APPENDIX A:
System Description

The purpose of this Appendix is to provide the installing engineer with an overview of system design, to answer questions and deal with uncertainties about various unconventional aspects of the design, and to provide the service technician with a moderately detailed overview of the system.

Each card is numbered. Reference will be made in each section to the number of the card on which the described circuitry is located.

The paragraphs in **Appendix B (CIRCUIT DESCRIPTION)** that correspond with topics in this Appendix have identical numbers and titles in order to expedite access to further information on a topic of interest.

REFER TO THE BLOCK DIAGRAM (p. J-25)

Comparison With OPTIMOD-TV Model 8180A: If you are familiar with the 8180A, this section may help you become familiar with the 8182A more quickly.

The following changes were made:

-- The Loudness Controller was added in the #2 card slot.

-- Two Hilbert-Transform Clippers were added in slots #0 and #1, substituting for the clippers on Cards #8 and #9.

-- The compressor control card (#5) was modified to accept control current from the Loudness Controller card, and to provide a choice of LINear or EXPonential compressor release shape. The circuit was also modified so that both Master and Bass bands gate to "0" on the G/R meter regardless of the setting of the BASS COUPLING control.

-- The Preemphasis/HF Limiter Card (#6) was modified to enable easy routing of the signal through the Hilbert-Transform Clipper cards. In addition, its LIMITER PROOF/OPERATE circuit was modified to defeat the distortion-cancelled clippers on Cards #8 and #9 by forcing them into PROOF mode whenever the Hilbert-Transform Clippers are in use. (The Hilbert-Transform Clipper functionally replaces the clippers on Cards #8 and #9. However, when the appropriate jumpers are moved according to instructions in **Emergency Bypass Of Cards #0 And #1** in **Appendix F,** the Hilbert-Transform Clipper cards can be removed for servicing, yet the OPTIMOD-TV system can still remain in service. In this case, the simpler distortion-cancelled clipping system on Cards #8 and #9 is re-activated.)

-- Cards #8 and #9 have been modified with jumpers so that they can be configured to serve as the crossover for the Hilbert-Transform Clippers (their normal function), or so they can serve as distortion-cancelled clippers (as in the 8180A), permitting the Hilbert-Transform Clipper cards to be removed for servicing if necessary.

-- Wiring has been added to the backplane and input filter card to permit remote control of the Loudness Controller OPERATE/DEFEAT function.

-- The Noise Reduction Port (Accessory Port #1), optional in the 8180A, is supplied standard in the 8182A and provides an interface to the Orban 8182A/SG BTSC Stereo Generator. The wiring has been substantially changed.

-- The rear-panel NORM/TEST switch (essentially an artifact of the 8100A) has been reconfigured to bypass Accessory Port #1 if desired, maintaining continuity of the signal path if the Orban 8182A/SG is not connected to the Port.

-- A matrix has been added to the Output Amplifier Card (#7) to supply optional L+R and L-R sends to the stereo generator. (If the Orban 8182A/SG Stereo Generator is in use, L+R/L-R sends are mandatory.)

The text below describes the 8182A:

1.a) Input Amplifier: (on Cards #3 and #4)

The audio is applied to an RFI suppression network and pad, the latter strappable for 0 or 20dB attenuation. The RFI-suppressed audio is then applied to a low-noise true instrumentation amplifier, whose "+" and "-" inputs are symmetrical and high impedance. The gain of this amplifier is adjustable from 0.88 to approximately 10.5 (a 21.5dB range). If this range does not yield the desired amount of gain reduction, the input pad should be restrapped.

In order to avoid distortion due to imperfections in the large-value coupling capacitors that would be necessary, the input is DC-coupled. Therefore, only small amounts of differential DC should be applied to the input. Ordinarily, the input is fed by the output of a transformer or capacitively-coupled amplifier, and no difficulty should arise. Slight amounts of DC offset are eliminated in the 30Hz highpass filter following the input amplifier.

1.b) 30Hz Highpass Filter: (on Cards #3 and #4)

The output of the input buffer is applied to a third-order Chebychev highpass filter with 30Hz cutoff frequency (0.5dB down) and 0.5dB ripple. This filter is not conveniently bypassable. It was felt that the advantages of this filter (i.e., elimination of modulation-wasting subsonic energy from stage rumble and other sources, elimination of subsonic energy's introducing distortion by modulating the compressor control voltages, and prevention of destabilization and/or distortion introduction in exciters' AFC's) merited the filter's inclusion as a standard part of the system.

The cutoff frequency of the filter is sufficiently low that the only commonly-found musical instrument producing lower fundamental frequencies is the pipe organ. Most records cut off at 30Hz, and no rock-and-roll instruments have fundamentals below 40Hz.

The ringing introduced by the filter is insignificant. The ear is very insensitive to ringing in this frequency range. Further, the ringing is comparable to that introduced by a well-designed vented box loudspeaker with 30Hz cutoff.

If there seems to be an on-air problem with bass response, please don't blame this filter! First investigate such problems as obviously measurable bass rolloff in the chain up <u>to</u> OPTIMOD-TV, excess numbers of transformers in the audio chain, non-linear group delay in phone lines, and rising bass harmonic and IM distortion at program levels (which are, in general, at least 14 dB higher than tone level at "0" VU). The 30Hz highpass filter does <u>not</u> cause significant loss of bass "tightness", and certainly does not introduce "thinness".

1.c) Allpass Phase Scrambler And Preemphasis/Deemphasis (on Cards #3 and #4)

The TV aural carrier has symmetrical positive and negative overload points (±100% modulation). Some music, and voice in particular, have highly asymmetrical waveforms. Therefore, maximum loudness and minimum distortion consistent with the overload constraints of the TV aural carrier are achieved by processing waveforms to make their peaks more symmetrical.

In OPTIMOD-TV this is achieved by a combination of the crossover network in the master/bass multiband compressor and a third-order non-minimum-phase filter. This crossover is 12dB/octave, and when its outputs are summed, it provides a single-order phase shift to complete the phase scrambler function.

The frequency response of the second stage of the phase scrambler is slightly peaked, and provides preemphasis into the multiband compressor to improve its accuracy. A deemphasis stage after the bands are summed restores flat response.

The phase scrambler is a low "Q" circuit which does not introduce ringing. Its audible effect is extremely subtle. It can be heard as a very slight change in the "sound" of some voices. Music, in general, is audibly unaffected. Despite the fact that square waves emerging from the scrambler no longer look like square waves, the purist should not fear that it is degrading audio quality. It is in fact significantly improving subjective distortion performance of the system.

2.a) Dual-Band "Master/Bass" Compressor:
(audio on Cards #3 and #4; control on Card #5)

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The major part of the 8182A compressor is the "Master" channel. This carries all program material above 200Hz. It is a feedback compressor, and its control voltage can be summed in a dB-linear manner (U.S. patent #4,249,042) with the control voltage developed by the "Bass" compressor to control the gain of the "Bass" VCA, which passes frequencies between 30 and 200Hz.

The summation is variable from none at all (in which case the "Master" and "Bass" bands operate independently, as in a conventional triband compressor) to unity gain (in which case the "Bass" channel always takes as much gain reduction as the "Master" channel). In the latter "quasi-wideband" case, the feedback compressor control loop in the "Bass" channel is still active, and causes further gain reduction in the "Bass" VCA when program material with excessive bass energy is present. This avoids the pumping which would occur in a fully-wideband system if excess bass were to force gain reduction of the entire program.

We feel that operating the third band of a conventional triband compressor independently of the rest of the bands yields very unnatural high frequency response when auditioned on high quality receivers. In addition, operating the low frequency band independently may result in unnatural frequency balances with certain program material. For this reason, the multiband compressor in the 8182A is quite dissimilar to other triband units, and offers unprecedented versatility in combination with very natural, unfatiguing sound.

2.b) Crossover and Bass Clipper: (on Card #3 and #4)

OPTIMOD-TV employs a 12dB/octave crossover. The 12dB/octave configuration is simply two identical 6dB/octave filters in series, with the polarity of the "Bass" band inverted. It can be shown that the sum of the two outputs has a perfectly flat magnitude response, but exhibits an overall phase shift. This phase shift is purposely used as part of the "phase scrambler" to make peaks more symmetrical.

In OPTIMOD-TV, this crossover is realized as a "distributed crossover" (U.S. patent #4,249,042). This means that the first 6dB/octave section is before the VCA, and the second 6dB/octave section is after the VCA and the control voltage rectifier. The control voltage circuitry is therefore fed from a 6dB/octave crossover only.

The advantage of this configuration is that it permits insertion of a soft clipper immediately after the "Bass" VCA to eliminate overshoots which would otherwise intermodulate with the output from the "Master" VCA when the sum of "Bass" and "Master" is preemphasized and clipped. The second part of the "Bass" crossover is after the "Bass" clipper, thus lowpass-filtering the clipper output and rolling off harmonics and out-of-band IM introduced by the clipping process. In-band IM is negligible because of the relatively narrow bandwidth processed by the "Bass" channel.

The sum of the "Bass" and "Master" channels is applied to a deemphasis network to "undo" the preemphasis introduced in the phase scrambler circuitry (see **1.c)**

2.c) Voltage-Controlled Amplifier (VCA) Operation:

The voltage-controlled gain block used throughout OPTIMOD-TV is a proprietary Class-A VCA which operates as a two-quadrant analog divider with gain inversely proportional to a current injected into the gain-control port. A specially-graded Orban IC contains two matched non-linear gain-control blocks with differential inputs and current outputs. The first of these is employed in the feedback loop of an opamp to perform the gain control function. The inputs of the first and second gain-control blocks are connected in parallel, and the output of the second block is a distortion-corrected current which is transformed into the desired gain-controlled voltage by means of an opamp current-to-voltage converter. For most gains, levels, and frequencies, THD is well under 0.1%.

Overload-to-noise ratio (noise measured in a 20-20,000Hz band) is typically 90dB, and is constant with respect to gain and level.

2.d) Compressor Control Circuitry: (on Card #5)

Each compressor (left and right "Master" and left and right "Bass") feeds its own rectifier with threshold. The drive to the clippers following the compressors and preemphasis/high-frequency limiters is determined by the setting of the CLIPPING control, which simultaneously adjusts all rectifier thresholds (and thus the average compressor output level). Left and right rectifier pairs (which have current-mode high-impedance outputs) are "OR"ed into individual timing circuitry for "Master" and "Bass" channels.

This timing circuitry is proprietary, and is located within sealed modules. The "Master" timing circuitry is most critical to achieving natural sound. It performs the following functions:

1) A peak limiting function with very fast recovery time for transient material;

2) A slower compression function whose recovery time is a function of gain reduction; and,

3) A recovery-delay function which provides extra smoothing of the gain control voltage to avoid low frequency distortion even with fast release times.

The recovery time of the compression function is adjustable in the "Master" band only by means of the RELEASE TIME control. In addition, a gating circuit slows the recovery time of the compression function if the input program level drops below a threshold adjustable by the GATE THRESHOLD control, thus preventing "noise swish-up" during pauses or during low-level material. In GATED mode, recovery occurs toward -10dB gain instead of 0dB, thus avoiding noise pump-up on very noisy material like 16mm optical sound tracks.

The "Bass" timing circuitry is similar to the "Master" timing circuitry, and performs all of the same functions. Its time constants are optimized for most natural, dynamic sound.

Both timing circuits process the signal in logarithmic form, and have low-impedance outputs. The timing circuits drive exponential converters which provide control-current outputs for the "Master" and "Bass" VCA's. The BASS COUPLING control provides the ability to sum a controlled amount of the "Master" timing circuit output into the "Bass" exponential converter, where it sums with the output of the "Bass" timing circuit in a dB-linear manner.

Extensive gain reduction metering is provided. Since the outputs of the timing circuits are dB-linear, the gain reduction meters are provided with dB-linear scales.

The output of the "Master" timing module is applied to a peak detector which "holds" the fast-limiting component of the control voltage until the gain reduction meter ballistics have a chance to "catch up". The output of this peak detector drives the "Master" gain reduction meter, which shows the true peak value of the gain reduction.

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The output of the "Master" timing module also drives a slewrate-limited amplifier which removes the fast limiting spikes from the voltage, and which drives the "compressor" meter to show the amount of slow compression occurring.

By subtracting the output of the slewrate-limited amplifier from the peak detector, the fast peaks only are derived. This difference signal feeds the "Limiting" meter.

The output of the "Bass" timing circuitry contains a much smaller fast peak limiting component than does the output of the "Master" timing circuitry. No peak detection is necessary to assure accurate metering, and the output of the "Bass" timing circuitry thus drives its gain reduction meter directly.

Except for the "Limiting" meter, all G/R meters are calibrated from -15dB to +10dB gain reduction. "0" thus corresponds to the normal gain of the system in its quiescent, gated state. In this state, the VCA gains are in fact 10dB below maximum.

The LIMITING meter is calibrated from 0 to 5dB for best resolution. When the RELEASE TIME control is operated in the slow part of its range, the LIMITING meter will ordinarily show little activity. However, as the release time is speeded up, the LIMITING meter will become more active, typically reading full-scale on transient material.

3) **Phase-Corrected Lowpass Filter/Preemphasis:** (on Card #6)

After the outputs of the "Master" and "Bass" channels have been summed, they are passed to a filter which performs three functions:

1) It lowpass-filters the signal at 15kHz and 24dB/octave to prevent frequencies beyond the bandwidth of the system from unnecessarily activating the high frequency limiter or causing unnecessary IM distortion in the clipper;
2) It provides a standard preemphasis (75us or 50us, depending on region); and,
3) It provides phase correction to make the delay of the lowpass filter plus preemphasis approximately constant, thus minimizing the unavoidable increases in peak level resulting from the preemphasis and filtering functions.

The lowpass filter is designed to partially equalize the frequency response variations in the main 15kHz lowpass filter following in the peak limiting system, thus providing flatter overall frequency response. The preemphasis is created by summing a second-order bandpass filter with the flat signal. The rising side of the filter slope provides the preemphasis; the falling side provides part of the lowpass filter function. The phase corrector is a fourth-order allpass filter, and is physically placed before the lowpass filter and preemphasis.

4) **High Frequency Limiter:** (on Card #6)

In order to perform the high-frequency limiter function, a variable-gain stage is placed between the output of the bandpass filter creating the preemphasis (see 3 immediately above) and the amplifier which sums the bandpass filter output with the main signal. Thus high frequency limiting is effected by dynamically reducing the preemphasis as required.

The variable gain stage is realized by a junction FET operating as a voltage-controlled resistor, instead of by a VCA as in other processing functions within OPTIMOD-TV. This simplification is possible because the high frequency limiters in the left and right channels are entirely independent, and need not track accurately together.

Each channel has its own rectifier and timing module. The timing in the high-frequency limiter is considerably simpler than in the compressor sections because only fast dynamic filtering occurs; there is no "compression" function.

It should be noted that the OPTIMOD-TV high-frequency limiter is activated by high frequency energy only. The high-frequency limiter therefore cannot be activated by, for example, low frequency overshoot components from the previous multiband compressor. This design is possible because OPTIMOD-TV's peak limiting system permits considerably greater amounts of clipping than other clipping schemes without introducing audible distortion, thus rendering the high-frequency limiter function far less critical and permitting substantial increases in perceived high frequency power output. The high-frequency limiter need not "know" about the actual peak level of the preemphasized signal -- only approximately how much HF energy is present.

An HF LIMITING control available to the user adjusts the threshold of high-frequency limiting over a range of approximately 3dB. The lowest threshold results in very little clipping on sinusoidal tone; the +3dB threshold results in moderate clipping of tone above approximately 2kHz. In most cases, users prefer operating this control in full "hard", which moves the threshold to the "+3dB" point and results in minimum high-frequency limiting and maximum high frequency control by clipping, while still limiting high frequency energy which would otherwise cause disturbing distortion if it were clipped.

Operation of the high-frequency limiter is metered by a simple comparator circuit which lights the appropriate front-panel high-frequency limit lamp if any high-frequency limiting at all occurs. It is primarily useful to verify that the high-frequency limiter circuit is operating properly.

5) **Peak Limiting System:** (on Cards #0, #1, #8, and #9)

The OPTIMOD-TV peak limiting system (U.S. Patent #4,495,643) is a complex "computed clipper" using distortion-cancelling techniques similar to those used in other Orban second-generation processors.

Basic peak limiting is provided by the exclusive Orban "Hilbert-Transform Clipper". This circuit (which is explained more fully below) behaves like an SSB RF clipper below 4kHz, and like a conventional hard audio-frequency clipper above 4kHz. An RF clipper produces no harmonic distortion -- only IM. Thus no harmonic distortion is produced in the voice frequency range below 4kHz, and voice (which is far more degraded by harmonic than by IM distortion) is processed as cleanly as possible.

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Conversely, above 4kHz the circuit produces more harmonic and less IM distortion, minimizing difference-frequency IM and yielding minimum degradation of vocal sibilance and music with substantial high frequency content.

A further crossover function (essentially unrelated to the change in behavior at 4kHz) eliminates almost <u>all</u> distortion of any type below 2.2kHz at the expense of a certain amount of overshoot. Overshoot is dealt with in the subsequent FCS Overshoot Compensator.

It should be noted that it is normal for sinewaves to modulate less than 100% when applied to OPTIMOD-TV in its normal OPERATE mode. There are two principal reasons for this:

1) Some headroom is left between the threshold of the peak limiting system and the threshold of the subsequent overshoot corrector in order to accomodate overshoots. With sinewaves, no overshoots are produced. Thus, the headroom is not used, and full 100% modulation is not produced.

2) Sinewaves have a very low peak-to-average ratio and high loudness potential compared to program material of identical peak levels. The audio processing, in order to maintain natural sound quality, pushes sinewaves down in level as it would any other similar program material with low peak-to-average ratio. In general, any audio processor which produces 100% modulation on sinewaves tends to sound somewhat unnatural because this psychoacoustic factor has not been accounted for.

5.a) Clipper With Dynamic Threshold: (on Cards #8 and #9)

(**NOTE:** This clipper is ordinarily disabled when the Hilbert-Transform Clipper is operative. The clipper described below is used in OPTIMOD-FM Model 8100A and in the older OPTIMOD-TV Model 8180A. By moving jumpers, it is possible to re-activate this circuit in an emergency situation requiring removal of the Hilbert-Transform Clipper cards for service. Therefore, for the sake of completeness this description is included.)

The clipper is a straightforward shunt clipper which is ordinarily biased with ±1.5 volts, thus providing a somewhat "soft" characteristic (but not nearly as soft as a pair of back-to-back unbiased diodes). The characteristic was chosen to obtain the best compromise between harmonic and IM distortion induced by clipping, when the IM-cancelling circuitry is considered.

