

# **GAIN BRAIN II**

## **Variable Ratio Limiter**

811

## **OPERATING INSTRUCTIONS**



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# 1. General Information

## 1.1 DESCRIPTION

Gain Brain II combines the functions of limiter, compressor and ducker, in a small but powerful package. A host of proprietary circuitry advances are employed, yielding a new level of performance, compared with other devices.

Particular care has been taken to structure Gain Brain II such that the dynamic integrity of the program is preserved, even during passages of heavy gain reduction. This is accomplished primarily through the use of an exclusive detection scheme based on the principle of LINEAR INTEGRATION. While ordinary Peak or RMS detectors respond to an arbitrary voltage or power level, Gain Brain II's response is variable, dependent upon the degree of waveform complexity. Thus, the higher complexity waveforms are allowed to exit Gain Brain II at a slightly higher absolute level than are the simpler waveforms. This relationship is musically correct and allows a significant increase in sonic "Naturalness" over conventional detection methods.

In spite of a dramatic increase in dynamic integrity, Gain Brain II is capable of maintaining a flatter VU reading than devices utilizing either Peak or RMS detection.

On the low frequency end of the spectrum, proprietary PEAK REVERSION CORRECTION CIRCUITRY compensates for the discrimination against low frequencies which occurs in many limiter/compressor designs, particularly those using RMS detection schemes.

Other advancements include a switch selectable LOGARITHMIC RELEASE SHAPE which counteracts excess pumping and low frequency distortion, as well as a superior audio path consisting of the Valley International TA-101 in a feed forward configuration.

## 1.2 GAIN BRAIN II SPECIFICATIONS

**Maximum Input Level:** +24dBv (Electronically Balanced - 50K)

**Maximum Output Level:** +21dBv into 2000 $\Omega$  or higher (47 $\Omega$  output impedance)

**Frequency Range:** 5Hz to 100KHz (3dB)

**Audio Slew Rate:** 13v/ $\mu$ sec (150KHz Full Power Bandwidth)

**Distortion (Static) (+10dBv input):** .01% Max IMD or 1KHz THD (Dynamic distortion is a function of the Release Time, as in all compressor/limiters)

**Signal to Noise Ratio (RMS signal to RMS noise, 20Hz to 20KHz):** 112dB (+21dBv in and out); 95dB (+4dBv in and out); 85dB (-16dBv in, +4dBv out) (20dB gain)

**Range of Gain Reduction:** Over 50dB

**Compression/Limiting Threshold:** Variable, -40dBv to +20dBv

**Compression/Limiting Ratio:** Variable, 1.3:1 to  $\infty$ :1

**Integration Time (Attack):** Variable, 200 $\mu$ sec to 200 msec/20dB

**Release Time:** Variable, 50msec to 5sec/20dB

**Release Shape:** Selectable, Linear or Logarithmic

**Output Gain:** Variable, 0dB to +48dB

**Gain Reduction Indication:** 0dB to 50dB, on 13 element LED display

**Input Mode Switch:** IN (Normal), KEY (Side Chain) or OUT

**Stereo Intercouple:** Via Rear Connector

**External VCA Control Inputs (2):** -20dB/volt, @ 4.99K $\Omega$

**Panel Dimensions:** 1 1/2" x 5 1/4"

**Powering:** Bipolar 15v, 100ma

**Additional Features:** Drive for External VCA or Meter; Master "OUT" Buss; Unbalanced Input Monitor Output; Balanced Side Chain Input (+24dBv, 50K)

**Note:** The notation dBv refers to .775v RMS

## 1.3 APPLICATIONS AND USES

**Uses.** Gain Brain II is highly useful in all applications requiring an exacting control over audio levels, concurrent with the preservation of dynamic integrity. A full compliment of front panel controls allows for optimum settings for any type of program material, and for any desired effect. Gain Brain II is not timid. It is capable of anything between remarkable unobtrusiveness in conventional limit/compress applications, and some very audible envelope shaping effects such as impact accentuation on transient material.

**Frequency Dependent Limiting/Compression.** By inserting an outboard equalizer into the side chain input, Gain Brain II may be made to operate as a frequency dependent device (the control path is equalized, not the signal path). A very effective de-esser may be configured in this manner, as can be a pre-emphasis compensated limiter for FM broadcasting.

**Audio Path.** Obviously, the audio path of any active processing device has an effect on the "sound" passed through it. This is particularly true of dynamic gain control devices which depend on some form of voltage controlled gain circuit. The employment of the TA-101 VCA in the Gain Brain II assures complete VCA transparency—extremely low noise and distortion, together with excellent transient response bandwidth and gain reduction range (50dB).

# 2. Installation

## 2.1 POWERING/HOUSING

Gain Brain II is designed to be housed in any of the Valley International "800" series powered or unpowered racks including: PR-2A; PR-10A; TR804; TR805; TR806; or CM 801A.

## 2.2 SYSTEM INTERFACE CONSIDERATIONS

Gain Brain II is designed to interface into essentially line level

circuits, having a nominal signal level in the range of -20dBv to +8dBv, re .775v RMS.

The audio inputs into the device are electronically balanced differential inputs, exhibiting an impedance of 50K ohms on the inverting leg (low side) and 100K ohms on the non-inverting leg (high side). For situations requiring a phase reversal, the high and low (+ and -) input connections may be reversed without adverse ramifications. The inputs will handle, without clipping, signal levels up to +24dBv.

The output circuit is unbalanced, and has a voltage drive capability of +21dBv into impedances higher than 2K ohms, diminishing to +18dBv into 600 ohms. The output impedance is 47 ohms.

## 2.3 CONNECTIONS IN UNBALANCED CIRCUITS

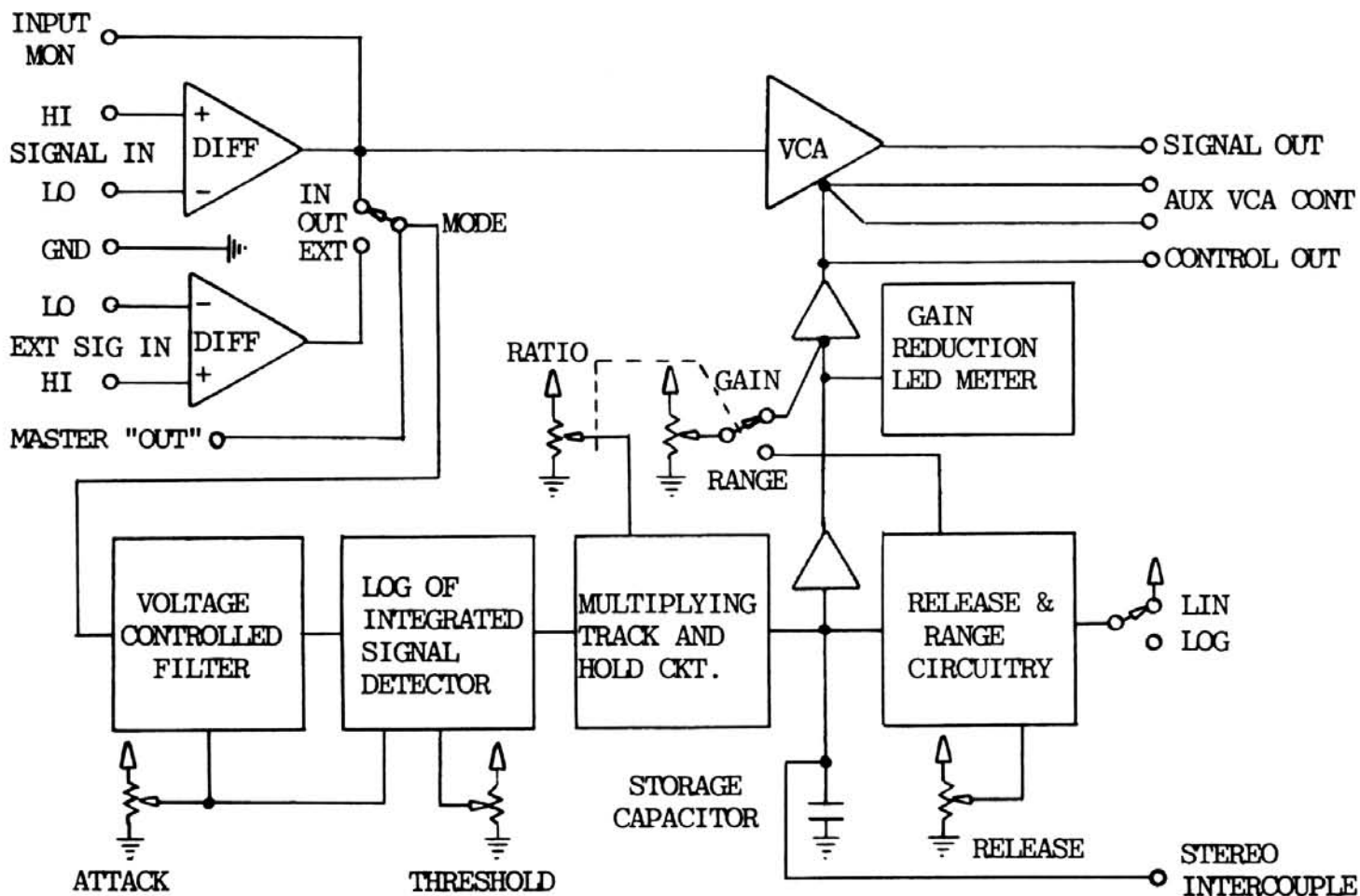
Often, in recording studio console installations, a patch point may be "unbalanced to unbalanced". In most such situations, the input and output circuits share a common power supply, and are integrally grounded together. In these cases, a beneficial scheme to avoid unwanted ground loops is to connect only the Gain Brain II output ground (to the circuit which the device is feeding its output signal), while leaving the Gain Brain II input ground(s) unconnected (connecting only the + and - inputs).

