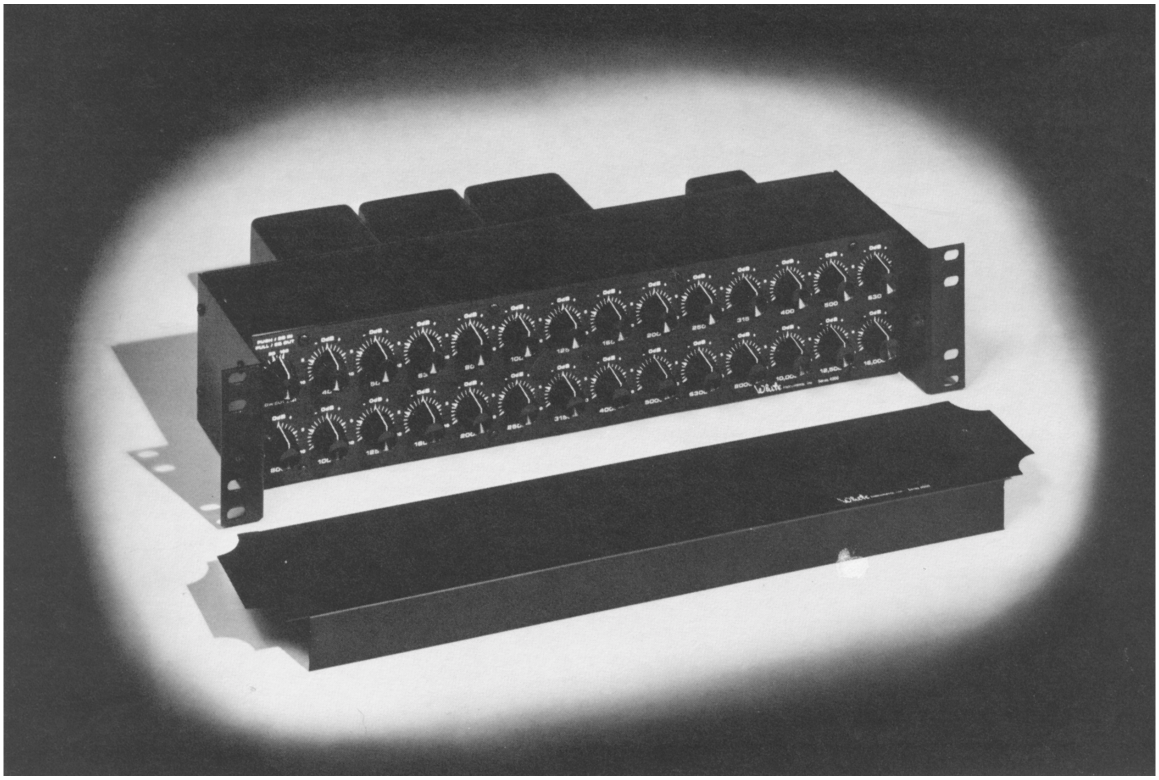
Series 4000

Models 4001, 4002, 4003

This document contains a reconstructed rendering of the original, printed data sheet and Users' Manual.



Series 4000 Active Equalizers

The Series 4000 Active Equalizers have been carefully designed using the latest integrated circuit operational amplifiers. All negative feedback circuitry assures high linearity and stability. An Optimum combination of LC and active circuits provides low noise operation.

FEATURES

27 1/3 octave bands on ISO centers from 40 Hz through 16 kHz.

10 d B boost or cut on continuous control. Equal Q in both boost and cut conditions.

Variable high-pass filter from 20 Hz to 160 Hz with 12 dB/octave roll-off.

Filter Q optimized for best summation with adjacent bands.

Precision inductors with all negative feedback circuitry to insure maximum linearity and stability.

Field replacable integrated circuits.

Noise guaranteed to be -90 dBm or better.

Tuned circuits sealed in magnetically shielded enclosures for low hum pickup.

Shielded power transformer.

Sealed Mil-Spec pots.

EQ IN/EQ OUT switch on front panel.

Dual buffered outputs for bi-amp operation.

Accessory socket to permit insertion of 12 dB/oct. or 18 dB/oct. 1ow 1evel crossover for bi-amp outputs.

MODEL 4001

Transformer coupled input, single-ended outputs.

Rack mounting. 3.5" by 19".

Security cover furnished as standard.

MODEL 4002

Single ended input.

Phono jack type connectors.

Input level control.

Natural wood end pieces.

3.5" x 18".

MODEL 4003

Transformer coupled input.

Transformer coupled outputs for full balanced operation.

Rack mounting. 3.5" by 19".

Security cover furnished as standard.

