Operating Manual

MODEL 8000 A

OPTIMOD-FM

orban/broadcast

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Introduction

General

The Optimod 8000 FM Limiter/Stereo Generator is the result of a new and exclusive systems approach to the design of the FM audio processing chain. In combining three conventionally separate components, the limiter, the compressor, and the stereo generator, Bob Orban has engineered a single system which is capable of achieving both high loudness and extremely high audio quality simultaneously. These two goals are mutually exclusive in conventional systems.

It is important that this manual be read carefully and that the instructions be followed conscientiously. *Make no assumptions on the basis of past experience with conventional systems.* A technical paper entitled "Combining High Signal Quality with High Modulation Levels in FM" has been included with this instruction manual. We suggest that you read this before proceeding with the actual installation and adjustment of your Optimod 8000.

Operating Characteristics

The maximum range of gain reduction in the Optimod has been purposely limited to 15 dB. If attempts are made to drive the input beyond this level, the front panel OVERLOAD lamp will light and the audio will become audibly dulled and distorted.

Optimum compression of modern recordings occurs when no more than 8 to 10 dB of total compression and limiting is used, and when the compressor is not gated, but is permitted to recover full gain during pauses or low-level passages. Because the amount of compression is purposely limited, excessive noise pump-up does not occur as it does in similar systems with 20 to 30 dB of potential compression.

The attack and release time constants of the AGC vary automatically as a function of the program. These constants have been determined by means of hundreds of hours of critical listening, under studio monitor conditions, to all types of modern recorded music from classical to hard rock. As a result of this extremely careful psychoacoustic tuning, a proprietary quadruple time-constant release time circuit, and extremely low static and dynamic distortion, it can be safely said that the Optimod is the first commercial FM broadcast limiter that can be described as "transparent" or "high-definition."

Unlike older limiters, Optimod has no "sound of its own," but instead faithfully passes the technical quality of the particular input material. In a vast majority of cases, comparing input and output reveals a gain change — as if a human operator were tastefully operating a fader — but absolutely no quality change. Nor is there an electronic quality to the high frequency control. Instead, it sounds as if a human operator momentarily and extremely tastefully operated a treble tone control. Unlike older systems, Optimod introduces neither the gritty sound of clipping distortion, nor timbre modulation, a gross and rapid change in the program high frequency content which sounds like a tape with edge damage.

When the Optimod is into gain reduction, increasing the input level will produce no audible difference in sound quality or loudness until the 15 dB gain reduction range has been exceeded, at which point dullness and distortion will rapidly ensue. Driving the Optimod harder will simply cause the low-level passages to be brought up progressively higher. However, this gain riding action is slow and subtle, and is not heard as a quality change.

The approximately 2 dB of fast limiting, plus instantaneous limiting, ride on a gain platform

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established by the slow time-constant gain reduction function. The amount of fast and instantaneous limiting is essentially independent of where the slow time-constant platform is located at any given moment within the 15 dB gain reduction range.

Applying Optimod to the FM Chain

The Optimod broadband AGC section is capable of producing optimum compression and limiting of music without the use of other signal processing devices. Such devices almost invariably are more audible in their action and have far more distortion than the Optimod. The "sound" of these devices will be faithfully passed by the Optimod. In most cases, this merely degrades audio quality without yielding any benefits.

We recommend that an external compressor be used only if your format is primarily talk from low-quality sources. The Optimod is not gated: an "intelligent" compressor will avoid audible noise pump-up in long pauses. Noise pump-up is primarily audible on low-quality program material with substantial background noise such as telephone lines, sports remotes, and the like.

If an "intelligent" compressor is employed, the RELEASE TIME control on the Optimod should be set fully CCW ("limit only"), and gain reduction should be limited to 3 or 4 dB.

For all other formats, the Optimod is the only audio processing device necessary between disc and transmitter and should be driven directly from the console output with nothing in between other than a pair of telephone lines. If a composite STL is used, the Optimod is installed at the studio and may be directly (or through the patch bay) wired to the console output.

Audio Operations and Optimod

The limited range of gain reduction requires that operators change their habits somewhat. Instead of peaking anywhere, operators should peak voice and music about as carefully as they would if they were doing production onto a tape recorder—i.e., somewhere around zero VU.

The station changing to Optimod from an older limiter will find that the audio quality of the station is no longer determined by the "sound" of the limiter as was the case before. Instead, the Optimod will pass the quality of the material being fed to its input. Therefore, installation of the Optimod will often call for a tightening up and improvement of the preceding audio chain.

If discs are re-recorded onto tape cartridge or reel-to-reel tape, Optimod will easily reveal the generational loss unless utmost care is used. Use of a noise reduction system internally in the station to encode and then decode tape will yield unmistakable audible improvement in an Optimod installation. Either Dolby or DBX appear suitable at this writing.

If a "phase enhancer" is used, it should be placed after stereo cartridge reproducers only rather than in the program line.

Regular alignment of tape equipment, and checking phono equipment with a test record to assure that it conforms to the RIAA playback equalization curve will pay audible quality dividends in an Optimod installation. For example, the excellent high frequency response of the Optimod reveals clearly the treble loss caused by misaligned or worn tape heads. Such heads should be lapped or replaced when 15 kHz response begins to deteriorate. Similarly, phono styli can exhibit subtle distortion long before wear becomes obvious under microscopic examination. Styli should be checked regularly and replaced if they begin to deteriorate audibly.

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Operating Instructions

General

In day to day station operations, the Optimod itself requires very little attention. Front panel controls are provided for monitoring of various functions with the front panel meter, and for switching from stereo to mono. Figure II-1 shows the front panel with operating controls labeled. Use of the SET-UP controls will be discussed in chapter IV, "INITIAL SET-UP AND ADJUSTMENTS."

As mentioned in the introduction, operations in the audio chain prior to Optimod may have to be tightened to a degree. Particularly, the audio level should be peaked close to zero VU to avoid driving the Optimod into either distortion or undermodulation. Also the recommendations in the INTRODUCTION section, "Audio Operations and Optimod," should be conscientiously followed (see page I-2).

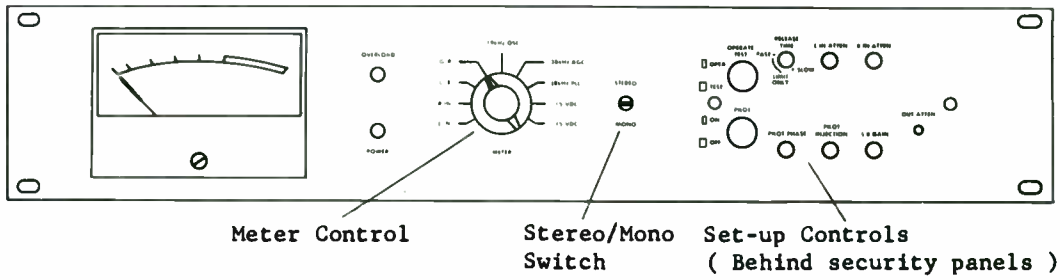

FIG. II-1 FRONT PANEL CONTROLS

Meter Selector Switch

The METER switch selects which of several signals or circuit parameters the front-panel VU meter measures. We have provided a list at the front of this manual of normal, no-load, readings of the various positions of the METER switch for your unit. The positions are:

(1) L IN — Indicates audio level after the L IN ATTEN control and buffer amplifier, but before highpass filtering and limiting. Will typically read around zero VU peak when L IN ATTEN control is correctly adjusted, although this will vary according to the amount of gain reduction being employed.

(2) R IN — As above.

(3) L-R — Meters the output of the L-R amplifier in the stereo generator. This position is ordinarily used to adjust the input attenuator controls for best channel balance. The audio observed here has been limited, low-pass filtered, and preemphasized.

(4) G/R — Indicates the amount of gain reduction in the broadband limiter directly in dB. As the high frequency limiter has no operator adjustments and does not increase its limiting as the broadband gain reduction is increased, no high frequency gain reduction metering is provided.

(5) 19 KHZ OSC — Indicates the output level of the 19 kHz oscillator. In the MONO mode the oscillator is squelched and this position will read 0%.

(6) 38 KHZ PLL — This indicates the DC control voltage of the voltage-controlled phase shifter in the phase locked loop in the stereo generator. This reading will normally vary widely. The purpose of the metering is to make sure that the circuitry has not drifted

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outside the lock range of the PLL (indicated by an offscale or less than about 20% reading) or that a circuit failure has not caused the PLL to lose lock.

(7) 38 KHZ AGC — This position monitors the DC control voltage at the input to the 38 kHz voltage-controlled amplifier in the stereo generator. This reading may vary widely. The purpose of this reading is to make sure that the unit has not lost AGC lock because of drift or circuit failure. An offscale reading, for example, implies that no 38 kHz is being applied to the AGC comparator at the output of the 38 kHz filter. This is normally the case in the MONO mode. In addition, this reading may be used to tune T401 in the stereo generator.

(8) +15 VDC — Monitors the level of the +15 volt regulated power supply.

(9) -15 VDC — Monitors the level of the -15 volt regulated power supply.

Stereo/Mono Switching

The Optimod has been designed so that extremely versatile STEREO/MONO switching is available. The three possible operating modes are STEREO, MONO LEFT, and MONO RIGHT. In STEREO, the unit produces a composite stereophonic output. In MONO LEFT, the unit takes the left channel mono signal and produces an output which is peak-controlled to the same level as the composite stereo output. MONO RIGHT performs the same operation with the right channel.

Remote switching is easily accommodated and is discussed in INSTALLATION, page III-4.

Front Panel Switching

Either STEREO or MONO modes may be selected by the momentary switch located on the Optimod front panel. A time delay of up to five seconds will be noted between the time that the switch is actuated and the time that stereo output is available. The switch need not be held for this time period, but may be briefly flicked, as the logic switches in microseconds.

Whether MONO LEFT or MONO RIGHT is selected by the front panel switch is determined by an internal jumper. Another jumper determines which mode, STEREO, MONO LEFT or MONO RIGHT, the logic will enter after an AC power interruption or in normal turn-on. Units are strapped for MONO LEFT front panel switching and STEREO initializing of the switching logic. Instructions for restrapping are found in the INSTALLATION section, page III-3 .

Operating in Mono Mode

It should be noted that switching from stereo to mono does not remove audio from either channel of the limiter section; it does defeat the summing of the two channels in the output. But, because the gains of the two limiter channels track, limiter gain will be forced down unnaturally if the input from the unused channel is greater than the input from the used channel. Therefore, in MONO operation the unused channel should either be driven with a mono signal of level identical to the signal on the channel being used, or should not be driven at all.

The remote selection feature can be used to keep the station on the air in mono mode in case of failure of one telephone line or one channel of a dual STL. It may be desirable to incorporate external remote control which can entirely disconnect either audio channel from the input of the Optimod, in order to avoid unnatural gain reduction in the case where the phone line or STL failure manifests itself as high noise, hum, etc.

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Installation

Preliminary Checkout

After unpacking the unit and checking for superficial damage, 115 volt AC power should be applied and preliminary check made using the Optimod's front panel meter. No input or load is required for this preliminary test. Compare the readings listed on the factory test sheet, inside the front cover, with the readings from your unit. If the unit disagrees with these readings by more than 10%, shipping damage should be suspected. Open the top and bottom covers by removing all of the binding-head screws (a Yankee screwdriver will expedite this tedious job.) Make a visual inspection to check that no components have been jarred loose from their sockets.

Strapping and Restrapping

Several of Optimod's performance characteristics and operating parameters can be altered by the addition or repositioning of internal jumpers. These restrapping operations, covered in the following paragraphs, include:

1. 115 or 230 volt AC power.
2. 20 dB attenuation in or out of input circuit.
3. Highpass filter in or out of limiter circuit.
4. Mono Left or Mono Right front panel control.
5. Stereo, Mono Left or Mono Right initializing of stereo generator switching logic, when AC power comes on.

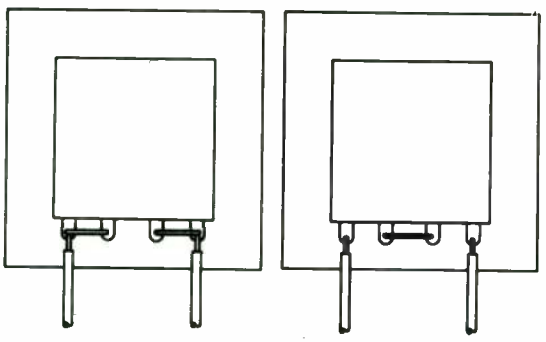
It is suggested that strapping changes be made prior to mounting of Optimod in the rack, as these changes require the removal of top, bottom, and/or back panels of the chassis. Instructions for removal of these panels and a diagram showing the screws to remove for access are found in the MAINTENANCE section, pages V-1 thru V-3.

1. AC VOLTAGE INPUT

Power supply transformers in Optimod units may be strapped for either 115 or 230 volts, and are shipped from the factory strapped for 115. To change the strapping, remove the *back panel* and locate the power transformer input lugs under the power supply circuit board. For 115 volt operation (figure III-1 a), the two primaries are paralleled by connecting lug 1 to lug 2 and lug 3 to lug 4. To change to 230 volt operation (figure III-1 b), the primaries are put in series by removing the two barewire jumpers and connecting lug 2 to lug 3. The line cord wires should be left in their positions on lugs 1 and 4.

A 1/4 amp slo-blo fuse is used for 115 volt operation and a 1/8 amp slo-blo fuse is used for 230 volt operation.

a. Power Transformer strapped for 115 volts



b. Power Transformer strapped for 230 volts

FIG. III-1

AC VOLTAGE INPUT STRAPPING

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2. INPUT ATTENUATOR PADS

The audio inputs of the Optimod come with 20 dB balanced pads connected across them in order to operate the input transformer and input level controls in the best part of their range. While most installations will require the use of the pads, with some telephone lines the input level will be too low and the pads will need to be bypassed. Figure III-2 below shows the various configurations for the input pad.

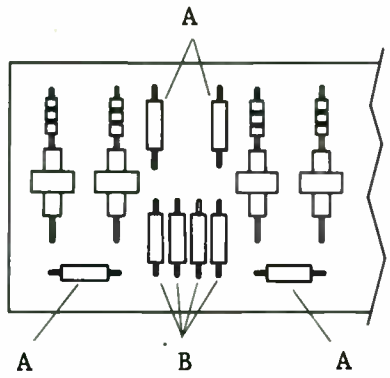

FIG. III-2 ATTENUATATOR STRAPPING

1. 20 dB Attenuation: resistors:"A"-750ohm
   resistors:"B"-1.5k
2. 6 dB Attenuation: resistors:"A" [illegible] 1.8k
   resistors:"B" [illegible] 220ohm
3. No Attenuation: resistors:"A"-out
   resistors:"B"-jumpered

WARNING: THE INPUT TRANSFORMERS UTILIZED IN THE OPTIMOD MUST SEE A SOURCE IMPEDANCE OF 600 OHMS, ± 10% TO PRODUCE CORRECT FREQUENCY RESPONSE. THEREFORE, A 6 dB PAD WILL ALMOST CERTAINLY BE REQUIRED BETWEEN THE PHONE LINES AND OPTIMOD INPUT IF THE INTERNAL 20 dB PAD IS BYPASSED. THIS 6 dB PAD ISOLATES THE OPTIMOD FROM THE REACTIVE COMPONENTS OF THE PHONE LINE SOURCE IMPEDANCE.

The pads are located inside the input filter shield box. This is the box into which the terminal lugs from the rear-panel terminal block extend. In order to restrap the pads, it is necessary to remove the back panel and then the input filter shield box.

3. HIGH PASS FILTER

Straps for a 30 Hz High Pass Filter in both the left and right input channels are located on the limiter board, which is accessible by removing the top cover. The units come with the High Pass Filter strapped into the circuit and figure III-3 shows the strap positions for both filter in and filter out configurations. This filter is required in situations where the exciter is unstable at low frequencies.

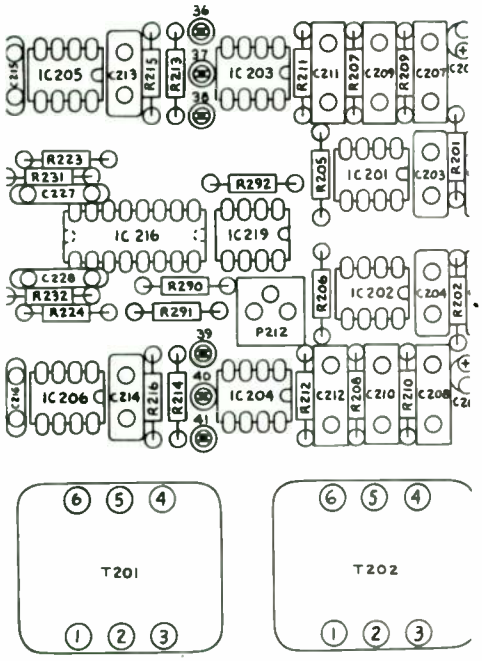

FIG. III-3
HIGH PASS FILTER STRAPPING
(Section of Limiter Board)

High Pass Filter IN
Pin 37 jumpered to pin 36
Pin 40 jumpered to pin 41

High Pass Filter OUT
Pin 37 jumpered to pin 38
Pin 39 jumpered to pin 40

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4. MONO LEFT/MONO RIGHT FRONT PANEL SWITCHING

A strap located on the stereo generator board determines whether MONO switching with the front panel switch will activate left channel or right channel MONO mode. This board is accessible by removing the bottom cover of the unit. The illustration below (figure III-4) shows positions for MONO LEFT, the configuration in which the unit is shipped, and MONO RIGHT.

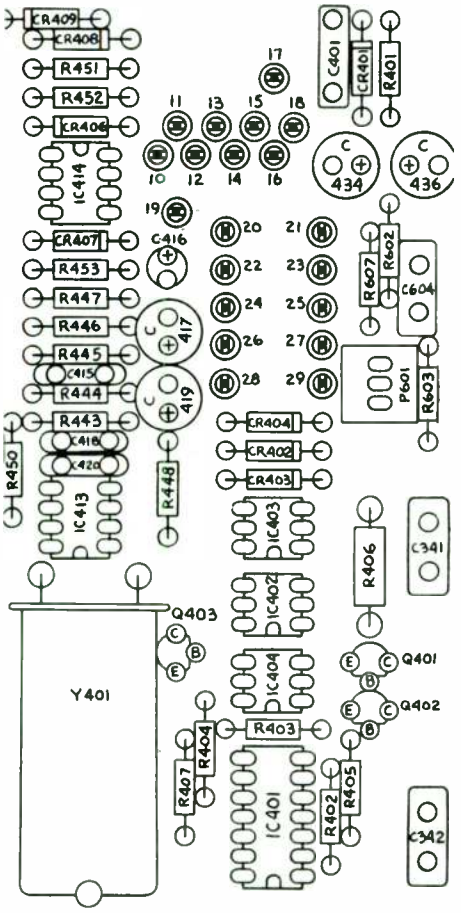

FIG. III-4 STRAPPING STEREO/MONO LOGIC
(Section of Stereo Generator Board)

Mono left/Mono right
Front Panel Switching

a. Mono left-jumper pins 20 & 21
   No jumper on 22 & 23

b. Mono right-jumper pins 22 & 23
   No jumper on 20 & 21

Power up Initialization

a. Stereo-jumper pins 24 & 25

b. Mono left-jumper pins 26 & 27

c. Mono right-jumper pins 28 & 29

5. POWER-UP INITIALIZATION

As mentioned in the section under OPERATING INSTRUCTIONS entitled "STEREO/MONO SWITCHING," the Optimod is shipped from the factory to come up in STEREO mode after AC power interruption and in normal power turn-on. This function of the switching logic can be restrapped for MONO left or MONO right initialization. The strap for this function is located on the stereo generator board (remove bottom cover) and the various positions of the jumpers are shown in the above drawing (figure III-4).

Mounting and Grounding the Chassis

The Optimod chassis mounts in 3½" (8.89 cm) of rack space. It is extremely important in any installation that the chassis be well-grounded. It may prove necessary to thoroughly scrape the paint from the rack in order to effect an adequate ground. FM wavelengths are short enough to render grounding by means of a wire lead totally ineffective, and the chassis should be grounded by connecting it to a well grounded rack — preferably the transmitter itself.

The chassis ground and circuit ground are normally not connected together. It is necessary to connect these terminals together whenever the unit is operated *outside* of a grounded rack (as

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when bench testing the unit), to assure that the chassis is grounded. Failure to do this can result in high noise, oscillation, and other problems.

After mounting the rack and grounding the chassis, measure the resistance between the panel and true ground. This measurement should be less than 0.5 ohms.

When the chassis ground and circuit ground are not jumpered together on the rear terminal strip, there is no connection between the two grounds. The shield of the composite output cable is bypassed to ground for RF by means of a large distributed capacitor. Therefore, the composite output, although unbalanced, can be connected directly to the exciter without going through a wideband transformer for ground loop isolation.

Audio Input Connections

The audio input is 600 ohms balanced and floating, and has been extensively RF suppressed. The audio inputs should be run in double-conductor balanced, shielded lines. Normally, the shields will be connected to chassis ground only at one end — usually the Optimod terminal strip. However, some experimentation may be necessary to obtain best results. Be sure that audio source equipment, such as a dual STL or TELCO termination box, is well-grounded to the station ground.

