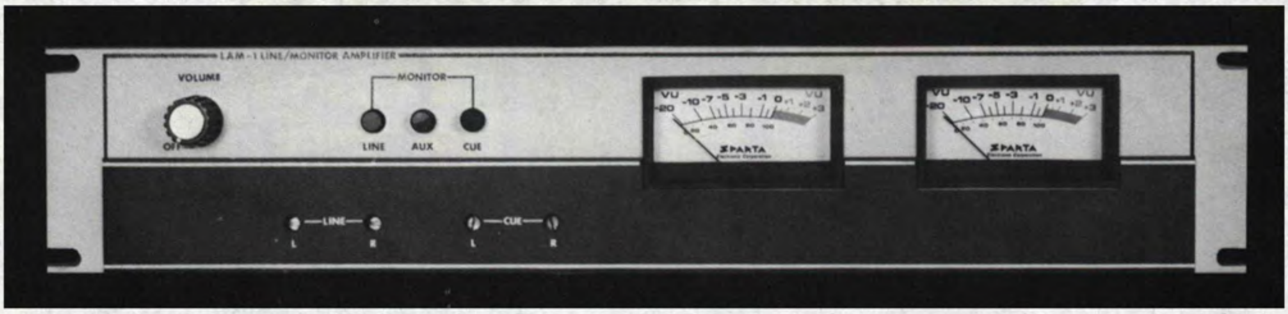
LAM-1 LINE AMPLIFIER AND MONITOR CONTROL

TECHNICAL MANUAL

SPARTA
Division of Cetec Corporation

5851 Florin-Perkins Road, Sacramento, Ca. 95828 • (916) 383-5353 • Telex 377-488 • Cable SPARTA

LAM-1 LINE AMPLIFIER AND MONITOR CONTROL



LAM-1 SPECIFICATIONS

LINE OUTPUT : 23 dbm, 600 ohms balanced. +8 dbm output gives 0 VU indication with standard pad configuration.

LINE INPUT : Unbalanced, 10K bridging. -12 dbm required for +8 dbm output.

CUE/AUX INPUT : Unbalanced, 10K bridging. -12 dbm required for 0 VU indication.

MONITOR OUTPUT: 1 volt nominal to high impedance load.

LINE AMP GAIN : 25 db. 4 db line isolation pad standard.

RESPONSE : 20 - 20,000 Hz, plus or minus 1 db.

DISTORTION : Line Amplifier - less than 0.5% 20 - 20,000 Hz @ +8 dbm output (no line pad) less than 1.0% 50 - 20,000 Hz @ +23 dbm output (no line pad).

NOISE : More than 100 db below line output of +23 dbm.

POWER : 117 volts, 50/60 Hz. [illegible]

DIMENSIONS : 3 1/2" high, 19" wide, [illegible] 11" deep. Power supply is 5" x 4" x 2".

WEIGHT : 12 pounds

OPTIONS : 8 watt per channel built-in monitor amplifier. Response plus or minus 2 db 30 - 20,000 Hz.

LAM-1 LINE AMPLIFIER/MONITOR CONTROL

INTRODUCTION: The LAM-1 (S) and LAM-1 (M) provide centralized monitoring and control of broadcast automation audio levels. Program output levels of up to +23 dbm are available. +8 dbm is standard for 0 VU meter indication. Three front panel push-button switches connect the VU meters and audio monitor output across the Line, Cue, or Aux output signals. Recessed level controls are provided on the front panel for the line amplifier(s) and cue amplifier(s). Optional 8 watt per channel monitor amplifiers are available and are contained within the 5 1/4" rack mount housing of the LAM-1. Otherwise, any external monitor amplifier can be used, such as the SPARTA MA-25 or MAS-50 series.

FUNCTIONS : In the Line monitor mode, the VU meters and audio monitor output are connected across the line amplifier output. This gives an accurate visual and aural indication of the automation audio output.

In the Cue monitor mode, the VU meters and audio monitor output are connected across the cue amplifier output. This switch position can be used for audition purposes, cueing tapes, and setting tape levels.

The Aux monitor mode feeds an uncommitted audio input to the cue amplifier and connects the VU meters and audio monitor across the cue amplifier. The Aux input can be used as an "air" monitor or with any other audio source of at least -15 dbm signal level. In SPARTAMATION systems, the Aux input is usually connected to the Monitor output of the 1052 Program Controller. This is a convenient point to check program audio before the 25Hz tone sensor and line amplifier. Since the audio is being monitored at a point before the high pass filters, 25Hz tone levels can be determined by using the Aux mode.

OPERATION:

The LAM-1 should be connected between the automation Program Controller and the transmitter, audio console, or amplifier which it feeds. If there is a 25Hz tone sensor external to the controller, the LAM-1 should be connected to its output. All inputs are 10,000 ohms unbalanced.

Levels should be adjusted using an NAB standard reference level tape. First adjust the output of the tape reproducer to the desired level (usually in the range of -10 to +4 dbm). With the LAM-1 monitor switch in the Line position, play the tape through the automation system. Using a screwdriver, adjust the front panel line amplifier gain control(s) until the VU meter(s) indicate 0 VU. Now play the tape through the audition channel of the controller, put the LAM-1 monitor switch in the Cue position and adjust the front panel cue amplifier gain control(s) until the VU meter(s) indicate 0 VU. It will now be possible to adjust the levels of the remaining tape reproducers by using the LAM-1 meter(s) as a reference. Play the standard reference level tape through the system on each tape reproducer and adjust the output of each to read 0 VU on the LAM-1. Since the Cue and Line readings have been set to be equal, it is also possible to set or check tape levels in the Cue monitor mode.

The Aux input does not have a separate gain control and so it may be necessary to attenuate the signal externally to provide meter readings comparable to Line and Cue. In the 1052 Program Controller, the Monitor and Audition outputs are at very nearly the same level, so no attenuation should be required.

CIRCUIT DESCRIPTIONS

LINE AMPLIFIER: The input stage, Q3 and Q4, is a differential comparator which performs three separate functions: First is signal amplification wherein Q3 operates in the transconductance mode; that is, the collector current is a function of base voltage. Second, a large proportion of the average dc voltage at the emitters of Q6 and Q7, which appears at the base of Q4, is compared to the base voltage of Q3 to stabilize the operating-points of the output transistors. And third, a small proportion of the output signal, which is fed back to the base of Q4, is compared to the input signal at the base of Q3, thereby setting the ac gain.

When power is first applied, C13 must be charged to one-half of the supply voltage through Q6, and to protect Q6 the charging-rate must be limited. Q6 cannot turn on until Q5 and hence Q3 begin to conduct. But Q3 cannot conduct any faster than C6 can charge, so C6 not only filters the bias current to Q3, but also controls the charge-rate of C13.

The ideal dc operating-point for the output transistors Q6 and Q7 is one half of the supply voltage, because this is the point at which the greatest peak-to-peak output-voltage swing, or headroom, is available. When first turned on, C6 charges and the base of Q3 is brought to 40% of the supply voltage. As C13 charges, the voltage common to the emitters of Q6 and Q7 rises towards the supply. Upon reaching one-half of the supply voltage, 80% of this (or 40% of the supply voltage) reaches the base of Q4 via dc divider R16, R15, R14 and R22.

These resistors form a dc divider because C11 prevents output signal currents from reaching Q4 via R15/R14. Thus the comparator Q3/Q4 compares the dc operating-point of the output to the base voltage of Q3, which is as stable as R9, R10 and R11 will allow. The dc gain of the amplifier, then, is very nearly unity, resulting in an extremely stable operating-point.

The ac, or signal gain, is determined in very similar fashion: The output signal is taken from the load end of C13 so the feedback signal is a true representation of the line output. At very low frequencies, both amplitude and phase of the output will change due to the rising reactance of C13. This change will appear as an error signal when compared with the input, and allows the reserve open-loop gain of the amplifier to correct the error, thereby permitting use of a capacitor of reasonable size and value while maintaining clean, undistorted response to below the audio range.

The ac feedback path is via divider R14 and R15 and gain is set by the ratio of these two resistors. The junction of R15 and R16 is at ac ground so R16 plays no part at audio frequencies. It can be seen, however, that ac gain would drop to near unity if C11 were open or removed. The ac gain is therefore set at 11, or 21 db.

The collector impedance of Q3 is so high that R13 has no effect on gain. In the event of circuit failure, however, it serves to protect Q5 by limiting base current. D1 provides ambient temperature compensation for Q6 and Q7, while R17, R20 and R21 provide operating bias and thermal stability. At maximum signal amplitudes Q6 and Q7 must approach saturation. Q6 can readily do so because its base current comes from Q5, and Q5's collector current is determined by its base current -- not its collector voltage. The base current to Q7, however, is dependent upon R18 and R19 and without C12 the base current would fall off as the base approached ground, resulting in clipping and/or distortion. With the junction of R18 and R19 "boot-strapped" from the output, R17 appears as a constant-current source to Q7 and the junction can be driven below ground.

R22 raises the source-impedance of the line amp, at the expense of nearly 6 db of signal level, so as to provide a good match for the 60 ohm primary of the line output transformer. The transformer produces 10 db of voltage gain, which is followed by a 4 db loss in a resistive isolation pad. The rms signal voltage at the emitters of Q6 and Q7 is therefore the same as the rms voltage delivered to the external 600 ohm load.

If we assume a nominal Ø dbm voltage-level at the top of the Master gain control the 1020 line amplifier will produce 8 dbm (at Ø VU) into the output line with 13 db of gain left to recover loss in the Master gain control.

