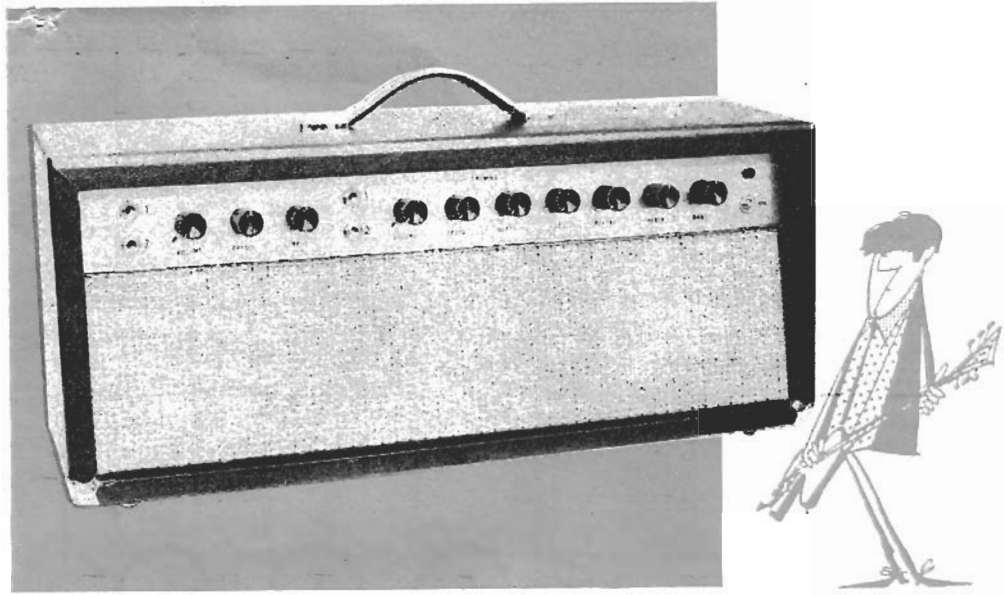


BUILD THE

M/M/M Instrument Amplifier

60-WATT SOLID-STATE GUITAR AMPLIFIER WITH TREMOLO, REVERB, AND FUZZ

PART

BY DANIEL MEYER

HOW WOULD YOU like to build a custom sound system for your electric guitar with the exact controls and features that you want? Or, if you are satisfied with your present arrangement, how would you like some "add ons"—such as controllable fuzz, tremolo, and reverb, that can very easily be hooked up to your system? If you already have a relatively low power amplifier, how about a clean 60-watt booster so that you can be heard?

If desired, the entire system can be built "from scratch" for about $85, and will have features not found in most professional units which cost many times as much. It even includes a high-quality straight preamplifier for vocals or voice announcements.

The M/M/M (Mix, Match, Musical) Instrument Amplifier is built on four printed boards each of which can be made or purchased as a complete kit, so circuit duplication will present no problem. To put the icing on the cake, the entire system has been tested over a period of eight months by a professional combo and has aroused much comment. Circuit reliability has proven excellent.

Power Amplifier. The power amplifier circuit, shown in Fig. 1, uses five silicon transistors to insure maximum temperature stability. The two power output transistors, *Q4* and *Q5*, are complementary types, as are drivers *Q2* and *Q3*. These four transistors form a class-B, push-pull, emitter-follower power ampli-

POWER AMPLIFIER PARTS LIST

C1, C3—10-μF, 15-volt electrolytic capacitor
C2—200-μF, 6-volt electrolytic capacitor
C4—50-μF, 25-volt electrolytic capacitor
C5—4000-μF, 50-volt electrolytic capacitor
D1, D2—1N3754 diode
D3—Silicon bias diode (1N645 or similar)
Q1, Q3—MM4005 transistor (Motorola)
Q2—MM3005 transistor (Motorola)
Q4—SJ3507 transistor (Motorola)
Q5—MJ2802 transistor (Motorola)
R1—10,000-ohm, ½-watt resistor
R2, R3, R4, R9—4700-ohm, ½-watt resistor
R5—68,000-ohm, ½-watt resistor
R6—220-ohm, ½-watt resistor
R7—50,000-ohm trimmer potentiometer
R8—47-ohm, ½-watt resistor
R10—2200-ohm, ½-watt resistor
R11, R12—470-ohm, ½-watt resistor
R13, R14—0.27-ohm, 5-watt resistor
SPKR—4-ohm, 60-watt capability speaker
Misc.—Heat sink, diode clamps (2), mica insulating washers (2), mica transistor insulator, silicone grease, mounting hardware, etc.