SPECIFICATIONS

ELECTRICAL

Frequency Range:	20 Hz (-3 dB) to 20 kHz (-2 dB)
Control Centers:	27 bands on ISO 1/3 octave centers from 40 Hz to 16 kHz
Control Range:	-10 to + 10 d B continuously variable and calibrated
Low-Cut Control Range:	12 dB/octave high-pass filter continuously variable from 20 Hz to 160 Hz
Level:	Output of channel 2 variable from unity to zero for the purpose of compensating for the superior efficiency of most horns
Recommended Operating Level:	0 dBm (approximately 0.8 Vrms)
Maximum Output:	18 dBm
Distortion:	Less than 0.2% to + 18 dBm
Noise:	Better than -90 dBm (20kHz bandwidth)
Output Load:	600 ohms or greater
Input Circuit (4001/4003):	Transformer coupled (balanced) 20,000 ohms
(4002):	Single-ended 20,000 ohms
Output Circuit (4001/4002):	Dual buffered single-ended outputs, 0 ohms
(4003):	Transformer coupled (balanced) 300 ohms
Number of Outputs:	Two independent outputs furnished for bi-amp capability with plug-in accessory crossover network
Filter Type:	Active LC negative feedback. Precision inductors in magnetically shielded enclosures
Frequency Tolerance:	±2% of center frequency
Power:	115/230 Vac nominal. 5 watts nominal consumption, fused for 1/2 amp. Front panel pilot lamp.

MECHANICAL

EQ IN/EQ OUT switch:	Push-pull switch on LOW CUT control on

	front panel
EQ BYPASS:	Slide switch on rear panel
Level Control:	On rear panel, unity to zero channel 2 only. Sealed Mil-Spec type potentiometer
Filter Controls:	All on front panel. Sealed Mil-Spec type potentiometers
Terminals (4001/4003):	Eight terminal barrier strip on rear panel
(4002):	One input and two output phono jacks on rear panel
Security Cover:	4001 and 4003 each furnished with matching security cover attached by thumbscrews
Dimensions (400114003):	3.5 inches by 19 inches, rack mounting. 9 inches required behind front panel. Mounting hardware furnished
(4002):	3.5 inches by18.5 inches by 8 inches deep. Rubber feet for table use
Weight:	Approximately11 pounds
Finish:	Black anodized aluminum

4000 Series - Users' Manual

UNPACKING

Your Series 4000 Equalizer has been carefully packaged to avoid damage in shipment. If the unit has been damaged in shipment, SAVE ALL PACKING MATERIALS and file a claim with the shipper.

The Model 4001 package should contain this Instruction Manual, a security cover and a plastic envelope containing eight 10-32 x 1/2" rack mount screws along with the unit.

The Model 4002 package will contain only this Manual in addition to the unit.

OPERATION

Circuit Description

Input

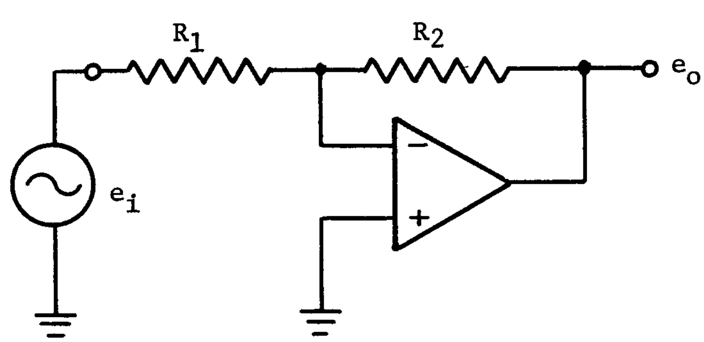
The input impedance of either the Model 4001 or Model 4002 is 20 kilohms. The Model 4001 has a floating input coupled by a 1:1 transformer to the input buffer stage. Either side of the input winding may be grounded or it may be left completely floating if desired. NOTE: It is very important that there be **NO DC** voltage component present on the input line as this will cause the transformer core to saturate and cause distortion.

The Model 4002 has a capacitor coupled input section and is single ended rather than floating. The gain of the input buffer is varied from 0 to unity via the Level control on the rear panel. This is to accommodate signal levels greater than 0.8 Vrms.

Filter Sections

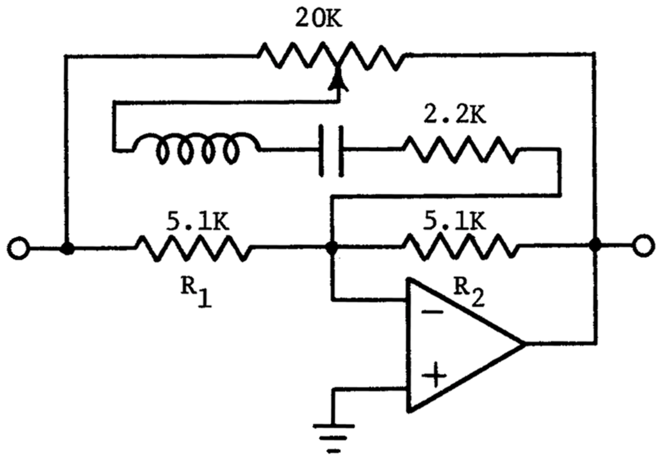
The Series 4000 Active Equalizer incorporates RLC elements for response control in an audio system. It contains 1/3 octave filter sections, continuously adjustable from +10 dB of emphasis to -10 dB of cut, in each 1/3 octave band.

Integrated circuit operational amplifiers are used in a NEGATIVE feedback circuit with very low distortion. The basic circuit follows:

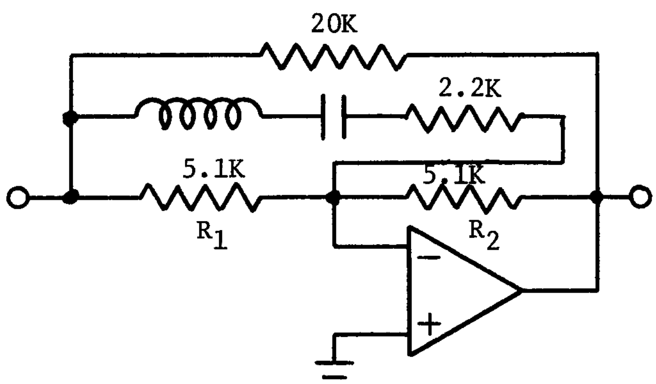


$$\frac{e_o}{e_i} = \frac{R_2}{R_1}$$

The filter sections axe added as shown in the following circuit, with only one section as an example.



