input terminals and set the DC Voltage Standard until the DC Voltmeter reads +1.90000 volts.

5-84. Connect the 5 1/2 digit DC Voltmeter to the output of the active 10 Amp shunt.

5-85. Adjust R51, the 20A RANGE CAL. ADJ. control, until the DC Voltmeter reads +1.90000 ± 3 digits. Allow for temperature effects and repeat this adjustment within five minutes.

5-86. Recheck the 2A RANGE calibration as detailed in paragraph 5-55. Touch up R52 if required.

5-87. Recheck the 100A RANGE calibration as detailed in paragraph 5-72. Touch up R55 if required and then again repeat the 20A RANGE calibration since they are independent.

5-88. 20A STABILITY ADJUSTMENT (C14)

5-89. Connect a short-heavy strap across the 20A output to the LO binding post.

5-90. Select the 20A RANGE and apply a +2 volt DC signal to the input HI/LO binding post.

5-91. Connect an Oscilloscope to the 1620A main printed circuit board with scope probe low to TP-1 and scope probe high to TP-4.

5-92. Set the Oscilloscope to 100 mV/cm sensitivity and 1 ms/cm time base.

5-93. Adjust C14, 20A Stability Adjustment, toward minimum capacity*, while at the same time, switching the input signal back and forth between +2 V and -2 V until oscillation is observed on the Oscilloscope. When oscillation occurs, adjust C14 until the oscillation just breaks with either +2 V or -2 V applied. If unable to obtain oscillation with C14 adjustment throughout its range, then set C14 to minimum capacity.

*(Minimum capacity occurs when C14 plates do not mesh across their full width.)

5-94. 100A DISTORTION ADJUSTMENT (R38)

5-95. Use the test set-up of figure 5-2 replacing the Model 1600B AC-DC Transfer Standard and DC Voltmeter with the Hewlett Packard 333A Distortion Analyzer (or equivalent) to monitor the active shunts 100 Amp Range.

5-96. Set the 1620A to the 100A RANGE.

5-97. Apply a 1 V, 1 kHz signal to the input of the 1620A. Allow the 1620A to OPERATE for at least three minutes delivering 100A of output current for obtaining the most optimum setting of the 100A Distortion Adjustment.

5-98. Set the Distortion Analyzer controls as follows:

FUNCTION Switch	SET LEVEL
MODE Switch	MANUAL
METER RANGE	1 Volt
FREQUENCY RANGE	X100
FREQUENCY VERNIER	10
HIGH PASS FILTER	OUT

5-99. Adjust the sensitivity control to a convenient reference near the meters full scale and note the indication in dB.

5-100. Transfer the function switch to "DISTORTION" and the mode switch to "AUTOMATIC".

5-101. Turn the analyzer "METER RANGE" switch to the lowest range that produces an on scale reading.

5-102. Adjust R38, 100A Distortion Adjustment, for a minimum indication on the analyzer.

tion level is by taking the difference in dB between the 2 readings. (The requirement is 60 dB or more down).

5-104. AC CALIBRATION

5-105. Connect the AC test set-up shown in figure 5-2.

5-106. Connect the 1k Ohm standard resistor as a load to the ≤ 2A current output binding post. Set the 1620A RANGE to 2m and short circuit the input HI/LO binding post.

5-107. Adjust the front panel ZERO ADJ for 0.00 ± 10 uV. Remove the short from the input binding post.

5-108. Check that the AC Voltage Calibrator and the Model 1600B Transfer Standard is normalized at 1.90000 V rms, 10 kHz.

5-109. Apply the nominal 1.9 V rms, 10 kHz to the input of the 1620A.

5-110. Adjust C10, the 10 kHz adjustment, for a reading of 1.90000 ± 3 digits.

5-111. TROUBLESHOOTING AND FAULT FINDING

5-112. The troubleshooting procedures should only be performed when the instrument cannot be calibrated with the procedure listed in paragraph 5-32 through 5-110. Should the instrument be inoperative or out of specification, follow the fault finding procedures starting with paragraph 5-113.

5-113. Carefully examine the instrument and check for any visual evidence of trouble. Check for broken wires, burned resistors, loose components, shorts, or open or defective solder joints on the printed circuit board. Check for separation of printed circuit board lands and pads. Check for open, defective, or intermittent switches. Check that connectors are clean and will mate properly.

5-114. Understand and be familiar with the circuit theory of Section 4. Use the simplified schematic diagram, figure 4-1 and the schematic diagram, figure 6-1 to isolate the probable circuit areas which may cause the problem. Always check the power supply voltages. Check for oscillations in the circuitry by using an oscilloscope. Then, refer to the fault finding and troubleshooting hints for that circuit. Figure 5-4 gives some probable corrections for specific symptoms.

5-115. FUSE REPLACEMENT

5-116. The ac ventilating fan FUSE, F1, is located on the rear panel. To replace the FUSE remove the power cord from the receptacle. Replace the FUSE with the amperage value and type specified and restore the instrument to normal operation by reversing this procedure.

5-117. PREVENTIVE MAINTENANCE

5-118. CLEANING. The instrument should be cleaned as often as operating conditions require. Thoroughly clean both the inside and outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or a vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulations of dirt or grease from connector contacts and component terminals. Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth.

5-119. REPAIR AND REPLACEMENT. Repair and replacement of electrical and mechanical parts must be accomplished with care and caution. Printed circuit component boards can become warped, cracked or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies.

a. Use a low-wattage, grounded soldering iron (Weller Model No. W-TCP 35 watt) with a 700°F tip, 1.5 mm (1/16") to 2.5 mm (3/32") wide.

b. Be sure that the soldering iron tip, cabinet and COMMON connectors are securely tied to "earth" ground. This avoids possible overvoltage damage to semiconductors and capacitors.

c. To Desolder components, use a commercial "solder sipper", (SOLDA PULLIT manufactured by Edsyn Products or equivalent) or use solder-removing SOLDER-WICK, size 3, manufactured by SOLDER REMOVAL CO., Covina, California.

d. To remove a component, clip a heat sink such as long nose pliers, tweezers, or alligator clips onto the component lead and as close to the body of the component as possible. This assures minimum heating of the component while desoldering.

e. Place the soldering iron directly on the component lead on the printed circuit conductor side of the board. Use a desoldering aid to remove all solder and free the component lead.

f. Straighten the bent over component lead with long nose pliers and pull the component out of the hole.

g. If a component is obviously faulty or damaged, simply clip the leads close to the body of the component and remove the remaining leads thru the conductor side of the circuit board.

CAUTION

Always use a short soldering cycle since excessive or prolonged heat may destroy the laminate bond and lift the copper conductors from the circuit board or cause immediate degradation or latent damage to the components.

h. Always clean the component lead holes by heating the solder on the circuit board conductor pad, then quickly removing the soldering iron and inserting a pointed non-metallic object such as a toothpick to clean the hole. Never let solder cover the hole, since the incoming new component lead may push the pad from the circuit board.

i. To install a new component, straighten and shape the leads. Insert the component into the proper holes. Bend the leads at the conductor side of the circuit board so they fall over the pad and extend over the foil of the incoming conductor path. Cut the bent leads approximately 2.5 mm (3/32") from the hole.

CAUTION

When replacing Q400 through Q419, the transipad (Ballantine P/N 65-10021-0) must be replaced and the mounting screws torqued to 6 in lb ± 1 in lb.

j. Clip a heat sink to the component lead at the body of the component. Heat the lead and pad with a soldering iron and use fresh solder (60-40) as required to cover the lead and form a meniscus over the hole to assure a good electrical connection.

k. Clean excess flux from the connection and surrounding area. Use TF Freon spray cleaner (such as Miller Stephenson Chemical Co., Type MS-180, Ballantine p/n 80-10004-0A) and use light air pressure (5 to 20 PSIG) and a clean soft brush to clean the board and components. Use a humidity seal spray (such as Humiseal, Columbia Technical Corp., Type 1015, Ballantine p/n 80-10005-0A) to seal the board and protect against humidity.

NOTE

Do not touch the cleansed board or excessively handle the components so as to avoid unwanted leakage which may affect performance when exposed to high humidity.

l. Always replace a component with the exact duplicate as specified in the parts list.

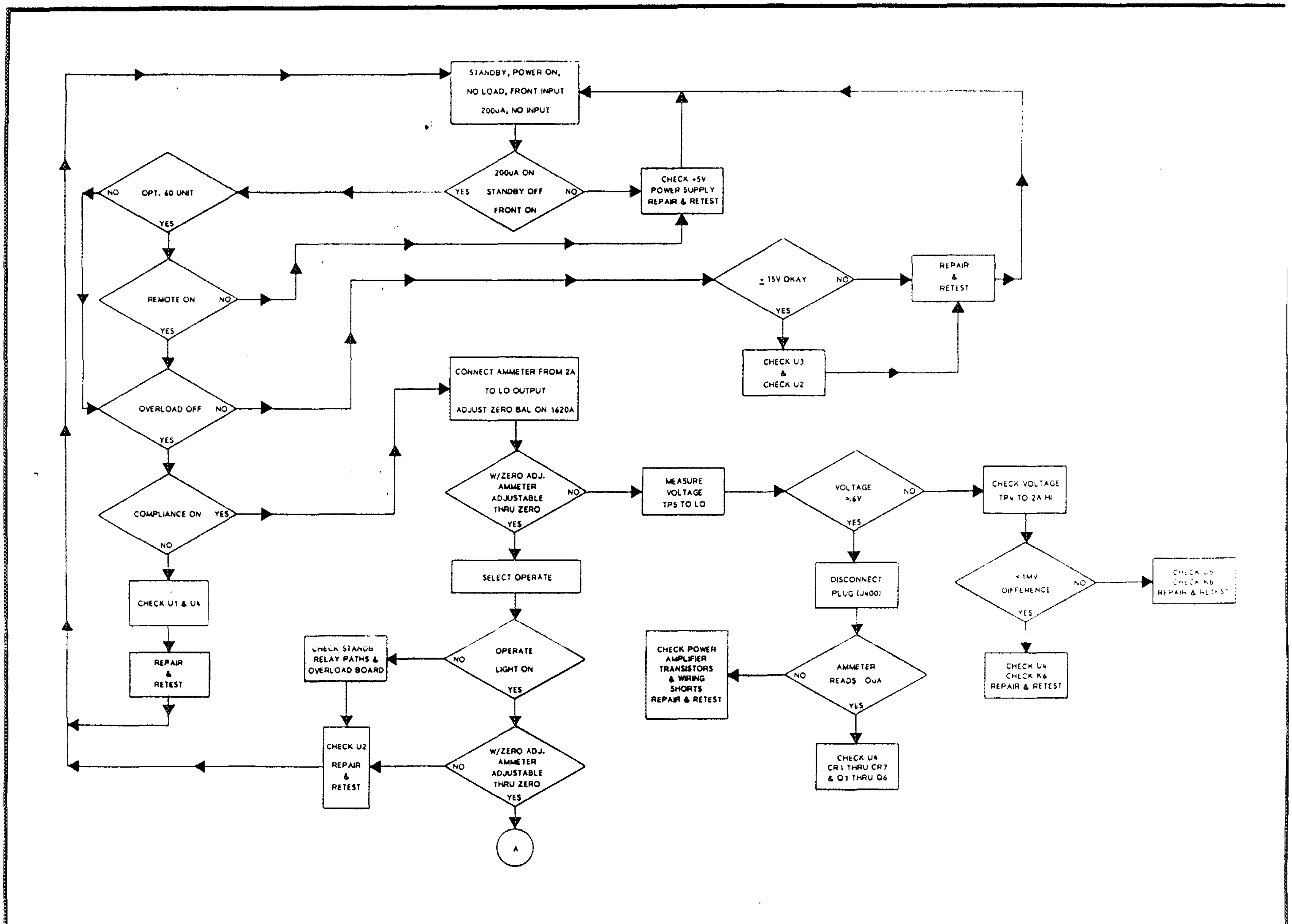


Figure 5-4. Troubleshooting Flow Chart - (Sheet 1 of 3)

