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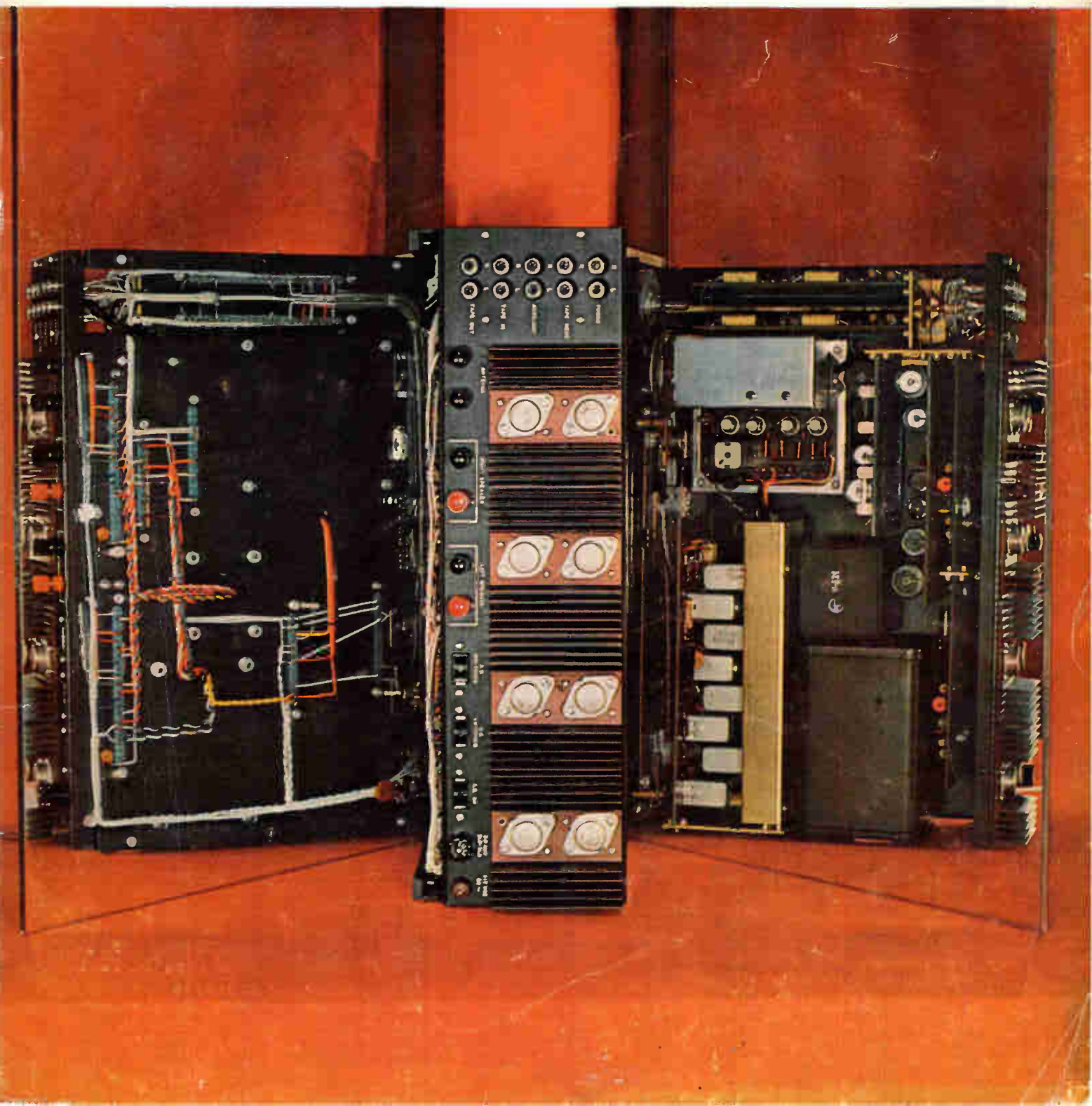


A solid state stereo set built in modules

A defense-oriented firm will invade the consumer market with a high-quality instrument constructed with the same techniques it used in making digital voltmeters. The set is easy to repair, works even when some circuits are out

By Sam Messin and Thomas E. Nawalinski

Non-Linear Systems, Inc., Del Mar, Calif.