## 2.4 POWER LINE GROUND

The PR-10 and PR-2 cases are connected to the ground prong of the line cord, and are thus grounded to the power line ground. In some installations, an earth ground, separate from the power line ground, is employed to reduce ground noise. To properly separate the audio ground from the safety ground, please refer to the schematics provided with each individual powered rack.

# 3. Theory of Operation

## 3.1 BLOCK DIAGRAM



VALLEY INTERNATIONAL GAIN BRAIN II  
VARIABLE RATIO LIMITER  
EFFECTIVE BLOCK DIAGRAM

### 3.2 AUDIO CIRCUITRY

The audio signal path is limited to an input differential amplifier, for providing an electronically balanced input, and the Valley International TA-101 VCA. The VCA is capable of a very wide dynamic range, has excellent noise and distortion levels, and exhibits exact conformity to the antilog of the sum of applied control voltages, over a 150dB gain control range.

The antilog format of the VCA control circuit is an important consideration in voltage controlled computational circuitry, as it allows great accuracy in the manipulation of control signals, over an extreme range. More discussion of this subject will appear in succeeding paragraphs.

A 3dB gain loss is incurred in both the normal SIGNAL INPUT diff amp, and the EXT SIGNAL INPUT diff amp. The purpose of this loss is to allow the device to accommodate input voltage swings of up to +24dBv, even though the unit has an internal clipping point of +21dBv. Conversely, a nominal 3dB gain is evident in the VCA circuit, in order to provide a net device gain of unity, when the RANGE/GAIN CONTROL is set for 0dB. Except in the DUCK MODE, up to 48dB of effective output gain may be introduced, to allow operation as a boost amplifier, and to make up for the gain reduction incurred in limiting/compression.

### 3.3 VOLTAGE CONTROLLED CONTROL CIRCUITS

All of the control parameters of the device deal with log form control voltages, and are processed via voltage controlled parameter establishing circuits. This combination allows great freedom in the parametric control process, over very large dynamic ranges, with simple linear taper potentiometers fed from an internally regulated  $\pm 5$  volt source. Throughout the various control circuits, a log scaling of 20dB/volt is employed. At some circuit points, the scaling is -20dB/volt, while at other points, it is +20dB/volt. In order to clarify the meaning of this terminology to those uninitiated into log domain processing, the following table compares various signal levels, showing their actual voltage levels, as well as the resulting voltages which would be obtained after conversion to a +20dB/volt log form, normalized to 0vdc @ 0dBv.

Signal Level (dBv)	Actual Voltage (RMS Volts)	Log Form (DC Volts)
+20dBv	7.75v	+1v
0dBv	.775v	0v
-20dBv	.0775v	-1v
-40dBv	.00775v	-2v
-60dBv	.000775v	-3v
-80dBv	.0000775v	-4v
-100dBv	.00000775v	-5v

Table 1.

As can be seen by this relationship, the signal voltage in its inherent form (linear form) exhibits a tremendous range of voltages, requiring critical circuitry and precision tapering of control elements, if a wide range of signals is to be accurately processed. However, in the log form, processing becomes much easier (and more accurate), using simple linear taper controls, and without the noise and offset voltage problems associated with the processing of very low voltages in linear form.

In the Gain Brain II, this log processing philosophy is applied not only to the threshold sensing circuits and VCA control voltages, but finds equally effective application in accurately defining the parameters of attack time, release time, and compression/limiting ratio.

### 3.4 EFFECTIVE CIRCUIT DESCRIPTION— THE BLOCK DIAGRAM

In referring to the block diagram, it is seen that the normal SIGNAL INPUT passes through a diff amp, and on to the VCA

audio input, the UNBALANCED INPUT MONITOR (a test point), and to the MODE SWITCH.

A second diff amp receives the EXTERNAL SIGNAL INPUT, and feeds it to the MODE SWITCH only. Depending upon the position of this switch, one, or neither, of the signal inputs is connected to the VOLTAGE CONTROLLED FILTER, which is the first stage of the control circuit.

The purpose of the VOLTAGE CONTROLLED FILTER is to adjust the frequency response of the signal fed to the detector circuit, as a function of the INTEGRATION TIME (ATTACK TIME) of the detector. This frequency response contouring is necessary in order to compensate for the detection level error which would otherwise occur in the processing of signal frequencies whose cyclic period were below the INTEGRATION TIME of the detector.

Following the filter circuit is a block of circuitry referred to as a "LOG-OF-INTEGRATED-SIGNAL DETECTOR". This circuit electronically implies the following mathematical steps, in producing a dc output voltage related to the log of the input signal:

The circuit performs the function of a precision full wave rectifier (absolute value converter), followed by a variable time constant voltage controlled integrator, followed by a temperature compensated log converter, summed with a variable offset voltage (the THRESHOLD CONTROL). These separate operations are implied in the overall circuit function, even though they do not take place in the specific order stated.

The final output of this circuit is in the form of a dc voltage having the characteristics shown in the "LOG FORM" column of Table 1, with the point of normalization (0 volts) occurring at an input signal level which corresponds with the setting of the THRESHOLD CONTROL.

Thus, the circuit will output a *positive* voltage of +1v for each 20dB that the input signal *exceeds* the selected threshold, or a *negative* voltage of -1v for each 20dB that the input signal is *below* the selected threshold. The resulting +20dB/v relationship may, if desired, be restated as a ".05v/dB" scaling, as the two statements are one in the same.

Next, this log form dc voltage is passed through a MULTIPLYING TRACK AND HOLD CIRCUIT. This circuit is unipolar, acting upon only the *positive* range of voltages presented at its input (those voltages which result when the input signal exceeds the selected threshold). Variable degrees of multiplication (or division) are imposed on these positive input voltages, by manipulation of the RATIO control, such that the log scale factor is altered from as little as .0015v/dB at the 1.3:1 ratio, to as much as .05v/dB at the 1:100 ratio.

The results of this calculation are presented to the STORAGE CAPACITOR in a rectifying manner such that the circuit may feed positive currents (attack currents) into the capacitor, yet may not remove those stored currents in a reverse direction. Thus, the STORAGE CAPACITOR tends to charge up to the *highest positive* voltages presented to it, and to hold those voltages.

Also connected across the STORAGE CAPACITOR is the RELEASE CIRCUITRY. This block acts to discharge the capacitor at a variable rate, as determined by the setting of the RELEASE TIME CONTROL, and by the position of the RELEASE SHAPE SWITCH.

Both of the mentioned release parameters are based on Log Format Current Multipliers, interacting as an overall Log Computational Circuit.

