OPERATING AND MAINTENANCE INSTRUCTION MANUAL

MODELS 390 / 990

MAGNETIC FILM RECORDING SYSTEM

INOVONICS
INCORPORATED

- USER'S RECORD -

Model 390 - Serial Nos. ______

____

Model 990 - Serial No. ______

Date Purchased ______________

Warranty Card Mailed ________

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MAGNETIC FILM RECORDING SYSTEM

January, 1990

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Section I

INTRODUCTION

MODEL 390 PRODUCT DESCRIPTION

General

Inovonics' 390 is an audio electronics package specifically intended for motion picture sound recording on sprocketed magnetic film. It was engineered to meet the needs of top-quality original installations, and to retrofit existing recording systems for a substantial improvement in performance.

Throughout the design of the 390, full consideration was given to motion picture production practices, as well as to the critical noise, headroom and other technical parameters particular to the film industry. Developed with the kind and patient cooperation of a film industry leader in magnetic head technology, the 390 is *system*-engineered for the highest film-sound quality.

System Components

The 390 Film Recording Electronics is made up from a combination of three system parts:

- The individual plug-in MODULES which contain Erase, Bias, Record, Playback and Recordist Monitor amplifier circuitry.
- An unpowered RACK FRAME which can accommodate from one to four of the plug-in modules.
- A SYSTEM POWER SUPPLY which provides power and routes control logic to as many as eight channel Modules in a single system.

These system parts may be configured by the user to make up any required recording system; for instance, a single- or dual-track 16mm recorder, a 2-, 3-, 4- or 6-track 35mm machine, or a multi-format system with plug-in heads to fit a variety of needs.

MODEL 390 FEATURES

The Inovonics 390 is distinguished by these operating features and special functions:

- Erase, Bias, Record, Play and Recordist Monitor functions are under remote control from the Recording Console.
- 4 separate Level and EQ setups accommodate any combination of 35mm and 16mm formats. Presets are automatically called-up as plug-in head assemblies are interchanged.
- Non-interactive IN/OUT pickup timing and "contoured" erase and bias ramping facilitate perfect inserts.
- An exclusive LINEUP mode with front-panel "trim" adjustments allows fine-tuning of critical recording parameters for reel-to-reel film stock variations.

- HFX^{tm}, Inovonics' unique "Program-Adaptive Biasing" system, eliminates high frequency self-erasure and extends top-end response and headroom.
- OLX^{tm} "Saturation Compensation" circuitry significantly reduces THD and IM distortions inherent in the magnetic recording Process.
- Unprecedented signal headroom in audio and bias electronics far exceeds the requirements imposed by film oxide formulations of even the highest coercivities.

PRODUCT BACKGROUND

The Company

Inovonics was incorporated in 1972 with an idea for a single product to manufacture and market. Though solid state circuitry was nothing new to the professional audio field in the '70s, there were tens of thousands of studio tape recorders still in use with vacuum tube electronics. The tape transports, themselves, were extremely rugged and reliable; but the overall performance of these machines fell short of what was then considered "state of the art." Inovonics' first product was a transistorized replacement electronics assembly for studio tape machines, notably the Ampex 350/351 series - by far the most popular of the older recorders still in widespread use.

Tape Electronics

Over the years that followed, and through several updates and generations, Inovonics manufactured several thousand channels of recorder electronics, while developing many other products for the sound recording, broadcasting and audio instrumentation fields. Today, with the ready availability of remarkably good and relatively inexpensive tape machines, the market for replacement electronics has dwindled to make this but a small part of Inovonics' total product family.

Film Use

We had noted for some time that an increasing proportion of our replacement channels were being modified for use in magnetic film recorders of one type or another. Communication between the factory and those brave people in the field who were involved in this effort revealed varying degrees of success. This prompted Inovonics' exploration of film recording practices, procedures and techniques, in hopes that a better acquaintance with this industry might help us develop new products to better serve it.

Credits

Inovonics is indebted to numerous film sound and other audio recording professionals who aided us in our endeavor to develop and offer an improved mag-film recording electronics. We particularly extend our thanks to: Frank Pontius and his crew at Westrex Corp, Bob Morrison of Standard Tape Lab., Jack Dimmers at Teccon Corp., and "Jay" McKnight of Magnetic Reference Lab. Additionally, our interviews with many film recorder users proved both valuable and frustrating; we were certainly inspired to include many of the 390's ultimate features, but were unable to incorporate all suggestions for fear that the product might become too complex for everyday use.

UNIQUE FEATURES OF THE 390 DETAILED

At this point, it might prove helpful to describe in detail (and, hopefully, thus to justify) those features which are unique to the Model 390, and set it apart from most systems already in use.

LINEUP Mode

Because the magnetic oxide coating is applied to normal motion picture film stock, which is necessarily thick and stiff to stand up to intermittent motion in the photographic application, it is difficult to maintain a consistently smooth surface and a uniform coating thickness. This can lead to substantial variation from one reel of stock to the next in certain performance characteristics, notably bias and signal sensitivities, particularly at high frequencies.

The 390's LINEUP mode permits off-line adjustment of BIAS, FLUX (Recording Level) and Record EQ (Equalization) prior to an actual "take." When a new reel of stock is threaded onto the recorder, the machine operator can plug an oscillator into the TEST jack on the front of the 990 Power Supply chassis. This immediately puts all channels of that system into RECORD, and patches the oscillator signal to the inputs of all channels, bypassing the program signal routing from the recording console. Now the transport can be started and adjustments trimmed. When calibration is completed, the oscillator is unplugged and full control reverts to the console.

The panel-knob TRIM controls for BIAS, FLUX and EQ are limited in range to about ±2dB, or to just a fraction of the total latitude afforded by the primary screwdriver adjustments. This gives adequate range for reel-to-reel variations, and good adjustment resolution.

PC (Phase Compensation)

There is an ongoing controversy over the subjective effect of phase distortion on an audio signal; that is, whether even a trained listener can discern anything short of a severe time displacement between the low and high frequency components of a complex waveform.

When a string is plucked, a "bing" sound is generated. Should the higher-order components be grossly delayed, the sound would be more of a "thunk" followed by the "-ing." This is, of course, an exaggerated example, but illustrates a worst-case situation with a transient sound. Repetitive complex waveforms, like a sustained violin note, would not produce a similar perceived result, even with the same phase displacement.

For all *practical* purposes, it is generally agreed that the phase distortions encountered in today's real world of audio are not audible. An exemplary exception (test your memory) might be the characteristic "sound" of network radio programming during the '40s and '50s. The repeatered 'phone lines for coast-to-coast hookups required such radical equalization that the 5kHz band edge could be many "rotations" (multiples of 360-degree phase shift) removed from the lower, voice-frequency components.

Unless corrective steps are taken, the magnetic recording process is inherently responsible for a certain amount of shifting or "smearing" of the audio signal phase response for two main reasons. First, equalizer circuits in both the record and reproduce amplifiers do not match the recording losses they compensate in *phase* response, though the overall *frequency* response can be made nearly flat. Secondly, an examination of the physics of magnetic recording show high frequencies recorded on the oxide at the *trailing* edge of the record head gap, whereas lower frequencies are recorded nearer the gap's *centerline*. This phenomenon is well illustrated in models of the recording process which deal with the "longitudinal" physics, but further studies show that oxide *thickness* (and bias field penetration) is an equally important factor.

At any rate, correction to phase response is infrequently made in magnetic audio recorders because the effect is slight and does not degrade the sonic quality. Instrumentation and video machines, on the other hand, always incorporate phase compensation to maintain as perfect integrity of the signal as is possible.

During development of the Model 390, it was decided to include phase compensation for a couple of reasons. First, motion picture production practices frequently call for tracks which are multiple generations of the original recording. Since phase response errors accumulate with each re-dub, there is the possibility that multiple-generatory quality could be impared. The second reason to provide phase compensation is to optimize performance of the OLX^{tm} feature.

OLX^{tm} (Oxide Linearity eXtension)

The process of *direct* magnetic recording (as distinguished from FM or digital *saturation* recording techniques) is, by nature, nonlinear. The only really workable method by which an audio signal can be directly recorded is through superimposition of an ultrasonic biasing field to force the magnetic oxide into the linear portion of its hysteresis characteristic. This yields a typical total dynamic range of 75 to 85dB.

To maximize the available dynamic range of the recording system, a reference "Operating Level" is established. This generally corresponds to the metered *average* value of speech and music waveforms, and is set sufficiently below oxide saturation to accommodate *peak* values of the program which can exceed the average value by as much as 10 or 15dB.

Unlike an amplifier stage which ultimately reaches a "brick wall" clipping point, magnetic oxide goes *gracefully* into saturation. There is an area of increasing waveform compression over the last 10dB or so of magnetic oxide headroom, with an attendant and inevitable increase in total harmonic and intermodulation distortions (THD and IM). Oddly enough, this effect has been used as an "enhancement" in radio broadcasting, for it was noted that commercials tape-recorded well "into the red" sound much "gutsier" than when performed live. Nevertheless, from the standpoint of audio purity, system headroom must be utilized judiciously.

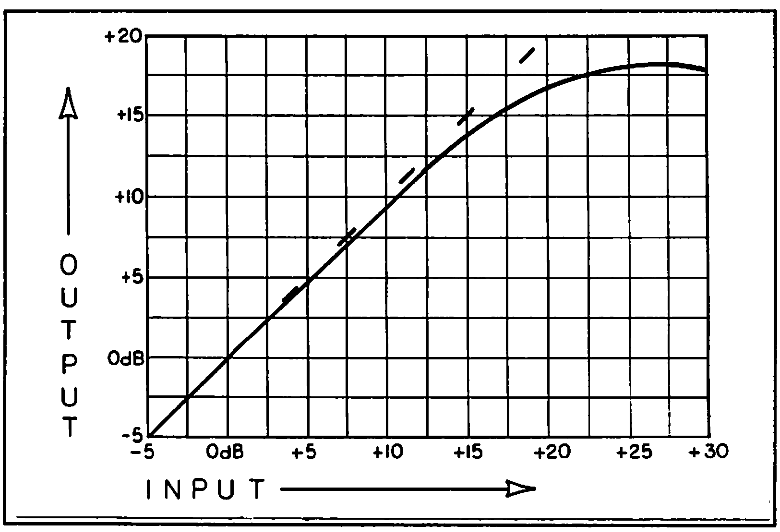


Figure 1 - Oxide Transfer Characteristic

The saturation (overload) characteristic of a magnetic recording system may be defined with good accuracy. By plotting the peak value of the input signal against that of the recovered output, the compression effects of that particular oxide will be described. An example of this relationship is graphed in Figure 1 on the previous page. Using such information, we not only can *predict* the compression characteristic of this magnetic stock, but can actually *predistort* the input signal in a manner complementary to the oxide saturation effects. This can effectively *cancel* the compression-induced distortion in the recording! Figure 2 is a sketch of waveshapes which illustrate this technique. Waveform distortions have been somewhat exaggerated to clarify the example.

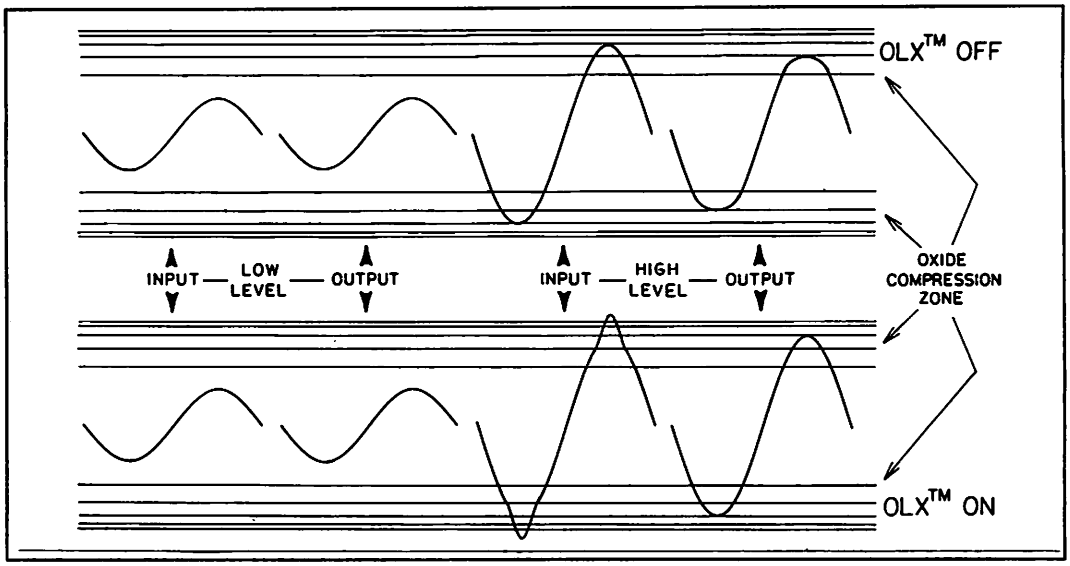


Figure 2 - Effects of Signal Predistortion

The OLX^{tm} predistorter circuit in the Model 390 utilizes nonlinear semiconductor devices in a variable network which may be adjusted to null distortion products generated in a variety of magnetic coatings. Figure 3 graphs recorded flux vs. harmonic distortion for two representative oxide formulations with the OLX^{tm} circuitry both defeated and enabled.

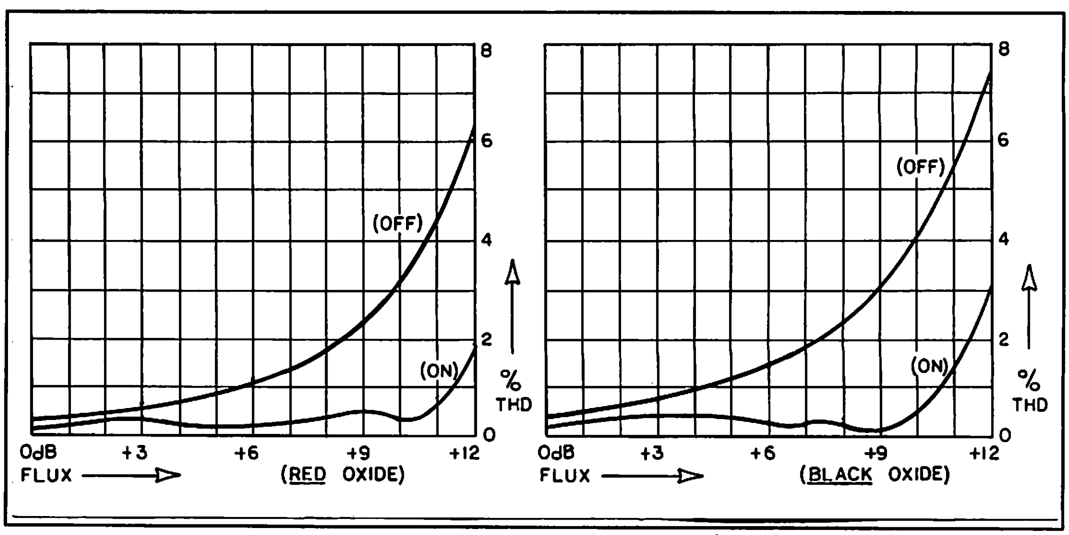


Figure 3 - Distortion Reduction by OLX^{tm} Circuitry

The advantage obtained by predistortion techniques may be interpreted two ways: either *lower* distortion at *customary* recording levels, or operation at an *elevated* level for a *customary* distortion.

Complementary predistortion techniques predate Inovonics' OLX^{tm} circuitry. There are, in fact, relative patents from the early 1950s. The technology was incorporated into certain studio-quality tape recorders many years ago, though lack of phase compensation in the recording amplifiers limited circuit effectiveness in these earlier implementations.

HFX^{tm} (High Frequency eXpansion)

System equalization compensates for a number of losses inherent in the magnetic recording process. These losses are almost always greater for the shorter recorded wavelengths, and are an increasing problem when striving for best top-end performance - especially at the slower, 16mm recording speeds.

Most real-world speech and music waveforms have little real *energy* at high frequencies. This is not to downplay the importance of good system frequency response, for recording quality certainly depends on accurate reproduction of subtle overtones to the limits of audibility. Statistically, however, the relative *power* in the higher-order signal components is much lower than at the fundamental frequencies. This relationship was researched at length when equalization standards were initially established. It remains valid for the majority of program material today, but recording practices and tastes in music have definitely changed over the years. With the ability to easily reproduce even the highest frequencies, there seems to have come a trend toward the "bright sound"; close miking of percussion instruments and unnaturally sibilant vocal tracks. This means that recording practices based on spectral distribution studies of the '50s may not hold completely true today.

As recording preemphasis is increased to overcome short wavelength losses, the high frequency energy can reach unnatural proportions - especially in the case of the cited "bright sound". With more than just modest amounts of preemphasis, either for slower recording speeds or to compensate for shortcomings in the magnetic coating, a phenomenon known as "*self*-erasure" can become a serious problem.

Self-erasure occurs when sufficient high frequency signal energy combines with the bias field at the recording head to *over*-bias the magnetic oxide, and actually begin to *erase* the audio signal as it is being recorded! Again, this poses a difficulty only when a good deal of recording preemphasis is required to overcome short wavelength losses.

The self-erasure effect was a particular complication in the very early days of magnetic recording. Oxide coatings were comparatively crude at the time, both in terms of sensitivity at short wavelengths and in surface smoothness. Resigned to living within the physical limitations of the magnetic material, recording pioneers turned to an electronic solution to the self-erasure problem.

Again in the early 1950s, a U.S. patent was granted for a system of "program-adaptive" biasing. The system monitored the spectral content of the input audio signal and *dynamically* controlled the level of the ultrasonic bias as a function of high frequency energy. The circuit ensured that the composite energy at the recording head would never reach a level which could cause self-erasure; for as high frequency energy increased, the bias level would automatically cut itself back. In an extreme case, the bias could even disappear altogether and the audio would effectively "*self*-bias!"

Coincident with development of this technology, improvements in oxide formulations were being made by leaps and bounds. By the time the program-adaptive bias scheme was ready for implementation, the improved oxides seemed no longer to require such a system. Remember, this was when studio tape machines ran at 30 or 15ips, and even home tape recordists used 7.5ips for everything but speech.

Recently, however, program-adaptive biasing technology has been resurrected and refined. It is now used in most equipment for the high speed duplication of audio cassette tapes, and in top-end broadcast audio cartridge machines running at 7.5ips.

Inovonics' HFX^{tm} is a system of program-adaptive biasing specifically adapted for film recording. It was included in the design of the Model 390 to help cope with potential self-erasure problems; particularly in the 16mm format, but also in consideration of the magnetic properties of available coated film stock. Figure 4 shows the effectiveness of the HFX^{tm} System at 35mm and 16mm speeds.

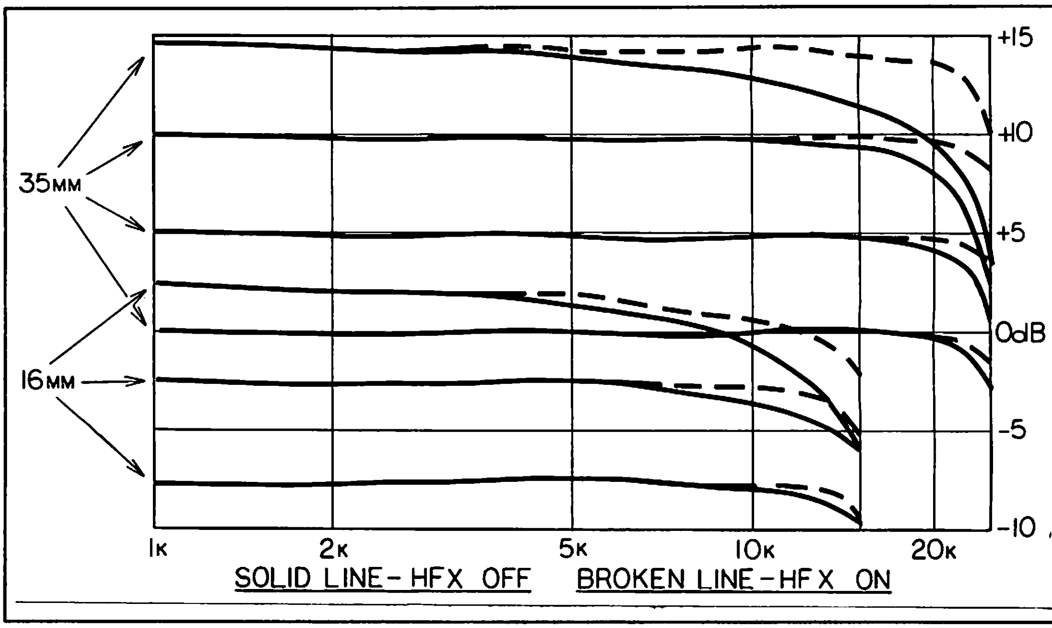


Figure 4 - Typical Overall Recorded Response, With and Without HFX^{tm} Program-Adaptive Bias System

HEAD SELECTION GUIDELINES

"Low-Z" Design

Heads in early magnetic recording systems were matched to vacuum tube electronics which had characteristically higher input and output impedances than later solid state designs. Most retrofit recording electronics, including those made by Inovonics, were developed specifically to match the high-Z heads common to older tape machines. Model 390 circuitry has been optimized for heads with windings in the *lower* range of inductance to better match solid-state circuit impedances.

