SERVICE MANUAL

THE POWER

SUMO ELECTRIC COMPANY LIMITED
[illegible]

James William Bongiorno

1944 - 2013

Before You Start

Operational Procedure: "Pre-Amp ON first and OFF last". This will minimize the possibility of turn-on and turn off thumps, which can be substantial with this amplifier.

This amplifier is a balanced bridge design with no output reference to ground. Although there are + and - output terminals, this is only for speaker phasing. The negative output terminal has no reference to ground and this MUST be taken into account for all operation, measurement and servicing.

The construction design of this amplifier is all monocque. The entire amplifier is virtually built on the power transformer as a foundation instead of the usual chassis approach. The top cover, bottom cover, rear panel and front panel can all be completely removed yet the amplifier still remains intact and fully operable. 99% of all interconnections are made through interlocking PC Board connectors that are gold plated. The only wiring is associated with the power transformer and the lights. When removing the top and/or bottom cover or both, it should be understood that they are integral with the front panel. The allen head button screws on the sides of the covers hold all three pieces (top and bottom covers, front panel). When removing either one, re-install the button head screws to secure the front panel before removing the other cover. This will prevent damage to the front panel and power switch. Be carefull not to damage the grill attached to the vent cover on the bottom of the amplifier as this is the main air intake vent and prevents dust buildup inside the unit.

This is a very heavy amplifier and care must be taken when moving it on the bench.

The main schematic was hand drawn by James Bongiorno. There may be some slight differences, mostly in the parts designations (R53, U5 etc), depending on the variant and serial number of your unit.

The Bias & AC Line in to Transformer out schematics were hand drawn by Craig Tathwell.

When the amplifier is placed in the service position, mount it on blocks to protect the power switch.

Pay attention to the Allen Head Button Screws and Philips Head Machine Screws and note where they go when dissassembling.

This document was created with the assistance of and input from James Bongiorno, Mark Wilson, Craig Tathwell and Barry Lambert.

SPECIFICATIONS

POWER OUTPUT

16 ohms--minimum	225 watts/channel 20Hz-20kHz
8 ohms--minimum	400 watts/channel 20Hz-20kHz
4 ohms--minimum	750 watts/channel 20Hz-20kHz
2 ohms--minimum	1000 watts/channel 20Hz-20kHz

TOTAL T.H.D. and I.M. DISTORTION

8 and 16 ohms--less than .05% at any frequency or combination of frequencies, and at any power level to peak.
2 and 4 ohms---less than .25% at any frequency or combination of frequencies, and at any power level to peak.

INPUT IMPEDANCE and SENSITIVITY

1.35 volts across 1 megohm for 400 watts into 8 ohms

2.70 volts across 10k ohms balanced

FREQUENCY RESPONSE and POWER BANDWIDTH AT RATED POWER or ANY LEVEL LESS THAN RATED

8 and 16 ohms--Better than ± .1 dB, 20Hz to 20kHz.
2 and 4 ohms--Better than ± .2 dB, 20Hz to 20kHz.

RISE TIME AT 8 OHMS

Better than 2 microseconds at full power.
Note: For those of you who wish to interpret this spec as a slew rate, it is EQUIVALENT to 80 volts per microsecond.

STABILITY

100% stable into any load angle 0 to 90 degrees, capacitive or inductive, regardless of waveshape.

DAMPING FACTOR

Greater than 300 at 20Hz.

NOISE

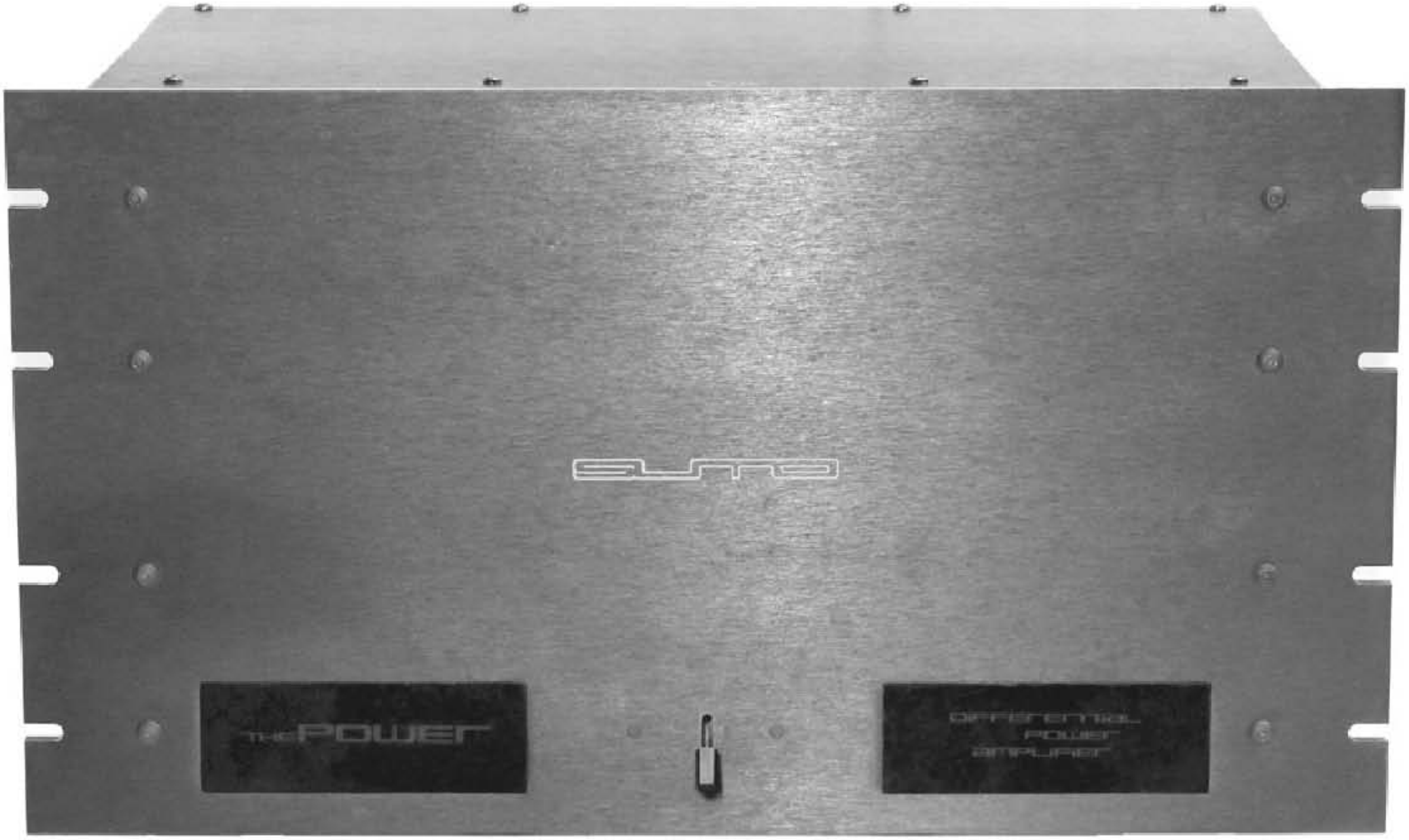
Better than -100dB relative to full rated power into 8 ohms.

PROTECTION

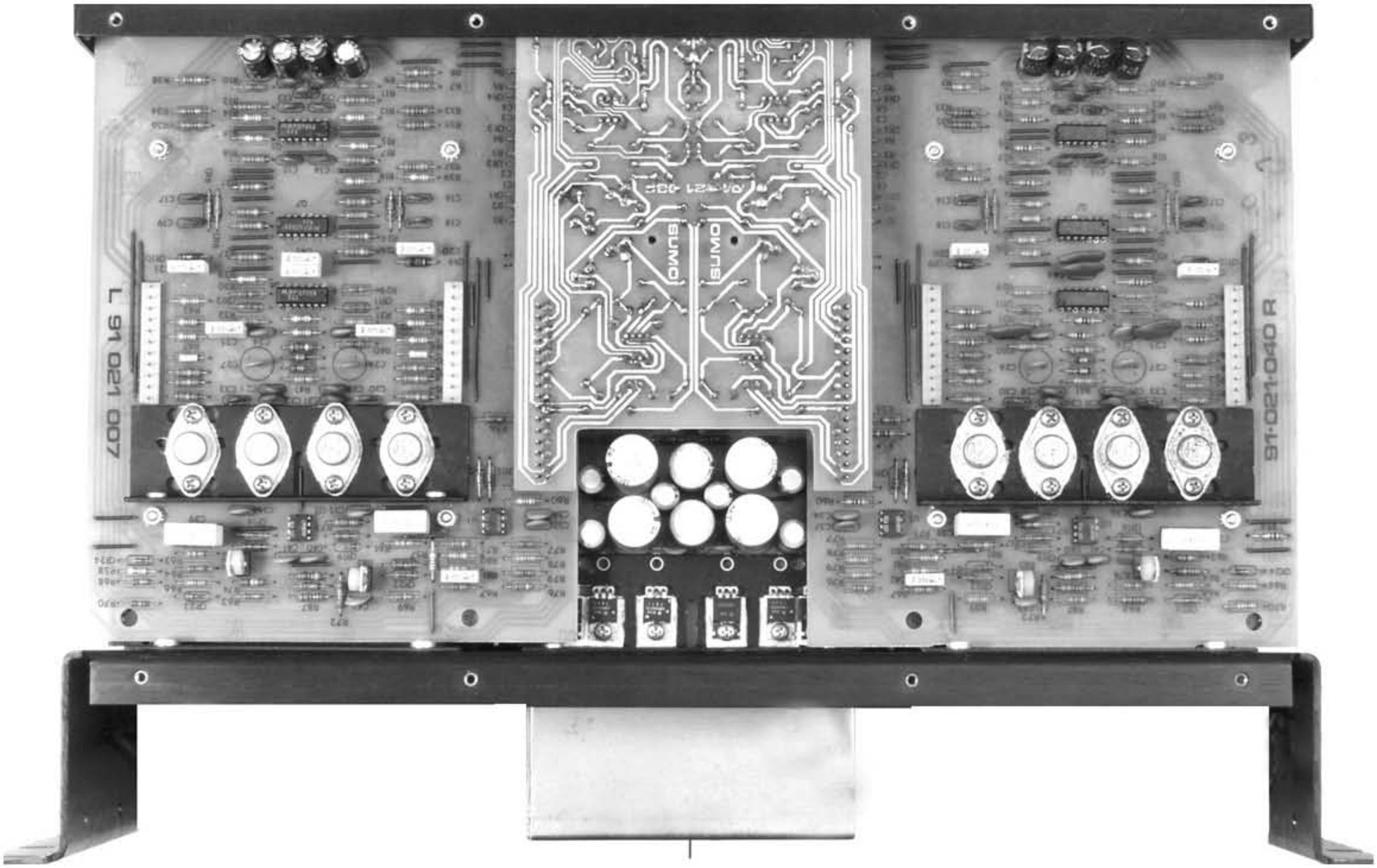
State variable processor
The state of the input and output is monitored at all times and will completely shut down the amplifier when any non-allowable condition exists In addition, the thermal shutdown is also tied into the processor. Acquisition time is less than 1/2 signal cycle or 100 nanoseconds, whichever is longer.

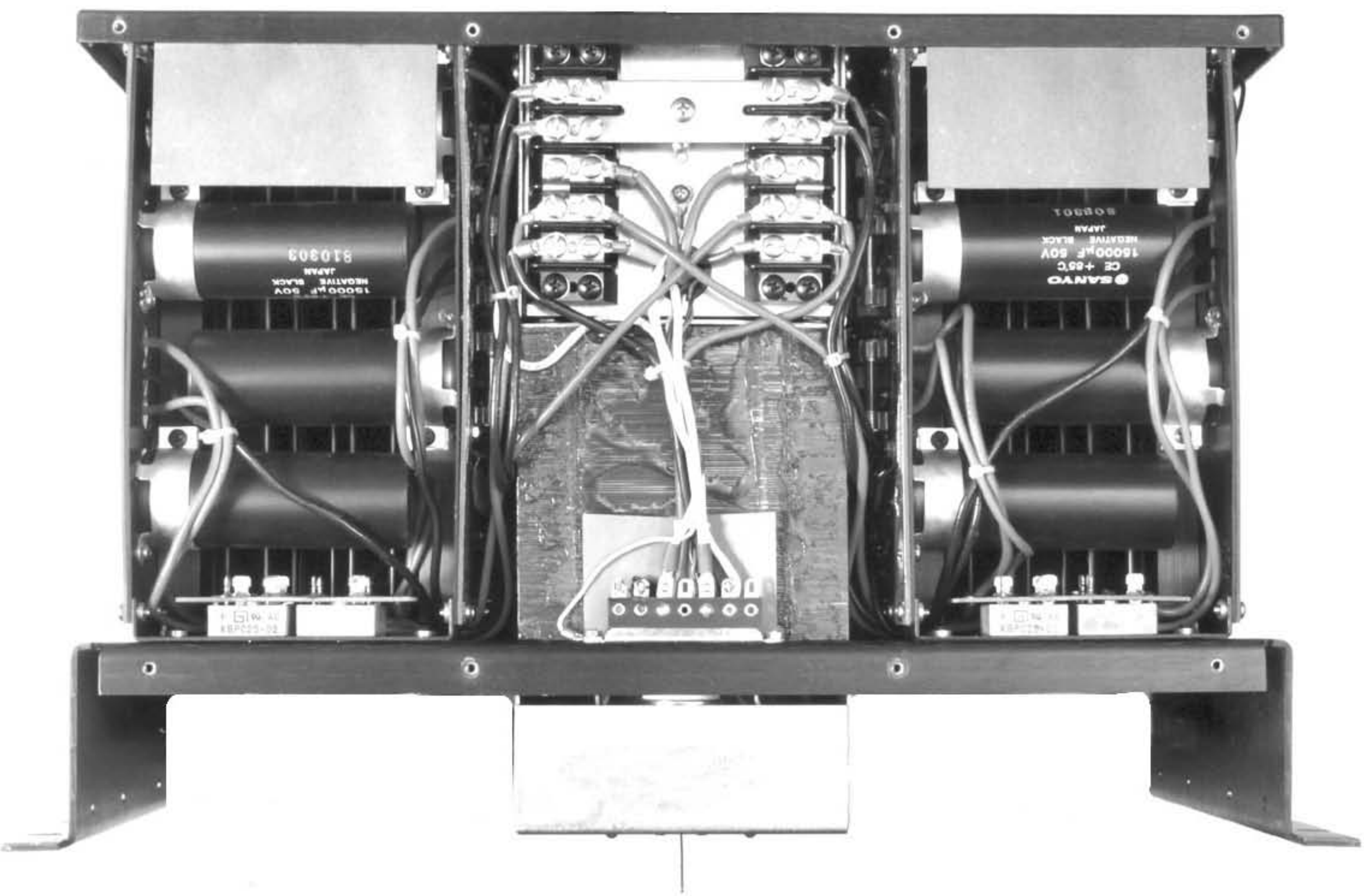
$B^{\pm}$ fuses for catastrophic failure, A.C. line fuse, relay surge fuse.