Component failures, if they occur, will almost always result in a shift of operating-point. If the operating-points in the 1020 are normal, all of the components associated with dc operation must be normal, including the transistors. So if an amplifier then has no ac gain, the logical suspects will be capacitors which may open without affecting dc operation. Capacitors C8, C9 and C10 may safely be ignored at this time since they are only effective above the audio spectrum.

Noise or hiss, may be due to almost any component but these associated with Q3 and Q4 would be most suspect since subsequent gain is the highest. Hum (120 Hz) would of course lead one to the power supply.

Distortion will be practically non-existent if normal dc and ac gain is obtained. The line amplifier, for example has an open-loop gain of more than 66 db, providing more than 45 db of feedback so that distortion is almost un-measureable. If distortion does arise, it will almost always be the result of transistor substitution.

MONITOR AMPLIFIER: The 1025 Monitor Amp provides 8 watts rms into an 8 ohm speaker load and will deliver slightly higher power into loads as low as 4 ohms. With loads higher than 8 ohms, power is limited primarily by the power-supply voltage and will be correspondingly reduced. The output circuitry is transformerless and can be considered as a virtually true voltage source; that is, the source impedance is very low compared to the load impedance. For this reason the load should never be less than 4 ohms, and a short-circuit should be avoided at all costs.

The input impedance is quite high, 50K ohms and the AC gain is set at approximately 40 (32 db) by a closed-loop feedback network. The open-loop gain is nearly 2000 which accounts in part for the typically low distortion of less than 0.5%.

DC stability (output "Q" point) is stabilized by a DC feedback loop which sets the DC gain to near-unity and samples the output-stage operating-point.

The input transistor Ql operates in the transconductance mode (output current proportional to input voltage) with both AC and DC feedback to the emitter. Since the output stage is in-phase with the input signal, feedback to the emitter tends to cancel the input voltage and is therefore negative feedback.

The second stage Q2 operates in the trans-impedance made by converting its base current to a rather large collector-voltage swing. The voltage gain, per se, of the 1025A takes place in this stage.

Transistors Q3 and Q4 are a complementary pair that provide current gain for driving the totem-pole output pair, Q5 and Q6. Although Q3 may appear to be providing voltage-gain, it actually is simply providing phase-inversion and base-current drive to Q5 as a conventional Darlington driver. To do so, its CE voltage must follow that of Q2.

DC FEEDBACK: The Key to circuit understanding and easy repair lies in the feedback networks. Referring to the schematic S-14, the collector voltage of Q5 should be very near to one-half of the supply voltage, or 14 volts, to assure that the output signal voltage can swing an equal amount in both directions before clipping occurs.

The output voltage is fed via R7 and R6 to the emitter of Q1, where it is compared to the base voltage of Q1 as determined by divider R2/R3. If the average output voltage tries to change in either direction, it appears as an error signal to Q1, and therefore the output operating-point is determined almost solely by R2 and R3. Capacitor C4 prevents output voltage changes at an audio rate from reaching Q1 via R7, so that at DC and sub-audible frequencies the gain is very near to unity, insuring that the average output-stage voltage is essentially the same as the base of Q1.

Closer examination will show that R5 will act as a divider with R6 and R7 so that the emitter voltage of Q1 would be less than the output voltage. Because of this attenuation, plus the EB drop of Q1, the base voltage of Q1 is set slightly higher than one-half of the supply.

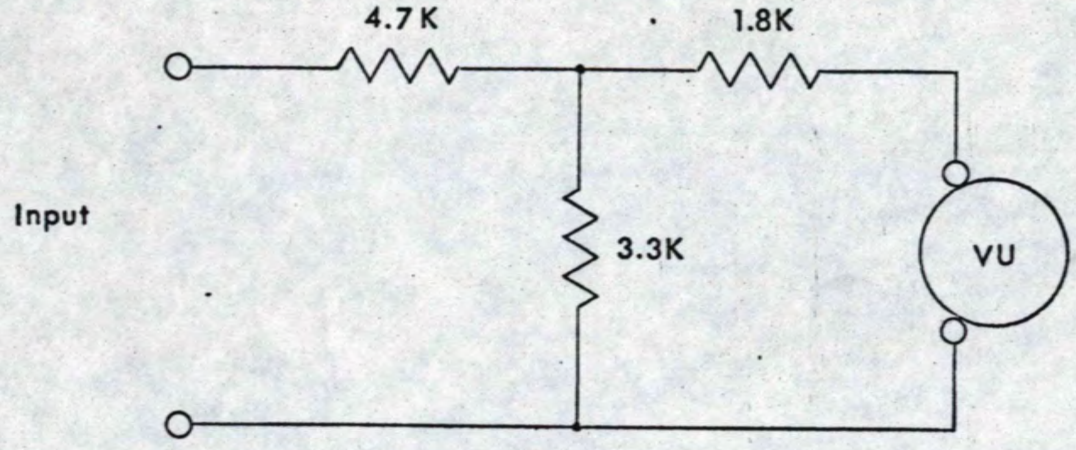
In the event of circuit failure, the first step is to measure the collector voltage of Q5. If it is correct, then all transistors and resistors are normal since neither can tell the difference between DC and audio AC!

AC FEEDBACK: The AC gain is determined by a secondary feedback network in a manner similar to the DC case. The output voltage from terminal 3 is fed back to Q1 via R5. Since the junction of R6 and R7 is AC bypassed to ground, R5 and R6 comprise an AC voltage divider. The AC output voltage, then, is allowed to be higher than the input by the ratio of R5 to R6. Since R5 is so much higher than R6 plus R7, it has little effect upon the DC operating point.

By taking the AC feedback from the load end of C6, the full open-loop gain of the amplifier is used to correct for amplitude loss and phase-shift at the lowest frequencies. This allows extended low-frequency response with a reasonable value for C6.

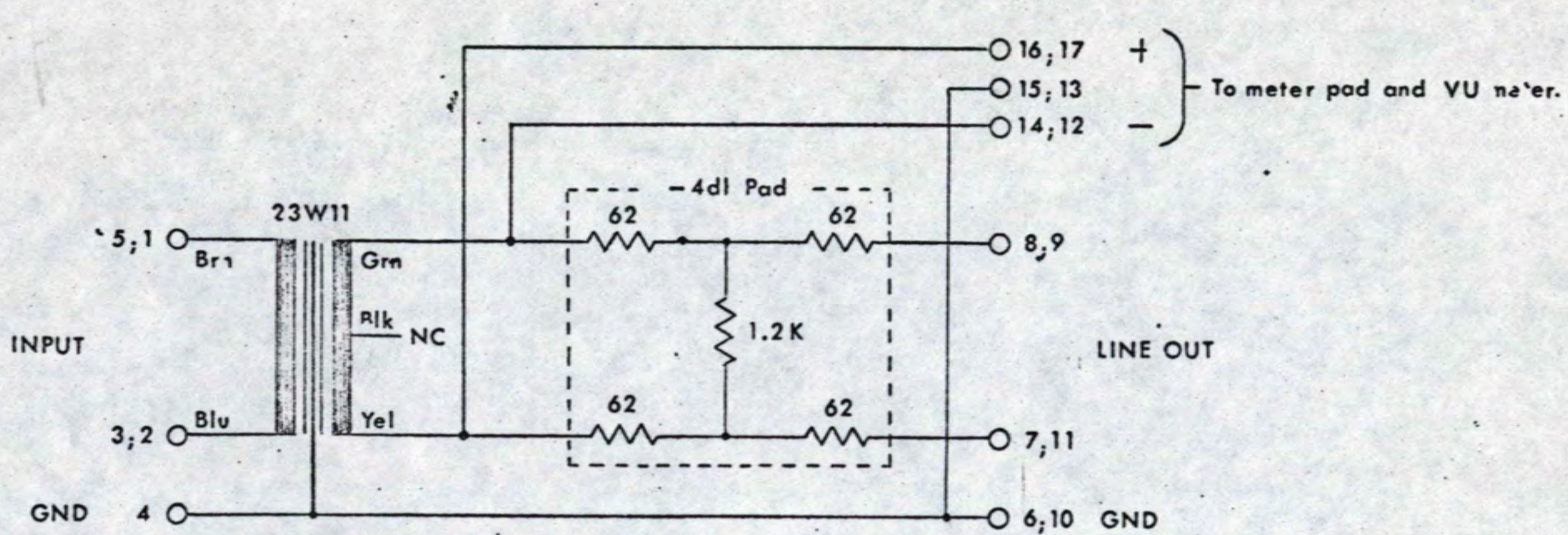
BIAS: Diode D1 and resistor R8 comprise a vias network to assure that Q3 to Q6 are always conducting so as to avoid "crossover" distortion. The quiescent current of the 1025 is determined primarily by the idling current of Q5 and Q6, and should normally not exceed 10 or 12 ma.

Since all transistors are silicon, if the quiescent current is too high diode D1 should immediately be suspect. If the operating-point is normal the problem can be localized by shorting the bases of Q3 and Q4 together. The idling current should drop sharply, thereby eliminating Q3 to Q6 as possible causes.



