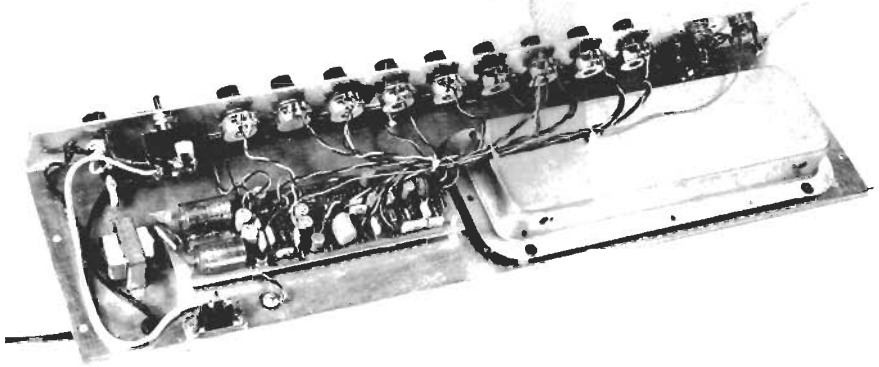
Build a Guitar Preamp



by GARY KAY

INTERESTED IN BUILDING A GUITAR PREAMP with a really unique and outstanding sound? One that has not only conventional tremolo and reverb, but also includes a full complement of five tone controls consisting of a three-octave variable basspass filter along with the conventional bass and treble controls. Note also that with the instrument preamp separate from the power amplifier, you are left with a wide choice of output power capabilities from a moderate 60 watts, (Build a 4-Channel Power Amplifier, **Radio-Electronics**, March-April 1973) to a strong 250 watts, (Tigersaurus 250-watt Hi-Fi Amplifier, **Radio-Electronics**, December 1973) to mention just two. You can also drive several power amplifiers from one preamp, starting with one power amplifier now and expanding to others as the need arises.

The outstanding feature of this preamp is the unique tone control system that provides the utmost in flexibility. Upon investigation, it became apparent that many electric guitarists try to get a sound in which the fundamental notes of the guitar are de-emphasized or toned down. The fundamental notes for most electric guitars, excluding the bass guitar, go from about 100 to a little over 1000 Hz and are generally the loudest. This leaves behind the bass notes on the low end and harmonics on the high end. For added tonal compensation, some guitar amplifiers have a single mid-range control in addition to the standard bass and treble controls, while others have a conglomoration of active filter level controls. Both operate over a fixed frequency range which cannot be varied.

With the advent of inexpensive op-amp integrated circuits and the flexability of active filter techniques, we can now have a tone control system which can variably de-emphasize any or all of almost one full decade of the fundamental note spectrum of a guitar. The use of this particular active filter configuration also provides the introduction of what seems to be a very interesting and unique control. It has been called an EMPHASIS control, and to understand its function it is necessary to describe the active filter circuitry in detail.

SPECIFICATIONS

Sensitivity —	1.5 V rms out at −40 dB input (tone controls set for flat response −A input)
Input Impedance —	100 K −A input 40 K −B input
Output Impedance —	1 K
Maximum Input Voltage —	0.5 V rms −B input
Maximum Output Voltage —	5 V rms
Harmonic Distortion —	Less than 1% at 1 kHz
Hum and Noise —	1 mV (full volume — tone controls set for flat response)
Power Requirements —	117 Vac @ 0.25 A