The STEREO INTERCOUPLE terminal connects directly to the STORAGE CAPACITOR in such a manner that, on intercoupled units, all STORAGE CAPACITORS are connected in parallel, and are thus forced to maintain exactly identical voltages. This, of course, places the units' release networks effec-



tively in parallel, thus the release times become identical, and are determined by the sum of all release currents. Accordingly, if two units have been intercoupled, and one release time is set to a fast position (high release current) and the other is set to a slow release time (low current), the overall release rate will be fast (although as little as half as fast as the setting of the fastest control, since two capacitors in parallel must be discharged).

The voltage across the STORAGE CAPACITOR is fed to a buffer amplifier, whose output normally feeds:

- A. The VCA control voltage input,
- B. The GAIN REDUCTION LED ARRAY, and,
- C. The control voltage output terminal (for feeding external VCA's or meters).

A better understanding of the relativity of the flow and results of the various control circuits may be had by studying the following typical example:

1. Assume the unit is set for a 0dBv THRESHOLD and a 2:1 RATIO.
2. Assume that a +20dBv steady state input signal is applied.

The LOG-OF-INTEGRATED-SIGNAL DETECTOR will, by nature of the 20dB over threshold signal, produce a dc output voltage of +1v. (+20dB = +1v scaling.)

At the assumed 2:1 RATIO, this voltage will be divided by a factor of two in the MULTIPLYING TRACK AND HOLD CIRCUIT; thus it will charge the STORAGE CAPACITOR to

+ .5vdc. (+20dB = +.5v scaling.) This voltage is fed to the VCA and to the gain reduction LED meter.

Since the VCA and the LED meter both respond at the rate of -20dB/volt, the application of +.5v will cause 10dB of VCA attenuation, and the meter will read -10dB. The +20dBv audio signal, therefore, incurs a 10dB loss in the VCA, and comes out as a +10dBv signal. Thus, the 2:1 RATIO statement is correct, since a 20dB input signal increase (over threshold) has been reduced to a 10dB output signal increase.

As for the remainder of the block diagram, it is seen that the RANGE/GAIN CONTROL, when in the GAIN position (DUCK SWITCH off), feeds a variable voltage source to the VCA control summing point. This voltage modifies the VCA gain upward by as much as 48dB, acting effectively as an output gain control. The effect of this additional output gain does not appear on the metering LED's, but it does appear on the control voltage output terminal.

The MASTER "OUT" BUSS fixes the electronic IN-OUT-EXT switch in the "OUT" position, regardless of the front panel toggle switch position.

The two AUX VCA CONTROL INPUTS are seen to connect directly to the VCA, thus are active at all times.

This completes the user level theory of operation. It is hoped that its presentation will lead to a better understanding of the workings and capabilities of the Valley International Gain Brain II, and that it will provide valuable information toward insuring proper operation of the device.

## 4. Operating Instructions

### 4.1 THE CONTROLS

**In/Out/Key Switch.** Selects normal operation (In), bypass (Out), or side chain operation (Key).

**Threshold.** (-40dBv to +20dBv). Determines the signal level at which Limiting, Compression or Ducking is initiated.

**Ratio** (1.3:1 to Infinity:1, plus switch stop for Ducking ratio of 1: -50). Establishes the compression ratio from extremely mild compression to absolute limiting. In Duck position, high ratio gating action assures consistent "duck depth".

**Gain** (0dB to 48dB) — Output gain control for the device.

"duck depth", while in other modes it serves as an output gain control. (Nominal gain in Duck position is unity.)

**Attack** (.2ms to 200ms). Varies the effective attack time by adjusting the Integration time of the LINEAR INTEGRATION DETECTOR. The 1000 to 1 range of this control allows a wide range of characteristics. At the fast 200µsec end, the device effectively acts as a Peak limiter, while at the slowest 200msec settings, a very pronounced overshoot occurs. This controlled overshoot produces dramatic effects of impact accentuation on percussive material...actually increases dynamics rather than reducing them. A proprietary Tracking Peak Reversion Correction Circuit is actuated by the Attack control for the purpose of eliminating the low frequency threshold error which most commonly occurs on integrating detectors, particularly of the True RMS type.

**Release** (.05 sec to 5 sec/20dB). Establishes the recovery rate after the Limit/Compress action.

**Release Shape** (Lin/Log). Another proprietary feature. In the Log position, the initial rate of release (following an attack) is lengthened, while the ultimate released rate is shortened, following a logarithmic curve covering the first 10dB of release from any point of gain reduction. For instance, should a particularly loud passage cause, say, 30dB of limiting, the initial rate of release will be substantially longer than that rate indicated on the Release Time Control. As release occurs, the rate of release will accelerate such that by the time 10dB of release has occurred, the release rate will be substantially faster than indicated. The action of this Log Release action is manifest in the ability to set fast recovery rates while maintaining freedom from the low frequency modulation distortion and excess pumping which normally result with fast release rates. The action also serves to maintain the natural amplitude envelope when limiting percussive material...thus eliminating the "squashed" sound common to conventional limiter/compressors during fast release operation.

**Metering.** A 13 element LED array indicates gain reduction from 0dB to 50dB.



## 4.2 CHECK-OUT/FAMILIARIZATION

In order that the customer ascertain proper operation of the Gain Brain II, as well as to gain an understanding of its capabilities, the following procedure is recommended:

1. Insert device into the point in the signal chain where it is to be used.

2. Provide access to the EXT SIGNAL INPUT (key) connections, such that either program material or an audio oscillator may be connected here also.

3. Ascertain that program material exists at the audio input, at a level between  $-20\text{dBv}$  and  $+8\text{dBv}$ , and that the output circuit is connected through to the monitor amplifier(s), and to suitable metering devices (such as VU meters, etc.).

4. Set the Gain Brain II controls to the following positions:

- a. RELEASE SWITCH = LIN
- b. RELEASE TIME = CCW (.05sec)
- c. ATTACK TIME = CCW (.2msec)
- d. GAIN = CCW (0dB)
- e. RATIO = CW (Inf:1)
- f. THRESHOLD = CCW ( $+20\text{dBv}$ )
- g. MODE = OUT

5. **Check "Out" Mode:** The unit should now pass audio, at unity gain, with no further effect. The only control which should be operational in "OUT" mode is the RANGE/GAIN CONTROL. Advancing this control should now increase the device gain in accordance with the panel markings (up to  $48\text{dB}$ ). The Gain Reduction LED Array should indicate 0dB, and should not move as the RANGE/GAIN CONTROL is rotated.

6. **Check "In" Mode:** Return the RANGE/GAIN CONTROL to 0dB(CCW) and set the MODE SWITCH to the "IN" position. At this point, the unit should again pass audio at unity gain, with no other effect. Now, advance the THRESHOLD CONTROL, while observing the Gain Reduction LEDs. When the THRESHOLD has been lowered to correspond to the level of the input program peaks, limiting action should begin, as indicated by the LEDs, and by a dropping output level. Continue advancing the THRESHOLD CONTROL until around 10dB to 20dB of Gain Reduction is indicated on the LEDs. The RANGE/GAIN CONTROL may now be advanced to make up for the level loss, and to establish a suitable VU meter reading. At these settings, the limiting action will be very aggressive, due to the fast attack and release settings, and the high compression ratio.

a. **Now, observe the effect of the Attack Time Control.** This effect can be noticed by using drums or other percussive program material. As the ATTACK TIME CONTROL is advanced, you will begin to hear a slight overshoot of the drum attack transients, and probably an increase in output level. As you continue increasing the ATTACK TIME, the overshoot will become quite audible, and the aggressive "squashed" limiting sound will give way to a more percussive (and probably more pleasing) effect. At maximum ATTACK TIME (full CW) you will find that the transient overshoot has become extreme, and that the effective release time has become longer. This lengthening of release rate occurs because the integration time of the attack circuit is now longer than the 50msec release time, thus the effective release rate is actually limited to the relatively long time constant of the attack time integrating circuit.