All resistors $\frac{1}{2}$ W, 5%

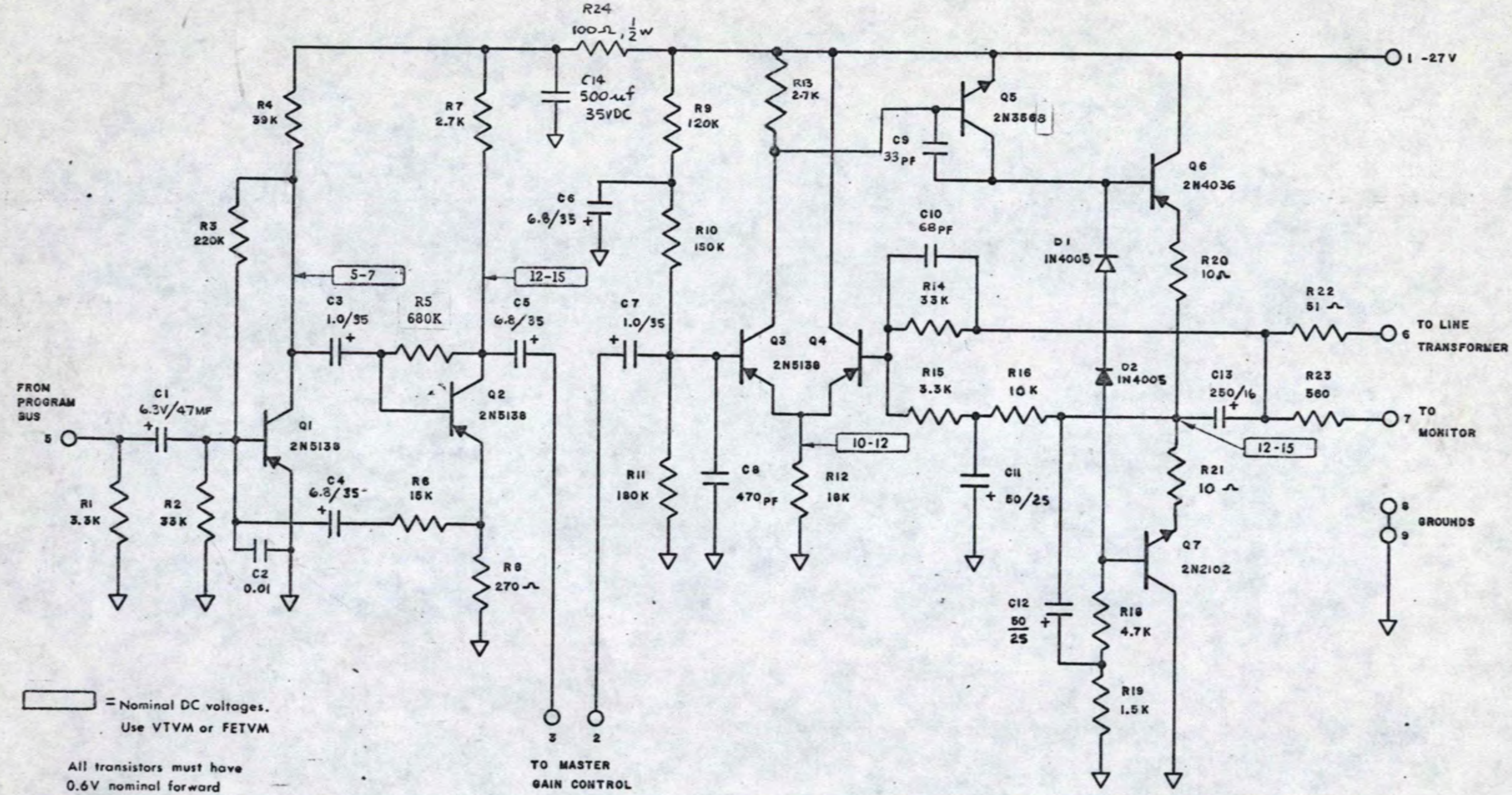
SPARTA ELECTRONIC CORP				
905 METER PAD				
Drawn	Checked	Date	Revised	Number
smu	RKO	11-20-69		S-23



Primary, 60 ohm
Secondary, 600 ohm
−1db, 20Hz to 20KHz at 24dbm

Resistors $\frac{1}{2}$ W 5%

SPARTA ELECTRONIC CORP				
1022 DUAL OUTPUT CARD				
Drawn	Checked	Date	Revised	Number
SMU	[illegible]	11-20-69	ECR98 8 JUN 70	S-22-C



= Nominal DC voltages.
Use VTVM or FETVM

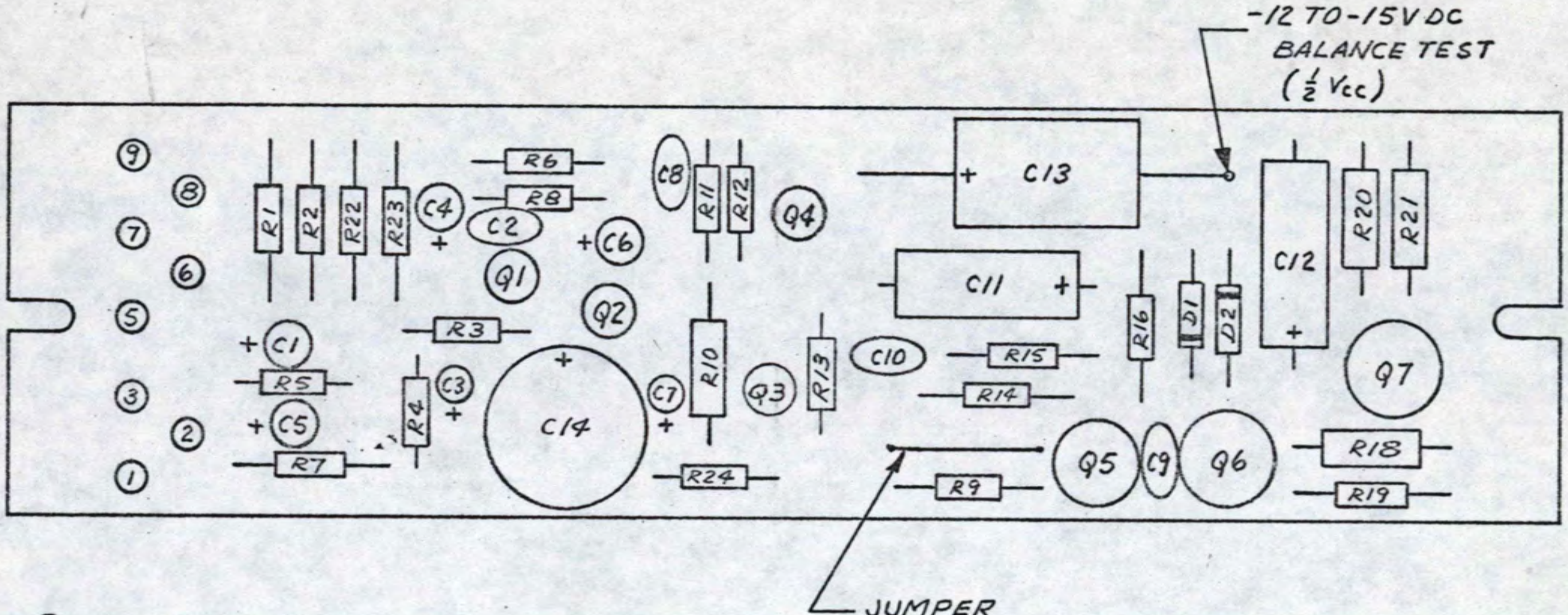
All transistors must have 0.6V nominal forward emitter-to-base bias.

- (L) ECR 580 R17 WAS 68Ω
- (K) ECR487 ADD R24 & C14
- (J) ECR278
- (H) ECR 199; C9 was 10pf
- (G) ECR177
- (F) 13Oct70 ECR 150
- (P) SEE ECR #1065, 12-3-76
- (E) 15 JULY70: ECR114, Q5 WAS 2N3568
- (D) 12 FEB70: ECR 52
- (N) ECR785 R5 WAS 270K
- (C) 6FEB70: ECR 46
- (M) ECR 692, R13 JUMPERED, R13 2.7K ADDED, R17 REPLACED BY D2.