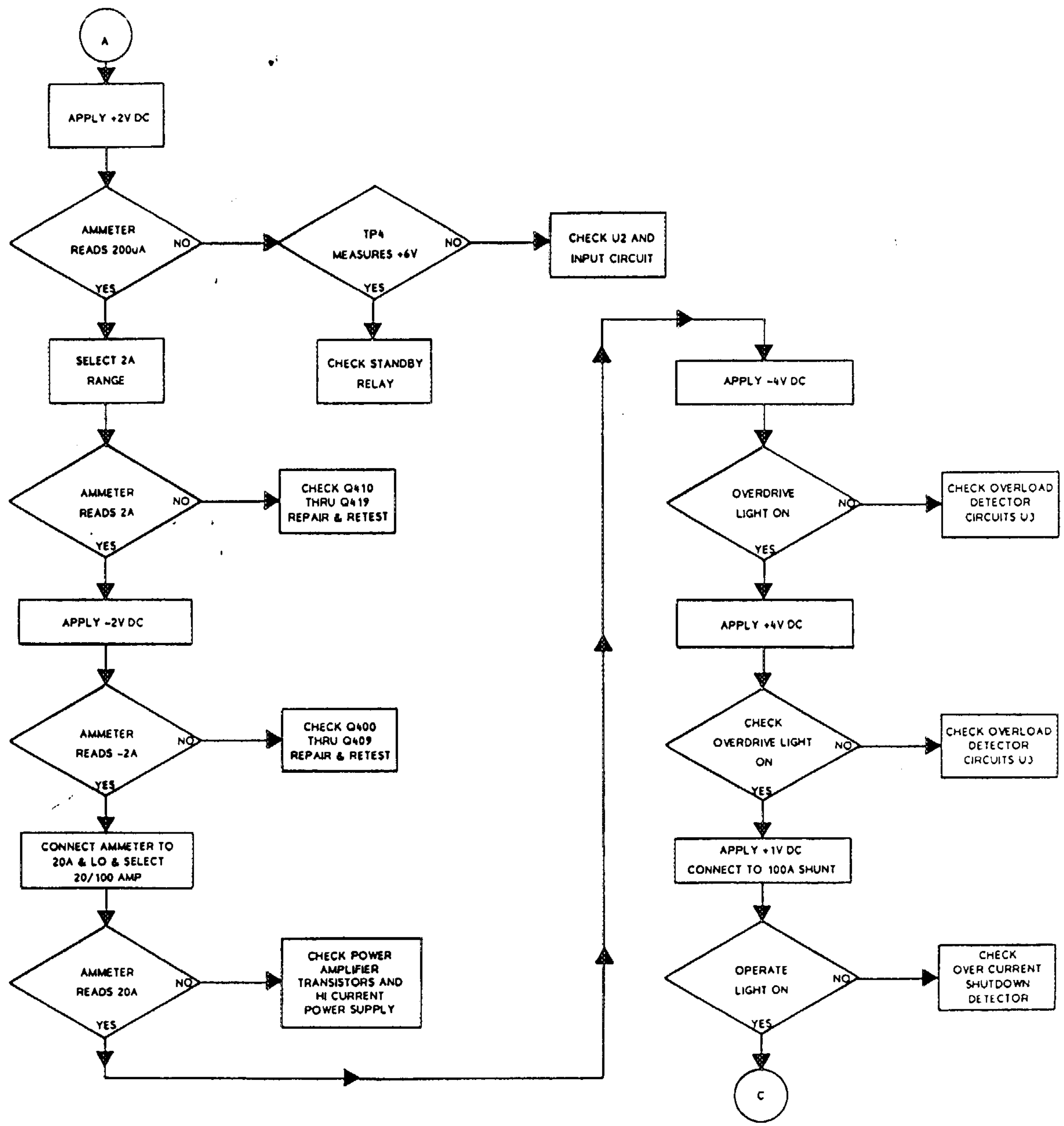


Figure 5-4. Troubleshooting Flow Chart - (Sheet 2 of 3)

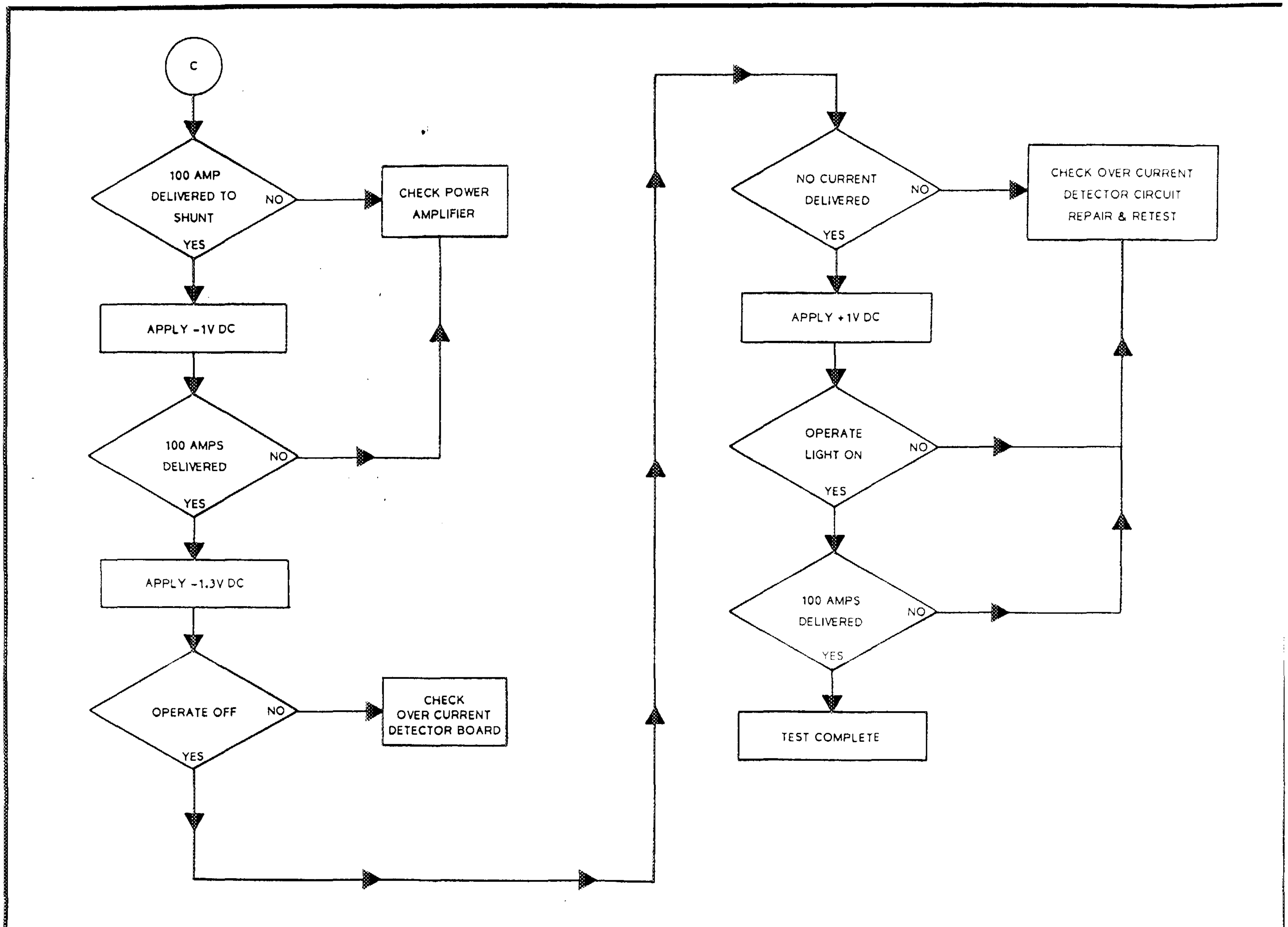


Figure 5-4. Troubleshooting Flow Chart - (Sheet 3 of 3)

PERFORMANCE VERIFICATION

TEST RECORD

Model 1620A Transconductance Amplifier   Serial No. ________________

Options Installed ________________

1. Verify ac mains connection and voltage __________ Volts
2. Pilot lamp illuminates with power ON __________ ( )
3. Range switches and lamps function __________ ( )
4. FRONT-REAR switch and lamps function __________ ( )
5. ZERO ADJUST (Paragraph 5-11) __________ ( )
6. DC Accuracy Verification (Paragraph 5-16)

NOMINAL INPUT VOLTAGE	RANGE	LOAD RESISTOR	VOLTMETER	
			LIMITS*	READING
+ 1.9 V	2m	1 k Ohm		
- 1.9 V	2m	1 k Ohm		
+ 1.9 V	200u	1 k Ohm		
+ 1.9 V	20m	100 Ohm		
+ 1.9 V	200m	10 Ohm		
+ 1.9 V	2A	1 Ohm		
+ 1 V	20A	20A Shunt		
+ 1 V	100A	100A Shunt		

7. AC Accuracy Verification (Paragraph 5-21)

AC INPUT		1620A		AC/DC TRANSFER VOLTMETER	
VOLTS	FREQUENCY	RANGE	SHUNT	LIMITS	READING
1.000	10 kHz	200u	100 uA	0.9964 to 1.0036	
1.000	10 kHz	2m	1 mA	0.9964 to 1.0036	
1.000	10 kHz	20m	10 mA	0.9964 to 1.0036	
1.000	10 kHz	200m	100 mA	0.9964 to 1.0036	
1.000	5 kHz	2A	1 A	0.9964 to 1.0036	
1.000	1 kHz	20A	10 A	0.9964 to 1.0036	
1.000	100 Hz	100A	100 A	0.9964 to 1.0026	
1.000	1 kHz	100A	100 A	0.9974 to 1.0026	

*INSERT LIMITS FROM TABLE 5-2A OR 5-2B FOR HIGH ACCURACY OPTION 04.

FORM 5-1

PARTS LIST, MODEL 1620A POWER AMPLIFIER ASSY (89-11250-1)

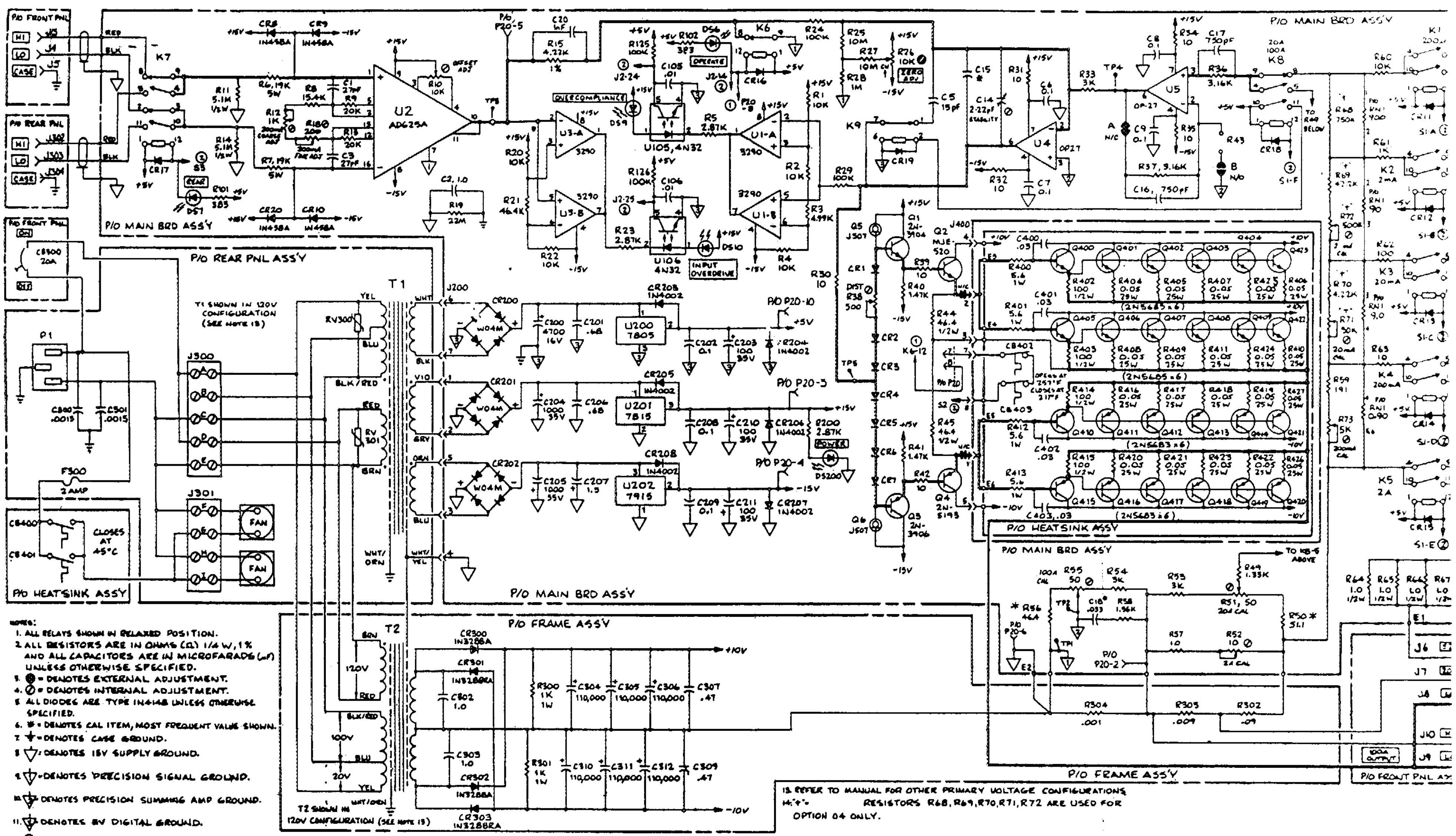
SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR. PART NUMBER