The output of the bandpass filter in the high frequency limiter [see (4) above] feeds a rectifier with threshold. When high frequency energy exceeds this threshold, the clipper bias voltage is reduced to reduce the clipping threshold by approximately 1.0dB. The purpose of this threshold reduction is to provide headroom between the clipper threshold and the subsequent overshoot corrector threshold. This headroom accomodates the distortion corrector signal (see **5.c** below) which is needed to correct the IM distortion produced when large amounts of HF energy are clipped. If this headroom were not provided, the overshoot corrector would clip off the distortion corrector signal, thus negating its effect. On the other hand, when the input signal to the clipper contains predominantly low frequency energy, the distortion corrector loop is essentially ineffective. In this case, the absolute amount of clipping is minimized by raising the clipping threshold to approximately the threshold of the overshoot corrector.

5.b) Hilbert-Transform Clipper: (on Cards #0 and #1)

The input signal to be peak-limited is split into two paths. The main path consists of a chain of phase-shift networks while the second path consists of a chain of phase-shift networks cascaded with a sharp 4kHz lowpass filter. The two chains are designed so that the phase difference between their outputs is 90 degrees from 30Hz to 4kHz.

The outputs of the two chains are applied to a vector sum generator which computes the square root of the sum of the squares of the two outputs. The output of the vector sum generator is applied to the control ports of two VCA's: directly to a "high-frequency" VCA, and through a delaying lowpass filter to a "low-frequency" VCA. The output of the main phase-shifter chain is applied directly to the audio input of the HF VCA, and through a lowpass filter to the audio input of the LF VCA. Thus the control voltage and audio to the LF VCA are both delayed equally.

If a sine wave below 4kHz is applied to the input of the Hilbert-Transform Clipper, the output of the vector sum generator is ideally DC without ripple, the control voltage to the VCA's is constant, and no distortion is produced by the action of the VCA's. However, when more complex waveforms are applied, ripple does occur in the control voltage, producing IM distortion (but no harmonic distortion). (Due to approximations in the design of the phase shifters, the actual THD produced on sinewave is typically 1-2% up to 10dB clipping.)

It can be shown that the output of the HF VCA is accurately peak-limited without overshoots regardless of its input spectrum, provided only that the phase difference between the inputs to the vector sum generator is 90 degrees over the frequency range in which both chains have substantial output energy (i.e., below

4kHz). However, the control voltage to the LF VCA is smoothed by the lowpass filter prior to its control port. Accordingly, little or no audible distortion is produced by this VCA, but smoothing its control voltage does cause some overshoots in its output.

. The output of the LF VCA contains only low frequencies, while the output of the HF VCA contains the full spectrum. As will be seen below, the output of the HF VCA is applied to a constant-delay 2.2-15kHz bandpass filter whose delay is identical to the delay of the audio lowpass filter prior to the LF VCA, as well as to the delay of the LF VCA's control-voltage lowpass filter. Thus summing the output of the LF VCA with the filtered output of the HF VCA results in a full frequency-range peak-limited signal with all frequencies arriving at the output at the same time, accurately preserving the peak-limited waveform. (Some overshoots are produced by the 2.2-15kHz bandpass filter as well as by the LF VCA, as discussed above. These are eliminated in the subsequent FCS Overshoot Compensator.)

This final signal contains essentially no distortion below 2.2kHz (the signal in this band being supplied by the LF VCA, whose output is distortion-free), only IM distortion between 2.2 and 4kHz, and both IM and harmonic distortion above 4kHz, where receiver deemphasis is in full force to reduce the audible effects of such distortion.

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5.c) 15kHz Phase-Corrected Bandpass Filter: (on Cards #8 and #9)

The output of the HF VCA is applied to a 15kHz constant-delay bandpass filter. This filter cuts off sharply above 15kHz, primarily to remove harmonics generated by the Hilbert-Transform Clipper. (Bear in mind that the unclipped signal was already filtered in the preemphasis lowpass filter.)

The bandpass characteristic is generated by applying the output of the HF VCA to two lowpass filters with cutoffs of 15kHz and 2.2kHz. The output of the 2.2kHz lowpass filter is subtracted from the output of the 15kHz lowpass filter to eliminate energy below 2.2kHz from the difference signal, creating a 2.2-15kHz bandpass characteristic. The 15kHz lowpass filter includes an allpass phase equalizer to achieve approximately constant delay, minimizing overshoot. The 2.2kHz lowpass filter is designed to have delay identical to that of the 15kHz lowpass filter in the 0-2.2kHz band so that most effective cancellation can occur in the subtraction process.

The 2.2-15kHz bandpass filter forms a constant-delay crossover network when summed with the output of the lowpass filter prior to the LF VCA: The summed output is equivalent to a constant-delay 15kHz lowpass filter.

6) Frequency-Contoured Sidechain (FCS) Overshoot Compensator:
(on Cards #8 and #9)

The FCS Overshoot Compensator (patent pending) is best thought of as a "bandlimited safety clipper". That is, it performs the function of clipping off overshoots from the earlier peak limiting system, but does not produce out-of-band frequency components as a simple clipper would. If such components were produced, they would cause "aliasing distortion" when applied to a (future) stereo generator and then decoded in a stereo receiver. Simultaneously, the FCS Overshoot Compensator does not significantly increase low frequency IM products when compared to a simple clipper performing the same function -- a problem particularly characteristic of competing overshoot compensation circuits.

Briefly, the FCS Overshoot Compensator functions by deriving the overshoots from its input with a "center clipper" circuit, lowpass-filtering the overshoots with a fifth-order passive LC filter to remove out-of-band frequency components, and then mixing the filtered overshoots out-of-phase with a delayed version of the input signal. This delay, created by an encapsulated active allpass network, is identical to the delay in the overshoot filter, thus assuring that the input signal and filtered overshoots arrive in the same place at the same time.

If no filter were used, this process would be identical to clipping the input signal, and would create a "differential clipper". However, the overshoot filtering process reduces the peak level of the high frequency components of the overshoot by removing harmonics. To compensate for this loss of peak level (which would cause less than full cancellation of overshoot), the frequency response of the overshoot filter rises at 15kHz -- thus increasing the level of the high-frequency fundamental to compensate for the loss of harmonics. This is why the system is called "Frequency-Contoured Sidechain".

The final sum of input and out-of-phase filtered overshoot is passed through a third-order lowpass filter to provide further attenuation of unwanted high frequency energy. Phase correction is applied to the combination of this filter and the overshoot filter. (The phase response of the overshoot filter is identical to its matched main-path delay network -- thus the phase correction also corrects the response of the main-path delay network.) This phase correction makes the overall time delay through the entire FCS Overshoot Compensator approximately constant, and assures that the various filters within the compensator do not upset carefully controlled peak levels in unpredictable ways.

If any very unusual waveforms cause residual overshoots, these are dealt with in a safety clipper at the output of the FCS Overshoot Compensator system. However, the basic circuit is so effective that this safety clipper is rarely active.

7) Balanced Line Amplifier and Deemphasis: (on Card #7)

The line amplifier is totally straightforward. It consists of a pair of inverting opamps. These are 5532 devices which can drive 600 ohm loads directly. The feedback resistor of the first opamp can be shunted by a capacitor (selected by a plug-in jumper) to effect deemphasis if desired.

The second opamp is a unity-gain inverter driven by the first opamp. The outputs of the two opamps thus provide an output balanced to ground which drives a non-overshooting EMI filter to interface to the outside world. The balanced driving capability of the circuit is approximately +20dBm into 600 ohms.

8) Power Supplies:

Primary power for the OPTIMOD-TV circuitry comes from a highly regulated ±15 volt power supply. The main supply is +15 volts. This is controlled by means of a 723C IC regulator with current-boosted output, current limiting, and overvoltage protection using a zener diode and fast-blo fuse.

The -15 volt supply is essentially a current-boosted opamp in a unity-gain inverting configuration which "amplifies" and inverts the +15 V supply, thus "tracking" it. The -15 volt supply is also current-limited and overvoltage protected. Both +15 and -15 supplies are located on a non-plug-in card mounted on the inside of the rear chassis apron. This apron is also used as a heat sink for the regulator power transistors.

Bias sources are required for the diode clippers in the audio processing. There are two such sources; the first creates approximately ± 1.2 volts (for Cards #3 and #4), while the second creates ± 4.2 volts (for Cards #8 and #9). Both sources employ a pair of opamps. The first is a unity-gain voltage-follower whose input is a temperature-compensated voltage created by a resistor/diode network; the second is a unity-gain inverter which creates the complementary negative voltage.

9) **Loudness Controller:** (on Card #2)

The subjective sensation of loudness is complex and is not readily measurable by simple electrical means. No common meter, whether PPM, VU, or true RMS, provides a good correlation to subjective loudness because loudness perception is a function of several factors:

1. The sensitivity of the ear as a function of frequency;
2. The spectral distribution of the sound energy (a given amount of energy spread out over a wide frequency range sounds louder than the same amount of energy located within a third-octave frequency band); and,
3. The duration of the energy.

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The Loudness Controller estimates the subjectively perceived loudness of a given piece of program material. If the loudness exceeds a certain threshold, the Loudness Controller produces an output current which is applied to the "Master" timing module on card #5, causing gain reduction to occur above and beyond that ordinarily produced by the compressor control circuitry. In this way, the Loudness Controller "takes control" of the gain reduction circuitry until the loudness is reduced below a preset threshold.

This gain reduction ordinarily occurs within 50-100ms, depending on how much extra gain reduction is required in a given case. While this action effectively reduces or eliminates viewer annoyance due to excessively loud commercials in most instances, it can also reduce the impact of certain dramatic sound effects in entertainment programming. The controller is thus defeatable either manually or remotely by means of optically-isolated terminals on the rear panel. Both the local Loudness Controller OPERATE/DEFEAT switch and the corresponding terminals on the rear panel interface with a CMOS flip-flop which latches to determine the state of the Loudness Controller. An internal strap determines whether the Loudness Controller is initialized in OPERATE or in DEFEAT mode upon power-up.

The Loudness Controller works by dividing the audio into seven frequency bands, rectifying their outputs, summing the rectified outputs together with different gains, applying the sum to a thresholding device (to determine at what point the Loudness Controller begins to act), and finally applying the weighted, thresholded sum to the "Master" timing module.

Factor (1) (above) is taken into account by choosing the weighting of the bands such that the summed output from the bands (after rectification) follows the 70 phon equal loudness curve as determined by psychoacoustical research at CBS Technology Center.

Factor (2) is taken into account by summing the outputs of the bands after rectification, thus eliminating phase cancellation effects and causing the output current to increase as the signal is "spread out" into more and more bands.

Factor (3) is taken into account by integrating the Loudness Controller output current inside the "Master" timing module with the correct time constant.

The Loudness Controller can be operated either from the system output (Cards #8 and #9), or from the output of the Dual-Band Compressor (Cards #3 and #4). Operation from the Card #8/#9 output achieves maximum accuracy because the effects of HF limiting and peak limiting are accounted for. In this mode, deemphasis must be applied to the Loudness Controller's input because the Card #8/#9 output is preemphasized.

Operation from the Card #3/#4 output is required when the system is operated in the split-chassis configuration since, in this case, the main system outputs are not available to the Loudness Controller card (which is located in the Accessory Chassis at the studio). However, if the system makes any errors in the split-chassis mode, it will be in the direction of slightly excessive loudness reduction, which should not cause any problems. (Because the output of Card #3/#4 are not preemphasized, no deemphasis of the Loudness Controller input is required in this case.)

All filters within the Loudness Controller are bandpass, each consisting of a third-order lowpass filter cascaded with a third-order highpass filter. (The top band uses a second-order lowpass filter instead of a third-order).

Rectification and further processing occur in "current mode". This makes troubleshooting somewhat challenging, because the usual signal voltages do not exist: the control signal is in the form of a current (which is much more difficult to observe with common bench instruments). **Appendix D (Field Audit Of Performance Procedure)** describes tests to determine if the Loudness Controller is working properly.

If servicing of the Loudness Controller is necessary, the OPTIMOD-TV system will function without degradation (except for loss of the Loudness Controller function) if Card #2 is simply removed from its slot -- no jumpers need be moved or other adjustments made.

This concludes **APPENDIX A (SYSTEM DESCRIPTION).**

APPENDIX B:

Circuit Description

The following section provides an extremely detailed description of the circuitry used in OPTIMOD-TV on the component level.

It may be wise to read **Appendix A** first, and to consult the block diagram on p. J-25. Referring to the appropriate Schematics and Parts Locator Drawings in **Appendix J** will help you to follow the text and will aid component-level troubleshooting.

In those cases where the circuitry is duplicated in the left and right channels, only the left channel circuit and component designators will be discussed.

1.a) Input Amplifier: (on Cards #3 and #4)

The input is applied to the RF filter chamber, and there encounters an RF filter and 10K bridging pad R303, R304, R305. Strapping R305 into the pad introduces 20dB loss, which is the normal condition of the pad.

The output of the pad is connected to a low-noise true instrumentation amplifier consisting of IC301A, IC301B, IC302A, and associated resistors. R306, R307 provide bias current for IC301, which is a low-noise bipolar-input dual IC opamp. R308, R311 are feedback resistors for the two sections of IC301. The differential gain is controlled by the series resistance of R310 and GAIN control R309. The common-mode gain of the IC301 pair is 1.

The differential output of IC301A and IC301B is converted to a single-ended output and the common mode component of the output is nulled by means of differential amplifier IC302A and associated resistors. R316 adjusts the balance of the resistor network to assure maximum common-mode 60Hz rejection.

NOTE:

Nearby lightning strikes may induce sufficient energy into OPTIMOD-TV's audio input wiring to pass through the RFI protective networks and destroy IC301 or IC401. If OPTIMOD-TV is installed in a lightning-prone location, it is advisable to keep spare NE5532's in stock.

Installation of Varistors or other protective devices between each side of the audio input line and earth may help prevent such problems. (IC301 is socketed, and is thus easily replaced.)

1.b) 30Hz Highpass Filter: (on Cards #3 and #4)

The non-bypassable 30Hz highpass filter IC302B, C303, C304, C305, R317, R318, R319 is a third-order Chebychev filter with 0.5dB passband ripple (nominal) and a ripple bandwidth (i.e., -0.5dB frequency) of 30Hz. It is realized as a unity gain Voltage-Controlled Voltage-Source (VCVS) active filter. This filter is non-inverting, has a gain of exactly 0dB in the passband, and uses positive feedback to "sharpen up" the response around the cutoff frequency. Most modern books on active filters extensively discuss this type of filter. (See for example -- Wong and Ott: Function Circuits. New York, McGraw-Hill, 1976, pp. 230-231.)

1.c) Allpass Phase Scrambler and Preemphasis/Deemphasis: (on Cards #3 and #4)

This filter contains a single-order allpass filter IC303A, R320, R321, R322, C306 followed by a second-order non-minimum-phase peaking equalizer IC303B, R323, R324, R325, R326, R327, C307, C308. The phase response of the first section varies from 0 to 180 degrees as a function of frequency, while the phase response of the second section varies from 0 to 360 degrees as a function of frequency. The amplitude response of the first section is flat; the amplitude response of the second section is broadly peaked at approximately 200Hz.

To restore flat response, a complementary dipping-equalizer section is inserted after the two bands of the dual-band compressor have been recombined. This circuit consists of IC307A, R359, R360, R361, R362, R363, C319, C320. Its gain far from 200Hz is -1.76dB, and it exhibits a second-order dip centered at 200Hz.

2.a) Dual-Band "Master/Bass" Compressor (General): (on Cards #3, #4, and #5)

The dual-band compressor consists of an audio path and control circuitry. We will first discuss the audio path generally. Details of the VCA operation and control circuitry operation are found immediately below in sections **2.c, 2.d,** and **2.e.**

2.b) Crossover and Bass Clipper (on Cards #3 and #4)

The crossover consists of 12dB/octave sections. The first 6dB/octave filter is located before the VCA, the second after. Since the input to the control rectifiers is taken from the VCA outputs, the control-voltage crossover is 6dB/octave.

The first 200Hz highpass section for the "Master" compressor is filter C309, R328. The second 200Hz highpass section is C318, R357. The first 200Hz lowpass section for the "Bass" channel is R342, R343, C314. The second lowpass section for the "Bass" channel is R367, R366, R365, C321.

A clipper, consisting of biased diodes CR303, CR304, and resistors R367, R366, is located before the second lowpass section. Thus the second lowpass section rolls off harmonics created by clipping. (**NOTE:** This "distributed crossover with embedded clipper" system is protected by U.S. patent # 4,249,042.)

In order to force the "Master" and "Bass" channels to add correctly, the polarity of the "Bass" VCA is inverted by using the appropriate inputs of IC309B (compare with IC305B).

2.c) Voltage-Controlled Amplifier (VCA) Operation:

NOTE

> This section contains a general description of the voltage-controlled amplifier circuitry used through OPTIMOD-TV. The "Master" VCA will be specifically described.

The basic operation of the VCA depends on a precisely-matched pair of gain-control blocks with differential voltage inputs and current-source outputs. The gain of each block is controlled by means of a control current.

If used alone, one such gain-control block would introduce considerable distortion. Therefore, the first of the two matched blocks IC305A is used as the feedback element in a high-quality operational amplifier, IC304. The second of the matched blocks IC305B is then driven by the predistorted output of IC304. To provide more detail: The output of IC304 is first attenuated by R334, R335, C311, and then applied to the input of the feedback element IC305A. The output of IC304 is predistorted as necessary to force the current output of IC305A to precisely and linearly cancel the audio input into the "virtual ground" summing junction of IC304. This same predistorted voltage is also connected to the input of IC305B. Thus the output of IC305B is an undistorted current, which is converted to a voltage in current-to-voltage converter IC306A, R341, R376, C312. The output of IC306A is the output of the VCA.

Because IC305A is in the feedback loop of IC304, the gain of the VCA is inversely proportional to the gain of IC305A. Thus, if the control current is applied to the control port of IC305A (through R333), then the VCA behaves like a two-quadrant analog divider.

In the case of the "Master" VCA, a fixed current is applied to the control port of IC305B through R339, R340, CR301 to fix the gain of IC305B. CR301 provides temperature compensation.

Second-harmonic distortion is introduced by differential offsets in either IC305A or IC305B. This distortion is cancelled by applying a nulling voltage directly to the input of IC305B by means of resistor network R336, R337, R338.

If the VCA is not perfectly balanced, "thumps" due to control current feedthrough can appear at the output. These are equivalent to multiplying the control current by DC. If a correct DC offset is applied to the VCA input, then this equivalent DC multiplication can be nulled to zero and the "thumps" eliminated. Such an adjustable DC offset is provided by R331, R332.

B

R329, R330, C310 are frequency-compensation components to prevent the VCA from oscillating supersonically.

2.d) Compressor Control Circuitry: (on Card #5)

The output of the "Master" VCA is applied to a voltage in/current out fullwave rectifier-with-threshold, IC507A, IC505, R519, R520, R521, C503, CR503. This is essentially an opamp with discrete class-B output stage. A bias voltage of -12V on the "+" input of IC507A holds the voltage at this opamp's "-" input at -12V by feedback and provides appropriate bias conditions for the rectifier to prevent saturation. R521 determines the rectifier's transconductance. C503 provides DC blocking between the nominal ground potential of the input side of R521 and the -12 volts at IC507A's "-" input.