Stereo/Mono Remote Control

A latching circuit is provided for STEREO/MONO switching. This latch has three states, corresponding to STEREO, MONO LEFT, and MONO RIGHT. Terminals on the rear panel are provided to select remotely any of these three modes. To switch to a desired mode, apply a momentary pulse of AC or DC between 6 and 24 volts. These terminals are optically isolated, but should not be floated more than ± 50 volts above ground. If you wish to use 48 volts, connect a 1 K, 2 watt resistor in series with either control terminal. The control pulses may be obtained from local switching, or from the station's remote control unit. If DC is used, observe the polarity indications on the terminal strip. If AC is used, the internal protection diode will rectify it appropriately.

Remote Gain Reduction Metering

If the Optimod is installed in the studio a console VU meter may be wired in parallel with the meter on the Optimod front panel to indicate gain reduction. To do this, connect one side of the console VU meter to circuit ground, and connect the other side through a 50K trimpot (rheostat connected) to the G/R output on the rear-panel terminal strip on the Optimod. If substantial RF is present, the line should be run through well-shielded cable like Belden 8451, with the shield connected to the Optimod chassis ground. To calibrate, wait until no gain reduction is indicated on the front-panel Optimod meter. Adjust the 50K trimpot until the external meter reads zero VU. The external meter will then indicate the amount of gain reduction directly in dB.

Installation Location

Before installation is effected, considerable thought should be given to the mounting location for the unit. Orban/Broadcast's field experience indicates that the best location to assure a trouble-free installation is inside the transmitter itself, preferably immediately adjacent to the exciter. The composite output lead from the Optimod must be as short as possible to avoid pick-up of RF which could be introduced either into the Optimod or into the broadband input of the exciter. In general this lead should be no longer than 24" (61 cm), and if it can be made shorter than this, so much the better. Physically, each chassis requires 3½" (8.89 cm) of rack space.

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If a composite STL is used, the Optimod may be mounted in a rack at the studio and its composite output introduced to the STL transmitter input. As this is a low-RF area, normal installation procedure may be followed and no particular RF precautions need be taken.

Interfacing with Exciter

The output of the Optimod has been designed to look exactly like the output of a composite STL receiver. It should be connected to the exciter in the manner specified by the exciter manufacturer for connecting a composite STL. In the case of exciters requiring an external interface, check with Orban/Broadcast for further information.

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Initial Setup and Adjustments

Setup

Once power, input, and composite output leads are appropriately connected the Optimod can be set up.

(1) Turn the multi-turn OUT ATTEN (located behind the front security panel) fully counter-clockwise, using a 3/32" blade screwdriver.

(2) Apply AC power to the Optimod, and allow one minute for stabilization. Turn on your carrier.

(3) Observing the PILOT LEVEL meter on your stereo monitor, you may now advance the OUT ATTEN on the Optimod clockwise until 9% pilot level is observed.

(4) With the console in MONO mode (i.e., equal outputs from left and right channels) play program material at normal level with both channel IN ATTEN controls fully CCW. Observe GAIN REDUCTION meter on Optimod, and advance L IN ATTEN clockwise until the desired amount of gain reduction is observed. Do not exceed 10 dB gain reduction, or insufficient headroom will remain for operator error, unusually hot records, etc.

(5) Observe L-R meter on Optimod, and advance R IN ATTEN clockwise until a null is observed. Channels are now balanced.

(6) Adjust RELEASE TIME control for sound appropriate to your format. Highest audio quality occurs with slowest release time (control full CW). Full RELEASE TIME instructions are found immediately following setup instructions on this page.

(7) Trim Optimod OUT ATTEN until station modulation monitor peak flasher flashes at 100% but does not flash at 105%.

(8) Use station stereo monitor to check pilot level. Readjust Optimod PILOT INJECTION control for 9% pilot, if necessary.

Release Time Control

There are two ways to affect the type of sound the Optimod produces. The first way is to vary the input level, thereby changing the extent to which low-level passages are increased in level. The second way is to adjust the RELEASE TIME control, located behind the security door on the front panel.

Optimum audio quality will be obtained with the RELEASE TIME control fully clockwise, corresponding to slowest gain platform release. This setting also reduces somewhat the amount of fast limiting that occurs.

As the RELEASE TIME control is turned progressively CCW, the release time of the gain platform becomes faster and slightly more fast limiting is introduced. Faster release times would tend to be employed by stations with "Top-40" formats and those stations which are concerned with obtaining absolute maximum loudness with a modest quality compromise.

Formats using longer release times might include classical, "beautiful music," MOR, and "freeform." In any event, the program director, manager, or chief engineer should feel free to experiment with the control, as its range has been limited so that there is no setting where the Optimod can be said to sound really "bad." However, to repeat, the unit has been optimized to give sound closest to the input with the control fully CW (slow).

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Note that the first 25% of rotation on the CCW side of the control is marked "limit only." This 25% of rotation is intended to put the Optimod into a peak limit mode so that it can be used with an external gated compressor in those formats employing large amounts of low-quality speech input such as "all news" or "telephone talk." If the RELEASE TIME control is operated in the "limit only" range, we recommend that no more than 3 or 4 dB gain reduction be normally used. Otherwise, pumping will tend to be audible.

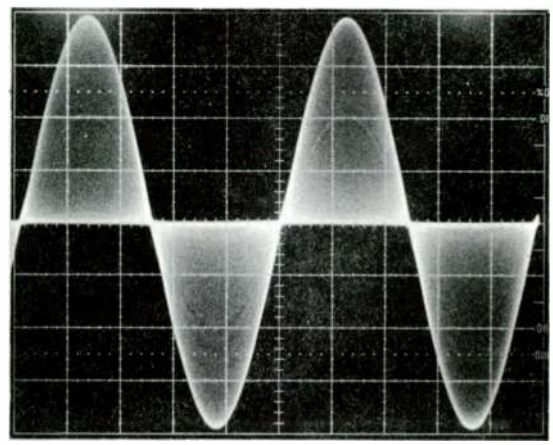
Final Adjustment

The preceeding installation instructions may be performed quickly, and should be done first in order to make sure that no gross problems, such as RF pickup exist. Such problems should be corrected before proceeding further.

If all seems well, then the Optimod stereo generator should be trimmed to the particular exciter employed by means of oscilloscope observation of the demodulated composite stereo waveform. In addition, a complete proof-of-performance is desirable at this time in order to ascertain proper system operation.

1. STEREO GENERATOR TRIM

(1) Connect a triggered-sweep oscilloscope of at least 5 MHz vertical bandwidth to the BROADBAND output jack of the station modulation monitor. Apply a 500 Hz sinewave to the left channel only at a level sufficient to cause some gain reduction. Trigger the oscilloscope from the 500 Hz sinewave. Turn the PILOT ON/OFF switch on the Optimod to OFF. Adjust the L-R GAIN control on the Optimod for a maximally flat baseline, as shown in figure IV-1 .



CORRECT L-R LEVEL (one channel, less pilot)
FIG. IV-1

NOTE: A X10 probe is not recommended for this observation, as such probes often have mid-frequency phase shift.

(2) Turn the PILOT ON/OFF control ON. Apply the 500 Hz sinewave to the two input channels out-of-phase (if necessary, by reversing one of the balanced audio input connections), and trim the R IN ATTEN on the Optimod for a null on the L + R meter of the station stereo monitor. Increase the VERTICAL GAIN on the oscilloscope until adjustment of the Optimod PILOT PHASE control produces an easily observed tilt. Adjust the PILOT PHASE control for a level pattern as shown in Figure IV-2 .

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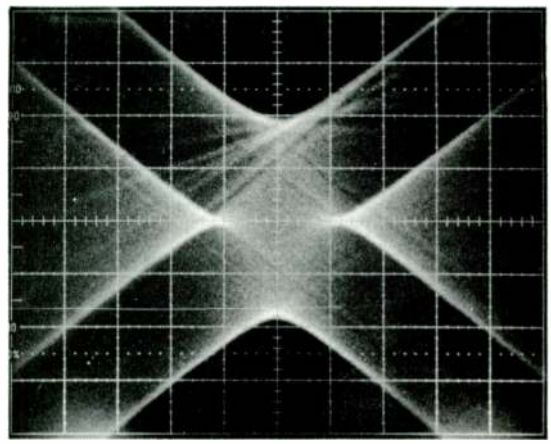

EXPANDED PILOT PHASE

FIG. IV-2

(3) Repeat steps 4 and 5 of INITIAL SETUP instructions (see page IV-1).

2. STEREO PERFORMANCE MEASUREMENTS

Measurements to demonstrate compliance of the stereo generator portion of the Optimod with part 73.322 of the FCC rules have been submitted to the Commission and are available for inspection.

> NOTE: The frequency response of the Optimod falls off extremely rapidly above 15 kHz. The lowpass filters have been verified on factory test to meet FCC requirements at 15.00 kHz. However, if the station test oscillator is miscalibrated even a few percent high in frequency at 15 kHz, the Optimod may appear not to pass proof at 15 kHz. If this appears to be the case, the output frequency of the station oscillator should be checked with a frequency counter, and set to 15.00 kHz. If this is done and no component failures have occurred in the Optimod, no difficulty should be encountered (assuming, of course, that the rest of the audio chain is not causing the problem).

To permit duplication of these measurements, we have made available a pair of audio test points, two RCA phono jacks located on the rear panel (J2, J3). They are unbalanced, and not RF-suppressed. A slide switch mounted on the rear panel of the Optimod determines the mode of these jacks. They are connected across the lines between the lowpass filter outputs and stereo generator inputs. Ordinarily, they are a test source of audio from the limiter. However, the slide switch can disconnect the limiter from the jacks, at which point they become stereo generator input terminals. These apply no preemphasis, and require approximately 3.0 volts rms to produce 100% modulation. They must be driven by a source impedance of 25 ohms or less. This requirement is satisfied by the output of any standard IC opamp.

The shells of the RCA phono jacks are grounded to the chassis. In order to avoid introducing RF into the input of the stereo generator, connections should be made with well-shielded cable, like Belden 8451, and leads between the test generator and these jacks should be kept as short as practical.

Inability to meet FCC separation requirements is usually caused by inadequacies in the interface between the Optimod and the exciter, or the exciter itself. If a wideband transformer is used between the Optimod and the exciter, anomalies in its phase and/or amplitude response can cause inadequate separation. Inadequate bandwidth in the exciter may also be

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responsible. Serrasoid™ exciters are particularly suspect, and are not recommended for use with Optimod.

In order to ascertain whether the fault lies within the Optimod or in external circuitry, the composite output of the Optimod may be directly observed with a scope and compared with figures IV-1 and IV-2. It may then be compared with the baseband output of the station modulation monitor to see if noticeable deterioration occurs after the Optimod output.

Mono Proof-of-Performance

Doing a routine proof-of-performance through the Optimod is very easy. Merely enter the MONO LEFT or MONO RIGHT modes, switch the OPERATE/TEST switch to TEST, and drive either the left or right channels with test signal, depending on the mono mode selected. Sufficient headroom is available to modulate at least 110% at all frequencies required to be measured. (See note, page IV-3)

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Maintenance

General

The Optimod FM Limiter and Stereo Generator, which contains all solid-state circuits, has been carefully inspected and adjusted at the factory by skilled technicians using special test equipment and procedures. The user is advised that it is extremely unwise to attempt any adjustment of the calibration controls inside the chassis in a field situation. The average user is not likely to have the requisite equipment or experience to adjust the calibration controls in the field. Exceptions to this general rule will be described in the CIRCUIT DESCRIPTION (page VII-1).

Routine Maintenance Procedure

Since the unit is effectively sealed against outside air, accumulation of dust within the chassis is not likely. Therefore, routine cleaning is not required.

If the front panel becomes soiled, it may be cleaned using a mild detergent, isopropyl alcohol, naptha or trichlorethane. Other solvents should not be used.

As there are no moving parts, no lubrication is required.

It is wise to occasionally check for corrosion, particularly in the area of connections, and for conditions which may affect the ability of the chassis to dissipate heat generated within it.

Field Repairs

We prefer that all service to the Optimod is performed by factory trained service personnel at our service facility in San Francisco. Orban Associates Division maintains a small stock of loaner units which, at the customer's request, may be made available where it is suspected that a malfunction has occurred.

Users who wish to avail themselves of factory service should telephone the service manager in San Francisco and discuss the difficulty. Be prepared to describe in detail the malfunction which is suspected because often simple repairs may be effected utilizing telephone advice.

After this communication takes place, the service manager may decide that it is best for the unit to be returned for examination at the plant. Where this is the case a loaner unit can be shipped to the user via air express.

Access

When field service is indicated or when restrapping any of the various functions discussed in "INSTALLATION," page III-1 thru 3, the following information on accessing the various circuit boards will be useful:

1. TOP AND BOTTOM COVERS
Removal of the TOP COVER will reveal the "Limiter Board" which incorporates the input amplifier, broadband limiter, high-frequency limiter, and power supply regulator circuitry.

Removal of the BOTTOM COVER reveals the "Stereo Generator" board which incorporates

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the instantaneous limiters, the 15 kHz low-pass filter section, the 19 kHz oscillator and the balance of the stereo generator circuitry. The STEREO/MONO control circuitry is also contained on the lower board.

Removal of either cover will reveal the raw DC power supply chamber and the 115-230 volt jumpers.

Each cover is attached with (26) 6-32 x 3/16" machine screws. We apologize for the large number of screws but a tight seal is necessary between the cover and the chassis flanges in order to prevent RF leaks. For maximum RFI protection, it is of the utmost importance that all screws be replaced and tightened when service is concluded.

2. REAR PANEL

The rear panel serves as a mount for the power transformer, the fuse holder, the line cord, raw DC power supply, certain DC filtering, the input and output connectors, and the input filter shield box.

For easy access to the various rear panel components, the rear panel may be tilted downward by removing the six screws marked "A" in figure V *1* as well as the eight screws along the back of both the top and bottom covers. If access to the interior of the input filter chamber is desired, the four screws marked "B" in figure V-1should also be removed thereby detaching the input filter chamber from the rear panel.

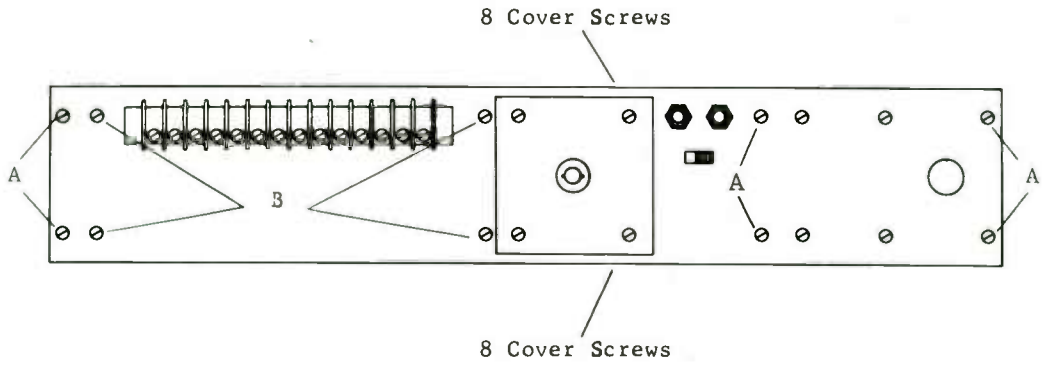

FIG. V-1 REAR PANEL ACCESS

When reassembling the rear panel, it is essential to install all screws for maximum RFI protection. The screws marked "A" should be inserted only finger tight at first and the flange of the rear panel should be carefully aligned with the flange on the sides of the chassis before tightening screws in order to permit the cover to lie flat all around the chassis for minimum RFI leakage. Similarly, the flanges on the rear panel should also be flush with the flanges on the silver colored vertical divider plate.

3. FRONT PANEL

Removal of the four screws marked "A" in figure will permit the front panel to be hinged downward allowing easier access to the two LED's, the stereo/mono switch, and the terminals and mounting screws for the meter. When reinstalling the front panel, all four screws should be inserted and tightened firmly in order to establish a reliable ground between the panel and the chassis.

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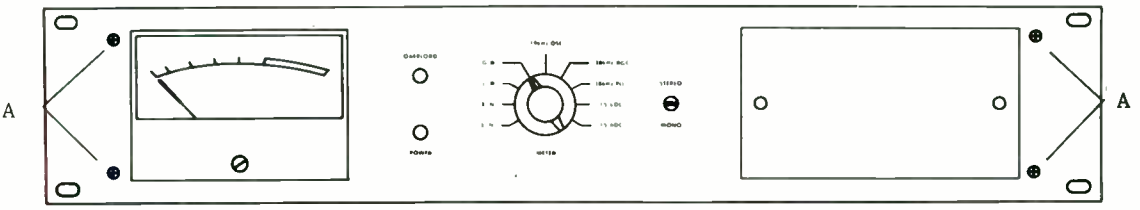
FIG. V-2 FRONT PANEL ACCESS



4. ROTARY SWITCH

If removal of the rotary switch becomes necessary, access may be obtained by removing the front panel (as above) and then removing the two screws near the meter hole cutout which hold the vertical divider plate. At the right side of the chassis, remove two screws holding the horizontal divider plate. At the rear panel, remove the four screws which are cornermost which attach the rear panel. Then, by carefully pulling at the rear panel the entire internal assembly may be retracted in order to permit space for the removal of the rotary switch.

When reassembling, be sure to line up the various flanges with each other so the cover will lie flat all the way around the chassis.

5. CIRCUIT BOARDS

The Limiter and Stereo Generator boards may be tilted upward for service by imagining a hinge at the rearmost edge of the board. To permit the board to hinge, remove six 4-40 x ¼" screws from either board. It is necessary to depress the push-button switch from the front for additional clearance. The board is slid backwards slightly and tilted up at the front being careful not to break off any of the ceramic feed-through capacitors entering the main chamber of the chassis.

It is not advisable to attempt to gain access to the bottom of the Input Filter printed circuit board (which is located within the input filter chamber). As there are no circuit traces located on the bottom side of this board, it is unlikely that any repair would ever be necessary. If components are to be replaced on the top side, the defective component should be removed by cutting its leads as close to the body as possible, and then attaching the replacement component to these leads.

In a most unusual circumstance, where this is not possible, a new input filter chamber assembly should be ordered from the factory.

CAUTION: The ceramic on the twelve feed-through capacitors extending through the input filter chamber wall is quite fragile and brittle and great care should be employed to avoid cracking the ceramic.

6. BNC CONNECTOR

If removal of the output BNC connector is effected, extra caution should be given in re-assembly to be sure that the connector is tightly seated against the chassis for a reliable connection to the metal plate. The metal plate to which the BNC connector is mounted acts as a capacitor plate with respect to the chassis and is an important part of the signal path.

It is also wise to make a continuity test between the BNC connector plate and the chassis to insure that there is no short circuit. (Mylar sheet and nylon screws ordinarily prevent this occurrence.)

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Replacement of Components in Printed Circuit Boards

CAUTION: PLEASE REFER TO SECTION "CIRCUIT DESCRIPTION" CONCERNING HIGH RISK IN CONDUCTING FIELD SERVICE OPERATIONS. Many components, if replaced, will cause a change in calibration which will require the unit to be returned to the factory for adjustment. Also, many components are selected for characteristics which are not indicated by the manufacturer's nomenclature on the component itself. Most of these components are indicated as "selected" in the parts list, but not all of them are. In addition, the selection criteria is not generally described. Therefore, it is almost always wiser to return the entire unit to the manufacturing plant for service.

Most circuit boards used in the Optimod are of the double-sided plated-through variety. This means that there are traces on both sides of the board and that the through-holes contain a metallic plating in order to conduct current through the board. Because of the plated-through holes, solder often creeps 1/16" up into the hole requiring a more sophisticated technique for component removal in order to prevent serious damage to the traces on the board. In particular, excessive heating of a point on the board will almost always cause damage.

If the user is not thoroughly familiar with elegant techniques of removing components from double-sided boards, it is wiser to cut each of the leads of an offending component from the body while the leads are still soldered into the board. The body is then discarded and each of the leads is heated independently and pulled out of the hole with a pair of long nose pliers. Each hole may then be cleared of solder by carefully heating with a low wattage iron and sucking the residual solder with a spring activated solder vacuum tool.

The new component should be installed in the usual way and soldered from the bottom side of the board. 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 carefully at the topside as well in order to avoid potential intermettent problems.

After soldering, the residual flux should be removed with a cotton swab moistened with a solvent such as 1, 1, 1, trichloroethane, naphtha, or 99% isopropyl alcohol. These first two solvents are often available in supermarkets marketed 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. Note: Rubbing alcohol is highly diluted with water and is not effective. There are also other solvents marketed under various trade names which contain Freon™. These are often available in electronic supply houses and are also useful.

It is good policy to make sure that this defluxing operation has actually removed the flux and not just smeared it about so that it is less visible. While rosin flux is not corrosive normally, it can absorb moisture and become conductive enough to cause severe deterioration in specifications over time.

Calibration and Adjustment

Except for the normal setup adjustments and other functional alternatives described in the INSTALLATION section, general alignment of the Optimod is not a practical field operation. This is because:

(1) The requisite test equipment is generally not available except in the most thoroughly equipped facility.