PARTS LIST, MODEL 1620A FRAME ASSY (89-11252-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C. 302	07-08134-0A	CYM 1. OUF 50 V M 20%	084411	TRW TYPE X663F
C. 303	07-08134-0A	CYM 1. OUF 50 V M 20%	084411	TRW TYPE X663F
C. 304	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 305	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 306	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 307	07-10326-0A	CMD 470. ONF 80. OVK 10%	056289	CDE WMF1P47
C. 309	07-10326-0A	CMD 470. ONF 80. OVK 10%	056289	CDE WMF1P47
C. 310	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 311	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 312	07-10592-1A	CEA 110KUF 25V	050423	BLI
CR300	05-10166-0A	DGP IN3288A 100A 100V REV	081483	IRC IN3288A DO-8 CASE
CR301	05-10167-0A	DGP IN3288RA 100A, 100V REV	081483	IRC IN3288RA DO-8 CASE
CR302	05-10166-0A	DGP IN3288A 100A 100V REV	081483	IRC IN3288A DO-8 CASE
CR303	05-10167-0A	DGP IN3288RA 100A, 100V REV	081483	IRC IN3288RA DO-8 CASE
R. 300	12-01272-0A	RFC 1. 0 K 1 W J 5%	001121	A-B TYP GB
R. 301	12-01272-0A	RFC 1. 0 K 1 W J 5%	001121	A-B TYP GB
T. . . 2	20-10076-1N	TRX 1620A POWER	050423	BLI

PARTS LIST, MODEL 1620A POWER TRANSFORMER INTERCONNECT CABLE ASSY (88-10117-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
J. 200	31-10248-0A	PLG 7PIN 24GA . 1" IN LINE	000779	AMP MTA-100 640441-7



NOTES:

1. ALL RELAYS SHOWN IN RELAXED POSITION.
2. ALL RESISTORS ARE IN OHMS (Ω) 1/4 W, 1% AND ALL CAPACITORS ARE IN MICROFARADS (μf) UNLESS OTHERWISE SPECIFIED.
3. ⊗ = DENOTES EXTERNAL ADJUSTMENT.
4. ⊘ = DENOTES INTERNAL ADJUSTMENT.
5. ALL DIODES ARE TYPE IN4148 UNLESS OTHERWISE SPECIFIED.
6. ✱ = DENOTES CAL ITEM, MOST FREQUENT VALUE SHOWN.
7. ⏚ = DENOTES CASE GROUND.
8. ▽ = DENOTES 15V SUPPLY GROUND.
9. ▽ = DENOTES PRECISION SIGNAL GROUND.
10. ▽ = DENOTES PRECISION SUMMING AMP GROUND.
11. ▽ = DENOTES 5V DIGITAL GROUND.
12. Ⓝ = DENOTES SHEET NUMBER.
13. REFER TO MANUAL FOR OTHER PRIMARY VOLTAGE CONFIGURATIONS.
14. "+" = RESISTORS R68, R69, R70, R71, R72 ARE USED FOR OPTION 04 ONLY.

Figure 6-1. Model 1620A, Schematic Diagr (Sheet 1 of 2)

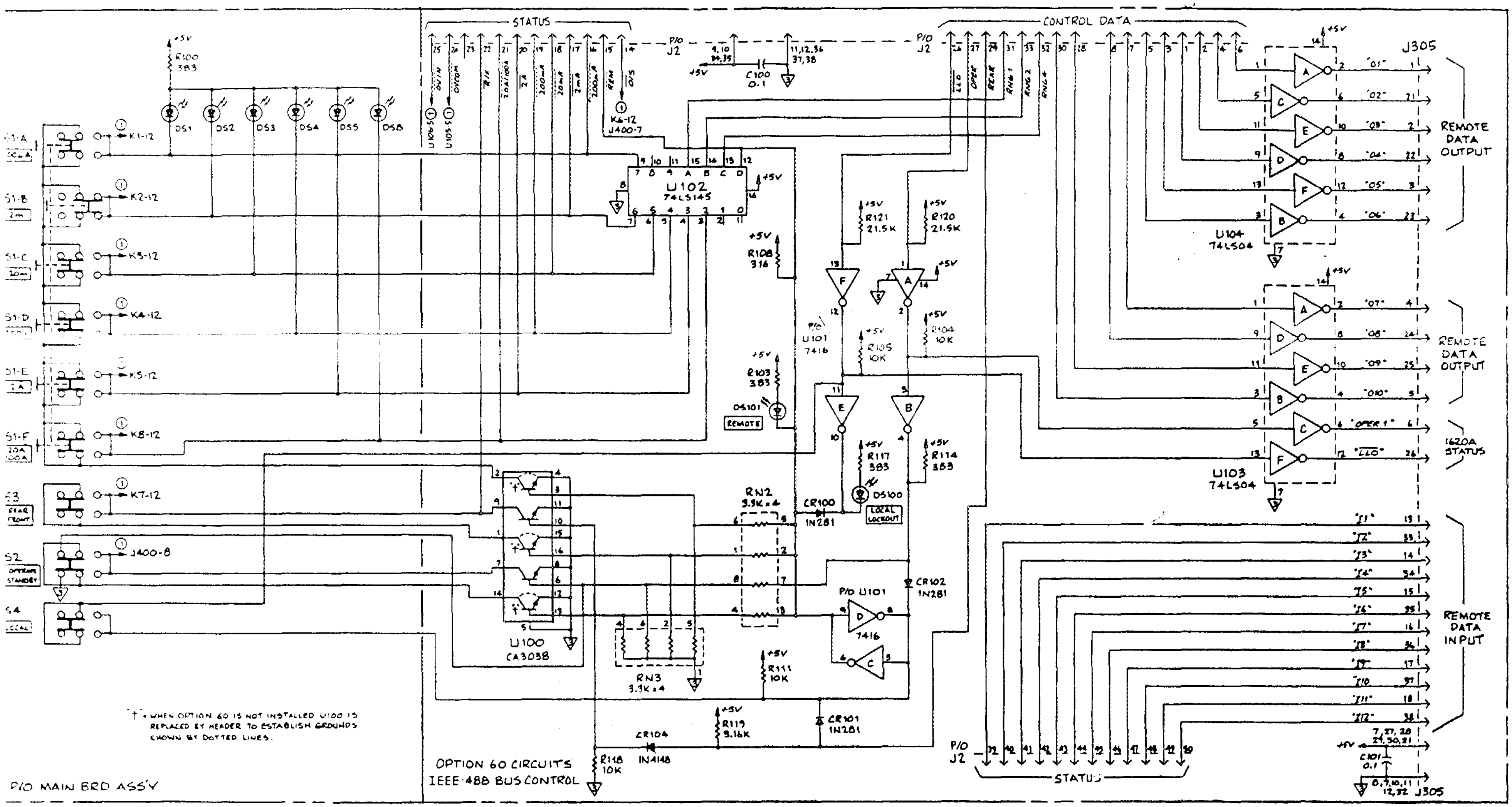


Figure 6-1. Model 1620A, Schematic Diagram
(Sheet 2 of 2)