A negative-going voltage at the input side of R521 pulls current away from the "AC virtual ground" at IC507A's "-" input. An equal current must therefore flow into "-" input by turning on the NPN transistor whose base is connected to the output of IC507A. Because of the class-B biasing, this assures that the PNP whose base is connnected in parallel to the NPN is off.

A collector current essentially equal to the NPN's emitter current flows into the NPN from the output terminal of the rectifier. Part of this current comes from the rectifier load; part comes from the fixed collector current of the top PNP transistor. This PNP creates the threshold of limiting by saturating and diverting all class-B output stage collector current away from the load until the output stage current exceeds the nominal PNP collector current. When the output stage current exceeds the PNP collector current, the PNP comes out of saturation, and the difference between the PNP collector current and the rectifier output current is delivered to the rectifier's load. The PNP transistor's collector current is fixed by its emitter resistor R519, and by its base voltage (determined by the setting of the CLIPPING control, R560). The CLIPPING control thus varies the collector current of the PNP, and therefore the threshold of limiting. In PROOF mode, CR503 and R520 parallel R519, increasing the collector current, and raising the limiting threshold by approximately 14dB.

If the voltage at the input side of R521 goes positive, then the bottom PNP transistor turns on, and its neighboring NPN turns off. The collector current of the PNP is inverted by the dual NPN current mirror, and the current mirror output is summed into the output port of the rectifier, where it is also subject to the action of the PNP threshold transistor as described immediately above.

The output of the left "Master" rectifier is "OR"ed with the output of the right "Master" rectifier by means of two diode-connected transistors: Q506 & Q508. Because the output of each rectifier is in the form of a current, voltage drops across the "OR"ing diodes do not affect the accuracy of the rectifier. Any number of rectifier outputs could be "OR"ed to this point.

The output of the "OR" circuit is applied to a proprietary circuit which computes the VCA control voltage. Release time control for the slow "compressor" function is provided by R516, R515.

This "compressor" function may have either a LINear (release proceeds at a constant number of dB per second) or an EXPonential (release starts slowly, then speeds up) shape. Support for the EXPonential release shape is provided by IC503A, IC504, and associated circuitry. IC504 implements a sample-and-hold circuit which "remembers" the control voltage at the beginning of each new release cycle. The hold capacitor is C502, and the sampling switch is Q503. IC503A and associated circuitry detect each time attack current flows into the "Master" release time module from either the rectifiers-with-threshold or the loudness controller, and switch Q503 ON when this occurs, updating the sample-and-hold. (The details of how the sample-and-hold interfaces to the release time module are beyond the scope of this document.)

A JFET switch Q505 is provided to slow the compression release when ordered to do so by the gating circuitry (described immediately below). In the case of the "Master" compressor, a pair of resistors R517, R518 whose Thevenin equivalent voltage is approximately -3.2VDC is connected to one side of Q505. When Q505 is ON, these resistors are swamped out by a low impedance drive on the other side of the FET. When Q505 is OFF, these resistors pull a small current from the timing module, forcing the gain reduction voltage to move slowly towards -3.2V (corresponding to 10dB G/R).

The output of the control voltage module varies between 0 volts (maximum gain) and approximately -10 volts (minimum gain=maximum gain reduction). Thus release is inhibited by applying a voltage of greater than +10 volts to the anode of CR502 which forces Q505 off. Release is enabled by applying a voltage of less than -10 volts to the anode of CR502. This reverse-biases CR502, and Q505 is forced on by R514's forcing Q505's gate to be at the same potential as its source.

In the case of the "Bass" compressor, IC503B attempts to make the "Bass" VCA control voltage (as read on the TOTAL BASS G/R METER) follow the "Master" VCA control voltage (as read on the TOTAL MASTER G/R METER) by feedback. When the GATE is OFF (i.e., when Q505 and Q510 are ON), this feedback through R536 is turned off and has no effect because it is swamped out by a low impedance appearing on pin #2 of the "Bass" timing module. However, when the GATE is ON, Q510 goes OFF, closing the IC503B feedback loop. Under this GATED condition, the gain of "Bass" VCA quickly becomes equal to the gain of the "Master" VCA, and both bands eventually gate to -10dB ("0" on the G/R meter) as the "Bass" VCA follows the "Master" VCA by feedback through IC503B. (This occurs accurately regardless of the setting of the BASS COUPLING control, correcting a problem in the old 8180A in which the "Bass" band would only gate to -10dB if the BASS COUPLING control was adjusted fully "wideband".)

The output of the release time module is a low impedance voltage source. It is applied to exponential converter circuit IC501, IC502, R501, R502, C501 through pad R504, R505 and R506. The collector current of either matched transistor in IC502 is an almost perfect exponential function of its base-emitter voltage. The scaling factor of the converter is stabilized by forcing a constant current through the left-hand transistor by means of IC501. This current is determined by the current injected into IC501's "-" input through R502. The base of the left-hand transistor is grounded; the emitters of the matched transistors are connected. Thus, assuming a perfect match between transistors, the collector currents of the two transistors will be equal if the base of the right transistor is grounded. Varying the base voltage on the right-hand transistor varies its collector current exponentially about the nominal current in the left-hand transistor. This nominal current determines the quiescent (no gain-reduction) gain in the VCA's.

The current output at the collector of the right-hand transistor is connected to a matched pair of resistors, one of which feeds the gain control port of the left VCA, and the other of which feeds the gain control port of the right VCA. This is a "current divider" and is analogous to the familiar resistive voltage divider.

The operation of the "Bass" control loop is similar to the operation of the "Master" control loop. However, provision is made to mix "Master" control voltage into the input of the "Bass" exponential converter through BASS COUPLING control R533, and R530. When R533 is fully clockwise, the "Bass" exponential converter is being fed as much "Master" control signal as the "Master" exponential converter. In the absence of output from the "Bass" release time module, "Bass" and "Master" VCA's will thus track exactly.

Because the "Bass" rectifier is always connected to the output of the "Bass" VCA, exceptionally strong bass will exceed the threshold of bass limiting and cause an output from the "Bass" release time module, thus momentarily decreasing the gain of the "Bass" VCA below that of the "Master" VCA. This is the low-frequency equivalent of familiar high-frequency limiting.

(**NOTE:** The "multiband feedback compressor with crosscoupling into dB-linear VCA's" concept is protected by U.S. patent # 4,249,042.)

2.e) Gain Reduction Metering:

Gain reduction metering in the "Master" band is provided by three meters.

The first, TOTAL G/R, is driven by a peak detector IC516, R561, C512, CR516. C512 captures negative-going peaks and discharges slowly through R561. To avoid being loaded by the meter, C512 is buffered by voltage-follower IC516B. The discharge time of C512 is sufficiently slow to permit the mechanical movement of the TOTAL G/R meter to rise to the actual peak level of the gain control voltage, thus accurately displaying it.

COMPRESSION is indicated by passing the output of the release time module through a grossly overcompensated 301A opamp IC515 connected as a voltage follower. The 2.2uF compensation capacitor C511 so limits the slew rate of IC515 that only the slow component of gain reduction is permitted to drive the COMPRESSION meter.

The LIMITING meter is connected differentially between the outputs of IC515 and IC516B. It thus indicates the fast component of gain reduction as the difference between the slow component and the peak-held TOTAL component.

"Bass" band gain reduction metering reads the sum of the "Master" and "Bass" control voltages through R535, R534, in the same proportions that are applied to the input of the "Bass" exponential converter. In the interests of simplicity, the "Bass" TOTAL G/R metering signal is not electronically conditioned.

2.f) Gating Circuitry: (on Card #5)

The gating detector consists of a peak detector followed by a comparator. IC opamps are employed for both functions.

The left and right input signals are summed in R551, R552, and lowpass-filtered at 3kHz by means of C509. The lowpass-filtered sum is amplified by means of non-inverting amplifier IC508B, whose gain is variable from 0 to approximately 40dB by means of R550, the GATE THRESHOLD control. Low frequency response of IC508B is rolled off with C510 to prevent low-frequency noise from inhibiting the gate.

The positive peak output of IC508B is detected by CR512 and C504. R549 determines the recovery time of this peak detector.

The output of the peak detector is applied to comparator IC508A. R547, R548 create a reference voltage of +1.9 volts. If the output of the peak detector exceeds this value, then the output of IC508A is driven towards the negative power supply, and the gate is inhibited. Otherwise, the output of IC508A rests close to the positive power supply, and the gate is enabled. In this condition, the GATE LED is lit by current supplied through R545, CR510.

Hysteresis to assure clean switching is provided by positive feedback through R546.

In PROOF mode, CR511 applies +15 volts to the "-" input of IC508A to inhibit the gate, thus permitting all VCA's to recover to full gain.

3) Phase-Corrected Lowpass Filter/Preemphasis: (on Card #6)

Phase correction for the preemphasis and fourth-order lowpass filter associated with it is provided by a fourth-order allpass filter IC601, R601, R602, R603, R604, R605, R606, R607, R608, R609, C601, C602, C603, C604. The overall magnitude response of the filter between the card input and the filter output at IC601B is flat, gain is 0dB, and the phase response varies from 0 to 720 degrees. The operation of the filter is difficult to explain in words, and is best left to a mathematical analysis.

The fourth-order lowpass filter is in fact quasi-fourth-order. The first section of the filter is generated by a conventional second-order multiple-negative feedback active lowpass filter IC602A, R610, R611, R612, C605, C606. (See, for example, Wong and Ott: Function Circuits, op. cit.). However, the second section has been combined with the preemphasis, and transformed from a purely lowpass form to a peaking bandpass equalizer.

To understand this, imagine first a preemphasis cascaded with a 12dB/octave lowpass filter. As frequency is increased, the response will first rise at 6dB/octave, following the preemphasis. However, when the cutoff frequency of the lowpass filter is encountered, the response will reverse itself and fall at 6dB/octave indefinitely.

This is similar to the response of a peaking equalizer. However, when the response of the peaking equalizer falls, it does not fall indefinitely, but only until it reaches unity gain again. Nevertheless, we can choose a peaking equalizer whose rising side matches the rising side of our original preemphasis-plus-lowpass-filter to very close tolerances.

The falling side, after deemphasis, represents the stopband of the filter. Thus, when considered as a totality, the response of the entire fourth-order filter will, instead of falling indefinitely at 24dB/octave, fall for approximately 20dB after cutoff at 24dB/octave, and at 12dB/octave thereafter.

4.a) Differential Preemphasis and High Frequency Limiter: (on Card #6)

The advantage of transforming the lowpass filter as described in the previous section is that it permits us to create the preemphasis differentially, by summing the output of bandpass filter IC602B, R614, R615, R617, C607, C608 with the filter's input. The summation occurs in IC605A. The output of IC602B is passed through a variable-gain stage, realized with FET IC603A, and low-noise non-inverting amplifier IC604. By varying the gain with which the output of IC602B is summed with its input, a high-frequency limiter is realized.

B

Ordinarily, IC603A is pinched off, thus producing maximum gain and full preemphasis. However, as the gate voltage on IC603A is reduced toward ground, the resistance of IC603A decreases, thus decreasing the gain of voltage divider R619, R620, IC603A and reducing the preemphasis.

The polarity reversal in IC602B requires that a compensating polarity reversal occur in the summing process. IC605A is thus non-inverting for the bandpass signal, and inverting for the main signal. In addition, R616 feeds some of the output of IC602B around the variable-gain stage out-of-phase. This permits complete cancellation of the preemphasis despite the inability of the FET variable-gain stage to achieve total cutoff.

4.b) High Frequency Limiter Control Circuitry: (on Card #6)

The high frequency limiter control circuitry is very similar to the compressor control circuitry described in **2.d** above. The output of the bandpass filter only is applied to the rectifier-with-threshold, which is identical to the ones used in the compressor control circuitry. Similarly, the output of the rectifier is connected to a proprietary release-time module, and the threshold-of-limiting adjustment and PROOF mode G/R defeat are also substantially identical to previously described circuits.

The output of the module, unlike the outputs of the release time modules in the compressor control circuitry, is high impedance. It drives the high impedance gate of FET IC603A through R625.

Gain reduction is indicated by a simple ON/OFF LED indicator, driven by IC606A. FET BIAS adjustment R626 determines the quiescent gate voltage of IC603A, assuring pinchoff under conditions of no limiting. This voltage is applied through release time resistor R627 to the "-" input of IC606A. This input will be pulled in the negative direction when gain reduction occurs.

The output of R626 is also applied to the "+" input of IC606A through R628. R629 pulls this "+" input slightly more negative than the output of R626 to hold the output of IC606A negative during conditions of no gain reduction. However, as soon as the "-" input of IC606A is pulled slightly less positive by the occurence of gain reduction, the output of IC606A goes positive and lights the HF LIMIT lamp through R630 and Q601, used as a zener diode.

5.a) Clipper With Dynamic Threshold: (on Cards #8 and #9)

(**NOTE:** This circuit is only used in an emergency situation when the Hilbert-Transform Clipper Cards #0 and #1 are removed from service. While we do not expect that the Hilbert-Transform Clipper circuits will exhibit any reliability problems, retaining the alternate clipping circuitry for emergency use was extremely convenient and cost-effective, and provides the customer with an extra measure of redundancy and security.)

The threshold of the first clipper CR801, CR802 is varied dynamically to make best use of the distortion-cancelling circuitry. When the clipper input signal contains substantial high frequency energy, then the threshold of clipping is lowered approximately 1.0dB to permit the difference-frequency IM distortion-cancelling signal to sum with the output of the main 15kHz lowpass filter without excessive clipping in the subsequent overshoot compensator. However, when the clipper input signal contains predominantly low frequencies, then the clipper threshold is raised to minimize the amount of low frequency clipping which occurs.

This is achieved by using the rectified output of IC602B (the high frequency bandpass filter employed differentially in the preemphasis filter) to control the clipper threshold. The output of IC602B feeds a rectifier-with-threshold IC806B, IC807 (and associated circuitry) whose operation is identical to the rectifier-with-threshold already described in **2.d.** This rectifier feeds an RC filter R844, R847, R848, CR807, C826. R844 determines the attack time of the circuit in conjunction with C826. The recovery time is determined by the series combination of R847 and R848.

If the high frequency energy present at the input to the rectifier is insufficient to overcome its threshold, then the "+" input of IC808A is held at ground by R847, R848. If output current flows into the rectifier, then C826 is pulled negative through CR807. If the voltage across C826 attempts to go more negative than approximately -13 volts, the rectifier will saturate and limit the voltage swing to this value. The voltage divider R847, R848 attenuates this 13 volt variation such that it causes a voltage variation of -0.2v at the output of IC808A, thus changing the threshold of clipping by approximately 1.0dB.

A 1.5 volt quiescent bias for the clipper diodes is provided by passing the output of a voltage divider through CR808 to R846. IC808A then acts as a unity-gain inverting amplifier for the voltage at CR808's anode. CR808 temperature-compensates the threshold of clipping by reducing the clipper bias voltage as the voltage drop across the diodes increases (with temperature variation). The final diode bias voltage at the output of IC808A is thus the sum of the quiescent voltage contributed by the circuitry connected to the "-" input of IC808A, and the voltage variation contributed by the circuitry connected to the "+" input of IC808A.

IC808B is connected as a unity-gain inverting amplifier, and provides a complementary negative bias for CR802.

It is important to understand that this scheme results in sinewaves not hitting 100% modulation in OPERATE mode. This occurs for two reasons. First, the dynamic response of the previous multiband compressor section is such that steady-state 1kHz sinewaves reach about 60% modulation if the CLIPPING control is adjusted to 12:00. This is a direct consequence of the natural loudness balances produced by this processing. Because sinewaves have a very low peak-to-average ratio compared with speech or music, their peak level must be reduced to prevent them (or similar program material) from being unnaturally loud and giving the processing an artificial, strained quality.

Second, a certain amount of headroom is left between the threshold of the first clipper and the threshold of the overshoot compensator to accomodate the distortion corrector signal and overshoots in the 15kHz lowpass filter without performing excessive, non-distortion-cancelled clipping in the overshoot compensator.

Because of the previously mentioned characteristics of the multiband compressor, sinewaves below about 2.5kHz are not ordinarily clipped; thus, no distortion-corrector signal is produced. However, varying the clip threshold does make better use of available headroom than would be the case if the clipper were always left at the "-1.0dB" threshold to which it switches in the presence of substantial high frequency energy.

It is important to note that despite (in reality, because of) this behavior with sinewaves, extremely high loudness is obtainable with speech or music because the processor's behavior is optimized for these signals.

B

5.b) Hilbert-Transform Clipper: (on Cards #0 and #1)

The input to the Hilbert-Transform Clipper is applied to a main chain of allpass filters (IC13, IC8A, and associated components), and to a 4kHz lowpass filter (IC14 and associated components) plus a second chain of allpass filters (IC10 and associated components). These filters are designed so that comparing the signal at pin #1 of IC8A with the signal at pin #7 of IC10B will show identical levels ($\pm$0.2dB) and a 90 degree phase difference ($\pm$2.5 degrees), 30-4000Hz. Above 4kHz, the output of the second chain should fall at better than 30dB/octave, and a 90 degree phase difference will no longer exist. (The existence of the 90 degree phase difference can be checked by means of a Lissajous pattern displayed on an oscilloscope with X/Y display capability. If the oscilloscope X and Y inputs are connected to the two points mentioned above, a circle should be produced on the screen, indicating an accurate 90 degree phase relationship between the two chains.)

The output of the main chain is full-wave rectified by means of precision rectifier IC8B and associated components, while the output of the second chain is full-wave rectified by means of precision rectifier IC9A, IC4A, and associated components. These two rectified outputs are applied to a vector sum generator using a single log-antilog XY/Z multiplier/divider. The vector sum (i.e., the square root of the sum of the squares of the two rectified inputs) is computed by the "implicit" technique using feedback (W.J. Wong and W.E. Ott: Function Circuits -- Design And Applications. New York, McGraw-Hill, 1976, p. 206.)

The vector sum is developed at pin 5 of IC4B. In addition, a threshold voltage (-2 volts when no input signal is present) is added in through R68 and R69 (the RATIO trimmer). IC4B serves as a threshold amplifier. If the instantaneous input level to the Hilbert-Transform Clipper is below 2.0V peak, the sum of the output of the vector sum generator and the threshold voltage will drive the output of

IC4B (pin 7) to the negative rail (due to its nominal non-inverting gain of 6.9), and CR3 will be OFF. Under this condition, the gain of the HF VCA (IC11, IC12 and associated components) is determined by the current flowing through the sum of R75, R76, and R19, which is constant since IC4B has been effectively disconnected by virtue of CR3's being OFF.