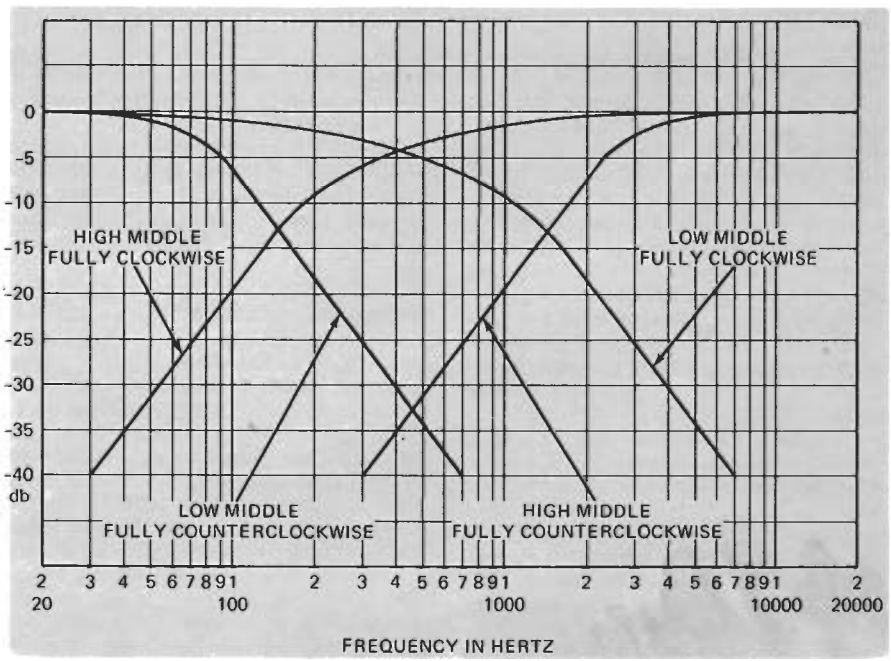
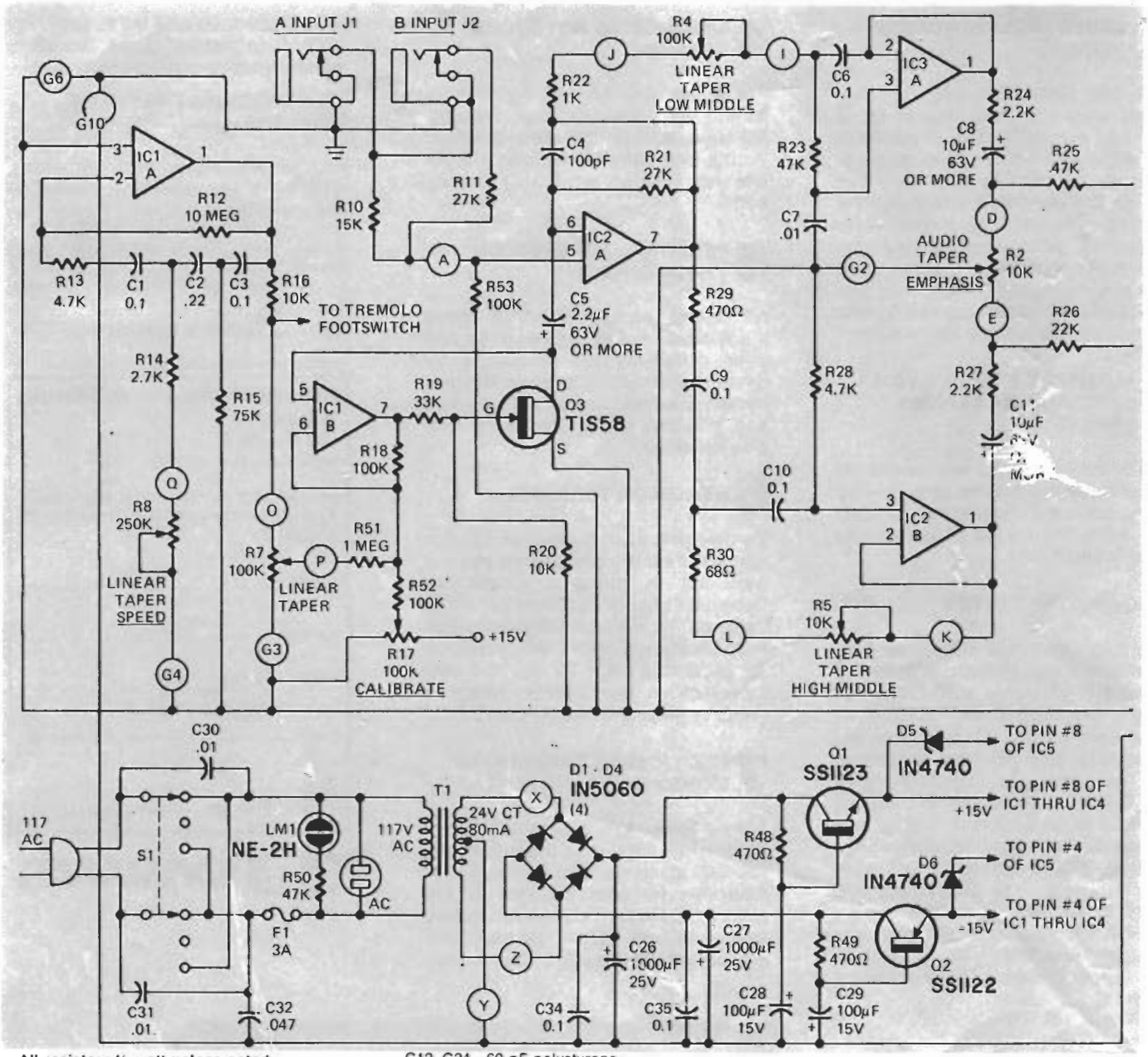