Erase Head

Erase head inductance is specified at 2 millihenries. Because the head forms part of a tuned circuit, this inductance is fairly critical. A ±10% tolerance is probably acceptable, but erase efficiency falls quickly on either side of the design-center value. The only penalty for an incorrect value of Erase head inductance is poor depth of erasure. Erasure noise remains low because the push-pull driver stage maintains waveform symmetry even if detuned.

Record and Reproduce Heads

In film recording, the Record head is used extensively for playback as well, because the signal reproduced by the Record head is in "sync" with what is being recorded on another track. This is essential when "looping," and when recording additional dialog, music or sound effects tracks.

Unfortunately, any Record/Play "combination" head is at best a compromise because of the gap length dilemma. (Gap spacer thickness largely determines gap *length*, often incorrectly referred to as gap *width*.)

The length of a recording gap is not nearly so critical as that of a reproducing gap. A "long" gap of 500-microinches in a Record head will generate a deeper bias field to better penetrate the oxide coating. This greatly reduces the effects of surface irregularities, and "dropouts" will be less of a problem.

The same 500 μ-inch gap in a Reproduce head, on the other hand, would introduce significant short-wavelength (high frequency) signal loss. Uncorrected, this loss translates to about 2.8dB at 15kHz for 35mm systems, or over 10dB loss at 10kHz for 16mm recorders. A gap loss equalizer, such as provided in the 390 playback circuitry, can compensate for gap losses to some extent, but optimum high frequency performance dictates a short Reproduce head gap.

The ideal solution is to depart from the practice of using an interchangeable combination R/P head. Instead, keep the longer recording gap and accept the playback performance compromise, but relegate this playback (from the Record head) to cueing and synchronous *monitoring* only. When the time comes to mix and re-dub the tracks, take the playback from the Recordist Monitor channel which comes from a dedicated Reproduce head with a shorter gap.

MODEL 390 SPECIFICATIONS

Overall system specifications will, of course, depend largely on the heads and film stock used. The following data were derived using representative coated materials, and Sendust alloy heads supplied by Teccon Corp. Track width was 200-mils, and nominal Operating Level approximately 185nW/m.

Reference to *absolute* signal levels in these Specifications uses the term "dBu." As of this writing, dBu is *not* a term which is officially recognized by standards organizations, yet it has come into widespread use through convention. A 0dBu signal has the same 0.775-volt r.m.s. *voltage* reference as 0dBm, but no impedance or power level is implied.

Overall Frequency Response:

35mm: ±1.5dB, 25Hz - 20kHz
16mm: ±2dB, 20Hz - 12kHz

Signal-to-Noise (in dB, referred to a "peak" flux level of 370nW/m, or 6dB above Operating Level):

	OVERALL		STANDBY	
	u'wtd.	A-wtd.	u'wtd.	A-wtd.
35mm:	-67	-75	-74	-82
16mm:	-63	-70	-70	-77

Distortion (OLX^{tm} - OFF):
Oxide-induced distortion will reach approximately 1% THD at a flux level of 290nW/m, or approximately 4dB above Operating Level. This depends on oxide formulation (See Figure 3). Distortion in the electronics is >0.1% at any level up to signal clipping. The electronics internal clipping points are at least 20dB above typical average operating levels.

Equalization: 35 μ-sec for 35mm tests, 70 μ-sec for 16mm, and a "flat" low frequency characteristic per the SMPTE Specification. Equalization presets are automatically switched with jumpers in plug-in head assemblies.

Line Input: Transformerless, electronically-balanced/bridging; appears at the back-panel "XLR" female connector. Differential input impedance >10k-ohms; accepts nominal program line levels between -5dBu and +15dBu, +4dBu nominal. Common Mode Rejection >40dB.

Line and Recordist Monitor Outputs: Transformerless, electronically-balanced; appear at back-panel "XLR" male connectors. Output impedance: 200-ohms, resistive. Output line level: +4dBu, corresponding to 0-VU. Output clipping level: > +24dBu into 600-ohm or higher impedance load.

Erase Frequency: 125kHz.

Erasure: >75dB erasure of 500Hz signal recorded at or below oxide saturation.

Bias Frequency: 250kHz.

IN/OUT Timing: Separate, non-interactive adjustments for 35mm and 16mm formats. IN and OUT timing delays are each independently variable between 40 and 500ms.

Head Specifications:
ERASE: 2mH, ±10%, with >90% magnetic efficiency at 125kHz; dual-gap construction.
RECORD: 5mH, ±20%, with >80% magnetic efficiency at 250kHz; recommended gap spacer, 500 μ-inches.
REPRODUCE (Recordist Monitor): 5mH, ±20%; recommended gap spacer, 200μ-inches.

Power Requirements: The Model 390 Channel Modules each require a preregulated bipolar supply of ±18vdc at 350ma, and a 500kHz Erase/Bias "pilot" signal of 15 volts p-p. The Model 990 Power Supply, which satisfies these requirements for a system of 8 channels or less, operates from 115/230-volt AC mains, 50/60Hz, and draws about 120 Watts fully-loaded.

Size and Shipping Weight:
390 Channel Modules: 7"H x 4.3"W x 8"D; 4 lbs.
990 Power Supply: 3.5"H x 19"W x 10"D; 17 lbs.
999 Rack Frame: 7"H x 19"W x 8"D (4U); 3 lbs.

Section II

INSTALLATION

UNPACKING AND INSPECTION

Immediately upon receipt of the equipment, inspect carefully for shipping damage. If any damage is observed, notify the carrier at once; if not, proceed as outlined below. It is recommended that the original shipping carton and packing materials be saved should future reshipment become necessary. In the event of return for Warrant repair, shipping damage sustained as a result of improper packing for return may *invalidate the Warranty!*

IT IS VERY IMPORTANT that the Warranty Registration Card found at the front of this manual be completed and returned. Not only does this assure coverage of the equipment under terms of the Warranty, and provide some means of trace in the case of lost or stolen gear, but the user will automatically receive specific SERVICE OR MODIFICATION INSTRUCTIONS should they be issued by the factory.

MOUNTING

Rack Frame

The Inovonics 390 System includes a Rack Frame which occupies seven vertical inches of standard 19-inch-wide rack space. This frame houses up to four of the individual Model 390 channel modules. When fewer than four modules are installed in a frame (systems of fewer than four tracks or, for instance, 6-track systems using two Rack Frames), blanking panels are available which will cover the unused spaces.

Magnetic Interference

The 390 channel modules employ extremely high-gain reproduce preamp circuits which are somewhat susceptible to induced hum from stray magnetic fields. It is therefore quite important that the Rack Frame housing the channel modules be located *away* from motors, fans and transformers which could aggravate hum problems. Additionally, the Model 990 Power Supply radiates a respectable hum field and should, itself, be located as far as practicable from the 390 module circuitry.

The Rack Frame which houses the Channel Modules must be located in an area convenient to adjustment, but out of the direct film path so that adjustments may be made with the film in motion.

It is important that the Rack Frame and Power Supply each be secured by rack-screws through *all* mounting holes. This not only provides rigidity, but a good chassis-to-rack ground connection. And *please* use nylon rack washers under the screw heads!

Power Supply

The Model 990 is a companion Power Supply used with the 390 System. It can power a maximum of 8 channel modules in a single system and, in addition to regulated DC voltages, also contains the bias pilot oscillator and LINEUP mode circuitry.

It is suggested that the 990 Power Supply be located at the *bottom* of the film recorder equipment cabinet - out of the way, and out of magnetic interference range of the channel modules. Moreover, the lower reaches are generally the coolest in the cabinet, and since most power dissipation is from Power Supply voltage regulators, such placement will aid longevity.

Loading the Rack Frame

Once the Rack Frame is located and mounted, the Channel Modules may be installed by sliding them into the Frame's Nylon guides. The *extra* guides accommodate half-width Playback-Only modules.

Each Channel Module and Blanking Panel is supplied with two, one-half-inch, 6-32 threaded spacers. These *may* be shipped with the Modules and Panels, secured by the captive thumbscrews. If so, *remove* these spacers and install them instead in the #6 clearance holes of the Rack Frame top and bottom rails which align with the Module centerlines. The threaded spacers come with short #6 screws and split washers, and should be tightened securely to the Rack Frame.

If everything is in alignment, the Channel Modules should slide effortlessly into the Rack Frame, and the captive thumbscrews thread easily into the spacers. If this is *not* the case, it may be necessary to loosen and retighten the twelve #6 screws which hold the Rack Frame together. This will relieve stresses incurred in shipping or mounting.

Channel Configurations

390 Channel Modules are loaded into the Rack Frame(s) from left-to-right, Track 1 of the system leftmost. Though any given system may be configured as multiple-format with plug-in head assemblies (ie: single-track 16mm *and* 3-, 4- and 6-track 35mm *combination*), it is *not advisable* to mix separate systems in a common Rack Frame, or try to use a single 990 Power Supply for more than one system. Though a 990 Supply can power 8 Channel Modules, control logic routing cannot be split between two or more systems.

390 MODULE HOOKUP

Power to Modules

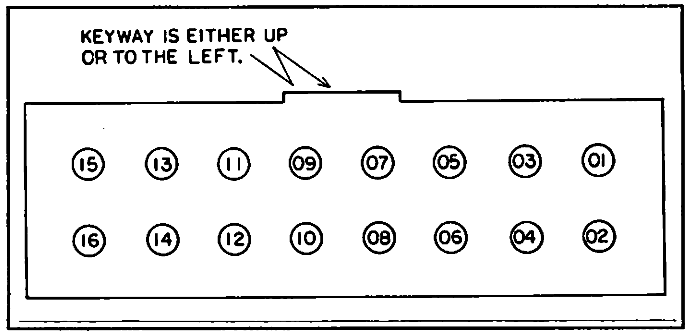
Each 390 Channel Module is supplied with a four-foot ribbon cable for a "home run" connection to the 990 Power Supply. Though the two ends of the cable are interchangeable, best practice is to maintain uniformity by keeping the color-coded edge of the ribbon cable either "up" or "to the right," which is the location of Pin 1 of the header connectors. Once the Modules are assigned channel numbers, they should be plugged into their designated connectors on the Power Supply.

Though the Module-to-Supply connection is essentially foolproof, ribbon connector pin connections are tabulated for reference at the top of the next page.

Line Input

LINE INPUT connection to the 390 Module is made via the rear-panel XLR female connector. Pin assignments follow established convention:

PIN 1 - GROUND, PIN 2 - INPUT "HIGH," PIN 3 - INPUT "LOW."



MODULE POWER CONNECTOR
(Male connector pins shown head-on)

PIN 01 - +18 VDC	**PIN 02** - +18 VDC
PIN 03 - -18 VDC	**PIN 04** - -18 VDC
PIN 05 - GROUND	**PIN 06** - GROUND
PIN 07 - 500KHZ BIAS PILOT	**PIN 08** - EQ SELECT A
PIN 09 - RECORD COMMAND IN	**PIN 10** - EQ SELECT B
PIN 11 - MONITOR SELECT	**PIN 12** - 16/35 SELECT
PIN 13 - RECORD TALLY OUT	**PIN 14** - (SPARE)
PIN 15 - LINEUP SIGNAL IN	**PIN 16** - LINEUP ACTIVATE

Line Output

The rear-panel XLR male connector labeled LINE OUTPUT is the primary output which may be remotely switched at the Recording Console to monitor either the Line Input, the output of the Reproduce Amplifier (playback from the Record head), or the Recordist Monitor Output (playback from a separate Reproduce head). The line level corresponding to a Module meter reading of "0-VU" is +4dBu. Pin assignments are:

PIN 1 - GROUND, PIN 2 - OUTPUT "HIGH," PIN 3 - OUTPUT "LOW."

Recordist Monitor Output

This rear-panel XLR male connector is a line-level output dedicated to the separate, "downstream" Reproduce head. Output level and pin assignments are the same as the primary LINE OUTPUT.

Head Connectors

The popular "DIN" connector was chosen for head cable connection to the 390 Module. These connectors are used extensively in computer, audio and video equipment, and are readily available in rugged, shielded versions which are very reliable. One set of the mating connectors is provided with each 390 Module.

8-pin DIN connectors have been specified for Erase, Record and Reproduce heads, alike. HOWEVER, the supplied connectors are color-coded with stick-on "dots," and *keyed* so that it is impossible to plug one type of head into the wrong rear-panel connector. The colored paper dots may be written-on to identify track assignments.

7-pin DIN plugs may also be used. These have identical pin locations and are somewhat easier to obtain. The only instance where an 8-pin plug *must* be used is for the Channel 1 (or single-track) Record head in a 16mm system. Pin 8 is used to switch the 390 Modules over to the 16mm format.

EQ (Format) Switching

The 390 System is set up to automatically switch between 35mm and 16mm, and among "formats" A, B, C and D, simply by plugging-in different head assemblies. Levels, EQ, etc. may be preset for different track formats to be automatically called-up when heads are interchanged.

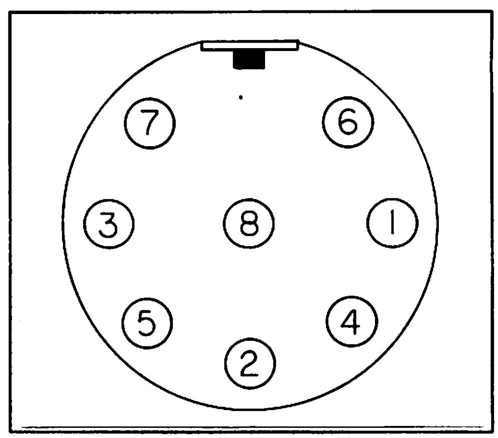
EQ (Format) Switching

The 390 System is set up to automatically switch between 35mm and 16mm, and among "formats" A, B, C and D, simply by plugging-in different head assemblies. Levels, EQ, etc. may be preset for different track formats to be automatically called-up when heads are interchanged.

Selection is made by interconnecting appropriate pins in *one* of the Record Head DIN connectors, typically Track 1 of the system. The four format selection lines are brought from the DIN connector up to spare connector pins on the head mounting plate. Various jumper combinations are set up on each mating connector of the different plug-in head assemblies. Switching logic is bussed between all channels through the Power Supply, so only *one* set of jumpers is required for switching *all* channels in the system. This jumpering is diagrammed in Figure 5 on the following page.

Head Plug Connections

Pin assignments for the Erase, Record and Reproduce head connectors are tabulated below. This information is shown schematically in Figure 5. (KEYWAY) on each of the three connectors indicates that the pin has been *cut off* the male connector and *pushed into* the same location in the female connector. This prevents an Erase head plug from being plugged into a Reproduce head socket or, worse yet, the other way around! Keep in mind that when new DIN connectors are purchased the proper (KEYWAY) pin must be cut off before it will fit the Module socket.



"DIN" CONNECTOR PINOUT
(Shown looking into the rear-panel FEMALE socket, or the back-end view of a MALE connector plug)

	ERASE	RECORD	REPRODUCE
PIN 1	GROUND	GROUND	GROUND
PIN 2	HEAD "LOW"	HEAD "LOW"	HEAD "LOW"
PIN 3	HEAD "HIGH"	(KEYWAY)	HEAD "HIGH"
PIN 4	(KEYWAY)	HEAD "HIGH"	GROUND
PIN 5	GROUND	+15 VDC	(KEYWAY)
PIN 6	GROUND	EQ SELECT A	GROUND
PIN 7	GROUND	EQ SELECT B	GROUND
PIN 8	GROUND	16/35 SELECT	GROUND

Head Cable Wiring

Figure 5 (below) diagrams the Erase, Record and Reproduce head wiring from the heads on the plug-in head assembly block to the 7- or 8-pin DIN connectors.

The choice of head cabling is important. The newer foil-shielded cables are superior to those with braided shields in a number of respects. The integrity of the

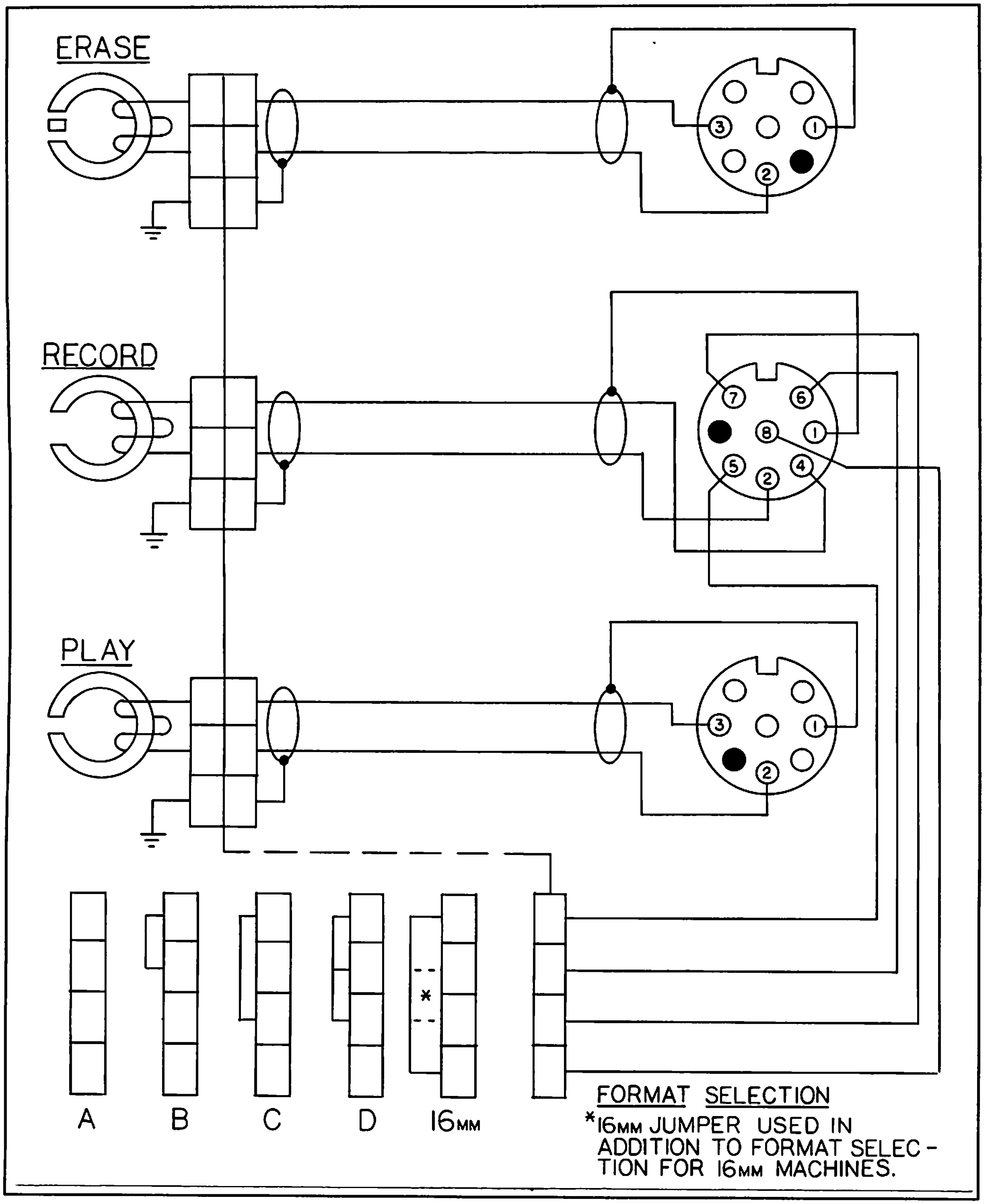


Figure 5 - System Head Connections; Channel 1 Shown

foil shield itself is certainly a major consideration, and the ease with which the bare "drain" wire can be connected surely beats anyone's pet method of terminating a braided shield.