(2) The field service technician does not have access to a supply of the specially selected spare parts which may be required during calibration.

(3) Field service personnel may not have an adequate knowledge of the circuitry in order to interpret the various interactions correctly. This knowledge is best developed through experience under the supervision of the chief engineer.

For these reasons we suggest that it is highly unwise to attempt calibration in the field. In order to aid station users who may desire recalibration, a small number of loaner units are available to maintain continuity of operations during the service interval. Nonetheless, complete calibration and adjustment instructions will be found in the appendix in case the user finds himself with no other alternative.

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Principles of Operation

General

Before discussing the details of circuit operation, we will survey the operation of the Optimod as a system in order to clarify the upcoming circuit discussion.

The Optimod system can be divided into seven basic sections. These are:

(1) INPUT — RF filtering, input transformers, input level controls, pre-amplifier, and high-pass filter.

(2) BROADBAND AGC — Utilizes a complex release time circuit to perform both compression and limiting functions with a single AGC control loop.

(3) HIGH-FREQUENCY LIMITER — Provides program control of the pre-emphasis on a moment-to-moment basis, thus eliminating overloads due to excessive high frequency content in the original program.

(4) LOWPASS FILTERS AND INSTANTANEOUS LIMITERS — Simultaneously eliminates energy above 15 kHz and provides precise control of peak levels.

(5) 19 KHZ OSCILLATOR — Provides 19 kHz pilot tone for stereo modulator L + R input.

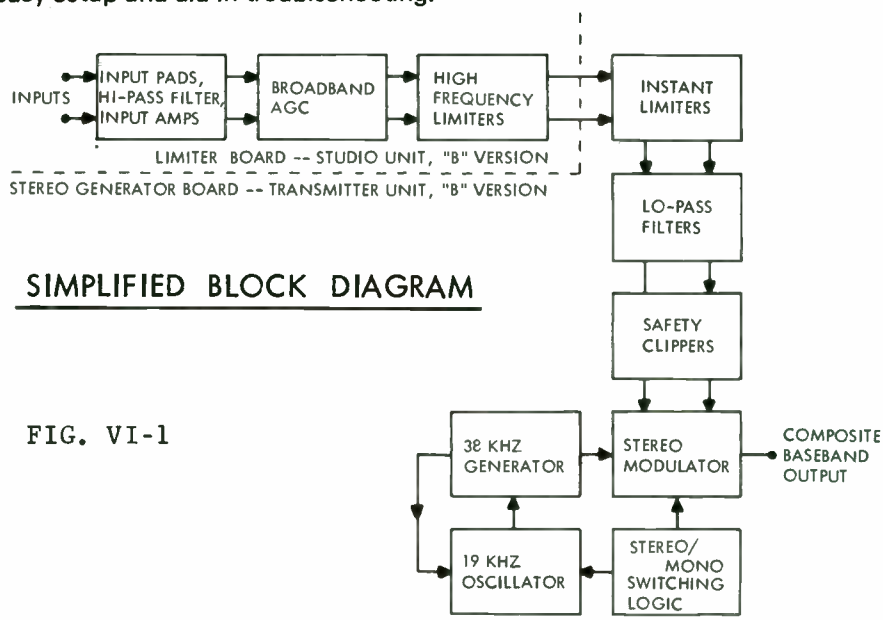
(6) 38 KHZ GENERATOR — Generates 38 kHz signal for amplitude modulation with L-R signal.

(7) STEREO/MONO SWITCHING — Provides logic and memory for switching the stereo generator into STEREO, MONO LEFT, and MONO RIGHT operating modes.

(8) STEREO MODULATOR — Generates the stereo composite baseband output from inputs provided by sections (4), (5), and (6).

(9) POWER SUPPLY — Provides operating voltages for the rest of the system, and also serves as the basic reference for a number of operating parameters, including limiting thresholds, L-R gain, and pilot level and phase.

Additionally, a meter circuit is provided which monitors key operating parameters, providing both easy setup and aid in troubleshooting.



SIMPLIFIED BLOCK DIAGRAM

FIG. VI-1

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The simplified block diagram above shows the relationship of the various sections. More detailed diagrams will be found at the end of this section on fold-out pages. The Limiter Block Diagram shows sections 1 thru 3, and the Stereo Generator Block Diagram shows sections 4 thru 9.

Input

The left and right channel signals enter the chassis through a Jones barrier strip on the rear of the chassis. They are passed through 20 dB pads located in the input filter shield box. These pads may be bypassed, depending on the available signal levels. The signals are then lowpass filtered in order to eliminate RF leakage into the main circuit card. Following this filtering, they are applied to input transformers, and thence to the input level controls. The input transformers are step-up 600-50,000 ohm types, and provide 19.2 dB voltage gain. The IC preamplifiers following the input level control provide 20 dB additional gain. This gain is necessary to permit the system to be driven from telephone lines, which may exhibit substantial loss.

The preamplifiers drive active 18 dB/octave highpass filters with a cutoff (-3 dB) frequency of 30 Hz. These highpass filters were included for the benefit of those users whose exciters' AFC loops can be upset by subsonic information. If such an exciter is not in use, best audio quality is obtained by bypassing these filters. The INSTALLATION section, page III-2, contains instructions on the appropriate procedure.

Broadband AGC

The output of the highpass filters drives a pair of voltage-controlled gain elements, realized with junction field-effect transistors. The FET's are found together in an IC to assure interchannel tracking. The outputs of the two channels are sensed by a pair of dual comparators, whose outputs are connected together. If either channel attempts to exceed the threshold of limiting, then the comparator on that channel produces an error voltage. This is integrated by the complex integration network, and provides a feedback signal for both FET's, thus reducing the gain of both channels simultaneously to the required extent.

High-Frequency Limiter

The output of the broadband limiter is applied to two paths. One is a direct path; the other path drives a bandpass filter. This filter has been designed so that it will produce a correct pre-emphasis characteristic when its output is added in correct proportion to the signal in the direct path. The output of the bandpass filter is passed through a voltage-controlled gain stage. Ordinarily, this VCA stays at its maximum gain, and the full pre-emphasis characteristic is produced.

The sum of the output of the VCA and the direct signal is sensed in each channel by a dual comparator, and the outputs of the comparators are combined to drive an integrator, as in the case of the broadband AGC circuit. The output of this integrator provides a feedback signal to control the gain of the VCA's, thus instantaneously reducing the pre-emphasis if excessive high frequency content is present. The pre-emphasis is decreased only to the extent necessary to avoid audible distortion by the instantaneous limiter. In a vast majority of cases, no high frequency loss whatever is perceived.

Lowpass Filters and Instantaneous Limiters

Because the output of the broadband and high frequency limiter contains considerable overshoots, it is necessary to employ instantaneous limiting in order to provide absolute control of the peak level. This limiting is provided by a pair of Schottky diodes connected as a shunt clipper.

The output of this instantaneous limiter is applied to the lowpass filter. This filter is necessary to eliminate audio interference with the 19 kHz pilot tone, and leakage between the main channel and subchannel.

Previous lowpass filter designs have tended to cause serious overmodulation problems due to

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overshoots and ringing. However, Orban/Broadcast engineering has successfully dealt with this problem and has succeeded in reducing the overshoot of the filter to less than 3%, insuring that no loudness capability is lost due to fast peak overmodulation by filter ringing.

The lowpass filter is realized with resistors, capacitors, and operational amplifiers, thereby eliminating inductors, which tend to be less perfect in realization than the other components. Alignment points are provided to enable the filters in the two channels to be matched as accurately as possible.

Because the lowpass filter does not eliminate all overshoot (particularly on "noisy" program material, like vocal sibilance), a second "safety" instantaneous limiter is introduced at the output of the lowpass filter. This limiter is almost never called upon to act, but nevertheless assures that no overmodulation will occur for any program material. The safety limiter is followed by a gentle lowpass filter to remove harmonics generated by the safety limiter's occasional action. This lowpass filter is a third-order type specifically chosen for its non-overshooting properties.

The OPERATE/TEST switch serves to defeat all limiting action, including the instantaneous limiters. It accomplishes this by strobing all of the comparators OFF, and by raising the threshold of the instantaneous diode limiters approximately 10 dB above the normal value. In this way, proof-of-performance can be done without concern for the "limited amplifier headroom" found in competitive units.

19 kHz Oscillator

The circuitry for generating the 19 kHz pilot and 38 kHz subcarrier modulating frequency has been designed in an unconventional way in order to assure maximum stability with temperature and time. The peak level of the 19 kHz oscillator, the peak level of the 38 kHz signal, and the phase relationship between the 19 and 38 kHz sine waves are compared to the positive power supply voltage, which is maintained stable to better than 0.1%. Any deviation from the desired values is detected and automatically corrected by means of feedback loops.

The crystal oscillator operates at 19 kHz, and is designed to put out a sine wave with less than 0.1% harmonic distortion. In order to do this without tuned circuits other than the crystal itself, the output of the oscillator is applied to a comparator, where it is compared to a fixed percentage of the positive power supply voltage. The comparator generates an output signal which is integrated and which is applied to the gate of a FET, operating as a voltage-variable resistor. Thus the oscillator is held within its linear range, and produces a low-distortion sine wave with a highly stable output amplitude, which is directly usable without further filtering.

38 kHz Generator

The output of the 19 kHz oscillator passes through a voltage-controlled phase shifter, realized with a FET plus opamp, which serves as the actuator for the phase-locked loop. The 19 kHz phase shifter drives a dual comparator biased in such a way as to produce a symmetrical 38 kHz square wave. The comparator drives a "current mirror" in the switching mode. The mirror current is controlled by another feedback loop, thus changing the 38 kHz drive as necessary to stabilize the 38 kHz sine wave produced later in the circuit by filtering.

The current mirror drives a 38 kHz tuned transformer, which serves to filter the square wave into a sine wave with approximately 1% harmonic distortion. In order to obtain lower distortion, this sine wave is further filtered by a lowpass filter which results in approximately 0.04% distortion. The output of this filter drives the amplitude comparator which closes the 38 kHz AGC loop. The filter also drives a buffer amplifier, which drives one half of a dual comparator which is biased as a phase comparator.

The other half of this dual comparator is driven by the 19 kHz oscillator. The 19 kHz and 38 kHz are compared so that the output of the dual comparator is a pulse whose duty cycle depends on the phase relationship between the 19 and 38 kHz sine waves. This pulse is applied to an integrator. A constant current is also applied to the integrator. When the average current from the pulse is equal to the constant current, then the output of the integrator does not change its voltage level.

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The output of the integrator is used to drive the voltage-controlled 19 kHz phase shifter. Thus a phase-locked loop is formed. The constant current injected into the integrator can be varied in order to adjust the phase relationship between the 19 and 38 kHz sine waves. Thus the phase relationship between the pilot and the 38 kHz subcarrier is controlled by the stability of the phase detector and the positive power supply (used as a reference), and is unaffected by drifts in the 38 kHz doubler or filters.

Stereo/Mono Switching

The STEREO/MONO switching functions are realized by means of four two-input CMOS NAND gates. Three of the NAND gates serve as memory elements to remember the three states: STEREO, MONO LEFT, and MONO RIGHT. The fourth NAND gate is operated as an inverter. The digital logic operates on the "negative logic" system: -15 volts (LOW) is ON, and 0 volts (HIGH) is OFF.

Mode switching is accomplished by briefly applying -15 volts to one of the three MODE SELECT lines in the logic. The front panel STEREO/MONO switch applies -15 volts directly to the appropriate gates, as does the start-up circuit which determines the mode in which Optimod comes on. Remote switching is achieved by passing current through the LED side of the appropriate opto-isolator. This causes the photo transistor in the isolator to saturate thereby applying -15 volts to the correct gates.

The CMOS NAND gates drive n-channel junction FET's which perform audio switching functions. These FET's are OFF when their gates are driven to -15 volts, and ON when their gates are driven to 0 volts. One FET turns off the right channel input to the summing amplifier in MONO LEFT mode, one performs the opposite function in MONO RIGHT mode, and a third FET increases the gain of the summing amplifier in either MONO mode so that either channel can drive the transmitter to 100% modulation.

Subcarrier and pilot are turned off by turning off the 19 kHz crystal oscillator. This is done by clamping the gate of the oscillator gain-control FET oscillator to -15 volts, turning it off and decreasing the gain of the oscillator section to the point where oscillation is no longer possible.

To turn STEREO on the -15 volt clamp is removed, permitting the oscillator amplitude control loop to recover. This may take up to five seconds, introducing a time delay in activation of the stereo after STEREO mode is selected by the logic.

Stereo Modulator and Output

The stereo modulator Fig. IV-2 uses the "direct" method of generating the stereo signal. That is, the L+R and L-R signals are generated by sum and differential amplifiers respectively. The L-R signal is modulated by the 38 kHz sine wave to produce a double sideband, suppressed-carrier, amplitude modulated subcarrier. The stereo signal is generated by addition of this signal to the L+R and pilot signals. Because of the advanced methods used, this technique has certain distinct advantages over the "switching" method more commonly employed. High frequency distortion is reduced, and superior separation is obtained, as no 53 kHz lowpass filter is required, with its attendant separation-reducing phase errors.

In order to obtain highest quality, the stereo modulator uses the "two-quadrant" form of the "Gilbert-linearized" transconductance multiplier, which multiplies the L-R signal by the 38 kHz sine wave. The L-R signal has a DC component added, so that the output produced is a 38 kHz amplitude modulated signal. The carrier level remains constant with any modulation. Therefore, a 38 kHz sine with correct amplitude and phase can be added to the amplitude modulated signal to cancel the carrier and produce the desired double-sideband suppressed carrier signal. This technique exhibits substantially lower noise and distortion than the use of a conventional "four-quadrant" multiplier, which could generate the suppressed carrier signal directly.

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STEREO MODULATOR BLOCK DIAGRAM

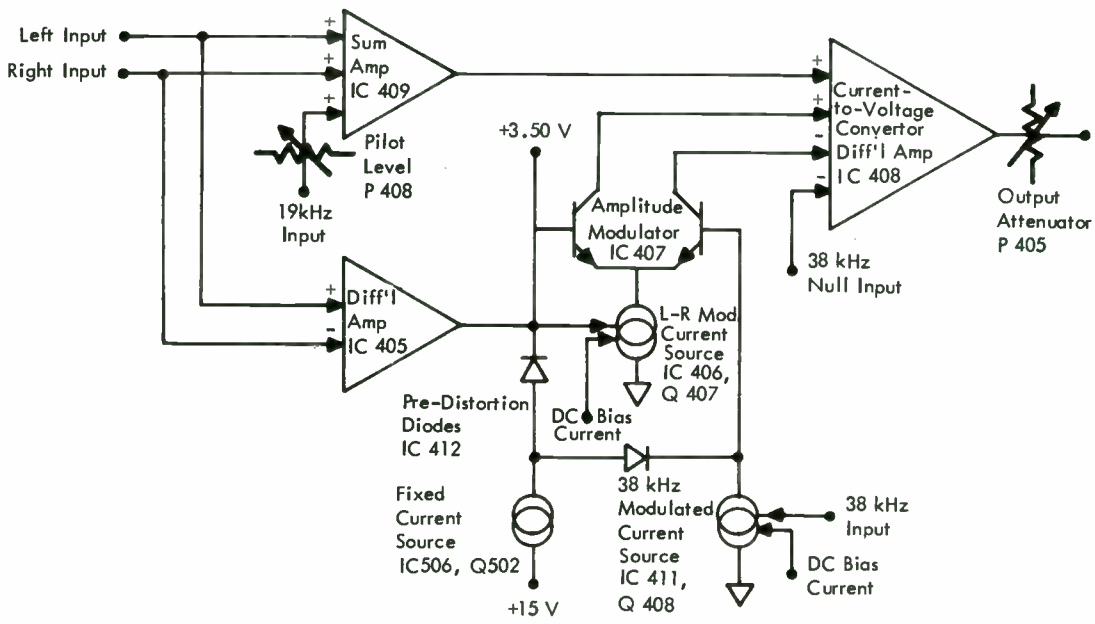

FIG. VI-5

The two-quadrant multiplier is a highly optimized discrete circuit. It permits cancellation of many of the error signals ordinarily associated with the transconductance multiplier (such as the second harmonic of the signal feed-through), thus resulting in an output characterized by extraordinarily low distortion and high spectral purity. Special provisions are made to reduce the 76 kHz spurious output component to better than -70 dB below 100% modulation, thus assuring that no interference will be introduced into SCA transmissions. This is accomplished by mixing a small amount of 38 kHz with correct amplitude and phase into the L-R input to the multiplier. This is multiplied by the 38 kHz input to produce a 76 kHz signal which is adjusted to cancel the residual 76 kHz output of the basic multiplier circuit.

Further discussion of the details of the stereo modulator are found in the "CIRCUIT DESCRIPTION" section of this manual.

The output of the stereo modulator is applied to a ten-turn potentiometer, and coupled through RF filtering to a BNC connector. This connector is mounted on a metal plate which is insulated from the chassis by means of mylar film and which exhibits approximately 1000 pF of capacitance to the chassis. This distributed capacitor, together with the two RF chokes inside the chassis, effectively bypasses RF to ground, while breaking the 60 Hz ground loop which would be formed if the shell of the BNC connector were connected directly to chassis ground. This way, the chassis receives its ground return through the rack in which it is mounted, while the internal circuit ground is connected to the outside world only through the output cable to the exciter.

This system eliminates the need for a performance-degrading wideband transformer in a vast majority of installations.

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Power Supply

The system operates from a bipolar power supply producing a stable regulated + and - 15 volts at approximately 200 ma per side. In addition, an auxiliary low-current supply produces + and - 4.55 volts to supply the shunt-clipper diodes in the instantaneous limiter circuits. This supply is temperature-compensated to track changes in the turn-on voltage of the Schottky clipped diodes, thus producing a limiting threshold independent of temperature. The TEST/OPERATE switch overrides this circuit in the TEST position, forcing it to produce approximately + and - 14 volts, thus raising the instantaneous limiting thresholds. In addition, the output voltage of the circuit has been made trimable in order to adjust the threshold of limiting to exactly the correct level.

The main + and - 15 volt supply is regulated by means of a 723 IC voltage regulator, which drives an external series pass transistor. The 723 contains a source of stable reference voltage, as well as an operational amplifier. Feedback compares a fixed fraction of the output voltage of the regulator with the reference voltage, thus stabilizing the output. In addition, the 723 is connected to provide current limiting, thus protecting the positive supply from damage in the event of a short circuit on the output.

The 723 also provides the positive supply voltage for the negative regulator, a 741 IC operational amplifier. The unregulated negative supply provides the negative supply voltage. The 741 is connected as an inverting, gain-of-one amplifier, and "amplifies" the + 15 supply, thus producing a - 15 volt supply which tracks the + 15 volt supply symmetrically. The 741 drives a conjugate pair to provide power-handling capability, and a third transistor is used for current limiting.

The unregulated supply is wholly conventional, consisting of a pair of full-wave rectifiers, a pair of energy-storage capacitors, and a power transformer with a center-tapped secondary and dual primary windings. Thus the system may be wired to operate on 230 volts — often the only AC available inside a transmitter cabinet.