From digital voltmeters to stereo sets is not such a long jump as it may seem. A West Coast company, Non-Linear Systems, Inc., is using the same modular techniques it developed for its dvm to produce a solid state stereo tuner-amplifier. Every major circuit function in the set is in a separate, electronically independent, plug-in module, and any failure can be repaired in minutes merely by replacing the defective module.

Since the failures will be isolated, the unaffected modules will still work. Pull out the multiplex module and you can still listen to monaural f-m. Pull out a module in the f-m tuner, and the amplifiers will still work for tape or records. If any module in one audio channel is removed, the other channel is available for monaural sound.

NLS is a defense-oriented company, and it was the shrinking defense market that led to its decision to market a consumer product. The company's instruments are of high quality and are expensive, and its stereo set will be the same. At $695, it will be in the range of the most expensive set made, the McIntosh. But NLS felt that its production techniques were more suited to the quality market than the popular market, and that there was more chance for a new name in the high-price area, where only a few manufacturers compete.

The company feels that its modular construction will be a real selling point. Hi-fi buffs might be tempted by a set which will still work even though part of it is on the blink. Also, the technique will let NLS use existing machinery for production.

The combination set will be on the market in September; the company plans to make separate f-m tuners and amplifiers in the future.

The authors

Thomas E. Nawalinski, now sales promotion manager for Non-Linear Systems, Inc., came to NLS from the General Dynamics Corp. in 1956 as chief applications engineer. He has written eight magazine article and a 60-page text on digital voltmeters for the NLS catalogue.

Sam Messin, who now heads the high-fidelity project at NLS, has been designing radar and audio circuits for 20 years. He also marketed his own audio product, the Mercury Disc Charger, a static discharger for phonograph records. Messin was previously manager of the instrument assembly department at NLS.