The shield can serve as a grounding bond between the head block and the Module chassis, but best practice is to keep both sides of the head wiring independent of the shield. Thus Figure 5 shows all three heads returned to circuit ground through the second wire of the internal pair. This is, of course, essential for the Reproduce head and for the Record head in its playback capacity. High gain, low impedance input circuits have least tendency toward inductive noise pickup when both sides of the input (high and low sides of the head) share identical physical paths.

In the low impedance head circuits of the Model 390, cable capacitance is not a significant factor for the typical 2- to 5-foot runs. Good shielding and lowest microphonic pickup of machine vibration are paramount. The wires listed below are ideally suited for head cabling:

BELDEN 8641; ALPHA 2400; OLYMPIC 2822.

MODEL 990 POWER SUPPLY HOOKUP

AC Mains

The Power Supply chassis is fitted with an "IEC" male power connector and a mating 6-foot power cord. The AC mains plug is a North-American-standard male connector, but the internal cord conductors are *supposedly* color-coded in accordance with CEE standards:

BROWN = AC "HOT," BLUE = AC NEUTRAL, GRN/YEL = GROUND.

If this turns out *not* to be the case, we offer our apologies (cord vendors vary) and advise that U.S. color coding applies:

BLACK = AC "HOT," WHITE = AC NEUTRAL, GREEN = GROUND.

Mains Voltage Selection

Unless specifically ordered for export shipment, the Model 990 Power Supply is delivered for operation from 115V, 50/60Hz AC mains power. The back-panel designation next to the fuseholder will be marked to confirm both the mains voltage selected and the value of the fuse supplied.

There is a mains voltage selector switch beneath the top cover of the Power Supply, on the printed circuit board, just behind the front panel POWER switch. It is clearly marked for setting to either 115-volt or 230-volt operation. A proper fuse must always be installed and the appropriate voltage designation marked. It is factory practice to cross out the *inappropriate* markings with black felt marking pen. This strikethrough can be removed with solvent if the markings need to be changed.

BE SURE that the mains voltage selector setting and primary fuse value are appropriate for the mains supply before plugging the Power Supply into the wall socket.

Connections to Console

The connector labeled "FROM CONSOLE" is a 25-pin "DB-25" (or "D-SUB") female connector which carries the logic-level signals required at the Recording Console for remote control of monitor and RECORD mode switching. No mating connector is supplied since several connector/cable options are equally suitable. Cable-end male connectors are readily available; either the "insulation-displacement" variety for ribbon cabling, or hard-wired version.

wo logic lines, plus a ground, are associated with each of the eight possible system channels.

RECORD Command

The RECORD line puts the channel Module into the RECORD mode when it is grounded. This ground must be maintained during recording, the channel will go *out* of RECORD when the ground is lifted. For non-interlocked, manual control of the RECORD function, a simple alternate-action (push-on/push-off) switch may be used. A more sophisticated approach is to latch the RECORD function through a SAFE/READY switch and spare relay contacts in the machine control logic. This would inhibit recording unless the machine were running in the forward direction, thus preventing unintentional erasure during cueing or shuttling.

The RECORD logic line sits at +15 volts. Either a direct contact closure or a saturating NPN transistor to ground will initiate the RECORD command. Only about 1.5 milliamps of current flows in this line, and "debouncing" is provided in the channel Module.

Monitor Selection

The MONITOR logic line enables remote switching of the Line Output between: **1)** the input signal, **2)** playback from the Record head, and **3)** the separate Recordist Monitor playback. This is accomplished with "tristate" logic. When the logic line is grounded, the input signal is monitored. When left floating "high" (about +9 volts), monitoring switches to playback from the Record head. To switch over to Recordist Monitor playback, the logic line is taken to ground through a 4.7k-ohm resistor. (See Figure 6 on Page 20.)

Easiest switching of Monitor selection is with a simple single-pole, three-position toggle or lever switch. Interlocking pushbuttons may also be used, as may be an electronically-latched pushbutton system.

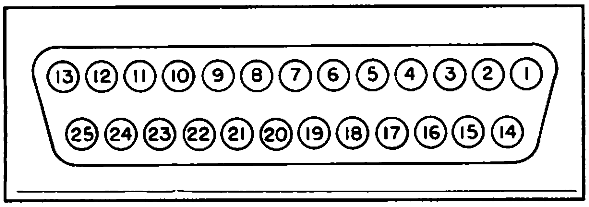
Record Tally

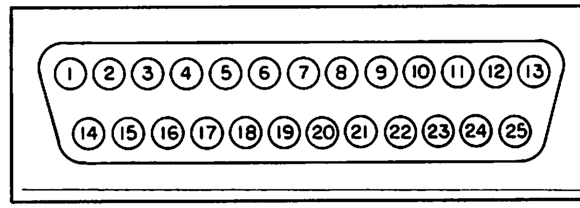
A second "DB-25" connector on the back panel of the Power Supply (this one a male connector) carries RECORD "Tally" logic from each of the eight channels. These are lines which are taken to ground through a saturating NPN transistor when the channel enters the RECORD mode. This ground is established at the beginning of the "ramp-up" of the bias waveform, and is removed at the end of the bias "ramp-down." Therefore it is offset by (and trails) the insert timing IN and OUT delays, and thus coincides more directly with the actual *recording* process than with the inputted RECORD command.

The Record Tally logic may be used to light a RECORD indicator at the Recording Console position, or to switch noise reduction equipment between *encode* and *decode*. The saturating NPN transistor to ground is capable of sinking 100 milliamps, and has a breakdown of 60 volts.

Pin Assignments

The table below tabulates the pin assignments for each of the "DB-25" connectors. The pin location drawings show the connectors as viewed from the rear of the power supply.





	FROM CONSOLE (DB-25 Female)	RECORD TALLY (DB-25 Male)
PINS 1 - 9	GROUND	GROUND
PIN 10	CHAN 7 MONITOR	GROUND
PIN 11	CHAN 7 RECORD	GROUND
PIN 12	CHAN 8 MONITOR	GROUND
PIN 13	CHAN 8 RECORD	GROUND
PIN 14	CHAN 6 RECORD	CHAN 1 TALLY
PIN 15	CHAN 6 MONITOR	CHAN 2 TALLY
PIN 16	CHAN 5 RECORD	GROUND
PIN 17	CHAN 5 MONITOR	CHAN 3 TALLY
PIN 18	CHAN 4 RECORD	CHAN 4 TALLY
PIN 19	CHAN 4 MONITOR	GROUND
PIN 20	CHAN 3 RECORD	CHAN 5 TALLY
PIN 21	CHAN 3 MONITOR	CHAN 6 TALLY
PIN 22	CHAN 2 RECORD	GROUND
PIN 23	CHAN 2 MONITOR	CHAN 7 TALLY
PIN 24	CHAN 1 RECORD	CHAN 8 TALLY
PIN 25	CHAN 1 MONITOR	GROUND

Remote Control Schematic

Figure 6 on the following page diagrams a very simple remote control switching position for a single channel of recording electronics. It uses an alternate-action (push-on/push-off) RECORD button which is *not* interlocked with the recorder mechanism. The Monitor Selector switch is presumed to be a 3-position miniature toggle switch, with the three positions normally specified in descriptive literature as: ON-NONE-ON, meaning that the "up" and "down" positions make connection with their respective contacts, but the center position is mechanical only, with no actual electrical connection. The light-emitting diode (LED) connected to the Record Tally line is a RECORD indicator and requires an external source of DC power from the Recording Console. A +15-volt supply was presumed, and the series dropping resistor scaled for about 10 milliamps through the LED.

Monitor switching and other logic-level control signals are "debounced" and RFI-bypassed within the 390 Module. Interconnection may be made with 25-conductor "ribbon" cable and crimp-on "insulation displacement" connectors, or with nearly any multi-conductor cable and solder-type connectors.

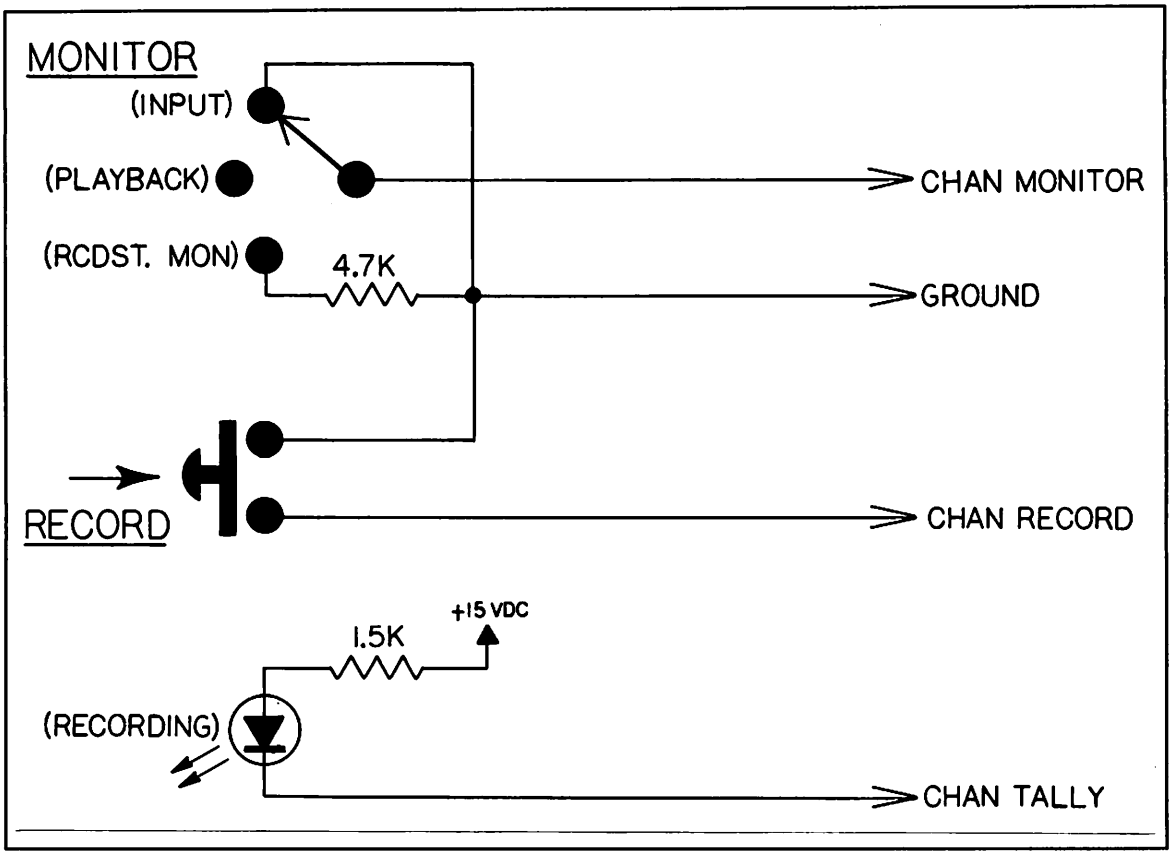


Figure 6 - Remote Control Switching Example

Section III

PANEL CONTROLS AND FUNCTIONAL DESCRIPTION

390 MODULE FRONT-PANEL CONTROLS

A listing of the various front-panel adjustments and indicators follows, along with brief descriptions of their specific functions. In-depth setup and calibration procedures are detailed in Section IV.

(MONITOR Switch and Jack)

The front-panel 'phone jack accepts a single-circuit (Tip/Sleeve) miniature plug for monitoring the output(s) of the 390 Module.

With the switch *down* (LINE position), the monitor function normally follows whatever selection is made at the Recording Console. The exception is that with the system in the LINEUP mode, the LINE position always gives a monitor of the program Line Input regardless of Recording Console selection.

When the switch is *up* (RCDST. position), "Recordist Monitor" playback from the separate reproduce head is monitored.

The MONITOR jack is a single-ended, ground-referenced output. The nominal level at the jack for a panel meter reading of "0-VU" is -2dBu. The output is essentially a zero-impedance voltage source for connection of test equipment, Hi-Z headphone, etc. Shorting this output will overload the output stages and effect the balanced Line Output.

(SYNC. PLAY and RCDST. MON. Adjustments)

LEVEL These are the Reproduce Gain controls for the normal (SYNC) playback from the Record Head, and the Recordist Monitor playback from a separate reproduce head. They are normally adjusted for a panel meter reading of "0-VU" during playback of a Standard Reproducer Test Film.

LO EQ Low Frequency Reproduce Equalization affects frequencies below 200Hz, with maximum "leverage" in the 20Hz to 50Hz range. The SMPTE Curve specifies a "flat" low-end, and the Reproduce Amplifier(s) maintain a true "integrating" characteristic down to 20Hz. A steep high-pass function is introduced at 20Hz to reduce 1/f noise, and filter "Q" is such that a slight emphasis is imparted at the 20Hz cutoff frequency. This helps preserve bottom-end response when the LO EQ control is adjusted to even-out the "head bump" effects.

HI EQ High Frequency Reproduce Equalization adjusts the turnover frequency for top-end control. This means that if, for instance, 10kHz is brought up by 2dB, all frequencies above 10kHz will be increased by 2dB as well. HI EQ is normally set for flat playback in the 4kHz to 6kHz region from a Standard Reproducer Test Film.

GAP EQ

A Gap Loss Equalizer has been included in the Reproduce Amplifier(s) to compensate for the high frequency loss associated with the relationship between reproduce head gap length and the wavelength of the recorded signal. An effective gap length equal to one-half the recorded wavelength yields a loss on the order of 4dB. Above this 0.5 factor loss is quite precipitous and is generally past the point of diminishing return for equalization.

The 390 Gap Loss Equalizer makes use of a second-order low-pass filter with a variable parameter affecting both cutoff frequency and "Q." As the GAP EQ control is turned clockwise, three things happen: **1)** the *amount* of boost at the highest frequencies increases, **2)** the *steepness* of the tip-up slope increases, and **3)** the frequency of the resonant equalizer "peak" *decreases.* This enables correction of moderate gap loss without increasing system noise at frequencies above the useful response of a particular head. A family of GAP EQ response curves is plotted for a range of control settings in Figure 7.

GAP EQ is adjusted *after* the HI EQ control has been optimized in the 5kHz region. It is set for flattest overall response to the useful system limit. It is often tempting to make certain tradeoffs when touching up the HI EQ and GAP EQ trimmers, slightly compromising overall flatness at the high end for a better system response specification. Keep in mind, however, that "bumps" in the response are *cumulative.* A 2dB peak at 12kHz will become 6dB in a third-generation copy. Thus it may be more prudent to accept a bit less in top-end "specsmanship" to favor a smooth response to a slightly less impressive cutoff frequency.

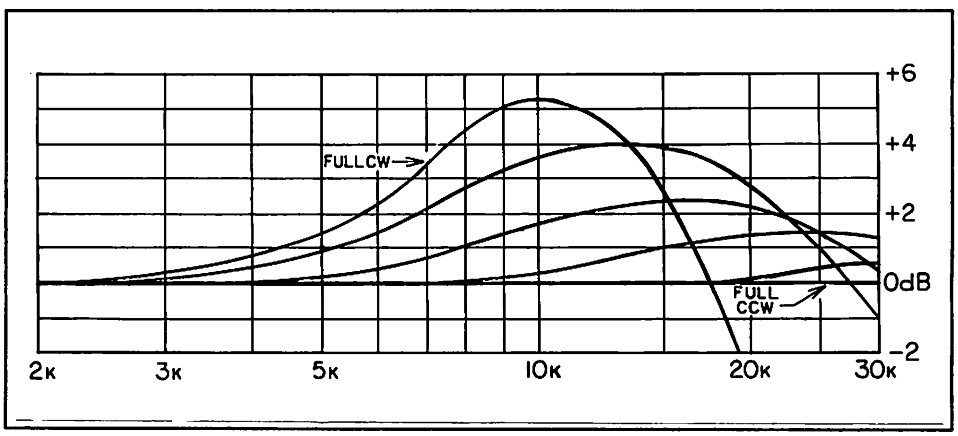


Figure 7 - Gap Loss Equalizer Adjustment Range

(Record Amplifier Adjustments)

INPUT GAIN

The INPUT GAIN trimmer is *not* an adjustment for recording level; rather, it adjusts the 390 Module input sensitivity to match the level of the incoming program signal. INPUT GAIN is set for a "0-VU" reading in Input Monitor with a reference level test tone from the Recording Console.

FLUX

The multiturn FLUX trimmers adjust the actual signal level (magnetic flux) being recorded on the film. These are set while monitoring Recordist Monitor playback, after BIAS has been optimized for the stock being used.

FLUX TRIM

This is a "fine-tune" adjustment of recorded flux. It is centered at the "0dB" mark during initial system setup, and used in making minor compensations for reel-to-reel stock variation.

EQUAL Once Reproduce Equalization has been optimized for best playback of a Reproducer Test Film, Record Equalization is adjusted for the best overall system response during a test recording on blank stock. Record amplifier response at low frequencies is fixed per the SMPTE Curve. The EQUAL controls affect high frequency equalization only.

EQ TRIM This is a "fine-tune" adjustment of (high frequency) Record Equalization. It is centered at the "0dB" mark during initial system setup, and used in making minor compensations for reel-to-reel stock variation.

OLX^{tm} "Oxide Linearity eXtension" circuitry compensates for nonlinearity of the magnetic stock as the recorded flux approaches saturation. Proper setting of this adjustment requires use of a wave analyzer or other means of isolating and quantifying the odd harmonic content of the recorded waveform. A 1kHz sinewave is recorded at a level elevated to produce about 2% or 3% third-harmonic product as monitored at the Recordist Monitor playback point. The OLX control is adjusted for a null in this reading.

PC Variable "Phase Compensation" in the recording amplifier optimizes overall squarewave response of the system. This adjustment is performed while monitoring the Recordist Monitor playback with an oscilloscope as a 1kHz squarewave is recorded at a level of about -10VU. The PC control is adjusted for the most symmetrical waveform.

(Bias Amplifier Adjustments)

BIAS The BIAS trimmer is used to optimize the ultrasonic bias signal essential to the recording process. Historically, bias level was set to the point of maximum recording sensitivity; that is, while recording a 1kHz tone, BIAS would be adjusted for a "peak" in the *reproduced* signal. Though more contemporary biasing procedures generally encourage *over*biasing to minimize recorded distortion, the OLX^{tm} distortion-cancelling feature of the 390 permits the more easily-defined "bias peaking" method to be used without performance sacrifices.

BIAS TRIM This is a "fine-tune" BIAS adjustment. It is centered at the "0dB" mark during initial system setup, and used in making minor compensations for reel-to-reel stock variation.

IN and OUT These are the insert (pickup) timing adjustments. IN programs the delay between the onset of ERASE and the actual beginning of the recording, so that they occur at the very same point on the film without overlap. Similarly, OUT adjusts the delay between the *shutoff* of ERASE and the time that recording stops to again make these points physically coincide to avoid a dead spot at the end of an insert.

HFX^{tm} The "High Frequency eXpansion" feature of the Model 390 minimizes short wavelength self-erasure effects. This control is adjusted to normalize top-end response at Operating Level, compared to the improved response at a reduced level where self-erasure is not a factor.

390 MODULE PANEL INDICATORS

RECORD The red RECORD indicator lights whenever the 390 Module enters the RECORD mode. The indication coincides with the inputted RECORD command, and does not reflect IN and OUT insert timings.

A, B, C, D This series of LED indicators identifies the group of level and equalization calibration adjustments which are activated by head assembly jumpering for different *track* formats.

35mm, 16mm These indicators identify the *system* format (35mm or 16mm), and the groups of timing and other calibration adjustments which are particular to the system format.

MODEL 990 POWER SUPPLY

POWER This switch does, indeed, turn ON and OFF the primary (mains) power to the Model 990 Power Supply and, hence, power to the 390 Modules thereto connected.