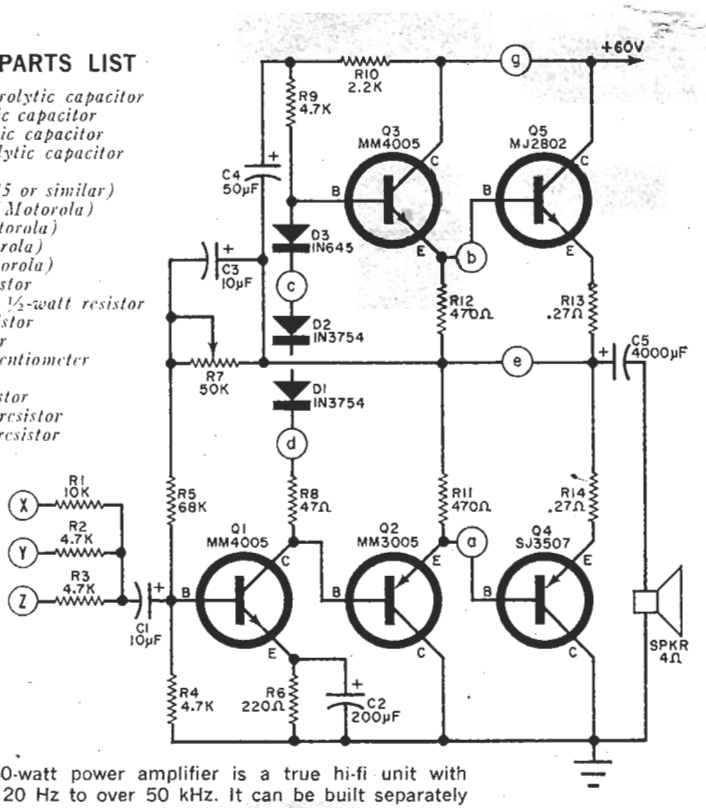


Fig. 1. This 60-watt power amplifier is a true hi-fi unit with response from 20 Hz to over 50 kHz. It can be built separately and used as a power booster for any instrument (or audio) system.

fier that provides exceptionally clean output at high power and low cost. The first stage, *Q1*, is a conventional voltage amplifier.

Diodes *D1*, *D2*, and *D3* are connected between the bases of the driver stages and provide forward bias to turn the output transistors slightly on to prevent crossover distortion. Two of these diodes (*D1* and *D2*) are clamped to the output transistors' heat sink so as to stabilize the forward bias for any variations in operating temperature of the output power transistors.

Power output is a continuous 60 watts, corresponding to a peak music power rating of about 140 watts. Frequency response is from 20 Hz to at least 50 kHz, and the amplifier is designed to supply any 4-ohm speaker that can carry the power. Two 8-ohm speakers, each having at least a 35-watt rating can be used connected in parallel.

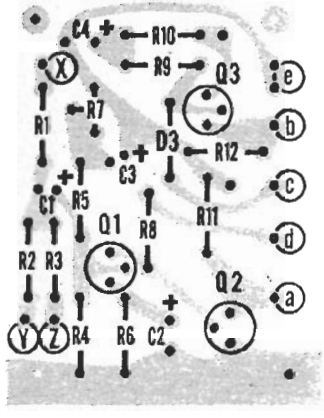
The power amplifier, with the exception of the two output transistors (*Q4* and *Q5*), their associated diodes (*D1* and *D2*), emitter resistors *R13* and *R14*, and output capacitor *C5*, is assembled on a printed board such as that shown actual size in Fig. 2. Components are affixed to the board as shown in Fig. 3. The letter-coded connections in Fig. 3 correspond to those in Fig. 1 for wiring to the external components.