Front and Rear Views



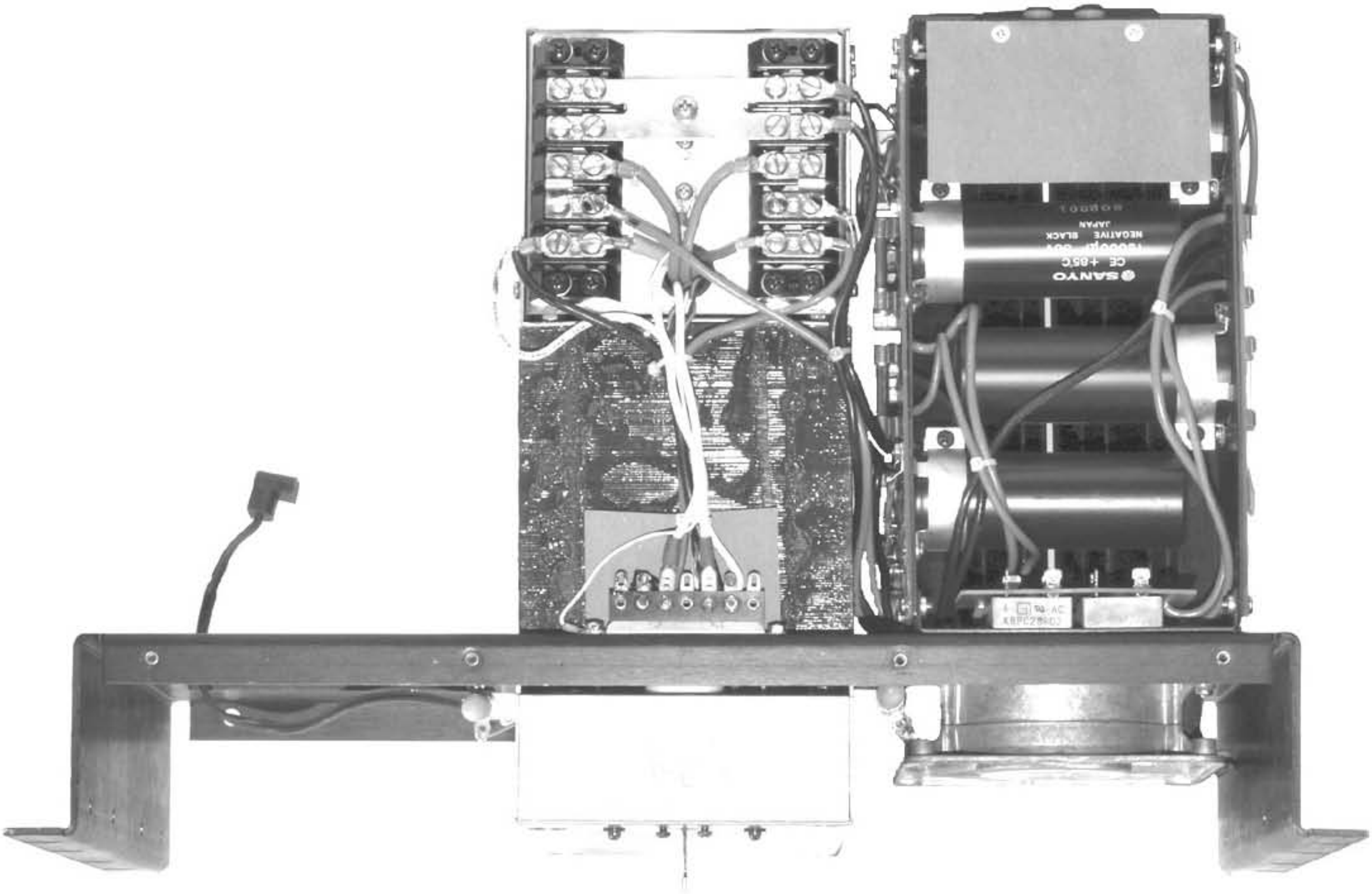
Top and Bottom Views



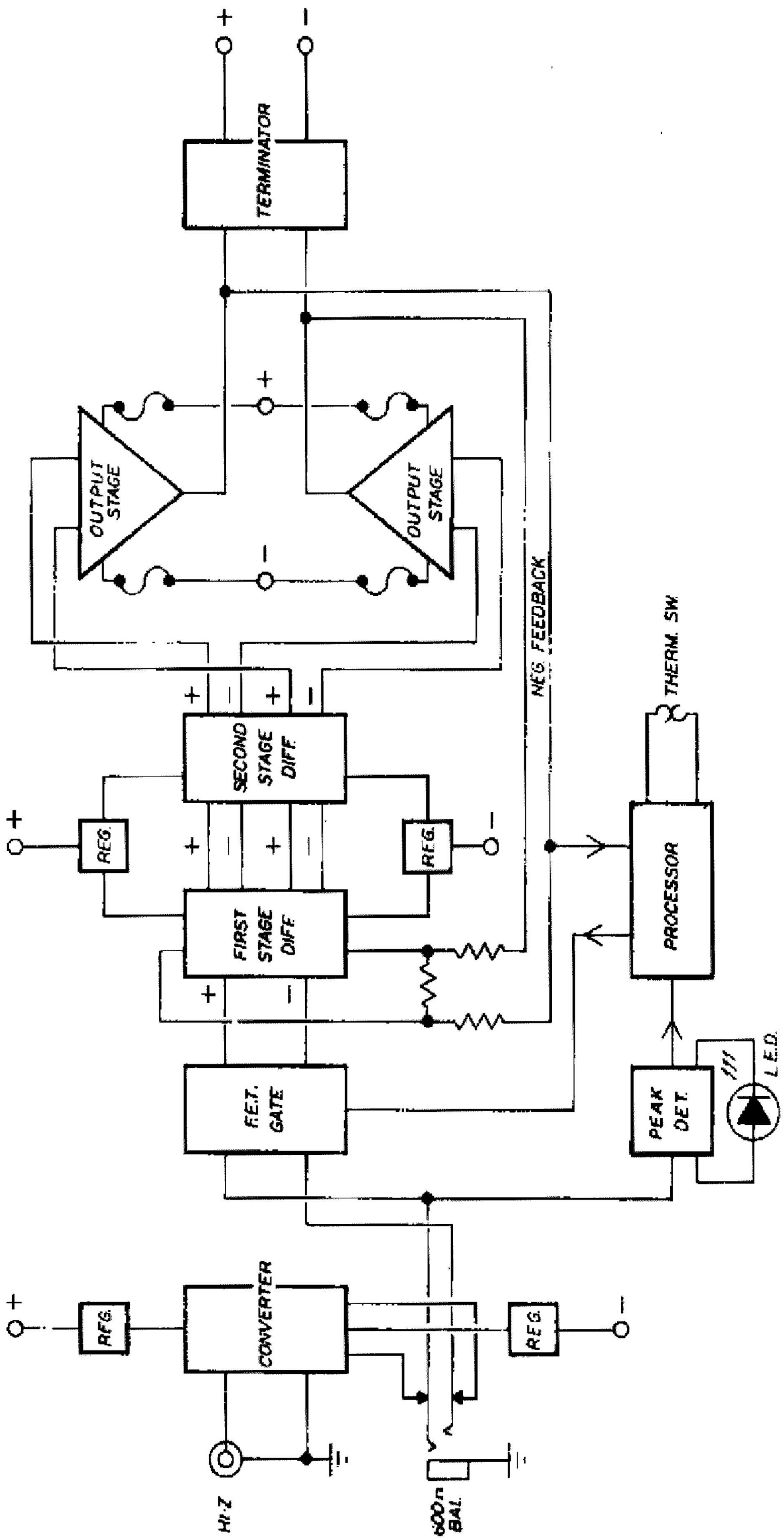


Amplifier in Service Position w/Right Channel Removed

Mount the amplifier on wood blocks to clear the on/off switch in this position



Block Diagram - One Channel



Circuit Description

With the exception of the input stage single-ended to balanced converter, all the circuits in this amplifier are 100% completely balanced utilizing push-pull quadrature feedback from each side of the speaker load.

The first stage converts a single-ended audio signal into a fully balanced to ground signal with two opposite phase outputs. The performance of this stage is at least an order of magnitude better than the following main amplifier, which insures no signal degradation. The bandwith of this stage exceeeds 5MHz. The output of this stage goes through the balanced input jacks and is automatically disconnected whan a standard balanced signal is inserted into the balanced input jacks. Obviously, a balanced signal can be sent directly to the main amplifier and needs no conversion.

From there the signal goes to the FET gates. These gates are arranged as on-off switches in series and shunt and are activated by the protective processor in order to protect the amplifier against non-allowable states. Under normal operating conditions the gates are fully on and have been carefully designed in order to add no degradation to the audio signal. The distortion of the gates is at least an order of magnitude below that of the main amplifier.

From the FET gates the balanced signal goes directly to the +/- inputs of the first stage of the main amplifier. This stage comprises two complete differential amplifiers with two out of phase inputs, four balanced outputs and four balanced feedback ports. In addition, these two stages are completely degenerated in order to have exceptionally wide bandwith and low distortion before the addition of overall feedback.

The outputs of the first stage are direct coupled to the next stage which is again a pair of completely degenerated differential amplifiers which in turn provide the output stages with four isolated differential balanced signals.

In each of the four corners of the bridge, there are four output devices. These are driven by four Class A driver stages which are made up of compound pairs. All stages operate in pure Class A up to the output devices.

The output transistors are arranged as two arms of a balanced bridge with nine paralled devices in each arm. The two floating power supplies act as the other two arms of the bridge.

The output stages of the bridge are powered by two independant supplies and there are two independant regulators per channel for the input and driver stages. There are also two regulated supplies for the convertor stages. In all, there are ten regulated supplies and four unregulated supplies in each amplifier.

Circuit Description - continued...

The power supply can supply over 50 amperes per channel so a rather unique protection circuit was designed in order to have reliability and immunity to failure modes.
Yet, at the same time, there are no limiters that might otherwise limit performance. Also, inadvertant shorts or overloads will not cause a fuse to blow as these are difficult to replace.
Very simply put, the protective processor continuously monitors the inputs and outputs at all times for voltage, current and phase. The detection points of the processor are arranged so that no conceivable normal operating condition will trigger the processor yet, any non allowable condition will completely shut down the amplifier in less than 100 nonoseconds.
Also, thermal cutouts are connected so that overheating past 70 degrees centigrade will inhibit operation.

The processor will select and detect high frequencies above 20kHz, low frequencies below 2Hz, blown fuses (for whatever reason), and direct short circuits. However, the processor will allow total reactive energy to be delivered without being activated. Special care must be used in testing this amplifier so you must understand the protection mechanisms. See the section on testing elsewhere in this document.

The overload peak indicators light when the output is driven into clipping. They are also part of the protection circuit and when the processor activates the latch, they will glow in accordance with the incoming signal level. Activation of the peak lights is the equivalent of approximately 1000 watts of peak energy into an 8 ohm load and approximately 1800 watts of peak energy into an 4 ohm load.

Other than caution concerning the power output capabilities of this amplifier, there are no special notes on operation. Always turn on the complete system first - waiting at least 30 seconds before tuning on the amplifier. Many pieces of associated equipment emit large transients at turn-on and continue to do so several seconds after turn-on. The reverse is also true when turning off the system. Always turn the amplifier off first, waiting at least 15 seconds for the power supply to discharge. Then turn off the rest of the system.

This amplifier has a delay relay in the primary circuit to prevent huge inrush currents which would likely blow house fuses or circuit breakers. The time constant is a few seconds and the action of the delay is audible. You may experience some hum from the speakers for a second or two before the relay closes.

False Triggering of the Protective Processor

There are several signal modes which may induce shutdown action of the protective processor.

1. Scanning the tuning dial on your tuner: Mute circuits are notoriously unreliable in their ability to completely eliminate interstation noise and related components. These high frequency transients (above 20kHz) will almost certainly trigger the protective processor and shut down the amplifier.

2. Switching transients: When using tape, CD, Selector, Filter, etc functions on your associated equipment, high frequency switching components sometimes occur. These glitches are caused by inadequate design of the assoicated equipment and are not the fault of the amplifier.