TEST SIG. INPUT This jack and the TEST LEVEL indicators are associated with the 390 LINEUP mode. The jack accepts either an unbalanced two circuit (Tip/Sleeve), or a balanced three circuit (Tip/Ring/Sleeve) 'phone plug input from an outboard Audio Oscillator. The oscillator signal is used in the LINEUP mode for adjustment of BIAS, FLUX (Record Level), EQ (Record Equalization), and the other recording parameters.

When an oscillator signal is applied to the TEST SIG. INPUT jack on the 990 Power Supply, three things occur: **1)** the entire system enters the RECORD mode, **2)** the oscillator signal is automatically routed to the Line Input of all channels in the system regardless of Recording Console assignments, and **3)** the Module MONITOR switch selects between the input test signal from the oscillator (LINE position), or playback directly from the film (RCDST. position) for both the front-panel meter and the MONITOR jack.

TEST LEVEL Indicators The external test oscillator signal applied to the TEST SIG. INPUT jack is buffered by an amplifier within the 990 Power Supply. The actual level delivered to the Modules is exactly +10dBu, and is metered by a series of three LED indicators. This metering circuit is activated when a test oscillator is plugged into the TEST SIG. INPUT jack.

The green LED in the center indicates a proper level from the external test oscillator, with a "window" of 0.25dB. A red LED lights to show that the oscillator input is either too LOW or too HIGH. The buffer amplifier has about 10dB gain, so the actual level of the test signal applied at the jack is approximately 0dBm.

LINEUP Switch Because the system can go immediately into RECORD when a test oscillator is plugged into the TEST SIG. INPUT jack, there is always a danger of inadvertently destroying an existing recording. To guard against this, a safety switch has been provided.

In the READY position of the LINEUP switch (actuator "in"), the system will go automatically into RECORD when a test oscillator is plugged into the TEST SIG. INPUT jack. With the LINEUP switch in SAFE (actuator "out"), the test signal will still be routed to all channels, but they will *not* enter RECORD. This switch is used as a local RECORD "button" when setting insert IN and OUT timing.

Section IV

SYSTEM SETUP

EQUIPMENT REQUIRED

SMPTE-Standard Reproducer Test Film(s) - in the format(s) to which the system will be configured and used.

Sinewave Audio Oscillator; variable output, 20Hz to 20kHz frequency range.
NOTE: if this oscillator is used for adjustment of the OLX^{tm} circuitry, it must have *low distortion*, on the order of 0.01% THD or less. This eliminates most of the sine/square "Function Generators."

Squarewave Generator (for Phase Comp. adjustment only); 1kHz, variable output.

Oscilloscope (for Phase Comp. adjustment only); "general-purpose" 'scope with 1MHz minimum bandwidth.

Wave Analyzer (for OLX^{tm} calibration only); tunable to 3kHz, 100Hz filter bandwidth, -60dBm sensitivity.

AC Voltmeter or alternative "Program Level Test Set" (for HFX^{tm} adjustment only); to resolve levels in the -10dBu to +10dBu range.

GENERAL ASSUMPTIONS

1. For the purpose of this calibration procedure, it is assumed that the film recording system has been installed per Section II of this Manual, and that plug-in head assemblies, if used, are properly jumpered for automatic format selection as described on Pages 15 and 16.
2. The various steps of this procedure describe complete calibration of only *one channel* of a system. The steps will, of course, have to be repeated for *each channel* in any particular format, and for each channel *once again* when heads are changed for alternate formats. Thus . . .
3. The individual calibration adjustments referred to in this procedure will be identified only by the *group* designation (LO EQ, FLUX, OUT, etc.), the *particular* trimmer to be adjusted will always be the one associated with the FORMAT INDICATOR (A, B, 35mm, etc.) which is lighted at the time.

REPRODUCER ALIGNMENT

Both the SYNC. PLAY and RCDST. MON. reproduce channels are calibrated in an identical manner. If the Monitor Select function at the Recording Console is left in PLAYBACK for all channels, the Module front-panel MONITOR switch then switches the meter between SYNC. PLAY, in the LINE position, and RCDST. MON., in the RCDST. position. This way *both* sets of controls may be adjusted with only *one pass* of the

Reproducer Test Film, first making one adjustment, then quickly switching the meter and making the corresponding adjustment to the other playback amplifier.

1. While playing the Operating Level tone on the Reproducer Test Film, adjust the LEVEL trimmers for a meter indication of "0-VU."
2. The LO EQ trimmers are adjusted for a meter reading of "0-VU" during playback of a tone in the 50Hz to 100Hz range, BUT ONLY IF THE FORMAT OF THE REPRODUCER TEST FILM IS THE SAME AS THAT OF THE PLAYBACK HEAD. This is important as "fringing" effects can seriously effect low-end response readings and calibration. If, for instance, the Reproducer Test Film is recorded across its entire width, and the playback track width is the typical 200-mil track of 35mm formats, the head's sensitivity to long-wavelength recorded signals *outside* the physical track confines can make the 50Hz test tone appear to be as much as 3dB *higher* than if the tone were recorded in the proper 200-mil format. This can lead to miscalibration of the LO EQ trimmer by -3dB. If the Reproducer Test Film does **not** have the proper recorded track format, **neglect** all frequencies below 1kHz and leave adjustment of the LO EQ trimmer until Record Equalization adjustments are made.
3. Set the GAP EQ trim controls fully counterclockwise. The HI EQ trimmers may then be adjusted for a meter indication of "0-VU" while reproducing a test tone in the range of 4kHz to 6kHz.
4. While playing the highest frequency test tones on the Reproducer Test Film, check playback head azimuth for maximum output; the GAP EQ trimmers may then be adjusted for optimum top-end response within the capability of the playback head. The hazard implied by availability of this adjustment was discussed in Section III. Essentially, the GAP EQ trimmer can permit extension of the top-end response *specification* at the expense of response *flatness*. Remember: "bumps" in the response are cumulative over several recording generations. Use the GAP EQ trimmer judiciously; a smooth response is preferable to a lumpy one extended to a slightly higher cutoff frequency.

INPUT GAIN CALIBRATION

1. Route a 1kHz tone from the Recording Console at normal Line Level. This will correspond to a "Zero Level" if the Console employs traditional "VU" meters, or to a steady-state reference level some 6 to 8dB below "Peak Reference" if the measurement standard is a Peak Programme Meter. (Peak-responding meters will usually include a scale "lineup" reference mark for system calibration with test tones)
2. With the remote Monitor Select facility at the Recording Console, switch the 390 Module to INPUT Monitor.
3. Adjust the INPUT LEVEL trimmer for a panel meter indication of "0-VU."

DISTORTION-REDUCTION PRESETS

If this is an *initial* system setup, the distortion-reduction controls (HFX, OLX and PC) should be turned fully counterclockwise. If these controls have been previously optimized, and the system record-related adjustments are only to be "touched-up" for similar film stocks, these trimmers may be left as-is. Calibration of the distortion-reduction circuitry follows Record Amplifier adjustment.

BIAS AND FLUX ADJUSTMENT

Before the Record Amplifier calibration adjustments can be made, BIAS first must be adjusted to properly accommodate the magnetic properties of the film coating. As mentioned earlier, there are several methods for setting bias level, including various procedures involving over-biasing to reduce distortion inherent in the recording process. Because more sophisticated distortion-reduction techniques are incorporated in the Model 390, the familiar "long-wavelength-peak" method of bias setting will be outlined here.

1. Thread the machine with the magnetic film stock usually used.
2. Center the BIAS TRIM and FLUX TRIM knobs at "0dB."
3. Put the system into RECORD via the LINEUP mode by plugging the Sinewave Audio Oscillator into the TEST SIG INPUT jack on the front of the system Power Supply. The LINEUP switch should be in the READY position.
4. Set the Sinewave Audio Oscillator frequency to 1kHz, and adjust its output level to light the *center* TEST LEVEL indicator on the Power Supply panel. This should produce a "0-VU" indication on the Module panel meter when the MONITOR switch is *down* in the LINE position. (The LINEUP mode forces an Input Monitor in the LINE position.)
5. Switch the MONITOR switch *up* to the RCDST. position to monitor playback from the film.
6. As the BIAS trimmer is rotated from full counterclockwise, the reproduced tone will increase in level to a maximum value, then decrease as the trimmer is turned further clockwise. Adjust the BIAS trimmer for a "peak" in the reproduced signal, and the FLUX trimmer for a meter indication of "0-VU" *at* the "bias peak." When BIAS and FLUX are properly adjusted, no level change should be observed as the MONITOR switch is alternated between the LINE and RCDST. positions.

RECORD EQUALIZATION

1. With the system in the RECORD mode, and the MONITOR switch in RCDST. (per the previous steps), decrease the Audio Oscillator frequency to 50Hz. If the Reproduce Amplifiers LO EQ trimmers were *not* previously adjusted (because of a difference in track width between the Reproducer Test Film and that of the Reproduce head), adjust the LO EQ trimmer of the RCDST. MON. amplifier at this time for a "0-VU" indication.
2. Slowly tune the Audio Oscillator back and forth between 20Hz and 200Hz, noting variations of the frequency response due to head geometry (head "bump") effects. Take special note of *increases* in the meter reading over the "0-VU" nominal level.
3. Use the LO EQ trimmer of the RCDST. MON. amplifier to normalize the response in the 20Hz to 200Hz range around "0-VU." If the reproduce head is of good mechanical design, this response should be within ±1.5dB of "0-VU." Because

response variations are cumulative over multiple recording generations, best practice is again to sacrifice an extension of the low-end *limit* for an overall *smoother* response. This may mean that with certain heads it might be necessary to let 20Hz drop as much as 3dB to have ±1dB response from 30Hz - up.

4. After the LO EQ trimmer has been optimized for the RCDST. MON. playback function, it will be necessary to repeat this adjustment for the SYNC. PLAY amplifier, using the low frequency recordings (of proper track width) made during Steps 1-3, above.
5. Center the EQ TRIM knob at "0dB."
6. Increase the Audio Oscillator frequency to 5kHz and adjust the EQUAL trimmer for a meter indication of "0-VU."
7. Slowly increase the Audio Oscillator frequency to 20kHz and note the response variation between 5kHz and 20kHz. If record head azimuth is adjustable, it may be fine-tuned for highest output at the maximum limit of system frequency response.
8. Use the EQUAL trimmer to flatten the response in the upper range, again sacrificing "specsmanship" for the smoothest response.

IN / OUT TIMING ADJUSTMENT

Doubtless, each Recording Technician will have a preferred method for adjusting Insert Timing. The procedure given here yields good results and requires no test equipment other than an Audio Oscillator and means of audible monitoring. If an alternative procedure is used, bear in mind that *clockwise* rotation of the IN and OUT trimmers *increases* the delay.

Only two sets of trimmers are provided, one for 35mm and one for 16mm film *size* formats. It is assumed that multiple *track* formats for either size will use plug-in head assemblies with identical spacing between Erase and Record heads. It thus makes best sense to calibrate the Insert Timing on the format which utilizes the greatest number of tracks; for instance, the 6-track configuration of a 35mm system.

1. Set up the system as follows:
    a. With a full reel of blank film stock threaded on the machine, use the LINEUP mode to record several minutes of 1kHz tone on *all* tracks of the system.
    b. Put the LINEUP switch in the SAFE position to take the machine out of the RECORD mode, and rewind the film to the start of the recording.
    c. Increase the Audio Oscillator frequency by about 100Hz, to approximately 1.1kHz.
    d. Set the MONITOR switch to RCDST. and provide an audible monitor from the MONITOR jack. This can be a headset, but a portable monitor amplifier and speaker is recommended.
    e. Restart the machine. While listening carefully to the Recordist Monitor playback, switch the LINEUP switch back and forth between the READY and SAFE positions. The IN and OUT trimmers may now be adjusted as follows:

2. IN Timing Adjustment:

   a. With the IN trimmer fully counterclockwise, a brief "beat" frequency should be heard when switching to READY. (As the Module enters the RECORD mode, the higher frequency tone will be recording *over* part of the tone recorded first. Ignore, for now, timing errors when the LINEUP switch is switched back to SAFE.)

   b. As the IN trimmer is rotated clockwise, the duration of the "beat" will become shorter. When the trimmer is advanced *too far,* the "beat" will be replaced by a "dropout," or dead spot. Proper adjustment of the IN trimmer will result in a clean upward shift in pitch, with neither "beat" nor "dropout" at the transition.

3. OUT Timing Adjustment:

   a. With the OUT trimmer fully counterclockwise, a brief "dropout" will be heard when switching to SAFE. (With Erase and Record functions ending simultaneously, a short section of erased film is created.)

   b. As the OUT trimmer is rotated clockwise, the duration of the "dropout" will become shorter. When the trimmer is advanced *too far,* a "beat" will be heard. (This is the opposite of the situation with the IN timing adjustment.) Proper OUT timing will yield a clean downward shift in pitch, with neither "dropout" nor "beat" at the transition.

PC - SYSTEM PHASE COMPENSATION

The PC trimmer is a variable phase compensation adjustment in the Record Amplifier signal path. It gives the least amount of *audible* performance improvement, yet is critical for proper operation of both the OLX^{tm} and the HFX^{tm} features. IT IS ESSENTIAL THAT THIS ADJUSTMENT BE MADE *PRIOR* TO THE OTHER DISTORTION-REDUCTION ADJUSTMENTS.

1. Connect the Oscilloscope input to the Module MONITOR jack. Place the MONITOR switch in the RCDST. position.
2. With a reel of blank film stock threaded, plug the Squarewave Generator into the TEST SIG. INPUT jack and start the machine.
3. Set the Squarewave Generator frequency to 1kHz, and the output level to yield a -10VU meter reading of the reproduced squarewave signal.
4. Monitor the reproduced waveform with the 'scope, and adjust the PC trimmer for the "squarest" waveform. With the PC trimmer fully counterclockwise, some degree of *leading*-edge overshoot will be observed. As the control is rotated clockwise, this overshoot should reach a symmetrical shape, then become *trailing*-edge overshoot. The control should be adjusted for a most symmetrical-looking waveshape.

OLX^{tm} CALIBRATION

Oxide Linearity eXtension circuitry is adjusted to yield minimum odd-order recorded distortion; odd-order distortion being a normal product of the direct-record process. The adjustment is made with the aid of a Wave Analyzer, or other form of frequency-selective voltmeter. Alternately, a "swept filter" type of Spectrum Analyzer could be used, but the "Real Time Analyzer" common to a wide range of audio testing has, regrettably, insufficient resolution to be of use here.

For this particular adjustment, it is **essential** that a very low distortion sinewave Audio Oscillator be used, as the OLX^{tm} circuitry could otherwise be adjusted to compensate for *oscillator* distortion, rather than for oxide compression distortion. The "Function Generator" variety of oscillator is *not* good enough for making this adjustment; a Wein Bridge type is the best choice.

1. Connect the Wave Analyzer to the Module MONITOR jack and place the MONITOR switch in the RDCST. position. The OLX trimmer should be fully counterclockwise.
2. Plug the *low distortion* Audio Oscillator into the TEST SIG. INPUT jack on the Power Supply, and put the system into the RECORD mode.
3. Set the Audio Oscillator frequency to 1kHz, and the Oscillator output level to yield a recorded tone 6dB *above* the normal Operating Level, as measured in Recordist Monitor playback with the Wave Analyzer tuned to 1kHz. (The "0-VU" level at the Module MONITOR jack is -2dBu. Therefore a +6VU level will measure +4dBu.) It will be necessary to fine-tune the Wave Analyzer frequency to that of the recorded tone to maximize the reading. If the Wave Analyzer has a "Reference Set" adjustment, set it to "0dB" or "100%" on the Wave Analyzer meter scale.
4. Reset the Wave Analyzer to 3kHz, and fine-tune for a maximum reading of the third harmonic of the recorded 1kHz signal. The third harmonic should measure in the neighborhood of -30dB to -40dB with respect to the 1kHz reference, or in the 1% to 3% range.
5. Rotate the OLX trimmer slowly clockwise. The measured third harmonic content of the 1kHz signal should start to decrease, reach a "null," and then *increase* as the trimmer is turned further clockwise. Leave the trimmer at the point of the best "null" in the recorded distortion.

<u>NOTE:</u> It will be necessary to repeat this adjustment whenever there is a *significant* change in the oxide formulation of the magnetic film stock to be used. However, one ferric oxide coating will probably not differ enough from another to require OLX^{tm} readjustment, even if the stock is from different suppliers.

HFX^{tm} CALIBRATION

The High Frequency eXpansion feature is adjusted to compensate for the tendency the recording system to *over*bias when recording high level program material which is rich in high frequency content. The HFX^{tm} feature is especially useful in 16mm systems which employ greater recording preemphasis and deal with shorter recorded wavelengths. Nevertheless, adjustments are provided for both 35mm and 16mm formats. Adjustment procedures are similar, and differences between 35mm and 16mm formats will be identified.

1. Put the system into RECORD using the LINEUP mode. Plug the Audio Oscillator into the TEST SIG. INPUT jack on the Power Supply, and an auxiliary level meter into the Module MONITOR jack. The MONITOR switch should be in the RCDST. position.
2. Set the Audio Oscillator output level to make a frequency response test recording at a level about 10dB *below* the normal Operating Level (-12dBu at the Module MONITOR jack). Touch-up Record EQUAL, as required, and make note of deviation from flat response at the top end of the passband.
3. Increase the Audio Oscillator output level and repeat the frequency response run;
   a. *At* the normal Operating Level for 16mm systems (-2dBu at the MONITOR jack), or . . .
   b. 6dB *above* the normal Operating Level for 35mm systems (+4dBu at the Monitor Jack).
4. While measuring overall frequency response at the *elevated* level, use the HFX trimmer to *match* this response to the response measured at the *lower* level. **DO NOT** attempt to *improve* the response at the higher level; rather, make it *equal* to the extent possible with the HFX trimmer.

Section V

CIRCUIT DESCRIPTIONS

PARTS LOCATION NOTE

In glancing over the Schematic Diagrams for the 390 Module and the 990 Power Supply, it will be noted that the schematic reference designations do not appear to follow any particular order. After seventeen years of keeping the designations in logical order on the *schematic*, and searching all over the *board* trying to find that "elusive C41," starting with the Model 390 it will be the other way around. Parts are designated in logical left-to-right, top-to-bottom order on the *board*, since troubleshooting a function usually begins with analyzing the schematic, *then* locating that area on the board to test for bad components.

REPRODUCE AMPLIFIER(S) (Assembly 184100; Schematic 184200)

Input Preamp Background

Configuration of the input stages of the Reproduce and Recordist Monitor Amplifiers closely follows circuitry developed by Doug Self of the U.K. firm, *Soundcraft*. Mr. Self's requirement was for a very low-noise gain stage to aid in determining whether passive components impart a characteristic "sound" to the circuits in which they are used. This work, published in the November, 1987 issue of the Journal of the Audio Engineering Society, supports the conclusion shared by all sane audio scientists; that not even a subtle difference can be measured (or heard) between, for example, capacitor types used in the audio signal path.

Mr. Self's gain circuit exhibited such good superior performance that he reconfigured it for a practical application, that of a preamplifier for moving-coil phonograph cartridges. Thankfully, the qualities that render this circuit ideal for its intended service are the same ones necessary for transformerless mag-film playback with low-Z heads.

Input Stage

Q2 and IC2A comprise a very high gain input preamplifier optimized for low impedance sources. Emitter-follower Q1 decouples and filters input power to the first stage, and IC2B serves a DC "servo" function to establish the quiescent operating point for the entire preamp. Gain of this circuit is on the order of 53dB, and, since the preamp has a flat frequency characteristic, the output signal has a 6dB/octave rising characteristic for a constant flux in the core of the (inductive) playback head.

The preamplifed audio is fed to the four GAIN trimmers, R12 through R15. IC3B is a binary-addressed "single-pole, 4-position" CMOS Analog Switch controlled by EQ SELECT logic. This logic is bussed from the Record Amplifier board on the ribbon interconnect cable plugged onto J1. A "Truth Table" common to all such "one-of-four" CMOS Switches used in the Model 390 is given on the next page.

CMOS ANALOG SWITCH TRUTH TABLE

CONNECTOR J1		CMOS LOGIC INPUT		SIGNAL
PIN 03	PIN 05	"A"	"B"	SELECTED
OPEN	OPEN	-9V	-9V	A
+15V	OPEN	+9V	-9V	B
OPEN	+15V	-9V	+9V	C
+15V	+15V	+9V	+9V	D

LF/HF Equalization Amplifier

The playback signal from IC3B is fed to an "integrating" amplifier, IC4B. Most of the negative feedback which establishes gain of this stage is through C17, causing amplification to have a 6dB/octave *falling* characteristic, and complementing that of the signal from the head.