When the input to the Hilbert-Transform Clipper exceeds 2V peak, the voltage on pin 5 of IC4B becomes more positive than -1.45V and IC4B comes out of saturation, turning CR3 ON and taking control of the HF VCA control current. This current is determined by the voltage drop across R19. Normally, pin 6 of IC11A sits at approximately -13.5V, so the control current is determined by the voltage at the cathode of CR3.

PROOF mode is activated by turning Q1 ON, thereby parallelling R68+R69 with R73 and increasing the threshold. This has one subtle and peculiar side-effect which needs to be understood. The input of IC4B is protected (internally) by two back-to-back diodes. Under certain conditions in PROOF mode, these diodes can turn on, coupling the control-voltage signal at pin 5 into pin 6. This coupling can modulate the gain control current of the VCA's even though pin 7 of IC4A is at the negative rail (which is its normal state in PROOF mode).

If sinewaves below 4kHz are applied in PROOF mode, this causes no problems because the output voltage from the vector-sum generator is almost ripple-free. However, above 4kHz substantial ripple appears on the control voltage because of the change in operating mode of the circuit above this frequency. Enough of this ripple can couple through the protection diodes of IC4B to produce as much as 1.0% THD before deemphasis and 15kHz filtering (i.e., as observed at pin 1 of IC5A). If observed at the output of Card #8 or #9 (after such deemphasis and filtering), THD may be as high as 0.25% between 4 and 5kHz only. This increase in distortion, as small as it may seem, is nevertheless entirely an artifact of the PROOF mode and does not represent the actual distortion capabilities of the system in its normal OPERATE mode. We felt that it was important to explain this phenomonon in some detail because its generating mechanism is very obscure, and because the increase in distortion above 4kHz in PROOF mode only might otherwise cause serious confusion in a troubleshooting situation if it were misinterpreted as a system fault.

To continue the discussion of circuit operation: The output voltage of IC4B (at the cathode of CR3) is buffered by IC6A and applied to a second-order unity-gain constant-delay lowpass filter (IC6B and associated components). IC6B drives R40, whose value is identical to that of R19. Thus, under steady-state conditions, equal currents flow through R40 and R19, applying equal gain-control currents to the HF VCA and LF VCA (IC1, IC2, and associated components).

[The HF and LF VCA's operate identically to those in the "Master" and "Bass" compressors, and the reader is referred to (2.c) above.]

The input to the LF VCA is processed by a lowpass filter consisting of IC7 and associated components. This filter is normally down 3dB at 3.0kHz and exhibits a deep notch at 6.9kHz.

For equal control currents, the gain of the LF VCA is normally approximately 5.5dB higher than the gain of the HF VCA because the sensitivity of the inputs on the filter cards (#8 and #9) driven by the VCA's are unequal.

5.c) 2.2-15kHz Phase-Linear Bandpass Filter: (on Cards #8 and #9)

The signal from the Hilbert-Transform Clipper's HF VCA is applied to inverting amplifier IC801A. This amplifier drives two lowpass filters with cutoff frequencies of aproximately 15kHz and 2.2kHz. The 15kHz filter is a fifth-order Cauer lowpass filter R806, R807, C801, C802, C803, C804, C805, C806, C807, L801, L802. This lowpass filter is realized as a "passive ladder" for maximum stability, and minimum noise and distortion. The filter's response is nominally +0, -0.6dB from 0 to 15.4kHz, with a sharp rolloff thereafter. There are notches at approximately 19kHz and 26.6kHz.

The load resistor for the filter, R807, is connected not to true ground but to the "virtual ground" of the summing junction of IC801B. IC801B is an inverting, frequency selective amplifier whose feedback network R808, R809, C808 provides a 2dB shelving rolloff. The purpose of this rolloff is to match the gentle rolloff of the 2.2kHz lowpass filter to achieve a maximally sharp slope on the lower skirt of the bandpass filter produced by subtraction of the outputs of the 15kHz and 2.2kHz filters. A complementary shelving filter R811, R812, R813, C809 in the feedback loop of IC803B restores flat response later.

The output of IC801B feeds a differential sidechain which creates a fourth-order allpass function when its output is correctly summed with the output of IC801B (i.e., the main signal). This allpass function does not change the frequency response of the 15.4kHz lowpass filter, but does add phase shift as necessary to make the overall time delay of the 15.4kHz filter plus allpass network more constant than the time delay of the 15.4kHz filter alone.

Basically, this phase corrector sidechain consists of a pair of active inverting bandpass filters built around IC802A, IC802B. The IC802A filter is driven by the output of IC801B through R815. Its output is summed into summing amplifier IC803B through R817.

The second bandpass filter (associated with IC802B) is driven by both the main signal (through R814) and the output of the first bandpass filter IC802A (through R818). The output of IC802B sums into IC803B through R820. The third input to IC803B is the main signal (through R810).

In addition to driving the 15kHz lowpass filter, the output of IC801A also drives 2.2kHz lowpass filter C814, L803, A1, whose magnitude and phase, when cascaded with additional rolloff R821, R822, C815, match the magnitude and phase of the 15kHz lowpass filter from 0 to 2.2kHz. IC803A is a unity-gain buffer to drive this final rolloff network, the output of which is directly summed into IC803B through R822.

If the output from the Hilbert-Transform Clipper's LF VCA were not summed into IC803, the output of IC803 would exhibit a sharply selective bandpass response due to the subtraction of the 2.2kHz lowpass filter output from the 15kHz lowpass filter output. (The "subtraction" is achieved because the 15kHz lowpass filter is inverting due to IC801B.)

However, the output of the Hilbert-Transform Clipper's LF VCA is summed into IC803 as well (through R855). Thus the output of IC803B is the final output of the Hilbert-Transform Clipper, and is equivalent to a linear-phase 15kHz lowpass filter. Because this output contains substantial overshoots, it is followed by the FCS Overshoot Compensator (see **6** below).

6) **Frequency-Contoured Sidechain (FCS) Overshoot Compensator:**
(on Cards #8 and #9)

Overshoots are derived from the input signal by center clipper IC804A, R823, R824, R825, R826, CR803, CR804. This circuit is a differential amplifier which subtracts the output of a clipper from the clipper's input. This clipper consists of Schottky diodes biased with approximately $\pm$4.2v, and is therefore substantially "harder" than the first clipper (associated with IC801A).

If the output of IC804A were simply added to its input, the sum would be a clipped signal; a "differential clipper" would be created. However, the output of IC804A contains clipper-induced high frequencies which could cause "aliasing" in a stereo generator or possible interference to the video. The output of IC804A is therefore lowpass-filtered by passive 15kHz ladder filter R828, R829, C816, C817, C818, L804, L805, before being added back into the input signal to cancel overshoots. This filter has a response that rises 4dB at 15kHz. This makes up for the loss of high frequencies which would otherwise reduce the peak level of the overshoots emerging from the filter. To compensate, the fundamental levels around 15kHz are increased by the frequency-contouring.

(**NOTE:** Patent claims are pending on this "Frequency-Contoured Sidechain" overshoot compensation scheme.)

The filter has phase shift. To assure correct addition of the filtered overshoot, the input signal is delayed in a modular phase shift network, A1, whose amplitude response is flat, but which accurately matches the phase response of the sidechain filter throughout its passband. A1 is also equipped with a summing input for the overshoot signal, which appears at the output of IC804B.

The time delay of this network is not constant at all frequencies. The output of A1 is thus passed through allpass network IC805A, R831, R832, R833, R834, C819, C820 to create constant time delay from the input of the overshoot compensator system to its output. The allpass network has a flat amplitude response, but frequency-dependent phase response. (This network is designed to also compensate for the non-constant group delay of the following third-order lowpass filter).

The output of IC805A is passed through a composite capacitor (consisting of two aluminum electrolytics back-to-back, bypassed by a polycarbonate) to remove accumulated DC offsets. Recent research has suggested that this sort of composite structure minimizes the audible degradation caused by passing audio signals through polar capacitors with high dielectric absorption.

The signal then passes through a third-order active 15kHz lowpass filter IC805B, R836, R837, R838, R839, C822, C823, C824 to provide further reduction of any remaining out-of-band energy above 19kHz.

Finally, to catch any slight errors made by the overshoot compensator, the signal is applied to safety clipper R840, R841, CR805, CR806. The basic overshoot compensator is extremely effective; thus, the safety clipper is virtually never active and no additional filtering is included after its output. The output of the safety clipper is buffered by IC806A.

7) **Balanced Line Amplifier With Deemphasis:** (on Card #7)

Card #7 contains two identical balanced line amplifiers with provision for jumpering deemphasis in or out. The operation of this circuit in completely straightforward, and no further information beyond that found in **Appendix A** is necessary for understanding.

8.a) Unregulated Power Supply: (on chassis outside RF-tight enclosure)

The unregulated power supply is wholly conventional. It consists of a dual-primary transformer T101, two full-wave rectifiers CR101, CR102 and CR103, CR104, and two energy storage capacitors C101, C102.

T101's primary may be switched for 115 Volt operation by paralleling its two primaries, or for 230 volt operation by connecting its two primaries in series. RF filtering is provided on the AC line by means of FL101. In addition, VHF and UHF RF is filtered from the unregulated DC supply lines as they enter the main chassis by means of C103, C104, C105, C106, C107, L101, L102. The RF suppression scheme divides the chassis into three major sections. The section to the left (unregulated power supply chamber) contains the AC wiring and the unregulated power supply, and is assumed to contain some RF. The card cage, to the right, uses RF suppression on each line entering or leaving the area, and is thus RF-free. (The RF filter box, on the rear panel, interfaces the audio input and output lines with the outside world. It contains the input pads. Its connections to the main RF-tight compartment are all RF-filtered.)

8.b) +15 Volt Regulator: (on Card #PS -- rear chassis apron)

The +15 Volt regulator is the main reference for all other voltages in the OPTIMOD-TV system. It employs a 723C IC voltage regulator IC101 in conjunction with an external series-pass transistor Q101. This transistor is mounted on the rear apron of the chassis, which serves as a heat sink.

The 723C contains a reference voltage source, an opamp (externally compensated by means of C109 to prevent oscillation), and a current limiting transistor. The reference voltage (nominally +7.15 Volts) is developed at pin 6. C108 filters high frequency noise from the reference voltage. The reference voltage is directly connected to the non-inverting input of the internal opamp, pin 5. Voltage divider R105, R106, R107 develops a precise fraction of the output voltage of the regulator at the wiper of R106. R106 adjusts this fraction. The wiper of R106 is connected to the inverting input of IC101's internal opamp. Negative feedback thus forces the voltage at the wiper of R106 to be equal to the reference voltage. Thus the output voltage of the regulator is always the reference voltage divided by the voltage divider gain.

The output current flowing through Q101 develops a voltage drop across R103. When the current exceeds approximately 3/4 Amp, said voltage drop is sufficient to turn on the current-limit transistor inside IC101, whose base-emitter junction is connected to pins 2 and 3 of IC101. The current-limit transistor then shunts base drive current from the external series-pass transistor Q101 and prevents damage due to overheating.

If a catastrophic failure in the +15 Volt regulator causes it to lose control over its output voltage, the rest of the circuitry must be protected against the full unregulated voltage, or the entire system will be severely damaged. This protection is provided by zener diode VR101, CR105, and 1 Amp fast-blo fuse F102.

In the event that the regulator loses control of the output voltage, VR101 will conduct and limit the output voltage to approximately 16.5 Volts, which will not damage the system. Extremely large amounts of current will flow in VR101. However, before VR101 is damaged, this current will blow F102, thus disconnecting the circuitry from the unregulated supply. VR101's clamping action will also prevent the negative tracking supply from going any higher than -16.5 Volts. If the regulator is operating properly, the current limiting circuitry will prevent F102 from blowing even if the regulator output is short-circuited.

Under certain unusual circumstances, the regulator may lose control of its output voltage, yet the current limiting circuit may still work. If this occurs, F102 will not blow, and VR101 will overheat and burn out. Fortunately, its failure mode is a short-circuit. It will therefore still protect the OPTIMOD-TV circuitry even in this exceptional circumstance.

8.c) -15 Volt Regulator: (on Card #PS -- rear chassis apron)

The -15 Volt regulator is an operational amplifier containing a discrete power-booster output stage with current limiting. It "amplifies" the output of the +15 Volt regulator by -1, thus producing a -15 Volt tracking supply. Shutdown of the +15 Volt supply (due to current limit conditions or to a fault which blows F102) will also result in the -15 Volt supply's shutting down.

The basic opamp is IC102; its input resistor R109 and feedback resistor R108 are equal-valued, resulting in a gain of -1 ±2%. IC102's negative supply comes from the unregulated -22 volt supply. The common-mode range of the 301A opamp includes its positive power supply, thus permitting operation with IC102's positive supply at ground. Under normal operating conditions, the "+" input of IC102 is grounded, and its "-" input is within 10mV of ground.

Q103 and Q102 form a conjugate emitter follower which can boost the output current of IC102 to more than 3/4 Amp. The basic emitter follower is Q103; Q102 is connected in a 100% negative feedback configuration to boost the current output capability of Q103.

Q104 is a current-limit transistor. If the -15 Volt supply is called upon to deliver more than 3/4 Amp, sufficient voltage drop (approximately 0.6 volts) will occur across R104 to turn on Q104, thus shunting drive current away from Q103 into the load and protecting Q102/Q103 from burnout. Under these conditions, IC102 is protected by internal current limiting circuitry.

C113 frequency-compensates the -15 Volt supply to protect it against high frequency oscillations. R102 increases the circuit's immunity to leakage in Q103.

The rest of the circuitry is protected against a catastrophic failure of the -15 Volt regulator by means of zener clamp VR102, CR106, and fuse F103. The operation of this circuit is identical to the operation of the corresponding circuit in the +15 Volt regulator (see **8.b)**.

8.d) Miscellanous Voltage Supplies:

The operation of these supplies is extremely straightforward. No further explanation beyond that given in **Appendix A** is required.

9) Loudness Controller: (on Card #2)

[**NOTE:** This section should be read in close conjunction with the corresponding section in **Appendix A (System Description)].**

The input signal to be sensed by the Loudness Controller is applied to summing amplifier IC201A and associated components. Here, the left and right channels are summed.

If the Loudness Controller is being driven from the preemphasized output of Cards #8/#9 (as is normal in a single-chassis configuration), then 75us (or, optionally, 50us) deemphasis is applied by means of feedback elements R204, C201. If the Loudness Controller is being driven from the output of Cards #3/#4 (in the split-chassis configuration), then deemphasis is not applied and gain is slightly increased to normalize the threshold at which loudness control occurs.

The output of IC201A is applied to seven parallel bandpass filters (IC201B through IC208A). Bandpass response is achieved by cascading a lowpass filter with a highpass filter. Except for the top band (which uses a second-order lowpass filter), the first filter in each band is a third-order unity-gain positive feedback filter. Explanations of such filters can be found in almost any handbook on active filters.

Each of the seven highpass filters is equipped with a Class-B transistor output stage. Each output stage is loaded with a resistor (R211, R218, R225, R232, R239, R246, R252). The resistor associated with a given filter draws a current proportional to its resistance from the filter's output stage. The same current flows in the collectors of the output transistors: positive-going currents flow through the NPN transistor while negative-going currents flow through the PNP transistor.

This provides a convenient means for obtaining a full-wave rectified current: A current mirror (Q215 and the PNP transistors in IC209) inverts the sum of the currents through the NPN's and adds it to the sum of the currents through the PNP's. This sum (a full-wave rectified current containing contributions from both the NPN's and the PNP's) is then applied to another current mirror (the NPN transistors in IC209) whose output is finally applied to the line going to the "Master" timing module on Card #5 (pin K of Card #2).

A positive-going threshold current is applied to the same line by means of Q216 to establish the threshold of loudness control: If the full-wave rectified current does not exceed the threshold current, no output current flows from pin K of the card, and Q216 saturates. The threshold current is determined by the voltage drop across R253 divided by the value of R253. The voltage drop is determined by the voltage on the CLIPPING BUS, supplied from Card #5. Thus the threshold of the Loudness Controller changes in proportion to the threshold of compression as determined by the setting of the CLIPPING control on Card #5.

B

The output current from the Loudness Controller can be totally suppressed by turning Q217 ON and diverting the output current to ground, thus defeating the Loudness Controller. Q217 is controlled by the Loudness Controller ON/OFF logic circuitry (IC210 and associated components).

ON and OFF modes can be selected by passing current through opto-isolators IC211 and IC212 respectively. Current limiting and RFI suppression are provided by resistors and feedthrough capacitors within the filter box; rectification for AC control signals is provided by CR207.

IC210B and IC210C are cross-coupled as a bistable multivibrator (flip-flop). This flip-flop changes state whenever a transistor in one of the optoisolators turns ON, pulling its collector down to -15 Volts. Local switching by means of the momentary ON/OFF switch on the subpanel also changes the state of the flip-flop.

Initialization circuit CR206, C243, R260 assures that the system always comes up in the mode selected by jumper "B" on power-up. Upon power-up, the transition of the negative power supply from 0 to -15 Volts is coupled through C243 and CR206 to either IC210B or IC210C, as selected by jumper "B". Under steady-state conditions R260 pulls the anode of CR206 up to 0 volts. CR206 then effectively disconnects the power-up circuitry.

When the Loudness Controller is ON, pin 10 of IC210 is at -15 Volts and pin 4 is at 0 volts. The opposite is true when the Loudness Controller is OFF.

IC210A and IC210D are connected as inverting buffers to drive Q217 and the ON/OFF LED driver circuitry (Q218 and associated components) respectively.

APPENDIX C:
User Access

The first part of this Appendix describes how to access those parts of OPTIMOD-TV ordinarily involved in setup, adjustment, or alignment.

The second part of the Appendix provides information on the disassembly techniques necessary to access the balance of the circuitry.

1: ROUTINE ACCESS

a) User Adjustments: To access the user adjustments, open the small access door using the key furnished. This will reveal all user-adjustable controls.

b) Line Fuse, Power Switch, and Line Voltage Selector: These are accessed by swinging down the entire front panel, which is hinged at the bottom. To avoid damage, this should be done only with the small access door locked. Using the 5/64" hex wrench supplied, remove the three hex-socket screws at the top of the front panel and carefully swing the panel out and down.

c) Circuit Cards: First, swing the front panel down (see **b**). You must then remove the subpanel by first loosening four DZUS fasteners by turning each one-quarter turn counterclockwise with a long 3/16" or 1/4" slotted-blade screwdriver. Taking care not to stress the flat cable beneath it, tilt the top of the subpanel outward and leftward to clear the upper chassis lip and the door support bail at the right. The PC cards may now be removed from their slots.

**** This procedure is directly reversible with cautions:

-- The subpanel should always be replaced to protect the cards from RFI.

-- DZUS fasteners turn only 1/4-turn. Don't force them, lest they be damaged in a way that is very time-consuming to repair.