3. Power ON and OFF: If for any reason the power switch on the amplifier is shut off during program material, it will be necessary to turn the level control all the way down before attempting to turn the amplifier back on again. If the level control is up and program material is still going to the input of the amplifier, the protective processor will likely be activated.

4. Preamp turn-on thumps: If for any reason the preamp is turned on after the amplifier, and there is any DC offset occuring at the preamp output during this period, the protective processor will probably be activated. It will then be necessary to turn the amplifier off again and wait a few seconds before turning the unit on again.

Testing the Amplifier

Because this amplifier has balanced outputs, You cannot test it in the normal, traditional way.

1. All test equipment must be totally floating. The 3rd wire ground must be disconnected or bypassed on all test instruments.

2. Only the amplifier's 3rd wire ground should be connected to a true ground.

3. The chassis or grounds of all test equipment must be isolated from each other.

4. The generator output ground must never be connected in any way to any other piece of test equipment other than the input ground of the amplifier under test.

5. Since the outputs of the amplifier are floating and isolated from each other (channel to channel), you can only measure one channel at a time.

6. Dn not test the amplifier at or near full power into 4 ohm loads for extended periods of time as this will cause the internal 10A fuses to blow and the amplifier must be disassembled to replace them.

7. Do not test the amplifier at 2 Ohms above 100 watts or the internal 10A fuses will blow.

8. Do not attempt to connect either of the output terminals to chassis ground or any of the test equipments chassis' grounds. The sole exception to this rule is when using Sound Technology equipment which has true balanced differential inputs. Under these circumstances, the jack on the Sound Technology -- labeled chassis -- should be connected to, or under a screw on the rear of amplifier chassis. Do not connect this lead to the minus (-) output terminal or the input ground.

9. Do not drive the amplifier into clipping at high frequencies (above 10kHz) as the protective processor will shut down the amplifier. Please note that although no damage will result from high frequency testing, the processor prevents high frequency disturbances such as spikes and oscillations from getting through the amplifier and damaging speakers.

10. SQUARE WAVE TESTING: Attempting to measure square waves may prove frustrating as the protective processor is most sensitive to the leading edge of square waves. These amplifiers have a rise time of approximately one microsecond at all power levels so square waves at levels above approximately 50 watts RMS will trigger the protective processor.

DC Offset Adjustment

Adjust R85 and R86 on each drive card.

R85 is the ground balance which is adjusted by having the voltmeter between either output terminal and the chassis.

R86 is the corner balance which is adjusted by having the voltmeter across the output terminals.

These adjustments are interactive, meaning you must go back and forth between the two.

When properly adjusted, ground and corner balances will be 1 mV or less.

BIAS Adjustment

A Distortion Analyzer with floating inputs must be used.

Adjustment with a Sound Technology ST1700B is described here.

Set to Low Distortion not Fast Response

Distortion Out - connect to scope vertical in (Y)

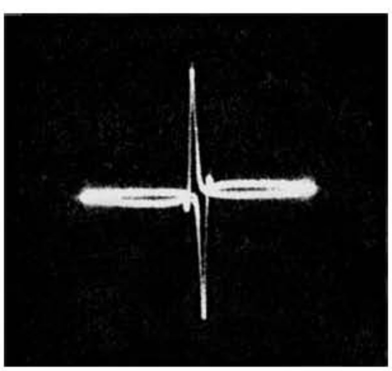
BNC Buffered Input Signal (on rear of ST1700B) - connect to scope horizontal in (X)

Set scope to X/Y mode. Set Level - use Auto. Attach an 8ohm load.

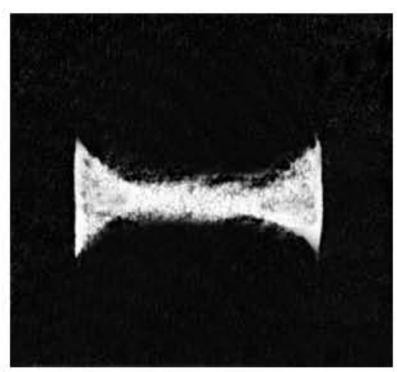
Set to 2Khz and feed about 100mv into amplifier or until you get about 3V out.
Ignore the wattage scale and use the voltage scale.

As voltage is increased the line will flatten out. Remove the cover from the amplifier and use the TWO POTS PER CHANNEL accessable thru the openings on each drive card and adjust to null the spikes. Slowly adjust one of the bias pots, watching that the two spikes decrease in amplitude. You will reach a point where further advancement of the pot will cause no lowering of the spikes. At this point, back off slightly so that the spikes JUST start to go higher again. Now adjust the other bias pot. You may have to play with these a fair bit to get it right. When finished, the bias pots should be approximately in the same position and the spikes slightly visible. When the amplifier warms up, these spikes will be gone. Adjust the other channel in the same fashion.

Distortion will be about .002% when bias is set correctly. You can still have spikes and be getting .002%. The goal is to null the spikes AND be get .002% distortion. You can't just use the distortion analyzer and not the scope to get it right.



Before Adjustment



Correct Adjustment

Protective Processor - Circuit Description and Adjustments

Overview:

The protective processor monitors input signals and other conditions that might damage the amplifier and loudspeakers or blow fuses:
- Any input signal above 20KHz that causes the amplifier to clip
- Any input signal below 20Hz that causes the amplifier to clip
- Blown fuses for any reason
- Short circuits at output any reason
- Excessive DC fed to the inputs
- Square waves above 50 Watts RMS encountered during testing
- Heatsink temperatures above 70c

When these conditions occur, the processor shuts down input to the amplifier until the offending condition is removed. The alignment is factory set and should normally not require any adjustment. If adjustment is required follow the procedures below.

Adjustment method:

Step 1: R63/64 (on Power Supply Board 91-021-009) - Sets the window comparator range. These pots should be set to their center position.

For the next steps, pot designations differ on the schematic and input board 91-021-036:
91-021-036: R41/43/45/47 (LEFT) - R42/44/46/48 (RIGHT)
Schematic: R49/51/53/55 (LEFT) - R50/52/54/56 (RIGHT)
so for these adjustments the 91-021-036 PCB designations will be used.

DO NOT attach a load until step 7

Adjust one channel at a time.

Step 2: R43/45 - Common Mode adjustment. Set this pot fully CC (off) if it is not already so.

Step 3: R41/42 - 1K Gain - Sets the overall clipping indicator LED threshold. Feed a 1KHz signal into the amplifier so that visible clipping just occurs on the scope. Adjust R41/42 for a null (LED not lighted or as dim as possible) from the LED. Slightly increase the input signal and again adjust R41/42 for a null. Turn down the oscillator and proceed to the next step.

Protective Processor - Circuit Description and Adjustments cont'd....

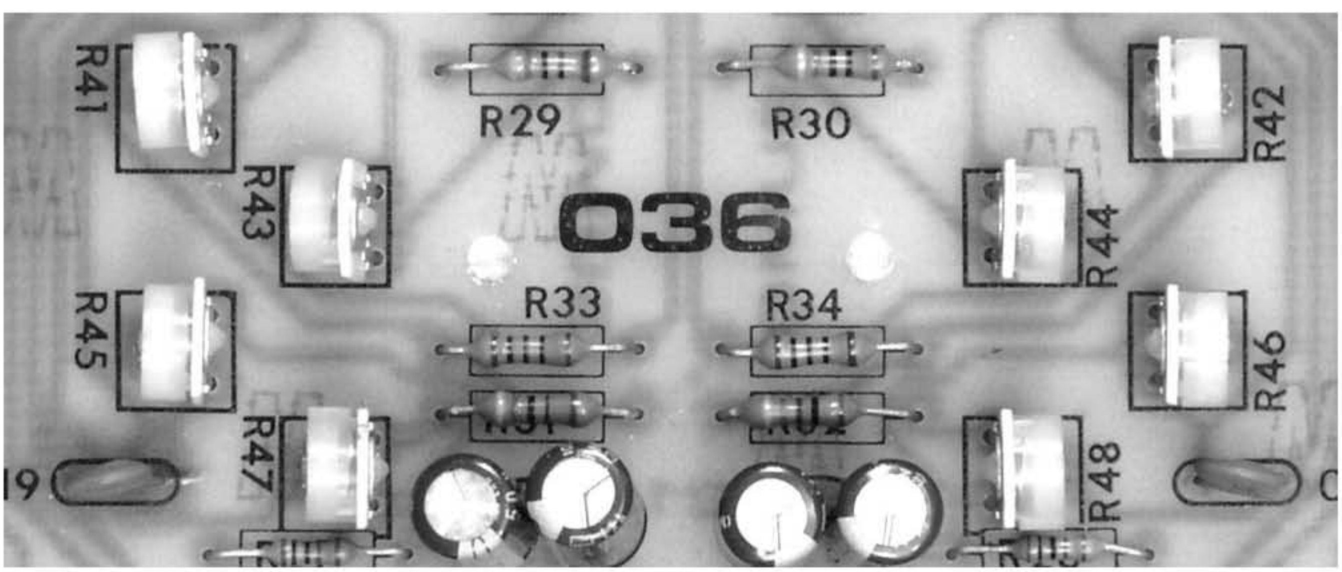
Step 4: R45/46 - 20KHz - Sets the cutoff threshold at 20KHz and above. Feed a 20KHz signal into the amplifier so that visible clipping just occurs on the scope. Adjust R45/46 for a null. Slightly increase the input signal and adjust so the LED is starting to glow. Slightly increase the input signal again and adjust so the LED is lit brightly and the processor cuts off the input signal. Turn down the oscillator and proceed to the next step.

Step 5: R47/48 - 20Hz - Sets the cutoff threshold at 20Hz and below. Feed a 20Hz signal into the amplifier so that visible clipping just occurs on the scope. Adjust R47/48 for a null. Slightly increase the input signal and adjust so the LED is starting to glow. Slightly increase the input signal again and adjust so the LED is lit brightly. Turn down the oscillator and proceed to the next step.

Step 6: Check that the LED lights at clipping at 1KHz but input does NOT get cut off if input amplitude is further increased.

Step 7: Attach an 8ohm load and briefly drive the amplifier to clipping at 1KHz. The LED should should come on just at the onset of clipping.

Input Board 91-021-036:



Updates recommended by James Bongiorno:

Replace the four (2 per channel) LM1458 opamps on the drive cards with any generic TLO72 FET input type. You will have to re-adjust the corner and ground balance. These are designated as U5 and U6 on the schematic but may be designated as U1 and U2 on some variants.

Replace the four (2 per channel) LF353 opamps (depends on the serial number as the first 50 units had FOUR LF351 singles which can't be replaced) with Analog Devices AD823. (U1, U2, U3, U4)

On the main drive cards, replace the four pairs (8) of back to back input (C5,C6,C7,C8) electrolytics with FOUR 330uF 16V MUSE ES SERIES bipolars. (Nichicon UES1C331MHJ) Jumper the unused positions.

Replace all the .1ufd disc bypass caps with .1ufd polyester. (Panasonic Type ECQB)

Replace all the ceramic disc compensation caps with dipped silver micas

Replace the .1's disc bypass caps on the output cards (near the speaker output connection jacks) and insulate their leads.

The 2 pots (R63, R64) on the PSU board adjust protection sensitivity are factory set and need no adjustment.

The 8 pots (4 per side) on the input board are phase & amplitude adjustments. These are R49 thru R56 on the schematic but may be designated as R41 thru R48 on some variants. Set at factory. Do not adjust.

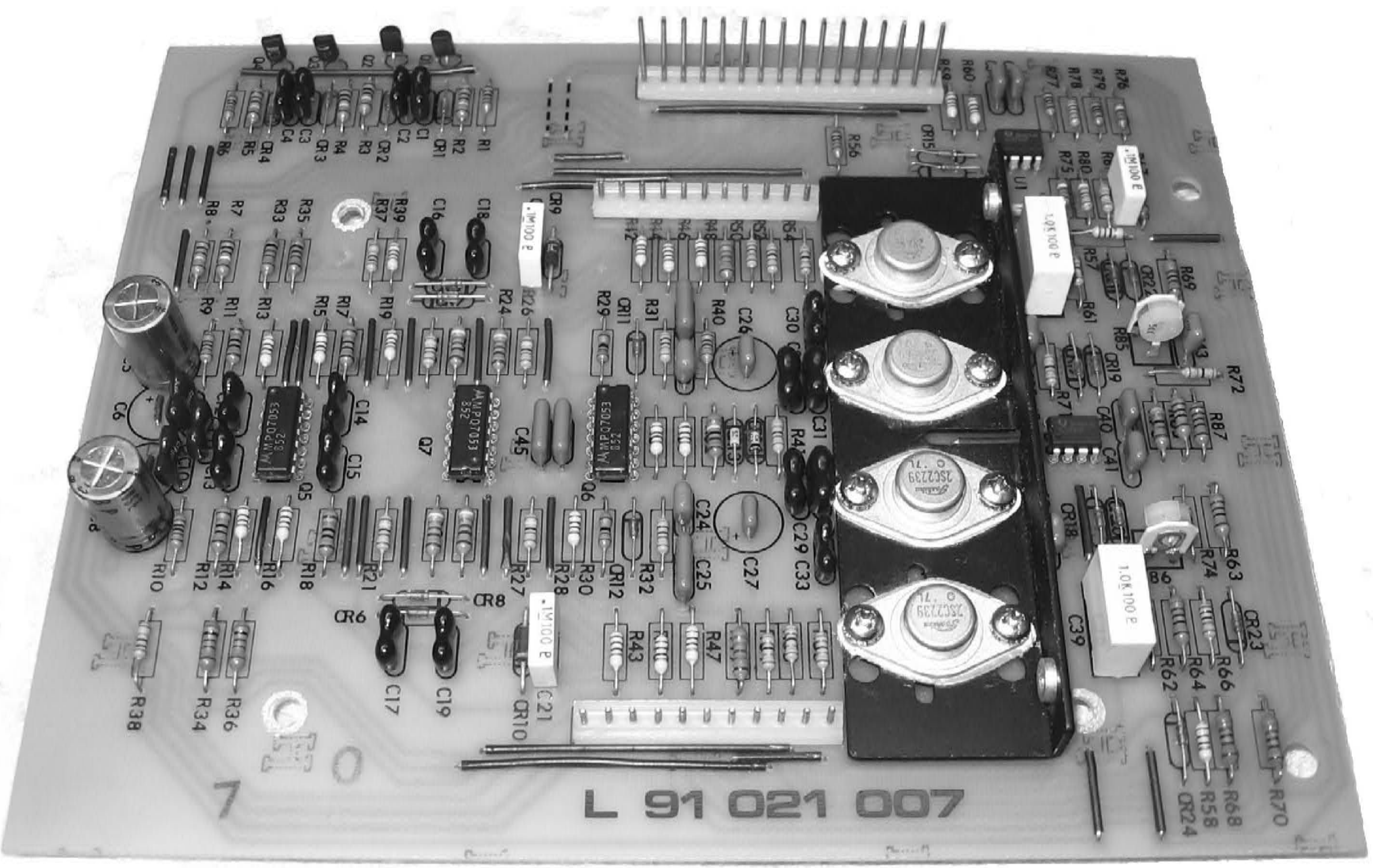
Replace the fans with newer ball-bearing units with the lowest CFM rating you can find.