FIG. 1—FREQUENCY RESPONSE OF THE MIDDLE CONTROLS can be varied from flat at one extreme to an adjustable notch with over 30 dB attenuation at around 450 Hz.



All resistors ¼ watt unless noted.

R1—50,000 ohms, audio taper potentiometer
R2—10,000 ohms, audio taper potentiometer
R3, R4, R7—100,000 ohms, linear taper potentiometer
R5, R9—10,000 ohms, linear taper potentiometer
R6—50,000 ohms, linear taper potentiometer
R8—250,000 ohms, linear taper potentiometer
R10—15,000 ohms,
R11, R21—27,000 ohms
R12—10 megohms
R13, R28, R32—4700 ohms
R14—2700 ohms
R15—75,000 ohms
R16, R20, R36, R54—10,000 ohms
R17—10,000 ohms, trimmer resistor
R18, R31, R35, R38, R46, R52, R53—100,000 ohms
R19—33,000 ohms
R22, R37, R39, R42, R43, R47—1000 ohms
R23, R25, R41, R45, R50—47,000 ohms
R24, R27, R34, R40—2200 ohms
R26, R44—22,000 ohms
R29, R33, R48, R49—470 ohms
R30—68 ohms
R51—1 megohm

C1, C3, C6, C9, C10, C34, C35—0.1-µF Mylar
C2—0.22-µF Mylar
C4, C19, C21—100-pF polystyrene
C5—2.2-µF @ 63 Vdc or higher electrolytic
C7, C15, C30, C31, C33—0.01-µF Mylar
C8, C11, C18, C25—10-µF @ 63 Vdc or higher electrolytic
C12, C24—60-pF polystyrene
C13, C22, C23, C32—0.047-µF Mylar
C14—0.47-µF Mylar
C16—.001-µF polystyrene
C17—30-µF @ 15 Vdc electrolytic
C20—4.7-µF @ 63 Vdc or higher electrolytic
C26, C27—1000-µF @ 25 Vdc electrolytic
C28, C29—100-µF @ 15 Vdc electrolytic

D1, D2, D3, D4—IN5060
D5, D6—10V 400 mW or greater Zener diode IN4740 or equal
Q1—SS1123 or 2N4238 silicon transistor
Q2—SS1122 or 2N4235 silicon transistor
Q3—TIS58 FET-yellow tracer
IC1, IC2, IC3, IC4, IC5—5558 dual op-amp

T1—Power Transformer - 117 Vac primary 24 Vac c.t. 80 mA secondary
F1—3A standard fuse (see text)
LM1—NE - 2H neon lamp
S1—dpdt center-off toggle switch
J1, J2—2-conductor shorting phone jack
J3—3-conductor non-shorting phone jack
J4—2-conductor non-shorting phone jack
J5—RCA phono jack

The following parts are available from
Southwest Technical Products Corp.
219 W. Rhapsody
San Antonio, Texas 78216