As frequency decreases, the capacitive reactance of C17 becomes smaller, causing gain to increase. A resistance placed in *parallel* with C17 "shelves" the gain increase by establishing a finite minimum feedback regardless of C17. Thus the LF-EQ trimmers, R35 through R38, selected by the CMOS Switch IC3A, adjust stage gain at the lower frequency limit.

The LF-EQ trimmers can only *decrease* low-end gain. This means that the SMPTE playback curve with its "flat" low end could be accommodated only by turning the trimmers to maximum resistance. Therefore a second R/C time constant (R17/R19/C4) is series-connected in the feedback path to increase the integration slope below 200Hz. The LF-EQ trimmers can then "spoil" this additional low-end boost to yield "flat" playback in the center of their adjustment range.

DC feedback for IC4B is established with R21, R22 and R23. C2 and C3 bypass audio frequencies to ground, but the insertion of R20 into this shunt leg forms a "bridged-T" network and imparts a second-order high-pass function with a corner frequency at 20Hz. This helps reduce the 1/f noise component of the input preamp. "Q" of the high-pass network is calculated to give a small rise in response at the 20Hz corner frequency as a first-order "head bump" correction.

Resistance placed in *series* with C17 "shelves" the falling response of the equalization stage by limiting feedback which otherwise would continue to climb as capacitive reactance drops with increasing frequency. The HF-EQ trimmers, R48 through R51, selected by CMOS switch IC7B, yield variable control over top-end response.

Gap Loss Equalizer

An additional equalization stage has been included in the Reproduce Amplifier to compensate for response loss associated with Reproduce Head gap length. The rationale for this equalization and a description of its use and its effect was given on Page 22.

IC4A is a unity-gain stage with a capacitor network in the feedback path. Resistance to ground at the junction of C19 and C20 forms a "T," bridged by C19 to create a second-order low-pass filter. The resistance in this instance is variable, being the four GAP-EQ trimmers, R60 through R63, selected by CMOS switch IC7A. The value of resistance determines both the filter "Q" and cutoff frequency, with the interdependent relationship graphed in Figure 7 on Page 22.

Jumpering and Monitor Selection

The only physical distinction between the Reproduce and the Recordist Monitor Amplifier boards is the way they are jumpered to perform the two different playback functions; otherwise, the two boards are identical. The jumper pin strip is located near the center of the board, and accepts a pair of plug-on "shunts" in either of two locations: at the two *ends* of the pin strip in the case of the Reproduce board, or together at the *center* of the strip for Recordist Monitor. The locations are also silkscreened in the board legend, as well as shown on the Schematic.

IC8, yet another CMOS Analog Switch, in this instance is used for monitor signal routing rather than for EQ selection.

The Recordist Monitor Amplifier is jumpered such that the A and B logic inputs of IC8 are "jammed" high through diodes CR3 and CR4. This routes the equalized playback signal from IC4A directly into the output amplifier, IC9. Jumpering also brings the Recordist Monitor playback signal off the board via J1, Pin 01.

On the Reproduce Amplifier board, IC1C and IC1B control monitor selection. These two sections of IC1 are level comparators, converting "tristate" logic from the Recording Console into monitor selection commands for IC8. When the MON SELECT TRISTATE bus from the Recording Console is *open*, the "+" inputs of both IC1C and IC1B are pulled to +9 volts through R8. This drives both comparator outputs (and IC8 logic inputs) high, routing the Reproduce signal from IC4A to the output stage.

When the MON SELECT TRISTATE bus is taken to *ground*, the outputs of IC1C and IC1B both go low, as do both logic inputs of IC8. This switches IC8 to pass the Input Monitor signal, which is bussed in from the Record Board on J1, Pin 02.

If, however, the MON SELECT TRISTATE bus is taken to ground *through a 4.7K resistor*, comparator biasing is such that the output of IC1C goes low, but the output of IC1B remains high. This switches IC8 to pass the Recordist Monitor signal, which is bussed in from the Recordist Monitor Amplifier board on J1, Pin 01.

Monitor Transfer

The output of IC1D is normally held high with negative bias through R5, back-biasing diodes CR1 and CR2. The outputs of either IC1C or IC1B (or both) can go high, and current through R5 will still keep the output of IC1D low. If, however, the outputs of IC1C and IC1B are both high, as would be the case in Reproduce Monitor, *and* a MONITOR TRANSFER logic high is received on J1, Pin 10, the sum of the positive currents through R2, R4 and R11 will exceed the negative current through R5 and, cause the output of IC1D to go low. Negative current through CR1 and CR2 overrides the outputs of IC1C and IC1B, switching IC8 to Input Monitor. This automatically switches the monitor function from Playback to Input when entering the RECORD mode.

Power-On Delay

When power is first applied to the Module, C21 drags the "inhibit" logic input of IC8 high. This turns IC8 completely off and prevents any signal from reaching the output stage. C21 then begins to slowly charge through R55, and after a few seconds the inhibit line reaches a logic low level and the selected signal is passed.

Line Output Amplifier

IC9 and the associated discrete transistor output stages comprise the Line Output Amplifier. IC9B provides a small amount of voltage gain and, with the R/C network in the input path, it also performs an active, third-order low-pass filter function. The filter begins an 18dB/octave rolloff at about 30kHz to reduce stray erase and bias frequencies which invariably show up in the Line Output.

IC9B drives one side of the Line Output, with Q3 and Q4 as current driver stages. Diodes CR15 and CR14 compensate for the V_{be} of the output transistors, and CR13 and CR12 furnish short circuit protection in conjunction with R67 and R68.

IC9A is simply a unity-gain inverting stage with an identical transistor current driver array. It drives the other side of the Line Output in opposite phase.

Two "buildout" resistors, R75 and R74, are in series with the Line Output for protection and isolation, and impart a purely resistive output impedance characteristic of 200 ohms. Most studio equipment nowadays has electronically-balanced, "bridging" (high impedance) inputs. **However,** should the source impedance of the 390 Line Output Amplifier pose a problem, the buildout resistors may be removed and replaced with bare wire.

The "VU" meter is driven directly from the Line Output(s) from the very low impedance side of the buildout resistors. Thus the meter with its internal rectifier is *not capable* of introducing any distortion to the output signal.

Power Supply Regulators

The Reproduce and Recordist Monitor amplifiers include a pair of on-board voltage regulators. These are *not* used in the 390 Module; bipolar 15 volts is supplied from J1, Pins 13 and 15, from regulators located on the Record Amplifier board. The on-board regulators are used when these same amplifier boards are employed in the Model 397 Reproduce-Only system.

Two 6.2-volt zener diodes, CR5 and CR6, drop the bipolar 15 volts to bipolar 9 volts for some of the amplifier stages and for the CMOS signal switching ICs.

RECORD AMPLIFIER (Assembly 184400; Schematic 184500)

Line Input Balancing

IC8A, a differential-input stage, converts the "balanced" Line Input to a single-ended signal. The circuit provides some degree of common-mode rejection for "longitudinal crosstalk," or noise which is coupled into both sides of the input equally. The INPUT GAIN trimmer, R1, adjusts circuit gain to accommodate a normal range of input levels.

LINEUP Mode Selection

IC1 is a "single-pole, double-throw" CMOS Analog Switch. With the LINEUP MODE ACTIVATE line (J2, Pin 16) *open*, +15 volts from R12 is dropped to +9 volts by zener diode CR1, maintaining the control input of IC1 at a logic-high level. IC1 then passes normal Line Input signals.

When the LINEUP MODE ACTIVATE line is taken to *ground*, the control input of IC1 is pulled low by R11, and test signals bussed in on the LINEUP MODE TEST SIG IN line (J2, Pin 15) are instead routed through IC1. R50 is a calibration trimmer on the back panel of the Module. It is adjusted to give a "0-VU" Input Monitor reading on the "VU" meter when the LED level indicator on the Power Supply shows a proper TEST LEVEL.

IC3A serves as a unity-gain buffer and second-order active low-pass filter. The corner frequency of about 25kHz attenuated noise above the audible range, particularly residual erase or bias from another recorder which could heterodyne with the system's own erase/bias waveforms.

Record Equalization

The EQ TRIM control, R27, fine-tunes record equalization for reel-to-reel film stock variations. It is restricted to a total range of ±2dB.

IC6B can be considered a standard inverting stage, but with *capacitors*, rather than resistors, as the input and feedback components. The input capacitor, C10, has a reactance which falls with increasing frequency, as does the feedback capacitor, C11. This means that the response of this stage remains flat, since both the input current and the feedback current increase at the same 6dB/octave rate.

If, however, a resistor is placed in series with C11, it will establish a maximum feedback value despite the falling capacitive reactance. Because the input capacitor reactance continues to fall, the stage assumes a *rising* response. This series resistance is provided in the form of the EQUAL (Record Equalization) trimmers, R16 through R19, selected by CMOS Analog Switch, IC2A

35mm recording requires very little, if any, recording preemphasis. The network comprising C13, R32, R33 and R34 inserts a second time constant in the feedback path of IC6B to yield a slightly *falling* slope from the equalization stage when the EQUAL trimmers are fully counterclockwise.

OLX^{tm} Predistortion Circuitry

From the Record Equalization stage, IC6B, the signal is introduced to a gain and combining amplifier, IC6A, through a voltage divider formed by R35 and R59. IC6A is an inverting stage with equal input and feedback resistors, R37 and R38. Feedback is taken from a second voltage divider (R36 and R39) with the same values as the input divider, establishing an overall gain of unity.

The output of the Record Equalization stage is also routed to potentiometers R51 and R53, the OLX^{tm} adjustment trimmers. IC7B, one section of a "3-pole, double-throw" CMOS Analog Switch, selects the output from one of the trimmers, depending on system format. The 35mm adjustment, R51, is selected unless the 16/35 SELECT line is taken to +15 volts, in which case R53 is connected into the circuit.

When the selected OLX^{tm} trimmer is turned clockwise, diodes CR9 and CR10 are brought into the circuit to selectively bypass R35. This gives a circuit gain which increases in a quasi-logarithmic fashion above the diode "knee." The choice of diodes and circuit impedances yields an amplification nonlinearity which can be adjusted to almost completely cancel the distortion generated as the oxide approaches saturation.

Phase Compensation Stage

A sample of the signal from the R35/R59 voltage divider is subjected to a variable phase-shift network comprised of C17, and either R52 or R54. IC7C is another CMOS Analog Switch section controlled by system format selection to engage the proper PC trimmer. The phase-shifted signal is introduced to the noninverting input of IC6A to generate signal phase displacement complementary to the combined phase errors of the recording system.

HFX^{tm} Feed

The output from IC6A is routed to the head driver stage, IC3B, and to the HFX^{tm} "program-adaptive" bias control circuitry on the Erase/Bias Amplifier board via J1, Pin 04.

Head Driver Stage

IC3B is a Howland "constant-current" output stage. It combines balanced negative *and* positive feedback to provide a very high output impedance and deliver a recording *current* which remains constant regardless of the frequency-dependent reactance of the inductive Record Head.

The input to IC3B is from one of the four FLUX trimmers, R2 through R5, selected by CMOS Analog Switch IC2B. The FLUX TRIM control, R5, permits a ±2dB adjustment of recording level for reel-to-reel variations in the film stock.

Power Supply Regulators

Preregulated ±18 volts from the Model 990 Power Supply is further regulated to ±15 volts and ±9 volts on the Record Amplifier circuit board by four voltage regulator ICs. This straightforward circuitry includes back-biased power diodes across each supply to prevent terrible things from happening should the wrong polarity somehow be carelessly applied.

Tally Driver

Q1, a power Darlington transistor, translates low-level RECORD logic from the Erase/Bias Amplifier board to the equivalent of a high current contact closure to ground. This may be used either for a RECORD "Tally" indicator, or for Noise Reduction *encode/decode* switchover. The Record Tally *follows* the pickup IN and OUT delay timings, and is coincident with the actual recording process, rather than the initial RECORD command from the Recording Console.

ERASE/BIAS AMPLIFIER (Assembly 184700; Schematic 184800)

RECORD Command

Entry into the RECORD mode is initiated by taking the RECORD COMMAND line (J1, Pin 06) to ground. Channel Modules may be put *individually* into RECORD from the Recording Console, or all channels of a system may be put *simultaneously* into RECORD by activating the LINEUP function from the Power Supply.

The inverting input of IC2B is normally held positive through R18. When the RECORD COMMAND line is grounded, this input goes negative, and the output of IC2B toggles to the +9 volt rail. This lights the front-panel RECORD indicator and switches CMOS Analog Switch sections IC11A and IC5A.

Erase "Ramp" Contouring

Erase and bias waveforms cannot be turned on and off abruptly; to do so would cause a very objectionable "pop" in the recording, both going into, and coming out of, RECORD. A simple R/C time constant is usually included in Erase/Bias circuitry to "ramp" the waveforms up and down over some fraction of a second.

The traditional R/C function works well for taking the Erase and Bias waveforms *up*; the exponential *charging* of the capacitor causes a rapid initial increase in the magnetizing field, during which period the oxide is barely affected due to its magnetic hysteresis. As the field increases to levels which actually begin to magnetize the coating, the R/C function has slowed the rate of waveform increase to take the magnetizing field *gently* to its final value.

However, when this same R/C network *discharges*, the resultant ramp becomes the *inverse* of the ideal curve. The waveform *rapidly* collapses from full value, and the "gentle" part of the exponential curve is wasted in the area of least magnetic consequence.

IC12 "contours" the Erase waveform ramp-up and ramp-down. IC12A is an integrator stage, with input resistor R66, and feedback capacitor C34. A RECORD command switches IC11A to feed a positive bias from R67 to the input resistor, R66. The output of IC12A begins to ramp negative and, as it does so, it begins to decrease the positive bias by pulling it negative through R69. This imparts an exponential curve to the negative-going ramp. At the end-point of the ramp, the junction of R67 and R69 sits slightly positive.

IC12B is a simple unity-gain inverter with its output a mirror-image of IC12A. When the RECORD command is removed, IC11A switches the integrator stage input resistor, R66, to the junction of R65 and R68 which sits slightly negative. This causes IC12A to begin ramping positive, slowly at first, but exponentially faster as the output of inverter IC12B ramps correspondingly negative, adding to the negative bias applied to R66.

Thus IC12 provides an exponential ramp which is *symmetrical* for ramp-up and ramp-down. The end-values of the ramp are fixed by diodes CR15 and CR14 at ±6 volts. The ramp is stopped when these diodes become forward-biased through the voltage dividers connected between each supply rail and the output of IC12A.

IC13A and Q7 comprise a compound inverting gain stage capable of delivering high DC current. The gain of this stage is set by R75 and R78 at 2.5. This amplifies the ±6-volt negative-going Erase-on ramp to a ±15-volt positive-ramping power supply for the output driver transistors.

Pilot Divider and Erase Amplifier

A 500kHz Erase/Bias "pilot" signal is generated in the Model 990 Power Supply. The frequency is crystal-controlled, and the signal is a 15-volt p-p squarewave.

IC4 is a dual "flip-flop" connected as a two-stage binary divider. The 500kHz BIAS PILOT (J1, Pin 06) is fed to IC4B and divided first to 250kHz, then again by IC4A to 125kHz. Each section of IC4 has complementary "Q" and "Q-bar" outputs which deliver symmetrical squarewaves. When power is first applied to the circuit, C23 pulls the "Reset" inputs high to inhibit all outputs until C23 ultimately charges through R29.

The complementary outputs from IC4B are capacitor-coupled to the gates of VMOS output devices Q5 and Q6. These are "enhancement mode" Power-FETs which require a positive gate voltage to bias them to saturation. Gate resistors R47 and R46 would normally hold the two transistors off, but the drive from IC4A causes them to alternately saturate. The two VMOS drains connect to the primary of wideband coupling transformer, T2. The transformer center-tap receives "ramped" DC power from Q7. The circuit configuration is a classic push-pull, Class-C output stage, and the 125kHz Erase power output is directly proportional to the DC supply.

L5, C37 and the inductance of the Erase head create a resonant network which changes the square wave coupled through T2 into a high voltage sinewave. About 350 volts p-p is developed across the head.

"Pickup" IN/OUT Timing

The output pf timing integrator IC6B normally rests at the -9-volt supply rail from positive bias developed across R39 through the selected OUT timing trimmer, R32 or R7. When a RECORD command is received, IC5A switches to the selected IN timing trimmer, R31 or R34, and a negative voltage is developed across R39. This sends the output of IC6B ramping linearly *positive* at a rate determined by the IN trimmer setting.

As the output of IC6B crosses the zero-voltage point, the output of IC6A toggles positive. This causes IC8A to switch, initiating a "contured" Bias ramp-up, somewhat similar to the Erase ramping action described earlier. The output of IC6B continues to ramp positive, finally coming to rest at the +9-volt rail. When the RECORD command is removed, IC5A switches back to the selected OUT timing trimmer connected to the +9-volt supply. This sends the output of IC6B ramping *negative* at a rate determined by the OUT trimmer setting. As the voltages crosses zero, IC8A switches to ramp-*down* the Bias waveform.

As its output is driven *positive,* timing integrator IC6B provides the IN delay between the start of the Erase ramp-up and the start of the Bias ramp-up. As it's driven *negative,* this same integrator furnishes the OUT delay between the start of the Erase ramp-down and the start of the Bias ramp-down. The IN and OUT delays are independent, and are variable over a sufficient range for both 16mm and 35mm film speeds.

Bias "Ramp" Contouring

IC9 "contours" the Bias waveform ramp-up and ramp-down. This circuit is similar to the Erase contouring circuit of IC12, but differs in that it produces what would appear to be the *wrong* contour, or the exact *inverse* of the Erase ramp shape! This ±6-volt "inverted" Bias ramp is applied to *inverting* stage IC3B, the output of which is a ±9-volt ramp with the "proper" contour, as described in the Erase ramp circuit explanation.

The output of IC3B rests at +9 volts, and ramps to -9 volts after the IN delay. Since the ±2dB BIAS TRIM adjustment, R21, and the four BIAS trimmers, R1 through R4, are connected between the output of IC3B and the +9-volt supply, the ramp can be scaled to any value required and still maintain the +9-volt value for a "Bias-off" condition.

The scaled Bias ramp voltage is selected by CMOS Analog Switch IC1B and fed to IC3A and Q2, configured as a compound inverting gain stage capable of delivering high DC current. The gain is set by R19 and R24 to 1.67, translating the ±9-volt negative-going Bias-on ramp to a ±15-volt positive-ramping supply for the Bias output driver transistors.

Bias Amplifier

VMOS devices Q4 and Q3 operate in an identical manner to the output stages of the Erase Amplifier previously described. The complementary drive from IC4B is 250kHz, and transformer T1 delivers a symmetrical squarewave drive to the resonant coupling network associated with the Record Head.

A very pure 250kHz sinewave is developed across the parallel-resonant network of L2 and C13. C15 is chosen to have sufficient impedance at audio frequencies, but negligible reactance at 250kHz, to effectively couple bias to the Record Head. C17 and L4 form a trap to isolate Bias from the Record Amplifier, and the series-resonant trap of C16 and L3 provide further attenuation at the bias frequency.

RECORD Switching and Monitor Transfer

The Record Head is connected to the input of the Reproduce Amplifier through normally-closed contacts of relay K1. The relay is energized as part of a logic sequence controlled by the Bias ramp voltage from IC9A.

When the output of IC6A toggles positive, following the IN delay, C33 is charged immediately through CR4. This sends the output of IC10B high, and a PLAYBACK Monitor selection at the Recording Console transfers to INPUT Monitor.

At the same time, the Bias ramp-up at the output of IC9A begins to go positive from its -6-volt resting value. When this voltage rises to approximately -5 volts, comparator IC10A actuates K1, transferring the Record Head from the *input* of the Reproduce Amplifier to the *output* of the Record Amplifier. When the voltage reaches -3 volts, the output of comparator IC13A toggles negative, turning off Q1. (FET Q1 maintains a ground across the output of the constant-current Record head driver stage when it is *not* connected to the head.)