Sectioning the circuit

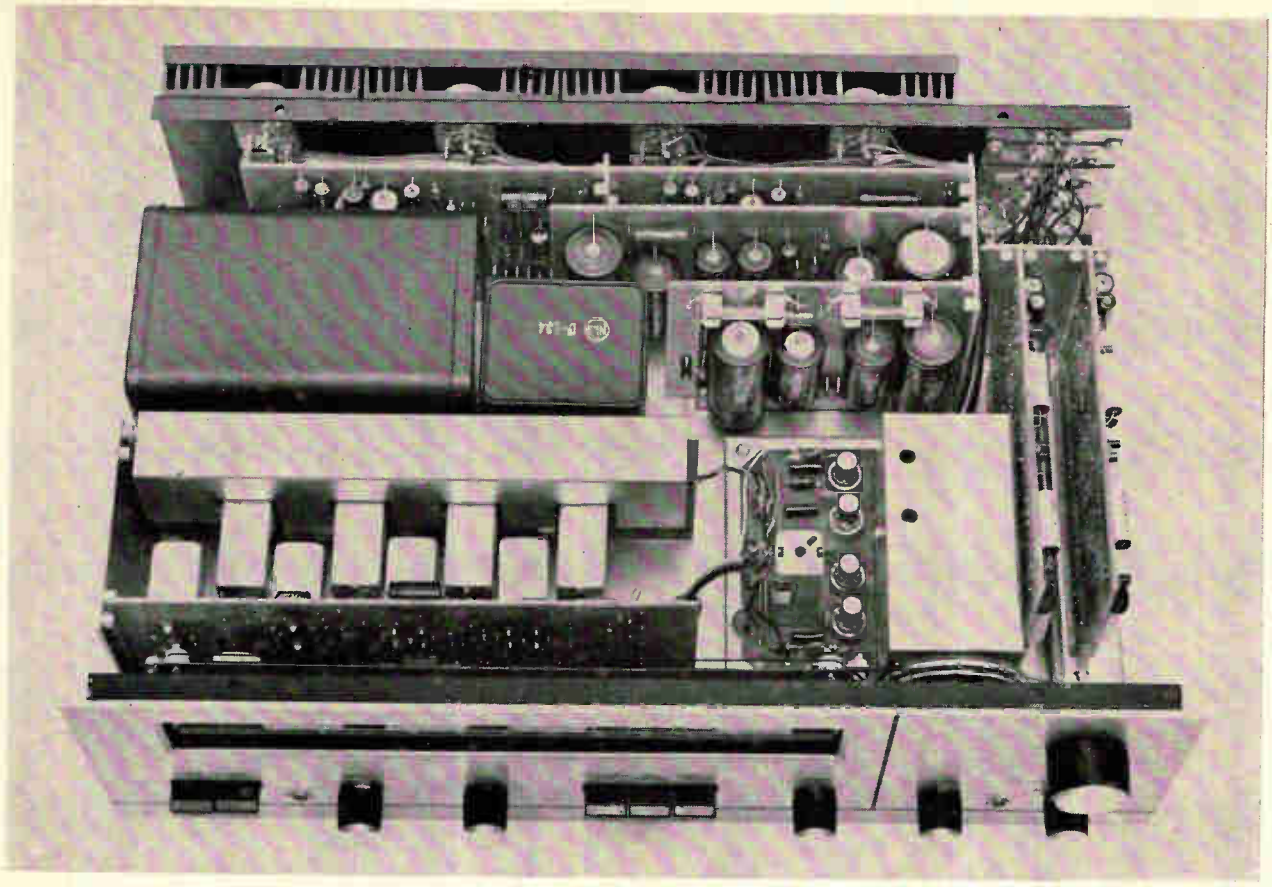
Each block in the diagram of the stereo f-m tuner-amplifier combination on the opposite page represents a separate circuit module. The photograph at the top of the page clearly shows these plug-in boards. Sectioning the circuit in this manner evolved over a two-year period.

The f-m tuner is separated into three modules: the radio-frequency front end, the intermediate-frequency amplifier, and the multiplexer. The left-channel supply also powers the tuner modules.