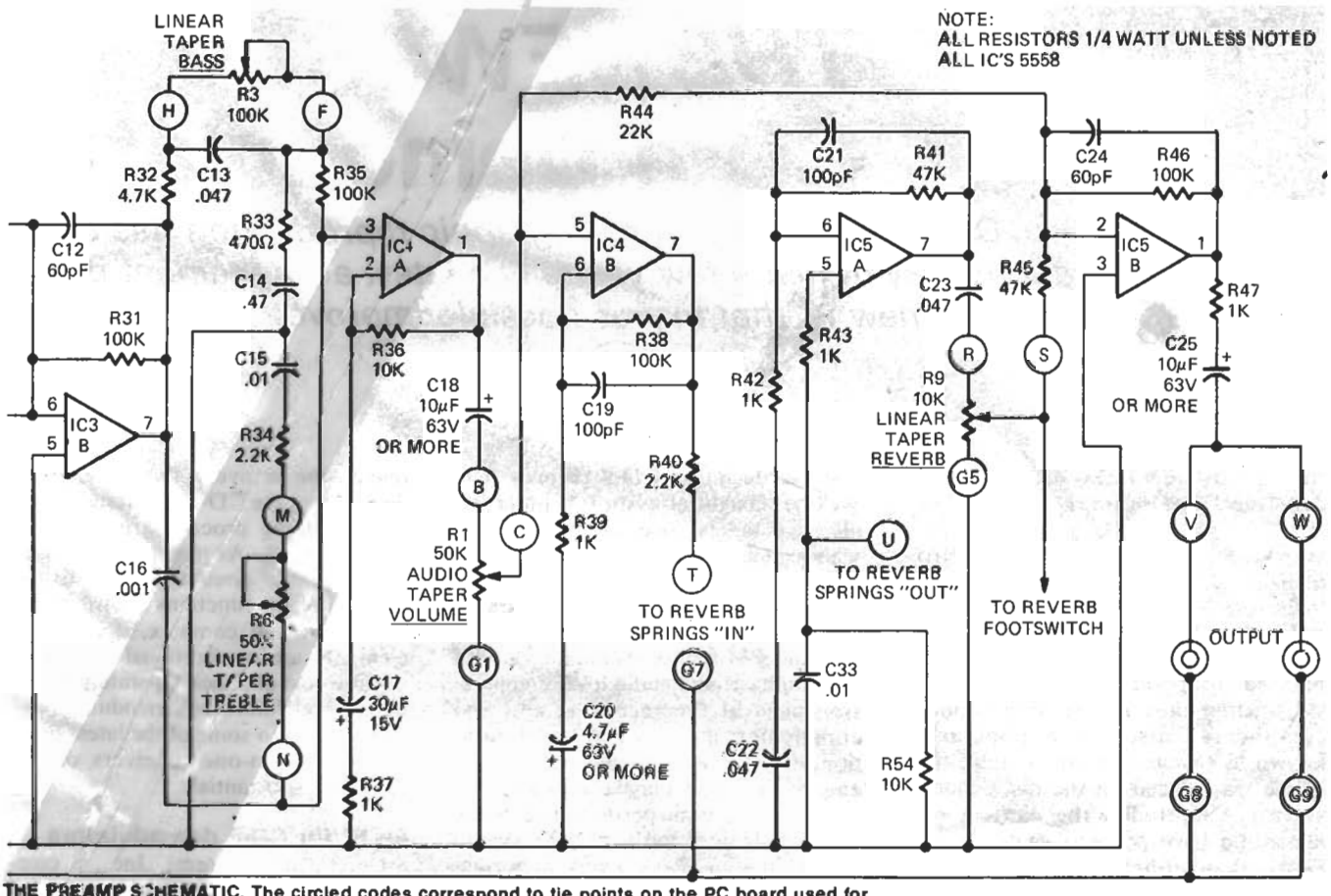
Kit of all parts. No. 211-C $96.50 plus postage for 7 lbs.
Circuit board only No. 211-lb $6.50
Reverb Spring No. Z—1C $11.00 pp

gotten from the ac receptacle on the bottom panel. Power for the preamp is provided by an internal ac supply. The reverb springs are mounted inside the chassis along with the printed circuit board and its components. The chassis is then mounted in a black-vinyl- covered wooden enclosure bringing the total dimensions to 24½" long x 6½" high x 7½" deep.

Assembly techniques

A printed circuit board should be used for this project. Mount all of the components on the printed circuit board, making sure to orient the diodes, transistors, integrated circuits and electrolytic capacitors as indicated in the parts list and component layout figure. Bend and trim the leads on the back side of the board and solder the connections using a low-wattage iron and 60/40 alloy resin core solder. Note there are four jumpers which must be installed on the board. They can be made from some short pieces of hook-up wire and should go between the solid lines shown on the component layout figure.