The replacement output devices to use are the newer "perforated emitter" power parts from Motorola (ON-Semi). The numbers are MJ21193(PNP) and the MJ21194(NPN). These are the ones JB used in his upgrade program.

There is even a stronger set of devices, the MJ21195 (PNP) and MJ21196(NPN). The ft is low enough so there should not be any instabilities.

For the pre-drivers (2SA969 / 2SC2239), what is needed are VERY high voltage parts and the ones JB recommended are Toshiba 2SA1837(PNP) and 2SC4793(NPN). Since these are 100MHz devices , the compensation might require some adjustment.

91-021-007 Left Channel Drive Card with Updates



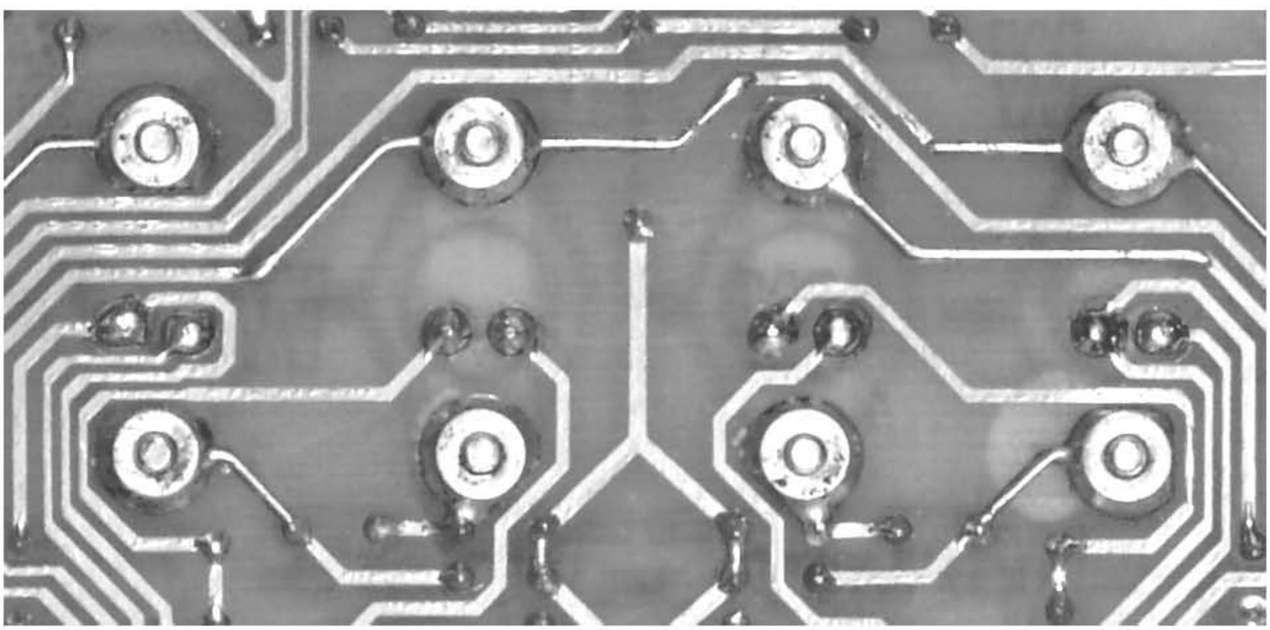
Possible TO-66 Cold Solder Joints on 91-021-007 / 91-021-040

Some units have seen problems with cold solder joints at the TO-66 screw sockets. These are the collectors for two 2SA969's & 2SC2239's on the main drive cards. A failure of any of these joints will cause 100VDC at the speaker outputs. The left channel card was sourced from a different vendor than the right card. The problem usually shows up on the left channel and sometimes only intermttently.

Resolder and reinforce the traces that go to these sockets on both cards.

There are eight screw sockets on each card.

The traces pictured below have been reinforced.



Additional information about the amplifier:

Only 385 were built.

Idles at about 25 watts Class A per channel and power consumption is typically between 100 & 200 watts at idle but each unit is different as they were biased individually when built.

Phase is non-inverting

Front panel lamps are #1815 14v 200ma.

Resistors are 1% metal film.

Adjustment trimmers are metal film types.

Thermal sensors are rated at 70 C

The Power is a full wave balanced bridge design and as such, each side of the output sees HALF of the load impedance. In the case of 2 ohm loads, each side of the bridge would be looking at 1 ohm. Even though the amplifier will drive this, prolonged output into 2 ohms at high levels may cause the thermal breakers to shut it down.

In 1980 the retail price of this amplifier was $3000.00. Bongiorno states if this unit were made today the retail price would probably be in the neighborhood of $15 to 20K considering all of today's factors.

This is a large amplifier and weighs about 90 lbs. There are 40 output devices yielding a total dissipation capability of 10,000 Watts.

Bongiorno intended the amplifier for high power ESL's. The rumor mill at the time (1980) suggested he designed it specifically for the Dayton Wrights. The Power has the same panel size as the Dayton Wright power supply unit.

Schematic Changes & Errors

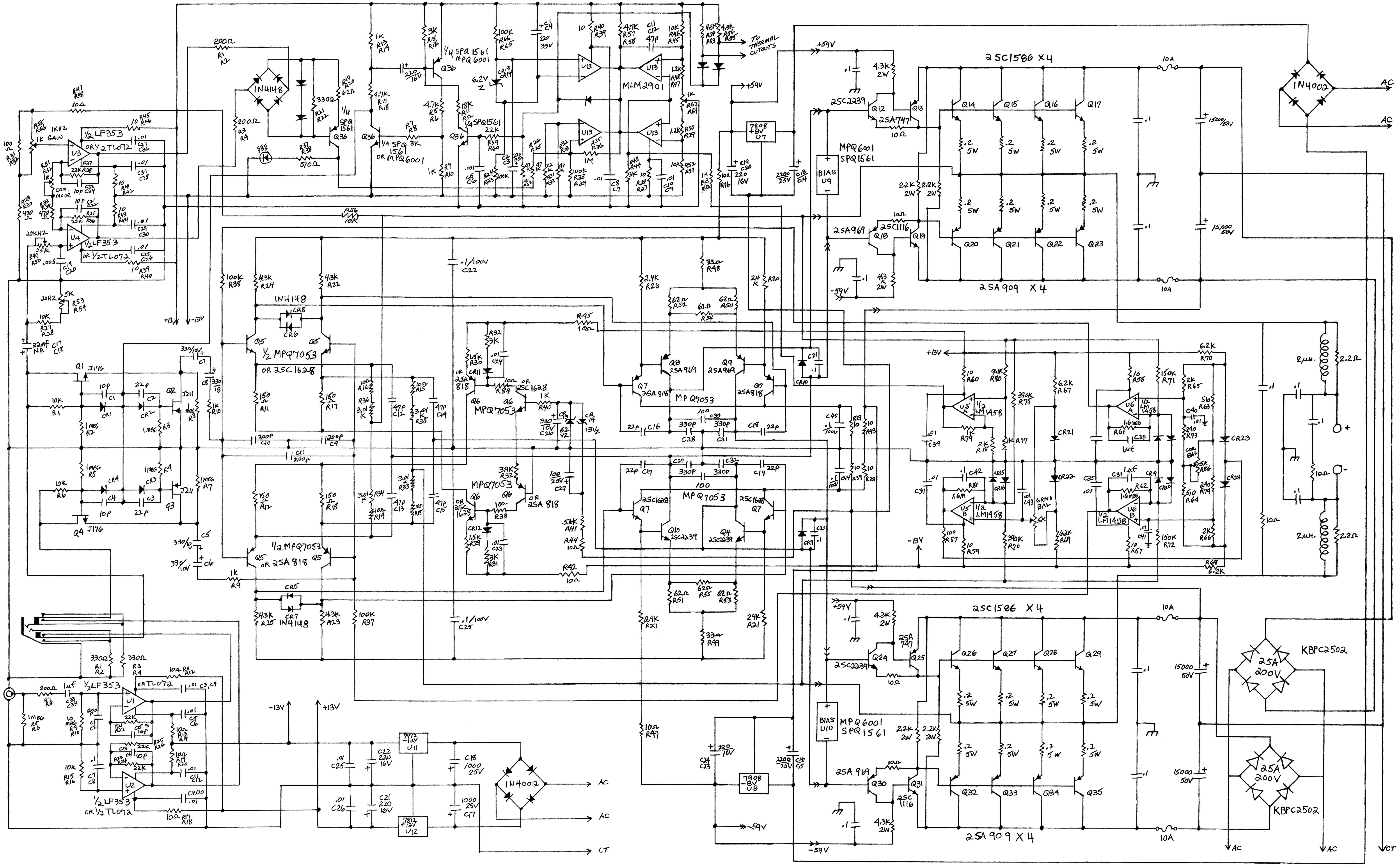
The main schematic contained in this document was created by James Bongiorno and and is presented exactly as he drew it. There are, however, possibly some differences we have found so they are listed here.

The FETs are swapped. The symbols for the J176 and J211 are correct but Reversed on the schematic. Q1/Q4 should be J211, Q2/Q3 should be J176.

C26 and C27 on the drive boards are films/ceramics mounted in an electrolytic location. All boards we have ever seen are like this but the schematic shows electrolytics in these locations.

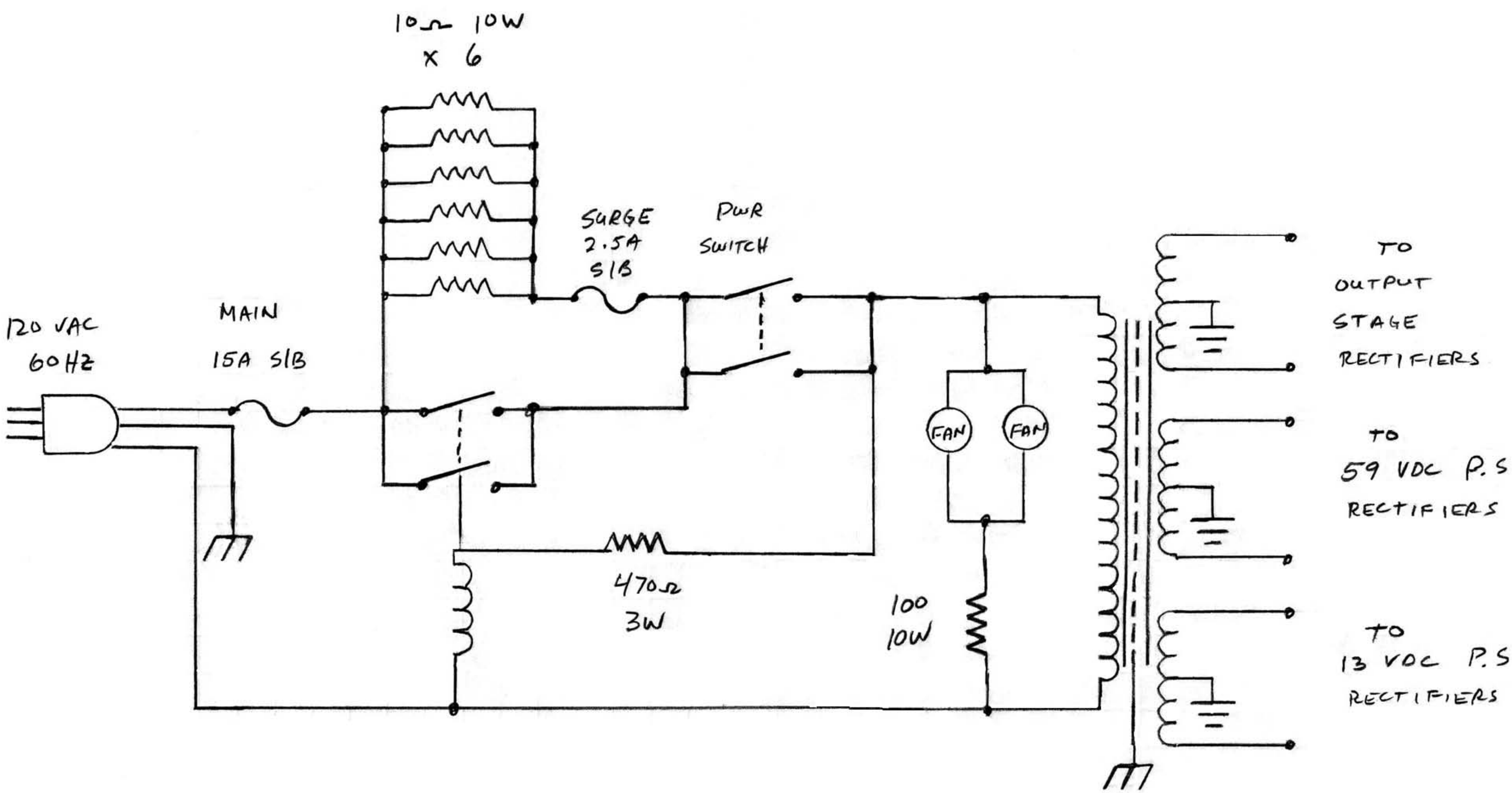
Where CR21 and CR22 cross the ground line, there should be connection dot. Same on the lower side of CR19 and CR20 where they go into the inverting input of U6.