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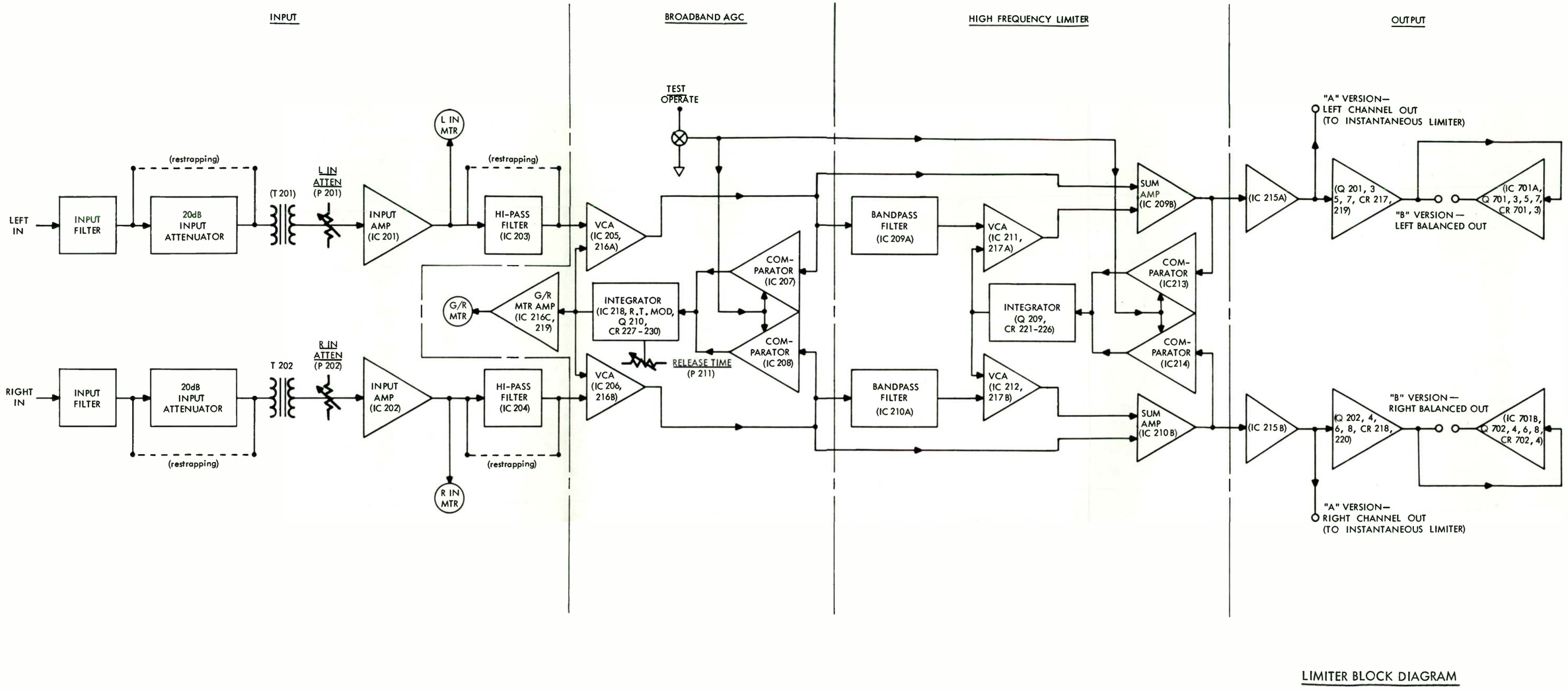

LIMITER BLOCK DIAGRAM

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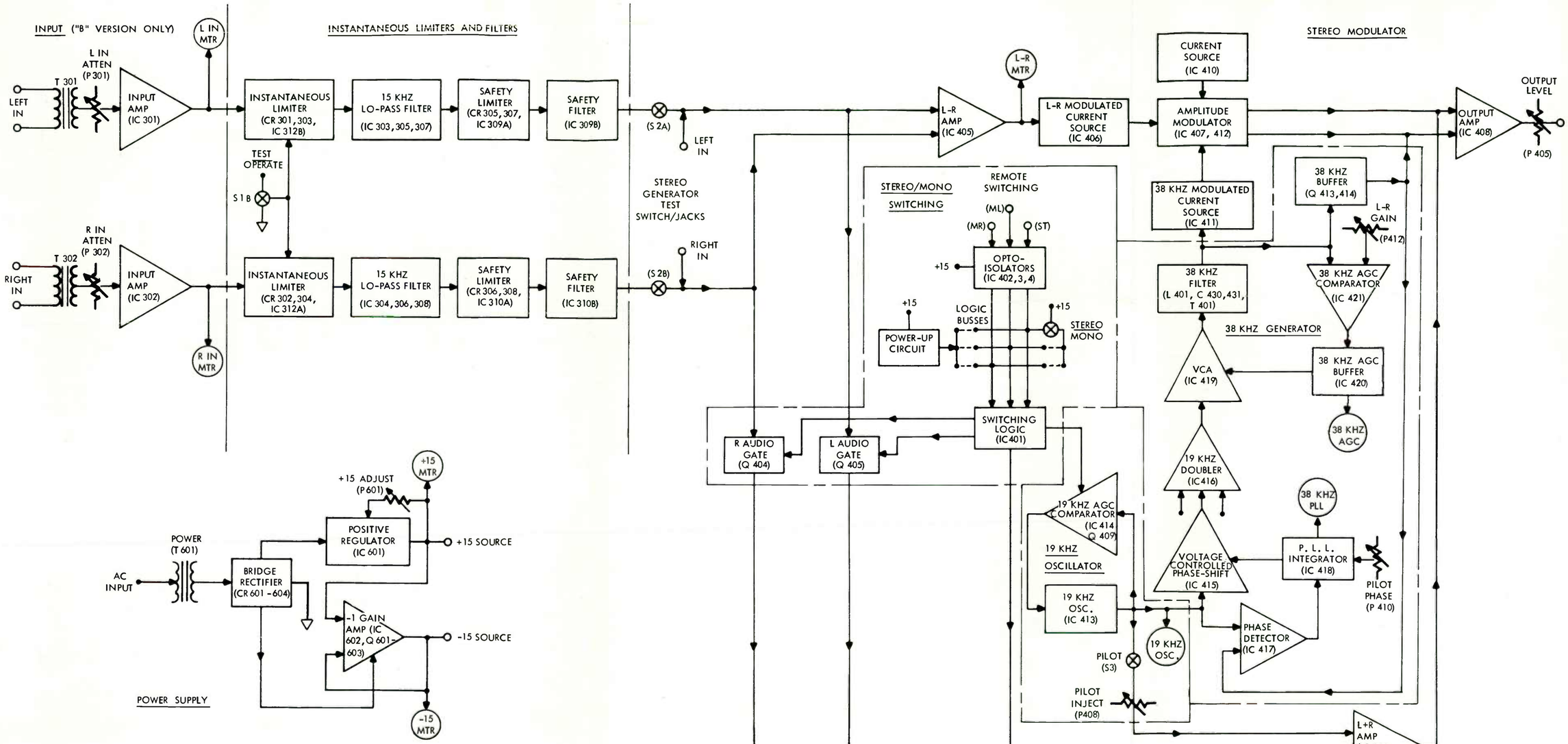

STEREO GENERATOR BLOCK DIAGRAM

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Circuit Description

(WITH TROUBLESHOOTING HINTS)

General

This section contains a detailed description of the circuitry used in the Optimod. It is designed as an aid to the technician troubleshooting the system.

The technician who is unfamiliar with the Optimod system should first read the PRINCIPLES OF OPERATION section which provides an overview of the circuit operation with particular emphasis on systems operation. This section can aid the technician in pinning down the problem to a particular area of the circuit. Once this is done, the technician can proceed to the appropriate part of this section in order to obtain detailed information.

WARNING: THE OPTIMOD UTILIZES ADVANCED AND SOPHISTICATED CIRCUIT TECHNIQUES, WITH PARTICULAR EMPHASIS ON LINEAR INTEGRATED CIRCUITS. THE TECHNICIAN SHOULD BE EXPERIENCED AND COMPETENT IN THIS AREA. OTHERWISE, THE OPTIMOD SHOULD BE SERVICED BY THE FACTORY. *NEVER!!!* ATTEMPT TO CURE A PROBLEM BY CASUALLY READJUSTING THE FACTORY-SET TRIMMERS. THESE TRIMMERS MUST BE ADJUSTED *ONLY* ACCORDING TO THE "COMPLETE ALIGNMENT" INSTRUCTIONS IN THE APPENDIX, AND *ONLY* IF THE SPECIFIED TEST INSTRUMENTS ARE AVAILABLE. THE SOLID STATE CIRCUITRY IS STABLE INDEFINITELY, AND *NO PERIODIC ALIGNMENT IS REQUIRED, OR DESIRABLE.*

NOTE: IF THE OPTIMOD IS BEING REPAIRED ON A BENCH, BE SURE TO JUMPER THE CHASSIS AND CIRCUIT GROUNDS TOGETHER TO ASSURE THAT THE CHASSIS IS GROUNDED.

Comments on IC Opamps

IC opamps are operated in such a way that their transfer characteristics are essentially independent of IC characteristics and dependent only on external feedback components. The feedback forces the voltage of the (-) input terminal to be very close to the voltage at the (+) input terminal. Therefore, if the technician measures more than a few millivolts difference between these terminals, the IC is probably bad.

Exceptions are IC's used open-loop as comparators (such as some of the 301A's in the Optimod), and IC's whose outputs have been saturated in one direction or the other due to abnormal inputs. However, if the technician measures that the (+) input is more positive than the (-) input, yet the output of the IC is sitting at -14 volts, this almost surely indicates IC failure. If all the above polarities are reversed, the same thing holds.

Because the characteristics of the Optimod are essentially independent of IC opamp characteristics, an IC opamp can usually be replaced with no change in performance. If the replacement opamp has substantially different offset voltage characteristics, it may affect the 38 kHz carrier null, which should then be touched up according to the TOUCHUP ALIGNMENT instructions (see Appendix, page A-1).

A defective opamp may appear to work, yet have extreme temperature sensitivity of DC characteristics. If parameters appear to drift excessively with temperature, use a can of freeze-spray to locate the offending component. Freeze-spray is also very useful in tracking down intermittents.

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Input

As both channels of the input section are identical, only the left channel will be discussed. The audio input is introduced into the input filter shield box. This box contains a 20 dB pad, R101, 103, 105, 107, which may be bypassed by restrapping if additional gain is needed. Restrapping instructions may be found in the INSTALLATION section.

Following the pad, the signal passes through RF chokes L101, 103. These are effective through the standard broadcast band, and prevent RF interference in those cases where the AM and FM operations are located in the same building.

L101, 103 are self-resonant below the FM band, and are therefore not effective at FM frequencies. The VHF and UHF spectrum are dealt with by means of ferrite beads placed on the output leads of L101 and L103, and by C101, 103 — feedthrough capacitors which connect the RF shield box with the main RF-tight circuit compartment.

The audio at this point is still balanced 600 ohm. It is applied to input transformer T201 located on the limiter circuit card. This transformer steps up the impedance to 50K. Loading for the T201 secondary is supplied by the INPUT LEVEL control P201.

P201 drives IC201, a 301A IC opamp connected for a gain of 11, non-inverting. C203 frequency-compensates IC201 to prevent oscillations. The INPUT position of the VU meter is connected to the output of IC201. Nominal level here is about +4 dBm.

IC201 drives IC203, a 1556C opamp connected as an 18 dB/octave highpass filter with a cutoff frequency of 30 Hz. IC203 is connected as a unity gain voltage follower; the necessary filter characteristics are produced by positive feedback from the output of IC203 into the filter network, C207, 209, 211, and R207, 209, 211. If the exciter used with the Optimod is not subject to destabalization by low-frequency information, then the highpass filter may be bypassed in order to achieve best and tightest bass response. Instructions for bypassing the highpass filter are found in the INSTALLATION section.

Broadband AGC

The gain control element is a P-channel junction field effect transistor, IC216A, operated as a voltage variable resistor. This FET shunts the lower leg of the voltage divider R213, 223 to reduce the gain. Note that the values of R213 and R223 are selected at the factory to complement the particular FET employed. If IC216 is ever replaced (a highly unlikely occurence), the factory should be consulted.

The audio level across the FET is 16 mv at the threshold of limiting. This level is amplified back up by IC205, a 709 opamp configured for 34.5 dB non-inverting gain. IC205 is frequency-compensated by C213, 217, 219 and R215, 217. The output of IC205 is clamped to ± 2.4 volts by the diode strings CR201, 203, 205, 207, 209, 211, 213, 215 to prevent damage to IC207 in the event that excessive input signal is applied with the system in the TEST mode. The gain of IC205 is determined by R219, 221, and C225. R229 forces a constant current to flow from the output of IC205 to the - 15 supply, thus forcing the output stage of IC205 to operate class A to eliminate crossover distortion.

The output of IC205 is applied to the two halves of IC207, a 711 dual comparator. The inputs of IC207 also receive reference voltages of + and - 1.2 volts derived from voltage dividers R294-297. If the peak level of the output of IC205 attempts to exceed ± 1.2 volts, IC207 turns on, producing a pulse which is coupled through C266 and CR228 to Q211. Q211 is turned on by the pulse, and discharges C267 and C268 through CR230 and CR229 respectively. This voltage change across C267 is coupled to the gate of the FET through R231, thereby decreasing the resistance of the FET and decreasing the gain of the circuit until the overload at the output of IC205 is removed. Attack time of the circuit is determined by R288 and is about 2 ms. The release time is a very complex function of the nature of the program, and is determined by the proprietary circuit inside the module. Basically, the module derives a voltage based on the previous history of the program and applies the voltage to one end of the RELEASE TIME control, P211. The other end of P211 is connected to C268, and permits C268 to charge at a rate controlled by the module in conjunction with the setting of P211. In addition, the network

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CR231 and R289 provides delayed release to assure low distortion at low frequencies. This is accomplished as follows:

When gain reduction occurs, both C267 and C268 are discharged to the same voltage because CR230 and CR229 have substantially identical voltage drops. However, C267 must charge (release) through CR231 and R289. R289 provides virtually no short-term release because of its high value. Therefore, C267 cannot charge until C268 has charged sufficiently to overcome the turn-on voltage of CR231. This time delay eliminates the usual sawtooth ripple on the control voltage, thus drastically reducing distortion.

The collector of Q211 is clamped to the ground through the base-emitter junction of Q210. This way, the gate of the control FET cannot be forward-biased. In addition, when Q210 conducts, it turns on the front-panel OVERLOAD LED, thus indicating that the permissible 15 dB gain reduction range has been exceeded.

P210 determines the quiescent gate voltage of the control FET, and is adjusted to pinch this FET off when no gain reduction occurs. Thus maximum gain is extremely stable, and no distortion is introduced by the FET.

The control FET is contained in a package with four matched, monolithic FET's. The second FET is used to control the gain of the right channel; the third FET is operated with DC across it to control the GAIN REDUCTION meter. The fourth FET is not used. The DC gain reduction signal is amplified by IC219, a non-inverting opamp. The output of this opamp is available at the rear panel to drive an external GAIN REDUCTION meter, which may be a standard VU meter. The output voltage is approximately 5 volts for 0 dB gain reduction.

IC207, the dual comparator, contains provisions for strobing (turning on or defeating the output) by means of a control voltage. One half of the TEST/OPERATE switch, S1A, provides this control voltage: +6 volts (from voltage divider R285, 286) for OPERATE; ground for TEST. Thus the TEST mode defeats the AGC action without bypassing any circuitry.

IC201 (as well as all of the other 711 IC's) requires a power supply of approximately +12 and -6 volts. +12.6 volts is supplied by dropping the +15 volts through 3 silicon diodes, CR232-234. C231, 269 bypass the fast risetime pulses produced by IC207 to ground.

A bypassed source of -14 volts for the pulse-handling transistor Q211 is provided by dropping the -15 volt supply through CR227, bypassed by C264, 265. -5.5 volts is derived by dropping the -15 volts through a 9 volt zener diode, CR235.

High Frequency Limiter

The basic operation of the high frequency limiter circuit is very similar to the operation of the broadband limiter circuit. Therefore, please read the preceding section if you have not already done so, in order to obtain a detailed description of the operation of the FET voltage-controlled amplifier, dual comparator, and integrator with delayed release. Then proceed to the next paragraph.

The operation of the high frequency limiter varies from operation of the broadband limiter in two significant respects. First, the signal is divided into two paths, and gain control is applied to the high-frequency path only. Second, the integrator has a simple resistor determining the release time, rather than a complex encapsulated circuit.

The high frequency limiter consists of two identical audio paths for the left and right channels. The FET gain control elements are combined in a single IC chip, similar to the chip used for the broadband limiter. The control voltage integrator is common to both channels, whereas each channel has its own dual comparator. This assures interchannel balance is maintained under conditions of gain reduction.

Only the left audio channel will be discussed.

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The signal enters the high frequency limiter and is applied to an active bandpass filter consisting of R233, 235, 237, C233, 235, and IC209A. This filter will normally exhibit its highest gain at 23.5 kHz. At this frequency, the gain of the filter should be roughly 10.8 dB.

The desired pre-emphasis curve is generated by adding the output of this bandpass filter to the un-filtered signal in correct proportion. Summing of the bandpassed and un-filtered signal occurs in IC209B. This IC acts as an inverting amplifier for the un-filtered signal introduced through R239. It acts as a non-inverting ampifier for the bandpass signal, which has already been inverted by its passage through the bandpass filter already described. In addition, the bandpass signal is passed through a non-inverting voltage-controlled amplifier of the type already described in detail in the "Broadband Limiter" section.

Some of the output of the bandpass filter is summed into the summing amplifier through R241. Its polarity is opposite from the polarity of the signal introduced from the output of the VCA. Therefore, even though the gain of the VCA cannot become zero (because of FET characteristics), sufficient out-of-phase bandpass signal is introduced to permit complete cancellation of the bandpass signal in the output of the summing amplifier with a low, but achievable, gain in the VCA.

The output of the summing amplifier is the correctly pre-emphasized signal. This signal has slightly more high-frequency content than called for by the 75 microsecond curve in order to equalize certain slight high-frequency losses in the following lowpass filter. Therefore, any test of the accuracy of the Optimod's adherence to the standard pre-emphasis must be made at the output of the lowpass filter, and not at the output of the high frequency limiter.

The output of the summing amplifier, IC209B, is applied to a dual comparator, IC213, as in the broadband limiter. The basic circuitry is identical to that in the broadband limiter, except for a different choice of attack time (3 ms determined by R284), and a simple release time (10 ms determined by R283).

The overall high frequency limiter exhibits a gain of 12.5 dB at 50 Hz. In order to permit the dual comparator to use the same reference voltage (±1.2 volts) as the broadband limiter, the output of the summing amplifier is reduced by the voltage divider R263, 265 before being applied to dual comparator IC213.

In the TEST mode, IC213 is defeated by grounding the strobe terminals, as in the case of the broadband limiter.

Instantaneous Limiters and Lowpass Filters

The output of the high frequency limiter is applied to an identical pair of instantaneous limiters and lowpass filters. Except for the voltage supply for the limiter diodes, each channel is separate. Therefore, we will again discuss only the left channel.

The signal from the high frequency limiter is first instantaneously limited by a shunt clipper. The signal is applied to a voltage divider consisting of R309, 311, 313, and P305. A pair of Schottky diodes, which exhibit a low turn-on threshold, are connected after R309. These diodes are reverse biased by IC311 and associated circuitry, which applies a voltage of ±4.55 volts to the diode pair. If the instantaneous peak value of the audio waveform attempts to rise above approximately ±4.8 volts, one of the diodes will turn on, thus shunting the audio into the low impedance output of IC311 and preventing the voltage from rising any further.

The +4.55 volt reference voltage is derived from the voltage divider R363, 364, P311, CR309. P311 permits slight adjustment of this reference voltage in order to align the instantaneous limiter to the thresholds of the preceeding limiters. CR309 is identical to the clipper diodes, and provides temperature compensation so that the limiting threshold remains the same regardless of temperature. It does this by varying the clipping voltage as the turn-on voltage of the clipping diodes (temperature dependent) varies.

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The voltage derived by this voltage divider is turned into a low impedance by IC311A, a voltage follower. The complementary negative voltage is created by IC311B, connected as a gain-of-one inverting amplifier.

The second half of the OPERATE/TEST switch, S1B, applies the +15 volt power supply voltage to the input of IC311 in the TEST mode, thus forcing the output up to the positive saturation voltage of IC311 — about +14 volts. This raises the threshold of clipping more than 10 dB above normal, permitting proof-of-performance measurements to be made.

The clipped audio voltage is divided by the voltage divider R311, 313, and P305. P305 permits trimming the gain of the lowpass filter, thus assuring identical low-frequency signal levels at the second instantaneous limiter, CR305, 307.

The output of P305 is buffered by IC312B, a voltage follower, which drives the first stage of the active lowpass filter. This stage includes R315, 317, 319, 321, 323, C307, 309, 311, 313, 315, P307 and IC303. It is essentially an asymmetrical "Twin-Tee" network with positive feedback to sharpen the response. It exhibits a peak in its frequency response, followed by a deep notch at higher frequency. The gain of the opamp (and therefore the amount of positive feedback) is trimmed by P307. This determines the amount of peaking in the frequency response.

IC303 drives a low-Q rolloff section consisting of R325, 327, 329, 333, C317, 321 and IC305A. R331 provides compensation for the input offset current of IC305; C319 bypasses R331 for lowest noise from IC305. Neither R331 nor C319 affect the filter characteristics.

R325, 327, 329 and C317 effect a shelving rolloff; R333 and C321 effect a 6 dB/octave rolloff with the -3 dB frequency at approximately 7 kHz.

IC305A drives another active "Twin-Tee" section identical to the first section in topology, but with different frequency characteristics. This second section produces a response which is also characterized by a peak followed by a deep notch at a higher frequency.

IC307 drives a phase shifter consisting of R345, 347, 349, C333 and IC305B. This circuit has a flat frequency response and a phase shift of 90° at roughly 16 kHz.

IC305B drives a second shunt clipper which operates in the same way as the first shunt clipper. Its output is buffered by IC309A, which drives a third-order lowpass filter consisting of R353, 355, 357, 361, C335, 337, 341, and IC309B. R359 and C339 reduce offset voltages and bypass respectively, and do not effect filter characteristics.

This lowpass filter is designed for less than 2% overshoot. It rolls off gently, and is normally down approximately 1.8 dB at 15 kHz. This filter is the last element in the lowpass filter chain, and drives the stereo generator and audio test points.

It should be noted that the entire lowpass filter is DC coupled in order to assure no baseline shifts when asymmetrical signals are clipped. As the filter is DC coupled to the stereo generator, excessive offset voltage or current drifts with temperature can cause a rise in the 38 kHz output from the stereo generator, as this 38 kHz component represents a DC component in the L-R signal. Therefore, in the case of difficulties with inadequate 38 kHz rejection, the lowpass filter must be investigated along with the stereo generator. The normal DC offset voltage between the left and right filter outputs has been recorded in the test sheet at the front of this manual. If the difference in the DC level in the two audio channels changes by 45 mv, this can introduce a 38 kHz component of -40 dB, assuming infinite rejection of the 38 kHz before said DC voltage change.