C

2: SERVICE ACCESS

General Cautions: These apply to all the procedures described below.

-- For best RFI protection, replace all screws and tighten normally to achieve firm contact.

-- If screws are lost, replace them with screws of the same length, since longer screws may cause mechanical interference or internal short circuits.

-- Most screws used in OPTIMOD-TV are binding head to achieve secure fastening without lockwashers. If a pan head screw is substituted, use an internal star lockwasher to retain this security.

-- Plating on all screws is Cadmium type II. Almost any other plating is acceptable unless corrosive atmosphere is present.

a) Cover Removal: Removing the top or bottom covers is tedious because thirty screws must be removed. (The large number of screws is necessary to achieve an RF-tight seal.) Luckily, most service access can be achieved without removing either cover! Specific instructions for doing this are found further below.

If you wish to remove either cover, simply remove all thirty screws.

**** This procedure is directly reversible with cautions:

-- When replacing a cover, align it as closely as possible with the corresponding holes, and start all screws. After all screws have been started, tighten all screws to normal tightness, "inland" screws first.

b) Access To Area Behind Rear Panel: If the covers are still in place, they needn't be removed.

Remove eight screws holding the top cover to the flange of the rear panel. Remove the corresponding eight screws from the bottom cover. The rear panel will remain solidly in place.

Set the chassis, bottom cover down, on a pad on a table. Allow 6" (15cm) between the rear panel of the chassis and the table edge. Unplug the power cord.

Now remove three groups of three screws which are circled in black on the rear panel.

VERY carefully and slowly, pull the rear panel about 3/4" (2cm) toward you, and tilt the top edge down until the rear panel is horizontal and resting on the table.

CAUTION

Watch for snags in the internal wiring, and for any stress on the ceramic feedthrough capacitors on the divider wall or RF filter box. These capacitors are very fragile and difficult to replace.

**** This procedure is directly reversible with cautions:

-- When positioning the rear panel over the corresponding holes, make sure that no wires are pinched under the flanges. Start, but do not tighten all nine screws. Observe the areas where the flanges on the rear panel meet the flanges on the side panels. Adjust the rear panel so that the flanges line up in order to provide a flat mounting surface for the cover when tightened.

c) Access To Input Filter Card: First open the rear panel (procedure **b** above).

Remove the four screws holding the RF filter box to the rear panel. **VERY** carefully and slowly, tilt the metal box back to vertical, taking care to avoid snagging the internal wiring and stressing the ceramic feedthrough capacitors.

This will reveal the internal circuit card, which is attached to the rear panel by four #4-40 screws. While this card can be removed for component replacement, it is easier (though less workmanly) to clip out the defective component from the topside and to install its replacement by tack-soldering to the old leads.

**** This procedure is directly reversible with cautions:

-- If components have been replaced, make sure that reassembly will not result in crushing of the component against the rear panel.

-- Tilt the box back to horizontal (so it rests against the rear panel) very slowly and carefully. Watch for wire snags and dress wires appropriately. Make sure that no wires are crushed under the flange.

d) Access To Unregulated Power Supply Chamber: If the covers are not already removed, remove the five cover screws which attach the top cover to the flange of the side panel. Remove the corresponding five screws from the bottom cover.

Open the front panel.

Remove the shoulder screw that attaches the door-support bail to the left chassis wall. Note that there is a nylon washer between the bail and chassis wall to prevent scraping.

Turn the chassis so that the left wall is facing you. Remove the left rack flange by removing the six unrecessed screws.

Remove the three screws that attach the rear panel to the main (steel) side panel.

Remove the remaining six screws and gently lift off the side panel by pulling outward.

**** This procedure is directly reversible with cautions:

-- Position the steel side panel and start, but do not tighten, all nine screws. Observe the areas where the flanges meet the rear panel and internal bulkhead, and align the flanges so that the covers will seat on a flat mounting surface.

e) Removal Of Card #PS (The DC Regulator) From Rear Panel And Power Transistor Replacement: Because the removal procedure is complex, this card was designed to permit many servicing operations to be performed without removing the card from the chassis.

IC's are conventionally socketed. Many unsocketed components can be replaced from the topside by tack-soldering the new component to the lead stubs of the old clipped-out component.

If the card must be removed, do it as follows:

CAUTION

The rear panel serves as a heat dissipator for the power transistors. Proper contact is necessary to insure sufficient transistor cooling. Please follow instructions carefully.

Remove the four press-fit plastic plugs on the power transistor covers with a pair of chain-noise pliers. This will reveal the transistor mounting screws. Remove the four screws holding the power transistors.

VERY carefully and slowly pull each transistor from its socket. If, as you do this, the silicone rubber insulator tends to stick to the panel, release it from the panel such that it sticks to the bottom of the transistor instead. After you remove each transistor, press its insulator back in close contact with it pending reinstallation.

NOTE

These insulators form themselves to the bottom surface of each transistor. Since they take a "set", they should not be interchanged or reversed. If you have to replace a power transistor, you may re-use the insulator if it is in good condition. With care, it will re-form itself as necessary. Otherwise, use a conventional mica insulator and white silicone heat-conducting compound.

Open the rear panel (procedure **b**). With the transistors removed, it is possible to release the circuit card from its plastic post mounts by squeezing the tangs in each of the four corners to permit pulling the card off the posts.

**** This procedure is directly reversible with cautions:

-- See the discussion above regarding heat-conduction insulators.

-- The power transistor sockets must be correctly aligned with the rear-panel holes to prevent short circuits.

-- The screws mounting the transistors should be tightened evenly. For best thermal contact, tighten each screw a small amount, alternating between screws. Tighten securely, but not enough to damage the threads in the sockets.

-- Note that there must be a split lockwasher under each screwhead to accomodate thermal cycling.

-- The Thermalloy (TM) plastic cover does not attach in a conventional or readily obvious way. It rides on the circumference of the special split lockwasher and does not (and should not) become captured under the head of the screw. Consequently, the cover may be slightly loose even after screws are tightened securely. This is normal, and should not (and cannot) be corrected.

-- Be sure to reinstall the press-fit plugs that cover the screwheads.

APPENDIX D:
Field Audit-of-Performance

GENERAL

This Appendix provides instructions enabling OPTIMOD-TV users to check the performance of their units using test equipment likely to be found in a well-equipped TV station. This procedure is a starting point for detecting and diagnosing a problem that you believe is caused by OPTIMOD-TV. It is also useful in routine maintenance, and can be used at Proof time to check routine equipment performance, thus providing more data than the Proof alone provides. By its nature, it is limited in scope to discovering static problems. A dynamic problem in the AGC circuitry (caused by the failure of a timing module on Card #5, for example) would not tend to be discovered by performing these tests.

For this reason, measurements must always be complemented by listening. If you are well-acquainted with the "sound" of OPTIMOD-TV as adjusted to your tastes, then faults that develop will ordinarily be readily detectable by ear.

If audio problems develop, many engineers immediately blame their processing. However, as is the case with any processing, faults in the audio equipment preceding OPTIMOD-TV will be magnified by the action of the processing. Program material that is marginally distorted at the OPTIMOD-TV input, for example, is likely to be unlistenable by the time it emerges from the output when aggressive processing is used. In addition, be sensitive to possible defects in the monitoring equipment; verify that a problem can be observed on at least two receivers before pushing the panic button.

REQUIRED EQUIPMENT

a) Audio Oscillator. An ultra-low-distortion type like the Sound Technology 1710B is preferred. However, a Heathkit or Eico-type oscillator (such as Heath IG-72) can be used to obtain approximate results, provided that residual distortion has been verified to be below 0.1%.

b) Noise and Distortion (N&D) Test Set. Once again, a high-performance type like the Sound Technology is preferred, but not required.

c) General-Purpose Oscilloscope. DC-coupled, dual-trace, with at least 5mHz vertical bandwidth. This is used to monitor the output of the N&D Test Set.

AUDIO PROCESSING

It is often more convenient to make measurements on the bench away from high RF fields which could affect results. For example, in a high RF field it is very difficult to accurately measure the very low THD produced by a properly-operating OPTIMOD-TV at most frequencies. However, in an emergency situation (is there any other kind?!), it is usually possible to do measurements under high-RF conditions which will reveal many of the grosser faults which could develop in the OPTIMOD-TV circuitry.

The rear-panel TEST JACKS serve as a convenient source of preemphasized audio. By strapping deemphasis IN on Card #7 (see **Part 3: Installation,** Fig. 3-2), an unbalanced deemphasized output is simultaneously available between the (+) audio output and circuit ground on the rear-panel barrier strip. To assure correct response from the output RFI suppression network, load the main output with a 300 ohm ±5% resistor between the (+) input and circuit ground.

a) **Standard Control Setup:** Record the normal settings of the controls so that they can be reset after the measurements have been completed. Then set the controls as follows:

L AND R INPUT ATTENUATORS:	0
CLIPPING:	+2
RELEASE TIME:	10
BASS COUPLING:	10
GATE THRESHOLD:	0
HF LIMITING:	0
LOUDNESS CONTROLLER:	DEFEATED

b) **Skeleton Proof:** This should be performed for both left and right channels.

1) Place both PROOF/OPERATE switches in PROOF.

2) Connect a low-distortion audio oscillator to the OPTIMOD-TV input. Set the frequency to 50Hz, and adjust the oscillator output level to produce 3.3V rms at the OPTIMOD-TV TEST JACK.

3) Adjust the appropriate OPTIMOD-TV OUTPUT ATTEN until 3.3V rms is also produced at the MAIN OUTPUT [between (+) and circuit ground, as described above].

The TEST JACK now serves as the PREEMPHASIZED OUTPUT, and the MAIN OUTPUT serves as the DEEMPHASIZED OUTPUT.

4) **Frequency Response:** Reduce the oscillator output level by 20dB (to avoid overloading the OPTIMOD-TV circuitry at high frequencies because of preemphasis). Connect the N&D set to the OPTIMOD-TV MAIN (DEEMPHASIZED) OUTPUT. Without changing the oscillator output level, measure the frequency response at 50, 100, 400, 1000, 5000, 10,000, and 15,000 Hz. The response should be better than ±0.75dB with reference to 1kHz.

(A more accurate frequency response evaluation can be performed by sweeping the system with a test set like the Tektronix 5L4N Spectrum Analyzer/Tracking Generator. If the station has such equipment, see paragraph 6.c of **Appendix E** for further information.)

5) **Distortion:** The deemphasized THD should now be measured at 100% modulation (corresponding to 3.3V rms at the TEST JACK). The level is most conveniently set for each frequency to be measured by adjusting the oscillator OUTPUT ATTEN to produce a reading of "+3VU" on the OPTIMOD-TV VU meter in its L (or R) FILTER OUT switch position. Alternately, you can adjust the oscillator at each frequency to produce the level at the MAIN OUTPUT tabulated in TABLE D-1 below.

TABLE D-1

50Hz	3.30V
100Hz	3.30V
400Hz	3.24V
1kHz	2.99V
5kHz	1.29V
10kHz	0.685V
15kHz	0.462V

The deemphasized THD+Noise should not exceed 0.1% at any frequency except 5kHz, where up to 0.25% is acceptable. (The increase in distortion at 5kHz is a subtle artifact of the PROOF mode in the Hilbert-Transform Clippers, and does not represent their performance in OPERATE mode. If you are interested in a further explanation, see paragraph **5.b** of **Appendix B.)**

In many cases, measured results will be determined entirely by the quality of oscillator and distortion analyzer available, and/or by the presence of RF fields which might affect the instruments.

6) **Noise:** Short both OPTIMOD-TV inputs, and measure the deemphasized noise at the OPTIMOD-TV MAIN OUTPUT. It should not exceed -63dBm. (Note that hum or buzz due to test equipment grounding problems and/or high RF fields may result in falsely high readings. If the output of the N&D set is monitored with a scope, problems like this should be immediately apparent.)

c) **Operate-Mode Measurements:** These measurements evaluate certain static characteristics of OPTIMOD-TV in its normal OPERATE mode. Normal measurements given herein are provided for service guidance only and are not guaranteed. As in the PROOF mode measurements above, these measurements should be repeated for both left and right channels.

1) Reconnect the audio oscillator to the OPTIMOD-TV input. Switch both PROOF/OPERATE switches to OPERATE. Be sure that operating controls are standardized as described in (a) above. Set the oscillator frequency to 1kHz, and adjust the oscillator output level until the TOTAL MASTER G/R meter on the front panel reads "0" dB.

2) Verify that the OPTIMOD-TV VU meter reads 0 VU ±0.5VU in the COMPR OUT position.

3) Change the setting of the CLIPPING control to "-1" (12:00) to avoid the normal sinewave clipping which ordinarily occurs when the CLIPPING control is set beyond "-1", and which would otherwise mask actual problems which might exist.

Measure the OPTIMOD-TV output level and THD at the MAIN OUTPUT for each frequency indicated in the table below, and compare your results with the typical readings provided.

TABLE D-2

FREQUENCY (Hz)	RESPONSE (Vrms/flat)	RESPONSE (Vrms/deemph)	THD (%)
50.0	1.70V	1.65V	0.07%
100.0	1.80V	1.80V	0.07%
1.0K	2.10V	1.90V	0.02%
3.0K	2.40V	1.40V	0.04%
12.0K	2.70V	0.45V	0.02%

NOTES:
1. THD measured with deemphasis.
2. CLIPPING control set to "-1" (i.e., 12:00).
3. THD highly sensitive to setting of CLIPPING control.
4. Increase in THD at 50Hz due to "Bass" band clipper action.

The increase in THD at 50Hz is caused by the action of the "Bass" band clipper located between the first and second sections of the bass crossover (see paragraph 2.b in **Appendix A).** By setting the threshold of clipping low enough so that a small amount of harmonic distortion is produced with sinewave test signals (unrepresentative of speech or music), the action of the clipper is optimized with respect to program material. This prevents audible IM between bass and high-frequency program material from occurring in the peak limiting circuitry which follows the preemphasis and HF limiting.

D

Excessive THD at 100Hz not present in the PROOF-mode test is usually caused by problems in the bass timing module on Card #5. Excessive THD at 500Hz is often caused by problems in the master timing module on Card #5. (See paragraph **2.d** of **Appendix B).**

Atypical THD at 3kHz can be caused by several factors. Excessively high THD can be caused by a failure in the high-frequency limiter on Card #6 (see paragraphs **4.a** and **4.b** in **Appendix B),** or by failure in the Hilbert-Transform Clipper. (3kHz is still within the frequency range in which the Hilbert-Transform Clipper normally produces less than 2% THD even with large amounts of limiting.)

Please note that it is normal for the THD to increase as high as 2% between 4 and 5kHz because of the action of the Hilbert-Transform Clipper as discussed immediately above.

4) Now turn the HF LIMITING control to 10. Sweep the oscillator frequency up from 1kHz, and determine what frequency first turns the front-panel HF LIMITING lamp ON. This frequency is typically 2.1kHz.

Steps (5) and (6) below provide a first-order test of the dynamics of the timing circuitry in the compressor. However, there are many possible faults which these tests will not detect. These must be diagnosed by more sophisticated tests at the factory.

5) Turn the BASS COUPLING control to "0". Switch the RELEASE SHAPE to LIN, and make sure that the RELEASE TIME control is at "10". Make sure the Loudness Controller is off. Set the oscillator frequency to 5kHz, and adjust the oscillator output level until the TOTAL MASTER G/R meter reads "-5dB". Abruptly reduce the oscillator output level 20dB, and measure the time required for the TOTAL MASTER G/R meter to rise from "-5dB" to "+5dB" indicated G/R. This time should be 7.5 seconds, ±1.5 seconds.

Switch the RELEASE SHAPE to EXP, and repeat the test. The time should be 11 seconds, ±3 seconds.

6) Change the oscillator frequency to 200Hz and adjust the oscillator output level until the BASS G/R meter reads "-5dB" G/R. Abruptly reduce the oscillator output level by 20dB, and measure the time required for the BASS G/R meter to rise from "-5dB" to "+5dB" indicated G/R. This time should be 3 seconds, ±0.75 second.

d) **Loudness Controller:** The Loudness Controller is tested by applying various frequencies to the OPTIMOD-TV input and observing the level at the output of the compressor with the normal compressor control circuitry defeated so that only the Loudness Controller determines the amount of gain reduction.

This test can only be made as described if the Loudness Controller is installed in the main 8182A chassis and Jumper "A" on Card #2 is in the correct ("FROM CARD #8/9") position for this configuration. If the Loudness Controller is installed in the 8182A/ST Accessory Chassis and you wish to perform this test, it is necessary to temporarily reconfigure the system for single-chassis operation. (Please refer to the **8182A/ST Manual.)**

Set the operating controls as follows (controls not listed: DON'T CARE):

CLIPPING	-4	BASS COUPLING	10
RELEASE TIME	5	COMP PR/OP	PROOF
RELEASE SHAPE	EXP	LIMITER PR/OP	PROOF

In addition, the GATE must be defeated. This is done by gaining access to the circuit cards [following the instructions in **Appendix C (User Access)**]. Turn off AC power. Then remove Card #5 from its slot, and temporarily remove IC508 from its socket. (To locate IC508, refer to the Card #5 Assembly Drawing in **Appendix J.**)

Replace Card #5 in its slot and restore AC power. (There is no need to replace the subpanel now unless high RF fields are present.)

Using its local OPERATE/DEFEAT switch, switch the Loudness Controller to OPERATE, and verify that its green LED glows.

Make sure that both channels of OPTIMOD-TV are being driven in parallel from the oscillator, and that the OPTIMOD-TV INPUT ATTEN controls are balanced such that equal readings are produced when the OPTIMOD-TV VU meter is observed in its L COMPR OUT and R COMPR OUT positions. Set the oscillator frequency to 3kHz and adjust its output level to produce a reading of "-10" on the OPTIMOD-TV TOTAL MASTER G/R meter. Then observe the OPTIMOD-TV VU meter in the L COMPR OUT position and verify that the following readings are produced at the following frequencies, ±2VU:

FREQUENCY	VU METER READING
300 Hz	0 VU
500 Hz	-5
700 Hz	-6
1 kHz	-7
2 kHz	-11
3 kHz	-14
4 kHz	-14
5 kHz	-13
7 kHz	-10
10 kHz	-6

TABLE D-3

D

If the readings vary substantially from those provided in **Table D-3,** the Loudness Controller circuitry is suspect. The most likely problem is a complete failure in one filter band (due to a defective opamp). However, faults in passive components within the filter circuitry can also cause difficulty. If diagnosis cannot be made by identifying a dead band or other obvious cause, we advise sending Card #2 (Loudness Controller) back to the factory for service so that the frequency responses of the individual filters can be accurately verified. OPTIMOD-TV operates normally (except for the loss of the Loudness Controller function) with Card #2 removed.