Upon leaving the RECORD mode, the opposite sequence takes place. The negative-going ramp first causes Q1 to ground the Record Amplifier output. A brief interval later, relay K1 drops off. C33, which was initially charged through CR4 to transfer the Monitor function, is held in a charged state by the ramp voltage through CR13, even though the output of IC6A has toggled negative. When C33 finally discharges through R60, Monitor can transfer from INPUT back to PLAYBACK. The additional R/C delay provided by C33 and R60 ensure that the Reproduce Amplifier has stabilized following its reconnection to the Record head.

HFX^tm Weighting and Control

A sample of the equalized input signal, HFX SIG IN, is routed from the Record Amplifier to the Erase/Bias Amplifier board (J1, Pin 04). This sample is fed to an active bandpass filter, IC2A, which has a 6dB/octave falling response *below* 25kHz, and a 12dB/octave falling response *above* 25kHz. This stage gives the input sample a 6dB/octave *rising* characteristic to a unity-gain value at the upper passband limit.

The equalized sample is fed to the two HFX trimmers, R33 and R36, and CMOS selector IC8C routes this to a "precision" full-wave rectifier. IC7B is a simple inverting gain stage, and IC7A provides a complementary, phase-inverted output. CR7 and CR8 perform full-wave rectification of the audio signal, with their forward drop compensated by a second pair of diodes, CR10 and CR9, in the feedback loop of IC7B.

The signal thus derived consists of rectified, *negative*-going, unfiltered DC, corresponding to "weighted" (equalized) high frequency energy present in the input signal. This raw DC is combined by IC3B to *subtract* from the *positive*-going Bias ramp voltage from IC9A. The time constant of C18 in the Bias Amplifier DC driver stage extracts the average value of the combined signals and filters out the high frequency audio ripple component. The end result is a Bias waveform which may be dynamically and selectively *reduced* by the average value of high frequency program energy. This is Inovonics' HFX^tm implementation of "Program-Adaptive" Biased Recording.

MODEL 990 POWER SUPPLY (Schematic 185900)

Mains Voltage Selection

The primaries of the two mains power transformers, T1 and T2, can be switched in parallel for 120-volt operation, or in series for 240 volts by switch S1. The secondaries are series-connected to ensure that the transformers share an equal load.

Supply Regulation

Full-wave bridge rectifier CR3 furnishes "raw" DC of about ±25 volts to the four integrated circuit voltage regulators, IC1, IC2, IC6 and IC7. The positive and negative loads are each shared between two regulators by assigning one regulator to the odd-numbered channels, and the other regulator to the even-numbered channels. Circuit values for each regulator yield regulated supplies of ±18 volts, which is further regulated to ±15 volts and ±9 volts in each 390 Module.

Bias Pilot Oscillator

Y1 is a 500kHz "Ceramic Resonator," very similar to the more familiar quartz crystal. Like a crystal, Y1 has series and parallel resonant modes, though tolerances on these devices are not held as tightly as on their quartz counterparts.

Two sections of IC9, a CMOS "Hex Inverter," are used with Y1 in an oscillator circuit. The four remaining sections are paralleled to buffer the 500kHz squarewave and drive Q2 and Q1, a complementary emitter-follower pair. The 15-volt p-p Bias Pilot signal is fed to Pin 07 of all eight CHAN connectors.

LINEUP Mode Circuitry

IC5A and discrete current-gain output stages Q3 and Q4 comprise an amplifier with about 10dB gain. An outboard Test Oscillator plugged into the TEST SIG. INPUT jack, J12, will be buffered by this amplifier and routed to each Module in the system via Pin 15 of the CHAN connectors.

A very low-current DC bias through R24 and R25 is applied to the TEST SIG. INPUT jack. When a Test Oscillator is plugged into the jack, the bias is shunted to ground through the Test Oscillator's output network. This causes the output of IC5B to toggle to the +18-volt power rail, turning on Q5. As Q5 saturates, a ground is applied to Pin 16 of all CHAN connectors to activate the LINEUP mode in each 390

Module. With LINEUP switch S3 in the READY position, Q5 will also put all Modules in to the RECORD mode by taking the Module RECORD COMMAND lines to ground through diodes CR10 through CR17.

TEST LEVEL Indicators

The LINEUP test signal routed to the Modules is also sampled by a "go/no-go" metering circuit. The signal is first peak-to-peak rectified by CR4 and CR5, then applied to the "+" inputs of comparators IC4A and IC4B. The "-" inputs of the comparators are biased to a DC level corresponding to +10dBu, with about 0.25dB differential between the two.

When the rectified test signal is *below* +10dBu, both comparator outputs are at ground. DC through R16 lights the LOW indicator, I2. With the test signal *above* +10dBu, both comparator outputs sit at the supply rail. I2 is back-biased, I3 has no potential across it, but the HIGH indicator, I4, lights with current through R18. At *precisely* +10dBu, the output of IC4B goes to ground, the output of IC4A stays high, and REF indicator I3 is lighted through R18.

This space may be used for notes or doodles.

Section VI

APPENDIX

The following section of this Manual contains Parts Lists for the Model 390 System Sub-assemblies, Schematic Diagrams of the Model 390 Module and the Model 990 Power Supply, and an explanation of Inovonics' Warranty Policy.

PARTS LISTS

EXPLANATION OF PARTS LISTINGS

The following pages contain listings of component parts used in the Model 390 Module and the Model 990 Power Supply.

The first parts listings are those components which are "peculiar" to individual circuit assemblies, or which require more than a "generic" description. These are listed by schematic component reference designation under each assembly heading. This is the *first* place to look for a parts description and ordering callout.

If the component in question is *not* listed under its subassembly heading, it is probably considered a "generic" part, common enough to most of the 390 / 990 circuitry to be lumped under a single heading. These components are referred-to by physical description and value, rather than by reference designation. The "GENERIC PARTS" section follows the individual subassembly listings.

Components which are *not listed at all* are probably not classed as typical replacement parts. Should it become necessary to specify an unlisted part, a call to the factory with a brief description should straighten the matter out.

REPRODUCE AND RECORDIST MONITOR AMPLIFIER CIRCUIT ASSEMBLIES

C5	Capacitor, Electrolytic, radial leads, 47µF, 25 VDC; Elna RE-series or equiv.
C10	Capacitor, Electrolytic, radial leads, 220µF, 6.3 VDC; Elna RE-series or equiv.
CR5,8	Diode, Zener, 6.2-volt; 1N4735 or equiv.
CR6,7,9,10	Diode, Rectifier, 1A; 1N4005 or equiv.
FB1,2	Ferrite Bead; Amidon FB 75B 101
IC1	Integrated Cct.; (National) LM324N
IC2,4	Integrated Cct.; (Raytheon) RC4458NB
IC3,7,8	Integrated Cct.; (open mfgr.) CD4052BE
IC5	Integrated Cct.; (National) LM317LZ
IC6	Integrated Cct.; (National) LM337LZ
J3	DIN Connector, 8-pin PC Female; Switchcraft 62 PC 8F
J5	"XLR" Connector, PC Male; Switchcraft RAPC 3M HG
Q1,4,6	Transistor, PNP; (open mfgr.) 2N3906
Q2	Transistor, Ultra-Low-Noise NPN; Rohm 2SB 737S *(LIMITED DISTRIBUTION - available from Inovonics)*
Q3,5	Transistor, NPN; (open mfgr.) 2N2904

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

RECORD AMPLIFIER CIRCUIT ASSEMBLY

CR1	Diode, Zener, 6.2-volt; 1N4735 or equiv.
CR3,4,5,6	Diode, Rectifier, 1A; 1N4005 or equiv.
IC1,7	Integrated Cct.; (open mfgr.) CD4053BE
IC2	Integrated Cct.; (open mfgr.) CD4052BE
IC3,6,8	Integrated Cct.; (open mfgr.) LF353N
IC4,5	Integrated Cct.; (open mfgr.) LM317-T
IC9,10	Integrated Cct.; (open mfgr.) LM337-T
---	HEAT FIN for IC4,5,9,10; Aavid 5936-B
J3	"XLR" Connector, PC Female; Switchcraft RAPC 3F G
Q1	Transistor, NPN Darlington; (open mfgr.) 2N6037 or MJE3301
R6,27	Resistor, single-turn variable, 1K; Piher PT 15NB 1K with PT15 / Fig.#3 spindle
---	KNOB for R6,27; Selco S111-004-BLACK with C111 (+ color) CAP

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

ERASE / BIAS AMPLIFIER CIRCUIT ASSEMBLY

C13	Capacitor, "Silver Mica," 910pF, 5%, DM19 case style
C15	Capacitor, "Silver Mica," 330pF, 5%, DM15 case style
C16,17	Capacitor, "Silver Mica," 750pF, 5%, DM19 case style
I1	LED Indicator, Red Diffused, T-1¾ size; Stanley SPR 5731 (or) SPR 5531
I2,3,4,5,6,7	LED Indicator, Diffused Pastel Green, T-1 size; Stanley MPG 3878S
---	Spacers for I2 - 7; Bivar 999-125
IC1	Integrated Cct.; (open mfgr.) CD4052BE
IC2,3,6,7,9,10,12,13	Integrated Cct.; (Raytheon) RC4458NB
IC4	Integrated Cct.; (open mfgr.) CD4013BCN
IC5,8,11	Integrated Cct.; (open mfgr.) CD4053BE
J3,4	DIN Connector, 8-pin PC Female; Switchcraft 62 PC 8F
K1	Relay, SPDT, 12-volt DIP Reed; Mouser ME433-D31C510 (or) Gordos 831C-3 (or) Hamlin HE721C12 (or) Clare PRMA1C12
L1,3,4	Inductor, shielded, 560μH, 5%; Delevan 1641-564 (or) Miller 9250-564
---	L4 (only) *additionally* shielded with Inovonics Part 2918 Mu-Metal Strip.
L2	Inductor, 1mH, 5%; Delevan 2500-28 (or) Mouser 43HH103
L5	Inductor, high current, 1mH, 5%; Caddell-Burns 6470-14
Q1	Transistor, N-Chan. JFET; (Siliconix) J108
Q2,7	Transistor, PNP; (open mfgr.) MJE350
Q3,4,5,6	Transistor, N-Chan. VMOS; (Siliconix) VN0808N
R21	Resistor, single-turn variable, 1K; Piher PT 15NB 1K with PT15 / Fig.#3 spindle
---	KNOB for R21; Selco S111-004-BLACK with C111 (+ color) CAP
T1,2	Transformer, Erase / Bias; Inovonics Part 186300

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

390 MODULE CHASSIS ASSEMBLY

J1	'Phone Jack, Single-Circuit Miniature; Switchcraft 142 A
M1	Meter, "VU"; Selco AL 19W (Front Adj.)
S1	Switch, Miniature DPDT; Mouser ME103-55TA2-03

MODEL 990 POWER SUPPLY

C1,2	Capacitor, Disc Ceramic, .005μF, 1kV
C7,8,9,10	Capacitor, Electrolytic, radial leads, 6800μF, 35 VDC; Elna RPE-35V682M.
C14	Capacitor, "Silver Mica," 56pF, 5%, DM15 case style
C19	Capacitor, Electrolytic, radial leads, 100μF, 25 VDC; Elna RE-series
C20	Capacitor, Electrolytic, radial leads, 22μF, 25 VDC; Elna RE-series
CR1,2,18,19	Diode, Rectifier, 1A; 1N4005 or equiv.
CR3	Diode Bridge, 5A; Mouser 33 BR 062 or equiv.
I1,3	LED Indicator, Green Diffused, T-1¾ size; Stanley MPG 3878S
I2,4	LED Indicator, Red Diffused, T-1¾ size; Stanley SPR 5731 (or) SPR 5531
IC1,2	Integrated Cct.; (open mfgr.) LM317-T
IC3	Integrated Cct.; (open mfgr.) CD4069BE
IC4,5	Integrated Cct.; (Raytheon) RC4458NB
IC6,7	Integrated Cct.; (open mfgr.) LM337-T
- - -	"Silpad" Silicone Rubber Insulator for IC1,2,6,7; Bergquist 7403-09-FR-51
- - -	Insulating "Shoulder" Washer for IC1,2,6,7; Thermalloy 7721-7 PPS (or) Keystone 3049
J9	Mains Connector, "CEE" Male; Switchcraft EAC-303
J12	'Phone Jack, Single-Circuit PC-mount; Switchcraft RN-112BPC
J13	Connector, "DB-25" Female; Mouser ME156-1725
J14	Connector, "DB-25" Male; ME156-1625
- - -	Fuseholder, "Universal" PC-mount; Littlefuse 345-101-010
- - -	FUSEHOLDER CAP, U.S. "inch"; Littlefuse 345-101-020
- - -	FUSEHOLDER CAP, European "metric"; Littlefuse 345-121-020
Q1,4	Transistor, PNP; (open mfgr.) 2N3906
Q2,3	Transistor, NPN; (open mfgr.) 2N3904
Q5	Transistor, NPN Darlington; (open mfgr.) 2N6037 or MJE3301
R42	Resistor, single-turn variable trimmer, 5K; Beckman 91AR5K
S1	Switch, DPDT "Voltage Select"; C&K V202-12-MS-02-QA
S2	Switch, SPST "Rocker"; Carling RA911-RB-B-O-N
S3	Switch, Alternate Action DPDT; Schadow FG-EE-FG/BLK
T1,2	Power Transformer; Signal 241-8-20
Y1	Ceramic Resonator, 500kHz; Radio Matls. Corp. MC CR30-FA-500kHz
- - -	Fan, DC "brushless"; IMC "Boxer," 3610PL-05W-830

CHECK "GENERIC" SECTION FOR PARTS NOT LISTED ABOVE

LISTING OF "GENERIC" COMPONENT PARTS FOR ALL ASSEMBLIES

This classification identifies all components which were *not* listed under individual subassembly headings. Grouped here are those components which are used "universally" and in large quantities. In searching for a particular component description (to order a replacement, etc.), look *first* under the proper subassembly heading. If the part is *not* found there, check the following listings.

UNLESS OTHERWISE SPECIFIED:

Capacitors:

a: **Under 1.0μF** are of the metalized mylar or polyester variety; value in microfarads, ±5%, working voltage of 50 volts or more. The style used in 390/990 circuitry is the "minibox" package with a lead spacing of 0.2 inches. **Preferred mfgr.:** WIMA, MKS-2 or FKS-2 series. **Alternates:** CSF-Thompson IRD series; Panasonic ECQ-V series (values above 0.1μF require lead forming).

b: **2.2μF caps** used throughout for power supply rail bypassing, etc. are 50-volt, high reliability radial-lead electrolytic. **Preferred mfgr:** Illinois Capacitor 225 RMR 050M.

Diodes, other than rectifier and Zener diodes, are general-purpose, small-signal silicon diodes of low leakage, and with a breakdown voltage of at least 50 volts. **Preferred part:** 1N4151. **Alternates:** 1N4148, 1N914, etc. in DO-7 or DO-35 package.

Resistors:

a: **Fixed resistors** with no tolerance specified are ¼-Watt, 5%, carbon-film type; with 1% tolerance specified are ¼-Watt, 1% metal-film type. Values are in ohms; manufacturer open.

b: **Multi-Turn Trimming Potentiometers** are Beckman 89PR series or equivalent "cermet" type.

Male "Shrouded Header" connectors are 16-pin, right-angle, PC board-mounted and accept mating female ribbon-cable-ends. **Preferred parts:** 3M 929340-01-16, Circuit Assembly CA-16HLR-1C.

Female Ribbon-Cable end connectors are polarized; there is only one way they can be mated with the rear-panel male headers. When crimping onto the ribbon cable, take care to observe the same polarity convention as those supplied with the System. *Pin 01 of the female connectors is indicated with a small arrow. This should match the colored edge of the ribbon cable at both ends.*
Preferred part: DuPont/Berg 66902-216.

Ribbon Cable to interconnect 390 Modules with the 990 Power Supply has 16 *stranded* conductors and is available from a number of sources.
Suppliers: Mouser ME172-1601; Digi-Key R022-ND; Active 58102.

MAIL-ORDER COMPONENT SUPPLIERS

The following electronic component distributors are reputable suppliers of both large and small quantities of parts. Any semiconductor, IC, capacitor, resistor, or connector used in the Models 390 and 990 are available from one or more of these firms.

Mouser Electronics - Call: 1-800-34-MOUSER
Digi-Key Corporation - Call: 1-800-DIGI-KEY
ACTIVE (div. of Future Electronics) - Call: 1-800-ACTIVE-6

INOVONICS WARRANTY

I **TERMS OF SALE:** Inovonics products are sold with an understanding of "full satisfaction"; that is, full credit or refund will be issued for products sold as new if returned to the point of purchase within 30 days following shipment, provided that they are returned in "as-shipped" condition.

II **CONDITIONS OF WARRANTY:** The following terms apply unless amended *in writing* by Inovonics, Inc.

A. Warranty Registration Card supplied with product *must* be completed and returned to the factory within 10 days of delivery.

B. Warranty applies only to products sold "as new." It is extended only to the original end-user and may not be transferred or assigned.

C. Warranty does not apply to damage caused by misuse, abuse or accident. Warranty is voided by unauthorized attempts at repair or modification, or if the serial identification has been removed or altered.

III **TERMS OF WARRANTY:** Inovonics, Inc. products are warranted to be free from defects in materials and workmanship.

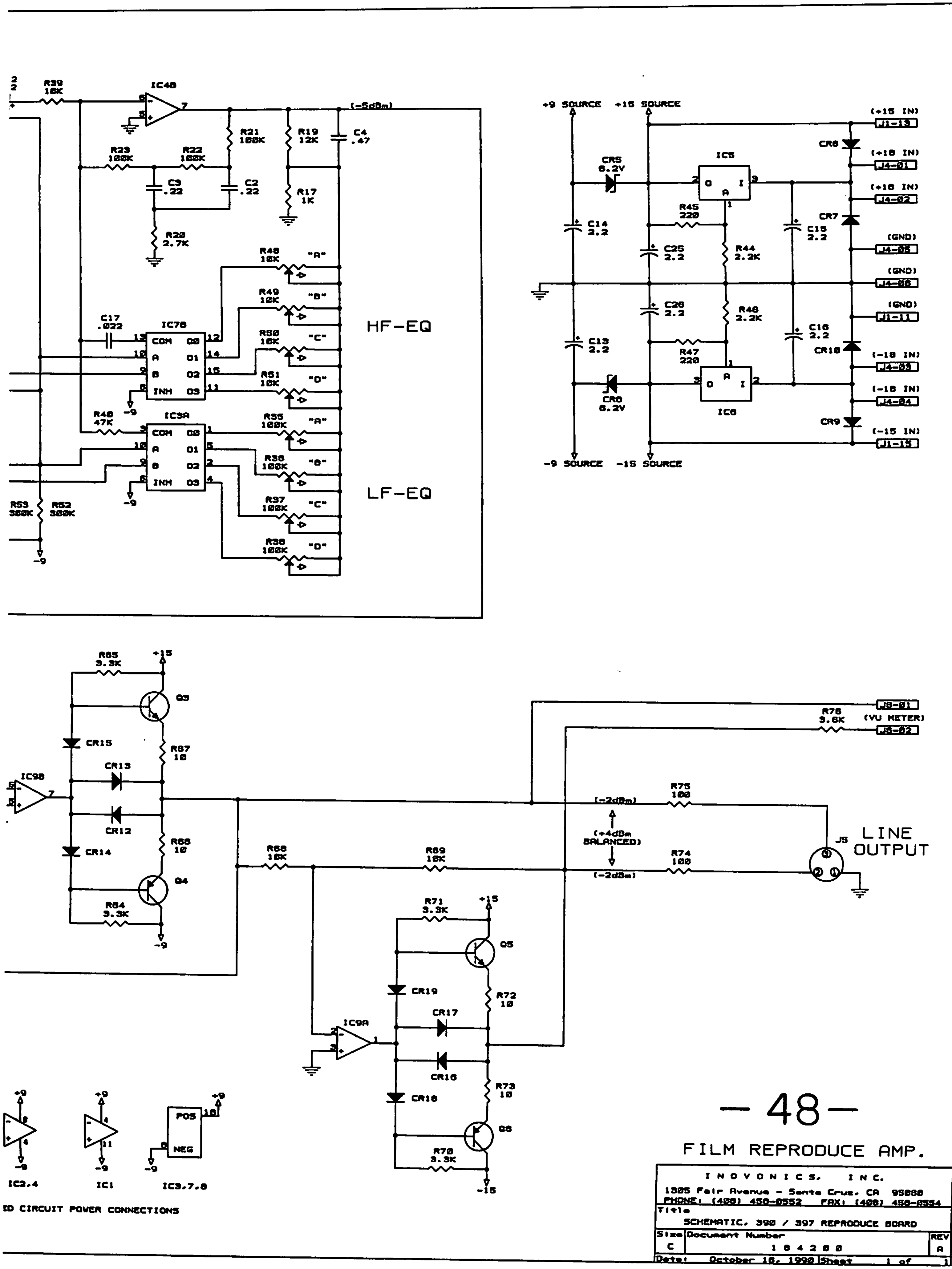
A. Any discrepancies noted within 90 days of the date of delivery will be repaired free of charge, or the equipment will be replaced at the option of Inovonics.