Now return the ATTACK TIME CONTROL to minimum (CCW) and:

b. **Observe the Effect of the Release Time Control:** As you advance the RELEASE TIME CONTROL, you will hear the aggressive, rapidly fluctuating limiting action give way to a much more natural effect, but at the cost of a lower average level. Return the RELEASE TIME CONTROL to around mid-position (.5sec) and,

c. **Check the Log Release Position:** With the RELEASE SHAPE SWITCH in LOG position, you should hear, on most program material, less pumping and rapid modulation, as well as a more natural sounding "trailing edge" to program bursts. You should notice that the effective release time immediately following an attack is longer than in the LIN position, but that the ultimate release time becomes faster. Leave the RELEASE CONTROLS in a position which sounds good on your program, and,

d. **Adjust the Ratio Control:** As you lower the RATIO from Inf:1 towards 1.3:1, you should notice that the amount of Gain Reduction decreases, the output level rises, and the severity of the limiting action decreases. You have left the limiting domain, and are now compressing. This can be explained as follows:

At the initial Inf:1 RATIO (absolute limiting), once the input signal exceeded the THRESHOLD, further increases in input level will be effectively "clamped"...causing no further increase in output level. As the RATIO is reduced to, say, 2:1, a 2dB increase in input signal (over THRESHOLD) will be compressed to 1dB rise in output signal. (Or 20dB reduced to 10dB, etc.) At the minimum RATIO of 1.3:1, compression is very mild, and an input signal increase of 13dB will be reduced by only 3dB, to yield an output level increase of 10dB. In this later example, the Gain Reduction is only 3dB, so the Gain Reduction Meter will read the closest increment, 2dB. While the lower ratios will give a less "processed" sound, they will also, obviously, give you less control of absolute output level.

At the extreme CCW position of the RATIO CONTROL, you will feel a switch action. By operating this switch, you will enter the...

7. **Check out the "EXT" Mode:** Returning the controls to those positions stated in paragraph 4, set the MODE SWITCH to the "EXT" position. This will disconnect the normal audio input signal from the control sections of the Gain Brain II, but will leave this signal passing through the VCA, where it will be affected by the control circuits, then passed to the output.

Simultaneously, the control circuits will be connected to any signal which is applied to the "External Signal Input" (or "KEY INPUT", or "SIDE CHAIN INPUT"). Thus, the EXT signal will control the gain (loss) of the VCA, but will not appear as an audio signal at the output. The output will contain only the normal INPUT SIGNAL, as Gain Controlled by the VCA. In short, the magnitude of the EXT SIGNAL will control the gain of the INPUT SIGNAL.

a. **As a Side Chain Limiter/Compressor:** General Check-out of the EXT MODE may be made by the simple expedient of

patching the program you have been listening to, both to the normal SIGNAL INPUT, as well as to the EXT SIGNAL INPUT. In this manner, the device should respond exactly as in paragraph 6, since the signal applied to the control circuits through the EXT SIGNAL INPUT is, in fact, the INPUT SIGNAL itself, forming the same connection which is inherent in the "IN" MODE.

To double check, disconnect the feed to the EXT SIGNAL INPUT, and attempt to perform the test of paragraph 6. Since there is now *no* signal fed to the control circuits, advancing the THRESHOLD *should not* cause Gain Reduction, since there should be no signal being fed to the threshold (control) network.

Another test which will serve to educate the user in the workings of the EXT position, is to leave the program connected to the EXT SIGNAL INPUT, and to connect an audio oscillator to the normal SIGNAL INPUT. As the program is played, and the various controls of the unit are adjusted, you should be able to observe the oscillator being GAIN MODULATED by the content of the program. You should not be able to hear the program itself, though, unless it is separately routed to the monitor system. You will notice, however, that the Gain Reduction caused in the process is indicated on the LEDs.

The same sort of test could also be performed, using two different program sources. This time, you should be able to observe the effect as one program source gain modulates the other.

**Sine Wave Testing the Gain Brain II:** The Gain Brain II is very carefully optimized to yield optimum results from music and speech waveforms, and contains a number of proprietary methods of achieving these goals. It must be understood that a limiter device which is optimized for music/speech, cannot be fully evaluated by sine wave testing. Complex music/speech waveforms have entirely different ratios of waveform peak to audible power, than do sine waves (or any other type of simple repetitive test waveform).

Should the user elect to perform a sine wave evaluation of the device, it will be seen that the effective limiting threshold appears to be higher for the lower frequencies than for the higher frequencies. It will also be seen that a graph of effective sine wave limiting threshold vs. frequency is variably dependent upon the position of the ATTACK TIME CONTROL, and that at the moderate to fast attack settings, a distinct rise in low frequency output during sine wave limiting is present. (Typically around 5dB.)

This effect is entirely normal, and is caused by the circuitry which is employed to cause the device to exhibit essentially a *non-discriminatory limiting threshold vs. music waveform frequency characteristic*. If a limiter of the integrating or RMS detector type were configured to exhibit a flat threshold to all sine wave frequencies, it would be found that its music response would be very discriminatory, causing excess limiting and pumping on low frequency audio material.

An effective, but complex method of testing for music/speech waveform threshold characteristics, would be to apply various examples of such waveforms, in various frequency ranges, and to observe the output levels obtained from these sources (during limiting) on a VU meter. The user who chooses to undergo this sort of "real world" testing will, in all probability, be very pleased at the results obtained from the Gain Brain II, as opposed to other devices.

As far as the actual signal frequency response (as differentiated from the effective threshold vs. frequency parameter), this will be found to be entirely flat, when sine wave tested over the audio spectrum.

## 4.3 USING THE GAIN BRAIN II: HINTS FOR OPTIMUM RESULTS

Your Gain Brain II is widely adjustable, to allow optimization for essentially all applications to which a limiter/compressor/ducker might be called upon. Of particular interest to the professional user, is the basic design philosophy of the device. Every effort has been made, in the design, to provide a device which is primarily sympathetic to the preservation of the dynamic integrity of *music and speech waveforms*, as opposed to configuring a device whose excellence is based solely upon bench testing procedures.

**Attack Time:** Much of the unit's ability to achieve this dynamic integrity depends upon proper setting of the ATTACK TIME CONTROL, which controls the INTEGRATION TIME of the proprietary detector network. To arrive at a "best setting" of this control, for various programs and desired results, requires that the user have some basic understanding of the principles involved.

The Gain Brain II detector network INTEGRATES the input signal waveform over time, as a means to best determine its effective audible content. The longer the INTEGRATION TIME used, the more effectively this circuit can perform. However, the principle of "time averaging" the input signal involves a response time, or a delay in the reaction of the network to a rapidly changing signal level. This effect is known as the ATTACK TIME of the device. The presence of a finite ATTACK TIME, in a device of this sort, indicates that, upon the abrupt application of an input signal, the device will fail to immediately respond, thereby allowing an overshoot to appear at the output. Eventually, after a period of time determined by the setting of the ATTACK TIME CONTROL, the overshoot will diminish, and the device output will settle to its final value.

In practice, this effect is both a blessing and an impediment, as next explained: In limiter devices exhibiting a very fast ATTACK TIME, which are often termed "Instantaneous Peak Limiters", the application of transients of such a short duration as to be inaudible will cause gain reduction in the same manner as will the application of audible program material. These inaudible transients, as well as transients of near-inaudibility, are common in percussive material such as drums and other struck instruments.



The effect of the stated limiting of inaudible or near-inaudible transients is perceived as an overlimiting action, which results in very low output levels and a very restrained "squashed" sound.

By introducing a finite ATTACK TIME, a device can be made to fail to respond to these inaudible transients...allowing them to overshoot the output and not cause undesirable overlimiting. Thus, the ill effects are removed (or diminished), and the program sounds better and appears at a higher average level.

As the attack time is increased further, the overshoot signal begins to become so great as to become audible. If sufficient headroom exists following the limiter device, the overshoot signal may not be clipped, still it can be heard as an added element of percussion to the program...a modification. This effect may be either beneficial, or detrimental, depending upon both the program material itself, and upon the desired result. In general, the resulting modified attack envelope will be welcome when processing percussion instruments, as it heightens the percussive nature which is desirable in the instrument itself.

On other program sources, such as voice signals and many others, the effect will be unnatural, as it causes a modification to the envelope which may be out of character with the instrument, and thus displeasing.

Where special effects—the purposeful modification of an instrument's natural attack envelope—are desired, exaggerated overshoots caused by long ATTACK TIMES can be quite useful.

As a general guide to optimally setting the Gain Brain II ATTACK TIME, the following is offered:

**A.** For general processing of various music/voice sources, where naturalness is the desired result, the mid-range of ATTACK TIMES (around 6msec) is a good choice.