When you have finished testing the Loudness Controller, remove AC power to OPTIMOD-TV. Replace IC508 in its socket on Card #5, carefully verifying that the end of the IC with a notch is at the end of the socket marked with a square or small flag on the circuit board foil. (Check the Assembly Drawing for Card #2 in **Appendix J** if there is any question.) If the IC is installed backwards, it will be instantly destroyed on powerup!

Then reinstall Card #5 in its slot, and replace the subpanel, following the instructions in **Appendix C (User Access).**

For further discussion of **Trouble Diagnosis and Correction,** see **Appendix F.**

APPENDIX E:
Field Alignment Procedure

1: GENERAL

The following section describes how to align and calibrate OPTIMOD-TV in the field. It is included primarily for purposes of reference as routine alignment is neither necessary nor desireable due to the high stability of the circuitry.

WARNING!

IF CALIBRATION IS NECESSARY, WE STRONGLY RECOMMEND THAT THE CARD IN QUESTION BE RETURNED TO THE FACTORY FOR CALIBRATION BY OUR EXPERIENCED TECHNICIANS, WHO HAVE ACCESS TO SPECIAL TEST FIXTURES AND A SUPPLY OF EXACT-REPLACEMENT SPARE PARTS. ONLY IN AN EMERGENCY SITUATION SHOULD AN ATTEMPT BE MADE TO ALIGN AND CALIBRATE OPTIMOD-TV IN THE FIELD.

The factory aligns each card independently to a standard, so that cards will be completely interchangeable. However, the user does not have access to the special test fixtures necessary to complete independent alignment of the cards. The user thus must use his own OPTIMOD-TV chassis as a test fixture, and align the entire unit as a system.

This section is organized on a card-by-card basis. Cards should be calibrated in the same order as their order in the signal path, from input to output. This will occur naturally if the instructions in this section are followed in order from beginning to end. If a card later in the signal path is aligned while an earlier card is misaligned, the later card may not be correctly aligned, even if the instructions for that card are followed conscientiously.

Before commencing alignment, remove OPTIMOD-TV from its normal rack mounting location and place it on the test bench away from RF fields. Jumper the chassis and circuit grounds together on the rear-panel barrier strip.

2: REQUIRED TEST EQUIPMENT AND MATERIALS

The following test equipment (or close equivalents) is required. It is assumed that the technician is thoroughly familiar with the operation of this equipment.

a) Digital Voltmeter, accurate to ±0.1%
b) Oscilloscope, DC-coupled, dual-trace, triggered-sweep, with 5mHz or better vertical bandwidth
c) Ultra-Low Distortion Sinewave Oscillator/THD Test Set/AC VTVM (Sound Technology 1700B or 1710B)
d) Low Frequency Spectrum Analyzer with Tracking Generator (Tektronix 5L4N plug-in with 5111 Bistable Storage Mainframe)
e) A 137K 1% resistor
f) A 243K 1% resistor
g) Six 6" alligator-to-alligator jumper leads
h) A 1uF ±20% film capacitor (voltage unimportant)

REFER TO THE SCHEMATICS AND PARTS LOCATOR IN **APPENDIX J.**

3: CARD #PS (POWER SUPPLY)

a) Measure the voltage across C111 (or other convenient point on the +15 Volt bus) with the DVM. Adjust R106 until the DVM reads +15.00 Volts.

b) Measure the voltage across C112 (or other convenient point on the -15 Volt bus). Make sure that the voltage is between -14.85 and -15.15 Volts. If it is not, refer to **Appendix B (CIRCUIT DESCRIPTION),** paragraph **8.c** for troubleshooting hints.

BEFORE ALIGNING EACH CARD AS DESCRIBED IN THE INSTRUCTIONS BELOW, REMOVE THE CARD OF INTEREST FROM ITS SLOT AND PLUG THE EXTENDER INTO THE EMPTY CARD SLOT. PLUG THE CARD INTO THE CARD EXTENDER. THIS WILL ALLOW ACCESS TO THE ALIGNMENT TRIMMERS AND TEST POINTS.

NOTE: Cards #0 and #1 will be aligned later. Card #2 requires no alignment.

4: CARDS #3 AND #4

a) Remove Cards #3, #4 and #5 from their slots. Plug the extender board into the Card #3 slot. Cards #3 and #4 will both be aligned on this extender, one at a time, without moving it from the Card #3 slot.

b) Plug Card #3 into the extender board.

c) Connect one side of a 137K 1% resistor, and one side of a 243K 1% resistor to a convenient ground point (like the chassis) by means of jumper leads. Using two more jumper leads, connect the other side of the 137K resistor to the side of R333 away from IC305, and connect the other side of the 243K resistor to the side of R348 away from IC309. These external resistors now force reference gain-control currents into IC305A and IC309A respectively: 97uA into the "Master" VCA and 55uA into the "Bass" VCA. (Short clip leads will minimize hum and noise pickup.)

d) Connect the chassis ground of the oscillator and the low side of the oscillator output to the chassis of OPTIMOD-TV. Using a pair of jumper leads, connect the high side of the oscillator output to both the "+" input of IC301A and the "+" input of IC301B. This provides common-mode excitation for the input differential amplifier.

e) Set the oscillator frequency to 60Hz, and the oscillator output to 0 dBm. Observe TP1 (pin D at the card connector) with the AC VTVM adjusted so that the common-mode feedthrough is readily observed. Adjust R316 (CMRR) to null it. The nulled level of the 60Hz should be less than -60dBm.

f) Connect the low side of the oscillator output to the "-" terminal of the left-channel audio input of OPTIMOD-TV. Connect the high side of the oscillator output to the "+" terminal. Set the oscillator output frequency to 1kHz and the oscillator output level to produce -15dBm at the output of IC302B (TP1 or pin D of the card connector).

g) Observe the output of IC307A (pin K of the card connector) with the AC VTVM, and adjust R376 (MASTER VCA GAIN) to produce +2.0dBm at this point.

h) Readjust the oscillator frequency to 35Hz. If necessary, readjust the output level of the oscillator until it is once again -15dBm at TP1.

i) Adjust R377 (BASS VCA GAIN) until the AC VTVM indicates +2.0dBm at pin K. The gains of both "Master" and "Bass" VCA's are now standardized, assuring card interchangeability.

NOTE: The following distortion and balance adjustments are made without disturbing the resistors jumpered into place in the steps above.

j) Without disturbing the oscillator output level, set its frequency to 5kHz. Switch the AC VTVM into its distortion-measuring mode, and measure the THD. Adjust R336 (MASTER DIST NULL) to null the THD. It should not exceed 0.04% if a noise-limiting 80kHz lowpass filter is employed in the measurement.

CAUTION!

> Any stray audio picked up on the leads of the 137K jumper resistor will cross-multiply with the desired signal in the VCA, and will produce second-harmonic distortion which cannot be nulled with the MASTER DIST NULL control. It may be necessary to bypass the R333 side of the 137K resistor to ground with a tantalum capacitor larger than 5uF and 15VDC. Ground the "+" terminal of the capacitor.

k) Set the oscillator frequency to 50Hz. Measure the THD as above, and adjust R351 (BASS DIST NULL) to null it. It should not exceed 0.04%.

l) Remove the oscillator from the OPTIMOD-TV input. Ground the low side of the oscillator output to the OPTIMOD-TV chassis and, using a pair of jumper leads, connect the high side of the oscillator output through a 1uF film capacitor to the side of R333 away from IC305. (The 137K resistor is already connected to this point. Don't disturb it.) Set the output frequency of the oscillator to 100Hz, and its level to produce approximately 0.25V rms at its output. Observe the output of IC307A with the AC VTVM at high gain. You will see a distorted feedthrough component from the oscillator. Adjust R331 (MASTER VCA BALANCE) to null the feedthrough.

m) Move the lead from the 1uF capacitor from R333 to the corresponding side of R348. Do not disturb the resistor already connected to this point. Set the oscillator output to approximately 0.25V rms. Continue to observe the output of IC307A, and adjust R346 (BASS VCA BALANCE) to null the feedthrough component observed.

n) Remove all jumper leads connected to Card #3, and remove Card #3 from the extender.

o) Insert Card #4 in the extender (still in slot #3), and repeat steps **c** through **n.**

5: CARD #5

Before embarking on this procedure, be sure that Cards #3 and #4 have been standardized according to the alignment procedure above, or are in their original factory-aligned condition.

a) Connect the oscillator to the OPTIMOD-TV's left input, high side to "+", low side to "-".

b) Pull Card #3 halfway out and connect the AC VTVM to TP1. TP1 may be readily accessed at the end of R323 closest to the edge of the board.

Reinsert Card #3. Make sure that Card #4 is also in its slot. (If only one card is inserted, all gain control current will be diverted to the VCA's in that card, reducing the gain 6dB below its correct value.)

c) Remove Card #5 from its slot. Referring to the Card #5 Assembly Drawing in **Appendix J,** remove IC508 from its socket and set it aside temporarily. (This defeats the gating function.) Then extend Card #5.

d) Set the oscillator frequency to 1kHz; set its output level to produce -15dBm at Card #3 TP1.

e) Switch the Compressor PROOF/OPERATE switch (on Card #5) to PROOF and allow the gain to settle for at least one minute.

f) While you are waiting, reconnect the AC VTVM to the output of IC307A on Card #3. This point can be readily accessed at TP#K or pin K on the edge connector by pulling the card halfway out, and reinserting it as above.

g) Adjust R501 (MASTER GAIN CAL) on Card #5 until +2.0dBm is observed on the AC VTVM.

h) Set the oscillator frequency to 35Hz. Be sure that the oscillator output level is the same as it was at 1kHz.

i) Adjust R525 (BASS GAIN CAL) on Card #5 until the AC VTVM reads +2.0dBm.

j) Remove Card #5 from the extender. Replace IC508 in its socket on Card #5, carefully verifying that the end marked with the notch is at the end of the socket marked with a square or small flag on the printed circuit foil. (If there is any doubt, check the Assembly Drawing in **Appendix J.)** If the IC is inserted backwards, it will be instantly destroyed on power-up!

k) Restore Card #5 to its slot.

6: CARD #6

This card serves both left and right channels. The procedure below is performed twice; once for the left channel and once for the right. When the reference designator of an alignment trimmer is specified, the reference designators for both left and right channel trimmers will be given in order, with the right in parentheses.

a) Extend Card #6. Place both PROOF/OPERATE switches in PROOF. Turn R626 and R660 (FET BIAS) fully clockwise to guarantee that the FET's in IC603 will be fully pinched-off.

b) Connect the output of the tracking generator in the 5L4N spectrum analyzer to the left (right) audio input of OPTIMOD-TV.

c) The PREEMPHASIS trimmers are used to adjust the entire OPTIMOD-TV for best conformance to the standard FM preemphasis. Connect a precision 75us (or 50us) deemphasis network to the TEST JACK corresponding to the channel which you are aligning. Connect the output of the deemphasis network to the input of the 5L4N spectrum analyzer.

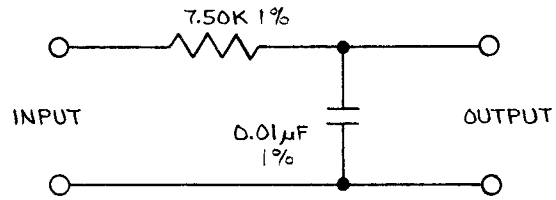

Fig. E-1: PRECISION 75us DEEMPHASIS NETWORK
(NOTE: To preserve accuracy, load must be greater than 1meg.)

d) Set the 5L4N for a 0-20kHz sweep (2kHz/div). Set its input sensitivity to -10dBV in dB mode. Set the vertical sensitivity to 2dB/division, and set the output level of the tracking generator to obtain an on-screen trace. (You may have to readjust the OPTIMOD-TV INPUT ATTEN if gain is insufficient.)

e) You are now sweeping the entire OPTIMOD-TV system, including the complex filters in Cards #8 and #9. Adjust R618(652) to achieve maximally flat response, similar to Fig. E-2. The response should be $\pm$0.75dB or better, 50-15,000Hz.

[**NOTE:** Misadjustment of the Hilbert-Transform Clipper circuitry on Cards #0 and #1 can affect the response below approximately 3kHz. Therefore, adjustment of R618(652) should be made primarily on the basis of the flatness of response from 3-15kHz.]

Fig. E-2: OVERALL DEEMPHASIZED RESPONSE

f) Now turn R626(660) (FET BIAS) slowly counterclockwise until the swept response just begins to roll off. Back off until no rolloff is observed, and go a little further for safety.

g) Repeat steps (d) through (f) for the right channel.

h) Connect the oscillator to the OPTIMOD-TV left (right) input.

i) Observe the output of IC605A(611A) with the distortion meter. Set the oscillator frequency to 10kHz, and the oscillator level to produce +10dBm at the output of IC605A(611A).

j) Turn R678 (HF LIMITING--front-panel control) fully CW. Turn the LIMITER PROOF/OPERATE switch (on Card #6) to OPERATE. The 10kHz level should go down to approximately +6dBm. Now adjust R631(665) (DIST NULL) to minimize THD. Bear in mind that you are observing a preemphasized signal, and that THD will be even lower after deemphasis. Even without deemphasis, THD is typically less than 0.1%.

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k) Repeat steps (h) through (j) for the right channel.

l) Observe the junction of R669 and R670 with a high-impedance (10 megohm or greater) DC DVM. Adjust R671 (OVERSHOOT COMPENSATION THRESHOLD) until the DVM reads +4.50VDC.

m) Return Card #6 to its slot.

7: CARDS #0 AND #1

This procedure is performed twice: once for Card #0 and once for Card #1. Only Card #0 will be referenced.

a) Extend Card #0.

b) Place the COMPRESSOR PROOF/OPERATE switch in PROOF, and the LIMITER PROOF/OPERATE switch in OPERATE. Switch the Loudness Controller to DEFEAT.

c) Connect the oscillator to the left OPTIMOD-TV input, and set its frequency to 1kHz. Connect the AC VTVM to pin Z (HF OUT) of Card #0. Increase the output level of the oscillator until the level observed on the VTVM stops increasing, indicating that the limiting threshold of the Hilbert-Transform Clipper has been reached. Vary the oscillator level between the threshold of limiting and roughly 5dB above threshold while observing the VTVM for changes in level. Adjust R69 (RATIO) to achieve no change in output level as the input level is varied over a 5dB range. Note that each time R69 is readjusted, the level at pin Z will change. To achieve a correct adjustment, you therefore have to readjust R69 slightly and <u>then</u> test by varying the input level through its 5dB range while watching to see if the output level changes.

When you are finished, reduce the oscillator level until you are exactly at the threshold of limiting. Measure the level at pin X of Card #0, and verify that it is +6.2dBm ±0.5dBm @1kHz.

d) Switch the LIMITER PROOF/OPERATE switch to PROOF. Adjust the oscillator output level to produce +6dBm at pin X (the Hilbert-Transform Clipper input). Observe pin Z with the THD analyzer, and adjust R25 (HF DIST NULL) to minimize the THD. Then adjust R50 (GAIN TRIM) to produce +7.0dBm at pin Z.

Observe pin Y with the THD analyzer, and adjust R44 (LF DIST NULL) to minimize the THD. Then adjust R52 (LF RESPONSE) to produce +11.4dBm at pin Y.

e) Disconnect the oscillator from the OPTIMOD-TV input, and connect it to the side of R56 closest to R61 (RIPPLE NULL). Adjust the oscillator output level to produce 1V rms @100Hz. Then observe pin Z with the AC VTVM and adjust R18 (HF THUMP NULL) to minimize the 100Hz observed. Move the AC VTVM to pin Y, and adjust R38 (LF THUMP NULL) to minimize the 100Hz observed.

f) Set the LIMITER PROOF/OPERATE switch to OPERATE. Reconnect the oscillator to the left OPTIMOD-TV input. Set the oscillator frequency to 2kHz, and adjust the oscillator level approximately 5dB above the threshold of limiting of the Hilbert-Transform Clipper. Observe the THD at pin Z and adjust R61 (RIPPLE NULL) to minimize the THD. (0.6% is a typical reading). When you are done, measure the level at pin Z and verify that it is +7.2dBm ±0.5dBm.

g) Return Card #0 to its slot.

h) Repeat steps (a) through (g) for the <u>right</u> channel (Card #1).

8: CARDS #8 AND #9

This procedure is performed twice -- once for Card #8, and once for Card #9. Only Card #8 will be referenced.

a) Extend Card #8.

b) Connect the oscillator to the left OPTIMOD-TV input. Set <u>both</u> PROOF/OPERATE switches to PROOF. Connect the AC VTVM to the input of Card #8 (input side of R801). Set the oscillator frequency to 100Hz, and adjust the oscillator output level until -3.9dBm is observed on the VTVM.

c) Adjust R841 (SAFETY CLIPPER THRESH) to produce 0dBm at pin 7 of IC806A (pin X of the card connector). This sets a standard gain of +3.9dB through the card.

d) **OPTIONAL PERFORMANCE VERIFICATION** Of Filters

1) Connect the output of the 5L4N tracking generator to TP1 of Card #8 (pin L on the card connector). Connect the input of the 5L4N to the left rear-panel TEST JACK. Observe the swept response with the 5L4N vertical span at 10dB/div, with 20-20kHz log frequency sweep. The swept response shows the response of the 2.2-15kHz bandpass filter which is created by subtracting the output of the 2.2kHz lowpass filter from the output of the 15kHz lowpass filter. Note the high amount of rejection below 2.2kHz, and the very steep slope at 2.2kHz (see Fig. E-3).

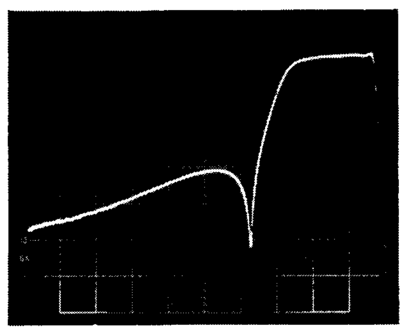

Fig. E-3: 2.2-15KHZ BANDPASS FILTER RESPONSE

If this swept response does not resemble Fig. E-3, then there is a fault in either the filters or phase correctors between the card input and the output of IC803B. This test is both fast and sensitive because accurate cancellation demands accurate matching of the phase and amplitude responses of both the phase-corrected 15kHz lowpass filter and the 2.2kHz lowpass filter. If <u>any</u> circuitry is faulty, then the cancellation will not occur accurately.

2) Temporarily remove Card #6 from its slot. Then measure the clipper bias voltages at the outputs of IC808A and IC808B. These should be approximately ±1.5VDC with no signal. (**NOTE:** The temperature-compensation circuitry will cause this bias voltage to change slightly with temperature to keep the clipping threshold constant.)

Replace Card #6 in its slot.

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e) **OPTIONAL PERFORMANCE VERIFICATION** Of FCS Overshoot Compensator

1) Connect the oscillator to the junction of R806 and L801 (this provides a convenient injection point that bypasses the first clipper).