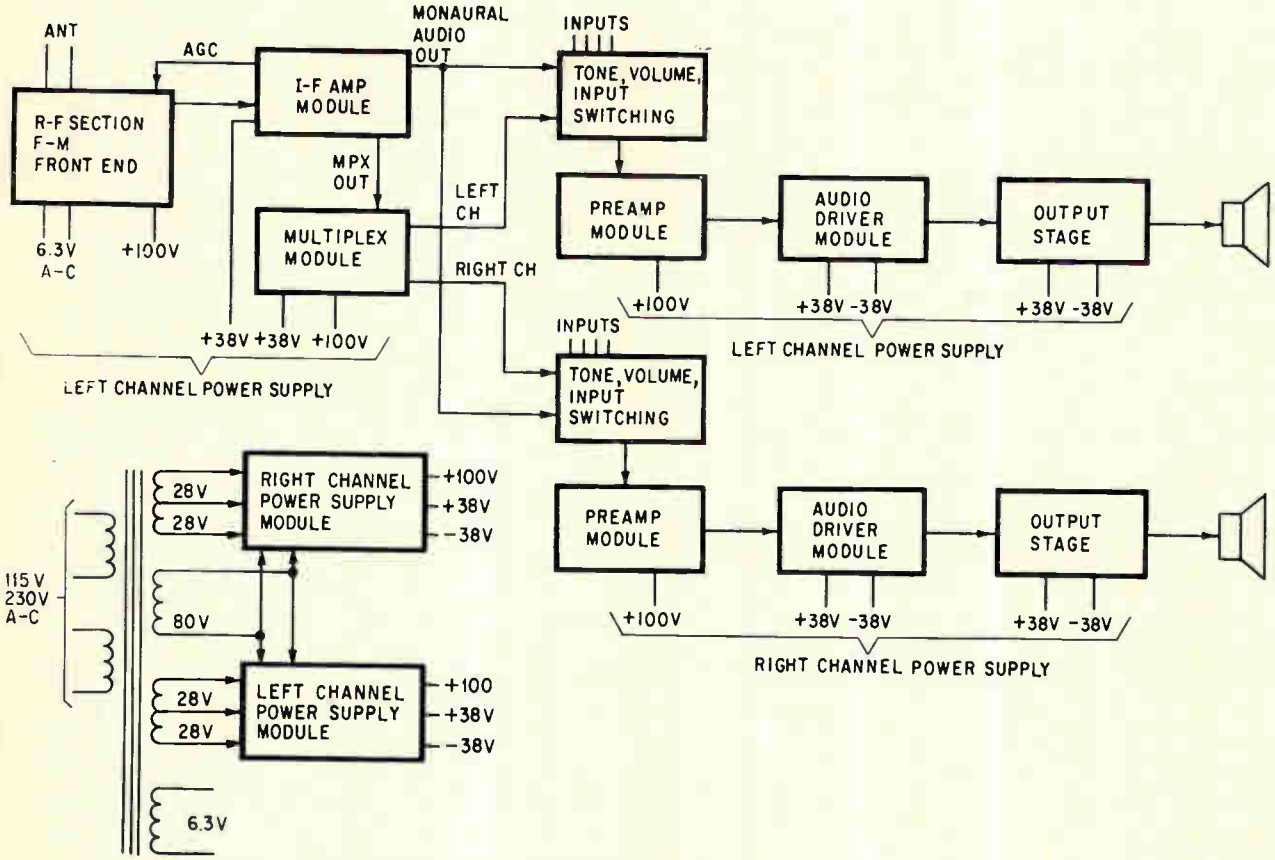
Circuitry for each 40-watt (rms) audio channel, with the exception of the power output transistors and driver transformer, is separated into two printed circuit boards, the preamplifier and audio driver modules. The four output transistors for each audio channel are mounted on heat sinks at the rear of the chassis, outside the cabinet.

The preamplifier, audio driver and power supply boards in the left and right channels are identical and interchangeable. For maximum reliability, the power transformer has separate secondary windings for each power supply.

Each circuit board has its own zener or transistor



Vertically mounted plug-in printed-circuit boards reduce space requirements. The two cases at upper left are the power and driver transformers. Stereo receiver and dual 40-watt amplifiers fit in 18 in. x 11 in. x 6½ in. cabinet.



Stereo f-m tuner-amplifier combination is made up of removable circuit boards, each of which is represented above by a block. Exceptions are the controls, switches and output stages, which are not on separate boards.

voltage regulator to prevent interaction between boards through a common power supply. Even a short-circuited board will not affect its power supply, which continues to supply the other modules.

NLS engineers specified gold-plated, scissor-type connectors for the printed circuits. The circuit boards themselves are made from epoxy-impregnated glass fibers which retain their strength even when subjected to soldering and flexing. Wiring is limited to the interconnection of modules, controls and external connectors; point-to-point wiring is virtually eliminated by the printed circuits.

R-f section

Nuvistors were used in the r-f section because their performance is superior to presently available equivalent transistor circuits.

A pair of nuvistor triodes serve as an r-f cascode amplifier; a low-noise triode nuvistor is the mixer; and a fourth nuvistor serves as a local oscillator. Frequency drift is kept within 20 kilocycles by a temperature compensating capacitor.