Note that the pre-emphasis network and lowpass filter have been designed as a system. Therefore, adherence to the 75 microsecond pre-emphasis curve must be tested at the output of the lowpass filter. This output is available at the "Audio Test Point" RCA phono jacks on the rear panel when the "Test Point Mode" switch is in the "Normal" position. The overall frequency response of the audio section, from input to audio test jacks typically adheres to the standard 75 microsecond pre-emphasis ±0.5 dB, 50-15,000 Hz. The MODE switch behind the security panel must be in the TEST position in order to make these measurements.

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19 kHz Oscillator

The 19 kHz crystal oscillator is designed to generate a low-distortion (0.1%) 19 kHz sine wave with no tuned circuits other than the crystal itself. In order to do this, an AGC loop is employed.

Oscillation occurs by using the crystal as a positive feedback element in operational amplifier IC413. Voltage divider R449, 450 reduces the output of IC413 to the point where the crystal is not overloaded. R448 provides bias current for IC413 and loads crystal Y401.

Negative feedback is applied around IC413 through R443, 444, and Q409, a junction FET operated as a voltage-variable resistor. Q409 is adjusted by means of a feedback loop such that the overall gain of IC413 and associated circuitry is just sufficient to permit oscillation.

IC414 is operated as a comparator. Its (-) input is driven by the output of the oscillator, and its (+) input is returned to a reference voltage. If the peak output of the oscillator attempts to rise higher than the reference voltage, IC414 produces a negative going pulse at its output, which is transmitted through CR407 and R453 to C416, developing a running average. The pulse will make the voltage across C416 more negative, thus increasing the resistance of Q409 and decreasing the gain of IC413, reducing the amplitude of the oscillation. CR406 clamps the output of IC414 and does not permit it to go positive. Because of CR407, C416 can only recover through R447, which determines the release time of the AGC loop.

The normal output level of the 19 kHz crystal oscillator is 3.00 volts rms. This output may be observed on the front panel meter in the "19 kHz" position.

R445, 446, and C415 introduce one-half of the 19 kHz signal across Q409 into its gate, thus linearizing Q409 by substantially eliminating even-order harmonic distortion.

38 kHz Generator

The 38 kHz sine wave is derived from the 19 kHz sine wave by doubling and filtering. The level of the 38 kHz sine is AGC'd, and the phase relationship between the 19 kHz and 38 kHz sines is controlled by means of a phase-locked loop. This guarantees maximum long-term stability, assuring that the stereo generator will stay in adjustment with changes in time and temperature.

The output of the 19 kHz oscillator drives a voltage-controlled phase shifter, R454, 455, 456, 457, C425, Q410 and IC415. Once again, a junction FET is utilized as a voltage-controlled resistor. This time, varying its resistance changes the phase shift of the circuit without affecting its gain. As in the case of the 19 kHz oscillator, the FET is linearized by R458, 459, and C424. We will return to an explanation of the gate drive for Q410 below.

The output of the phase shifter drives dual comparator IC416. This comparator is biased by voltage dividers R460, 461, P409 and R462, 463 to produce a transition every time the 19 kHz sine goes through a multiple of 90°. Thus the output of IC416 is a 38 kHz square wave. P409 adjusts the symmetry of the output of IC416 to assure that no residual 19 kHz component remains.

IC416 drives a transistor of the IC array IC419 through R473, switching this transistor on and off at a 38 kHz rate. Two other transistors in IC419 are connected as a current mirror. IC420, the 38 kHz AGC buffer amplifier, feeds a given current through R474 into one transistor of the current mirror, thus producing a certain base-emitter voltage. That base-emitter voltage is connected to the base-emitter junction of the other transistor in the mirror. Because the two mirror transistors are matched, the collector current in the second transistor is the same as the collector current forced into the first transistor by IC420 through R474. Therefore, IC420 has control over the current through the second transistor, and control over the 38 kHz gain. We will see that IC420 is controlled by a 38 kHz AGC sensor after 38 kHz filtering.

The second current mirror transistor is switched on and off by the transistor driven from IC416. The collector of the second current mirror transistor drives a tuned bandpass transformer,

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T401, which is tuned to peak the 38 kHz output. The output across the secondary of this transformer is a 38 kHz sine wave with about 1% distortion. The output of T401 is buffered by emitter follower Q412. Q412 drives a passive 18 dB/octave Chebychev lowpass filter C430, 431, and L401, which removes virtually all of the remaining harmonics from the 38 kHz. The output of the filter typically has 0.04% harmonic distortion. Input and output terminations for the filter are provided by R477 and R482 plus P411 respectively.

The filter is buffered by conjugate emitter follower Q413, 414. This follower drives the stereo generator, and also drives one half of the dual comparator IC417 which serves as a phase detector for the phase-locked loop. The signal is coupled through C421. R467, 468 provide equal voltage drops for IC417's bias current, which is relatively high.

The other side of IC417 is driven by the 19 kHz sine. This side is compared against a voltage derived from divider R465, 466. The stability of this voltage is essential to assure stability of phase control. Bias current compensation is provided by R464.

The resulting output of IC417 is ordinarily a positive-going pulse with a duty cycle of roughly 20%. This duty cycle is a measure of the phase relationship between the 19 kHz sine and the filtered 38 kHz sine. The phase detector thus determines the basic stability of the phase-locked loop.

This pulse is coupled to Q411 through C422, CR410, and R469. The pulse quickly changes Q411 from a saturated to a cutoff condition. In the saturated condition, it essentially connects precision resistor R470 to the positive power supply. In the cutoff condition, no current flows through R470.

The other end of R470 is connected to the (-) input of opamp IC418, which is connected as an inverting integrator. Because the (+) input of IC418 is grounded, the feedback holds the (-) input at ground also. Thus, whenever Q411 turns on, there is exactly 15 volts (less the saturation voltage of Q411 — approximately 50 mv) across R470, producing a precisely defined current flow through R470.

Simultaneously, current is taken from the IC418 summing junction through R471 and P410, the PILOT PHASE control. In order to have the output of the integrator, IC418, stay constant, the average current supplied through R470 must equal the current taken by R471 plus P410. The output of IC418 is connected to the gate of Q410, which controls the phase shift of the voltage-controlled phase shifter IC415. Therefore, feedback forces the phase shifter to adjust the phase of the 38 kHz sine until the average current flowing into the IC418 summing junction is zero. Thus, varying the PHASE control, P410, changes the current that must be supplied by the phase detector through Q411 and R470, and forces the phase to change in order to supply the correct current.

It should be noted that this phase-locked loop is not the same as the type of PLL with which many people are familiar. That is, the Optimod PLL activates a phase shifter, not a voltage-controlled oscillator. Because there is an integrator in the loop, and the loop activates a phase shifter, the theoretical steady-state phase error in the Optimod PLL is zero, as desired.

The amplitude of the 38 kHz sine is also controlled by a feedback loop. IC421 is connected as a comparator, and turns on if the peak value of the 38 kHz sine after C432 exceeds a voltage supplied by P412, the L-R GAIN control. In a manner similar to the operation of the 19 kHz AGC circuit, the error pulses from IC421 are integrated. The integrated voltage is buffered by IC420, a voltage-follower, which drives the current mirror in a manner described above.

The principal purpose of the 38 kHz AGC and PLL circuits is to render the stereo generator insensitive to drifts in the 38 kHz filtering, as the hi-Q transformer, T401 can easily drift with time and temperature. With the AGC and PLL circuits operating, T401 can be fairly seriously detuned with no observable effect on the output quality.

Metering points are provided for both the AGC control voltage and the PLL control voltage. The purpose of these metering points, which may be switched to the front-panel meter for

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observation, is to make sure that both loops are locked. An example of their being unlocked occurs when the MONO mode is selected, and the operator should familiarize himself with the difference between the locked and unlocked meter indications.

In addition, the AGC control voltage is a useful indication in tuning T401, as the peak in T401 is unambiguously indicated by a dip in the AGC control voltage. Tuning T401 will also cause the 38 kHz phase to change, and a mistuned T401 can drive the PLL outside of its lock range. This is indicated by a meter reading either off-scale or less than about 20%.

Stereo/Mono Switching

The STEREO/MONO switching circuit consists of three basic sections. Remote control interface is provided by opto-isolators IC402, 403, 404. The isolators consist of a light-emitting diode packaged with a photo-transistor. When current is passed through the LED, it causes the photo-transistor to conduct, essentially clamping the transistor's collector to its emitter.

Memory for the three-state (STEREO, MONO LEFT, and MONO RIGHT) logic is provided by a single CMOS digital IC, IC401, consisting of four two-input NAND gates. IC401 is operated between -15 volts and ground. Negative logic is used: -15 volts at the output of a given gate is considered ON; 0 volts is considered OFF.

The outputs of the gates drive N-channel JFET switches Q404, 405, 406, associated with the L + R summing amplifier in the stereo generator, IC409. Q405 squelches the left-channel feed when its gate is at -15 volts. Its gate is at 0 volts (left channel ON) in the STEREO, and MONO LEFT modes. This is when IC401C (MONO RIGHT) is OFF (at 0 volts). Therefore, IC401C (MONO RIGHT) drives the gate of Q405 directly.

Q404 squelches the right-channel feed when its gate is at -15 volts. It is driven by IC401B (MONO LEFT) by arguments identical to those in the preceding paragraph.

It is necessary to decrease the gain of IC409 in the STEREO mode from 100% to 45%. This is because in STEREO mode, it is driven by both left and right channels plus 10% pilot. Q406 effects this gain change by paralleling IC409's feedback resistor R439 with another resistor, R440, when Q406's gate is at 0 volts. Therefore, Q406 must be driven by the output of IC401A (STEREO), inverted so that 0 volts is ON and -15 volts is OFF. This inversion is effected by the fourth NAND gate, IC401D.

The 19 kHz oscillator is squelched by Q403, which clamps the gate of the oscillator gain-control FET, Q409, to -15 volts, thus reducing the gain of the oscillator circuit to a level insufficient to produce oscillation. When the 19 kHz oscillator is squelched, no 38 kHz is produced and the amplitude modulator in the stereo generator passes no L-R component except for a very slight leakthrough component.

When Q403 is turned OFF, the 19 kHz oscillator AGC loop is permitted to recover, and oscillation commences within five seconds. Q403 is driven directly by IC401A (STEREO ON).

The three-state latch works as follows: In the negative logic convention, each gate is ON only if both of its inputs are OFF. Otherwise, it is OFF.

The two inputs of each gate are fed by the outputs of the other two gates. Therefore, a given gate is ON only if the other two gates are OFF. 470K current-limiting resistors, R402, 403, 404 are connected between the output of each gate and the inputs of the other two gates. Each input gate can be clamped ON (-15 volts) by means of the local STEREO/MONO switch, or by turning on the photo-transistor in any of the optoisolators. If a given gate is clamped ON, immediately the other two gates are turned OFF, which creates an input condition in the clamped gate to latch it ON, even if the clamp is removed.

The power-up circuit works as follows: It is desirable to be able to consistently define in which state the logic will fall after AC power is applied. When power is applied, the -15 volt bus is

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pulled from 0 volts to -15 volts, thus pulling the other side of C401 to -15 volts also. This clamps any of the three states ON through CR401, depending on the connection of the power up jumper. Within 0.2 seconds of turn-on, C401 discharges through R401, pulling the CR401 side to 0 volts. CR401 now effectively disconnects C401 from the logic, which operates normally as long as power remains up.

Stereo Modulator

An overview of the operation of the stereo modulator should first be obtained by reading the appropriate part of the PRINCIPLES OF OPERATION section.

The stereo modulator performs three basic functions.

(1) It derives the sum (L + R) and difference (L - R) signals;

(2) It modulates the L - R by the 38 kHz sine to produce a double-sideband suppressed carrier AM signal;

(3) It sums the signal so created with the L + R and the pilot to create the composite output.

The output of the 38 kHz lowpass filter is a low-distortion 38 kHz sine wave. It is used directly to drive the 38 kHz input port of the amplitude modulator. The output of the buffer emitter follower Q413, 414 is used to sum a 38 kHz signal with the output of the amplitude modulator (through R427) in order to cancel the 38 kHz carrier, yielding a suppressed carrier signal.

The output of the 38 kHz lowpass filter passes through C432 before being loaded by a combination of R431, 482, P407, and P411. P411 varies the loading on C432, thus producing a slight variation in the phase shift caused by C432. This enables the phase of the 38 kHz to be adjusted so as to obtain maximal cancellation of the 38 kHz carrier at the output. Similarly, P407 adjusts the amount of 38 kHz being driven into the amplitude modulator, thus permitting adjustment of the amplitude of the carrier to secure a maximal null.

IC411 serves with Q408 as a unilateral current source. The 38 kHz sine is injected into the IC411 summing junction through R431 plus P407. A bias current is injected into the summing junction from the -15 volt supply through R432 plus P406. It turns out that this controls the balance of the differential transistor pair IC407, and thus the direct feedthrough of L - R audio into the output. This feedthrough is equivalent to sub-to-main crosstalk.

The basic amplitude modulator is a "two-quadrant current-mode Gilbert-linearized Multiplier."* The theory of the circuit is that the gain (transconductance) of a matched, differential pair of transistors (IC407) is directly proportional to the emitter current through them. Therefore, if the carrier is applied to the bases of the pair, and the audio modulates the emitter current, a very linear amplitude modulator results.

If the differential pair is used "as is," the carrier input is not linear, and distortion products (harmonics of the carrier) are produced which must be filtered out. However, if the signal applied to the bases of the differential pair is properly pre-distorted, then the distortion produced by the pair is canceled out, and the amplitude modulated signal is produced with essentially no spurious outputs.

The pre-distortion is produced by changing the carrier voltage into a pair of currents. When the carrier voltage is zero, each of the two currents has a fixed quiescent value. When the carrier voltage is not zero, it drives one current more positive and the other equally less positive. These currents are passed through a pair of matched diodes, the anodes of which are both connected to AC ground. The voltages developed across the diodes are appropriately pre-distorted, and may be applied directly to the bases of the differential transistor pair.

The Optimod modulator uses a variation of this scheme. Instead of two varying current sources, one varying source (IC411, Q408) and one fixed source (IC410 with associated resistors) is used. The fixed source is connected to the junction of the two anodes of the matched diodes in IC412. The variable source drives diode #1's cathode. The cathode of

*See, for example, *Analog Devices Non-Linear Circuits Handbook*, pp. 203-269. Available from Analog Devices, Inc., Norwood, Massachusetts 02062, 1974.

diode #2 is AC grounded. If the fixed current source is adjusted to produce exactly twice the quiescent current of the variable current source, then the current in diode #2 will have the same quiescent value as the variable current source (and thus diode #1), but will vary in an equal and opposite way from the current in diode #1. Thus we obtain the desired result with the use of a single variable current source, instead of two such sources.

In the actual circuit, the cathode of diode #2 is not grounded, but is connected to a low-impedance source of +3.50 volts, as generated by R429, 430, and bypassed to ground for AC by C411. This is done in order to create appropriate DC bias conditions.

The pre-distorted signal is thus generated at the drain of Q408, since the cathode of diode #2 is held to AC ground. This pre-distorted signal is applied to one base of IC407. The other base is AC-grounded. Because IC407 operates in a purely differential mode, it doesn't matter whether the drive for IC407 is generated equally and opposite at both bases, or whether it is generated as described above — all that counts is the voltage difference between the two bases of IC407. In fact, our variation permits us to conveniently introduce an offset null voltage at the undriven base of IC407. This is provided by current injected across R428 by trimmer P403. It is essential to null the offset voltage of IC407, as small offset voltages (even less than 1 mv) cause appreciable amounts of second-harmonic (in our case, 76 kHz) distortion.

The fixed current source, IC410, is a matched pair of PNP transistors operating as a current mirror with emitter degeneration. The network R434, 436, 437 and CR405 forces a constant current through the base-emitter junction of 1/2 IC410. CR405 temperature compensates said base-emitter junction, assuring that the total voltage across current-determining resistors R434 plus R436 is always exactly 15 volts. Because the two halves of IC410 are matched, as are their emitter resistors, the collector currents of the two halves of IC410 are also identical. Thus IC410 is a highly stable fixed current source.

The purpose of C413 is to AC couple the R436, 437 junction to the +15 volt supply, thus canceling supply-induced noise across R433 (both sides of R433 see the same noise voltage), and assuring that the output current of IC410 is not modulated by power bus noise.

In addition, a small fraction of the L-R audio is permitted to slightly modulate the fixed current source through R415, 435, P402, C402, and C414. This has the effect of canceling even-order harmonic distortion in the L-R feedthrough signal. This distortion is caused by operating the bases of IC407 in an unbalanced manner, combined with the non-ideal nature of IC407.

To review: we have converted the 38 kHz sine to a current, which has been passed through the diodes of IC412 to convert it to a pre-distorted voltage. This pre-distorted voltage is applied to the base of the differential transistor pair IC407.

In order to amplitude modulate this 38 kHz by the L-R audio, we must first derive the L-R, and then change it into a current. This current is then applied to the emitters of IC407.

The L-R is derived in the differential amplifier IC405, with associated resistors R410-414, and P401. This circuit is a conventional differential amplifier, designed to be driven from a low-impedance source like the output of the audio lowpass filter. P401 enables the user to trim the circuit for equal gain from the left and right audio input lines. This is equivalent to nulling main-to-sub crosstalk.

The output of IC405 drives the L-R meter position, and also drives the sub-main distortion null control discussed above in conjunction with the fixed current source. In addition, the output of IC405 is divided by voltage divider R416, 418, and drives the voltage-to-current converter IC406, Q407. This circuit is a unilateral current source essentially identical to the variable current source already discussed.

Bias current is injected through R419 plus R420 into the current source summing junction. C403 bypasses power bus noise to ground. This bias current determines the amount of 38 kHz carrier present. It is important that this current be very stable if the carrier cancellation scheme is to be stable.

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In addition, a small amount of 38 kHz is injected into the summing junction through P404, C405, and R421, 422. C404 provides an appropriate phase shift. The purpose of this is to multiply this 38 kHz component by the 38 kHz carrier, thus creating a 76 kHz component. This 76 kHz component is adjusted to be of appropriate amplitude and phase to cancel the residual 76 kHz which cannot be nulled from the output of the modulator by means of the OFFSET trimmer. It is possible to obtain 76 kHz which is stably down more than 70 dB below 100% modulation. This is important in those installations using 67 kHz SCA.

Thus a current is generated, consisting of L-R audio, fixed DC bias, and a small 38 kHz component. This current amplitude modulates the 38 kHz carrier.

To derive the composite output, it is necessary to take the difference of the collector currents in IC407, and turn that difference into a voltage. In addition, we must add the 19 kHz pilot and the L + R, as well as the 38 kHz carrier cancellation sine.

The differential current-to-voltage conversion is accomplished by IC408, with associated resistors R424, 425, 426, 427, 438. Trimmer capacitor C406 serves to stabilize IC408 and to limit its high frequency response. The 38 kHz cancellation signal is derived from the filter buffer Q413, 414, and is applied through R427. The left, right and pilot signals are summed in IC409, connected as an inverting summing amplifier. The function of Q404, 405, 406 is described in the preceding section, "Stereo/Mono Switching." The sum is applied to the input of IC408 through R438. It should be noted that in order to maintain balance in the current-to-voltage conversion function of IC408, both R427 and R438 must see AC ground. This is accomplished by their being connected to low-impedance sources. However, a failure in Q413, 414, or IC409 can cause these sources to become high impedance, thereby unbalancing the circuit and introducing large amounts of sub-to-main crosstalk. Trimmer capacitor C406 balances the circuit at high frequencies.

The output of IC408 is AC-coupled through an extremely large capacitor, C409, to the OUTPUT LEVEL trimmer. The purpose of this capacitor is to eliminate the DC offset component at the output of IC408 without introducing low frequency phase shifts which would compromise separation.

The output of IC408 at 100% modulation is approximately 4 volts peak-to-peak at the 100% modulation point as defined by the limiter thresholds. In the TEST mode, the output clips about 3 dB above this point with worst-case signal (pure L-R). P405 permits this level to be reduced as necessary to accommodate any exciter.

It will be noted that there are no controls for L + R gain or L - R gain on the stereo modulator. L + R gain is fixed by IC408, IC409, and associated circuitry, and is designed to operate the stereo modulator in the optimum part of its available dynamic range. Since the subcarrier is generated by linearly multiplying the L - R audio by the 38 kHz sine, the subcarrier gain may be trimmed by adjusting the amplitude of the 38 kHz sine applied to the modulator. This adjustment is made by P412 in the 38 kHz generator section. P412 adjusts the 38 kHz AGC reference voltage. The adjustment range available is sufficient to provide optimum separation with any direct-FM exciter.

Power Supply

NOTE: The ±4.55 volt power supply for the instantaneous limiters is described in the "Instantaneous Limiters and Lowpass Filters" section.

The AC, which is assumed to be contaminated by RF, enters the chassis and is applied through the fuse to the power transformer. This transformer may be strapped for 115 volt or 230 volt operation; instructions for doing so are found in the INSTALLATION section.