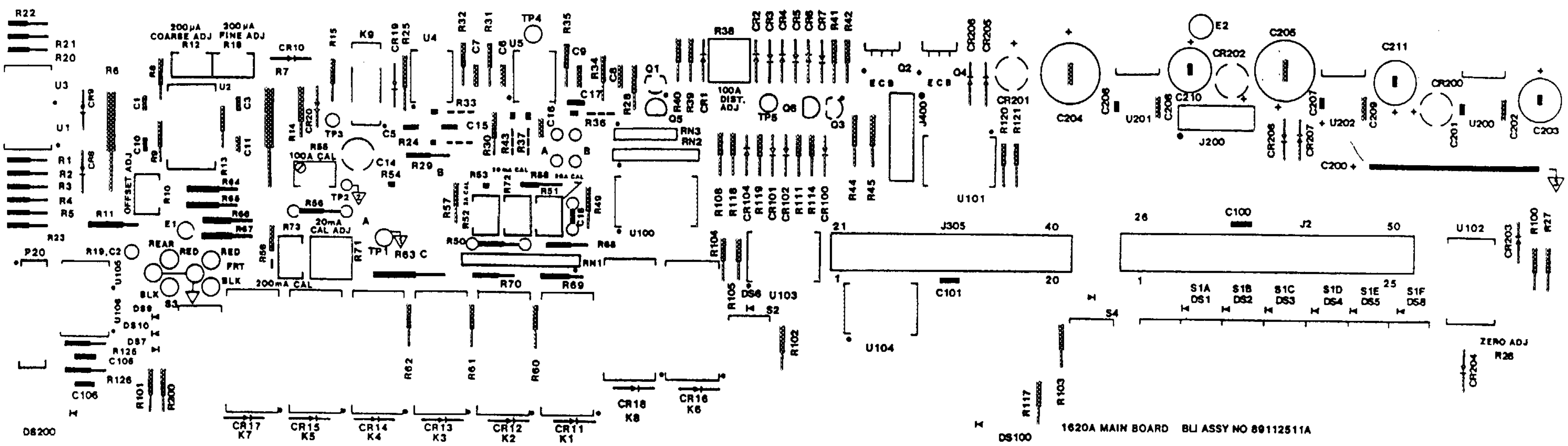


Figure 6-3. Model 1620A Main Board, Component Layout

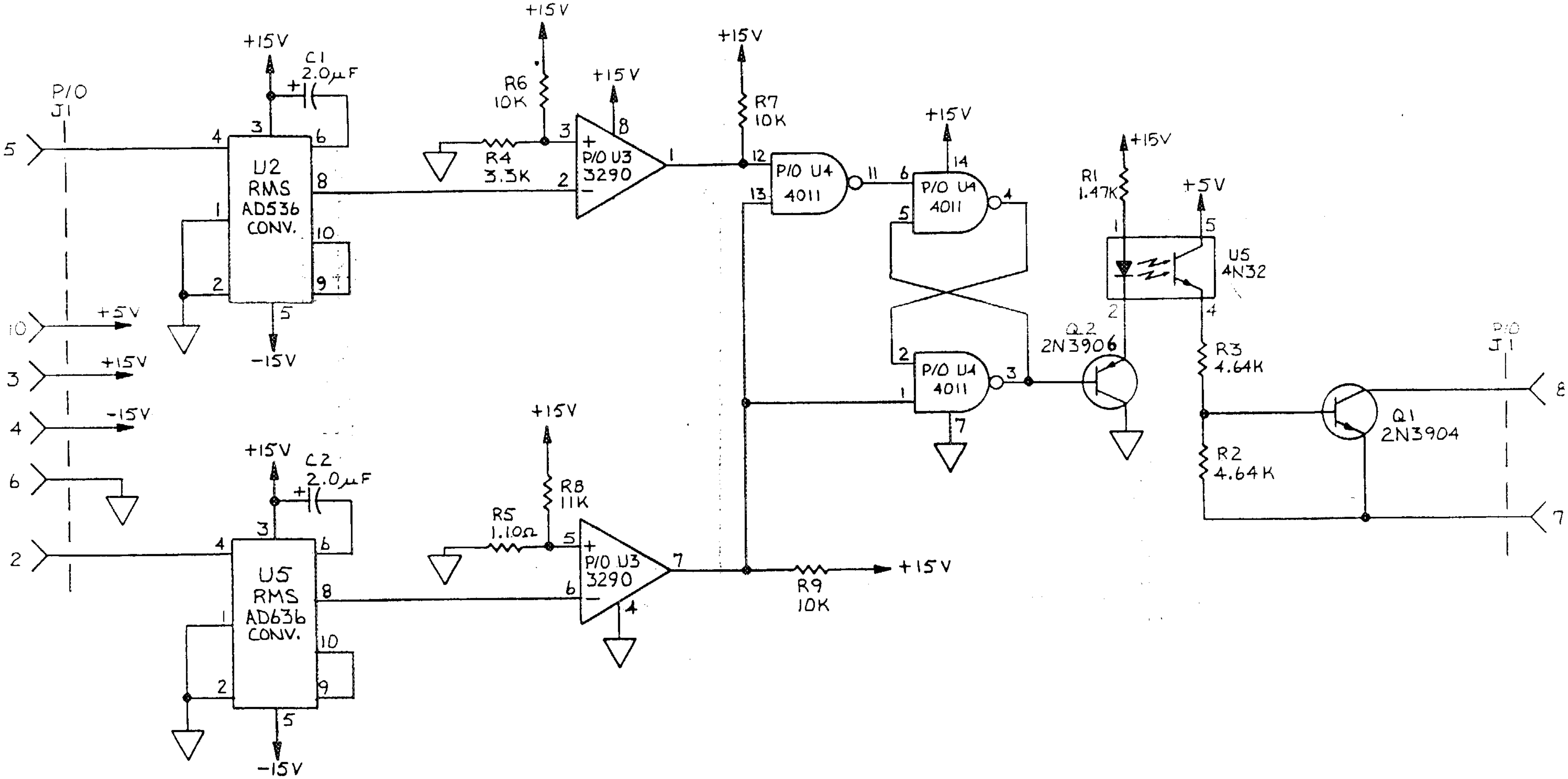


Figure 6-2. Model 1620A, 100A Overload Protection Schematic Diagram

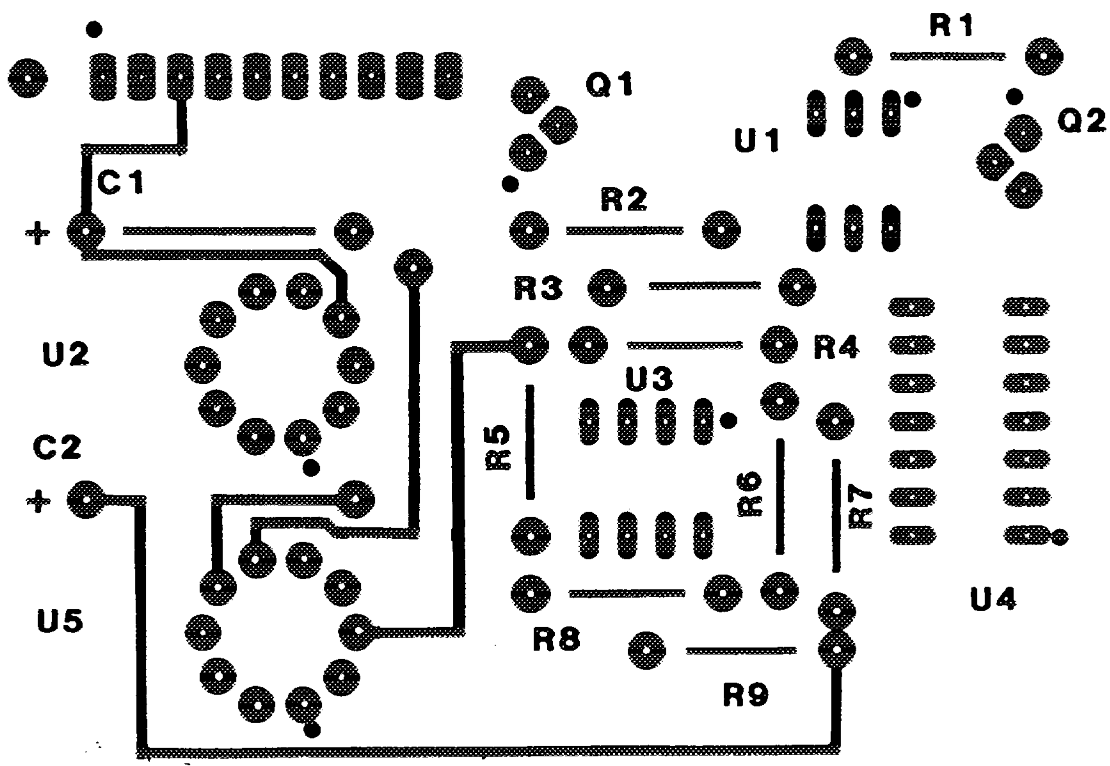


Figure 6-4. 100A Overload Protection Board, Component Layout

SECTION 7

OPTIONS

7-1. INTRODUCTION

7-2. OPTION 60. Option 60 is an IEEE-488 Standard Interface which uses the subsets SH1, AH1, T6, TEØ, L4, LEØ, SR1, RLØ, PPØ, DC2 and DTØ. All programming of the instrument is based on a character-serial, seven-bit ASCII Code. Any characters not included in the instruction set are ignored by the interface. Status may be requested and an alphanumeric coded response of the status obtained.

7-3. The 1620A will vary its output as commands are entered through a control device. In addition to the programmable output current range, control can be exercised over the INPUT (FRONT/REAR), Mode (OPERATE/STANDBY), and Interrupt Enable. The instrument may be addressed to obtain a twelve character status response or a six character data response or serial polled for a one byte response.

NOTE

Installation of the IEEE-488 Interface Assembly into the Model 1620A does not degrade the 1620A Analog performance. However, when control is exercised by a high speed controller, through the interface, significant high frequency noise may be coupled to the 1620A output through radiation and system ground loops. Since the noise encountered varies with the controller connected into the system, the user should determine the amount of noise in his system.

The I/O Remote Connector on the rear panel has the same pin assignment as J305 and the same signal assignment.

7-4. SPECIFICATIONS

7-5. The specifications of the IEEE-488 Interface are: full remote programming of current magnitude, INPUT (FRONT/REAR) and Mode (OPERATE/-STANDBY). In addition, REMOTE EXPANSION of ten output and twelve input lines can be used for control and reading of external data. The interface is directly compatible with IEEE Interface Standards. Data returned on request includes Status of the LOCAL/REMOTE, STANDBY/OPERATE, Limits and External Parallel Data Input. Selection of the OPERATE/STANDBY can be overridden from the front panel and front panel indication of the status is indicated.

7-6. OPERATING FEATURES

7-7. Installation of the Option 60 in the 1620A adds the operator switches shown in Figure 7-1. Switches S3-1 through S3-5 are used to control the local address of the Calibrator. They may be set to the binary equivalent of any number, 1 through 3Ø, that the controller has assigned the 1620A for an address. The setting for number 31 (11111) is reserved for the "Unlisten" instruction and sets the interface address using the codes in Table 7-1. In addition, switching S3-6 is used to select SRQ Enable, S3-7 is used to select EOI Enable, and S3-8 is used to select CR or LF Terminator.

TABLE 7-1.

ALLOWABLE LISTEN AND TALK ADDRESSES

DECIMAL	SWITCH NO.					ASCII CHARACTER	
	5	4	3	2	1	LISTEN	TALK
0	0	0	0	0	0	SP	@
1	0	0	0	0	1	!	A
2	0	0	0	1	0	"	B
3	0	0	0	1	1	#	C
4	0	0	1	0	0	$	D
5	0	0	1	0	1	%	E
6	0	0	1	1	0	&	F
7	0	0	1	1	1	'	G
8	0	1	0	0	0	(	H
9	0	1	0	0	1	)	I
10	0	1	0	1	0	*	J
11	0	1	0	1	1	+	K
12	0	1	1	0	0	,	L
13	0	1	1	0	1	-	M
14	0	1	1	1	0	.	N
15	0	1	1	1	1	/	O
16	1	0	0	0	0	0	P
17	1	0	0	0	1	1	Q
18	1	0	0	1	0	2	R
19	1	0	0	1	1	3	S
20	1	0	1	0	0	4	T
21	1	0	1	0	1	5	U
22	1	0	1	1	0	6	V
23	1	0	1	1	1	7	W
24	1	1	0	0	0	8	X
25	1	1	0	0	1	9	Y
26	1	1	0	1	0	:	Z
27	1	1	0	1	1	;	[
28	1	1	1	0	0	<	\
29	1	1	1	0	1	=	]
30	1	1	1	1	0	>	^

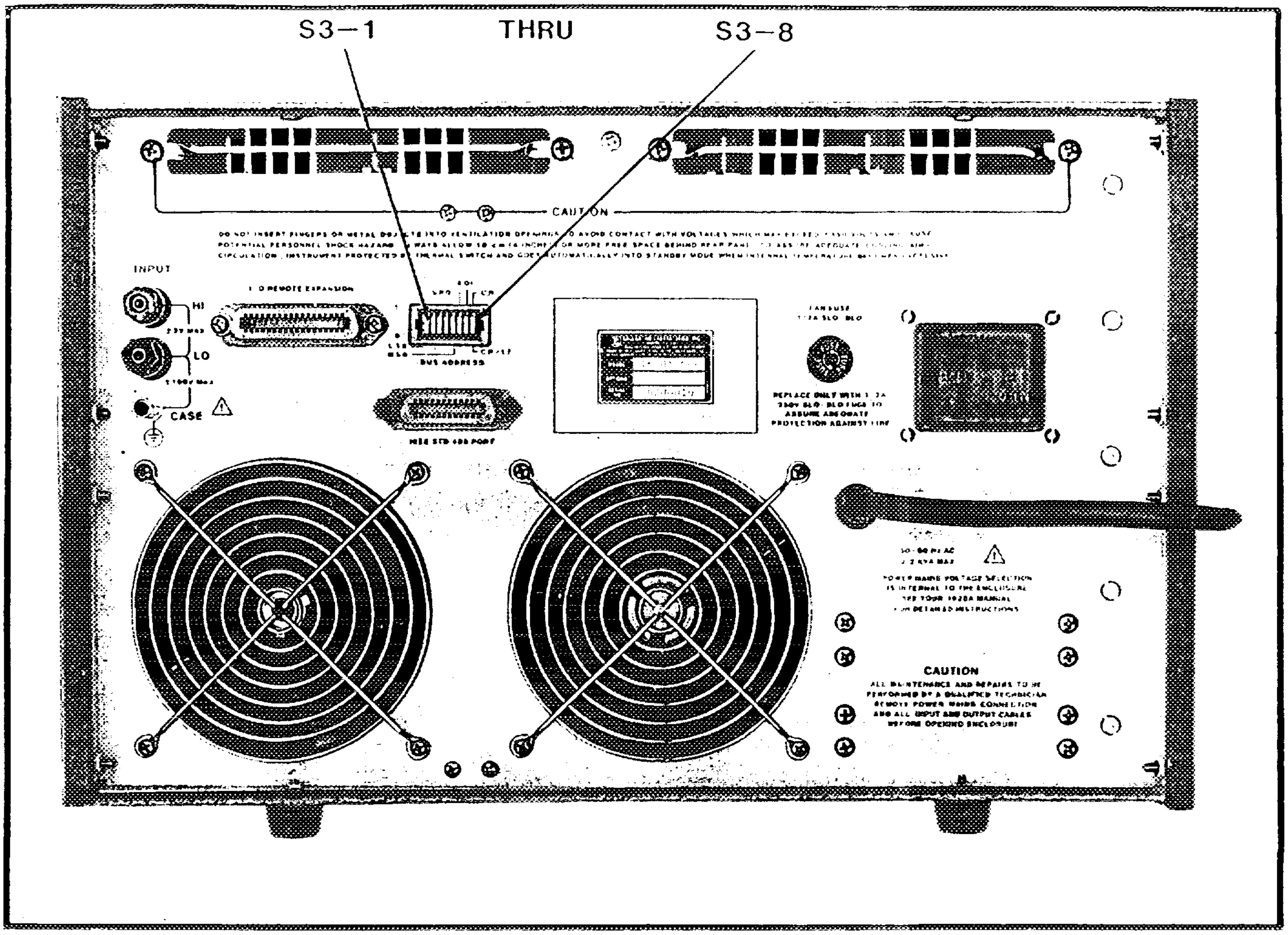


Figure 7-1. Model 1620A60 Rear Panel

7-8. OPERATING NOTES

7-9. Programming Instructions

7-10. Instructions can be either instrument control or output control. In addition, a status response may be obtained. An explanation and breakdown of these instructions and their respective codes are given in the following sub-paragraphs. All the codes with a brief explanation of each are listed in Table 7-2. Positive true logic is assumed in all the text. 1 = Positive.