SPARTA
ELECTRONIC CORPORATION
SACRAMENTO, CALIFORNIA

TITLE
1020
PROGRAM LINE AMP
& MIXER AMP

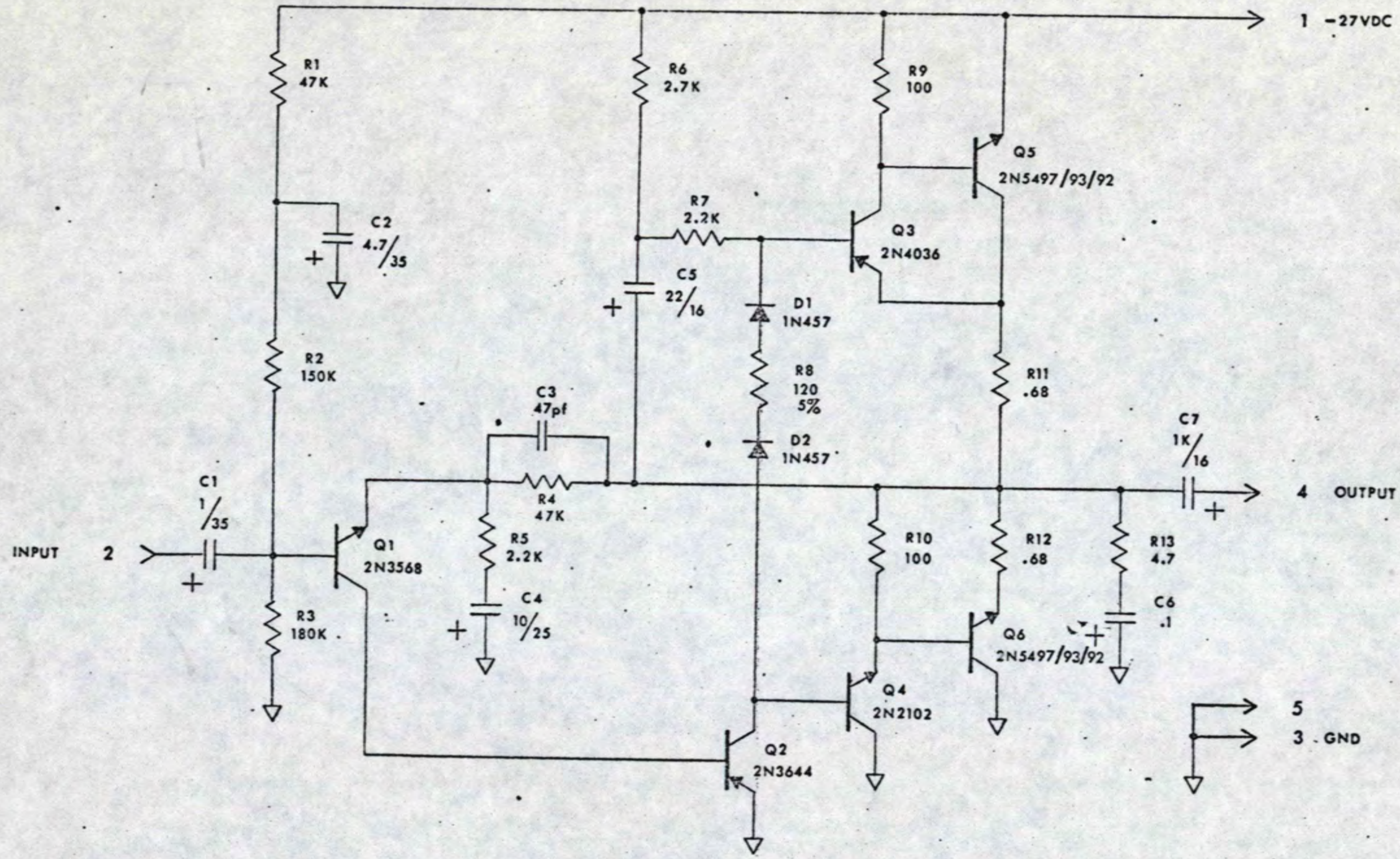
DRWN.	SMU	DATE	4-15-69	SHT OF	DWG. NO.	S-2P

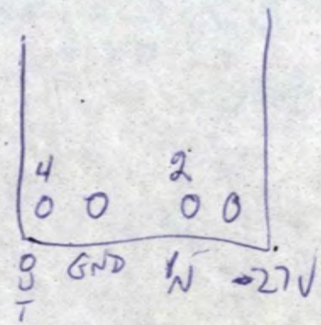


① -27 V DC
② LINE AMP IN
③ MIX AMP OUT
⑤ MIX AMP IN
⑥ LINE AMP OUT
⑦ MONITOR
⑧ ⑨ GND

REFER TO SCHEMATIC S-2K

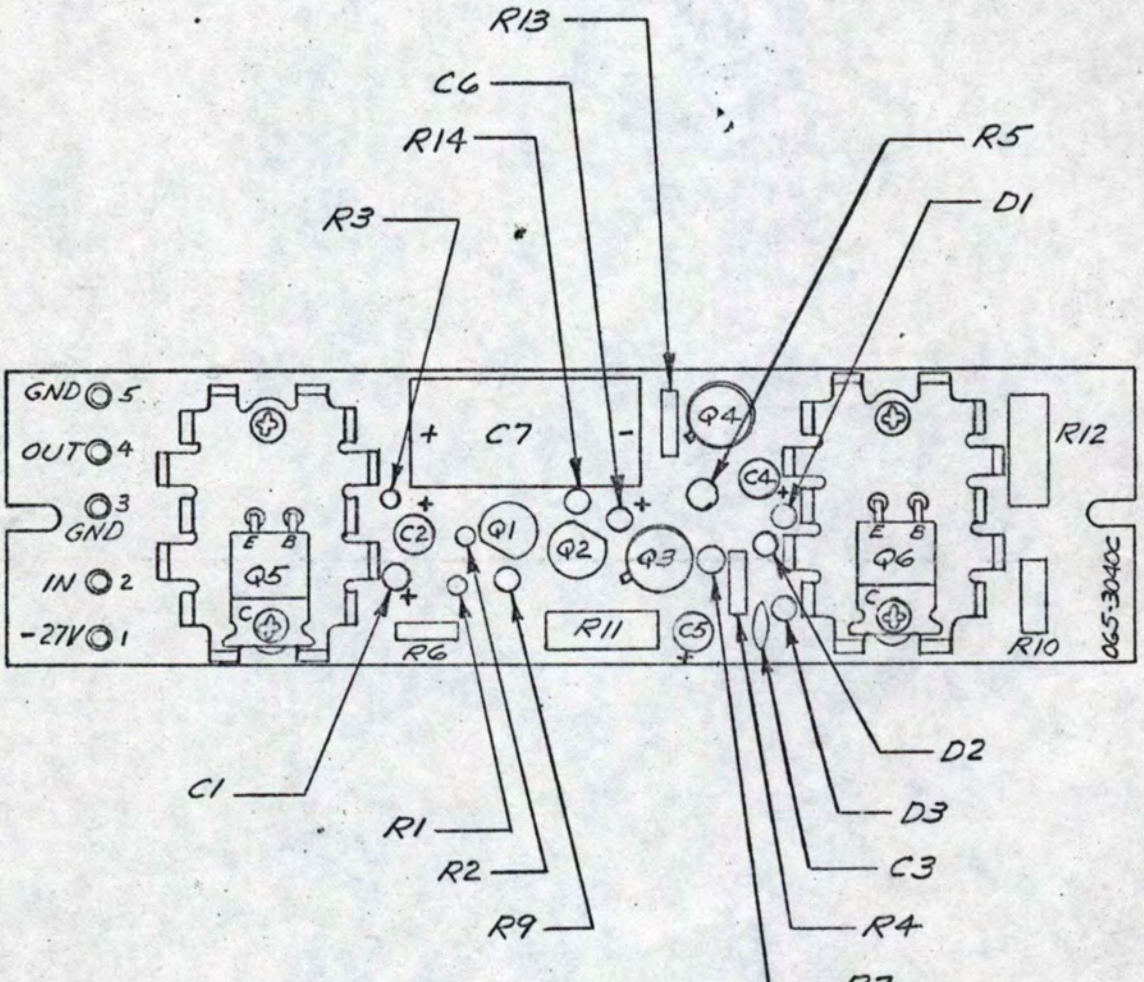
SPARTA ELECTRONIC CORPORATION SACRAMENTO, CALIFORNIA 95828 A DIVISION OF COMPUTER EQUIPMENT CORPORATION			TITLE: 1020 MIX/LINE AMP P.C. BOARD #065-3010B	
DWN SMU	DATE 7 JAN 73	SCALE	SHT OF	DWG NO. P-31B
APPD [signature]	DATE 7 JAN 74			





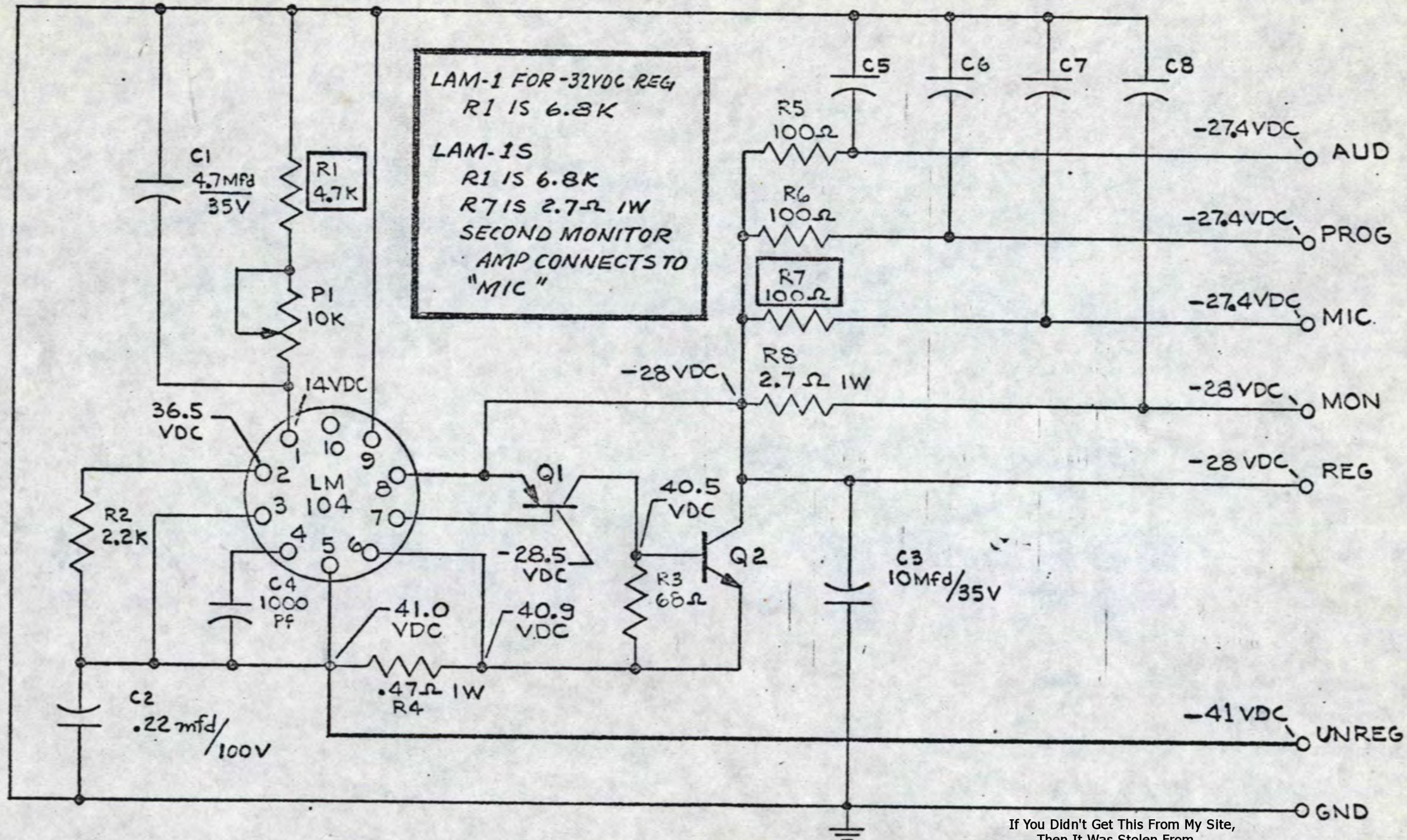
C ECR517
B ECR177, Q1 was 2N3566
A ECR151, C3 was 120pf