The center-tapped secondary of the power transformer is applied to two pairs of diodes, CR601-604, operating as a pair of full-wave rectifiers to derive unregulated voltages of approximately ± 22.5 volts DC. The outputs of the rectifiers are smoothed by energy-storage capaci-

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tors C601-602. The unregulated voltage is then heavily filtered to eliminate RF, and passes through the RF shield bulkhead to the regulator circuitry.

Most of the positive regulator is contained in IC601, a 723C voltage regulator. IC601 contains a stable source of reference voltage (nominally 7.15 volts), an operational amplifier to compare the output with the reference, a series pass transistor to drive the external power transistor Q604, and a current-limit transistor. The reference voltage output at pin 6 is filtered by C603 to reduce noise and is introduced to the (+) input of the opamp, pin 5. The unregulated positive voltage is applied to pins 11 and 12, and to the collector of series pass transistor Q604, operated as an emitter-follower. The output current of Q604 passes through R601, which develops a voltage drop proportional to the current through it. This voltage drop is sensed across pins 2 and 3 of IC601. If it exceeds approximately 0.55 volts, the internal current limit transistor turns on and prevents further increase in output current, thus providing short-circuit protection for Q604.

The output is sensed by the voltage divider R602-603, P601, and is applied to the (-) input of the internal opamp (pin 4). The voltage divider reduces the output voltage until it is equal to the reference voltage. The output voltage is therefore held at a multiple of the reference voltage by means of feedback. This multiple (and therefore the output voltage) is adjusted by means of P601. C604 frequency-compensates the internal opamp to prevent high-frequency oscillations. Further stabilization is provided by C605 across the output of the regulator.

The - 15 supply is generated by means of a 741C opamp, IC602, in conjunction with external transistors. IC602 is connected as an inverting, unity gain amplifier with input resistor R607 and feedback resistor R606. Thus, the negative output tracks changes in the positive output.

The positive power supply for IC602 is provided by IC601. IC601 contains an internal 6.8 volt zener diode, which drops the + 15.7 volt output of the internal series pass transistor to approximately + 9 volts. This voltage is available at pin 9. Negative supply voltage for IC602 is provided by the unregulated negative supply. This scheme assures that the total supply voltage for IC602 can never exceed IC602's maximum 36 volt rating.

IC602 drives a conjugate emitter follower, Q602-603, R604. As in the case of the positive supply, the output current is dropped across R605, and if the voltage across R605 exceeds approximately 0.55 volts, Q601 turns on and shunts drive current away from Q602, simultaneously activating the protective current limiting circuitry inside IC602 which limits IC602's own output current to a safe level.

Normal current drain from the supply is approximately ± 200 ma.; current limiting occurs at 250 ma or so.

Because the positive voltage supply serves as a reference for many other circuits inside the Optimod, the minimum instrumentation required for adjusting the + 15.00 volt supply is a well-calibrated 3 ½ digit digital voltmeter. If IC601, R602-603, or P601 are replaced, an acceptable alternative is to adjust P601 for a correct composite stereo output. Assuming that the stereo generator was correctly adjusted before the power supply failure, this procedure assures that no other circuit alignment need be redone to adjust for changes in the positive power supply voltage.

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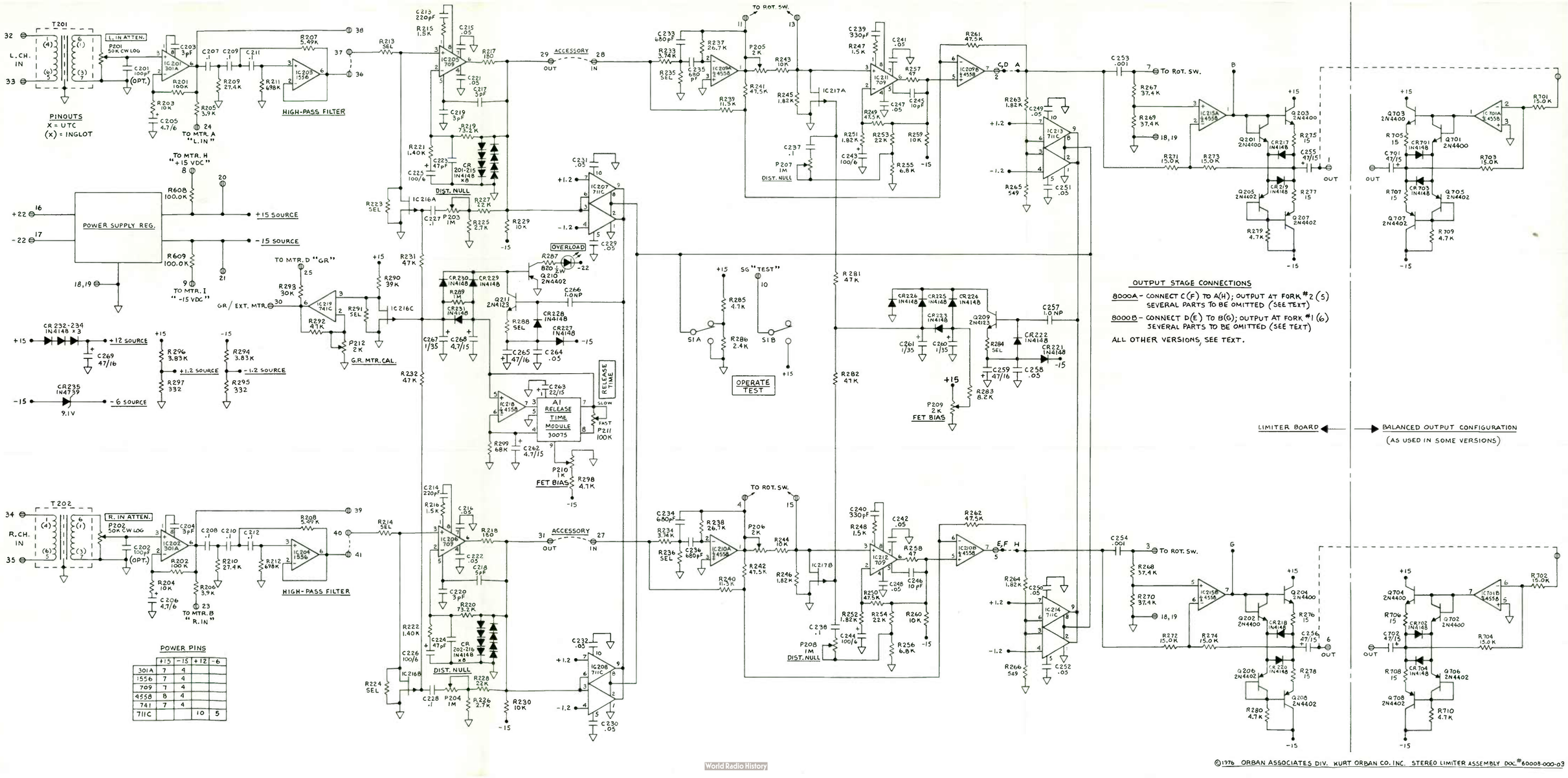

	+15	-15	+12	-6
301A	7	4		
1556	7	4		
709	7	4		
4558	8	4		
741	7	4		
711C			10	5

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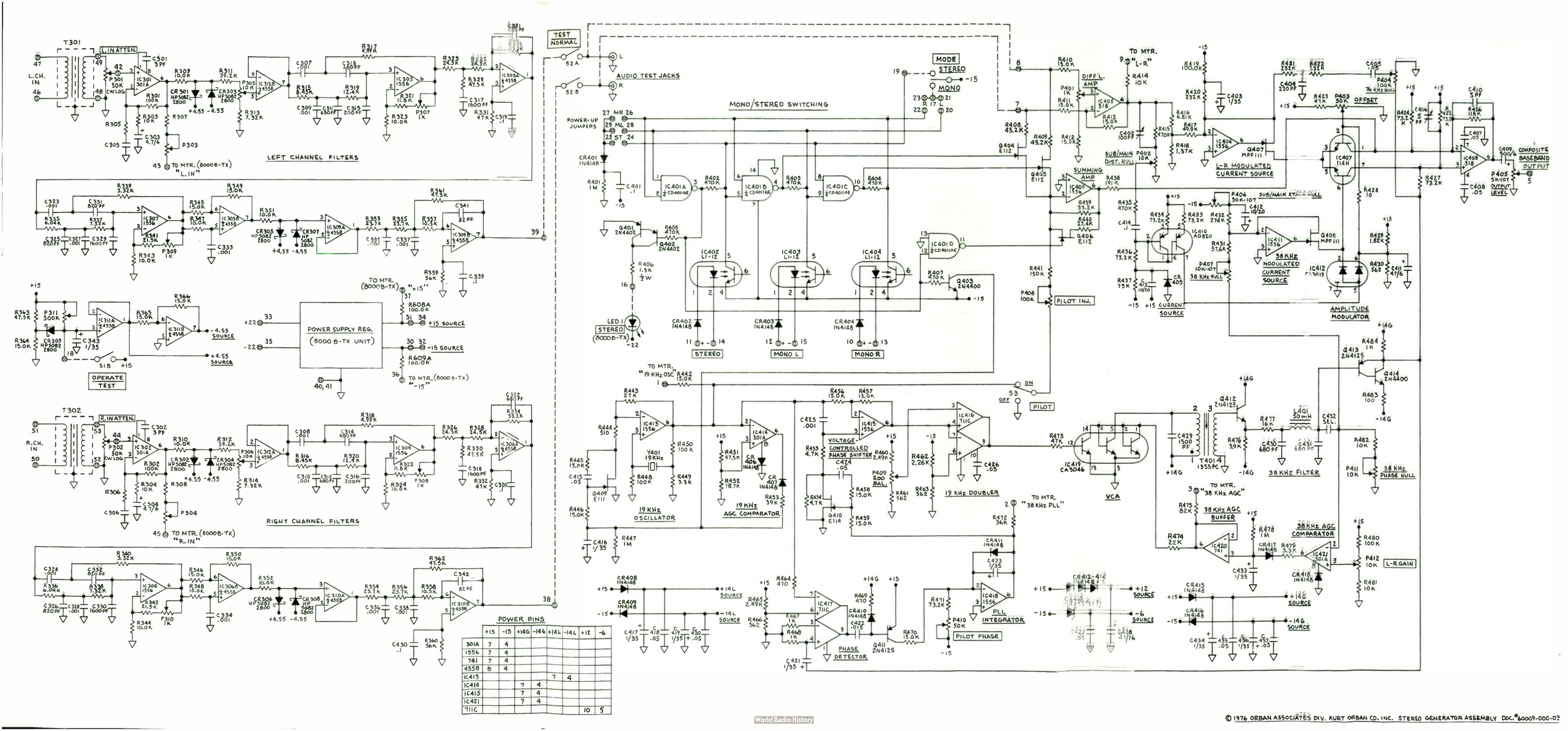

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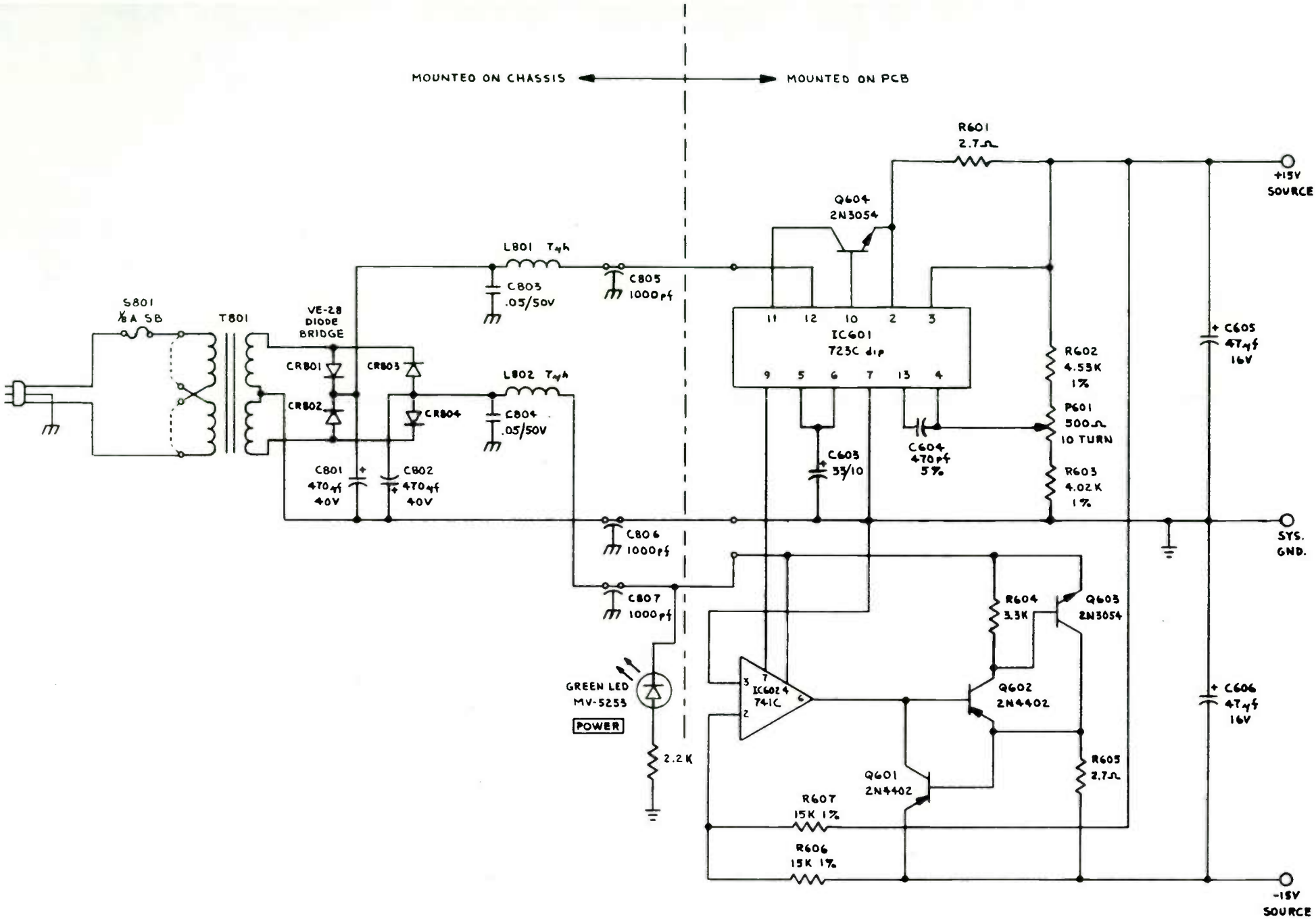

BIPOLAR 15 VOLT POWER SUPPLY--200 MA/SIDE

DOC#60011-000-01

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Alignment Procedure

Touchup Alignment

Ordinarily, the Optimod circuitry is extremely stable and does not require periodic alignment. However, unusual circumstances may require touchup alignment of the 38 kHz carrier null adjustments, which are the least intrinsically stable adjustments. The ratio between the gain of the two-quadrant multiplier and the gain of the cancellation signal injection must be kept stable within 0.5% in order to meet the -40 dB — 38 kHz cancellation requirement. In addition, offset drifts in the audio section can cause changes in the DC level difference between left and right channels which also translates as a 38 kHz component. Fortunately, touchup of the 38 kHz carrier cancellation requires only the station's stereo monitor for instrumentation, and is easily done if rejection should drift to less than the -40 dB legal requirement.

In order to touch up the 38 kHz carrier null, observe the 38 kHz level on the station's stereo monitor, following the monitor manufacturer's instructions. Adjust P407, the ten-turn 38 kHz amplitude null trimmer on the stereo generator board, for minimum 38 kHz component. Adjust P411, the 38 kHz phase null trimmer and attempt to reduce the 38 kHz component still further. P411 is relatively non-critical; P407 is extremely critical. These alignment points can be located by referring to the Stereo Generator Alignment Points diagram at the end of this section.

If the user owns a digital voltmeter accurate to 0.03% or better, P601, the +15 volt adjust trimmer may be tweaked at this time (if necessary) to adjust the positive power supply to +15.00 volts. IF THE REQUIRED VOLTMETER IS NOT AVAILABLE, DO NOT ATTEMPT THIS ADJUSTMENT.

To complete touchup alignment, the STEREO GENERATOR TRIM procedure in the INITIAL SET-UPsection of this manual should be performed to touch up the user setup controls.

Complete Alignment

This section of the manual is included primarily for purposes of reference, as PERIODIC COMPLETE ALIGNMENT IS NOT RECOMMENDED OR NECESSARY. Complete alignment is a step-by-step procedure which assumes that none of the trimmer controls are correctly adjusted. The average radio station does not have either the technical skill or the test equipment necessary to successfully complete this procedure. IF THE REQUIRED TEST EQUIPMENT IS NOT AVAILABLE, DO NOT ATTEMPT TO PERFORM COMPLETE ALIGNMENT.

REQUIRED INSTRUMENTATION

The following instrumentation is required for complete alignment:

(1) Audio Sinewave Generator, with less than 0.05% residual harmonic distortion

(2a) Audio Sweep Generator, sinewave output flat ±0.1 dB, or

(2b) Tracking Generator supplied with Low-Frequency Spectrum Analyzer (e.g. Tektronix 5L4N)

(3) Digital Voltmeter, basic DC accuracy 0.03% or better

(4) Audio Voltmeter/Harmonic Distortion Meter with 1 megohm or higher input impedance (e.g. H-P 334A).

(5) Frequency Counter, 0.1% accuracy or better

(6) Triggered Sweep Oscilloscope with X-Y capability and minimum 5 MHz vertical bandwidth

(7) Low-Frequency Spectrum Analyzer, 0-100 kHz minimum range; 100 Hz minimum resolution (Tektronix 5L4N)

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SETUP FOR COMPLETE ALIGNMENT

Complete alignment must be performed on a test bench away from strong RF fields, as the protective covers must be removed from the equipment and abnormal behavior is otherwise likely to result. Before commencing alignment, apply power and allow 30 minute warmup with covers in place. Remove the top and bottom covers immediately before starting alignment procedure. ALIGNMENT MUST BE PERFORMED SEQUENTIALLY. DO NOT SKIP STEPS. Alignment points can be found on the two fold-out pages at the end of this section.

POWER SUPPLY, LIMITERS AND FILTERS

(1) Connect digital voltmeter across C605, and read voltage.

(2) Adjust P601 for a reading of +15.00 volts on DVM.

(3) Jumper chassis and circuit grounds together.

(4) Center all user-alignment controls normally located behind security panel, except PILOT PHASE. Place PILOT PHASE at 10:30. Place OPERATE/TEST switch in OPERATE.

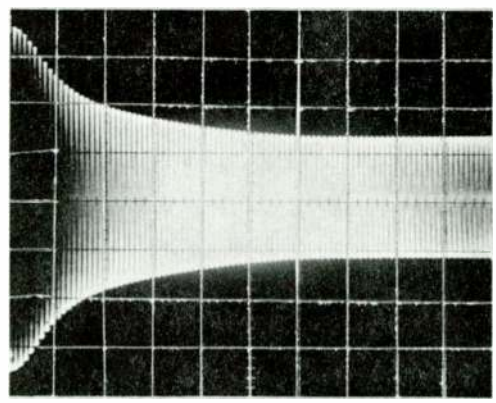
(5) Turn P210 (broadband FET bias) CW until the GAIN REDUCTION meter indicates that gain reduction is beginning. Back off P210 until no further change is noted in GAIN REDUCTION.

(6) Adjust P212 (G/R Meter Cal) until the GAIN REDUCTION meter indicates 100%.

(7) Connect oscillator to LEFT AUDIO INPUT. Adjust oscillator for 5 kHz. Increase oscillator output until GAIN REDUCTION meter indicates -8.5 dB.

(8) Connect oscilloscope to SCOPE OUTPUT of distortion analyzer. Connect input of distortion analyzer to the left channel broadband limiter output (terminal 29), which is a fork terminal close to the right rear of the limiter board when viewed from the front. Operate distortion analyzer such that the oscilloscope displays the input to the distortion analyzer (normally the "SET LEVEL" mode). Operate the scope in NORMAL TRIGGER mode, and adjust trigger level so scope barely stops triggering.

(9) Remove the hot lead of the oscillator from LEFT AUDIO INPUT. Turn the RELEASE TIME control full CCW. Now reconnect the hot lead of the oscillator, trying to make a clean reconnect. Observe the scope, which should trigger on the overshoot produced by the finite attack time of the broadband limiter. With the scope time base set at 2 ms/cm, adjust P210 (Broadband FET Bias) trimmer for a scope pattern similar to fig. A-1. This pattern will be transient, but should be easily visible. Fig. A-1 was photographed using a storage scope. To repeat the pattern, it is necessary to alternately disconnect and reconnect the hot lead of the oscillator.