Attach the plastic standoffs, terminal



THE PREAMP SCHEMATIC. The circled codes correspond to tie points on the PC board used for connections to components that are mounted on the front and bottom panels.

strip, ac outlet, RCA-type output jack, power transformer and line cord to the chassis using 6-32 hardware. Place a finished panel over the front of the chassis and secure by installing all of the potentiometers, input/output jacks, fuse holder, lamp cover and power switch.

Attach all of the wires from the component side of the printed circuit board, making twisted pairs or triples for each set of control wires. Snap the board into place and connect each wire bundle to the correct control. Position the wires as shown in the picture and use different colored wire for ease of identification. Attach and solder all of the power supply connections as well as those on the input/output connectors. Snap the reverb springs down onto the standoffs and connect the RCA plugs to the correct jack, also press all of the knobs onto the potentiometer shafts.

On the circuit board, temporarily solder a 1K ¼-watt resistor between the Q3 end of resistor R15 and the C5 end of resistor R21 and set trimmer resistor R17 so the tab on the knurl of the control is adjacent capacitor C3. Check to make sure all connections have been soldered and insert fuse F1 into the fuse holder.

Testing and calibration

Without any input connections to the preamp, make the following settings on the controls.

Volume	- 0	Treble	- 0
Emphasis	- 4	Depth	- 0
Bass	- 0	Speed	- 0
Low Middle	-10	Reverb	- 0
High Middle	-10		

Using either one of the two output jacks, connect the preamp to a power amplifier and speaker system. If the power amplifier has an input level control, turn it all the way down. Apply power to the preamp/power amplifier system and slowly advance the power amplifier input level control until it is at its maximum. There should be little if any noise coming from the speaker. If you have access to an audio signal generator, set it for a sinewave output of 0.1 volts rms at 1 kHz and plug it into the A input of the preamp. Slowly advance the preamp's volume control until you can hear the output through the speaker. If you never hear the output, unplug everything in the system and check the preamp, assuming you are sure your power amplifier and speaker system are working correctly. If you cannot visually locate the problem, use an oscilloscope to pinpoint the source of the trouble. If you do not have access to an audio generator, use a guitar following basically the same procedure.

Next you must calibrate the input gain for proper tremolo operation. Using either a voltmeter or oscilloscope and with the audio generator still connected, note the output level of the unit for some reference voltage input. Unsolder the 1K resistor. The output level should drop considerably. Now slowly advance trimmer resistor, R17, until the gain is the same as it was when the 1K resistor was in place. *Do not* advance the control any farther. The chassis may now be attached to the case.

Operation and use

Input: The unit has two input jacks with the **A** input being the more sensitive of the two. The **B** input is down about 9 dB and should be used on instruments with a very high output level.

Footswitch: The footswitch jack is provided to allow both the reverb and tremolo to be turned on and off at will. This requires an additional 3-conductor plug and pair of switches.

Volume: the volume control is a conventional level control.

Emphasis: The emphasis control determines the ratio of highs to lows and sets the overall tone of the output. An equal balance is achieved at a setting of about 4.

Bass: The bass control sets the amount of bass boost in the circuit with a setting of 0 resulting in no bass boost and 10 yielding a little under 20 dB.

Low Middle: The low-middle cmntrol determines the low-end frequency above which the mid-band notes are attenuated.

High Middle: The high-middle control determines the high-end frequency below which the mid-band notes are attenuated. The combination of low-middle and high-middle controls result in a variable mid-band notch filter providing multi-octave mid-band attenuation at one extreme (both controls at 0) or almost flat response (both controls at 10).

Treble: The treble control sets the amount of treble boost in the circuit with a setting of 10 resulting in no treble boost and 10 yielding a little under 20 dB.

Tremolo: The tremolo depth and speed controls provide a variable intensity tremolo effect varying from about 3 to 13 Hz.

Reverb: The reverb control determines the amount of reverberated sound mixed into the output of the preamplifier.

Power Switch: The center-off power switch serves the dual function of line reverse and on-off control. It also provides

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GUITAR PREAMP

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the same function for the ac outlet located on the bottom panel of the preamp.

Fuse: The fuse holder located on the front of the preamp fuses both the preamp's power transformer as well as whatever is connected to the ac outlet located on the bottom panel of the preamp. This means that if a power amplifier is plugged into the ac outlet on the bottom panel, the fuse must be large enough to handle both the preamp's current (about 0.25 A) and the power amplifier's current which is dependent upon which power amplifier is used. A 3 A standard fuse has been specified for the preamp which is sufficient for most power amplifiers and should not be increased beyond the rating of the power switch.