SPARTA ELECTRONIC CORPORATION, SACRAMENTO, CALIFORNIA 95828 — A DIVISION OF COMPUTER EQUIPMENT CORPORATION			TITLE: 1025A MONITOR / CUE AMPLIFIER	
DWN SMU	DATE 14Sep70	SCALE 0	SHT 1 OF 1	DWG NO. S-103C
APPD KKO	DATE [illegible]			



SPARTA ELECTRONIC CORPORATION SACRAMENTO, CALIFORNIA 95828 A DIVISION OF COMPUTER EQUIPMENT CORPORATION			TITLE 1025 PICTORIAL P.C. BOARD	
DWN R.A.G.	DATE 7-21-75	SCALE FULL	SHT 1 OF 1	DWG NO. P-49
APPD UWE	DATE 7-21-75			

E	SEE ECR 583	F	SEE ECR 636



Q1 = 2N4036
Q2 = 2N3055

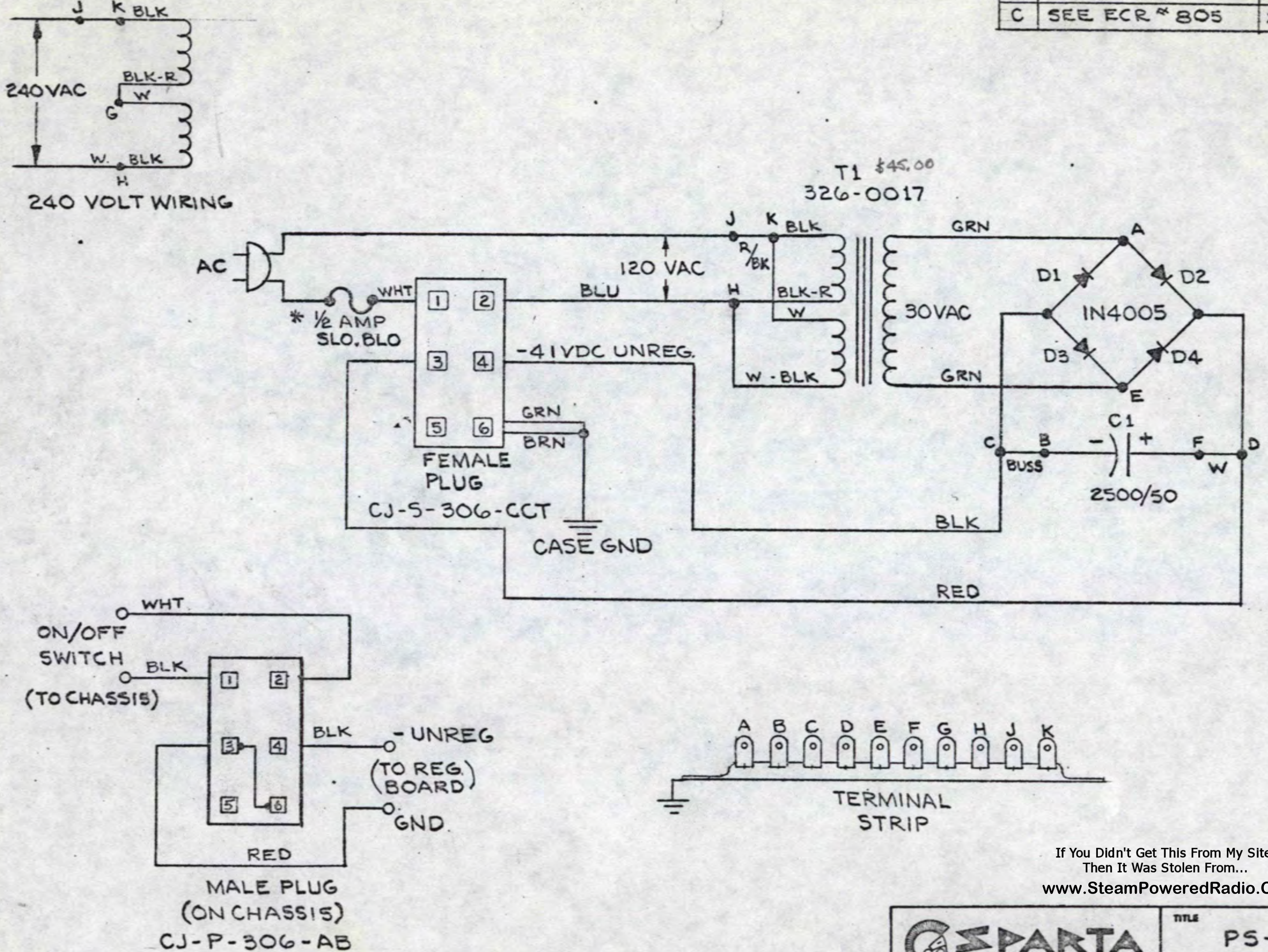
C5, C6, C7, C8 } 1000uf @ 50V

LM = 104 OR 304

VOLTAGES MEASURED WITH 20,000Ω/VOLT METER WITH ALL POTS TURNED DOWN. ALL VOLTAGES ± 5%.

SPARTA ELECTRONIC CORPORATION, SACRAMENTO, CALIFORNIA 95828	TITLE: 1200 REGULATOR (065-1200A)
DWN B. SCUDDER	DATE 7-25-72
SCALE	SHT 1 OF 1
DWG NO.	S-189F

B	SEE ECR 636	25APR74	[illegible]
C	SEE ECR # 805	2-10-75	[illegible]

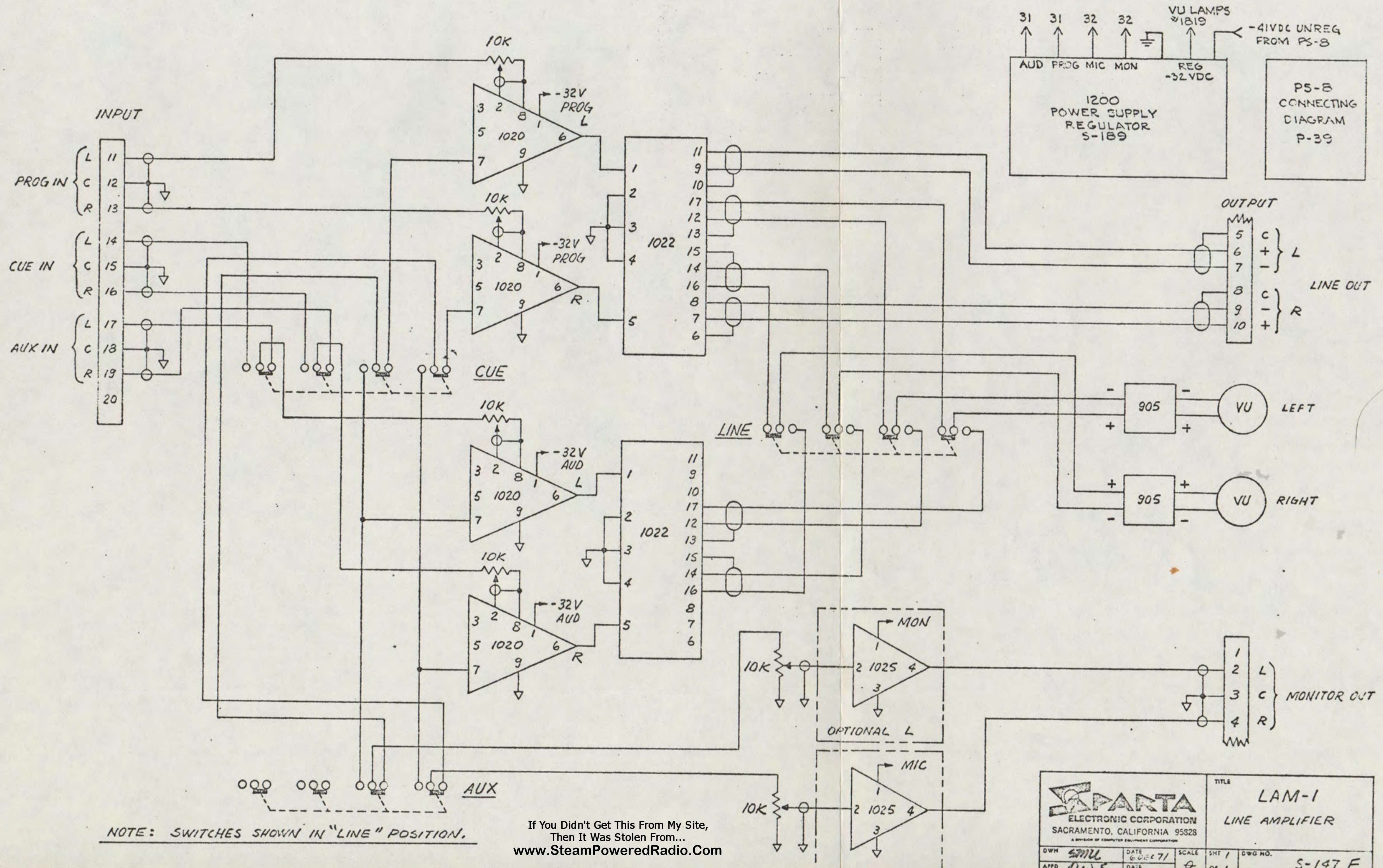


*SHOULD BE ¼ AMP SLOW BLOW FOR 240VOLT.