BROADBAND LIMITER ATTACK
(no signal to 10 dB gain reduction;
2 mS/cm; 1V/cm)

FIG. A-1

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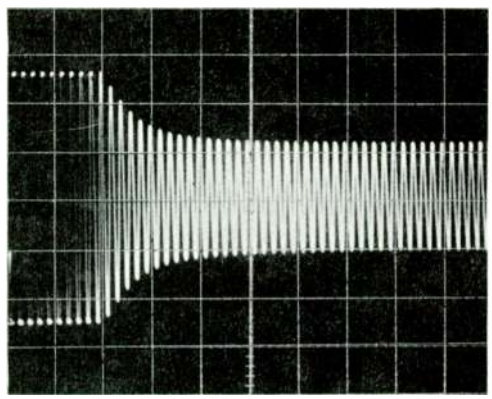
(10) Reconnect the oscillator. Switch frequency to 1 kHz, and reduce the output level until 4 dB gain reduction is observed. Without moving the distortion analyzer input, measure the harmonic distortion, and adjust P203 (left distortion null) for minimum THD. Typical reading will be 0.025% if an 80 kHz lowpass filter is employed to reduce the effects of out-of-band noise on the reading.

(11) Connect the oscillator to the RIGHT AUDIO INPUT, and follow the instructions of step 10, substituting P204 (right distortion null), and observing the right channel broadband limiter output (terminal 31).

(12) Connect the distortion analyzer to the right channel h. f. limiter output (terminal 5). This is a fork terminal located towards the left rear of the limiter board when viewed from the front. Increase oscillator frequency to 5 kHz; decrease oscillator output until GAIN REDUCTION meter just barely reads 0 dB.

(13) Operate the distortion analyzer such that the scope displays the input to the distortion analyzer. Reduce analyzer sensitivity until no overload occurs. With scope in NORMAL TRIGGER mode, adjust TRIGGER LEVEL until sweep barely shuts off.

(14) As you did with the broadband limiter test in step 9, alternately connect and remove the hot lead from the oscillator, while observing the scope as it triggers on the overshoot from the high frequency limiter. Adjust P209 (high frequency FET bias) until the scope displays a single-shot pattern like fig. A-2 with the scope time base adjusted for 1 ms/cm.



HIGH FREQUENCY LIMITER ATTACK
(5 kHz -- no signal to 10 dB gain reduction; 5V/cm; 1 ms/cm)

FIG. A-2

(15) Without changing the test setup (except for readjustment of the oscilloscope triggering so that the distortion signal can be viewed), measure the harmonic distortion. Reduce the level of the oscillator until the distortion is maximum. Adjust P208 (right h. f. distortion null) to minimize THD. It may be easier to see the effect of this control if a 75 microsecond de-emphasis network is placed between the limiter output and the distortion analyzer input, as the signal at this point is pre-emphasized, thereby increasing noise and distortion from the broadband limiter unnaturally.

(16) Connect the oscillator to the LEFT AUDIO INPUT and repeat step 15, connecting the distortion analyzer to the left channel h. f. limiter output (terminal 2), and adjusting P207 (left h. f. distortion null) for minimum distortion.

The following test adjusts the system for best adherence to the 75 microsecond pre-emphasis curve. It is most easily performed using the tracking oscillator of the Tek 5L4N Spectrum Analyzer as a signal source, and the analyzer portion of the Tek 5L4N for display. However, it is also possible to sweep the system with a conventional audio sweep generator (with logarithmic sweep), using a conventional X-Y oscilloscope for display. The instructions which

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follow refer to the 5L4N; a competent technician should easily deduce the alternate procedure using a sweep generator and conventional oscilloscope.

In addition, an accurate 75 microsecond de-emphasis network is required for reference. One may be easily constructed by connecting the network input to the output through a 7.50K, 1% resistor, and shunting the output to ground with a 0.01 uF, 1% mylar capacitor. This network should be loaded by no less than 1 megohm, or its accuracy will be degraded.

> WARNING: The 75 uS de-emphasis network incorporated in several popular modulation monitors displays insufficient accuracy for this adjustment, and should not be used!

There are three controls for each channel which determine the frequency response. The adjustment procedure for each channel is identical. Each time a trimmer is referenced in the text, two numbers will be given. The first number refers to the left channel; the second number refers to the right channel.

(17) Place the OPERATE/TEST switch in TEST. Connect the tracking generator output of the 5L4N to the AUDIO INPUT of the Optimod channel under test. Connect the analyzer input of the 5L4N to the audio test jack on the rear panel, J2, 3, through the 75 microsecond de-emphasis. Place the rear-panel slide switch in NORMAL. Adjust the 5L4N input impedance to 1 megohm. Operate the 5L4N in the 2 dB/division logarithmic vertical mode. Operate the 5L4N in the 20-20K log sweep mode, with a sweep speed of approximately 100ms/division. Manually adjust the 5L4N bandwidth control for maximum control of the fuzziness at low frequencies without causing visible low-frequency rolloff.

Three separate peaks will be visible in the frequency response curve produced. The lowest frequency peak (around 2 kHz) is affected by P205, 206 (pre-emphasis trim) on the limiter board. This control will also gently shelve the high frequencies up or down.

The second peak (approximately 10 kHz) is affected by the low-Q filter trim, P309, 310. The third peak (approximately 14.5 kHz) is affected by the hi-Q filter trim, P307, 308. These adjustments are on the lower (stereo generator) PC board.

Adjust all three controls to achieve maximally flat frequency response. Be sure that the 5L4N is not over-driving the filters by adjusting the input level to the Optimod and ascertaining that the frequency response curve stays the same shape as it moves up and down the display.

If all controls are correctly adjusted, it is typically possible to achieve a flatness of +0, -0.6 dB from 50-15,000 Hz, using a precision 75 uS de-emphasis network as a reference.

(18) Connect the oscillator to the LEFT AUDIO INPUT. Put the OPERATE/TEST switch in OPERATE. Adjust the output level of the oscillator until 5 dB gain reduction is observed. Connect the scope to the junction of R309 and R311 (on the stereo generator board, close to the right rear when viewed from the front), using a 10 megohm probe. Adjust oscillator frequency to 1 kHz. Adjust P311 until wave form is visibly clipped. Back off P311 until clipping just vanishes.

(19) Change oscillator frequency to 100 Hz. Using VARIABLE sensitivity on scope vertical amplifier, adjust scope until peaks of waveform just exactly fill screen. This is a reference level. Now move scope probe to pin 3 of IC309A, and adjust P305 to produce this reference level.

(20) Move scope probe to the junction of R310 and R312. Connect oscillator to the RIGHT AUDIO INPUT, and trim output level of oscillator to produce 5 dB gain reduction. As above, trim scope attenuator (slightly) to produce full-screen waveform. Move scope probe to pin 3 of IC310A, and adjust P306 to produce full-screen reference level.

This completes the alignment of the limiters and filters.

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STEREO GENERATOR ALIGNMENT

(NOTE: The following steps may be performed independently of the limiter/filter alignment above. However, once this procedure is started, ALL STEPS MUST BE PERFORMED IN ORDER UNTIL THE END OF THE PROCEDURE IS REACHED.)

(1) Connect a BNC-to-BNC cable from the COMPOSITE OUTPUT of the Optimod to the analyzer input of the Tek 5L4N spectrum analyzer. Adjust the 5L4N for 10 kHz/division horizontal and 10 dB/division logarithmic vertical. Adjust 5L4N sensitivity to -10 dBV.

(2) Turn the PILOT ON/OFF switch to ON, and operate the Optimod in the STEREO mode. Turn the rear panel NORMAL/TEST switch to TEST.

(3) Adjust the OUTPUT ATTENUATOR on the Optimod until the 19 kHz pilot reads -20 dBV (one major division below the top of the screen).

(4) T401 ADJUSTMENT. (Note: This adjustment may be made independently of the rest of the alignment procedure, without using external instrumentation. It is highly unlikely to be required, however.) Observe the 38 kHz AGC meter position on the front-panel meter, and adjust the slug in T401 for a minimum reading. Now observe the 38 kHz PLL position on the front-panel meter, and make sure that the phase-locked-loop is locked by observing a reading of 50% to 120%. If it is not, tweak the slug of T401 slightly until the PLL is observed to lock, and go somewhat further so that drifts in T401 will not unlock the loop. This assumes that the front-panel PILOT PHASE control is close to its correct adjustment. If it is not, make sure that the PLL does not lose lock when the PILOT PHASE control adjustment is corrected.

When the PLL has been tweaked, return to the 38 kHz AGC meter position and be sure that the reading does not exceed 70%. Otherwise, the AGC loop may have inadequate range.

(5) Connect the analyzer input of the 5L4N to the emitter of Q413, located close to the left-hand edge of the stereo generator board (front view). Adjust P409 (balance) for minimum 19 kHz and 53 kHz components. (Note: The 38 kHz component will be off-screen. This should not affect the accuracy of the adjustment.)

(6) 76 kHz Null: Reconnect the 5L4N input to the Optimod COMPOSITE OUTPUT. Alternately trim P403 (offset) and P404 (76 kHz null) to null out the 76 kHz component observed.

(7) 38 kHz Null: Adjust P407 (38 kHz null) for minimum 38 kHz. After a null has been found, deepen it by adjusting C406. Alternate between P407 and C406 to secure a maximum null.

(8) Sub-to-Main Crosstalk Null: Cut one lead of an 8.2K ¼ watt 5% resistor to ¼ Remove power from the Optimod. Tack-solder the short lead of the 8.2K resistor to pin 2 of IC405. This permits injection of audio directly into the L-R balanced modulator.

Connect the output of the oscillator to the long end of the 8.2K resistor through a 0.1 mf or larger capacitor. Adjust the frequency of the oscillator to 1.5 kHz, and its output level to 3.0 v rms. Reduce the span of the 5L4N to 500 Hz/div, and observe the fundamental (1.5 kHz) and second harmonic (3.0 kHz) of the crosstalk. Adjust P406 (sub/main crosstalk null) to minimize the level of the 1.5 kHz component. Adjust P402 (sub-main dist. null) to minimize 3.0 kHz component. Readjust P406 to null the 1.5 kHz component.

(9) High-Frequency Sub-to-Main Crosstalk Null: Adjust the frequency of the oscillator to 15 kHz. Adjust the 5L4N span to 5 kHz/div. Turn the PILOT ON/OFF switch OFF. Trim C402 for minimum 30 kHz component. Trim C406 for minimum 15 kHz component. This trim will compromise the 38 kHz rejection. Adjust P407 and P411 (38 kHz phase null) for minimum 38 kHz. If the rejection is less than 50 dB (center-screen: 30 dB below pilot), choose a compromise adjustment of C406 which permits at least 50 dB rejection of both the 38 kHz and 15 kHz components.

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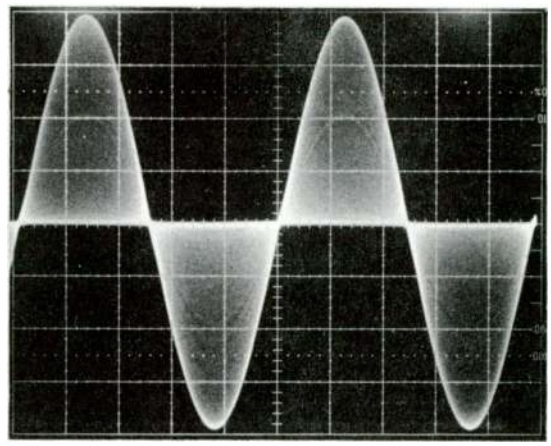
(10) Separation Check and Main-to-Sub Crosstalk Null: Ground the RIGHT audio input to the stereo generator, J3, and apply a 3.0 v rms 400 Hz signal from the oscillator to the LEFT input of the stereo generator, J2. Connect the COMPOSITE OUTPUT of the Optimod directly to the input of the scope through a shielded cable. DO NOT USE AN ATTENUATOR PROBE. Such probes have sufficient phase shift to compromise the accuracy of the following adjustments. Trigger the scope externally from the oscillator output, and adjust the front-panel L-R GAIN control for a maximally flat baseline (see fig. A-3). Separation may be directly measured as the ratio between the peak-to-peak baseline tilt and the peak-to-peak voltage of the entire composite output waveform. With 400 Hz, this should be unmeasurable (better than -50 dB) because noise and residual spurious output will obscure the tilt.



CORRECT L-R LEVEL (one channel, less pilot)

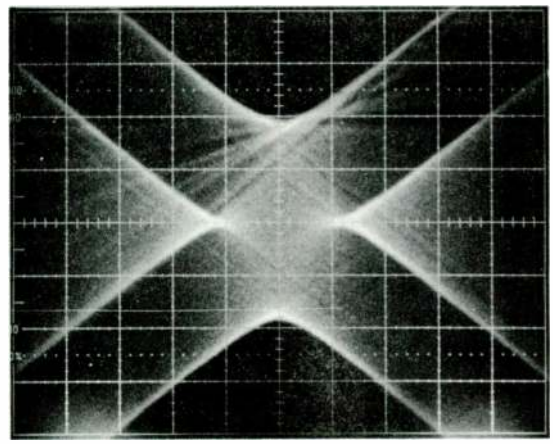
FIG. A-3

Switch the oscillator to 15 kHz, and measure the separation. It should typically be slightly better than 50 dB.

Now ground the LEFT audio input of the stereo generator, J2, and apply the oscillator output to the RIGHT stereo generator input, J3. Adjust P401 (main-to-sub crosstalk null) for a maximally flat baseline, as before. Check separation at 15 kHz. Once again, separation at both frequencies will typically exceed 50 dB. However, note that the guaranteed limit is 40 dB, and some units will not exhibit the full 50 dB separation at 15 kHz.

(11) Pilot Phase: Connect the oscillator to the 8.2K resistor tack-soldered in step 8. Apply 3.0 V rms at 400 Hz, and turn the PILOT ON/OFF switch ON. Adjust the front-panel PILOT PHASE control for a flat pattern per fig. A-4. Turn the meter to 38 kHz PLL, and make sure that the PLL is still in lock. If not, tweak T401 until the PLL locks, and readjust the PILOT PHASE control as necessary. Once the PLL is in lock, the pilot phase will be unaffected by adjustment of T401. Turn power off, and remove the tack-soldered 8.2K resistor.

World Radio History



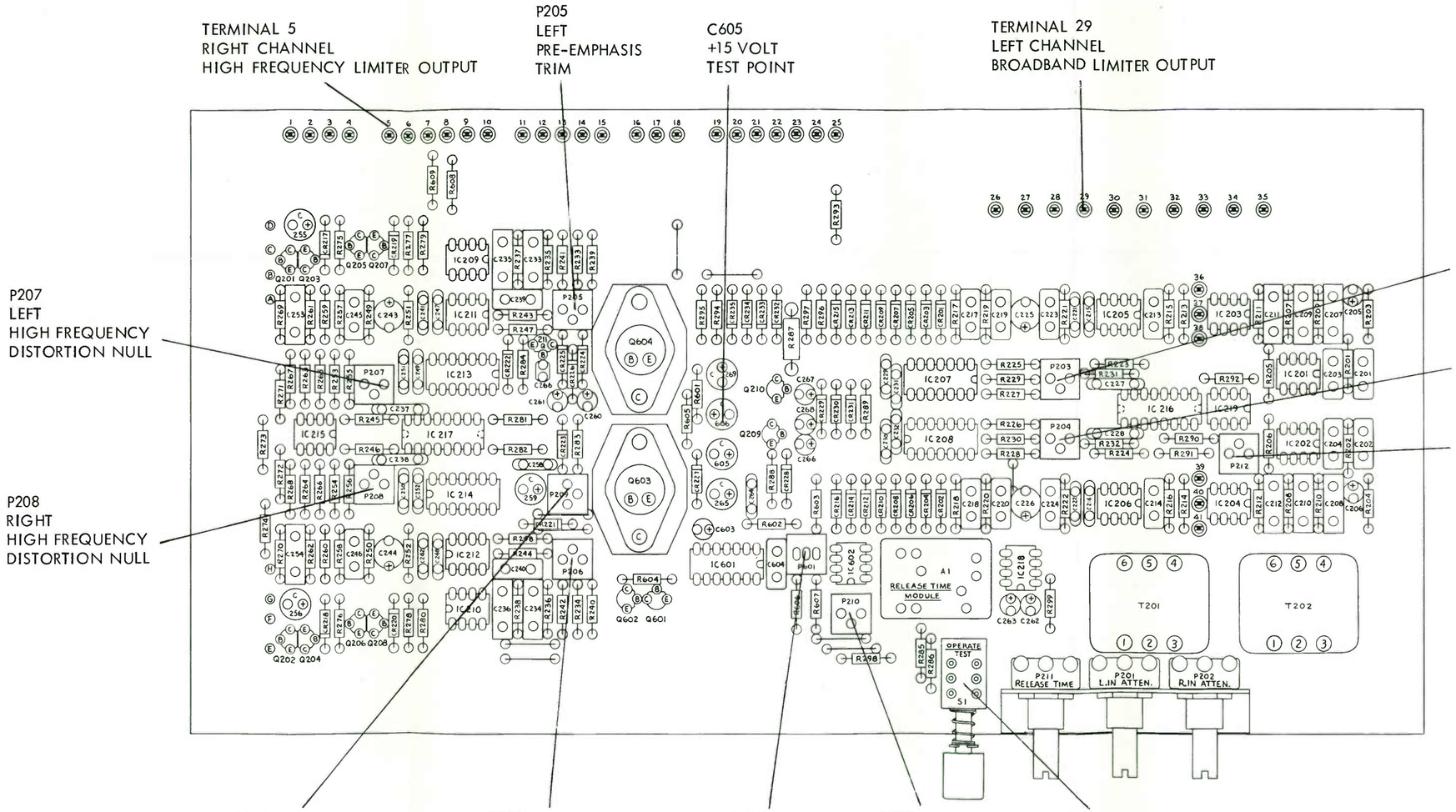
EXPANDED PILOT PHASE
FIG. A-4

(12) Reconnect the COMPOSITE OUTPUT of the Optimod to the 5L4N analyzer input. Apply power to the Optimod, and let it warm up for 30 seconds. Turn the rear-panel switch to NORMAL. Tweak P407 to secure a null in the 38 kHz component. This level will typically be less than -55 dB.

This concludes the alignment procedure. Replace the top and bottom covers. Be sure to replace all screws to assure an RF-tight seal.

World Radio History

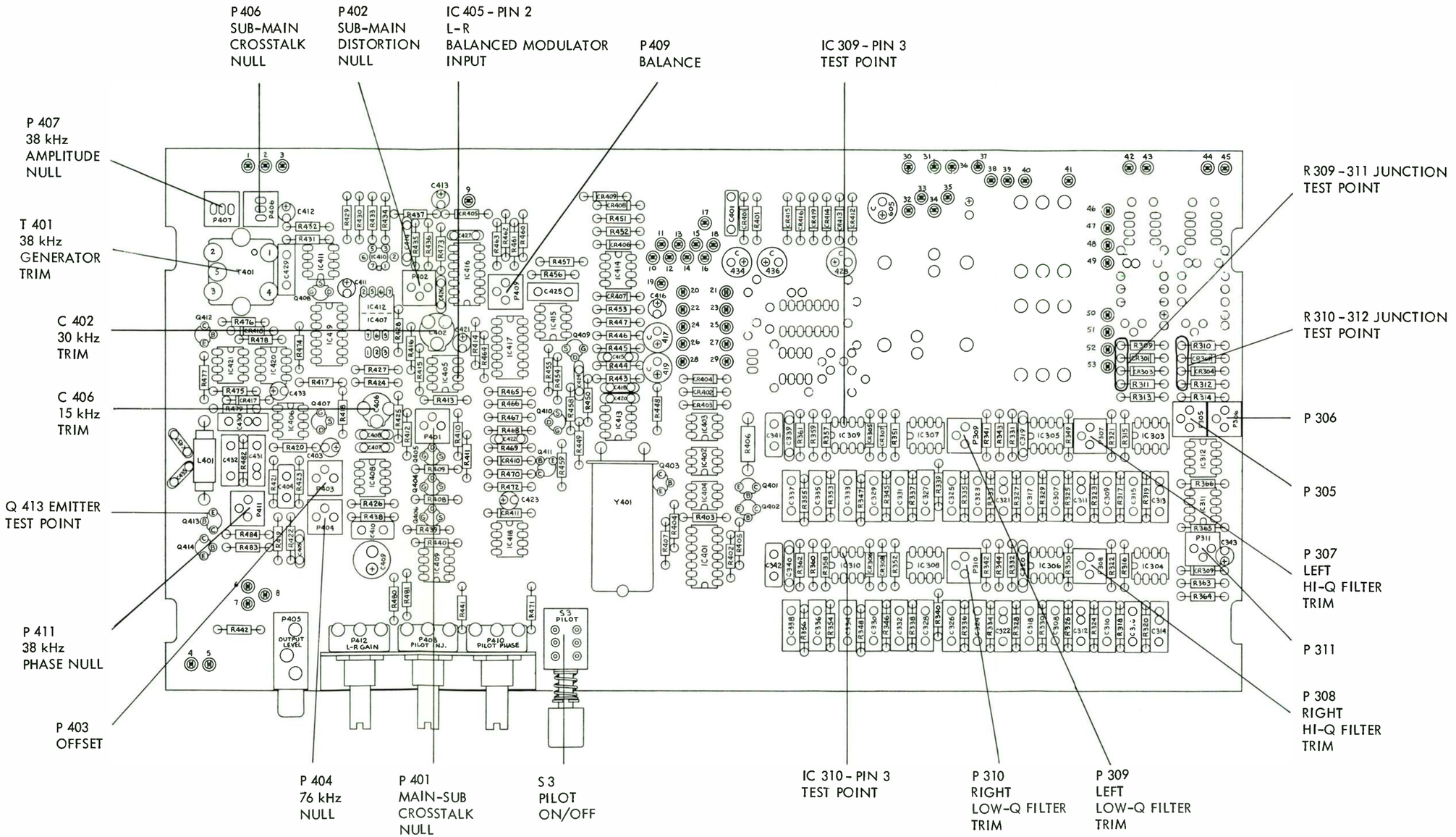
World Radio History



LIMITER BOARD ALIGNMENT POINTS

World Radio History

World Radio History



STEREO GENERATOR BOARD ALIGNMENT POINTS

World Radio History

World Radio History

PARTS LIST
INPUT FILTER BOARD ASSEMBLY P/N 30090-001-01

REF DES	PART DESCRIPTION	ORBAN P/N
	PRINTED CIRCUIT BOARD	30091-000
	INDUCTORS	
L 101	1.2 mH, MILLER 73F123AF	
102	" " "	
103	" " "	
104	" " "	
105	7 uH, OHMITE Z-50	
	RESISTORS	
R 101	CC, 750 ohm	
102	" "	
103	" 1.5 K	
104	" "	
105	" "	
106	" "	
107	" 750 ohm	
108	" "	
109	" 270 ohm	
110	" "	
111	" "	
112	" "	
113	" "	
114	" "	