I-f amplifier

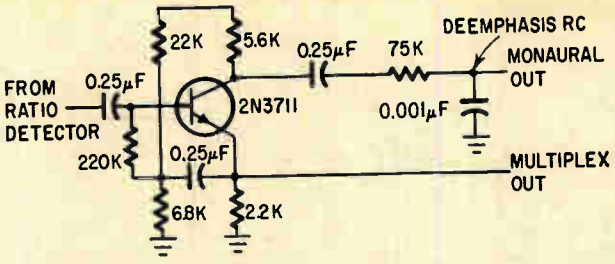
Five transistors in the intermediate-frequency module amplify the mixer output from the r-f section. The last two transistors act as limiters and feed a wideband ratio detector which uses two matched diodes. The ratio detector output is amplified, as shown above, by a transistor with a split load in the emitter and collector circuits.

The emitter circuit provides a low impedance output to the multiplex module, while the collector feeds a deemphasis network for the monaural f-m output. In this way, stereo and monaural f-m are completely separated, so that removing the multiplex module has no effect on monaural reception.

Multiplexer

The low impedance output from the i-f module feeds the multiplex module shown at right. In the presence of a multiplex signal, this output contains the 19-kc pilot frequency and the stereo signals.

Adding the composite signals to the regenerated subcarrier forms a 38-kc amplitude-modulated signal containing right and left channel information.



Final stage of i-f amplifier module has two outputs to allow independent operation of monaural f-m.

The subcarrier is regenerated by selecting, amplifying, limiting, and doubling the 19-kc signal.

The multiplexer cannot operate when there is no multiplex signal or when the 19-kc signal is below an acceptable power level. In this case, f-m reception is monaural. Rectification of the 19-kc signal provides the turn-on voltage to the frequency doubler, thus automatically providing stereo operation.

When the frequency doubler is on, a neon lamp driven by a transistor indicates stereo reception. A second neon lamp limits the voltage to protect the transistor when the stereo signal is absent.

Preamplifier

The audio preamplifier on page 92 uses both a zener diode and a transistor regulator for failure decoupling and voltage regulation. The phonograph and tape inputs feed a direct-coupled, low-noise pair of transistors which shape the audio in accordance with the RIAA-phono and NAB-tape playback-equalization curves. Switching in different resistance-capacitance circuits in the equalizing network provides the appropriate feedback. A 27-volt collector supply enables the transistors to handle large inputs without overload. Input switching selects either the output of this transistor pair, the tuner, or another external signal and feeds it to the balance and volume controls.

Bootstrapped emitter followers allow high impedance external signals to be used, and minimize loading of the high impedance controls. The emitter follower is direct-coupled to the following amplifier that drives a feedback bass and treble circuit. Another bootstrapped emitter follower places a minimum load on the tone circuits and is again coupled directly to the output amplifier of the module. The amplifier compensates for losses in the tone circuits and provides sufficient signal to drive the following driver module board.