For the drivers Q10/Q4 (2SC2239), Q4 should actually be designated as Q11. This is printed on the board underneath the heatsinks.

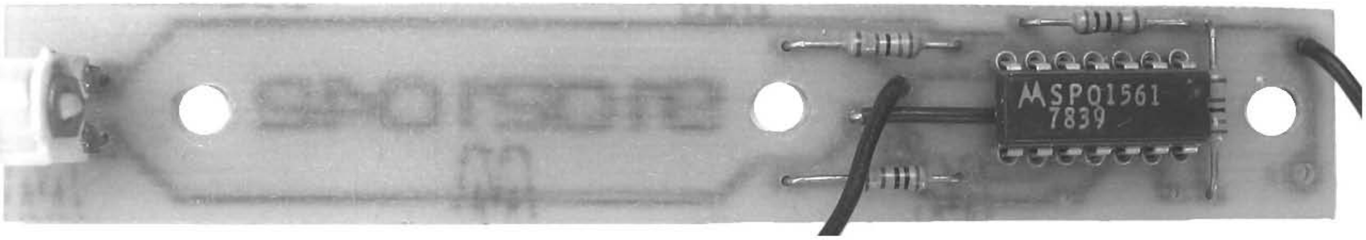


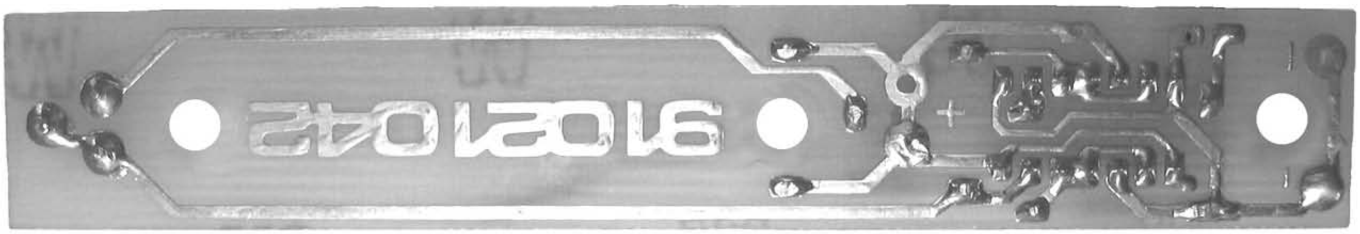
SUMO POWER DUAL DIFFERENTIAL AMPLIFIER

AC Line in to Transformer Out Schematic



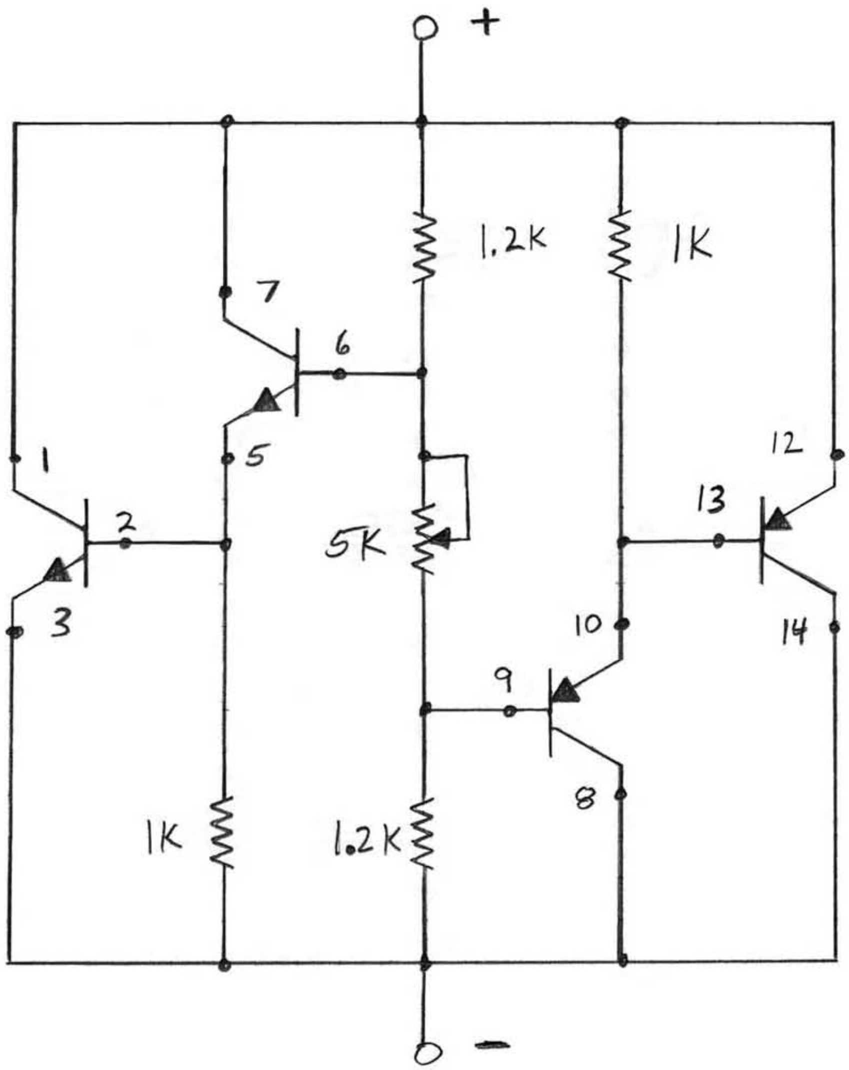
91-021-042 Bias Card Component & Foil Views





91-021-042 Bias Card Schematic

(U9 / U10 Detail)



Semiconductor & PCB Listing

Main Output Boards - Each channel has one 91-021-041 board and one 91-021-008 board

On each Output Board:

4 - SUMO 34001-001 or Sanken 2SC1586 NPN TO-3
4 - SUMO 34001-002 or Sanken 2SA909 PNP TO-3
1 - SUMO 34001-008 or Sanken 2SA747A PNP TO-3
1 - SUMO 34001-007 or Sanken 2SC1116A NPN TO-3
1 - Toshiba 2SA969 PNP TO66
1 - Toshiba 2SC2239 NPN TO66

Drive Boards - There are 2 drive boards. Left Channel = 91-021-007 Right Channel = 91-021-040

On each Drive Board:

2 - Toshiba 2SA969 PNP TO66
2 - Toshiba 2SC2239 NPN TO66
2 - LM1458 Dual OpAmp 8 Pin DIP
3 - MPQ7053 OR 2x 2SC1628 (NPN) & 2X 2SA818 (PNP)
2 - J211 N-Channel JFET
2 - J176 P-Channel JFET

Power Supply & State Variable Processor Board - 1 Board

91-021-009

2 - LM7908CT -8V
2 - LM340T8 or LM7808CT +8v
1 - LM7912CT -12v
1 - LM340T12 or LM7812CT +12v
2 - LM2901P Quad Comparator
2 - SPQ1561 or MPQ6001 or MPSA13/MPSA63 Darlingtons.
MPSA13 - EBC goes to 5,2,1
MPSA63 - EBC goes to 12,9,8
(Need only two per channel)

Semiconductor & PCB Listing - continued...

Input/Balanced Converter/State Variable Processor Board - 1 board

91-021-036

4 - LF353 or TL072

BIAS Adjustment Board - 4 boards - 2 per channel

91-021-042

On each BIAS Adjusment Board:

1 - SPQ1561 or MPQ6001

Rectifier Board - 2 Boards - 1 per channel

91-021-045

On each Rectifier Board:

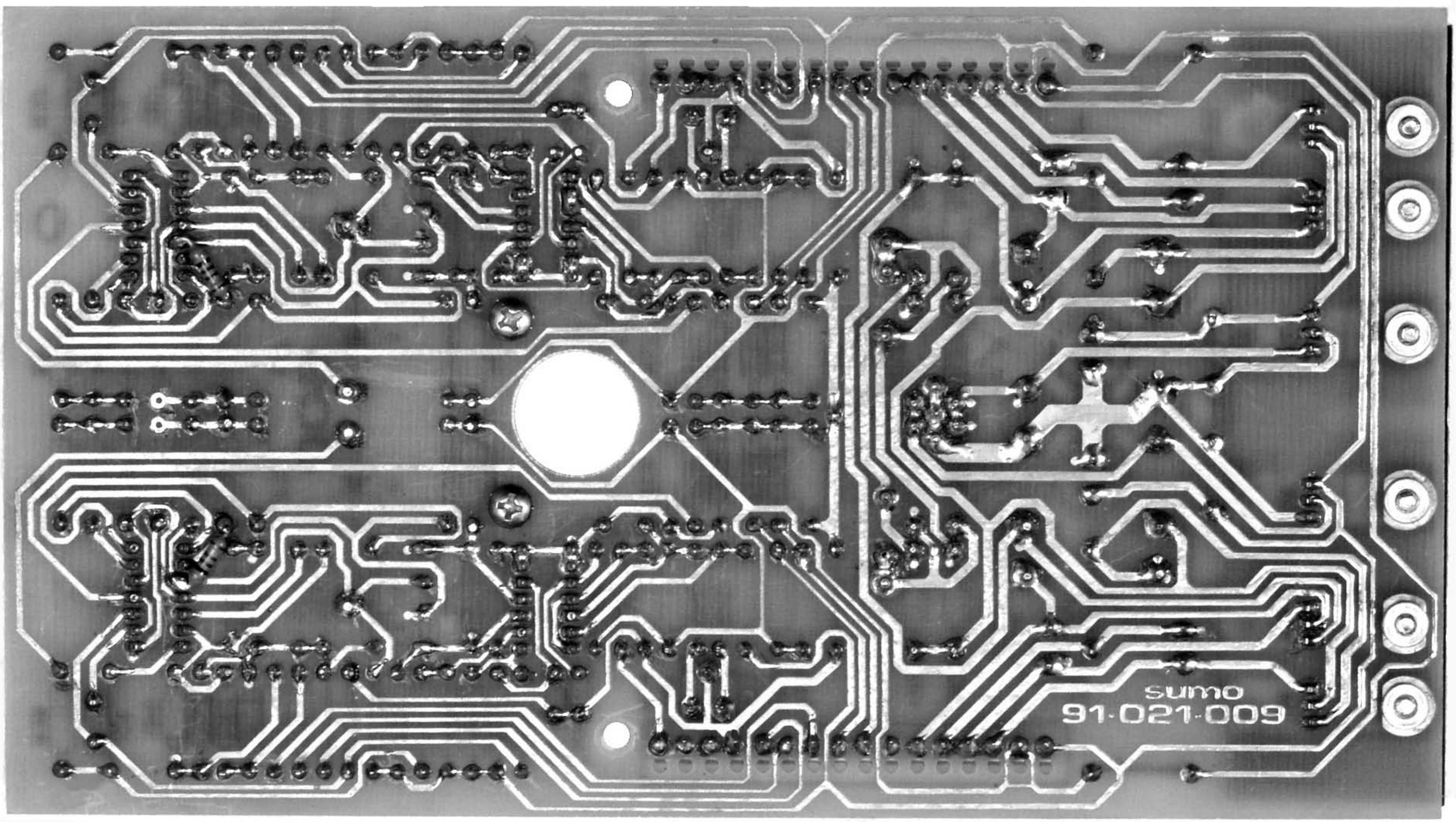
2 - KBPC25-02

Output Network Board - 2 Boards - 1 per channel

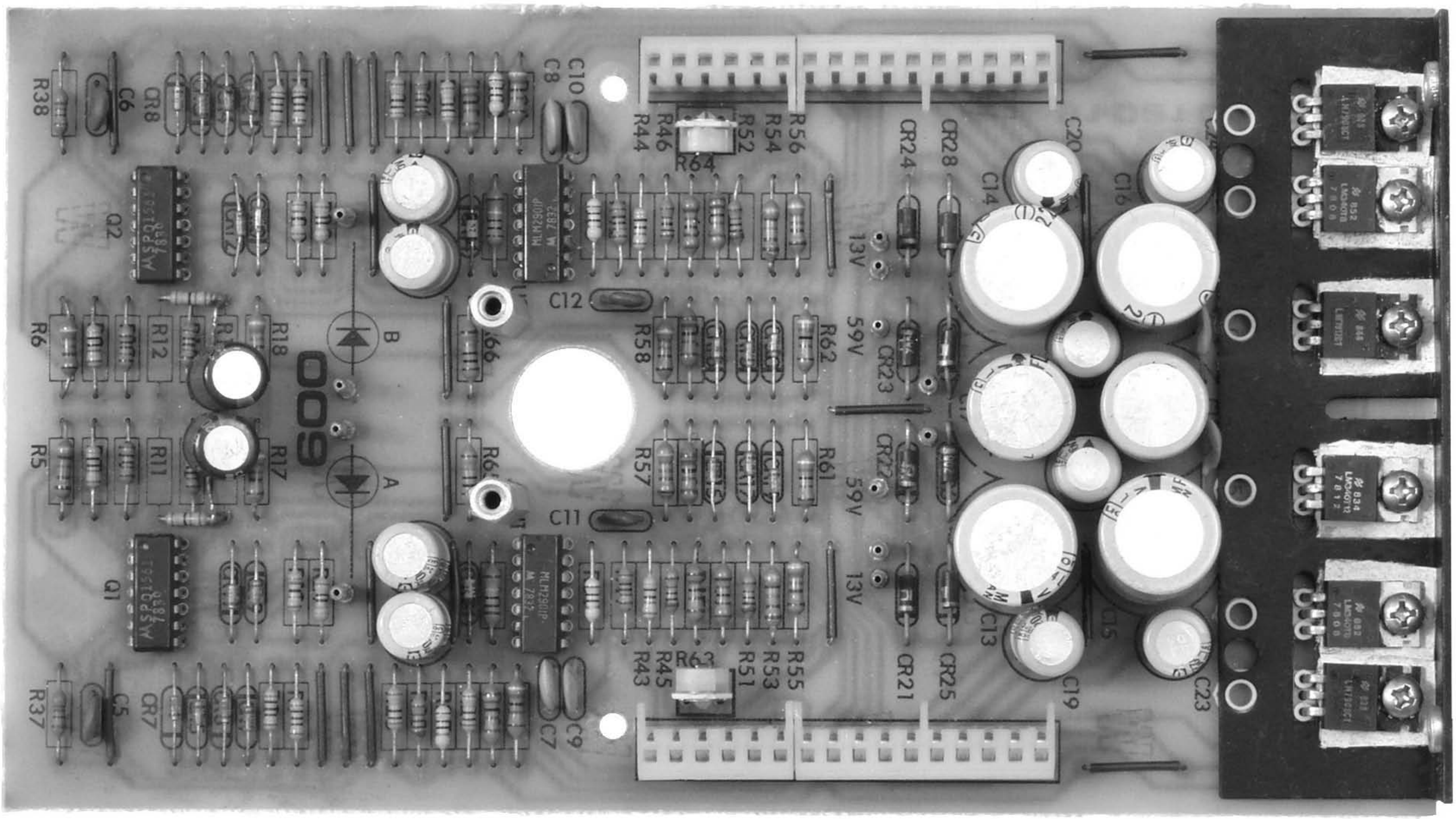
91-021-035

No Semiconductors

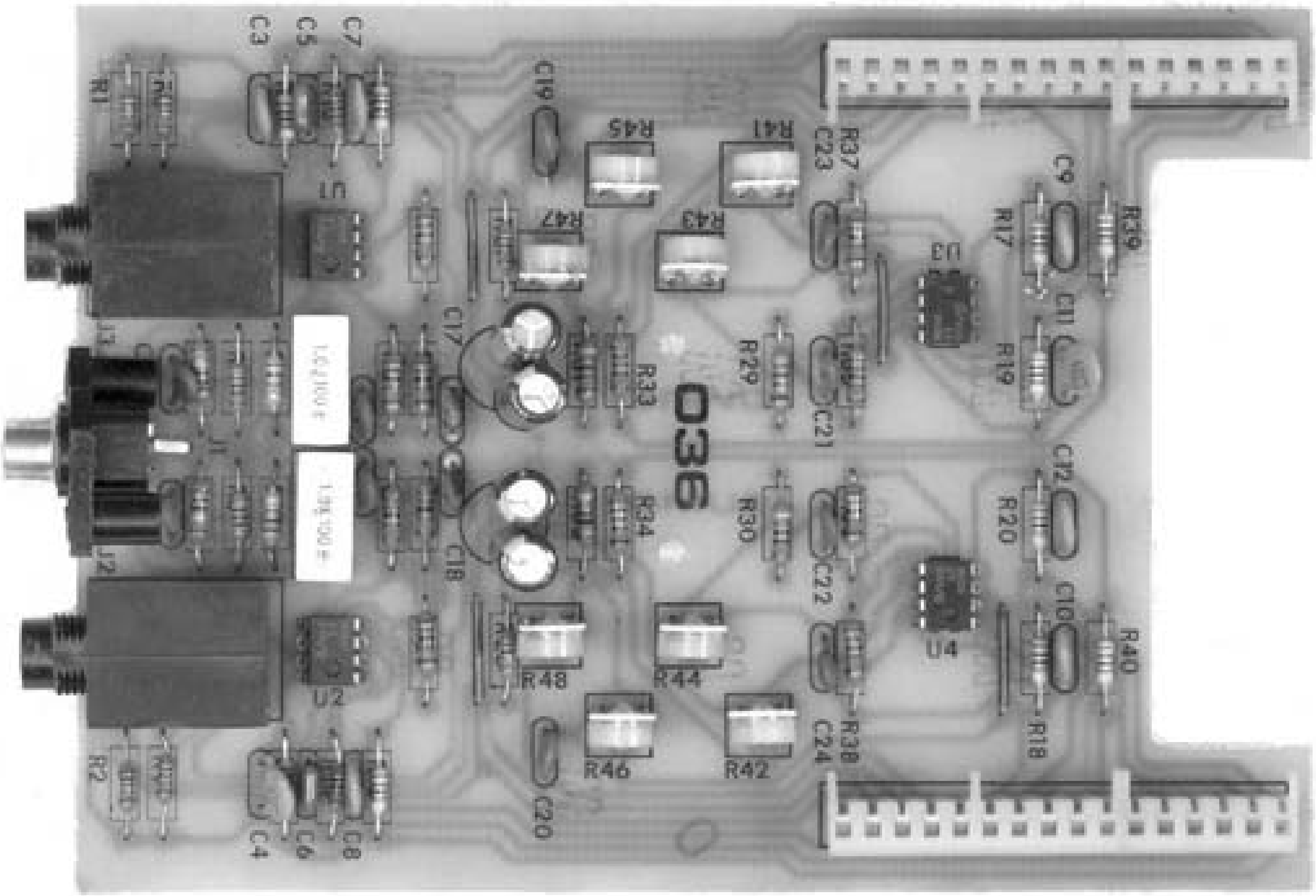
91-021-009 Power Supply & State Variable Processor Card Foil View