CC-1/2W, 5%, Carbon Composition

World Radio History

World Radio History

PARTS LIST
LIMITER BOARD ASSEMBLY P/N 30080-001-02

REF DES	PART DESCRIPTION	ORBAN P/N
	PRINTED CIRCUIT BOARD	30081-000-
	RELEASE TIME MODULE ASSY	30075-000-
	INTEGRATED CIRCUITS	
IC 201	OPAMP, 301A	
202	" "	
203	" 1556C	
204	" "	
205	" 709C	
206	" "	
207	COMPARATOR, 711C	
208	" "	
209	OPAMP, DUAL, 4558C (RAYTHEON)	
210	" " " "	
211	" 709C	
212	" 709C	
213	COMPARATOR, 711C	
214	" "	
215	OPAMP, DUAL, 4558C (RAYTHEON)	
216	QUAD FET (SELECTED)	
217	" " "	
218	OPAMP, DUAL, 4558C (RAYTHEON)	
219	" 741C	
IC 601	POWER REGULATOR, 723C	
602	OPAMP, 741C	
	TRANSISTORS	
Q 201*	NPN, 2N4400	
202*	" "	
203*	" "	
204*	" "	
205*	PNP, 2N4402	
205*	" "	
206*	" "	
207*	" "	
208*	" "	
209	NPN, 2N4123	
210	PNP, 2N4402	
211	NPN, 2N4123	
Q 601	PNP, 2N4402	
602	" "	
603	NPN, 2N3054	
604	" "	

REF DES	PART DESCRIPTION	ORBAN P/N
	DIODES	
CR 201	SILICON, 1N4148	
202	" "	
203	" "	
204	" "	
205	" "	
206	" "	
207	" "	
208	" "	
209	" "	
210	" "	
211	" "	
212	" "	
213	" "	
214	" "	
215	" "	
216	" "	
217	" "	
218	" "	
219	" "	
220	" "	
221	" "	
222	" "	
223	" "	
224	" "	
225	" "	
226	" "	
227	" "	
228	" "	
229	" "	
230	" "	
231	" "	
232	" "	
233	" "	
234	" "	
235	ZENER, 1N4739 (9.1V)	

World Radio History

World Radio History

PARTS LIST
LIMITER BOARD ASSEMBLY P/N 30080-001-02

REF DES	PART DESCRIPTION	ORBAN P/N
	CAPACITORS	
C 201*	CD, 100 pF, 20%, 1 KV	
202*	" " " " "	
203	MI, 3 pF, ± 1/2 pF, 500 V	
204	" " " " "	
205	DT, 4.7 uF, 6 V	
206	" " " "	
207*	MY, .1 uF, 2.5%, 100 V (SELECTED)	
208*	" " " " "	
209*	" " " " "	
210*	" " " " "	
211*	" " " " "	
212*	" " " " "	
213	MI, 220 pF, 5%, 500 V	
214	" " " "	
215	CD, .05 uF, 20%, 25 V	
216	" " " "	
217	MI, 5 pF, ± 1/2 pF	
218	" " "	
219	" 3 pF, ± 1/2 pF	
220	" " "	
221	CD, .05 uF, 20%, 25 V	
222	" " " "	
223	MI, 47 pF, 5%	
224	" " "	
225	DT, 100 uF, 6 V	
226	" " "	
227	CD, .1 uF, 20%, 25 V	
228	" " " "	
229	" .05 uF, " "	
230	" " " "	
231	" " " "	
232	" " " "	
233	MI, 680 pF, 1%	
234	" " "	
235	" " "	
236	" " "	
237	CD, .1 uF, 20%, 25 V	
238	" " " "	
239	MI, 330 pF, 5%	
240	" " "	
241	CD, .05 uF, 20%, 25 V	
242	" " " "	
243	DT, 100 uF, 6 V	
244	" " "	
245	MI, 10 pF, ± 1/2 pF	
246	" " "	
247	CD, .05 uF, 20%, 25 V	
248	" " " "	
249	" " " "	
250	" " " "	
251	" " " "	
252	" " " "	
253*	MI, 1000 pF, 1%	
254*	" " "	
255*	AL, 47 uF, 16 V	
256*	" " "	
257	DT, 1 uF, 50 V	
258	AL, 47 uF, 16 V	
259	CD, .05 uF, 20%, 25 V	
260	DT, 1 uF, 35 V	
261	" " "	
262	" 4.7 uF, 15 V	
263	" 22 uF, 15 V	
264	CD, .05 uF, 20%, 25 V	
265	AL, 47 uF, 16 V	
266	DT, 1 uF, 50V	
267	DT, 1 uF, 35 V	
268	" 4.7 uF, 15 V	
269	AL, 47 uF, 16 V	
C 603	DT, 33 uF, 10 V	
604	MI, 470 pF, 5%	
605	AL, 47 uF, 16 V	
606	" " "	

REF DES	PART DESCRIPTION	ORBAN P/N
	VARIABLE RESISTORS	
P 201*	POT, PANEL, 50 K, CWLOG, (input)	
202*	" " " " " "	
203	" TRIM, CERMET, 1 M	
204	" " " "	
205*	" " " 2 K	
206*	" " " "	
207	" " " 1 M	
208	" " " "	
209	" " " 2 K	
210	" " " 1 K	
211*	" PANEL, 100 K, LIN, (release time)	
212	" TRIM, CERMET, 2 K	
P 601	POT, TRIM, CERMET, 10 T, 500 ohm	
	FIXED RESISTORS	
R 201	CF, 100 K	
202	" "	
203	" 10 K	
204	" "	
205	" 3.9 K	
206	" "	
207*	MF, 5.49 K	
208*	" "	
209*	" 27.4 K	
210*	" "	
211*	" 698.0 K	
212*	" "	
213	SELECTED VALUE	
214	" "	
215	CF, 1.5 K	
216	" "	
217	" 180 ohm	
218	" "	
219	MF, 73.2 K	
220	" "	
221	" 1.40 K	
222	" "	
223	SELECTED VALUE	
224	" "	
225	CF, 2.7 K	
226	" "	
227	" 22 K	
228	" "	
229	" 10 K	
230	" "	
231	" 47 K	
232	" "	
233*	MF, 3.74 K	
234*	" "	
235	NOT LOADED FOR 75 uS	
236	" " " "	
237*	MF, 26.7 K	
238*	" "	
239	MF, 11.3 K	
240	" "	
241	" 47.5 K	
242	" "	
243*	CF, 10 K	
244*	" "	
245	MF, 1.82 K	
246	" "	
247	CF, 1.5 K	
248	" "	

*Not used in some versions.

AL-Aluminum CD-Ceramic Disc DT-Dipped Tantalum
MI-Mica MY-Mylar

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D

World Radio History

World Radio History

PARTS LIST
LIMITER BOARD ASSEMBLY P/N 30080-001-02

REF DES	PART DESCRIPTION	ORBAN P/N
	FIXED RESISTORS	
R 249	MF, 47.5 K	
250	" "	
251	" 1.82 K	
252	" "	
253	CF, 22 K	
254	" "	
255	" 6.8 K	
256	" "	
257	" 47 ohm	
258	" "	
259	" 10 K	
260	" "	
261	MF, 47.5 K	
262	" "	
263	" 1.82 K	
264	" "	
265	" 549 ohm	
266	" "	
267*	" 37.4 K	
268*	" "	
269*	" "	
270*	" "	
271*	" 15.0 K	
272*	" "	
273*	" "	
274*	" "	
275*	CF, 15 ohm	
276*	" "	
277*	" "	
278*	" "	
279	" 4.7 K	
280	" "	
281	" 47 K	
282	" "	
283	" 8.2 K	
284	SELECTED VALUE	
285	CF, 4.7 K	
286	" 2.4 K	
287	CC, 1/2 W, 5%, 820 ohm	
288	SELECTED VALUE	
289	CF, 1 M	
290	" 39 K	
291	SELECTED VALUE	
292	CF, 47 K	
293	" 30 K	
294	MF, 3.83 K	
295	" 332 ohm	
296	" 3.83 K	
297	" 332 ohm	
298	CF 4.7 K	
299	" 68 K	
R 601	CC, 1/4 W, 5%, 2.7 ohm	
602	MF, 4.53 K	
603	" 4.02 K	
604	CF, 3.3 K	
605	CC, 1/4 W, 5%, 2.7 ohm	
606	MF, 15.0 K	
607	" "	
608	" 100.0 K	
609	" "	

*Not used in some versions.

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D

World Radio History

World Radio History

PARTS LIST
STEREO GENERATOR BOARD ASSEMBLY P/N 30085-001-03

REF	PART DESCRIPTION	ORBAN P/N
	INTEGRATED CIRCUITS	
IC 301*	OPAMP, 301 C	
302*	" "	
303	" 1556 C	
304	" "	
305	DUAL OPAMP, 4558 C	
306	" " "	
307	OPAMP, 1556 C	
308	" "	
309	DUAL OPAMP, 4558 C	
310	" " "	
311	" " "	
312	" " "	
IC 401	DIGITAL, CD 4011	
402	OPTOISOLATOR, MCT - 26 (Monsanto)	
403	" " "	
404	" " "	
405	OPAMP, 318	
406	" 1556 C	
407	ARRAY, LM 114 AH	
408	OPAMP, 318	
409	" 1556 C	
410	ARRAY, AD 820	
411	OPAMP, 1556 C	
412	ARRAY, CA 3019	
413	OPAMP, 1556 C	
414	" 301 C	
415	" 1556 C	
416	DUAL COMPARATOR, 711 C	
417	" " "	
418	OPAMP, 1556 C	
419	ARRAY, CA 3046	
420	OPAMP, 741 C	
421	" 301 C	
IC 601*	REGULATOR, 723 C	
602*	OPAMP, 741 C	
	TRANSISTORS	
Q 401	PNP, SIGNAL, 2N4402	
402	" " "	
403	NPN, SIGNAL, 2N4400	
404	FET, E 112	
405	" "	
406	" "	
407	" MPF 111	
408	" "	
409	" E 111	
410	" E 114	
411	PNP, SIGNAL, 2N4125	
412	NPN, SIGNAL, 2N4123	
413	PNP, SIGNAL, 2N4125	
414	NPN, SIGNAL, 2N4400	
Q 601*	PNP, SIGNAL, 2N4402	
602*	" " "	
603*	POWER, 2N3054	
604*	" "	

REF	PART DESCRIPTION	ORBAN P/N
	DIODES	
CR 301	SI, HOT CARRIER, HP 5082 - 2800	
302	" " " "	
303	" " " "	
304	" " " "	
305	" " " "	
306	" " " "	
307	" " " "	
308	" " " "	
309	" " " "	
CR 401	SI, SIGNAL, 1N4148	
402	" " "	
403	" " "	
404	" " "	
405	" " "	
406	" " "	
407	" " "	
408	" " "	
409	" " "	
410	" " "	
411	" " "	
412	" " "	
413	" " "	
414	" " "	
415	" " "	
416	" " "	
417	" " "	
418	" " "	
419	ZENER, IN4739, 9.1 V	
	CAPACITORS	
C 301*	MI, 3 pF, ± 1/2 pF	
302*	" " "	
303*	DT, 4.7 uF, 6 V	
304*	" "	
305*	SELECTED	
306*	"	
307	MI, 1000 pF, 1%	
308	" " "	
309	" " "	
310	" " "	
311	" 680 pF, 1%	
312	" " "	
313	" " "	
314	" " "	
315	" 200 pF, 5%	
316	" " "	
317	" 1600 pF, 1%	
318	" " "	
319	CD, .1 uF, 20%, 25 V	
320	" "	
321	MI, 680 pF, 1%	
322	" " "	
323	" 1000 pF, "	
324	" " "	
325	" 820 pF, 1%	
326	" " "	
327	" 1000 pF, 1%	
328	" " "	
329	" 1600 pF, "	
330	" " "	
331	" 820 pF, 1%	
332	" " "	
333	" 1000 pF, 1%	
334	" " "	
335	" " "	
336	" " "	
337	" " "	
338	" " "	
339	CD, .1 uF, 20%, 25 V	
340	" "	
341	MI, 82 pF, 5%	
342	" " "	
343	DT, 1 uF, 35 V	

*Not used in some versions.

AL-Aluminum MI-Mica CD-Ceramic Disc MY-Mylar DT-Dipped Tantalum

World Radio History

World Radio History

PARTS LIST
STEREO GENERATOR BOARD ASSEMBLY P/N 30085-001-03

REF	PART DESCRIPTION	ORBAN P/N
	CAPACITORS	
C 401	CD, .1 uF, 25 V	
402	TRIMMER, 10 - 100 pF	
403	DT, 1 uF, 35 V	
404	MI, 220 pF, 5%	
405	CD, .05 uF, 20%, 25 V	
406	TRIMMER, 1 - 5 pF	
407	CD, .05 uF, 20%, 25V	
408	" " " "	
409	AL, 500 uF, 6 V	
410	MI, 2 pF, ± 1/2 pF	
411	DT, 47 uF, 6 V	
412	DT, 10 uF, 20 V	
413	" " "	
414	CD, .1 uF, 25 V	
415	CD, .05 uF, 25 V	
416	DT, 1 uF, 35 V	
417	AL, 1 uF, 50 V	
418	CD, .05 uF, 25 V	
419	AL, 1 uf, 50 V	
420	CD, .05 uF, 25 V	
421	DT, 1 uF, 35 V	
422	CD, .015 uF, 20%, 50 V	
423	DT, 1 uF, 35 V	
424	CD, .05 uF, 20%, 25 V	
425	MI, 1000 pF, 1%	
426	CD, .05 uF, 20%, 25 V	
427	" " " "	
428	AL, 47 uF, 16 V	
429	MI, 1500 pF, 5%	
430	MI, 680 pF, 1%	
431	" " "	
432	MY, SELECTED	
433	DT, 1 uF, 35 V	
434	AL, 1 uF, 50 V	
435	CD, .05, 20%, 25 V	
436	AL, 1 uF, 50 V	
437	CD, .05 uF, 20%, 25 V	
C 603	DT, 33 uF, 10 V	
604	MI, 470 pF, 5%	
605	AL, 47 uF, 16 V	
606	" " "	
	VARIABLE RESISTORS	
P 305	POT, TRIM, 10 K	
306	" " "	
307	" " 1 K	
308	" " "	
309	" " "	
310	" " "	
311	" " 500 K	
P 401	POT, TRIM, 1 K	
402	" " 10 K	
403	" " 50 K	
404	" " 100 K	
405	" " 10 T, 5 K (output)	
406	" " 10 T, 50 K	
407	" " 10 T, 10 K	
408	" PANEL, 100 K, LIN (pilot inject)	
409	" TRIM, 200 ohm	
410	" PANEL, 50 K, LIN (pilot phase)	
411	" TRIM, 10 K	
412	" PANEL, 10 K, LIN (1-r gain)	
P 601	POT, TRIM, 10 T, 500 ohm	

REF	PART DESCRIPTION	ORBAN P/N
	RESISTORS	
R 301*	CF, 100 K	
302*	" "	
303*	" 10 K	
304*	" "	
305*	SELECTED	
306*	"	
307*	"	
308*	"	
309	MF, 10.0 K	
310	" "	
311	" 39.2 K	
312	" "	
313	" 7.32 K	
314	" "	
315	" 8.45 K	
316	" "	
317	" 4.99 K	
318	" "	
319	" 12.4 K	
320	" "	
321	" 11.8 K	
322	" "	
323	" 10.0 K	
324	" "	
325	" 24.3 K	
326	" "	
327	" "	
328	" "	
329	" 47.5 K	
330	" "	
331	CF, 47 K	
332	" "	
333	MF, 33.2 K	
334	" "	
335	" 6.04 K	
336	" "	
337	" 7.32 K	
338	" "	
339	" 3.32 K	
340	" "	
341	" 21.5 K	
342	" "	
343	" 10.0 K	
344	" "	
345	" 15.0 K	
346	" "	
347	" 10.0 K	
348	" "	
349	" 15.0 K	
350	" "	
351	" 10.0 K	
352	" "	
353	" 23.7 K	
354	" "	
355	" "	
356	" "	
357	" 10.5 K	
358	" "	
359	CF, 56 K	
360	" "	
361	MF, 47.5 K	
362	" "	
363	" "	
364	" 15.0 K	
365	" "	
366	" "	

*Not used in some versions.

AL-Aluminum CD-Ceramic Disc DT-Dipped Tantalum
MI-Mica MY-Mylar

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D

World Radio History

World Radio History

PARTS LIST
STEREO GENERATOR BOARD ASSEMBLY P/N 30085-001-03

REF	PART DESCRIPTION	ORBAN P/N
	RESISTORS	
R 401	CF, 1 M	
402	" 470 K	
403	" "	
404	" "	
405	" "	
406	CC, 1/2 W, 5%, 1.5 K	
407	CF, 470 K	
408	MF, 43.2 K	
409	" "	
410	" 15.0 K	
411	" "	
412	" "	
413	" "	
414	CF, 10 K	
415	" 470 K	
416	MF, 6.81 K	
417	" 49.9 K	
418	" 1.37 K	
419	" 100.0 K	
420	" 232 K	
421	" "	
422	" "	
423	CF, 47 K	
424	MF, 73.2	
425	" "	
426	" 118 K	
427	" 73.2	
428	CF, 10 ohm	
429	MF, 1.82 K	
430	" 562 ohm	
431	" 57.6 K	
432	" 274 K	
433	" 73.2 K	
434	" "	
435	CF, 470 K	
436	MF, 73.2 K	
437	CF, 75 K	
438	MF, 191 K	
439	" 33.2 K	
440	" 27.4 K	
441	CF, 150 K	
442	MF, 15.0 K	
443	CF, 27 K	
444	" 510 ohm	
445	MF, 15.0 K	
446	" " "	
447	CF, 1 M	
448	" 100 K	
449	" 3.3 K	
450	" 100 K	
451	MF, 47.5 K	
452	" 18.7 K	
453	CF, 39 K	
454	" 4.7 K	
455	" "	
456	MF, 15.0 K	
457	" "	
458	" "	
459	" "	
460	" 2.49 K	
461	" 562 ohm	
462	" 2.26 K	
463	" 562 ohm	
464	CF, 470 ohm	
	RESISTORS	
R 465	MF, 2.49 K	
466	" 562 ohm	
467	CF, 1 K	
468	" "	
469	" 470 ohm	
470	MF, 15.0 K	
471	" 73.2 K	
472	CF, 36 K	
473	" 47 K	
474	" "	
475	" 82 K	
476	" 3.9 K	
477	" 16 K	
478	" 1 M	
479	" 3.3 K	
480	" 100 K	
481	" 10 K	
482	" "	
483	" 100 ohm	
484	" 1 K	
R 601*	CF, 2.7 ohm	
602*	MF, 4.53 K	
603*	" 4.02 K	
604*	CF, 3.3 K	
605*	" 2.7 ohm	
606*	MF, 15.0	
607*	" "	
L 401	INDUCTOR, 50 mH, Miller 70F502AF	
Y 401	CRYSTAL, 19 kHz	
T 401	TRANSFORMER, 38 kHz, Miller 1355 PC	
S 3	SWITCH, PUSH-PUSH, DPDT	

*Not used in some versions.

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D

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PARTS LIST
POWER SUPPLY ASSEMBLY P/N 40001 - 000 - 01

REF DES	PART DESCRIPTION	ORBAN P/N
	DIODES	
CR 601	1/4 FULL WAVE BRIDGE, VARO VE-28	
602	" "	
603	" "	
604	" "	
	CAPACITORS	
C 601	AL, 470uF, 40 V	
602	" " "	
	TRANSFORMERS	
T 601	POWER, PRI: 115/230 VAC, 50/60 HZ SEC: 38 VCT, 13 WATTS	

CC-Carbon Composition, 5% CF-Carbon Film, 1/4 W, 5%
MF-Metal Film, 1/8 W, 1%, RN55D
AL-Aluminum CD-Ceramic Disc DT-Dipped Tantalum
MI-Mica MY-Mylar

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