**B.** When feeding disc cutters and other devices which cannot tolerate overshoots, the fastest settings should be used—with the knowledge that the usual ill effects associated with peak limiting will be evident. Use sparingly.

**C.** When processing highly transient material, and for obtaining effects such as the introduction of exaggerated percussion, experiment with the longer settings.

**Release Times:** A situation exists with the selection of optimum RELEASE TIMES, which is similar to those considerations mentioned regarding ATTACK TIMES.

The faster RELEASE TIMES will increase the effective average output level from the device, but will do so at a cost of added alteration of the natural dynamics, and the introduction of modulation distortion and certain pumping effects.

On the other hand, the selection of longer RELEASE TIMES will smooth out the undesired aspects named, but will result in lower average output levels.

Optimum RELEASE TIMES, then again, are a function of the type of program, as well as of the desired result (and tolerable ill effects). Here is a general guide:

**A.** On general material, where moderately high output levels are desired, but severe modulation effects cannot be tolerated, use the mid-range of RELEASE TIMES (around .5sec/20dB).

**B.** When limiting individual tracks, and in other applications where high average output levels are desired, experiment with the faster RELEASE TIMES, but listen for the onset of excess modulation effects.

**C.** Where absolute signal purity is paramount, particularly on fully mixed music, lean toward longer RELEASE TIME settings. Average output level will be necessarily lowered.

**Log Release Shape:** The proprietary LOG RELEASE pattern can be very beneficial as a means to obtain both high average output levels, as well as minimal modulation effects. It should be tried whenever these are the goals. In certain uses, where the "sound of a limiter" is desired, the LIN RELEASE SHAPE may give a more beneficial result. Experiment with both RELEASE SHAPES to get the desired result.

**Ratio Control:** The selection of compression/limiting RATIO is often a subjective decision. Where the control of output levels

is of the greatest concern, most users will automatically opt for the maximum RATIO of Inf:1. Since, in this position, Gain Reduction will occur only at the loudest excursions of the input signal, modification will occur less often than at the lower RATIOS. Thus, less pumping and breathing effect will be apparent in the Inf:1 position.

In some uses, the object of using the device is not to control the output level, as much as it is to restrict the overall program dynamic range (making soft passages louder, and loud passages softer). For such purposes, the lower RATIOS may be more desirable. Some degree of Gain Reduction will be evident nearly all of the time that signal exists, but the output level will contain more variation than at the higher RATIOS, thus will be less controlled.

Most uses in the production recording studio will probably lean toward the higher RATIOS, while some broadcast and other reproduction uses will benefit from the lower RATIOS.

## 4.4 USING THE EXTERNAL SIGNAL INPUT

**Interactive Gain Control:** By placing the RATIO CONTROL in various positions between 1.3:1 and Inf:1, an INTERACTIVE GAIN CONTROL configuration results. Normally, the use of this configuration will entail the processing of two separate program sources—one applied to the normal SIGNAL INPUT, and a second applied to the EXTERNAL SIGNAL INPUT.

The degree of gain reduction incurred in this mode is a function of where the RATIO CONTROL is set, and by how much the EXT SIGNAL exceeds the setting of the THRESHOLD CONTROL. For instance, if the RATIO is set at Inf:1, and an EXT SIGNAL of 10dB above THRESHOLD is applied, 10dB of gain reduction will be caused. Thus, at the Inf:1 position, an inversely linear gain situation exists, in that the gain of the normal INPUT SIGNAL will be reduced in a direct proportion to the amount by which the EXT INPUT SIGNAL exceeds the threshold. (If the EXT SIGNAL gets louder by X dB, the normal SIGNAL gets softer by a similar amount.)

Taking the RATIO CONTROL to a lower setting reduces the degree of interaction. As an example, at a RATIO of 1.3:1, an EXT SIGNAL rise of 13dB (above threshold) causes a gain reduction to the normal INPUT SIGNAL of 3dB.

While no specific applications are tendered for employing this relationship, it is obvious that any number of potential uses might be envisioned—uses wherein the magnitude of one program source *gradually* affects the gain applied to a second program source.

**Frequency Dependent Limiting:** In some uses, such as FM broadcasting, it is desirable that the limiter itself have a flat frequency response, while the threshold of limiting be made frequency dependent. This can be readily accomplished, in the Gain Brain II, by the simple expedient of selecting EXT MODE, then feeding the program source directly to the normal SIGNAL

INPUT, and through a suitable equalizer to the EXT SIGNAL INPUT. When so configured, the device threshold will become frequency dependent (as determined by the settings of the equalizer), yet will pass audio on a flat response basis.

Other applications are evident, such as structuring a "de-esser" (by peaking the equalizer at the "ess" frequency).

**Stereo Intercoupling:** Provisions have been made to intercouple two or more Gain Brain II's in such a fashion that gain reduction in any unit will cause an equal amount of gain reduction to occur in the other unit(s). This is accomplished by simply tying the stereo intercouple terminals of the units together. (rear connector... see drawings.)

When so connected, the total amount of gain reduction is a function of the *highest* amount of gain reduction originating in *any* individual unit. The ATTACK TIMES remain independent, as set on each unit, although all units respond simultaneously when one attacks. The RELEASE TIME is a function of the unit whose RELEASE TIME is at the fastest setting.

Adjustments to an individual unit's GAIN CONTROLS are fully independent, and do not cause corresponding changes in the coupled units.

The RELEASE LIN/LOG SWITCHES of coupled units should be placed in the same position, as unpredictable release patterns will otherwise result.

## 4.5 MISCELLANEOUS REAR CONNECTOR CAPABILITIES

**Master In/Out Buss:** This is a logic buss which extends across all Gain Brain II's which share a TR 804 Package. If a source of +5vdc is applied to this buss, all Gain Brain II's will be effectively placed in the "OUT" position. Thus, A/B tests (IN/OUT tests) may be simultaneously performed on a number of units.

**Aux VCA Control Inputs:** Gain Brain II incorporates two auxiliary VCA control inputs, accessible at the rear connector. Application of an external dc voltage source to either, or both, of these inputs will cause gain modification at the rate of -20dB/volt. The range of applied voltage may be either positive (causing attenuation), or negative (causing gain). Any number of conceivable uses may be applied in using these control inputs. For instance, a variable voltage source of from 0v to +5v, applied to a control input of each of a number of units, will form a master output gain control, which can simultaneously fade any number of units, over a 100dB range. Another potential use would be to feed the control voltage output terminal of a Kepex II unit, into a control voltage input of a Gain Brain II unit. The audio signal then instead of passing through two VCA's (one in each unit), could be routed such that it passed only through the VCA in the Gain Brain II, even though it were controlled by both the Kepex II and the Gain Brain II, thus minimizing the audio circuitry.

Any number of uses, so diverse as to be beyond the scope of these instructions, can be put to the aux VCA control inputs, at the election of the creative user.

As a note of caution, if the aux VCA control inputs are not used, they should be left terminated to ground, as supplied, as they are a potential source of modulation distortion if left open to the pickup of stray audio or hum signals.

**Control Voltage Output:** The control voltage which is produced within the unit, and which drives the internal VCA, is separately available at the rear connector. It produces a -20dB/volt scaling (+1v = -20dB gain). This voltage can be used to drive an external VCA (such as the Kepex II), as well as to drive external gain reduction meters, etc.

As evidenced in many of the paragraphs above, the Valley International Gain Brain II is, indeed, a very flexible and powerful signal processing tool. When placed in the hands of a creative engineer/producer, the device can far exceed the mental image of the meaning "limiter/compressor". From here on, it's all up to you, the user. Experiment with the unit, and you will surely come up with a valuable collection of Gain Brain II effects you can call your own. Good Luck.

## 4.6 SAMPLE SETTINGS

### 1. Vocals—Leveling.

Release .3 Log  
Attack 6  
Gain Adj for 0VU out  
Ratio Inf  
Threshold As required for desired amount of limiting  
Note: Should serve well for all vocals. Experiment with Attack and Release.