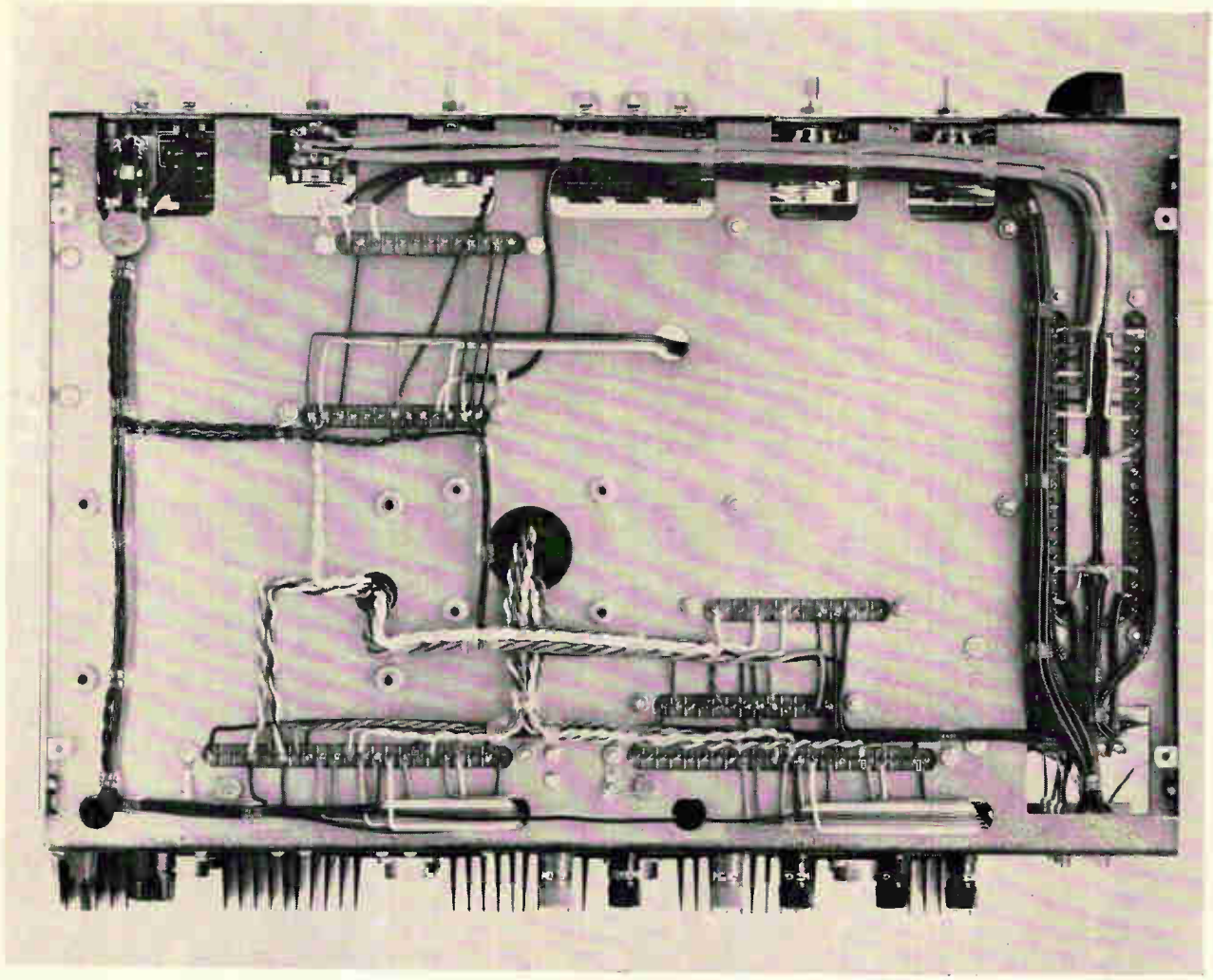
The tone circuits are the Boxandall type; the bass control affects only the low frequencies; the treble control, the high frequencies. Controls at the center position give a flat response. Adjusting the controls first boosts (or cuts) only the ends of the audio spectrum, while the rest of the band remains flat. Further advancing of the controls affects more central frequencies as well.