7-11. Instrument Control

7-12. These instructions are used to control the internal operation of the instrument. They perform such housekeeping tasks as clear and reset. The first instruction of any message must be preceded by the listen address assigned the instrument by the system controller. Each of these functions are explained below.

7-13. CLEAR

7-14. The character "CØ" sets the remote expansion output to all Ø's (Low) or "C1" sets the output to all 1's (High).

7-15. RESET

7-16. The character "*" resets the instrument to the initialize state, which is:

1. 100uA selected
2. Front selected
3. Standby
4. Remote
5. Outputs set Low

TABLE 7-2.

1620A BUS STRUCTURE & CODE SET

CODE	VARIABLE CONTROLS	
R5	1620A RANGE	100A/20A
R4		2A
R3		200mA
R2		20mA
R1		2mA
RØ		200uA
SØ	State	STANDBY
S1		OPERATE
IØ	Input	FRONT
I1		REAR
CØ	Clear Control Pins to Ø's	
C1	Clear Control Pins to 1's	
Q	Query For Status (1620A - Sets)	
*	Reset to Wakeup State	
0 X X X X X	Remote Output (Rear Panel)	

Digit		LSB		MSB
5th X	Pin	23	&	5
4th X	Pin	4	&	22
3rd X	Pin	3	&	21
2nd X	Pin	2	&	20
1st X	Pin	1	&	19

X = 0 thru 3
for binary control of pin set

7-17. LOCAL LOCKOUT

7-18. When the command string LLO is sent across the bus to the 1620A, all front panel switches are disabled with the exception of the STANDBY switch. Depressing the LOCAL switch will not initiate LOCAL control. This function may be cancelled by sending the command string GTL.

7-19. Output Control

7-20. These instructions program and control the output of the instrument. They select the output current range magnitude and select the operating mode and conditions.

7-21. OUTPUT CURRENT

7-22. The output current range magnitude is programmed by entering the numerics for the value of magnitude desired. Examples of current range instructions are given in Table 7-3.

TABLE 7-3.

CURRENT RANGE INSTRUCTIONS

INSTRUCTION	REQUIREMENT
R4S1IØ	Selects 2A RANGE, OPERATE State and FRONT INPUT
R2I1	Selects 20mA RANGE and REAR INPUT

7-23. OPERATING MODE

7-24. The instrument is placed in OPERATE by programming the character "S1" and returned to STANDBY with the character "SØ".

7-25. Status Response

7-26. The message returned for a status response varies with the last interrogation. A special case occurs when a Q has been sent to the 1620A and the interface addressed as a talker. Then a twelve character ASCII string is returned. As an example:

Status Response After Q Has Been Sent:

RXSXIXOXXXXX

X is a number code as specified in Table 7-2 representing the current status of the Model 1620A.

In all other cases, when the interface is addressed as a talker, a six character string, as shown in Table 7-4, is returned. The data contained in the last four characters presents an octal code representing three data bits per character.

TABLE 7-4.

STATUS MESSAGE, SIX CHARACTER STRING

VALUE	CHARACTER 1 STANDBY	CHARACTER 1 FRONT	CHARACTER 1 LOCAL
0	YES	YES	YES
1	YES	YES	NO
2	YES	NO	YES
3	YES	NO	NO
4	NO	YES	YES
5	NO	YES	NO
6	NO	NO	YES
7	NO	NO	NO

VALUE	CHARACTER 2 OVERLOAD	CHARACTER 2 OVERCOMPLIANCE
0	NO	NO
1	YES	NO
2	NO	YES
3	YES	YES

CHARACTER	DATA BIT	I/O PIN NO.
3	DB-1	13
	DB-2	31
	DB-3	14
4	DB-4	32
	DB-5	15
	DB-6	33
5	DB-7	16
	DB-8	34
	DB-9	17
6	DB-10	35
	DB-11	18
	DB-12	36

OCTAL CODES

VALUE	BIT STATUS
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

7-27. SERIAL POLL RESPONSE

7-28. On a serial poll, the unit returns the following status as a response.

SERIAL POLL STATUS BYTE

BINARY VALUE OF FIRST FOUR BITS (BIT 3 2 1 0)	ERROR #	EXPLANATION
0 0 0 0	0	No Error
0 0 0 1	1	Overvoltage Error
0 0 1 0	2	Overcompliance Error
0 0 1 1	3	Overvoltage & Overcompliance Error
0 1 0 0	4	Range Bits Stuck (2 or more Range Bits)
0 1 0 1	5	No Range Indication from Hardware
0 1 1 0	6	Bad Command in IEEE Buffer
0 1 1 1	7	IEEE Buffer Overflow
1 0 0 0	8	Improper Terminator for Bus Transfer
1 0 0 1	9	Remote Cannot Control Operate

BIT	FUNCTION PRESENT WHEN HIGH	FUNCTION PRESENT WHEN LOW
4	LOCAL	REMOTE
5	REAR/INPUT	FRONT/INPUT
6	SRQ	NO SRQ
7	OPERATE	STANDBY

7-29. PIN ASSIGNMENT FOR I/O REMOTE EXPANSION

I/O REMOTE EXPANSION PIN NO.	FUNCTION	DESCRIPTION
1 19	Character 1 LSB MSB	Remote Data Output
2 20	Character 2 LSB MSB	
3 21	Character 3 LSB MSB	
4 22	Character 4 LSB MSB	
23 5	Character 5 LSB MSB	
6 24	OPERATE/STANDBY LOCAL/REMOTE	Status
13 33 14	LSB Character 3 MSB	
32 15 33	LSB Character 4 MSB	Remote Data Input
16 36 17	LSB Character 5 MSB	
35 18 36	LSB Character 6 MSB	
7, 25 - 39	+5V	Maximum 50mA
8 - 12, 30	Gnd	Logic Ground

7-30. THEORY OF OPERATION

7-31. The theory of operation for the IEEE-488 Interface is given in the following paragraphs on a block diagram level. The description includes an explanation of the operation of the interface in both the listen and talk modes since the 1620A is capable of both listening (accepting commands to change current status) and talking (transmitting status information) to the bus. The calibrator is assigned, through the interface, a five bit address, which is the five low order bits of an ASCII character. The two high order bits determine whether it is to be a talk to or listen address. Refer to Table 7-4 for the addresses available. The block diagram of the interface used in the discussion is found in Figure 7-2.

7-32. Listen Mode

7-33. To operate in the Listen Mode, the pre-selected address must be on the Data Lines and the REN and ATN command lines active. This action, followed by active DAV and RFD signals, sets control flip-flops in the Data Decoders and Control Storage, preparing the interface microprocessor to accept instructions from the controller. After the data has been accepted, the DAC lines becomes active, inactivating ATN and DAV. The last action results in the DAC signal returning to inactive so that the interface is now ready to accept instruction.

7-34. Starting an instruction requires the ASCII code for the desired instruction on the data lines with ATN inactive and RFD active. The Controller drives DAV active to start the Handshake sequence. Once the data has been accepted in the microprocessor, the DAC signal goes active to complete the Handshake sequence. The microprocessor acts on the instruction, transforms it into the digital format required and outputs the instruction to the counter, passing through the digital-to-analog converter or stored pending a complete instruction, if required.

7-35. Talk Mode

7-36. The Talk Mode requires the ATN signal active and the correct address, just as the Listen Mode, to differentiate between it and an instruction. The start of the Handshake sequence latches the command into the Data Decoders and Control Storage for transfer to the microprocessor. Once the Handshake sequence is complete, the interface is in the Talk mode and can begin transmitting data to the Controller.

7-37. After the addressing has been completed, the microprocessor accepts the data on the lines from the counter and outputs it through Data Storage to the Data I/F Transceivers and Controller. After completion, dependent upon the mode selected, it will transmit either a single character or double character message, as determined by the serial poll status.

7-38. MAINTENANCE

7-39. Refer to the General Maintenance portion of Section 5 and the Installation portion of the procedure for instructions of removing and cleaning the pcb.

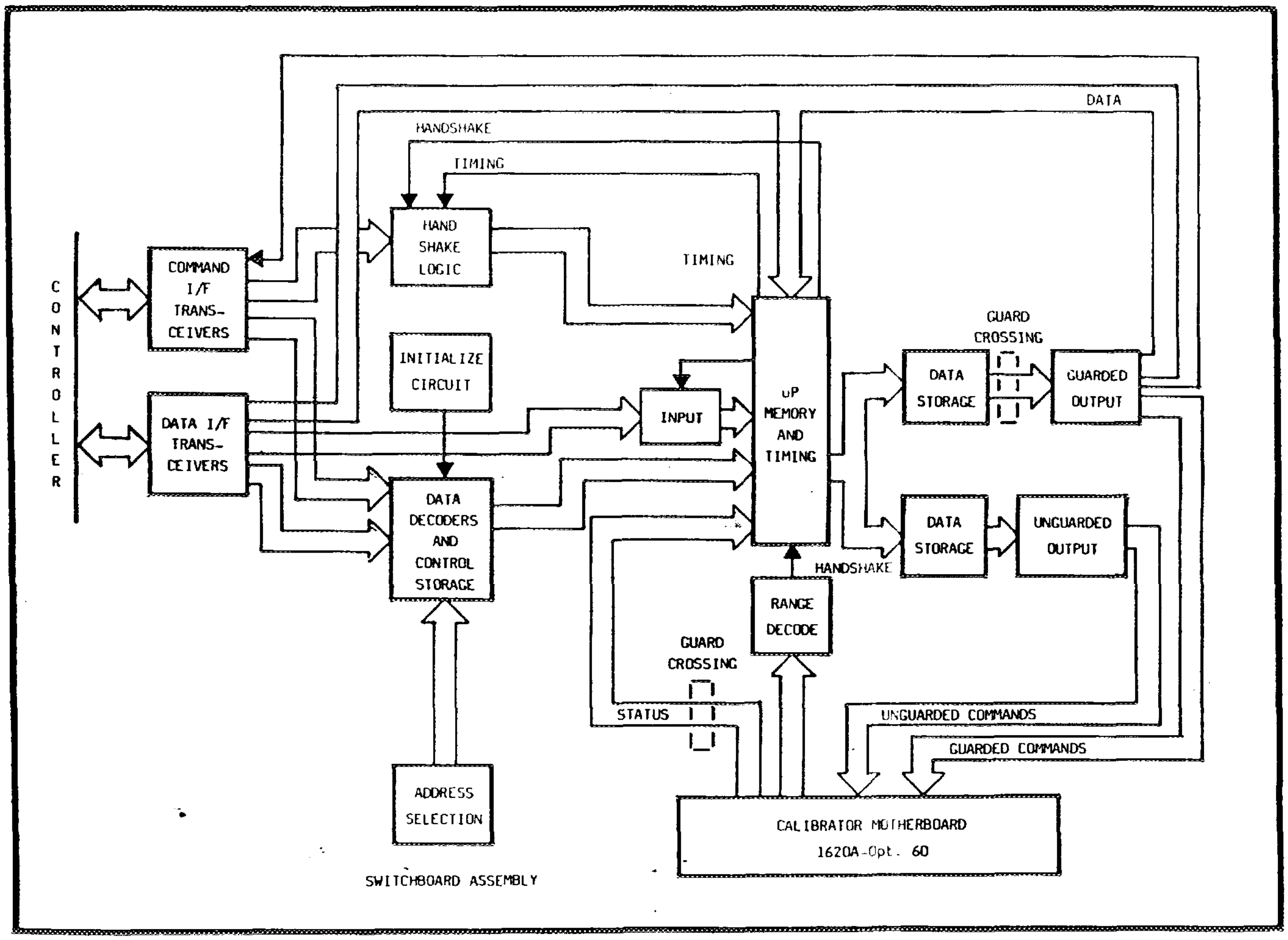


Figure 7-2. Model 1620A60 Block Diagram

PARTS LIST, MODEL 1620A60 FINAL ASSY (89-11273-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
J...2	88-10125-1B	CAA 7" 50 CONDUCTOR RIBBON CBL	050423	BLI
P...1	88-10124-1A	CAA 23" IEEE 26 RIBBON	050423	BLI
P.305	88-10126-1A	CBL 1620A 40 COND I/O EXPAN.	050423	BLI
S...3	88-10127-1B	1620A ADDRESS SW 23"	050423	BLI