### 2. Piano—Normal sound but with leveling action.

Release 1 Log  
Attack 2 to 6  
Gain Adj for -3VU out (Percussive instruments should be recorded at a lower level on tape to prevent peak distortion)  
Ratio 3 to Inf  
Threshold As required for desired limiting  
Note: Log release will enable faster release settings, with minimal low frequency distortion. Percussiveness may be varied by adjusting Attack control.

### 3. Drums—Normal sound but with leveling action.

Release .1 to 1  
Attack 6  
Gain As required for -3VU out  
Ratio 3 to Inf  
Threshold As Required  
Note: Same as Piano, above.

### 4. Horns, Strings, Other More Sustained Instruments.

A setup for vocals should serve well as a starting point for such instruments. Experiment with Attack and Release times, and with Release Lin/Log.

**5. Full Mix—**For preparing for mastering, for broadcast leveling, etc.

Set up as for vocals. If a very "hot" mix is desired, use fast Release (.1 to .3) and use Lin Release shape. Of necessity, this sort of use will result in considerable pumping and modulation distortion.

To combat these undesirable effects, try lengthening the Release time (.3 to 3), and try Log Release shape. The mix will become less "hot"; i.e., more natural, and the distortion effects will subside.

Experiment with Attack time. Longer Attack will allow transients to pass without causing limiting, thus often giving a more desirable sound with less pumping. If Attack is made too slow, the transient overshoot will begin to become annoying on some material.

If your purpose is to directly feed a disc cutter or transmitter, and this equipment cannot tolerate instantaneous overshoots on peaks, use the fastest Attack setting (.2), thus effectively making Gain Brain II a Peak Limiter.

## 5. Maintenance

### 5.1 INTERNAL ADJUSTMENTS

**Note:** Your Gain Brain II has been factory calibrated, and should not require readjustment. This information is provided only as a servicing aid.

**1. Detector Symmetry:** This pot adjusts the precision with which the detector circuit responds to both positive and negative input signal swings. It may be adjusted by inputting a low frequency sine wave (i.e., 100Hz), setting the ATTACK TIME for minimum (CCW), and observing the voltage at U5 Pin 1 with an oscilloscope. The pot should then be adjusted so that the log form rectified signal appearing at this point is symmetrical...having equal positive excursions for each half cycle of the input waveform.

**2. Threshold Trim:** This pot adjusts the accuracy of the threshold setting, with respect to the markings on the front panel. It may be adjusted as follows:

- Set the controls for: RATIO = CCW, THRESHOLD = -40dB (CW), GAIN = 48dB (CW), ATTACK = .2msec (CCW), RELEASE = .05 sec (CCW), MODE = IN.
  - Apply a 1KHz sine wave, at a level of -40dBv (7.75mv RMS) to the input.
  - Adjust the THRESHOLD TRIM exactly to the point where the Gain Reduction LEDs begin to swing downward, indicating gain reduction.
- 3. Ratio Trim:** This pot calibrates the accuracy of the RATIO CONTROL at its extreme CW position (Inf:1). It may be adjusted as follows:
- Set the controls as in 2a, except set the RATIO CONTROL to Inf:1 (CW).
  - Apply a 1KHz sine wave to the input, at an initial level of -30dBv. (10dB of Gain Reduction should now be indicated.)
  - With some metering device on the output (VU meter, etc.), adjust the GAIN CONTROL for a convenient reading (0VU, etc.).
  - While varying the sine wave input signal between -30dBv and +20dBv, adjust the Inf:1 TRIM for minimum change in the

output metering device. The Gain Reduction LEDs should reach the 50dB indication at an input signal level of about +10dBv.

### 5.2 VCA ADJUSTMENTS

**1. Control Rejection:** This adjustment trims for minimum feedthrough of the control signals into the audio output. It may be adjusted as follows:

- Set the controls as in 2a above, except place the MODE SWITCH in EXT position.
- Apply a very low frequency sine wave (i.e., 10Hz) to the EXT SIGNAL INPUT.
- Ground the normal SIGNAL INPUT.
- Adjust the osc. signal level and/or the THRESHOLD CONTROL such that as much motion as possible occurs on the Gain Reduction LEDs.
- While monitoring the device output with an oscilloscope, adjust the CONTROL REJECTION TRIM for minimum output voltage. (Should be less than 20mv.)

**2. VCA Unity Gain Distortion Trim:** The trim adjusts the VCA for minimum distortion at the unity gain point. A distortion analyzer (either THD or IMD) is required for proper adjustment. Use the following procedure:

- Place the Gain Brain II in "OUT" position.
  - Set the GAIN CONTROL to 0dB.
  - Apply a test signal from the distortion measuring equipment to the device input. (1KHz if using THD.)
  - Adjust the level of the test signal so that the Gain Brain II output is +10dBv.
  - Adjust the trim pot for minimum distortion (under .01%).
- 3. VCA Gain/Loss Distortion Trim:** This trim adjusts for minimum VCA distortion at VCA gains (losses) other than unity. Use the same procedure as above, except set the GAIN CONTROL to about the 20dB setting, and lower the test oscillator level by about 20dB, to maintain a +10dBv Gain Brain II output level. Adjust this trim, also, for minimum distortion (under .01%).

## Warranty

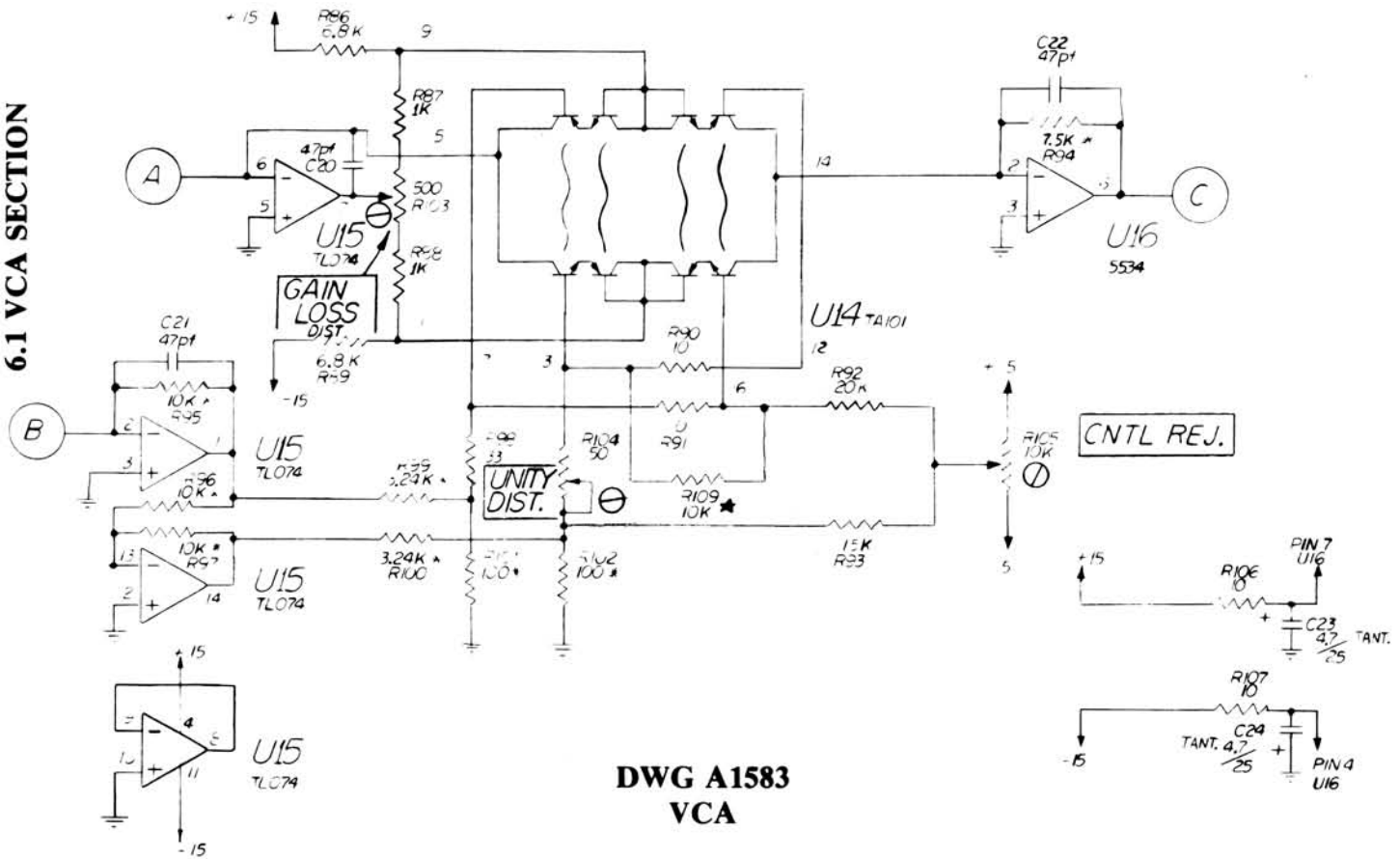
VALLEY INTERNATIONAL, INC. warrants its products and their related enclosures and power supplies to be free from defects in workmanship and material under normal use and service. Said warranty is to extend for a period of twelve months after date of purchase. In the case that a VALLEY INTERNATIONAL, INC. product or any of its related enclosures or power supplies is believed to be defective, same may be returned with transportation prepaid to VALLEY INTERNATIONAL, INC., within twelve months after date of purchase, accompanied by proof of purchase. If the product is found by VALLEY INTERNATIONAL, INC.'s inspection to be defective in workmanship or material, it will be repaired or replaced (at VALLEY INTERNATIONAL, INC.'s election) free of charge and returned, transportation prepaid, to any point in the United States. If inspection by VALLEY INTERNATIONAL, INC. of such products does not disclose any defect in workmanship or material, VALLEY INTERNATIONAL, INC.'s regular charges will apply.