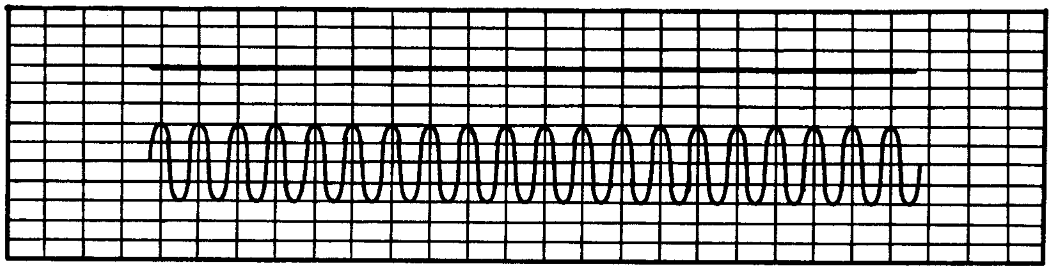
The amplifier summation resistors are equal, and without the filter controls, they give a gain of unity (0 dB). Then if a potentiometer is connected from input to output as shown below, it has no effect on the gain. Next the **RLC** circuit is added. With the pot set at electrical center, the RLC circuit is at a balance position and has no effect on the response. If it is turned all the way to one end, it looks as follows:



At the resonant frequency f_0 of the LC**,** the 2.2k resistance is in parallel with the 5.1k, and the gain ratio R_2/R_1 is about 3/1 or +10 dB. Far away from f_0, the gain returns to unity because L or C is high in impedance and the 2.2k resistance is effectively out of the circuit. Tuning through f gives a band-pass peak in the response that may be adjusted from any value from 10 dB down to flat.

Conversely, if the pot is set at the other end, the gain ratio is inverted and the response is a 10 dB notch.

The 1/3 octave bandwidth is set by the ratio of L/C, and is chosen to give a proper addition of adjacent channel response curves. In effect, the individual filter sections combine to make up a single filter whose electrical response curve is free of unwanted ripple and excessive phase shift. In fact, the Series 4000 can provide extended shelving functions up to +10 dB with <u>no</u> ripple and <u>no</u> phase shift between adjacent center frequencies. The importance of this feature is pointed out in the figure below.



Both curves will measure "flat" on a 1/3 octave analyzer because both have uniform energy in all 1/3 octave bands. But the lower curve (produced by some equalizers) will introduce audible degradation of program material in critical monitoring applications and can trigger acoustic feedback in sound reinforcement installations.

The RLC filters are divided into 3 groups. All filter sections in one group are one octave apart. All in one group are "stacked" on one operational amplifier. The octave separation makes reactive tuning effects small between the stacked sections.

Output Circuits

Both Models 4001 and 4002 have two identical output sections. These output sections are buffered and independent of one another. Access to the output of the filter section and the inputs to the output buffers is gained via the octal socket on the rear of the unit. In this socket various filter functions can be installed which will affect either or both of the outputs. The impedance of each output is virtually zero ohms and is capable of driving signal levels as great as +18 dBm into load impedances of 600 ohms or greater. Model 4003 has floating transformers in each output for complete isolation.

By-Pass Switch

On the rear of both Model 4001 and 4002 is located a By-pass switch for the purpose of switching the unit in or out of the circuit. In the OUT position, IN HI is switched to OUT 1, IN LO is switched to COMNON. OUT 2 is unaffected and the input circuit to the equalizer is left connected. Thus, if it will be necessary to be able to switch the active equalizer out of the circuit at some future date, OUT 1 must be the preferred output.

In-Out Switch

Units with serial numbers greater than 1051 are equipped with an EQ IN-EQ OUT function by a push-pull switch on the LO CUT control knob. This switch bypasses only the 1/3 octave equalizing circuitry and NOT the bi-amp circuitry.

Installation

Mechanical

The Model 4001 fits a standard 3.5" by 19" rack space. A package of eight 10-32 screws is furnished for the purpose of mounting the unit and the security cover in a rack. About eight inches of space is required behind the rack to accommodate the unit, Model 4002 is equipped with rubber feet for use on a table or shelf.

Power

The unit operates from a nominal 117 Vac and is fused for 1/10 amp slow-blow. No power switch is provided and the unit is ready to operate as soon as power is applied. A solid state pilot light is provided in the center of the front panel to indicate when the unit is on.

Connections

Connection is made to the Model 4001 via a barrier type terminal block on the rear of the unit. Model 4002 utilizes standard phono type connectors.

Grounding

In neither unit is the circuit common connected to the chassis. It is up to the user to provide a circuit ground compatible with the rest of his system. Care should be taken to prevent ground loops and excessive hum pickup.

It is recommended that the chassis of the unit be electrically connected to the ground bus common to the other equipment in the system. The circuit common should be connected to either the system ground bus or to the system common bus.