PARTS LIST, MODEL 1620A60 IEEE-488 MICROPROCESSOR ASSY (89-11213-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C...1	07-20004-0A	CCD 27.0PF 500.0 VK +-10%	071590	CTL DD-270
C...2	07-20004-0A	CCD 27.0PF 500.0 VK +-10%	071590	CTL DD-270
C...3	07-10083-0A	CET 1.5UF 35.0 V	056289	SPRAGUE 196D155X0035JA1
C...4	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C...5	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C...6	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C...7	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C...8	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C...9	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C..10	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104MAA
C..18	07-02592-0A	CCD 1.0NF 1.0KVK+-10%	084171	ARCO TYPE CCD-102
C..19	07-20072-0A	CCD 470.0PF 10%	091418	JF470-10
CR..1	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI D035 1N4148
CR..2	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI D035 1N4148
J...1	31-10198-0A	CON 26 PCB TAIL HEADER STCON	015912	ANSLEY 609-2627
J...2	31-10187-0A	CON 50 PIN	015912	ANSLEY 609-5027
R...1	12-08024-0A	RFC 3.3 K 250.0MW J+- 5%	001121	A-B TYP CB
R...2	12-08024-0A	RFC 3.3 K 250.0MW J+- 5%	001121	A-B TYP CB
R...3	12-12452-0A	RFF 34.8 K 250.0MW F+- 1%	016299	CGW RN55D 3482 F
R...4	12-12300-0A	RFF 1.0 K 250 MW F+- 1%	016299	CGW RN55D 1001 F
R...5	12-12452-0A	RFF 34.8 K 250.0MW F+- 1%	016299	CGW RN55D 3482 F
R...6	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
RN..1	13-10102-0A	RNF 4.7K 10 PIN SIP, 9 RES	080053	BECKMAN 785-1-R4.7K
RN..2	13-10120-0A	RNF 3.3K/6.8K SIP 8 PIN 12R	001121	ALLEN BRADLEY 408E-302-622
U...1	24-10262-0A	ICP MC6802P 8 BIT MICRO	004713	MOT MC6802P
U...2	24-10314-0A	ICP MC9602 RE-TRIG ONE SHOT	004713	FAIRCHILD 9602 PC
U...4	24-10142-0A	ICP 74LS04 HEX INV 14 DIP	001295	TI N74LS04N
U...5	24-10267-0A	ICP MC3448AP QUAD BUS TRASIV	004713	MOT MC3448AP OR EQUAL
U...6	24-10267-0A	ICP MC3448AP QUAD BUS TRASIV	004713	MOT MC3448AP OR EQUAL
U...7	24-10267-0A	ICP MC3448AP QUAD BUS TRASIV	004713	MOT MC3448AP OR EQUAL
U...8	24-10267-0A	ICP MC3448AP QUAD BUS TRASIV	004713	MOT MC3448AP OR EQUAL
U...9	24-10234-0A	ICP 81LS97 OCTAL DRIVER	012040	NATL SEMI DM81LS97AN
U..10	24-10264-0A	ICP MC68488P GPI ADAPTER	004713	MOT MC68488P OR EQUAL
U..11	24-10287-0A	ICP 74154N DECODER/DEMULTPLX	027014	NATIONAL 74154
U..13	24-10291-0A	ICP MC14503BCP	004713	MOT MC14503BCP
U..14	24-10291-0A	ICP MC14503BCP	004713	MOT MC14503BCP
U..15	24-10291-0A	ICP MC14503BCP	004713	MOT MC14503BCP
U..16	24-10291-0A	ICP MC14503BCP	004713	MOT MC14503BCP
U..17	24-10288-0A	ICP 93L08PC DUAL 4BIT LATCH	007263	FAIRCHILD 93L08PC
U..18	24-10288-0A	ICP 93L08PC DUAL 4BIT LATCH	007263	FAIRCHILD 93L08PC
Y...1	04-10021-0A	CRS 4 MHZ .01% H3W	011237	CTS MPO 40

PARTS LIST, MODEL 1620A60 IEEE-488 MICROPROCESSOR WITH SOCKET ASSY (89-11338-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
U...3	48-10007-0A	SOC 16 PIN SOLDER TAIL	001295	TI C841602

P305 PIN #	I/O EXPANSION PIN #	P305 PIN #	I/O EXPANSION PIN #
1	1	21	19
2	2	22	20
3	3	23	21
4	4	24	22
5	5	25	23
6	6	26	24
7	7	27	25
8	8	28	26
9	9	29	27
10	10	30	28
11	11	31	29
12	12	32	30
13	13	33	31
14	14	34	32
15	15	35	33
16	16	36	34
17	17	37	35
18	18	38	36
19	NOT USED	39	NOT USED
20	NOT USED	40	NOT USED