The two power transistors are mounted on the heat sink, with a mica insulating sheet and insulating washers used on *Q5* only. Use a thin coating of silicone grease on both sides of the mica insulator sheet, and on the bottom of both transistors so as to make a good thermal bond between the transistors and the heat sink. One mounting screw of each power transistor should also secure a diode clamp. Insert one 1N3754 diode in each clamp, then tighten the screws. (The author's assembly is shown in Fig. 4.)

Make sure that diodes *D1* and *D2* are correctly wired into the circuit by ob-

Fig. 2. Actual-size printed board for amplifier. The two power transistors and associated components are mounted externally due to their heat dissipation.

Fig. 3. Install the board components as shown. The letter designations correspond to those in Fig. 1.



(or point "e" on the circuit board), and adjust trimmer *R7* for half the power supply voltage (about 30 volts). If you have a sine-wave audio generator and oscilloscope, drive the amplifier to full output with a 4-ohm load connected and adjust trimmer *R7* for symmetrical clipping of both sides of the sine wave.

Instrument Preamplifier. The major difference between a preamplifier designed for a hi-fi system and one designed for an instrument amplifier is that in the latter case there is no need for equalization, and a greater dynamic range must be handled. A recording seldom has more than a 40-dB dynamic range (due to the limitations of the tape or record being used). However, this limitation is not placed on a musical instrument, and the preamplifier must be capable of handling

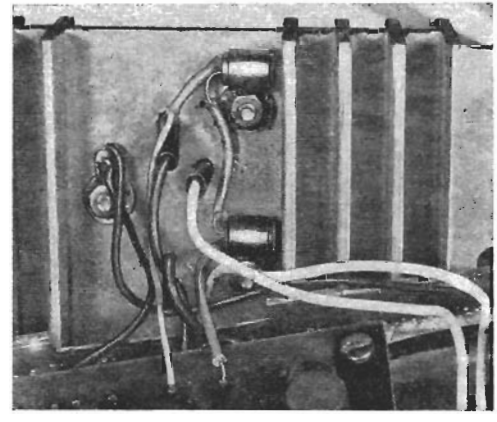


Fig. 4. Diodes D1 and D2 are thermally coupled to Q4 and Q5 by means of a heat sink and diode clamps.

serving that a red dot on each diode case identifies the cathode of the diode. Failure to wire these diodes correctly may damage the power transistors.

Once the heat sink assembly has been completed, it can be wired to the printed board (see Fig. 1). The two emitter resistors (*R13* and *R14*) and output capacitor *C5* are mounted elsewhere on the chassis.

In testing the power amplifier, use a 60-volt power supply, preferably the one designed for this circuit and covered in Part 2 of this article. Connect a voltmeter to the junction of *R13* and *R14* in excess of 60 dB dynamic range during operation. It must also be capable of handling signals from a millivolt up to a volt or so without overloading or clipping.

The main circuit, shown in Fig. 5, makes a very useful instrument preamplifier and incorporates a number of circuits not usually found in most preamps. Besides the usual bass and treble tone controls, this preamp features a built-in fuzz and tremolo circuit.

The first stage (*Q1*) is a common-emitter amplifier directly coupled to an emitter follower output stage (*Q2*). The