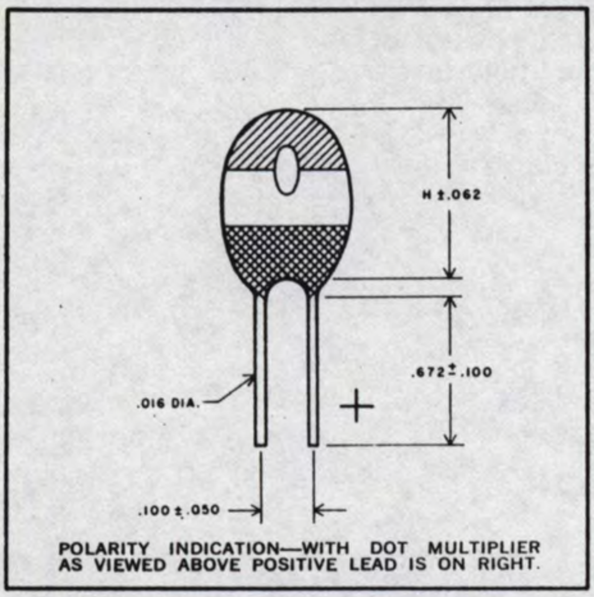
SPARTA ELECTRONIC CORPORATION
SACRAMENTO, CALIFORNIA 95828

TITLE: PS-8 $125.00 CONNECTING DIAGRAM

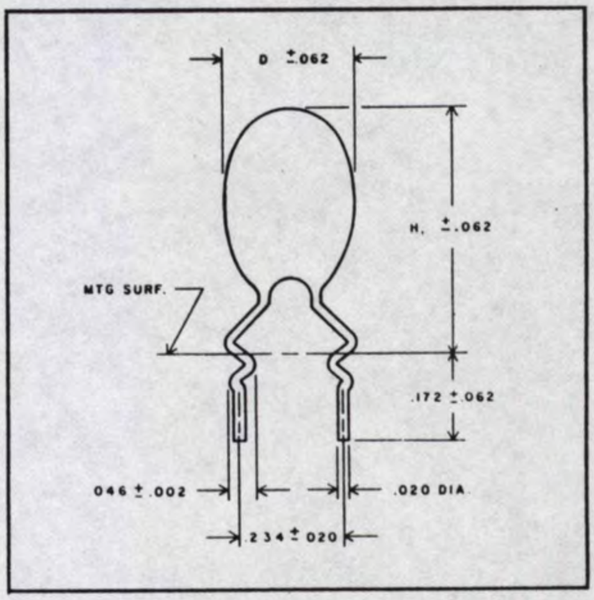
DWN: B. SCUDDER | DATE: 7-30-73 | SCALE | SHT 1 | DWG NO. P-39C


INPUT
PROG IN
CUE IN
AUX IN
L 11
C 12
R 13
L 14
C 15
R 16
L 17
C 18
R 19
20
10K
-32V PROG
L
R
1020
-32V AUD
1022
CUE
LINE
AUX
OUTPUT
LINE OUT
L
R
905
VU
LEFT
RIGHT
31 31 32 32
VU LAMPS #1819
-41VDC UNREG FROM PS-8
AUD PROG MIC MON
REG -32VDC
1200 POWER SUPPLY REGULATOR S-189
PS-8 CONNECTING DIAGRAM P-39
MON
MIC
1025
OPTIONAL L
MONITOR OUT
NOTE: SWITCHES SHOWN IN "LINE" POSITION.
SPARTA ELECTRONIC CORPORATION
SACRAMENTO, CALIFORNIA 95828
LAM-1
LINE AMPLIFIER
S-147 F

Solid Tantalum Electrolytic Capacitors



TAG—STRAIGHT LEADS

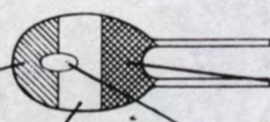


TAG—CRIMPED LEADS
(SPECIAL ORDER ONLY)

CASE DIMENSIONS—TYPE TAG **TABLE 3**

CASE	DIA. (D)	LENGTH (H)	*(H_1)
1	.138	.238	.378
2	.159	.258	.397
3	.159	.278	.421
4	.178	.278	.421
5	.178	.298	.437
6	.219	.338	.457
7	.238	.338	.457

*CRIMPED LEAD VERSION ONLY



MARKING CODE **TABLE 4**

CAPACITANCE (MFDS)				WORKING VOLTAGE	
COLOR	CAP 1ST SIGNIFICANT NUMBER	RING 2ND SIGNIFICANT NUMBER	DOT MULTIPLIER	COLOR	VOLTAGE
BLACK	—	0	x1	WHITE	3
BROWN	1	1	x10	YELLOW	6.3
RED	2	2	—	BLACK	10
ORANGE	3	3	—	GREEN	16
YELLOW	4	4	—	BLUE	20
GREEN	5	5	—	GREY	25
BLUE	6	6	—	PINK	35
VIOLET	7	7	—		
GREY	8	8	x0.01		
WHITE	9	9	x0.1		

Eliminate that RFI in your Audio Circuits

Once the symptoms are understood, RF in your audio circuits can be eliminated. Here is your guide to symptoms and cures.*

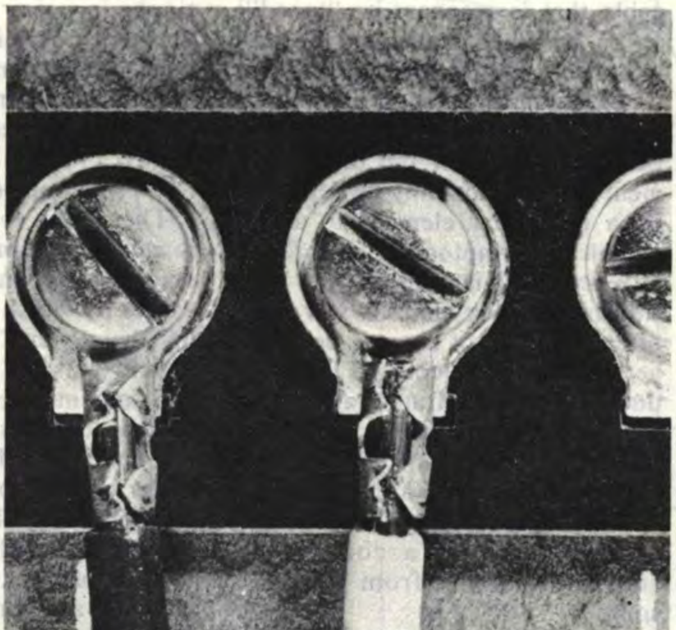


Fig. 1 The terminal connectors shown here are crimped to the wires. This is an especially hazardous practice if the wires are copper. Creeping corosion inside the clamp is possible.

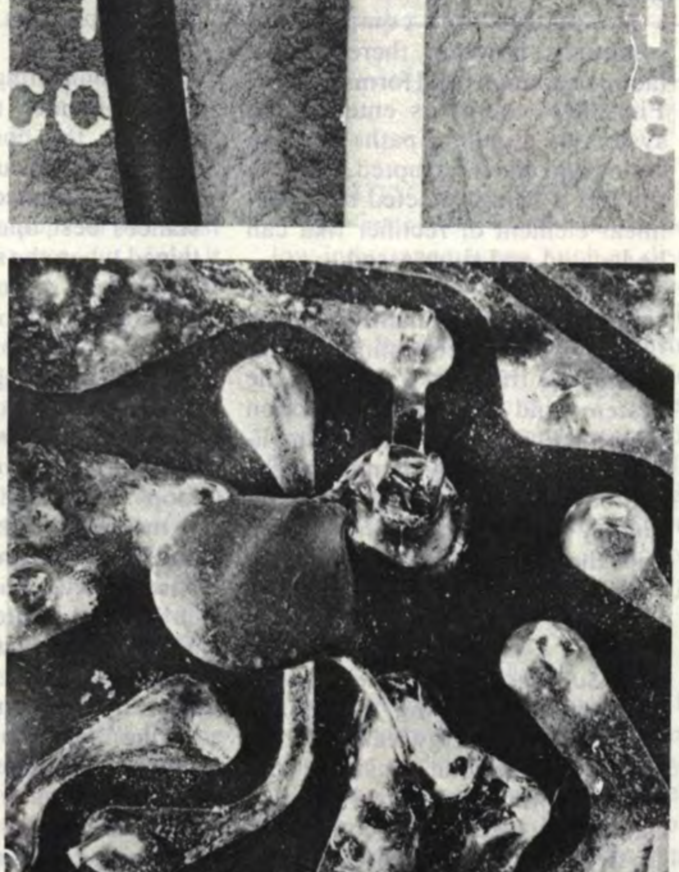


Fig. 2 A disc capacitor is shown here with minimum possible leads. It is a good practice to keep all leads short and to trim excessive wire protruding through connectors after soldering.