Figure 7-3. Model 1620A60 I/O Expansion Cable, Schematic Diagram

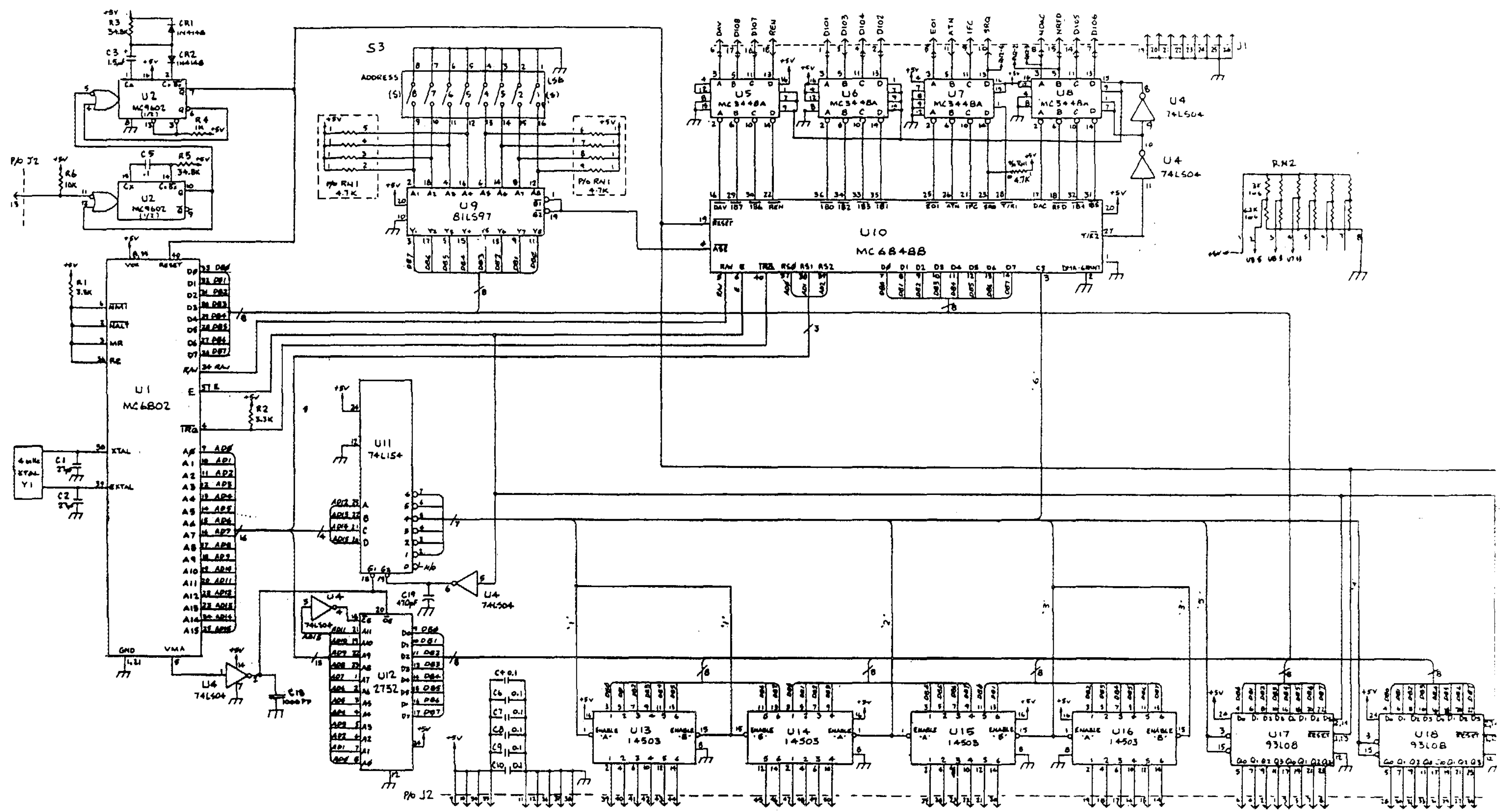


Figure 7-4. Model 1620A60, Schematic Diagram

PARTS LIST, MODEL 1620A
MAIN PC BOARD ASSEMBLY (89-11251-1) - CONT'D

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
Q...3	10-07473-0A	TRQ 2N3906 PNP 1 40 PTO-92	004713	MOT 1 200M 60
Q...4	10-10087-0A	TRQ 2N5193 PNP 1 40 P77-03	004713	MOT 40 2M 10
Q...5	10-10099-0A	TRQ E507	017856	SILICONIX
Q...6	10-10099-0A	TRQ E507	017856	SILICONIX
R...1	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R...2	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R...3	12-12367-0A	RFF 4.99K 250 MW F+-1%	016299	CGW RN55D 4991 F
R...4	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R...5	12-12344-0A	RFF 2.87K 205.0MW F+- 1%	016299	CGW RN55D 2871 F
R...6	12-12600-0A	RFF 1.00M 500 MW F+-1%	016299	CGW RN60D 1004 F
R...7	12-12600-0A	RFF 1.00M 500 MW F+-1%	016299	CGW RN60D 1004 F
R...8	12-13321-0A	RFP 65.0 K .75W 0.1% 1PPM	018612	VISHAY S105 65K 0.1%
R...9	12-13320-0A	RFP 35.0 K .5W 0.1% 1PPM	018612	VISHAY S104 35K 0.1%
R..10	09-10214-0A	RVF 500.0 500.0MW K 18 TURN	073138	HELIPOT 68W R500 VERT. ADJ.
R..11	12-12440-0A	RFF 26.1 K 250.0MW F+- 1%	016299	CGW RN55D 2612 F
R..12	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..14	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..15	12-13322-0A	RFF 4.22K 250.0MW +- 1%	016299	CGW RN55E 4221 F
R..18	09-10278-0A	RVF 2.0 K 500. MW 18T VERT	073138	HELIPOT 68WR2K OR EQUIV.
R..19	12-01087-0A	RFC 22.0 M 500.0MW J+- 5%	001121	A-B TYP EB
R..20	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R..21	12-12464-0A	RFF 46.4 K 250.0MW F+- 1%	016299	CGW RN55D 4642 F
R..22	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R..23	12-12344-0A	RFF 2.87K 205.0MW F+- 1%	016299	CGW RN55D 2871 F
R..24	12-12635-0A	RFP 100.0 K 200.0MW +_.25%	018612	VISHAY S102C 100K .25%
R..25	12-08020-0A	RFC 10.0 M 250.0MW J+- 5%	001121	A-B TYP CB
R..26	09-10216-0A	RVW 10.0 K 1.8 W J 10 TURN	080294	BOURNS 83C1D-E16-J15
R..27	12-08020-0A	RFC 10.0 M 250.0MW J+- 5%	001121	A-B TYP CB
R..28	12-08029-0A	RFC 1.0 M 250.0MW J+- 5%	001121	A-B TYP CB
R..29	12-12500-0A	RFF 100.0 K 250.0MW F+- 1%	016299	CGW RN55D 1003 F
R..30	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..31	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..32	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..33	12-13319-0A	RFP 3.0 K .3W 0.1% 1PPM	018612	VISHAY S102 3K 0.1%
R..34	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..35	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..36	12-12348-0A	RFF 3.16K 250.0MW F+- 1%	016299	CGW RN55D 3161 F
R..37	12-12348-0A	RFF 3.16K 250.0MW F+- 1%	016299	CGW RN55D 3161 F
R..38	09-10125-0A	RVF 500.0 250.0MW K CER	073138	HELIPOT 72PM FLAT MTG
R..39	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..40	12-12316-0A	RFF 1.47K 250 MW F+-1%	016299	CGW RN55D 1471 F
R..41	12-12316-0A	RFF 1.47K 250 MW F+-1%	016299	CGW RN55D 1471 F
R..42	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..44	12-13323-0A	RFF 46.4 500.0MW +- 1%	016299	CGW RN60D 46R4 F
R..45	12-13323-0A	RFF 46.4 500.0MW +- 1%	016299	CGW RN60D 46R4 F
R..49	12-12312-0A	RFF 1.33K 250 MW F+-1%	016299	CGW RN55D 1331 F
R..50	12-12168-0A	RFF 51.1 250.0MW F+- 1%	016299	RN55D 51R1 F
R..51	09-10256-0A	RVF 50.0 500.0 MWK 18 TURN	073138	HELIPOT 68W R50
R..52	09-10255-0A	RVF 10.0 500. MW K 18 TURN	073138	HELIPOT POT 68W R10
R..53	12-13319-0A	RFP 3.0 K .3W 0.1% 1PPM	018612	VISHAY S102 3K 0.1%
R..54	12-13319-0A	RFP 3.0 K .3W 0.1% 1PPM	018612	VISHAY S102 3K 0.1%
R..55	09-10256-0A	RVF 50.0 500.0 MWK 18 TURN	073138	HELIPOT 68W R50
R..56	12-12164-0A	RFF 46.4 250.0MW F+- 1%	016299	RN55D 46R4 F
R..57	12-12100-0A	RFF 10.0 250.0MW F+- 1%	016299	RN55D 10R0 F
R..58	12-12328-0A	RFF 1.96K 250.0MW F+- 1%	016299	CGW RN55D 1961 F
R..60	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R..61	12-12300-0A	RFF 1.0 K 250 MW F+-1%	016299	CGW RN55D 1001 F
R..62	12-12200-0A	RFF 100.0 250.0MW F+- 1%	016299	CGW RN55D 1000 F
R..63	12-13324-0A	RFC 10.0 1.0 W +- 5%	001121	AB TYPE GB
R..64	12-12720-0A	RFC 1.0 500.0MW J+-5%	001121	TYPE EB
R..65	12-12720-0A	RFC 1.0 500.0MW J+-5%	001121	TYPE EB
R..66	12-12720-0A	RFC 1.0 500.0MW J+-5%	001121	TYPE EB
R..67	12-12720-0A	RFC 1.0 500.0MW J+-5%	001121	TYPE EB
R..73	09-10214-0A	RVF 500.0 500.0MW K 18 TURN	073138	HELIPOT 68W R500 VERT. ADJ.
R.100	12-12256-0A	RFF 383.0 250 MW F+-1%	016299	CGW RN55D 3830 F
R.101	12-12256-0A	RFF 383.0 250 MW F+-1%	016299	CGW RN55D 3830 F
R.102	12-12256-0A	RFF 383.0 250 MW F+-1%	016299	CGW RN55D 3830 F
R.200	12-12344-0A	RFF 2.87K 205.0MW F+- 1%	016299	CGW RN55D 2871 F
RN..1	13-10097-0A	RNF 3028B CURRENT SHUNT	019647	CADDOCK MODEL 1787-312
S...1	25-10200-1L	SWC 9635M RANGE/FUNCTION SWT	050423	BLI
S...2	25-10157-1G	SWC PUSH PUSH 2-POLE	050423	BLI
S...3	25-10157-1G	SWC PUSH PUSH 2-POLE	050423	BLI
S...4	25-10158-1F	SWC RESET SWC.	050423	BLI
U...1	24-10397-0A	ICP 3290E MINIDIP DUAL COMP	086684	RCA CA3290E OR EQUIV.
U...2	24-10376-0A	ICP LM363H-10 INST AMP 30 MHZ	027014	NATIONAL LM363H-10
U...3	24-10397-0A	ICP 3290E MINIDIP DUAL COMP	086684	RCA CA3290E OR EQUIV.
U...4	24-10395-0A	ICP OP27-CZ LODRIFT,NOISE 8M	006665	PRECISION MONO OP27-CZ
U...5	24-10395-0A	ICP OP27-CZ LODRIFT,NOISE 8M	006665	PRECISION MONO OP27-CZ
U.200	24-10153-0A	ICP UA7805 5V REG.	007263	FAIRCHILD UA7805UC
U.201	24-10152-0A	CIP UA7815 15V REG.	007263	FCH UA7815UC
U.202	24-10228-0A	ICP 7915 15V NEG REG TO-220	004713	MOT MC7915CP O/E

PARTS LIST, MODEL 1620A
POWER AMPLIFIER ASSEMBLY (89-11250-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C. 400	07-09588-0A	CCD 30 NF 100 V M 20%	084171	ARCO TYPE TCP-R03
C. 401	07-09588-0A	CCD 30 NF 100 V M 20%	084171	ARCO TYPE TCP-R03
C. 402	07-09588-0A	CCD 30 NF 100 V M 20%	084171	ARCO TYPE TCP-R03
C. 403	07-09588-0A	CCD 30 NF 100 V M 20%	084171	ARCO TYPE TCP-R03
CB400	25-10226-0A	SWC 45 DEG C KLIXON THERMO SWT	014604	ELMW 3450-285F113B209T107
CB401	25-10226-0A	SWC 45 DEG C KLIXON THERMO SWT	014604	ELMW 3450-285F113B209T107
CB402	25-10228-0A	SWC OPEN 257F CLOSE 217F+-8	014604	ELMW 3450-285-B209T107 SI
CB403	25-10228-0A	SWC OPEN 257F CLOSE 217F+-8	014604	ELMW 3450-285-B209T107 SI
Q. 400	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 401	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 402	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 403	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 404	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 405	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 406	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 407	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 408	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 409	10-10197-0A	TRQ 2N5685 NPN 60V 50A 300W	004713	MOT OR EQUIV 2N5685
Q. 410	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 411	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 412	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 413	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 414	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 415	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 416	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 417	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 418	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
Q. 419	10-10196-0A	TRQ 2N5683 PNP 60V 50A 300W	004713	MOT OR EQUIV 2N5683
R. 400	12-01276-0A	RFC 5.6 1.0 W J+- 5%	001121	A-B TYP GB
R. 401	12-01276-0A	RFC 5.6 1.0 W J+- 5%	001121	A-B TYP GB
R. 402	12-01068-0A	RFC 100.0 500.0MW J+- 5%	001121	A-B TYP EB
R. 403	12-01068-0A	RFC 100.0 500.0MW J+- 5%	001121	A-B TYP EB
R. 404	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 405	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 406	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 407	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 408	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 409	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 410	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 411	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 412	12-01276-0A	RFC 5.6 1.0 W J+- 5%	001121	A-B TYP GB
R. 413	12-01276-0A	RFC 5.6 1.0 W J+- 5%	001121	A-B TYP GB
R. 414	12-01068-0A	RFC 100.0 500.0MW J+- 5%	001121	A-B TYP EB
R. 415	12-01068-0A	RFC 100.0 500.0MW J+- 5%	001121	A-B TYP EB
R. 416	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 417	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 418	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 419	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 420	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 421	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 422	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%
R. 423	12-13354-0A	RFW 0.05 OHM 25W +-3%	091637	DALE RH25 0.05 OHM 3%

PARTS LIST, MODEL 1620A
POWER AMPLIFIER INTERCONNECT CABLE ASSEMBLY (89-10118-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
J. 400	31-10342-0A	PLG 8PIN 22GA 1" IN LINE	000779	AMP 640440-8

PARTS LIST, MODEL 1620A
100A PROTECTION BOARD ASSEMBLY (89-11309-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C...1	07-09581-0A	CET 2.2UF 35 V K 10%	031433	KEM TYP T310B225K035AS
C...2	07-09581-0A	CET 2.2UF 35 V K 10%	031433	KEM TYP T310B225K035AS
J...1	31-10258-0A	CON MTA-100 POST 10 PIN	000779	AMP MTA-100 640098-0

SECTION 8

BACKDATING INFORMATION

Applicable to Units With

Serial No. Prefix 020– and Below

PARTS LIST, MODEL 1620A
MAIN PC BOARD ASSEMBLY (89-11251-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR CODE	MFR. PART NUMBER
C...1	07-10358-0A	CBM 1.0UF 100.0 VK MET POL	080031	MEPCO 719B1GG105PK101SB
C...2	07-25003-0A	CYM 1.0UF 160.0VK+-10%	073445	C296AB/AIM
C...3	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C...4	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C...5	07-10084-0A	CCD 15.0PF 500 V	090201	MALLORY CPC150J
C...6	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C...7	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C...8	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C...9	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C..10	07-10455-0A	CVC2-22.0PF 300.0 V	080031	MEPCO 2807C00222MJ02F
C..11	07-10182-0A	CCD 100.0PF 1.0KVK	033883	RMC JL-100 TEMP STABLE
C..12	07-10418-0A	CMD 750.0PF300.0 VJ	053201	SANGAMO CM05E0751J03, EQ
C..13	07-10489-0A	CMD 62.0PF 300.0 VJ	084171	ARCO TYPE DM-15-BC62JN1
C..14	07-10455-0A	CVC2-22.0PF 300.0 V	080031	MEPCO 2807C00222MJ02F
C..16	07-10418-0A	CMD 750.0PF300.0 VJ	053201	SANGAMO CM05E0751J03, EQ
C..17	07-10418-0A	CMD 750.0PF300.0 VJ	053201	SANGAMO CM05E0751J03, EQ
C..18	07-10054-0A	CYF 33.0NF 250.0V M	034553	AMPEREX C280MAE/A33K
C.200	07-10425-0A	CEA4700.0UF 16.0 V -10+50%	052763	ST.TR. EG 4T/16
C.201	07-10591-0A	CCR 680 NF 50V X 7R	031433	KEMET C330C684K5R5CA
C.202	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C.203	07-10588-0A	CEA 100 UF 35V CRE SERIES	062462	CAPAR CRE-E 100 UF 35V
C.204	07-10485-0A	CEA1000.0UF 35.0 V	062462	CAPAR CRE 1000UF/35V
C.205	07-10485-0A	CEA1000.0UF 35.0 V	062462	CAPAR CRE 1000UF/35V
C.206	07-10591-0A	CCR 680 NF 50V X 7R	031433	KEMET C330C684K5R5CA
C.207	07-10083-0A	CET 1.5UF 35.0 V	056289	SPRAGUE 196D155X0035JA1
C.208	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C.209	07-10562-0A	CCR 0.1 UF 50V .3 SPACE	004222	AVX CERAMICS MD015E104ZAA
C.210	07-10588-0A	CEA 100 UF 35V CRE SERIES	062462	CAPAR CRE-E 100 UF 35V
C.211	07-10588-0A	CEA 100 UF 35V CRE SERIES	062462	CAPAR CRE-E 100 UF 35V
CR..1	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..2	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..3	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..4	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..5	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..6	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR..7	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.11	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.12	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.13	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.14	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.15	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.16	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.17	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.18	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR.19	05-07920-0A	DGP 1N4148 75 10M	007263	FCH SI DO35
CR200	05-10006-0A	DGP W04M 4000 1.5A	005828	GIC
CR201	05-10006-0A	DGP W04M 4000 1.5A	005828	GIC
CR202	05-10006-0A	DGP W04M 4000 1.5A	005828	GIC
CR203	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
CR204	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
CR205	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
CR206	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
CR207	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
CR208	05-09472-0A	DGP 1N4002 100 1A	004713	CSD1 05-09472-0A MOT SI DO41
DS..1	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..10	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..2	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..3	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..4	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..5	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..6	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..7	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..8	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS..9	16-10033-0A	LMP LED YELLOW WIDE ANGLE	000000	HP 5082-4555
DS100	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS101	16-10028-0A	LMP LED RED WIDE ANGLE	028480	HP 5082-4655
DS200	05-10060-0A	GREEN LED	028480	HP HLMP 3502
J.200	31-10256-0A	CON MTA-100 POST 7 PIN	000779	AMP 640098-7
J.400	31-10341-0A	CON MTA-100 POST 8 PIN	000779	AMP 640098-8
K...1	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...2	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...3	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...4	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...5	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...6	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...7	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...8	14-10034-0A	RLY 2A2B 5V COIL	061529	AROMAT S2E-5V
K...9	14-10020-0A	RLY REED FORM C 5V 200OHM DIP	095348	GORDOS 831C-1S
LA..1	14-10037-0A	REG SURGE SUPR 250V +-20%	071482	C.P CLARE CG2-250L 20%
Q...1	10-10043-0A	TRQ 2N3904 NPN 1 40 PTO-92	004713	MOT 1 300M 40
Q...2	10-10004-0A	TRQ MJE520 NPN 1 30 P77-03	004713	MOT 25 25