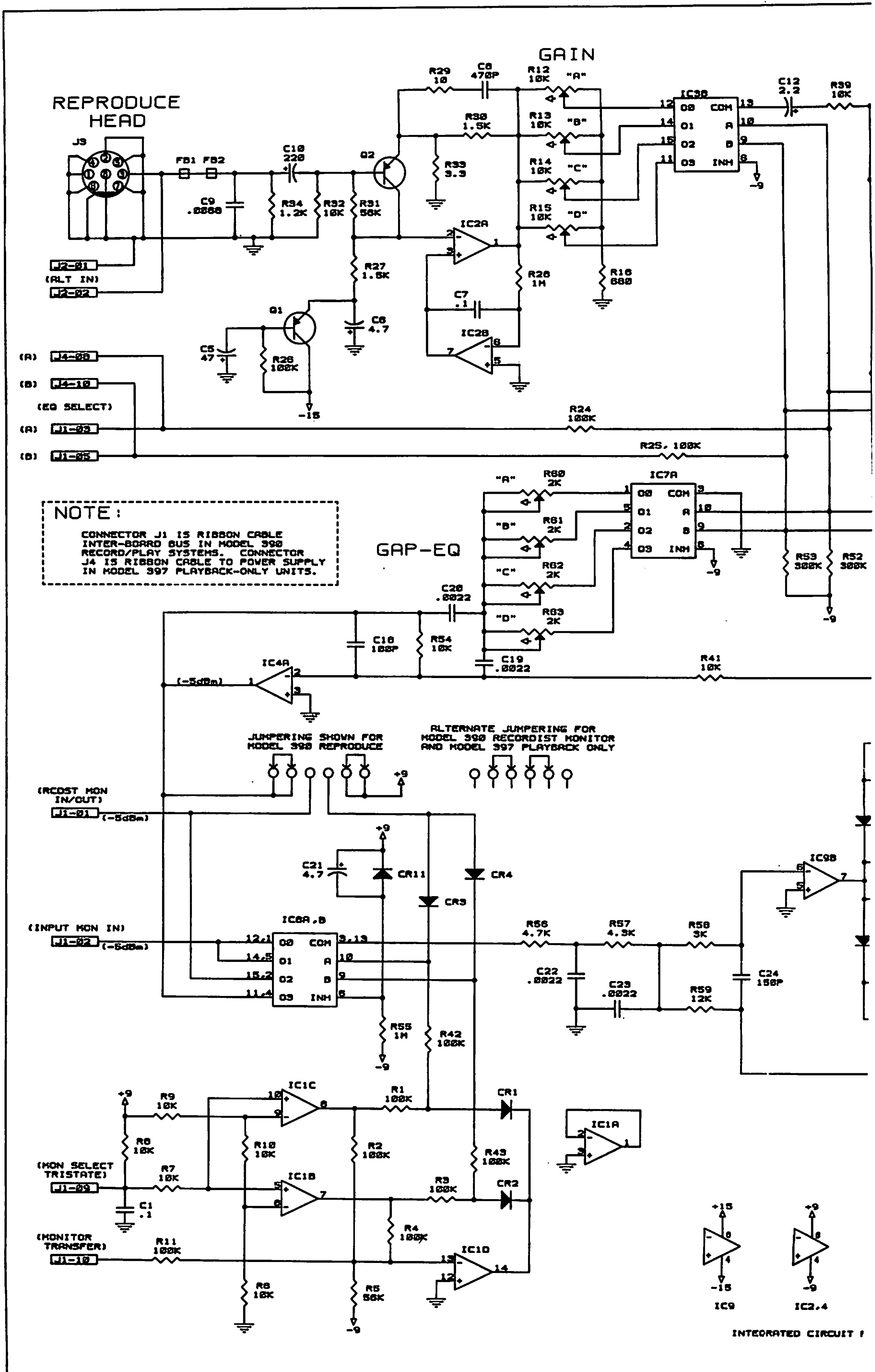
B. Additionally, parts for repairs required between 90 days and one year from the date of delivery will be supplied free of charge. Labor for *factory* installation of such parts will be billed at the prevailing "shop rate."

IV **RETURN OF GOODS FOR FACTORY REPAIR:**

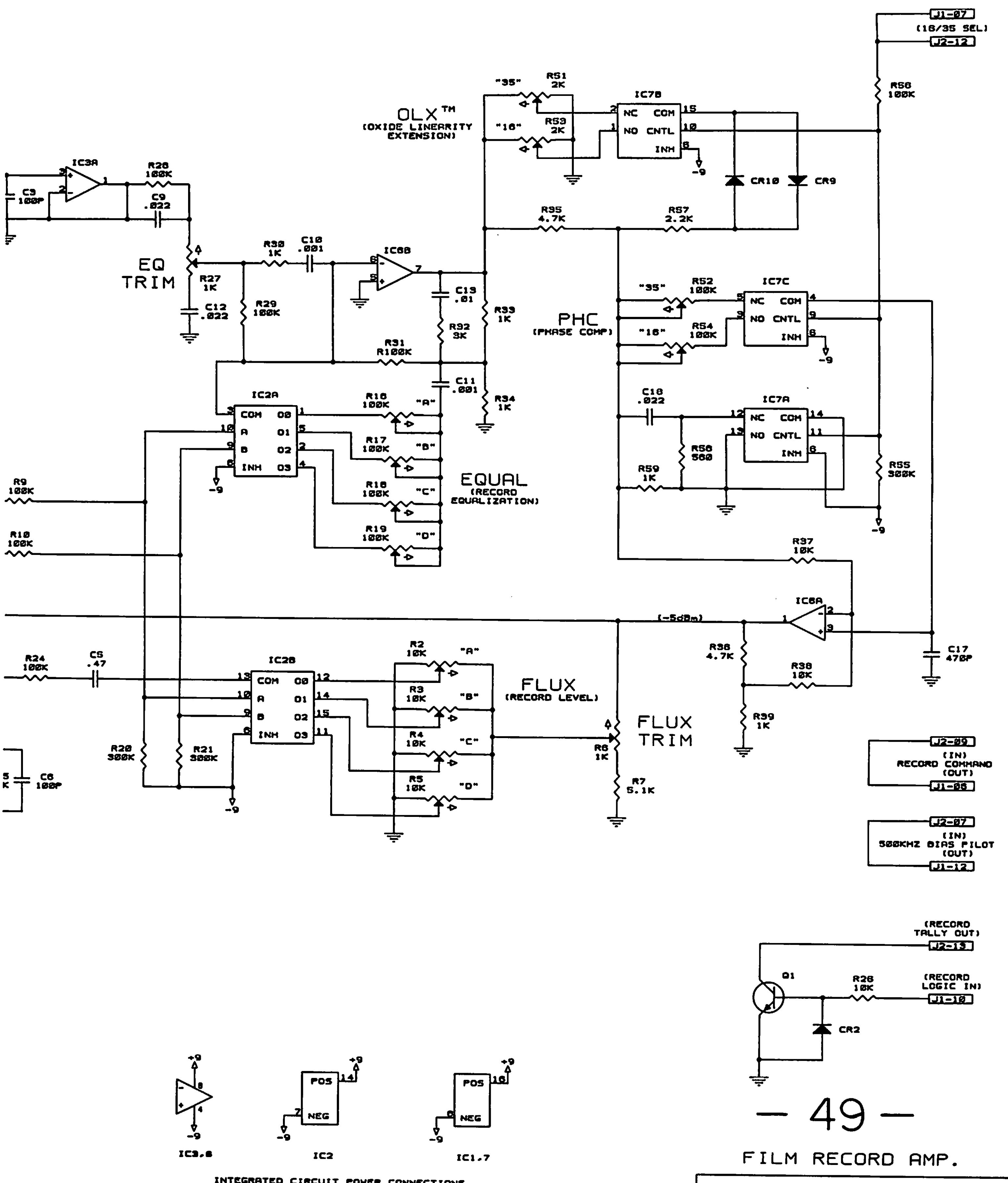
A. Equipment *will not be accepted* for Warranty or other repair without a Return Authorization (RA) number issued by Inovonics prior to its return. An RA number may be obtained by calling the factory, and should be prominently displayed on the outside of the shipping carton.

B. Equipment must be shipped *prepaid* to Inovonics. Shipping charges will be reimbursed for valid Warranty claims. Damage sustained as a result of improper packing for return to the factory is *not* covered under terms of the Warranty, and may occasion additional charges.


IC4B
R39 10K
(-5dBm)
R21 100K
R19 12K
C4 .47
R23 100K
R22 100K
C3 .22
C2 .22
R17 1K
R20 2.7K
R48 10K "A"
R49 10K "B"
R50 10K "C"
R51 10K "D"
C17 .022
IC7B
COM A B INH 00 01 02 03
HF-EQ
R40 47K
IC3A
R35 100K "A"
R36 100K "B"
R37 100K "C"
R38 100K "D"
LF-EQ
R53 300K
R52 300K
+9 SOURCE
+15 SOURCE
-9 SOURCE
-15 SOURCE
(+15 IN) J1-13
(+18 IN) J4-01
(+18 IN) J4-02
(GND) J4-05
(GND) J4-06
(GND) J1-11
(-18 IN) J4-03
(-18 IN) J4-04
(-15 IN) J1-15
CR5 6.2V
CR6 6.2V
IC5
IC6
R45 220
R44 2.2K
R46 2.2K
R47 220
C14 2.2
C25 2.2
C26 2.2
C15 2.2
C16 2.2
C13 2.2
CR6
CR7
CR10
CR9
R65 3.3K
Q3
CR15
R67 10
CR13
IC9B
CR12
R66 10
CR14
Q4
R64 3.3K
J8-01
R76 3.6K
(VU METER)
J8-02
(-2dBm)
R75 100
(+4dBm BALANCED)
R74 100
(-2dBm)
R68 10K
R69 10K
J5
LINE OUTPUT
R71 3.3K
Q5
CR19
R72 10
CR17
IC9A
CR16
R73 10
CR18
Q6
R70 3.3K
POS NEG
IC2,4
IC1
IC3,7,8
ED CIRCUIT POWER CONNECTIONS
— 48 —
FILM REPRODUCE AMP.
INOVONICS, INC.
1305 Fair Avenue - Santa Cruz, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554
Title
SCHEMATIC, 390 / 397 REPRODUCE BOARD
Size C
Document Number 164200
REV A
Date: October 16, 1990 Sheet 1 of 1



REPRODUCE HEAD
GAIN
GAP-EQ
J3
FB1 FB2
C10 220
C9 .0068
R34 1.2K
R32 10K
R31 56K
Q2
R29 10
C8 470P
R30 1.5K
R33 3.3
R12 10K "A"
R13 10K "B"
R14 10K "C"
R15 10K "D"
R16 680
R26 1M
IC3B
IC2A
IC2B
C7 .1
R27 1.5K
C6 4.7
Q1
C5 47
R28 100K
-15
-9
C12 2.2
R39 10K
J2-01
(ALT IN)
J2-02
(A) J4-09
(B) J4-10
(EQ SELECT)
(A) J1-03
(B) J1-05
R24 100K
R25, 100K
NOTE:
CONNECTOR J1 IS RIBBON CABLE INTER-BOARD BUS IN MODEL 390 RECORD/PLAY SYSTEMS. CONNECTOR J4 IS RIBBON CABLE TO POWER SUPPLY IN MODEL 397 PLAYBACK-ONLY UNITS.
R60 2K "A"
R61 2K "B"
R62 2K "C"
R63 2K "D"
IC7A
R53 300K
R52 300K
C20 .0022
C18 100P
R54 10K
C19 .0022
R41 10K
IC4A
(-5dBm)
JUMPERING SHOWN FOR MODEL 390 REPRODUCE
ALTERNATE JUMPERING FOR MODEL 390 RECORDIST MONITOR AND MODEL 397 PLAYBACK ONLY
+9
(RCDST MON IN/OUT)
J1-01 (-5dBm)
C21 4.7
CR11
CR3
CR4
IC6A,B
(INPUT MON IN)
J1-02 (-5dBm)
R56 4.7K
R57 4.3K
R58 3K
C22 .0022
C23 .0022
R59 12K
C24 150P
IC9B
R55 1M
R42 100K
IC1C
R9 10K
R8 10K
R10 10K
R1 100K
R2 100K
CR1
IC1A
R43 100K
(MON SELECT TRISTATE)
J1-09
R7 10K
C1 .1
IC1B
R3 100K
CR2
R4 100K
(MONITOR TRANSFER)
J1-10
R11 100K
IC1D
R6 10K
R5 56K
+15
IC9
IC2,4
INTEGRATED CIRCUIT



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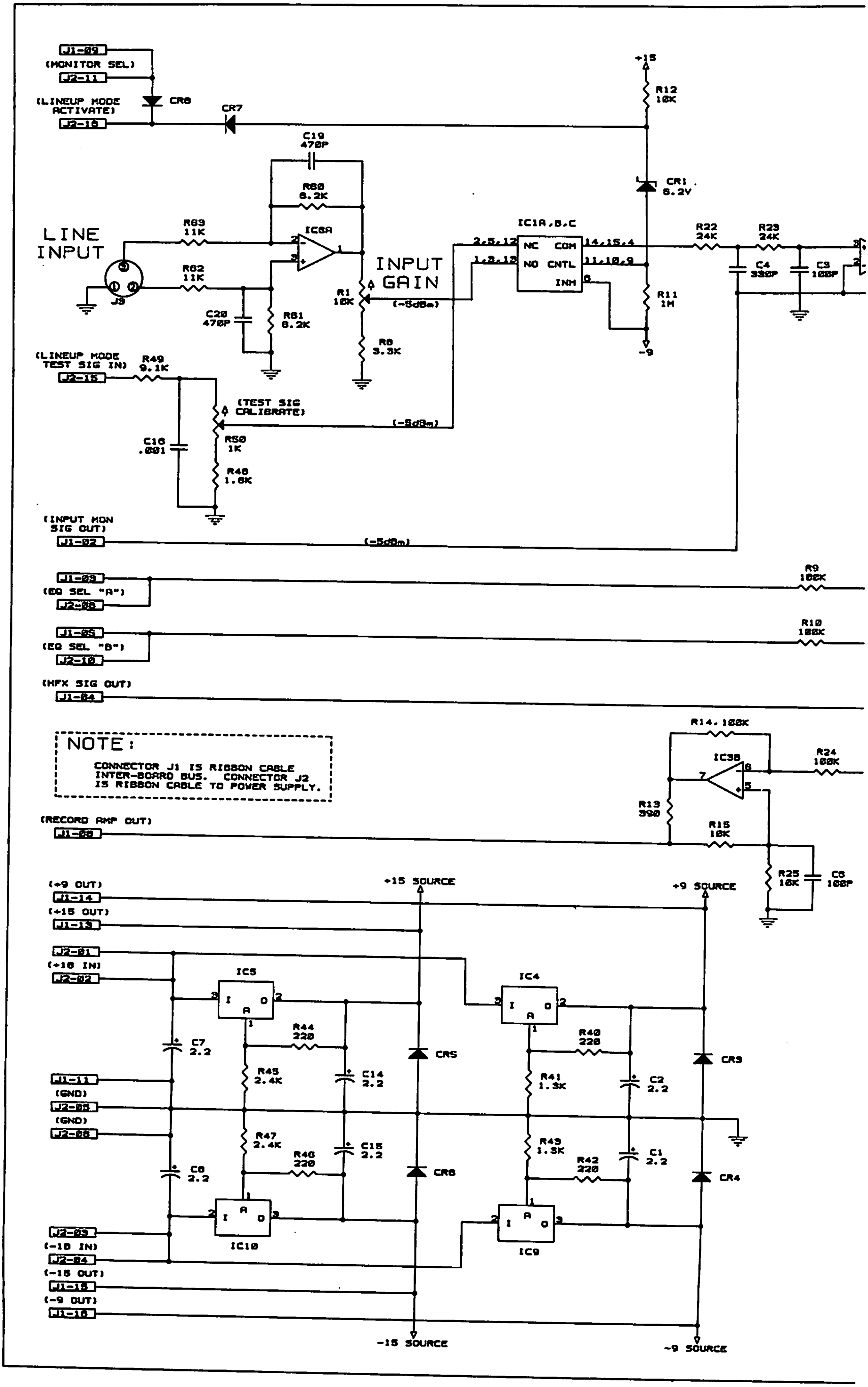
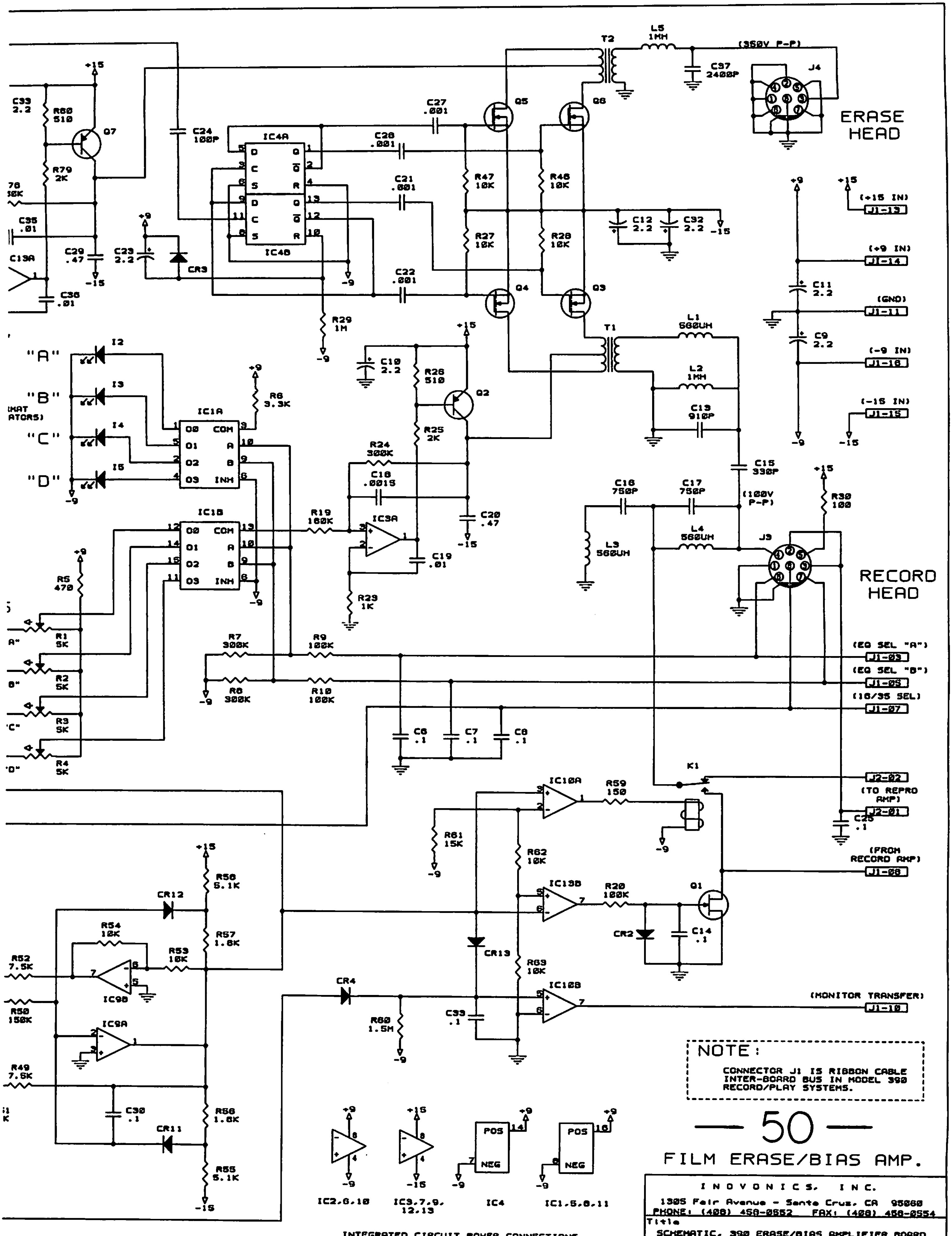
FILM RECORD AMP.