****Written by the engineering staff of Sparta Electronics and edited by Paul Gregg.***

Radio frequency interference, or RFI, is always a possibility when audio equipment is operated in the presence of RF fields. It can be particularly troublesome in solid-state systems containing low-level program lines and high-gain preamplifiers because less RF voltage or current is needed in such systems to cause interference.

With properly-designed audio equipment, particularly that intended for use by radio broadcasters, the incidence of RFI is relatively low when proper installation practices have been followed. But RFI does occur in even the best of installations because of its virtually unpredictable nature. It does not necessarily require a strong field for RFI to result, and it is not uncommon for an audio system to be unaffected by a nearby high-power transmitter, yet be ridden with RFI from a distant source at a different frequency.

The obvious question, of course, is "Why can't audio equipment be made RFI-proof?" The answer, unfortunately, cannot be so obvious. Although normal gain and frequency response of an amplifier can be limited to the audio range, this is not the case for individual components and conductors. Capacitors, resistors, inductors, wires and transistors continue to function as such at frequencies far beyond the bounds of the audio spectrum: the wire that is a simple conductor at audio frequencies may become a highly efficient antenna or inductor at radio frequencies; the insignificant stray capacitance at audio frequencies can become a very effective coupling or tuning capacitor at radio frequencies; the semiconductor junction that is a linear control element at audio levels will become an excellent diode detector or modulator if sufficient RF energy reaches it.

The task of RFI suppression, then, is just that—suppression rather than elimination. No matter what pains are taken at the design and manufacturing levels to minimize susceptibility to RF, the possibility will still exist simply because there is no way to force a component (such as a semiconductor) to recognize the difference between a change of voltage or current at audio frequencies and a similar or greater change at some higher frequency.

Fortunately, there are many effective preventive measures that can be taken, and the ultimate solution to RFI becomes that of providing reasonable suppression during initial design and manufacture followed by additional effort during subsequent installation if required by an unusually severe environment. It is well to note that the best of built-in suppression can be undone by improper or careless installation.

RFI Symptoms

The symptoms of RFI are varied, depending upon the strength of the field, how it is entering the system, where and how it is being detected, and what kind of modulation it carries. An AM carrier may enter a system, be partially or completely detected by a non-linear element (more on this later) and produce the modulation superimposed over the normal program. If the two programs are different, the intruder is usually recognized as such quite readily. If they are the same, the symptoms may appear as hum, noise, raspiness or similar distortion. Also, if the RFI is strong enough, the result may be a completely blocked amplifier stage with only noise or perhaps silence as a symptom.

An audio system normally does not contain the necessary elements for FM detection, so when the intruding carrier is frequency modulated the symptom is usually that of an un-modulated carrier: hum, noise, distortion of the normal program, or again the silence of a blocked amplifier stage. If the offender is a VHF FM carrier, however, it will often enter the audio system via a conductor or cable that is resonant or "tuned" at or near the frequency of the interfering carrier, quite literally a tuned antenna. In such a case the FM can be converted to AM by riding the slope of the tuned element and subsequently be detected by a non-linear element so as to exhibit the symptoms of AM RFI.

When RFI is caused by a TV transmitter, the symptoms will most often, though not always, be characterized by a raucous 60 Hz buzz due to the AM frame-rate sync-pulse. Since two carriers may be involved, one AM and one FM, the symptoms may also become involved, even to the extent of including those of a completely separate carrier from another source.

No matter how complex the symptoms, however, there are two factors common to all forms of RFI. First, RF energy is entering the system by a path or paths that can be located and interrupted. Second, the RF is being detected by a non-linear element or rectifier that can be located and suppressed.

The process of eliminating or suppressing RFI, then, involves two basic steps; preventing or minimizing the transfer of RF into the system, and preventing detection of the RF. The first step is simplified considerably by identifying the source and particularly the frequency of the interfering carrier, and the second requires locating the point at which it is being detected.

Suppressing Entering RFI

When considering the means whereby RF energy can enter an audio system, one must be constantly aware that stray capacitances may be excellent conductors for RF and that any wire or metal structure will be resonant at many different frequencies. The most prevalent example, of course, is the twisted pair shielded audio cable feeding a console which may act as a quarter-wave stub antenna at one frequency and as a multi-wavelength long-wire antenna at a much higher frequency. Of nearly equal importance are instances where turntable tone-arm leads act as VHF antennas—particularly troublesome because of their locations in very low-level, high impedance circuits—and AC powerlines, which can be very efficient longwire antennas at the lower radio frequencies.

Problem Cables

The search for the route of RFI is generally a process of eliminating, one by one, the connecting cables by which RF may be entering the system. At the same time, judicious use of operating switches and potentiometers will provide positive clues as to the source. For example, if reducing a turntable mixer control to zero will stop the interference it is a near certain indicator that both injection and detection are taking place in that channel and prior to the mixer control, perhaps in another part of the system.

If a connecting cable is found to be an offender, the first step is to examine the connections at both ends and particularly the way the shield is connected. In most instances best operation will be obtained when the shield is connected at the load or console end and left open at the source end. This is because the equipment at each end of the connecting cable will always have some sort of return to a common ground, and connecting the shield at both ends completes a loop which quite often will respond to magnetic fields. There is no hard and fast rule, however, and it is wise to try various combinations.

When the interference is in the VHF range, it will often be found that shortening *or* lengthening a cable will eliminate RFI by "detuning" it. Also, it may be found that simply moving or re-routing will accomplish the same effect. In such cases it is often true that touching cables or connections will result in a change of level or symptoms of the RFI. Obviously, con-

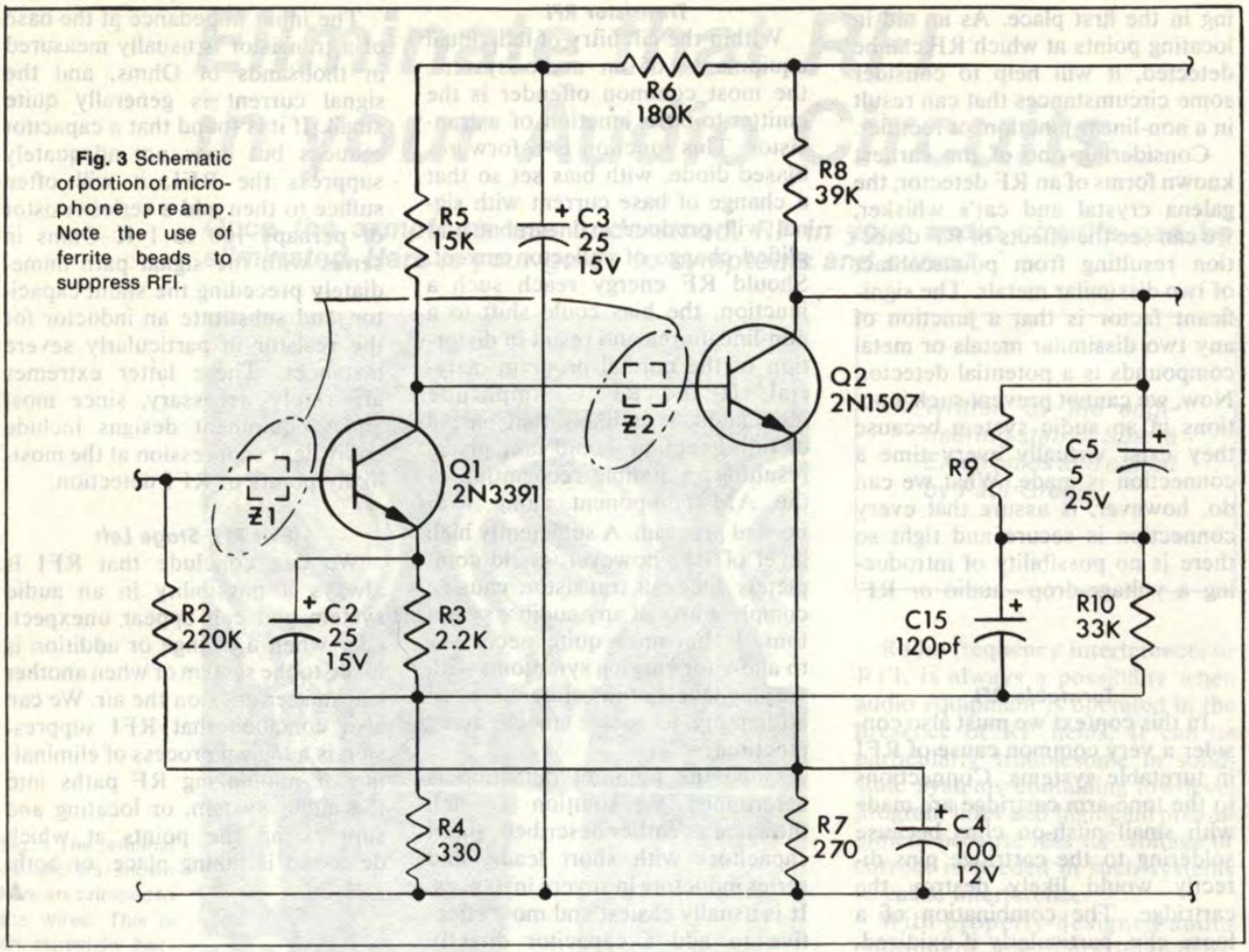


Fig. 3 Schematic of portion of microphone preamp Note the use of ferrite beads to suppress RFI.

necting cables should never be coiled and tied in loops. If one must be shortened but not cut, fold it back and forth upon itself and tie it securely.