Audio driver and output

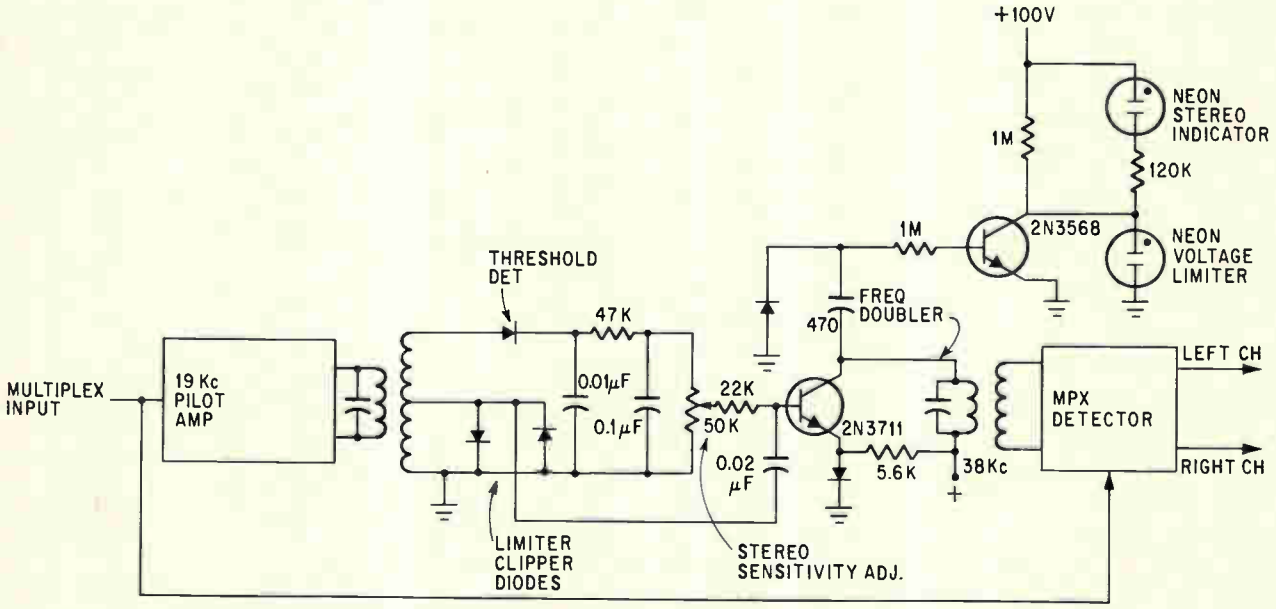
A pnp-npn transistor pair provides voltage regu-

Specifications

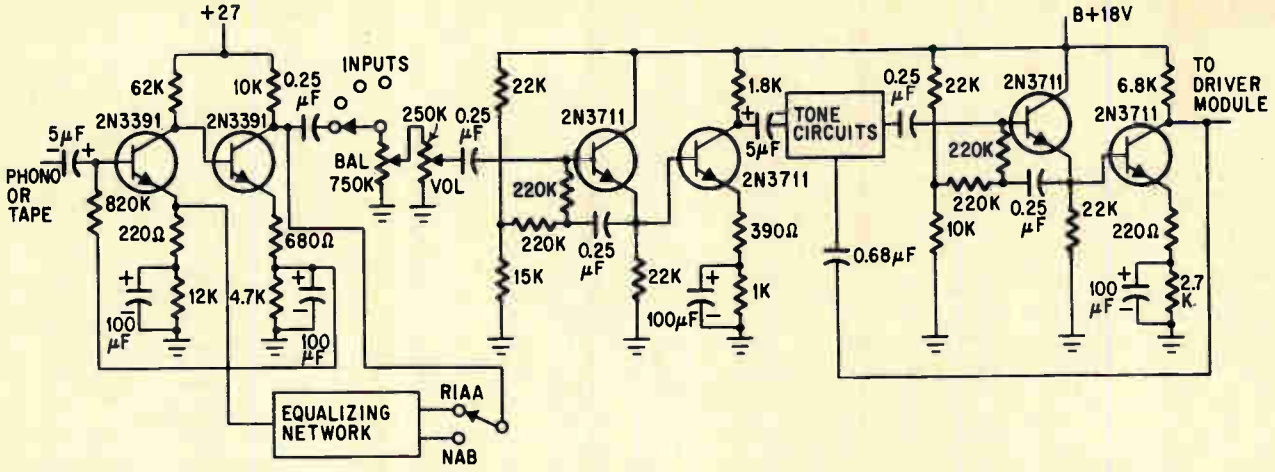
F-m tuner	
Sensitivity, 30 db quieting	2.5 uv
Drift (maximum)	20.0 kc
Stereo separation at 10 kc	25.0 db
Stereo separation at 1 kc	35.0 db
Stereo amplifier	
Frequency response, ±1db	20 cps—20 kc
Total harmonic distortion at full power	0.7%
Rms power per channel	40 watts
Hum and noise	—70 db
Phono sensitivity	2.7 mv
Tape head sensitivity	4, 8, 16 ohms
Output impedance	25 mv



Chassis wiring is limited to the interconnection of modules, controls and external connectors. Heat sinks for output transistors can be seen outside the cabinet.