Source and Load Impedances

The Model 4001 can operate from a source impedance of 1000 ohms or less. The Model 4002 can be operated from any source impedance, though impedances approaching 20 kilohms will cause attenuation in signal. Both units have virtually zero output impedance and are capable of driving impedances as low as 600 ohms. Higher load impedances require no accommodation.

Levels

Both the Model 4001 and 4002 have a maximum output level of +18 dBm or 6 Vrms. It is recommended that the units be operated at an average input level of 0 dBm (0.78 Vrms) to allow adequate headroom for variation in program material and boost equalization.

For the Model 4002, it is recommended that the level be set by turning all controls to the 0 dB position (flat) and adjusting the input LEVEL control until the output averages 0 dBm on a suitable voltmeter with typical input signal level. With the Model 4001, it may be necessary to limit the input signal level with gain controls in previous stages of equipment.

Models 4001 and 4003 have an attenuator in the second output for the purpose of setting levels when bi-amping.

Accessory Socket

On the rear of both units is located an accessory socket. Various filter functions may be inserted prior to the output stages. If no accessory filters are plugged in, it is necessary to have jumpers inserted to complete the circuit. Pins 6 and 7 are jumped to pins 2 and 3. These jumpers are normally installed at the factory.

Security Cover

The Model 4001 Active Equalizer comes provided with a security cover and four 10-32 rack screws to hold it in place. The holes in the cover are spaced to utilize the leftover holes in between the normal mounting holes for a 3.5" panel. A center hole is provided for viewing the pilot lamp on the front panel.

EQALIZATION

Program Shaping

The low distortion and low noise of the Series 4000 equalizers make them well-suited for recording and broadcast program equalization. Shelving, peaking, and band-limiting functions all can be performed simultaneously. Also, the relatively narrow bandwidth of individual filter sections makes it possible to "scrub" unwanted hum and noise from tape recordings.

Playback and Monitor Equalization

Series 4000 equalizers can be used in conjunction with established 1/3 octave acoustic measuring techniques and instrumentation, such as the White Instruments Model 140 Sound Analyzer, to improve the performance of almost any program reproducing chain. An explanation of detailed equalization procedures is beyond the scope of this manual; however, the following brief hints may be helpful:

1. Know the characteristics of your measuring microphone. A laboratory-quality, non-directional unit such as the Bruel & Kjaer 4134 is recommended. But all microphones become somewhat directional at high frequencies and it is important to avoid erroneous measurements resulting from microphone characteristics.
2. Average two or three sets of readings for each listening location. Using a single fixed microphone location can introduce errors of several decibels in comparison with the average response in an imaginary two-foot diameter sphere occupying the same position as a listener's head.
3. Don't equalize for flat high frequency response. Depending on listener preference and the particular loudspeaker system used, acoustic response of recording studio monitors is usually rolled off above 5 kHz or so. Home high fidelity systems usually require greater rolloff, typically starting around 2.5 kHz.

4. Be careful not to exceed the limitations of loudspeakers and power amplifiers when equalizing low frequency performance. Small listening rooms inevitably introduce large peaks and dips at low frequencies; trying to electrically compensate for a 15 dB hole in measured response can overload both amplifier and speaker with little benefit in audible performance.

5. Don't try to "fill in" isolated 1/3 octave dips. A relatively narrow response hole cannot be heard on most types of program material. Trying to flatten it may result in introducing a peak in overall response too narrow to show up in 1/3 octave analysis, but clearly audible when listening to the system.

   NOTE: It is this effect – the result of incorrect equalization technique – that is responsible for the comment that boost filters "ring". The bandwidth of Series 4000 filter sections is much too broad to allow perceptible hangover. However, if a single control is set several decibels higher than either of the adjacent controls, the boosted frequency band is narrow enough to be analyzed by the ear as an emphasized single tone.

6. Always strive for the least amount of equalization that will make the system sound right. If you can achieve desired performance with several of the controls left at zero, so much the better.

7. Using 1/3 octave bands for acoustic analysis is a powerful technique which has been standardized internationally for numerous applications other than sound system equalization. Remember, however, that no instrumentation, no matter how expensive or sophisticated, corresponds <u>exactly</u> with the subjective assessment of the human ear. While it is impossible to properly equalize a monitor system solely by ear, it is just as impossible to do it solely by instrument.

Equalization of Sound Reinforcement Systems

Most of the comments in the preceding paragraphs also apply to sound reinforcement work. However, we now must be concerned not only with sound quality but with maximum gain before acoustic feedback. The use of electrical equalization to achieve these often contradictory requirements stems from the pioneering work of Dr. C. P. Boner and most of the techniques in use today are outgrowths of his findings.

Again we emphasize that this brief manual cannot serve as a textbook for sound system equalization. The following outline briefly describes a sequence of steps that is used successfully by some acousticians and sound contractors, but considerable experience is needed to be confident in using this or any other procedure.