Using Capacitors

If cable-dress and shielding techniques are insufficient, bypass program-carrying conductors to ground or shield terminals with suitable capacitors. Since the reactance of a capacitor decreases as frequency increases, the procedure is to choose a capacitor value which will have no significant effect at program line impedances and frequencies, yet form a low reactance shunt path to ground for the radio frequencies. For the typical 600 Ohm system, a value of 0.001 mfd to 0.002 mfd is nearly ideal since the reactance is about 5K Ohms at the higher audio frequencies, falls to 100 Ohms at the middle of the AM broadcast band, and is close to 1 Ohm at the middle of the FM-TV bands.

The capacitors used should be low-inductance types, such as disc ceramics. Lead-lengths should be kept short, otherwise, the capacitor and leads could become resonant at a frequency which could add rather than cure RFI. The preceding given values can be extrapolated to other impedance levels simply by following the reciprocal relationship: if the audio line impedance is higher, the capacitor should be proportionally smaller, and vice versa.

RF Chokes

In severe circumstances, RF-chokes may be inserted in series with the audio lines, and with bypass capacitors to ground at each end a very effective filter section will result, if lead lengths are kept short. The Ohmite Z-50 and Z-144 chokes are typical and quite popular for suppression at the higher frequencies. Alternately, passing audio leads through ferrite beads is very effective and space-saving at VHF frequencies. Chokes are generally not too practical at AM broadcast frequencies, however, since those with high enough reactance usually have enough DC resistance to affect audio levels in low-impedance lines. When filtering AC power lines, 0.01 to 0.1 mfd, 600 Volt capacitors may be used, although it may be simpler and more effective to employ a commercial filter designed for the purpose.

RF Detection

The suggestions so far have dealt with means of preventing RF from entering the audio system. Of equal importance and often the most effective approach is to isolate and suppress the point of detection. Even though it may require going into the circuitry of equipment in the audio system, it often requires less effort than adding multiple filters to prevent the RF from entering in the first place. As an aid in locating points at which RF can be detected, it will help to consider some circumstances that can result in a non-linear junction, or rectifier.

Considering one of the earliest known forms of an RF detector, the galena crystal and cat's whisker, we can see the effects of RF detection resulting from point-contact of two dissimilar metals. The significant factor is that a junction of any two dissimilar metals or metal compounds is a potential detector. Now, we cannot prevent such junctions in an audio system because they exist virtually every time a connection is made. What we can do, however, is assure that every connection is secure and tight so there is no possibility of introducing a voltage-drop—audio *or* RF.

Turntable RFI

In this context we must also consider a very common cause of RFI in turntable systems. Connections to the tone-arm cartridge are made with small push-on clips because soldering to the cartridge pins directly would likely destroy the cartridge. The combination of a loose clip, particularly if oxidized, plus the tone arm lead (an excellent VHF antenna) and the following high-gain amplifiers is an excellent invitation to RFI. Also, the usual tone arm with plug-in cartridge-shell and plug-in connecting cable provides two additional sets of contacts at which RFI detection can take place.

Transistor RFI

Within the circuitry of individual equipments of an audio system, the most common offender is the emitter-to-base junction of a transistor. This junction is a forward-biased diode, with bias set so that a change of base current with signal will produce a linear but amplified change of collector current. Should RF energy reach such a junction, the bias could shift to a non-linear area and result in distortion of the normal program material. If the RF is amplitude modulated, it is likely that partial or full detection would take place, resulting in audible recognition of the AM component along with normal program. A sufficiently high level of RF, however, could completely block a transistor, causing complete loss of any audible symptom. It becomes quite necessary to allow for varying symptoms with varying levels of interference when attempting to locate an offending junction.

Once the point of detection is determined, the solution is much the same as earlier described; shunt capacitors with short leads, and series inductors in severe instances. It is usually easiest and most effective to add a capacitor directly across the emitter-to-base junction. The most effective capacitor value will vary with particular circuit parameters, but a value of 100 pf is a good starting-point. As a general guide, the capacitor should be as large as practical without causing a loss at the highest audio frequencies.

The input impedance at the base of a transistor is usually measured in thousands of Ohms, and the signal current is generally quite small. If it is found that a capacitor reduces but does not adequately suppress the RFI, it will often suffice to then add a series resistor of perhaps 100 to 1 K Ohms in series with the signal path immediately preceding the shunt capacitor, and substitute an inductor for the resistor in particularly severe instances. These latter extremes are rarely necessary, since most audio equipment designs include equivalent suppression at the most-likely points of RFI detection.

Exit RFI, Stage Left

We can conclude that RFI is always a possibility in an audio system and can appear unexpectedly when a change or addition is made to the system or when another transmitter goes on the air. We can also conclude that RFI suppression is a logical process of eliminating or minimizing RF paths into the audio system, or locating and suppressing the points at which detection is taking place, or both. ▲

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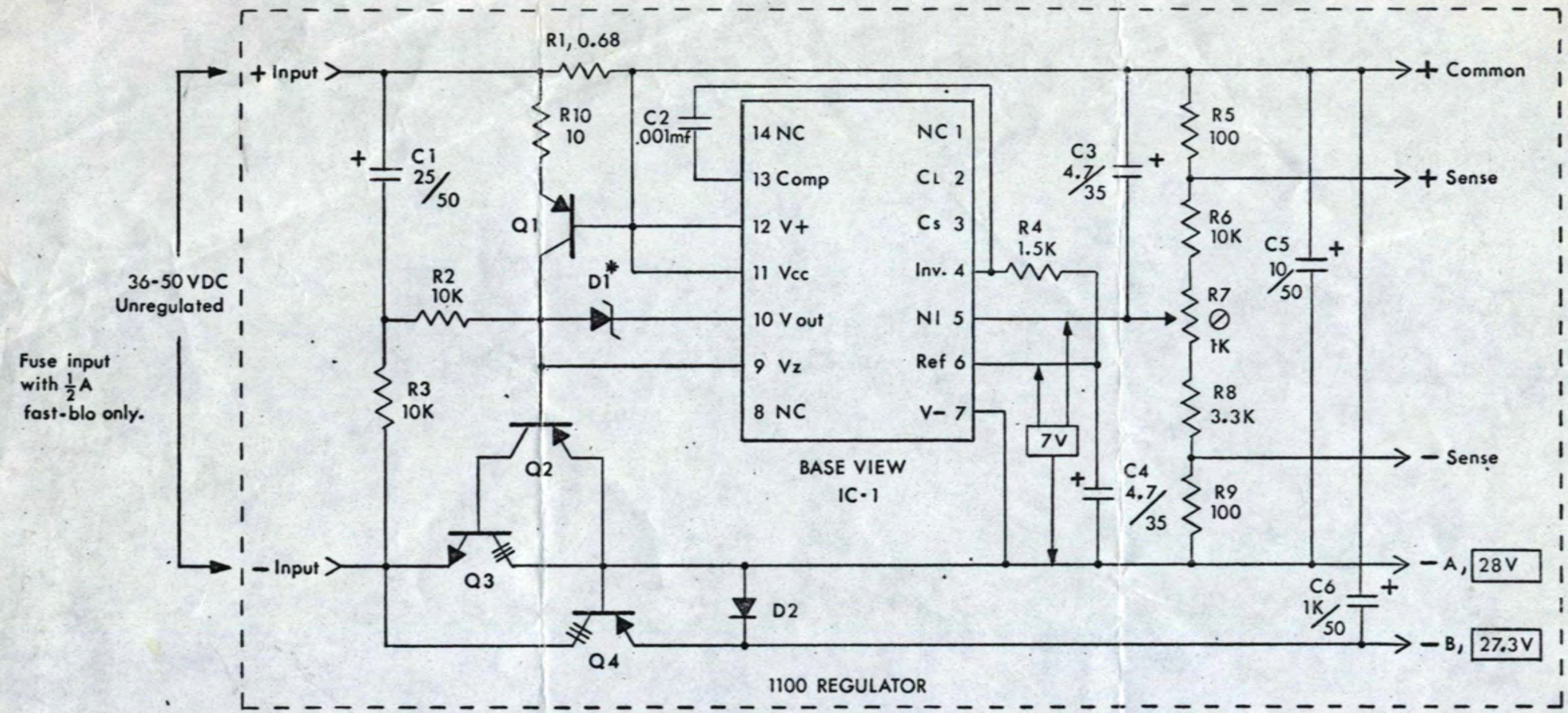

Load Imax (A+B), 500ma

Short-circuit Imax, 900ma

Q1,Q2	2N4036 (RCA)
Q3	2N5492/3 (RCA)
Q4	D43C7/8 (GE)
	or 2N6108/9 (RCA)
* D1	7V, 150 mw. zener (2N5138) Not used with 723 IC
IC1	723, 823
D2	1N4003 or equal

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