Multiplex module is prevented from operating when multiplex signal is below an acceptable power level. In this case, f-m reception is monaural.



Preamplifier module connects with all switches and controls, which are mounted on the front of the chassis.

lation, filtering, turn-on time delay and decoupling for the audio driver module shown below.

The time delay prevents spurious noises from appearing at the output when the equipment is switched on.

All of the remaining audio components are on this module, except for a driver transformer on the chassis and the output transistors on heat sinks.

Output stage

The output stage is a push-pull type for low distortion, with a single-ended output for transformerless connection to a speaker. Two transistors in series are used to amplify each half-cycle of the signal so that less peak inverse voltage is across each transistor. This provides a safety margin against secondary breakdown at high power.

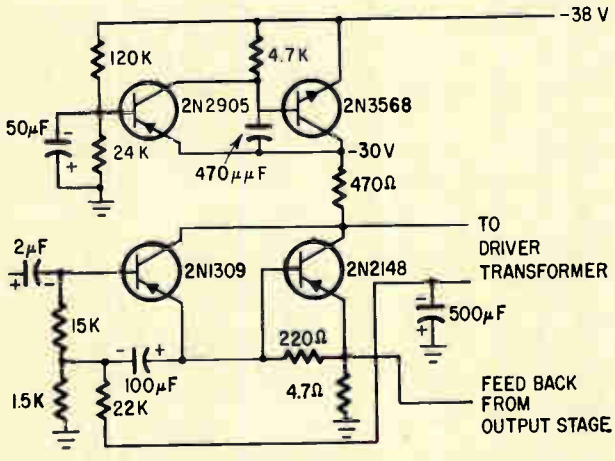
Since each transistor pair can take more voltage than a single transistor, less current is needed for a particular power output. Regulation is much easier and more reliable with low-current supplies.

Biasing resistors used in this amplification stage are mounted on the audio driver module.

A driver transformer which isolates the power transistors from earlier stages maintains a low impedance between base and emitter of the output transistors, so that there is less chance of thermal runaway. The transformer also isolates the output stages from earlier stages where a failure might, in turn, destroy the output stage. The output transistors operate in a voltage and current feedback loop, reducing distortion. A short circuit in the output will cause the current feedback loop to reduce the gain to a safe level, protecting the output stage.

The use of two identical power supplies provides better voltage regulation and increased power output per channel.

Each supply provides three full-wave rectified voltages: positive and negative 38 volts and 100 volts. Positive and negative power supplies are fused, but each output has separate filter capacitors.



Audio driven module, simplified above, is a complete audio amplifier except for the driver transformer and output transistors mounted on the chassis.

Self-service

The circuit isolation not only isolates failures, but also allows the owner of the equipment to determine which module has failed within minutes.

For example, if the left audio channel fails, the owner has only to replace each circuit board in that channel with the identical board from the right channel until the defective module is located.

If there is no audio output at all, it is almost certain that either the power transformer primary windings or the 80-volt common secondary have failed or the primary is not being energized.

For most repairs, the owner of the equipment need only mail the defunct circuit board back to the factory or exchange it for a replacement board at the distributor. Stocking circuit boards will be no problem for the distributor, since a handful of circuit boards will serve all models. Audio and power supply modules will fit both the amplifier and tuner-amplifier models. R-f, i-f and multiplex modules for the tuner-amplifier fit the tuner.

The modular design also protects the instrument against obsolescence. If NLS improves the circuitry or performance, the owner may improve his own set merely by buying a new module, rather than replacing the whole set.