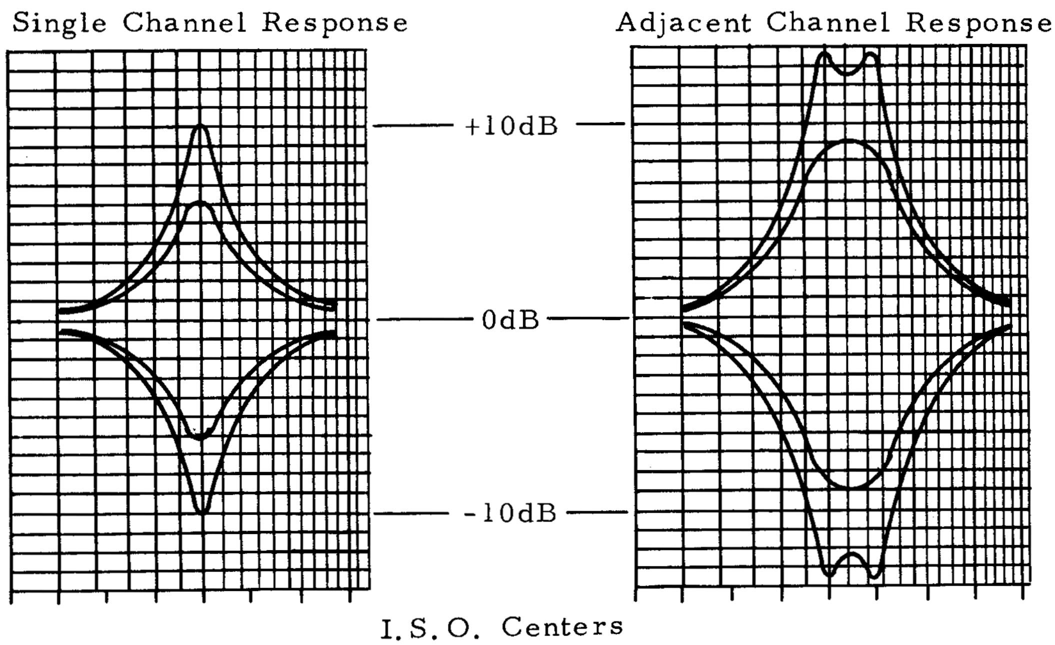
1. Begin equalization only after the installation is completed and balances, and after seat-to-seat coverage is acceptable. If high frequency coverage is spotty, this deficiency will become more apparent after the system is equalized.

2. Choose three or more typical listening locations at which acoustical measurements will be made. The idea is to find representative seats, neither the best nor the worst, to establish the house curve.

3. Using standard 1/3 octave measuring techniques, make accurate response

measurements at the chosen locations and then average these to obtain the unequalized house curve. NOTE: In some cases it is possible to save time by using the system microphone for acoustical measurements and thus automatically compensating for its characteristics in the equalization process. However, unless one is familiar with this technique, it probably is safer to rely on a calibrated microphone or precision sound level meter.

4. From the unequalized house curve you have drawn, calculate the electrical equalization which will be required to arrive at the desired house curve. Required equalization is the <u>difference</u> between the measured curve and the desired curve. For most typical churches and auditoriums, the desired curve will closely follow Dr. Boner's "Listener Preference Curve".



5. Check the system under normal operating conditions for intelligibility and natural voice quality. Make further equalization adjustments as required. However, if initia1 measurements have been made correctly, such adjustments should not change the original equalization curve by more than 3 dB.

6. Once the system sounds right, check for maximum gain before feedback. Identify the first two or three feedback frequencies and further attenuate the corresponding equalization controls 2-3 dB. There are several ways in which ring frequencies can be pinpointed. If self-oscillation can be sustained, the correct 1/3 octave band can be identified on a real time analyzer display. Alternatively, one can beat a ring frequency against a signal from a sine wave oscillator connected to the system. Or, if a frequency counter is at hand, it may be connected to the system at some suitable point (such as the speaker terminals) and used to measure the frequency of oscillation directly.

7. After you are satisfied that the best trade-off between sound quality and system gain has been achieved, measure the house curve once more, measure the electrical response of the system, and log a11 equalizer control settings.

8. Additional Helpful Hints

   A. Don't pull down the entire 1-2 kHz region in an effort to get more "gain". It is in this region that the ear is most sensitive, and you will only degrade sound quality without improving loudness or intelligibility.

   B. The 2-5 kHz region is critical for intelligibility and subjective high frequency smoothness. A 2 dB change in this region will make a clearly audible change in system performance.

   C. Avoid substantial boost in the loudspeaker system crossover range. Increasing the power fed to high frequency units near crossover effectively reduces the power handling capability of the whole loudspeaker system.

   D. Listen to the performance of the system under all typical operating conditions.

   E. In some cases, a sound system can be <u>too</u> natural. If the audience or congregation is not aware of the sound system, they may think it is not working. Just a little bit of extra "presence" in the 2-5 kHz region is sometimes a good idea.

   F. Trust your ears as well as your instruments.

BI-AMPING

A. Types of Low Level Crossover Networks Available

Both 12 dB/octave and 18 dB/octave passive LC networks are available. Frequencies of 500 Hz, 800 Hz, and 1200 Hz are standard. Other frequencies are available on request. These units are magnetically shielded to minimize hum pickup.

B. Installation

To utilize the bi-amp feature of the 4000 Series, one only need to insert the appropriate network in the octal socket on the rear of the unit. OUT 1 then becomes the low frequency output and OUT 2 becomes the high frequency output. In the event that it is necessary to switch the unit out of the circuit, only the low frequency side is switched. This prevents the introduction of low frequency program material into the high frequency drivers.