2) Set the LIMITER PROOF/OPERATE switch (on Card #6) to OPERATE.

3) Observe the left rear-panel TEST JACK with a scope. Set the oscillator frequency to 100Hz, and advance the oscillator output level until clipping just barely occurs. Measure the oscillator output, and verify that it is approximately 0.63V rms. (The "clipping" is the action of the overshoot compensator. If this clipping doesn't occur, then there is a fault in the overshoot compensator sidechain.)

4) Increase the oscillator output 4dB. Substantial clipping should occur. Now sweep the oscillator frequency upward, and verify that the peak level of the output waveform never exceeds the "flat-top" level of the 100Hz clipped sinewave by more than 0.7dB, and that this 0.7dB peak occurs at approximately 4.4kHz. At this frequency, the waveform should resemble a filtered square wave with two equal cycles of ringing on the top and bottom of the wave (Fig. E-4). If substantially more than 0.7dB overshoot occurs, particularly if the ringing is not symmetrical, then suspect problems in the filters or phase-shift networks associated with the FCS circuit.

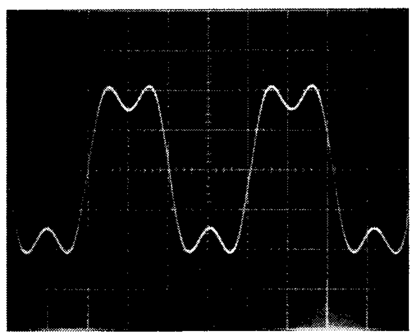

Fig. E-4: 4.4kHz OVERDRIVEN FCS OUTPUT

f) Repeat procedures (a) thorough (e) for the right channel (Card #9).

This concludes the Field Alignment Procedure for the entire OPTIMOD-TV system. Insert the extender board in its slot, and replace the subpanel, being sure that all four DZUS fasteners are fully tightened for RF suppression. Close the front door, and fasten with its three screws. Remove the jumper between chassis and circuit grounds, unless it is ordinarily used in your installation.

OPTIMOD-TV is now ready for reinstallation in the station.

APPENDIX F:

Trouble Diagnosis and Correction

This Appendix is the first place you should go to obtain information on what to do if OPTIMOD-TV develops a fault.

Many problems experienced in the field can be resolved or conclusively diagnosed with the following diagnostic routines. Even if the repair cannot be done in the field, the information provided by these diagnostic routines can speed the work of the factory service department in making the repair. Please perform these routines and make notes if you observe anything exceptional or unusual.

1) Use systematic troubleshooting techniques to positively determine that the problem is in fact being caused by OPTIMOD-TV and not by other equipment. If a standby processor is available, it should be substituted for the supposedly faulty unit to see if the problem vanishes. If a standby processor is not available, audio quality at the OPTIMOD-TV audio input terminals should be checked with a high-quality monitor system. Note that even slight distortion can be seriously exaggerated by "heavy" processing, and that this sort of processing can only be successful if the input audio is extremely clean. A relatively minor problem which develops in the station's audio chain or STL can therefore be magnified by the action of OPTIMOD-TV, even if the unit is in no way defective. This is a further argument for adjusting the OPTIMOD-TV controls conservatively to produce low distortion and superior high frequency response.

If the audio is clean going into OPTIMOD-TV, problems can still arise in the aural exciter. If a standby exciter is available, it should be substituted to see if the problem vanishes. If no standby exciter is available, you can connect the audio output of OPTIMOD-TV directly into a high-quality amplifier and loudspeaker to see if the problem can still be heard. If you ordinarily operate un-deemphasized, then you should first remove Card #7 and move the jumpers to the deemphasized position (see **Part 3: Installation**) in order to hear flat sound from the audio monitor. If the problem vanishes when you observe the output of OPTIMOD-TV directly, then the exciter (or phase-linear STL, if used) is strongly suspect.

Changes in or deterioration of grounding and/or exterior lead dress can sometimes cause RFI or hum problems to appear in a correctly-operating OPTIMOD-TV.

If it seems impossible to conclusively isolate the problem to OPTIMOD-TV, yet no other definite cause is found, then performing the **Field Audit-Of-Performance** procedure in **Appendix D** may help diagnose a problem.

2) If the fault has been positively isolated to OPTIMOD-TV, the **Problem Localization Routine** described below should be performed to identify the faulty PC card.

PROBLEM LOCALIZATION ROUTINE

General Principles: The most powerful and general technique for localizing a problem within OPTIMOD-TV is signal tracing. This simply means that the signal is observed at various points as it passes from OPTIMOD-TV's input to its output. If the signal is normal at some point "A" in the circuit, and is abnormal at a point "B" further towards the output, then the problem clearly lies in circuitry between points "A" and "B".

Signal tracing in OPTIMOD-TV is facilitated by the fact that much of the circuitry is duplicated for stereo, and is arranged so that the bad channel can be readily compared with the good one, which serves as a "normal" reference.

Power Supply Tests: Some circuitry is common to both channels, and failures will therefore affect both channels in a symmetrical way. In particular, problems in the power supply may affect many circuits simultaneously. For this reason, the first step in any troubleshooting procedure is to check the power supply for normal output. Gross changes in power supply voltage can be detected with the "+15VDC" and "-15VDC" positions on the VU meter. Normal readings are 0VU ±0.5VU. If normal readings are obtained, skip to the next section on **VU Meter Techniques.**

If either "+" or "-" power supply output is significantly low, it could indicate a defect in the supply itself. But it is more likely to indicate a shorted IC or capacitor somewhere in the circuit that is overloading the supply and causing it to current-limit.

The power supply is electronically protected against excessive current demand by other parts of the circuitry. If a failure causes a high current demand on the power supply, its output voltage will drop as far as necessary to reduce output current to approximately 0.75A. If the power supply voltage is observed to be abnormally low, unplug each circuit card in turn and check if the power supply recovers by observing the "-15VDC" meter position. (The negative regulator tracks the +15V supply. So the -15V supply will go down if the +15V supply does, even if the -15V supply or load is completely normal. A normal "-15VDC" reading thus assures a normal "+15VDC" reading.) If recovery occurs, then troubleshoot the unplugged board. Ordinarily, the defective component will become very hot, and is easily detected by touch. (Wet your finger first to avoid burns!)

If all cards are removed and an undervoltage problem does not disappear, examine the meter card, motherboard, and chassis wiring before suspecting the supply itself. (A wiring problem will be indicated by an ohmmeter's indicating very low resistance between the "+15V" or "-15V" power busses with AC power OFF.)

Even if power supply voltages appear normal on the VU meter, subtle problems such as hum, noise, or oscillation may still exist with the supply. To check for this, test the regulated DC with a well-calibrated DVM, scope, and AC VTVM with 20-20kHz bandpass filter. Voltages should be +15.00V ±0.075V, -15.00V ±0.375V. Ripple must be less than 2mV r.m.s., 20-20,000Hz. There must be no high frequency oscillation.

VU Meter Technique: If one channel goes dead, the VU meter provides a means for fast signal tracing. Note, however, that problems other than gross gain changes or total failure to pass signal may not be detected by the meter alone.

First, switch through the first eight VU meter functions (which monitor the audio processing) to see where the signal disappears (or the VU meter pegs, implying that a defective IC opamp has latched up to the power supply rail.) Refer to the block diagram (p. J-25) to locate the exact points in the signal path monitored by the meter.

If the signal is normal at the input terminals and abnormal in either INPUT BUFFER position, then the problem lies with Card #3 (left channel) or Card #4 (right channel), or with the incoming audio circuitry prior to these cards.

If the signal is normal at the INPUT BUFFER positions but abnormal in the COMPR OUT position, then the problem probably lies with Card #3 (left channel), with Card #4 (right channel), or, if both channels are equally affected, with Card #5.

If the signal is normal at the COMPR OUT positions, but abnormal in either FILTER OUT position, then the problem may lie with Card #6 (which contains both channels), Card #0 (left channel), Card # 1 (right channel), Card #8 (left channel), or Card #9 (right channel).

If the signal is normal at both FILTER OUT positions, but abnormal at either SYSTEM OUT position, then the problem lies in Card #7 (line amplifiers).

The **Card Swap Technique** might be used to localize the problem more precisely.

CARD SWAP TECHNIQUE

The instructions below provide more detailed information on troubleshooting at the "card exchange" level. Servicing on the "component replacement" level requires more profound understanding of OPTIMOD-TV circuit operation, which is provided by **Appendix A (SYSTEM DESCRIPTION)** and **Appendix B (CIRCUIT DESCRIPTION).** If the technician wishes to troubleshoot at the component level, he should first use **Appendix A** to help track down the fault to a given subsystem, and then refer to **Appendix B** for an extremely detailed explanation of the circuitry at the component level.

If the defective card has not yet been conclusively identified and if the fault appears on one channel only, the next step involves a card swap technique. The PC cards in OPTIMOD-TV have been specifically configured to aid troubleshooting if a fault appears in one stereo channel only. Cards #0 and #1, Cards #3 and #4, and Cards #8 and #9 are identical. Therefore, these card pairs can be interchanged one pair at a time to see if the problem moves from one channel to the other (implying that the fault is with one of the cards just moved), or stays the same (implying that the problem lies elsewhere in the system).

If the card swap technique reveals that either Card #0 or Card #1 is faulty, the system can be operated without these cards by following the instructions in **Emergency Bypass Of Cards #0 and #1,** below.

If interchanging these card pairs fails to affect the location of the problem, then Card #6 should be investigated. This card passes both left and right audio. To aid troubleshooting, jumper "B" is provided at the output of the card to interchange the outputs of the left and right channels (See Fig. F-1). Jumper "B" contains links if the system is operating in its "normal" mode (with Cards #0 and #1 present). If this jumper is moved and the fault moves from one channel to the other, then Card #6 is probably faulty.

(Jumper "C" will contain links if the system is operating in its "emergency" mode. In this mode, moving the links on jumper "C" will perform the same function as moving the links on jumper "B" in "normal" mode, so diagnosis of problems in Card #6 can still occur.)

Problems in Card #7 (Line Amplfiers) are unlikely because the circuitry is so simple. If one channel of Card #7 is bad, audio will be normal at the rear-panel TEST JACK corresponding to that channel, and abnormal at that channel's MAIN AUDIO OUTPUT.

Cards Common To Both Channels: Cards #PS (Power Supply), #2 (Loudness Controller), and #5 (Compressor Control Circuitry) are common to both channels. Card #6 contains the common ±4.2V clipper bias supply used by Cards #8 and #9.

Diagnosis of power supply problems was discussed above.

The Loudness Controller can be defeated simply by removing Card #2 from its slot. If this is done, the system will operate normally (although without the Loudness Controller function) without requiring adjustments, movement of jumpers, or other considerations.

Abnormal gain reduction characteristics (occurring in both channels) which disappear when the Loudness Controller card is removed from its slot almost certainly indicate a problem with Card #2. We recommend that this card be serviced by the factory unless obvious problems like opamp or logic chip failures have occurred. These may be serviced in the field by replacing the faulty component. The Loudness Controller requires no alignment, and should work satisfactorily with any chips meeting generic specifications. Loudness Controller performance can be evaluated by following the procedure in part (d) of **Appendix D (Field Audit-Of-Performance).**

A failure in Card #5 (the common processing control card that controls both Card #3 and #4) can manifest itself on both channels as distortion (too little gain reduction), low loudness (too much gain reduction), pumping or other dynamic problems (failure in the timing circuitry), or failure of the gating circuitry (which is usually indicated by abnormal behavior of the front-panel GATE lamp). First-order problems in card #5 are often indicated by a failure to produce the "standard level" under "standard control setup" conditions. (See **c.1** and **c.2** in **Appendix D** for instructions on how to make this test.)

FAILURES WHICH CANNOT BE DIAGNOSED BY CARD-SWAPPING

Phase Corrector Failures: One possible problem which is difficult to diagnose by means of a card swap is failure of a phase corrector on Cards #6, #8, or #9. Some failures can grossly change the phase response of a given channel without significantly affecting the frequency response. While each channel sounds normal by itself, the mono sum will exhibit gross frequency response aberrations due to phase cancellations. If OPTIMOD-TV is driven by mono material, the "L-R" meter on your (forthcoming) TV stereo monitor will fail to null.

The principal difficulty is determining which channel is abnormal, since phase corrector failures will cause audible problems (most often increased distortion) only with certain types of program material. The following describes listening tests to detect phase corrector failures. If the ear can detect the usually subtle effect of the corrector failure by listening to one channel only, then the card-swap technique can be successfully applied to isolate the problem. In these tests, it is important to drive both channels with identical program material, as the usual differences between the left and right channels can totally mask any differences due to phase corrector failure. The easiest way to assure identical L and R drive is simply to drive both L and R inputs in parallel from a single signal.

A phase corrector failure on Card #6 will cause slightly more high frequency clipping than would otherwise be expected, so the failed channel may sound slightly grittier when program material containing large amounts of high frequency energy is processed.

A phase corrector failure in the first part of Cards #8 and #9 will cause the below-2.2kHz selectivity of the 2.2-15kHz bandpass filter (driven by the HF VCA in the Hilbert-Transform Clipper) to severely deteriorate, resulting in sibilance distortion (splattered "ess" sounds on voices).

A phase corrector failure in the FCS Overshoot Compensator (second part of Cards #8 and #9) will result in inaccurate overshoot cancellation. This will result in overdriving the safety clipper when significant high frequency energy is present, which will, in turn, cause out-of-band frequency components to be generated. These components will cause aliasing distortion when decoded in a stereo receiver, and could conceivably cause interference with the video.

If you have a spectrum analyzer which covers 0-50kHz or so, the easiest way to test for this is to observe the spectrum of the signal at the left and right TEST JACKS when both channels are driven by pink noise at a level sufficient to cause the TOTAL MASTER G/R meter to read "0". Once this G/R meter indication is obtained, switch the COMPRESSOR PROOF/OP switch to PROOF to grossly overdrive the clippers and overshoot compensator, thus stressing the system highly. If one channel shows much more "trash" beyond 15kHz than the other channel, the channel showing the excess "trash" is suspect.

EMERGENCY BYPASS OF CARDS #0 AND #1

If the **Card Swap Technique** above reveals that either Card #0 or #1 is faulty, both cards can be removed for servicing while keeping OPTIMOD-TV on the air on an emergency basis. Basically, this involves re-routing the signal directly from Card #6 to Cards #8 and #9, and re-activating the normally dormant clippers on Cards #8 and #9. This mode of operation is identical to that used in the old OPTIMOD-TV Model 8180A and in OPTIMOD-FM, and therefore does not involve serious compromises in quality: The "emergency" can last as long as necessary without any penalty other than possibly a slight increase in clipping distortion on low-quality feeds like optical film.

CAUTION!

Do not try to bypass only one card while leaving the good card in service: In stereo operation, you will experience severe phase-cancellation in the mono sum because the delays in the left and right channels will be radically different! In addition, because the Loudness Controller operates from the sum of the channels, it will work incorrectly.

Procedure:

1) Remove Cards #0 and #1 from their slots.

2) Remove Card #6 from its slot. Remove the links from jumper "B" and place them on jumper "C" as shown in Fig. F-1. Then move the link on jumper "A" as shown in Fig. F-1. Replace Card #6 in its slot.

   (**NOTE:** Jumper "C" permits swapping channels at the output of Card #6 for trouble diagnosis even in the "emergency" mode.)

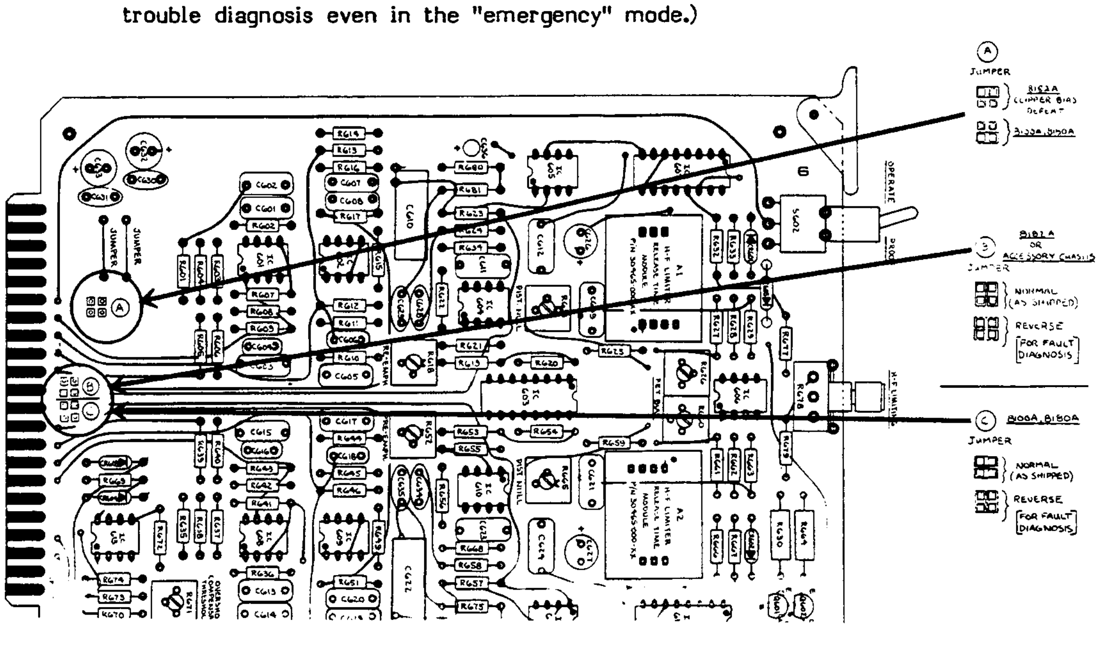

Fig. F-1: CARD #6: JUMPER LOCATIONS

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3) Remove Cards #8 and #9 from their slots. On each card, move the link on jumper "A" according to Fig. F-2 below. (This rearranges the lowpass filters such that distortion-cancellation is applied to the "emergency" clippers.) Then replace Cards #8 and #9 in their slots.

The completes the Emergency Bypass Procedure. Assuming that there are no other faults, OPTIMOD-TV is now ready to operate after mechanical reassembly. If clipping distortion seems excessive you may wish to turn down the CLIPPING control.

To restore the unit to its normal mode after repair of the faulty #0 or #1 Card, follow the above instructions in reverse.