PARTS LIST, MODEL 1620A
100A PROTECTION BOARD ASSEMBLY (89-11309-1) - CONT'D

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
Q...1	10-10043-0A	TRQ 2N3904 NPN 1 40 PTO-92	004713	MOT 1 300M 40
Q...2	10-09473-0A	TRQ 2N3906 PNP 1 40 PTO-92	004713	MOT 1 200M 60
R...1	12-12316-0A	RFF 1.47K 250 MW F+-1%	016299	CGW RN55D 1471 F
R...2	12-12364-0A	RFF 4.64K 250.0MW F+- 1%	016299	CGW RN55D 4641 F
R...3	12-12364-0A	RFF 4.64K 250.0MW F+- 1%	016299	CGW RN55D 4641 F
R...4	12-12350-0A	RFF 3.32K 250.0MW F+- 1%	016299	CGW RN55D 3321 F
R...5	12-12204-0A	RFF 110.0 250.0MW F+- 1%	016299	CGW RN55D 1100 F
R...6	12-12404-0A	RFF 11.0 K 250.0MW F+- 1%	016299	CGW RN55D 1102 F
R...7	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
R...8	12-12404-0A	RFF 11.0 K 250.0MW F+- 1%	016299	CGW RN55D 1102 F
R...9	12-12400-0A	RFF 10.0 K 250.0MW F+- 1%	016299	CGW RN55D 1002 F
U...1	24-10088-0A	ICP 4N32 OPTICAL ISCLATOR	026483	MONSANTO 6 PIN DIP
U...2	24-10431-0A	ICP .5% RMS-TO DC CONVERTER	024355	ANALOG DEVICES AD536AJH
U...3	24-10397-0A	ICP 3290E MINIDIP DUAL COMP	086684	RCA CA3290E OR EQUIV.
U...4	24-10254-0A	ICP MC14011 QUAD NAND	004713	MOT 14 PIN DIP
U...5	24-10392-0A	ICP AD636JH RMS-DC CONV.	024355	ANALOG DEVICES

PARTS LIST, MODEL 1620A
FRONT PANEL ASSEMBLY (89-11249-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
CB300	25-10227-0A	SWC 20A CKT BREAK. SPST SWT	074193	HEINEMANN JA1-A3-A-20-2
J...3	31-10057-0A	BPS INS. NYL. 2KV RED	083330	H.H. SMITH 257-102
J...4	31-10058-0A	BPS INS. NYL 2KV BLACK	083330	H.H. SMITH 257-103
J...5	31-03962-0A	BPS BINDING	083330	H.H. SMITH #208
J...6	31-10057-0A	BPS INS. NYL. 2KV RED	083330	H.H. SMITH 257-102
J...7	31-10057-0A	BPS INS. NYL. 2KV RED	083330	H.H. SMITH 257-102
J...8	31-10332-0A	BPS INS. NYL 2KV WHITE	083330	H.H. SMITH 257-101
J...9	31-10334-0A	CON WHITE 100A SOCKET RECEPT	058474	SUPERIOR ELEC R5100GWT
J..10	31-10333-1A	CON RED 100A SOCKET RECEPT.	050423	BLI

PARTS LIST, MODEL 1620A
REAR PANEL ASSEMBLY (89-11248-1)

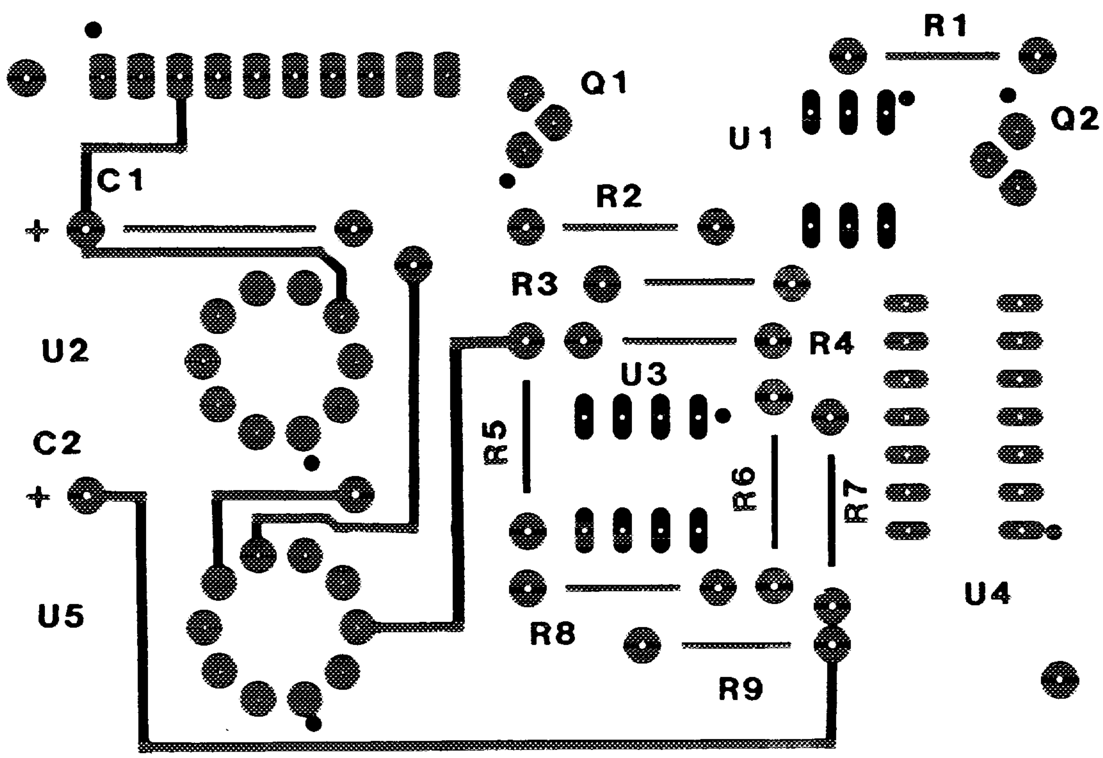
SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C.300	07-02543-0A	CCD 1.5NF 3 KV M -20+80%	072982	ERIE 878 H1-K DISC Y5V
				SPRAGUE #30GAD15
C.301	07-02543-0A	CCD 1.5NF 3 KV M -20+80%	072982	ERIE 878 H1-K DISC Y5V
				SPRAGUE #30GAD15
F.300	19-03411-0A	FUS .5AMP SLOBLOW TYPE 3AG	075915	LITTELFUSE 313.500
J.302	31-10057-0A	BPS INS. NYL. 2KV RED	083330	H.H. SMITH 257-102
J.303	31-10058-0A	BPS INS. NYL 2KV BLACK	083330	H.H. SMITH 257-103
J.304	31-03962-0A	BPS BINDING	083330	H.H. SMITH #208
RV300	14-10000-0A	REG LINE SURGE SUPPRESSOR	024446	GE V150LA10A
RV301	14-10000-0A	REG LINE SURGE SUPPRESSOR	024446	GE V150LA10A
T...1	20-10028-1N	TRX 3620A REPL IEC +-L5V/5V	050423	BLI

PARTS LIST, MODEL 1620A
POWER TRANSFORMER INTERCONNECT CABLE ASSEMBLY (89-10117-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
J.200	31-10248-0A	PLG 7PIN 24GA .1" IN LINE	000779	AMP MTA-100 640441-7

PARTS LIST, MODEL 1620A
FRAME ASSEMBLY (89-11252-1)

SCHEMATIC REF.	BALLANTINE PART NO.	DESCRIPTION	MFR. CODE	MFR. PART NUMBER
C. 302	07-08134-0A	CYM 1.0UF 50 V M 20%	084411	TRW TYPE X663F
C. 303	07-08134-0A	CYM 1.0UF 50 V M 20%	084411	TRW TYPE X663F
C. 304	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 305	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 306	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 307	07-10326-0A	CMD 470.0NF 80.0VK 10%	056289	CDE WMF1P47
C. 309	07-10326-0A	CMD 470.0NF 80.0VK 10%	056289	CDE WMF1P47
C. 310	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 311	07-10592-1A	CEA 110KUF 25V	050423	BLI
C. 312	07-10592-1A	CEA 110KUF 25V	050423	BLI
CR300	05-10166-0A	DGP IN3288A 100A 100V REV	081483	IRC IN3288A DO-8 CASE
CR301	05-10167-0A	DGP IN3288RA 100A, 100V REV	081483	IRC IN3288RA DO-8 CASE
CR302	05-10166-0A	DGP IN3288A 100A 100V REV	081483	IRC IN3288A DO-8 CASE
CR303	05-10167-0A	DGP IN3288RA 100A, 100V REV	081483	IRC IN3288RA DO-8 CASE
R. 300	12-01272-0A	RFC 1.0 K 1.0 W J+- 5%	001121	AOB TYP GB
R. 301	12-01272-0A	RFC 1.0 K 1.0 W J+- 5%	001121	AOB TYP GB
T. . . 2	20-10076-1N	TRX 1620A POWER	050423	BLI



Model 1620A 100A Overload Protection Board

Ballantine

ADDENDUM

TO INSTRUCTION MANUAL: **MODEL No.** 1620A

#2 (90-10296-5B)

Page 5-10. AC CALIBRATION 89-11251-1 1620A MAIN BOARD ASSEMBLY

Delete: Paragraph 5-110.

Adjust C10, the 10 kHz adjustment for a reading of 1.90000 +/- 3 digits.

Ballantine

ADDENDUM

TO INSTRUCTION MANUAL: **MODEL No.** 1620A

#1 (90-10296-5B)

Page 6-3. PARTS LIST 89-11251-1 1620A MAIN BOARD ASSEMBLY

Delete: From the parts list

C20	07-10219-0A	CSF 1.0NF	63.0 VJ	026625	MIAL TYPE 611	

ADD:

C15	07-10372-0A	CMD 47.0PF	500.0V	053201	SANGAMO CM05ED 470F03, EQ	

Page 6-4. PARTS LIST 89-11251-1 1620A MAIN BOARD ASSEMBLY

Delete: From the parts list

R60	12-12400-0A	RFF 10.0K	250.00MW	F+- 1%	016299	CGW RN55D 1002 F
R61	12-12300-0A	RFF 1.00K	250.00MW	F+- 1%	016299	CGW RN55D 1001 F
R62	12-12200-0A	RFF 100	250.00MW	F+- 1%	016299	CGW RN55D 1000 F
R63	12-13324-0A	RFF 10.0	1.0 W	+- 5%	001121	AB TYPE GB

ADD:

R60	12-12300-0A	RFF 1.00K	250.00MW	F+- 1%	016299	CGW RN55D 1001 F
R61	12-12200-0A	RFF 100	250.00MW	F+- 1%	016299	CGW RN55D 1000 F
R62	12-12100-0A	RFF 10.0	250.00mW	F+- 1%	016299	CGW RN55D 10R0 F
R63	12-12720-0A	RFF 1.0	500.0MW	J+- 5%	001121	AB TYPE EB

Ballantine

ADDENDUM

TO INSTRUCTION MANUAL:

MODEL No. 1620A

Applies to all units
#2 (90-10296-5B)

Page 5-1.

Paragraph 5-14

Change to read:

Set the 1620A to OPERATE. Adjust the front panel ZERO ADJ screwdriver control for minimum indication on the DC Voltmeter. Set for zero ±200 uV and note the reading.

Paragraph 5-16

Add:

Add the following note.

NOTE

On the 2 Amp, 20 Amp, and 100 Amp ranges a settling time of fifteen minutes must be allowed for shunts to stabilize.

ADDENDUM

TO INSTRUCTION MANUAL: **MODEL No.** 1620A

Applies to all units
#1 (90-10296-5B)

Page 1-1. Paragraph 1-6.

Add: Add the following note:

NOTE

If Option 60 is installed, the 1620A will go to the wake up state for operator safety on power up or after a power interrupt. The 1620 wake up state is: REMOTE operation, 200 u range, STANDBY mode, and FRONT input. In order to select local operation the LOCAL momentary switch must be depressed.

Page 5-1. Paragraph 5-7.

Add: Add the following note:

NOTE

If Option 60 is installed, the 1620A will go to the wake up state for operator safety on power up or after a power interrupt. The 1620 wake up state is: REMOTE operation, 200 u range, STANDBY mode, and FRONT input. In order to select local operation the LOCAL momentary switch must be depressed.

Page 7-1. Paragraph 7-2.

Add: Add the following note:

NOTE

With Option 60 is installed, the 1620A will go to the wake up state for operator safety on power up or after a power interrupt. The 1620 wake up state is: REMOTE operation, 200 u range, STANDBY mode, and FRONT input. In order to select local operation the LOCAL momentary switch must be depressed.