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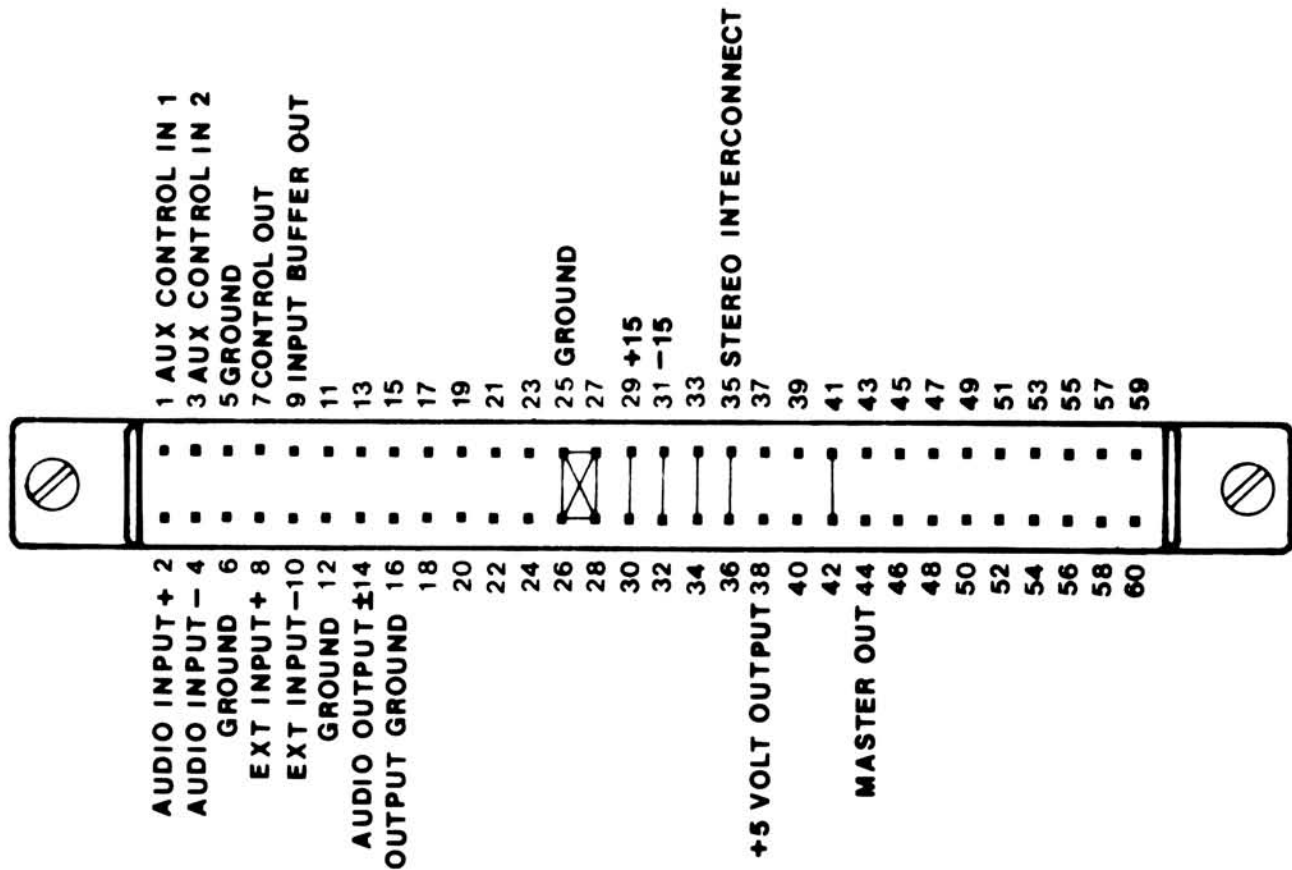
## 6. Illustrations