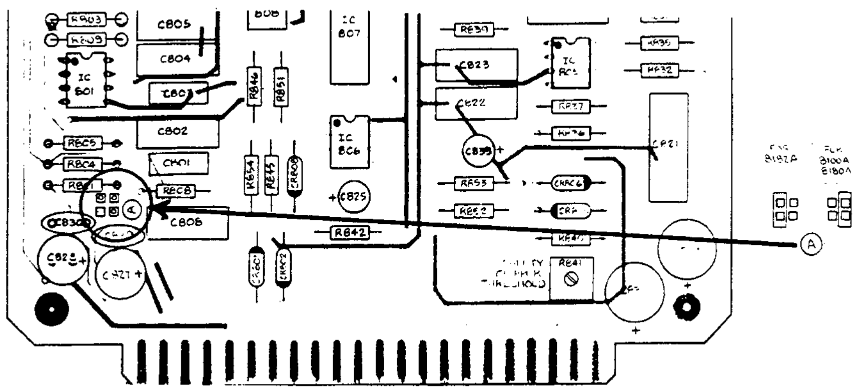

Fig. F-2: CARD #8/#9 EMERGENCY BYPASS JUMPERS

CATALOG OF TYPICAL SYMPTOMS AND PROBABLE CAUSES

This troubleshooting guide is a catalog of some possible failure modes in OPTIMOD-TV. It should be used in conjunction with **Appendices A** and **B** to aid troubleshooting at the component level.

ALWAYS BE SURE THAT THE PROBLEM IS NOT IN THE SOURCE MATERIAL FEEDING OPTIMOD-TV.

Whistle is heard on air.

1. Power supply oscillation. Suspect C111, C112, IC101, IC102.
2. Whistle on one stereo channel only probably due to oscillating IC. Use signal tracing techniques to isolate defective IC.

Buzz or hum.

1. Improper grounding. Chassis not properly grounded to rack. Circuit and chassis grounds connected through excessively long path. No direct connection between OPTIMOD-TV circuit ground and circuit ground of exciter with balanced input.
2. RFI. Improve grounding scheme. Relocate OPTIMOD-TV chassis. Change length of input or output cables to retune them.
3. Low line voltage causing regulator to drop out and pass ripple.
4. C101, C102 in unregulated power supply failed, resulting in extremely high ripple. Power supply regulator drops out on each ripple cycle which instantaneously goes lower than 17.5 volts.

Loss of modulation control.

1. Make sure LIMITER PROOF/OPERATE switch (on Card #6) is in OPERATE.
2. Check for tightly-controlled peak levels at rear-panel TEST jacks. If levels not well-controlled, check $\pm$4.2V supply on Card #6.
3. If levels are well-controlled, check connection to aural exciter, including STL (if used). Inadequate phase linearity and/or frequency response in the circuit path after OPTIMOD-TV can change peak levels, causing overshoots and loss of modulation control. This problem will ordinarily appear immediately upon installation.

Bass incorrectly balanced.

1. It is normal when operating OPTIMOD-TV "independent" to have it accentuate bass on many different types of program material. If you want the frequency balance between "Air" and "Program" to be substantially identical, operate the BASS COUPLING control closer to "wideband".
2. Possible misalignment or failure in exponential converter circuitry for either "Master" or "Bass" compressors. This will cause frequency response to be non-flat even in PROOF mode. If this is the case, check circuitry associated with IC501, IC502, IC510, IC511.
3. Failure in Input Conditioning Filter (on Cards #3 and #4). This will be revealed in PROOF mode.
4. Failure in either "Bass" or "Master" VCA, causing gain shift.

Insufficient high frequency response.

1. Due to the preemphasis curve, some high frequency loss is inevitable when OPTIMOD-TV is operated aggressively for maximum loudness (i.e., large amounts of clipping, and fast release time). To obtain more highs, back off both the CLIPPING and RELEASE TIME controls.
2. In "independent" mode, the increase in bass response with certain program material may cause an apparent loss of highs. Try operating "wideband" temporarily to see if the highs are then balanced like the input material.

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3. R626 (left channel) or R660 (right channel) misadjusted, such that IC603A (left channel) or IC603B (right channel) is always turned ON, thus partially defeating the preemphasis.

4. HF limiter working too hard. Check IC605B, IC607 (left channel); IC611B, IC612 (right channel) for correct rectifier action and correct HF limiting threshold. (These circuits are independent. Thus, the bad channel can be compared to the good channel with a mono source.)

Gross distortion.

1. Power supply voltage low. (Check AC power line voltage first.)
2. IC opamp failure. This must be diagnosed by signal tracing.
3. Failure in clipper-diode bias supplies. Low bias voltage will cause excessive clipping, and will also result in abnormally low modulation. Check IC806B, IC808 and associated circuitry (on Cards #8 and #9) to make sure that the output is approximately $\pm$1.5VDC under no-signal conditions, and approximately $\pm$1.35VDC when a 5kHz sinewave at level sufficient to cause gain reduction is applied to the input of the appropriate channel. Check IC613 and associated circuitry (on Card #6) to make sure that the output is approximately $\pm$4.2VDC under all OPERATE conditions.
4. Gross failure in a sidechain, such as IC latchup. This will either misbias the main signal path, or add distortion to the main signal, without causing the main signal to disappear. IC's in sidechains include IC601A, IC608A, IC602B, IC609B, IC604, IC610 (on Card #6); IC802A, IC802B, IC803A, IC804A, IC804B (on Card #8 and Card #9).
5. Exponential converter(s) IC501, IC502, IC510, IC511, or timing module(s) A1, A2 (on card #5) defective, causing very low (or no) control current to VCA's on Cards #3 and #4, thus causing these VCA's to take very high gain. Timing module failure will be indicated by COMPRESSION MASTER G/R or BASS G/R meter's pegging at the top of the scale (beyond "+10").
6. Failure in Hilbert-Transform Clipper control circuitry, particularly that causing the threshold of limiting to be excessively low.

Moderate to Subtle Distortion.

1. Distorted program material and/or distortion problems in studio or STL.
2. Check points listed in "Gross Distortion" (immediately above), for moderate deviations from normal parameters.
3. CLIPPING control misadjusted.
4. Failure in rectifiers IC507A, IC505, IC507B, IC506, IC514A, IC512, IC514B, IC513, or in timing modules A1, A2 on card #5. These problems will usually be indicated by failure to produce standard level under standard conditions (see **c.1** and **c.2** in **Appendix D).**
5. Safety clipper misalignment (R841). This alignment is most unlikely to drift by itself from its factory-adjusted condition. But humans with alignment tools sometimes do strange things. If you are in doubt about this alignment, it can be checked (and readjusted if necessary) by performing the Card #8/9 alignment procedure in **Appendix E.**
6. Phase corrector failure. See "Phase Corrector Failures" earlier in this Appendix for a further discussion.
7. Failure in distortion-cancel sidechain on Cards #8 and #9. This is indicated by a "gritty" high end with severe sibilance splatter.
8. Misalignment of DISTORTION NULL controls on VCA's on Cards #0, #1, #3, or #4. Such misalignment will introduce mainly second-harmonic distortion, which might actually sound pleasing on some program material.

L-R does not null on mono material.

1. This is caused by gain, frequency response, or phase response differences between the left and right channels. So before assuming that the problem is internal to OPTIMOD-TV, make sure that the feed is really 100% mono. This can be reliably assured by driving both left and right OPTIMOD-TV inputs in parallel from a single signal source.
2. If L-R will not null in PROOF mode, then the problem is static, and is caused by abnormal frequency and/or phase response in one channel. If the frequency response is normal, suspect the phase correctors on Cards #6, #8, and #9 (including A1, the phase delay network module).
3. If L-R will null in PROOF mode, then the left and right VCA's or high frequency limiter circuitry are failing to track dynamically under gain reduction conditions. In the case of the VCA's, the dual gain block (IC305, for example) is suspect. In the case of the HF limiter, the rectifiers or timing modules are suspect.

Sibilance Distortion.

1. Source material at OPTIMOD-TV input terminals distorted.
2. Failure in highpass filter on Cards #8 or #9.
3. Failure of the HF limiter. If the HF limiter isn't working at all, then even a properly-operating distortion-cancelling clipper may generate some audible distortion.

FACTORY ASSISTANCE

Orban maintains a Customer Service Department to help Orban product users who experience difficulties. Orban Customer Service is supplied at two levels. The first is telephone consultation. Often, a problem is due to misunderstanding, or is relatively simple and can be fixed by the customer aided by phone advice from the factory. Telephone consultation should always be the first step in any factory service transaction. Units will be accepted for factory service (the second level) only after consultation, and only after a Return Authorization (RA) code number has been provided by phone or letter. The RA number flags the returned unit for priority treatment when it arrives on our dock, and ties it to the appropriate information file.

The purpose of this formality is to save both the customer and the factory time and trouble by attempting to weed out problems which are caused by equipment other than OPTIMOD-TV, misapplication, or environment, and to identify those problems that lend themselves to quick field repair.

Before calling Customer Service, be prepared to give the model number (8182A) and serial number of your unit. If the unit is in its warranty period and the Registration Card was never returned, we will also need the name of the dealer from which the unit was bought, the invoice number, and the invoice date.

Be prepared to accurately describe the the problem. What is the complaint? Is it constant or intermittent? If it is intermittent, can it be correlated to environmental conditions like line voltage, temperature, humidity, electrical storms, vibration, etc? Do problems only occur with certain program material (live voice, very bright music, music with heavy bass transients, etc.)? What about source: network, VTR, film chain, cart, disk, reel-to-reel tape, live microphone?

Be prepared to describe any unusual observations made during the **Problem Localization Routine** you performed using the instructions above.

Then, contact the Customer Service Department by telephone, letter, or Telex (see title page for numbers). A Customer Service Engineer is ordinarily available during local business hours, Monday through Friday. The Customer Service Engineer will do everything practical to help correct the fault and have your OPTIMOD-TV up and running again as quickly as possible.

In many cases, field repairs can be effected by merely exchanging a single PC card, rather than by returning the entire OPTIMOD-TV chassis for repair. The factory ordinarily maintains a small number of "loaner cards". One of these may be provided as a spare PC card for use while the customer's card is being repaired at the factory. In most cases, factory service of defective cards is preferable to field service by the customer because the factory maintains a supply of exact-replacement spare parts, and has the experienced technicians and special test fixtures necessary to assure that the repaired card meets factory specifications in all respects. Instructions for packing and shipping cards or the complete chassis are found at the end of this Appendix.

DIAGNOSIS AT THE COMPONENT LEVEL

After following the above diagnostic procedure to localize the problem to a single card, you may want to troubleshoot the card on the component level instead of returning the card to the factory for service.

Here are some suggestions...

Troubleshooting IC Opamps

IC opamps are operated such that the characteristics of their associated circuits are essentially independent of IC characteristics and dependent only on external feedback components. The feedback forces the voltage at the "-" input terminal to be extremely close to the voltage at the "+" input terminal. Therefore, if the technician measures more than a few millivolts between these two terminals, the IC is probably bad.

Exceptions are IC's used without feedback (as comparators) and IC's whose outputs have been saturated due to excessive input voltage because of a defect in an earlier stage. However, if an IC's "+" input is more positive than its "-" input, yet the output of the IC is sitting at -14 volts, this almost certainly indicates that it is bad. The same holds if the above polarities are reversed. Because the characteristics of OPTIMOD-TV are essentially independent of IC opamp characteristics, an opamp can usually replaced without need for recalibration.

NOTE

THE DUAL CURRENT-CONTROLLED GAIN BLOCKS EMPLOYED IN THE VCA's(IC 305, 309, 405, & 409 on Cards #3 and #4; and IC 1 & 11 on Cards #0 and #1) ARE NOT OPAMPS. IF THEY ARE REPLACED, RECALIBRATION IS ABSOLUTELY NECESSARY.

A defective opamp may appear to work, yet it may have extreme temperature sensitivity. If parameters appear to drift excessively, freeze-spray may aid in diagnosing the problem. Freeze-spray is also invaluable in tracking down intermittent problems. But, use sparingly, because it can cause resistive short circuits due to moisture condensation on cold surfaces.

Selecting And Ordering Replacement Parts

Nearly all parts used in Optimod-TV have been very carefully chosen to make best use of both major and subtle characteristics. For this reason, parts should always be replaced with exact duplicates as indicated on the Parts List. It is very risky to make "close-equivalent" substitutions because of the possibility of materially altering performance and/or compliance with FCC requirements. The Factory is ordinarily able to supply any replacement part rapidly at an uncommonly reasonable price.

Specifically, such parts include all FET´s and precision metal-film resistors, almost all capacitors, trimmer resistors, and integrated circuits, most transistors, and certain diodes.

Certain cards contain potted modules which, if diagnosed as defective, must be replaced as a unit. Ordinarily, this requires return of the entire card to the factory.

Certain parts are selected by the factory to tighter than normal specifications in order to obtain circuit performance which meets our exacting standards. Such parts are footnoted in the Parts Lists.

Certain parts, if replaced, require partial recalibration which may or may not be practical in the field. Such parts are footnoted in the Parts Lists. The recalibration requirements are outlined in the appropriate section of **Appendix B (Circuit Description)** and/or **Appendix E (Alignment).**

Service in areas involving selected parts or recalibration is best referred to the factory, which, as a result of training, experience, availability of special equipment, and availability of exact replacement parts, is generally far better qualified to perform repairs efficiently and correctly.

Ordering Parts From The Factory: If parts are ordered from the factory, we require all of the following information:

-- The Orban part number, if ascertainable from the Parts List
-- The Reference Designator (e.g., R503)
-- A brief description of the part
-- And, from the serial label on the rear of the unit
  - the exact Model Number
  - the Serial Number
  - the "M" number, if any

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REPLACEMENT OF COMPONENTS ON PRINTED CIRCUIT BOARDS

It is important to use the correct technique for replacing components mounted on PC cards. Failure to do so may result in circuit damage and/or intermittent problems.

Many components, if replaced, will cause a change in calibration which will require returning the affected circuit card to the factory for recalibration. Also, some components are selected for characteristics which are not indicated by the manufacturer´s part number. Most of these components are listed as "selected" on the parts list, but not all. In addition, the selection criteria are not generally described. It is therefore almost always wiser to return the defective card to the factory for service.

Most circuit cards used in OPTIMOD-TV are of the double-sided plated-through variety. This means that there are traces on both sides of the card, and that the through-holes contain a metallic plating in order to conduct current through the card. Because of the plated-through holes, solder often creeps 1/16" up into the hole, requiring a sophisticated technique of component removal to prevent serious damage to the card.

If the technician has no practical experience with the elegant and demanding technique of removing components from double-sided PC cards without card damage, it is wiser to cut each of the leads of an offending component from its body while the leads are still soldered into the card. The component is then discarded, and each lead is heated independently and pulled out of the card with a pair of long nose pliers. Each hole may then be cleared of solder by carefully heating with a low-wattage soldering iron and sucking out the remaining solder with a spring-activated desoldering tool. THIS METHOD IS THE ONLY SATISFACTORY METHOD OF CLEARING A PLATED-THROUGH HOLE OF SOLDER IN THE FIELD!

The new component may now be installed by following the directions below starting with step (4).

Otherwise, use the following technique to replace a component:

1) Use a 30 watt soldering iron to melt the solder on the solder side (underneath) of the PC card. Do not use a soldering gun or a high-wattage iron! As soon as the solder is molten, vacuum it away with a spring-actuated desoldering tool like the Edsyn "Soldapullt". AVOID OVERHEATING THE CARD; overheating will almost surely damage the card by causing the conductive foil to separate from the card base.

Even with care, you are likely to blister the enamel solder-mask coating on the card, which, in most cases, is no cause for concern. The coating exists mainly to prevent moisture from condensing between the traces and to simplify wave-soldering.

2) Repeat step (1) until each lead to be removed has been cleared of solder and freed.

3) Now release the component by gently wiggling each of the leads to break solder webs. Then lift the component out.

4) Bend the leads of the replacement component until they will fit easily into the appropriate PC card holes. Using a good brand of rosin-core solder, solder each lead to the bottom side of the card with a 30 watt soldering iron. Make sure that the joint is smooth and shiny. If no damage has been done to the plated-through hole, soldering of the topside pad is not necessary. However, if the removal procedure did not progress smoothly, it would be prudent to solder each lead at the topside as well in order to avoid potential intermittent problems.

5) Cut each lead of the replacement component close to the solder (underneath) side of the PC card with a pair of diagonal cutters.

6) Remove all residual flux with a cotton swab moistened with a solvent like 1,1,1 trichloroethane, naptha, or 99% isopropyl alcohol. The first two solvents are usually available in supermarkets under the brand name "Energine" fire-proof spot remover and regular spot remover, respectively. The alcohol, which is less effective, is usually available in drug stores. Rubbing alcohol is highly diluted with water and is ineffective.

It is good policy to make sure that this defluxing operation has actually removed the flux and has not just smeared it so that it is less visible. While most rosin fluxes are not corrosive, they can slowly absorb moisture and become sufficiently conductive to cause progressive deterioration of performance.

SHIPPING INSTRUCTIONS

Circuit Cards: A circuit card is best shipped in the special Orban Associates shipping carton used to supply loaner cards. If you wish to ship a card without this carton, cut two pieces of 1" or thicker soft foam to 6.5" x 9" (17cm x 23cm) or larger. Sandwich the card between the two foam pieces, and ship the foam "sandwich" in a rigid cardboard carton.

A "JIFFY-BAG" OR SIMILAR SOFT MAILING BAG DOES NOT PROVIDE SUFFICIENT PROTECTION FOR THE CARD, AND MUST NOT BE USED!

Shipping The Complete Chassis: If the original packing material is available, it should be used. Otherwise, a sturdy, double-wall carton of at least 200 pounds bursting test and no smaller than 22" x 15" x 12" (56 x 38 x 31 cm) should be employed.

OPTIMOD-TV should be packed so that there is at least 2" of packing material protecting every point. A plastic wrap or bag around the chassis will protect the finish. Cushioning material such as Air-Cap, Bubble-Pak, foam "popcorn", or thick fibre blankets are acceptable. Folded newspaper is <u>not</u> suitable. Blanket-type materials should be tightly wrapped around OPTIMOD-TV and taped in place to prevent the unit from shifting out of its packing and contacting the walls of the carton.

The carton should be packed evenly and <u>fully</u> with the packing material filling all voids such that the unit cannot shift in the carton. Test for this by closing but not sealing the carton and shaking vigorously. If the unit can be felt or heard to move, use more packing. The carton should be well-sealed with 3" (8 cm) reinforced fibreglass or polyester sealing tape applied across the top and bottom of the carton in an "H" pattern. Narrower or parcel-post type tapes will not stand the stresses applied to commercial shipments.

The package should be marked with the name of the shipper, and the words in red: DELICATE INSTRUMENTS, FRAGILE!. Even so, the freight people will throw the box around as if it were filled with junk. The survival of the unit depends almost solely on the care taken in packing!

After a formal Return Authorization (RA) number is obtained from the factory, units should be shipped to the Service Manager at the address shown on the title page.

YOUR <u>RETURN AUTHORIZATION</u> NUMBER MUST BE SHOWN ON THE LABEL, OR THE PACKAGE WILL NOT BE ACCEPTED!

INSURE YOUR SHIPMENTS APPROPRIATELY!

SHIP PREPAID -- DO NOT SHIP COLLECT!

DO NOT SHIP PARCEL POST!

(Otherwise, have a nice day.)