C. Special Networks

Special networks providing special functions may be inserted into the accessory socket. Plug-in networks providing Tri-amp capability may be provided on special order. The user should contact the factory to discuss special applications.

MAINTENANCE

A. Troubleshooting

The circuitry of the Series 4000 consists of state-of-the-art integrated circuits and high reliability military grade components. If the circuit fails to operate, check the following:

1. Power connected (pilot lamp illuminated on front panel)
2. Fuse: 1/2 amp, 3AG, slow-blew
3. Proper connection and signal present from previous stages
4. Jumpers or bi-amp network inserted in octal accessory socket
5. (4002) Level control turned up

B. The integrated circuits in the Series 4000 are field replaceable.

If you suspect that an integrated circuit is not functioning, replacement units may be obtained from the factory.

C. If trouble cannot be located

Permission should be sought to return the unit to the factory (see Warranty).

WARRANTY

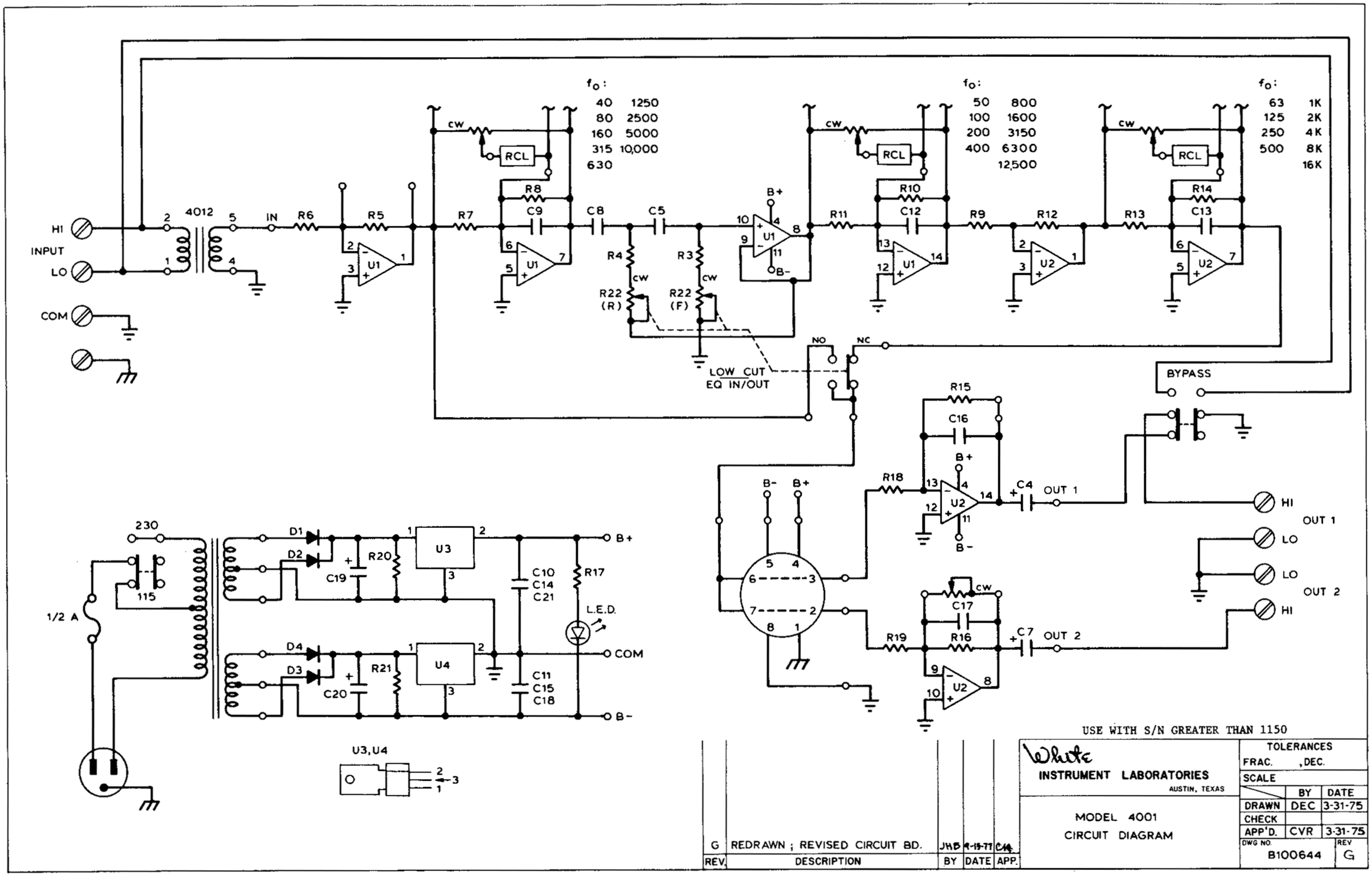
All our products are guaranteed against defects in materials and workmanship for one year from date of shipment. Our warranty is limited to repairing or replacing any product which fails during the warranty period from normal use. White Instruments, Inc. will not be liable for any damage resulting from the use of this instrument.

Damage in Shipment

Our instruments are shipped with full insurance unless the buyer instructs otherwise under his self-insurance. Prompt inspection should be made upon delivery and any necessary claims made against the carrier. Please notify us at once and we will cooperate in obtaining repairs or a replacement.