### 6.1 VCA SECTION



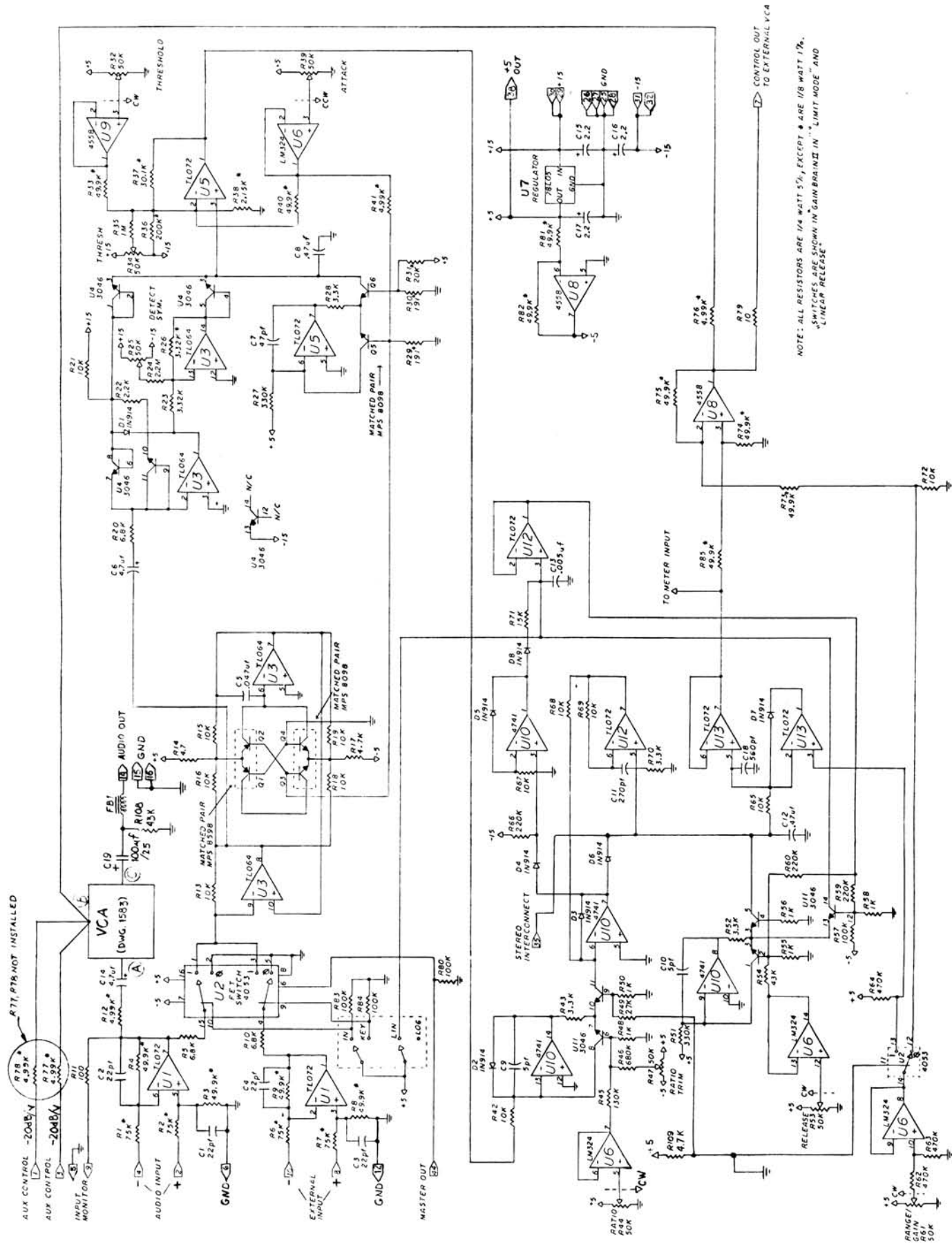
DWG A1583  
VCA

### 6.2 PIN OUT DIAGRAM

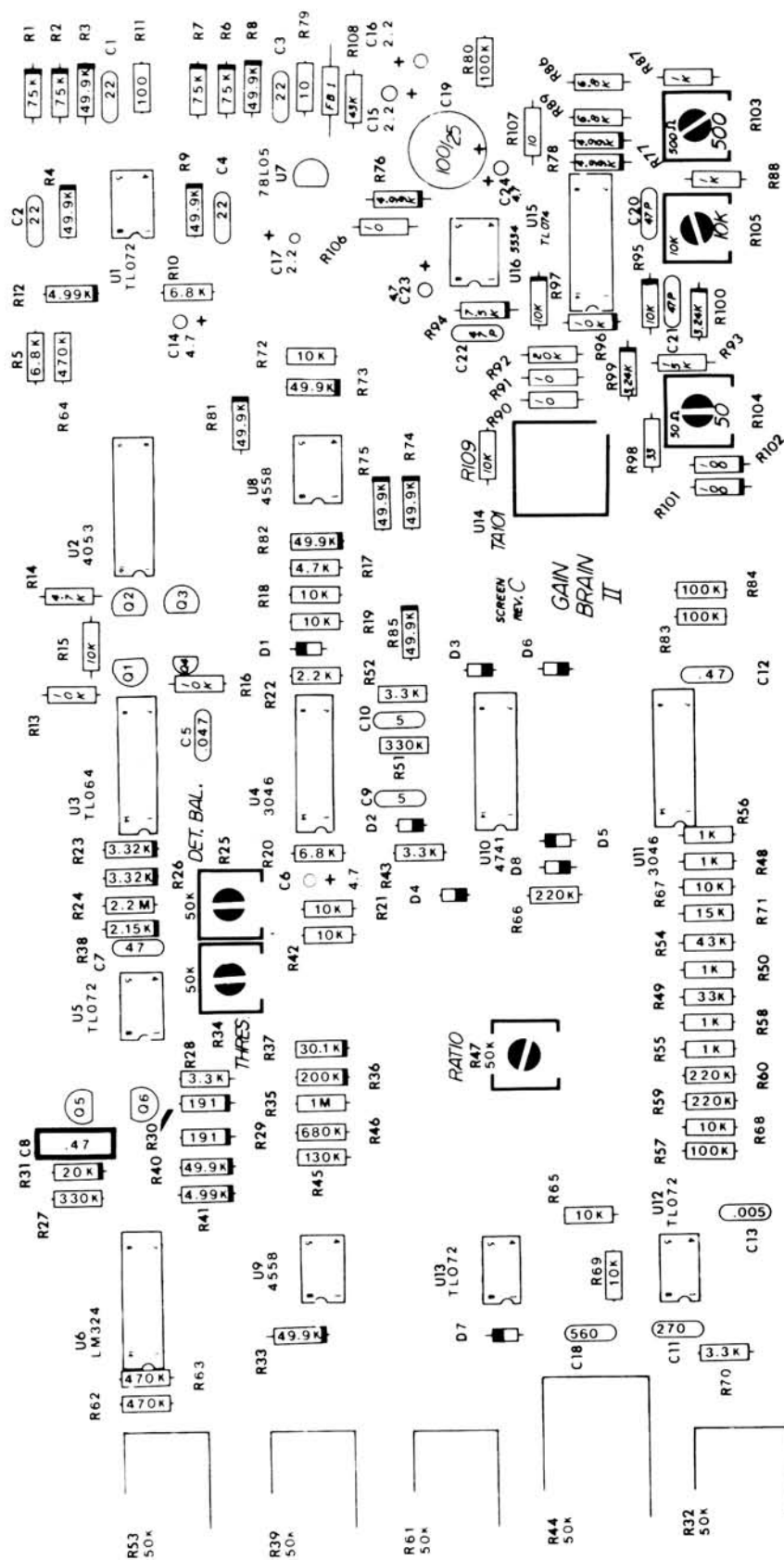




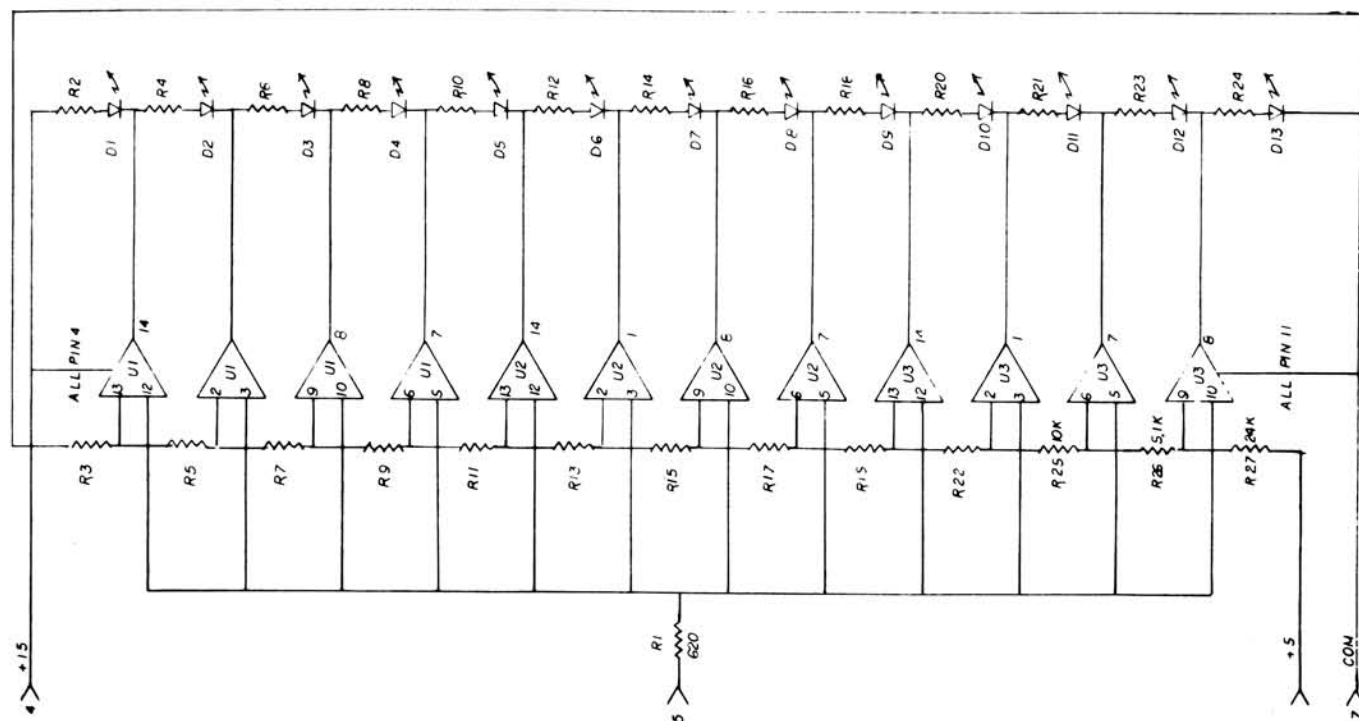
# 6.3 GAIN BRAIN II SCHEMATIC DRAWING



## 6.4 GAIN BRAIN II PARTS OVERLAY



# 6.5 METER BOARD



D1-D13 414P 1301  
R2-R24 1K  
U1-U3 LM324