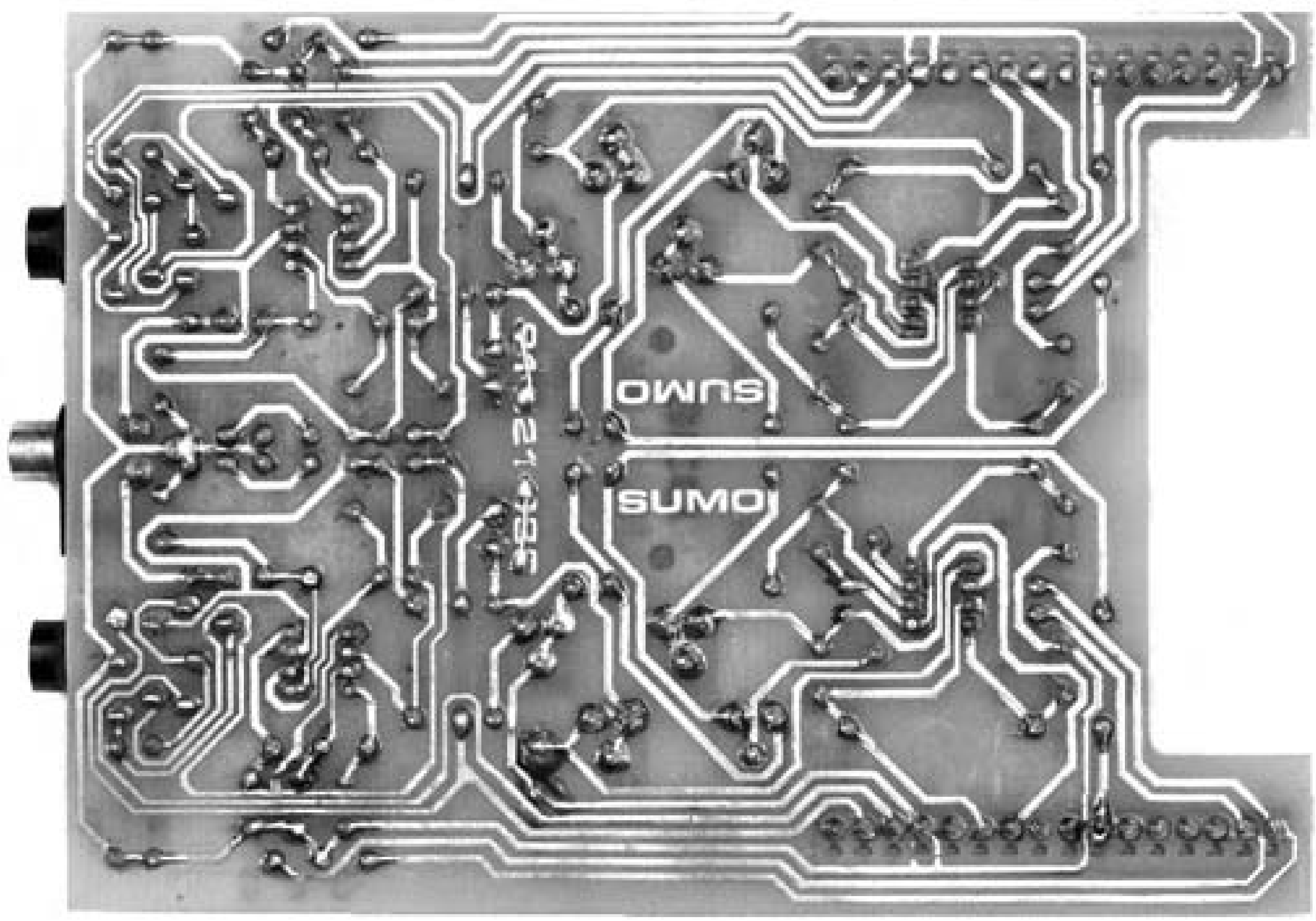


91-021-009   Power Supply / State Variable Processor Card   Component View

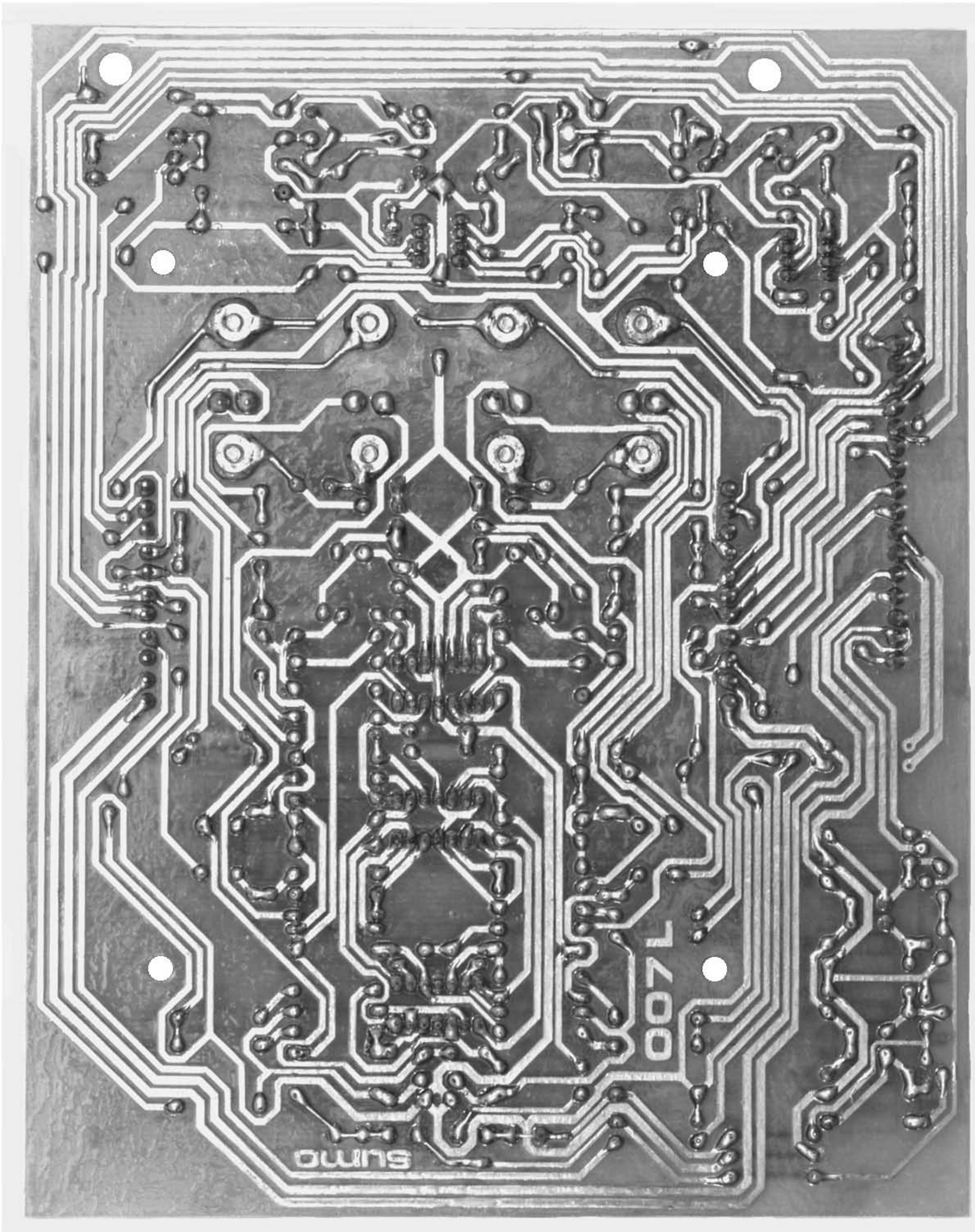


91-021-036   Input & Balanced Converter Card   Component & Foil Views

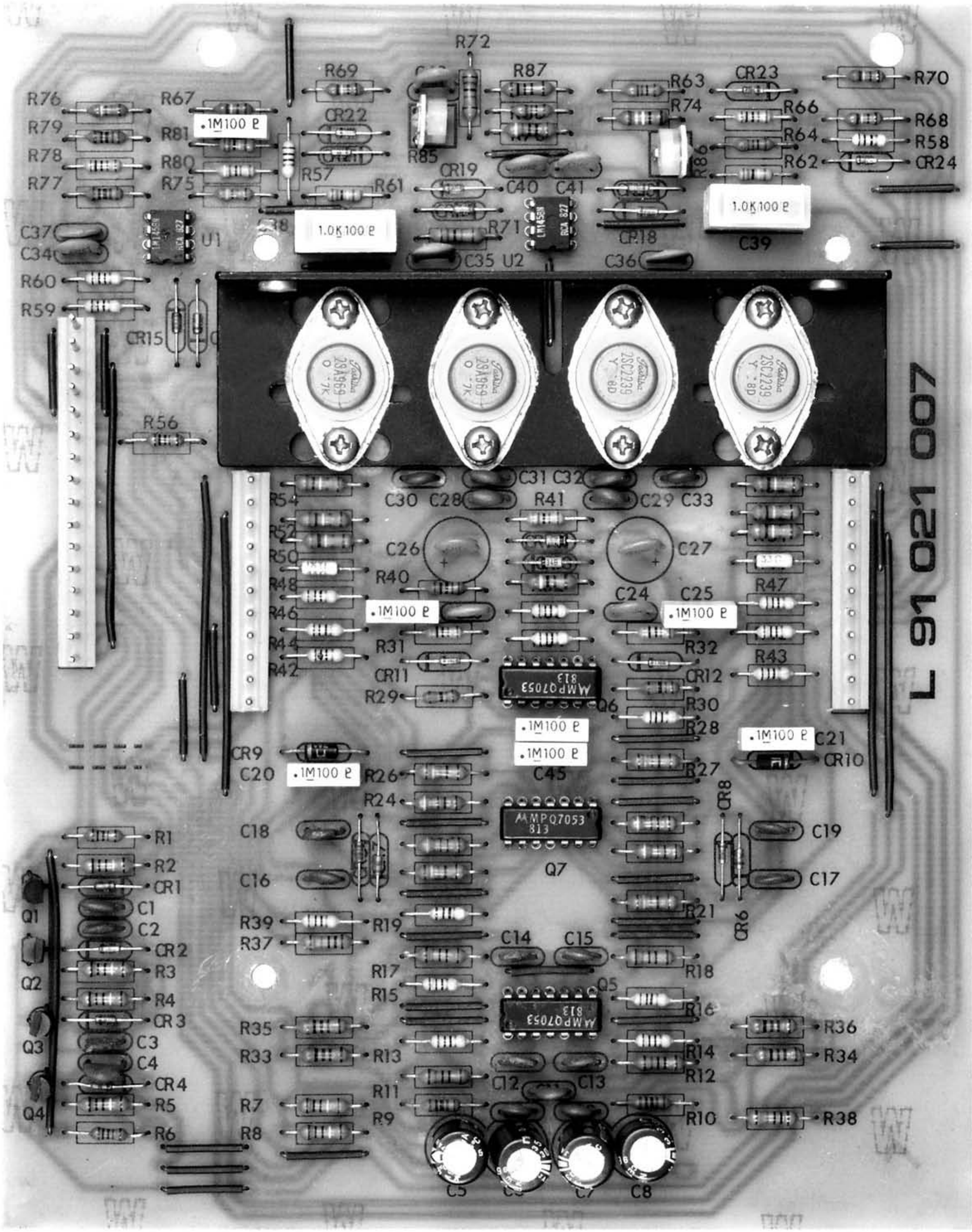




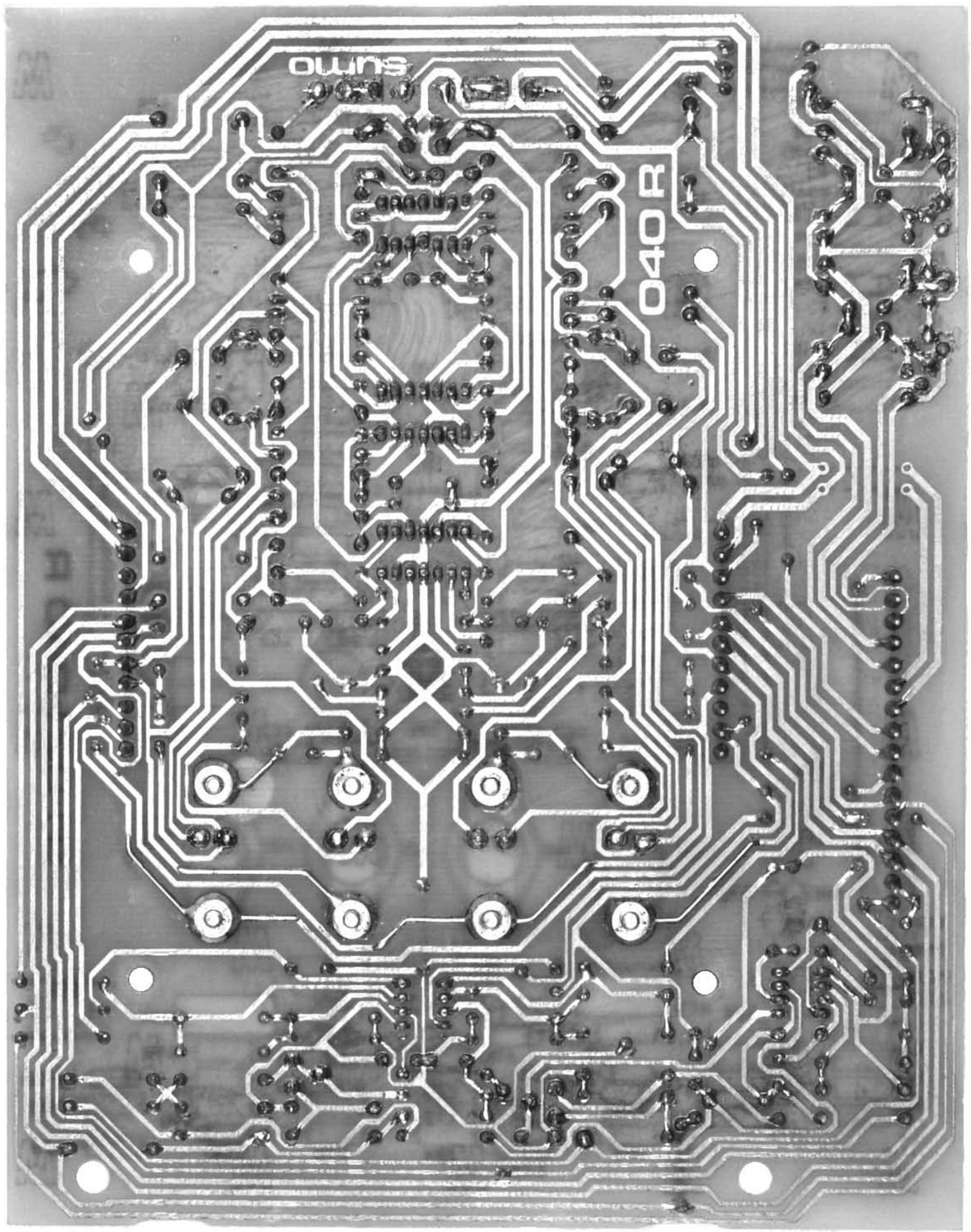
91-021-007 Left Channel Drive Card Foil View



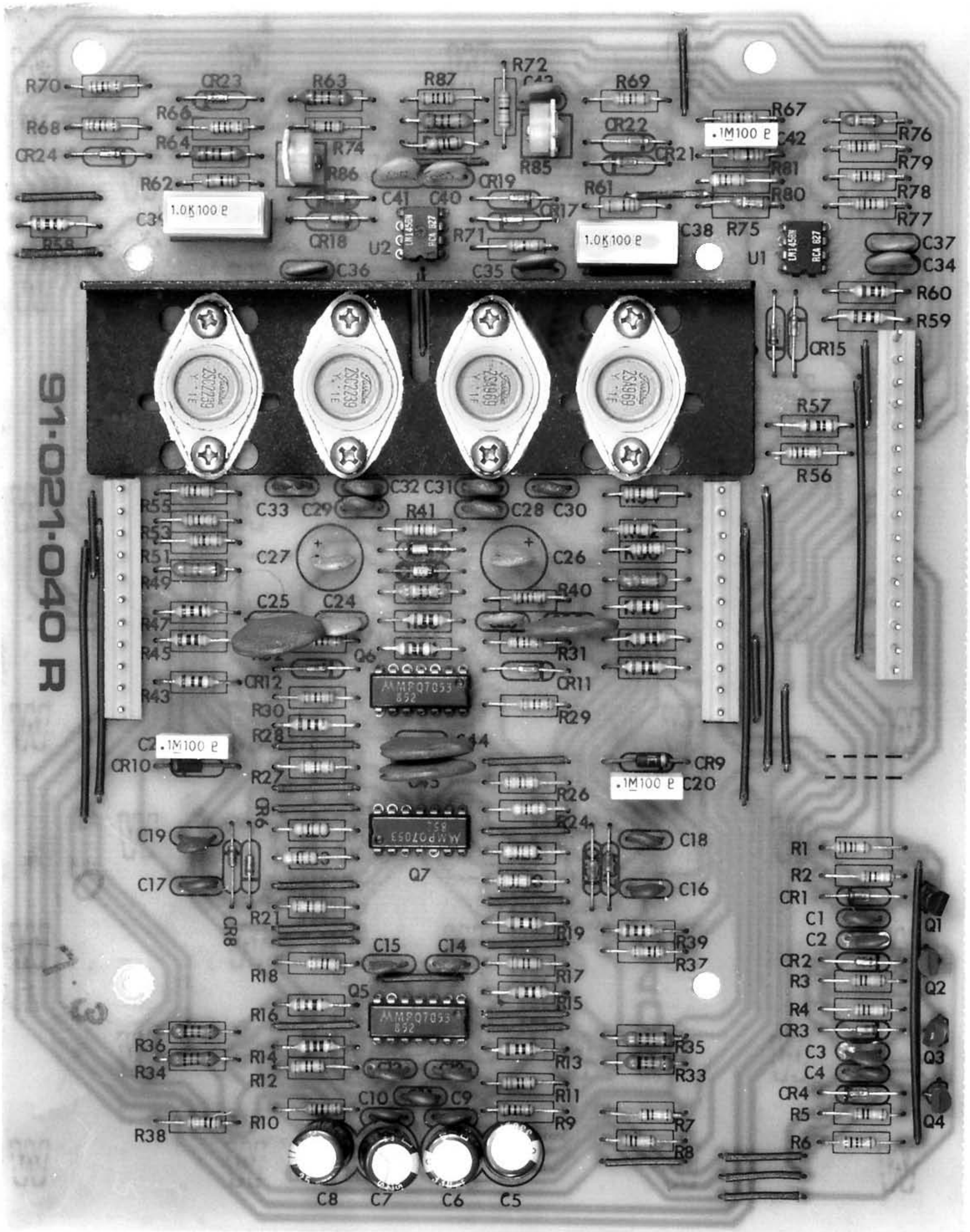
91-021-007   Left Channel Drive Card   Component View



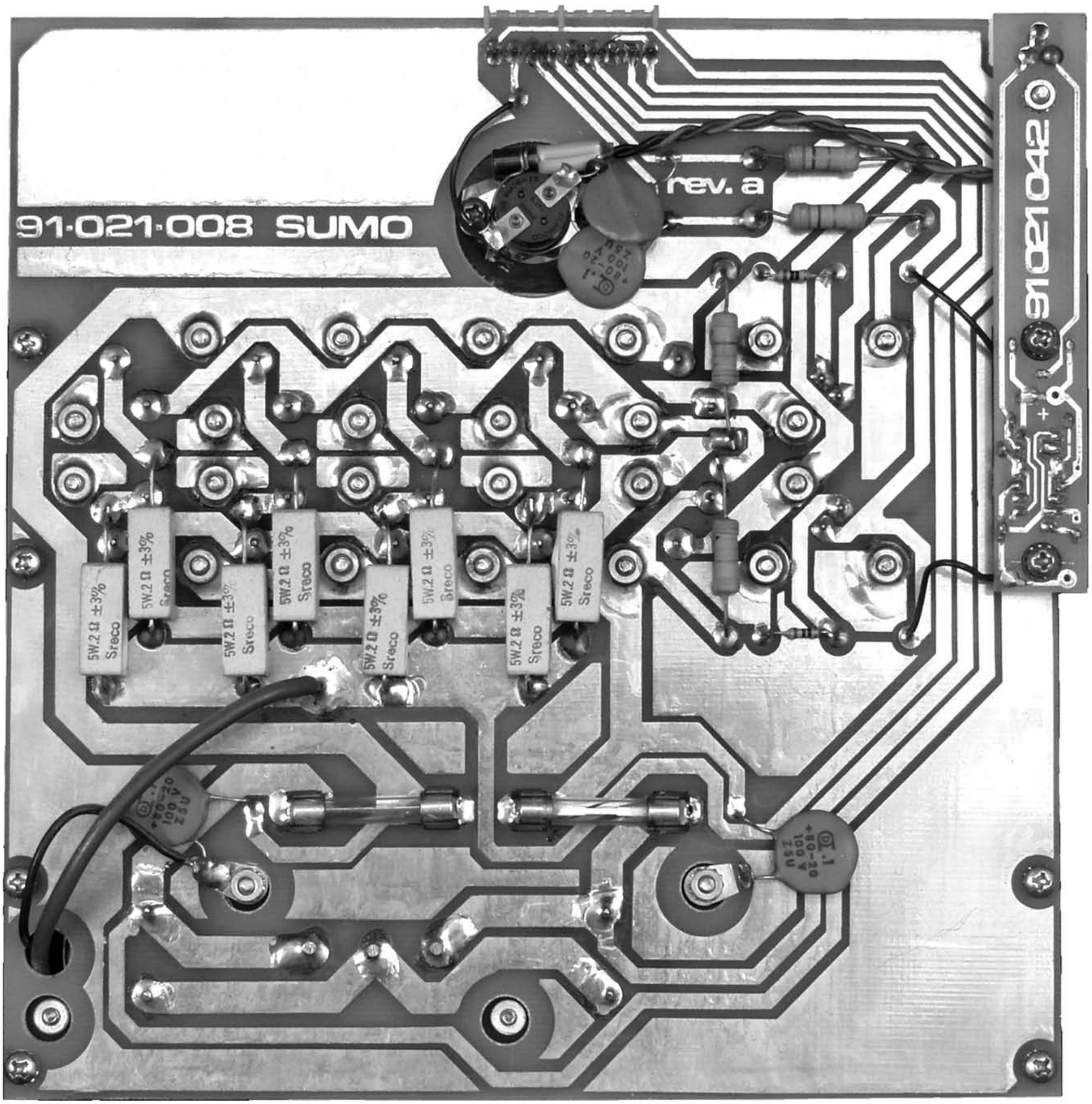
91-021-040   Right Channel Drive Card   Foil View