Return Shipment

Any instrument returned for repair should be safely packed and shipped prepaid to us. An explanation of the type of trouble encountered should accompany the instrument, or be sent to us separately in writing, or transmitted by phone. Repairs and checks will be made promptly. Return will be made collect by the best way, or by the owner's choice of method.



INPUT
HI
LO
COM
4012
IN
R6
R5
U1
R7
R8
C9
CW
RCL
C8
C5
R4
R3
R22 (R)
R22 (F)
B+
B-
f_o:
40 1250
80 2500
160 5000
315 10,000
630
50 800
100 1600
200 3150
400 6300
12,500
63 1K
125 2K
250 4K
500 8K
16K
R11
R10
C12
R9
R12
U2
R13
R14
C13
NO
NC
LOW CUT
EQ IN/OUT
BYPASS
R15
C16
R18
C4
OUT 1
R17
C17
R19
R16
C7
OUT 2
230
115
1/2 A
D1
D2
D3
D4
C19
C20
R20
R21
U3
U4
C10 C14 C21
C11 C15 C18
L.E.D.
COM
U3,U4
USE WITH S/N GREATER THAN 1150
G REDRAWN ; REVISED CIRCUIT BD. JHB 4-19-77 C14
REV. DESCRIPTION BY DATE APP.
White INSTRUMENT LABORATORIES AUSTIN, TEXAS
MODEL 4001
CIRCUIT DIAGRAM
TOLERANCES
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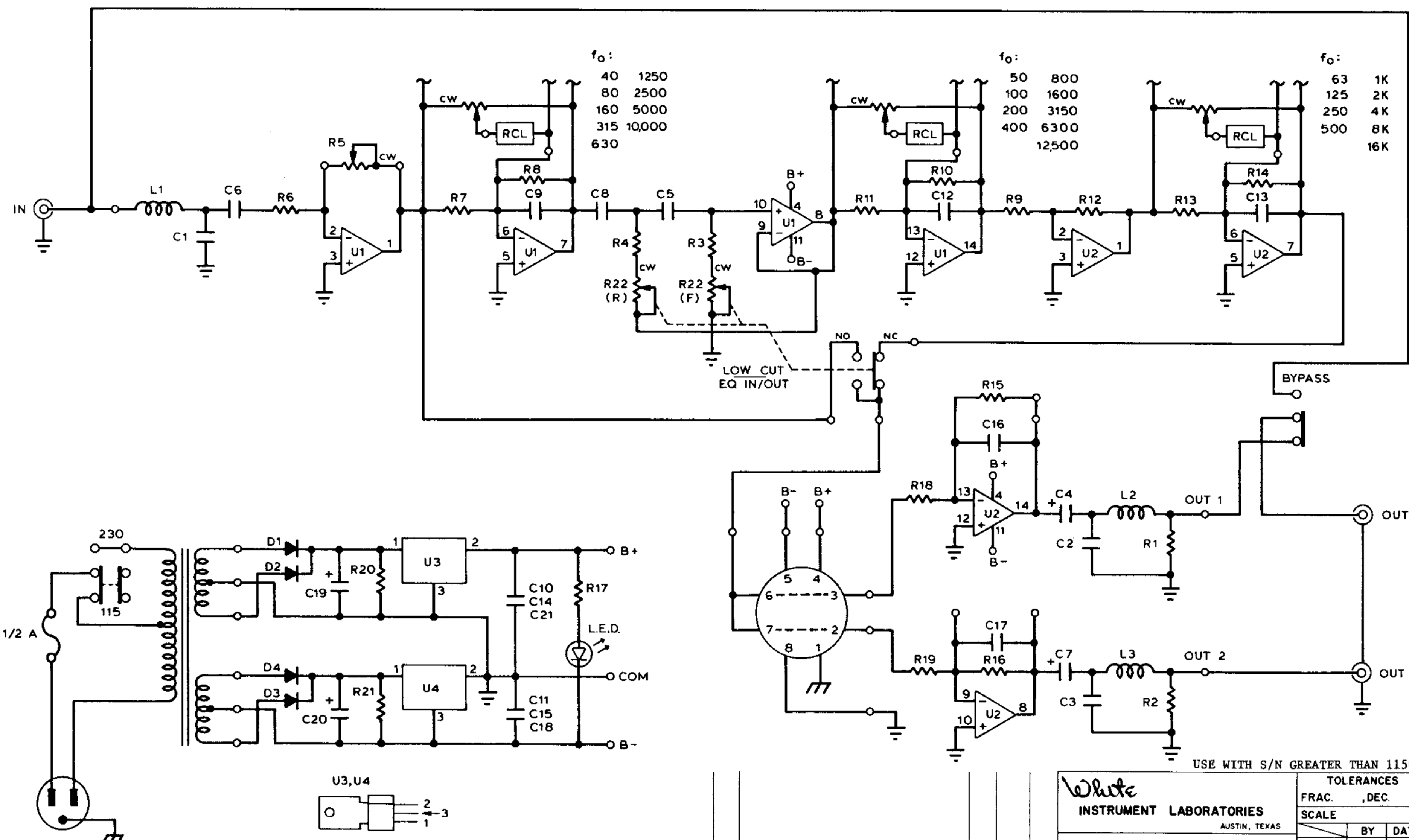
REV G



USE WITH S/N GREATER THAN 1150

REV.	DESCRIPTION	BY	DATE	APP.
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White
INSTRUMENT LABORATORIES
AUSTIN, TEXAS