Output: Two output jacks are provided on the unit. One is on the front panel while the other is on the bottom. They may be used to drive more than one power amplifier as long as the paralleled load is no less than 5K.

The guitar preamp has been designed as an independent unit and should work well with any power amplifier that does not require more than 2 volts rms for full output. Since the preamp has been packaged by itself, I recommend that you mount the power amplifier in the speaker cabinet or place it somewhere between the preamp and speaker. Do not place the preamp and power amplifier one on top of each other or side by side without first checking for increased hum pickup. The large power transformer on power amplifiers radiate 60-Hz hum that will be picked up and amplified if placed too close to the preamp.

If desired, a set of the long reverb springs can be mounted on the lower shelf of the preamp cabinet. Keep the springs as close to the lef side of the cabinet as possible. There are two ½'' holes in the bottom panel of the chassis through which the wires can pass. Use shielded cable on these wires rather than the twisted pair used on the springs inside the chassis.

When connecting the output of the preamp to the input of the power amplifier, be sure to use high-quality shielded cable. This is especially important if the connecting cable is more than a few feet in length. Of course, shielded cable must also be used between the instrument and the input to the preamp.

To minimize hum pickup and string popping, the unit is provided with a center-off line reversing switch. Operate the unit in the position which produces the least noise. **Note also that you can receive an electrical shock by touching anything connected to the unit's chassis ground while either standing on or coming into contact with any well grounded surface if the ac reversing switch is in the high-hum/high-noise position.**

When using the preamp, try to avoid making volume corrections with the guitar's volume control. It is best to operate your guitar with its volume control wide open and to use the volume control on the preamp to set the actual output level. If your guitar has a very high output, it may be necessary to use the **B** input to keep from overdriving the input of the preamplifier.

How it works

The guitar output is fed into either input **A** or **B** with the **B** input providing about a 9-dB cut in the input signal level. The signal is amplified by IC2-a at a gain dependent upon the drain-to-source resistance of field effect transistor Q3. Trimmer resistor R17 sets Q3's dc gate bias through IC1-b for a drain-to-source resistance of about 1K. IC1-a is the phase-shift oscillator used in the tremolo circuit. Its output is summed along with part of the drain signal from transistor Q3 in IC 1-b which in turn drives the gate of Q3.

The tremolo circuit varies the drain-to-source resistance of Q3 and thus causes the gain of input amplifier IC2-a to vary with the frequency of the tremolo oscillator, thus creating the tremolo effect. The feedback connection of IC1-b to the drain of FET Q3 helps to eliminate the distortion generally encountered in FET voltage variable resistor circuits of this type. The output of IC2-a feeds the inputs of the low- and high-pass active filters composed of IC3-a and IC2-b respectively.

THE LOW MIDDLE control R4 and HIGH MIDDLE control R5 set the passbands for each of the two filter circuits while the outputs of the filters are then summed in proportions determined by EMPHASIS control R2 and amplified by IC3-b. The circuitry between the output of IC3-b and the input of IC4-a is a conventional passive bass and treble-boost circuit with BASS control R3 and TREBLE control R6 setting the boost anywhere from zero to around 20 dB. Amplifier IC4-a makes up for the signal attenuation in the tone control circuit and drives VOLUME control R1. Part of the signal from the wiper of the VOLUME control is then fed to the output of summing amplifier IC5-b, while the other part is fed to reverb driver amplifier IC4-b. Amplifier IC5-a boosts the delayed output from the reverb springs which is also fed to output summing amplifier IC5-b, after passing through the REVERB level control R9. Resistor R47 and capacitor C25 protect the output of the preamp should anything other than a power amplifier input ever be plugged into it. It will also help protect the power amplifier should the preamp fail.

The power supply for the circuit consists of a conventional full-wave rectifier that provides both a positive and negative 15 volts with respect to ground. Power line reversing switch S1 and capacitor C32 help prevent a pop when the power switch is flipped to the off position. Transistors Q1 and Q2 are used as series regulator transistors while Zener diodes D5 and D6 limit the output of IC5, as well as help reduce turn-on and turn-off transients generated in the early stages of the preamp. **R-E**

POWER SUPPLY SPLITTER