91-021-040 Right Channel Drive Card Component View



91-021-008 Power Output Board (Left -) Foil View

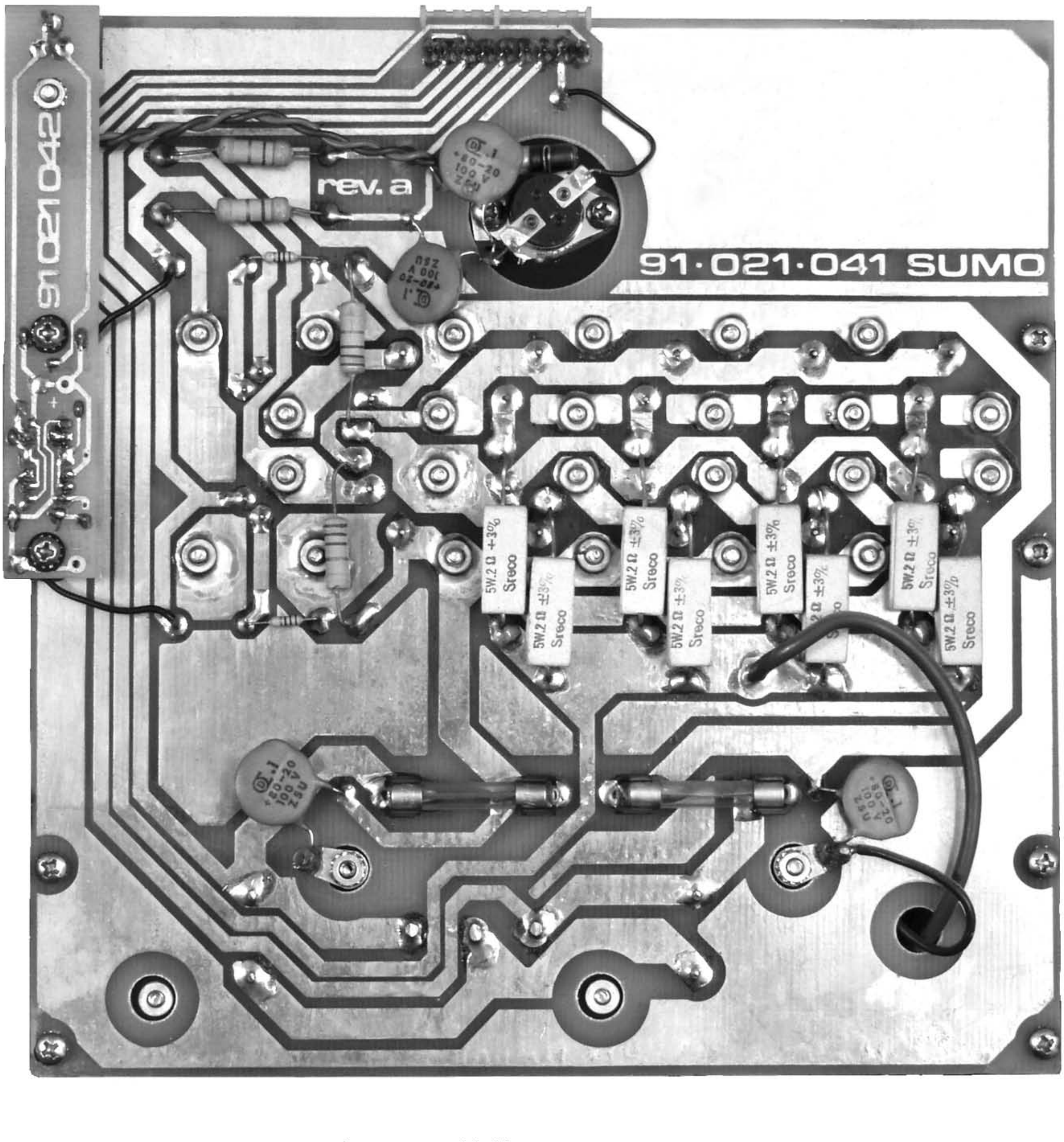


Front of Amplifier ------>

91-021-008 Power Output (Left -) Heatsink View

<------ Front of Amplifier

91-021-041 Power Output Board (Left +) Foil View

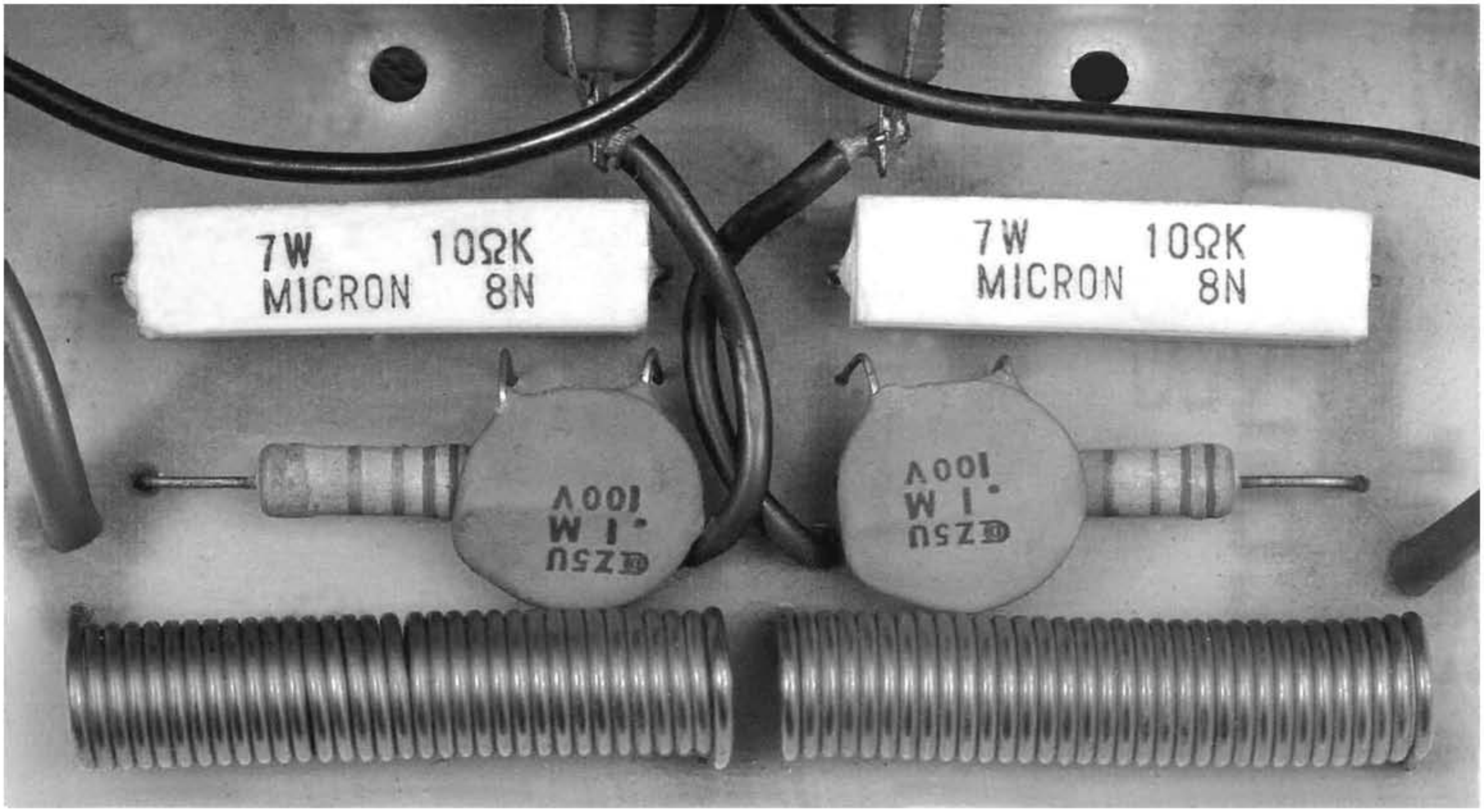


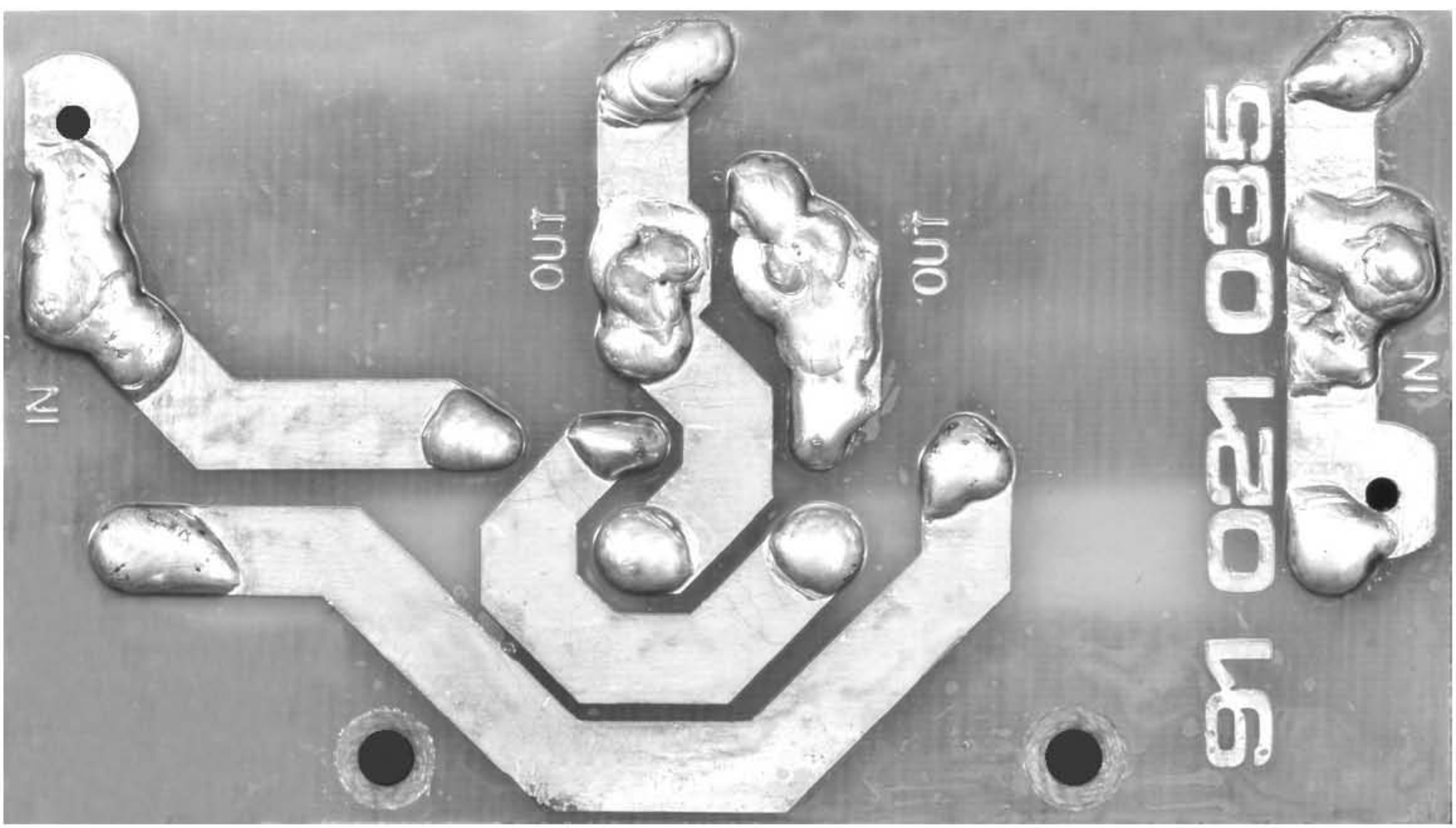
<------ Front of Amplifier

91-021-041 Power Output (Left +) Heatsink View

Front of Amplifier ------>

91-021-035 Output Termination Network Card Component & Foil Views





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