MODEL 4002
CIRCUIT DIAGRAM

TOLERANCES		
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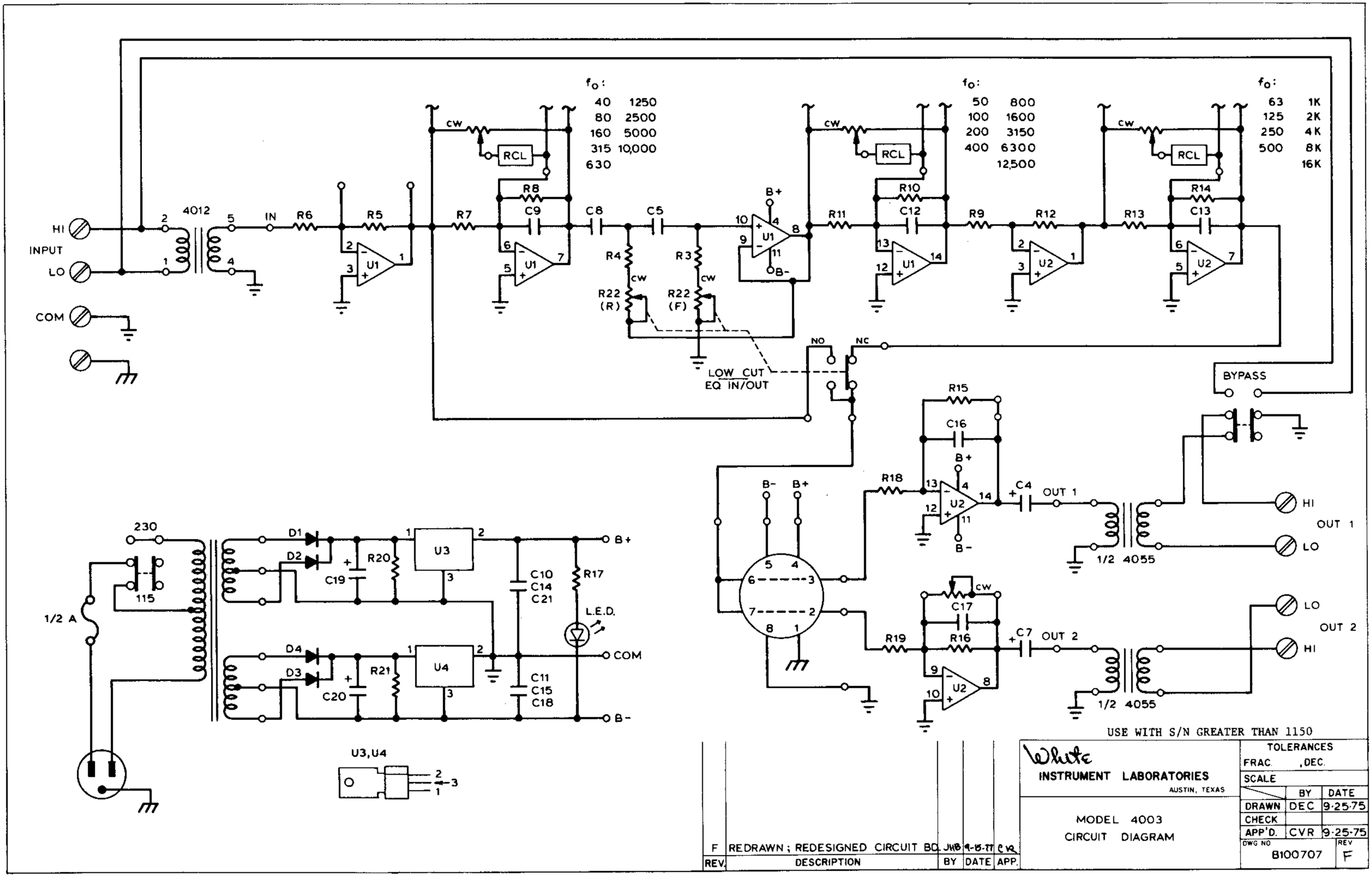
INPUT
HI
LO
COM
4012
IN
R6
R5
R7
R8
C9
U1
C8
C5
R4
R3
R22 (R)
R22 (F)
CW
RCL
fo:
40 1250
80 2500
160 5000
315 10,000
630
50 800
100 1600
200 3150
400 6300
12,500
63 1K
125 2K
250 4K
500 8K
16K
R11
R10
C12
R9
R12
R13
R14
C13
U2
B+
B-
NO
NC
LOW CUT
EQ IN/OUT
BYPASS
R15
C16
R18
C4
OUT 1
1/2 4055
R19
R16
C17
C7
OUT 2
230
115
1/2 A
D1
D2
D3
D4
C19
C20
R20
R21
U3
U4
C10
C14
C21
C11
C15
C18
R17
L.E.D.
COM
U3,U4
USE WITH S/N GREATER THAN 1150
White
INSTRUMENT LABORATORIES
AUSTIN, TEXAS
MODEL 4003
CIRCUIT DIAGRAM
TOLERANCES
FRAC. ,DEC.
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DWG NO B100707
REV F
F REDRAWN; REDESIGNED CIRCUIT BD. JHB 9-15-77 CVR
REV. DESCRIPTION BY DATE APP.