INOVONICS, INC.
1305 Fair Avenue - Santa Cruz, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title		
SCHEMATIC, 390 FILM RECORD BOARD		
Size: C	Document Number: 184500	REV: A
Date: January 31, 1990	Sheet 1 of 1	



J1-09
(MONITOR SEL)
J2-11
(LINEUP MODE ACTIVATE)
J2-16
CR8
CR7
+15
R12 10K
CR1 6.2V
C19 470P
R60 8.2K
R63 11K
IC6A
LINE INPUT
R62 11K
J3
C20 470P
R61 8.2K
R1 10K
INPUT GAIN
(-5dBm)
R8 3.3K
IC1A,B,C
NC
NO
COM
CNTL
INH
2,5,12
1,3,13
14,15,4
11,10,9
R11 1M
-9
R22 24K
R23 24K
C4 330P
C3 100P
(LINEUP MODE TEST SIG IN)
R49 9.1K
J2-15
(TEST SIG CALIBRATE)
(-5dBm)
C16 .001
R50 1K
R48 1.6K
(INPUT MON SIG OUT)
J1-02
(-5dBm)
J1-03
(EQ SEL "A")
J2-08
R9 100K
J1-05
(EQ SEL "B")
J2-10
R10 100K
(HFX SIG OUT)
J1-04
NOTE:
CONNECTOR J1 IS RIBBON CABLE INTER-BOARD BUS. CONNECTOR J2 IS RIBBON CABLE TO POWER SUPPLY.
R14, 100K
IC3B
R24 100K
R13 390
(RECORD AMP OUT)
J1-08
R15 10K
R25 10K
C6 100P
(+9 OUT)
J1-14
(+15 OUT)
J1-13
+15 SOURCE
+9 SOURCE
J2-01
(+18 IN)
J2-02
IC5
IC4
C7 2.2
R44 220
R45 2.4K
C14 2.2
CR5
R40 220
R41 1.3K
C2 2.2
CR3
J1-11
(GND)
J2-05
(GND)
J2-06
R47 2.4K
R46 220
C15 2.2
C8 2.2
CR6
R43 1.3K
R42 220
C1 2.2
CR4
IC10
IC9
J2-03
(-18 IN)
J2-04
(-15 OUT)
J1-15
(-9 OUT)
J1-16
-15 SOURCE
-9 SOURCE



NOTE:
CONNECTOR J1 IS RIBBON CABLE INTER-BOARD BUS IN MODEL 390 RECORD/PLAY SYSTEMS.

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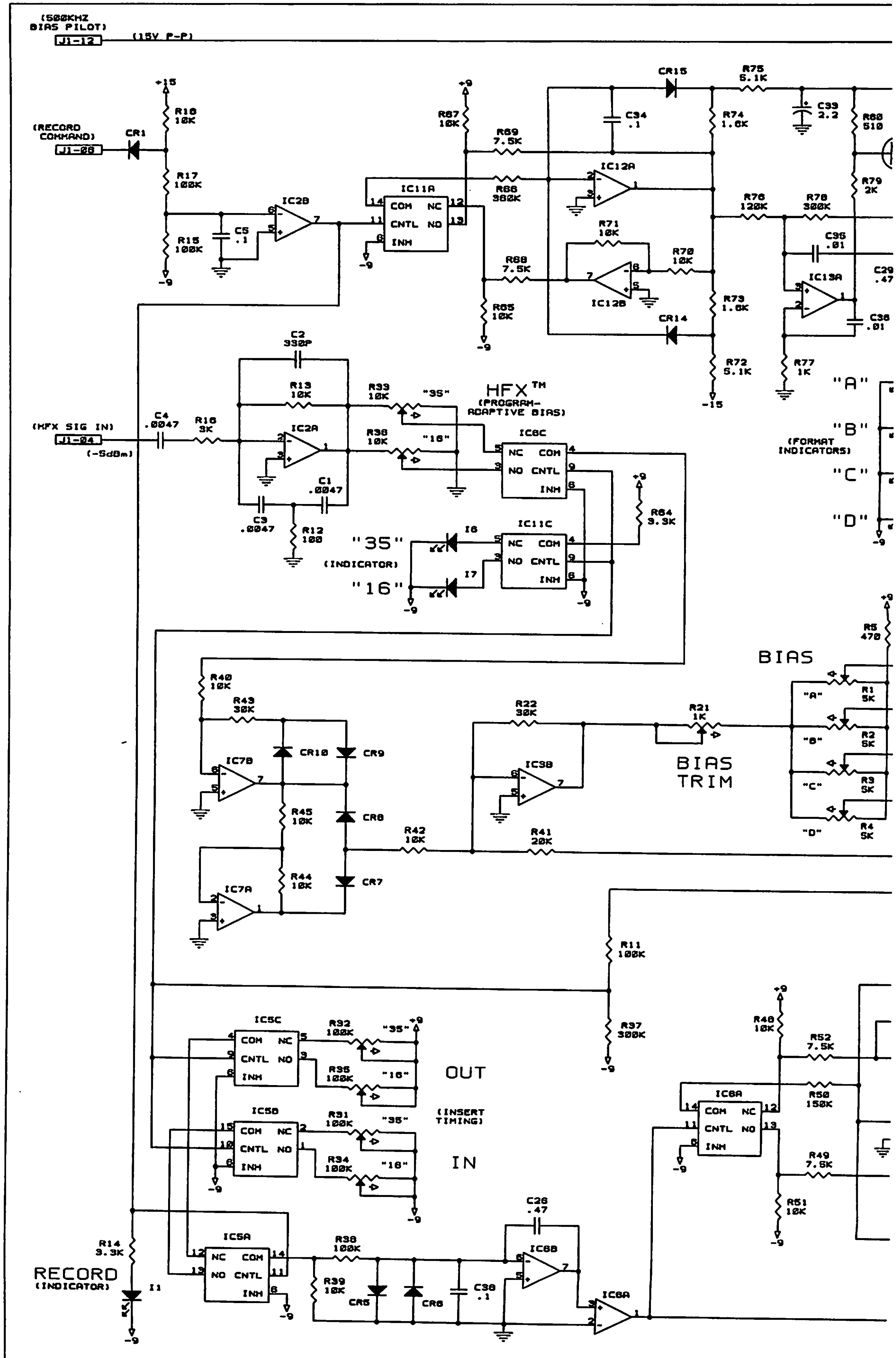
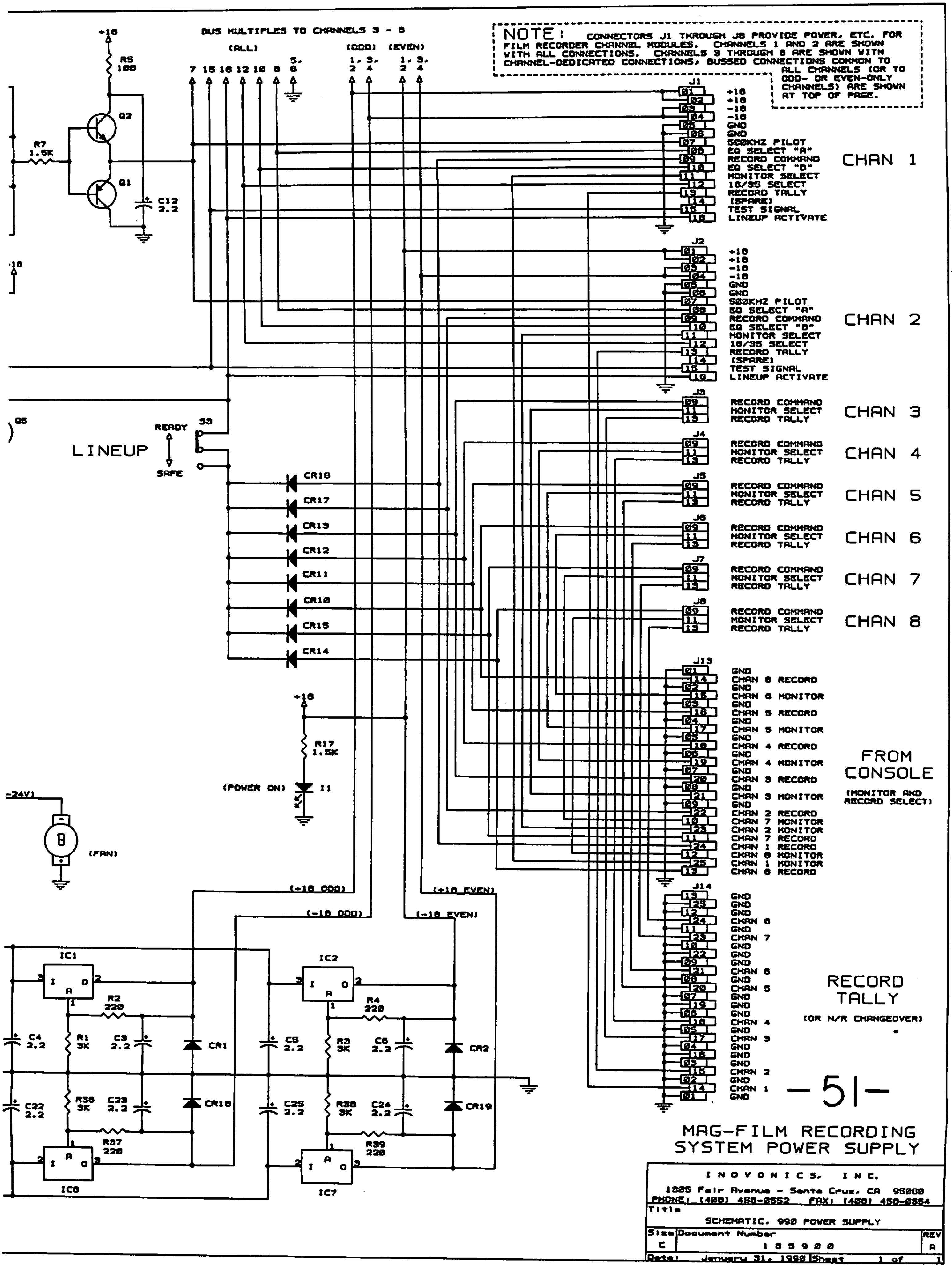
FILM ERASE/BIAS AMP.

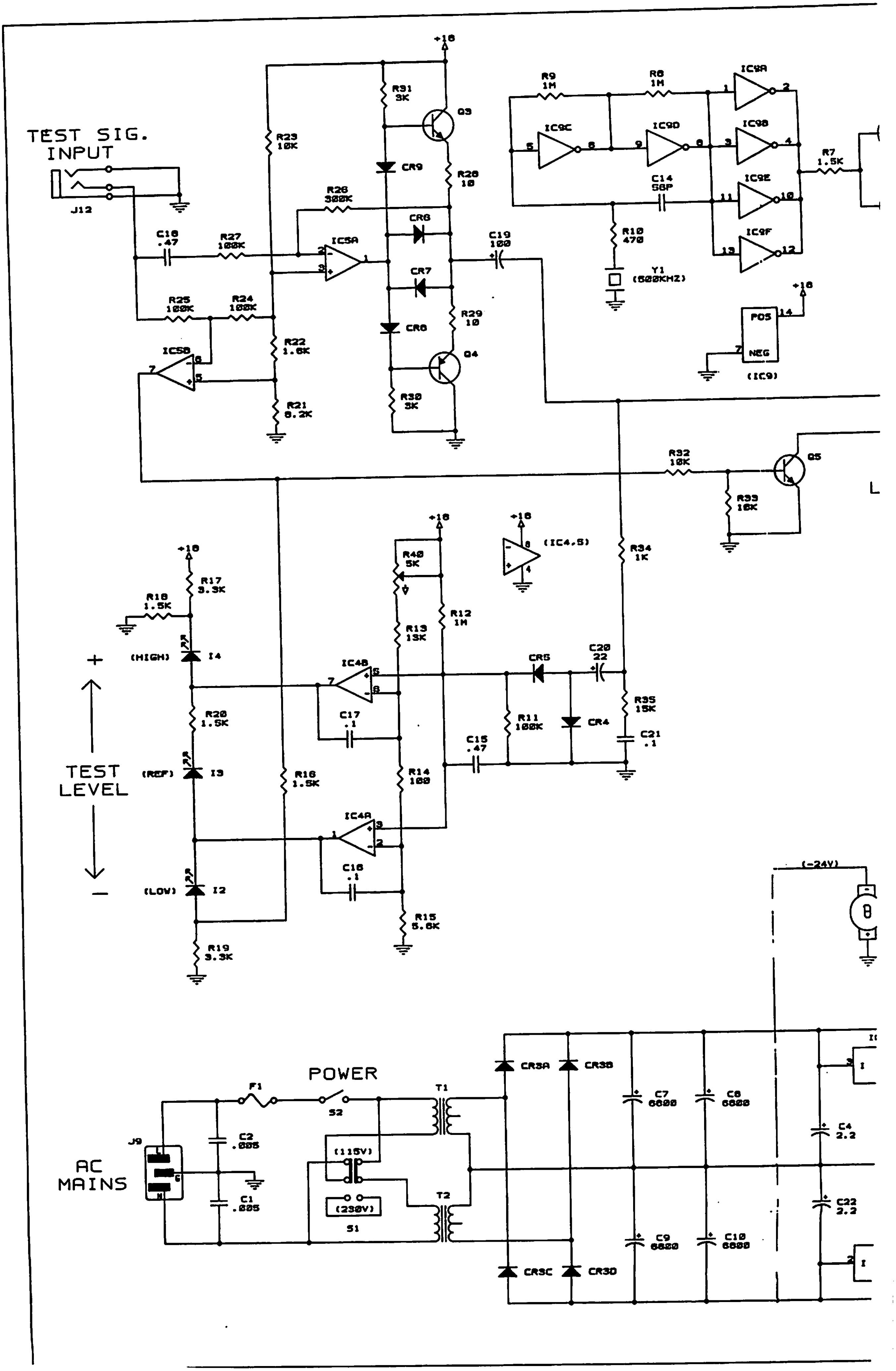
INOVONICS, INC.
1305 Fair Avenue - Santa Cruz, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554

Title		
SCHEMATIC, 390 ERASE/BIAS AMPLIFIER BOARD		
Size	Document Number	REV
C	104800	C
Date: May 14, 1991	Sheet 1 of 1	



(500KHZ BIAS PILOT)
J1-12
(15V P-P)
(RECORD COMMAND)
J1-08
CR1
R16 10K
R17 100K
R15 100K
C5 .1
IC2B
IC11A
COM NC CNTL NO INH
R67 10K
R69 7.5K
R68 360K
R66 7.5K
R65 10K
CR15
C34 .1
IC12A
R71 10K
R70 10K
IC12B
CR14
R75 5.1K
R74 1.6K
R73 1.6K
R72 5.1K
C33 2.2
R60 510
R79 2K
R76 120K
R78 300K
C35 .01
IC13A
C36 .01
C29 .47
R77 1K
C2 330P
R13 10K
R33 10K
"35"
R38 10K
"16"
HFX™
(PROGRAM-ADAPTIVE BIAS)
(HFX SIG IN)
J1-04
(-5dBm)
C4 .0047
R18 3K
IC2A
C1 .0047
C3 .0047
R12 100
IC8C
NC COM NO CNTL INH
IC11C
R64 3.3K
"35"
(INDICATOR)
"16"
I6
I7
"A"
"B"
(FORMAT INDICATORS)
"C"
"D"
R40 10K
R43 30K
IC7B
CR10
CR9
R45 10K
CR8
IC7A
R44 10K
CR7
R42 10K
R22 30K
IC9B
R21 1K
BIAS TRIM
R41 20K
BIAS
R5 470
R1 5K
R2 5K
R3 5K
R4 5K
R11 100K
R37 300K
IC5C
R32 100K
R35 100K
OUT
(INSERT TIMING)
IC5B
R31 100K
R34 100K
IN
R48 10K
R52 7.5K
R50 150K
IC8A
R49 7.5K
R51 10K
R14 3.3K
RECORD (INDICATOR)
I1
IC5A
R38 100K
R39 10K
CR5
CR6
C38 .1
C26 .47
IC6B
IC6A


NOTE: CONNECTORS J1 THROUGH J8 PROVIDE POWER, ETC. FOR FILM RECORDER CHANNEL MODULES. CHANNELS 1 AND 2 ARE SHOWN WITH ALL CONNECTIONS. CHANNELS 3 THROUGH 8 ARE SHOWN WITH CHANNEL-DEDICATED CONNECTIONS, BUSSED CONNECTIONS COMMON TO ALL CHANNELS (OR TO ODD- OR EVEN-ONLY CHANNELS) ARE SHOWN AT TOP OF PAGE.
BUS MULTIPLES TO CHANNELS 3 - 8
(ALL)
(ODD)
(EVEN)
+18V
R5 100
Q2
Q1
R7 1.5K
C12 2.2
J1
+18
+18
-18
-18
GND
GND
500KHZ PILOT
EQ SELECT "A"
RECORD COMMAND
EQ SELECT "B"
MONITOR SELECT
16/35 SELECT
RECORD TALLY
(SPARE)
TEST SIGNAL
LINEUP ACTIVATE
CHAN 1
J2
CHAN 2
J3
CHAN 3
J4
CHAN 4
J5
CHAN 5
J6
CHAN 6
J7
CHAN 7
J8
CHAN 8
LINEUP
READY
SAFE
S3
CR16
CR17
CR13
CR12
CR11
CR10
CR15
CR14
J13
FROM CONSOLE
(MONITOR AND RECORD SELECT)
R17 1.5K
(POWER ON)
I1
-24V
(FAN)
(+18 ODD)
(-18 ODD)
(+18 EVEN)
(-18 EVEN)
IC1
IC2
IC8
IC7
R2 220
R4 220
R1 3K
R3 3K
C4 2.2
C3 2.2
C5 2.2
C6 2.2
CR1
CR2
C22 2.2
R36 3K
C23 2.2
CR18
C25 2.2
R38 3K
C24 2.2
CR19
R37 220
R39 220
J14
RECORD TALLY
(OR N/R CHANGEOVER)
MAG-FILM RECORDING SYSTEM POWER SUPPLY
INOVONICS, INC.
1305 Fair Avenue - Santa Cruz, CA 95060
PHONE: (408) 458-0552 FAX: (408) 458-0554
Title
SCHEMATIC, 990 POWER SUPPLY
Size C
Document Number 185900
REV A
Date: January 31, 1990
Sheet 1 of 1


TEST SIG. INPUT
J12
+18
R31 3K
Q3
R23 10K
CR9
R28 10
R26 300K
CR8
C18 .47
R27 100K
IC5A
C19 100
CR7
R25 100K
R24 100K
R29 10
CR6
IC5B
R22 1.8K
Q4
R21 8.2K
R30 3K
R9 1M
R8 1M
IC9A
IC9C
IC9D
IC9B
C14 56P
IC9E
R7 1.5K
IC9F
R10 470
Y1 (500KHZ)
POS
NEG
(IC9)
R32 10K
Q5
R33 10K
R34 1K
(IC4,5)
R40 5K
R17 3.3K
R18 1.5K
R12 1M
R13 13K
(HIGH)
I4
IC4B
CR5
C20 22
R20 1.5K
C17 .1
R11 100K
CR4
R35 15K
C15 .47
C21 .1
TEST LEVEL
(REF)
I3
R16 1.5K
R14 100
IC4A
C16 .1
(LOW)
I2
R15 5.6K
R19 3.3K
(-24V)
POWER
F1
S2
T1
CR3A
CR3B
C7 6800
C8 6800
C4 2.2
J9
C2 .005
AC MAINS
(115V)
(230V)
S1
T2
C1 .005
C22 2.2
C9 6800
C10 6800
CR3C
CR3D