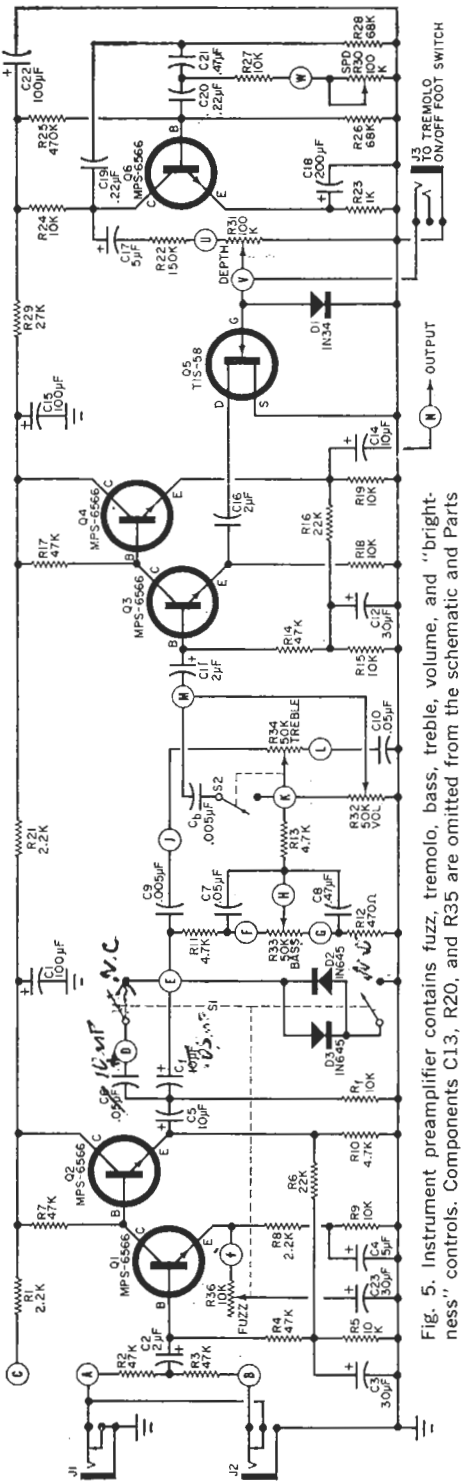


Fig. 5. Instrument preamplifier contains fuzz, tremolo, bass, treble, volume, and "brightness" controls. Components C13, R20, and R35 are omitted from the schematic and Parts List since they are not used here but in the straight preamp which is built on a similar board.

two inputs are fed to *Q1* through isolation resistors *R2* and *R3* wired so that they will be in parallel only when *J1* is being used. The emitter circuits of *Q1* and *Q2* contain the fuzz arrangement.

When "Fuzz" level control *R36* is rotated from its off position, switch *S1* operates. One pole of this switch introduces a pair of clipping diodes (*D2* and *D3*) into the audio circuit. The other pole introduces a parallel coupling capacitor (*C6*) into the interstage coupling. This switching does two things to the signal: first, the diodes clip all signals that exceed one-volt amplitude; second, all low-frequency signals are attenuated and given a sawtooth shape. As *R36* is rotated, the amount of unbypassed emitter resistance in the *Q1* circuit is reduced and the stage gain is increased, which, in turn, increases the amount of clipping and distortion caused by the diodes. This type of variable fuzz is far more versatile than the more conventional fixed fuzz.

INSTRUMENT PREAMPLIFIER PARTS LIST

C1, C15, C22—100-μF, 50-volt electrolytic capacitor
C2, C11, C16—2-μF, 15-volt electrolytic capacitor
C3, C12, C23—30-μF, 6-volt electrolytic capacitor
C4, C17—5-μF, 15-volt electrolytic capacitor
C5, C14—10-μF, 25-volt electrolytic capacitor
C6, C7, C10—0.05-μF capacitor
C8, C21—0.47-μF capacitor
C9, C6—0.005-μF capacitor
C18—200-μF, 6-volt electrolytic capacitor
C19, C20—0.22-μF capacitor
Cf—10-μF, 15-volt electrolytic capacitor
D1—1N34 or similar germanium diode
D2, D3—1N645 or similar silicon diode
J1, J2—Closed-circuit phone jack
J3—3-conductor phone jack
Q1, Q2, Q3, Q4, Q6—MPS6566 transistor (Motorola)
Q5—TIS58 field-effect transistor (Texas Instruments)
R1, R8, R21—2200 ohms
R2, R3, R4, R7, R14, R17—47,000 ohms
R5, R9, R15, R18, R19, R24, R27, Rf—10,000 ohms
R6, R16—22,000 ohms
R10, R11, R13—4700 ohms
R12—470 ohms
R22—150,000 ohms
R23—1000 ohms
R25—470,000 ohms
R26, R28—68,000 ohms
R29—27,000 ohms
R30, R31—100,000-ohm linear potentiometer
R32, R33, R34—50,000-ohm potentiometer
R36—10,000-ohm CCW log taper potentiometer
S1—D.p.s.t. switch (on R36)
S2—S.p.s.t. switch (on R34)

all ½-watt resistors

Fig. 7. Component layout for instrument preamplifier. Components Rf and Cf determine the degree of fuzz, and may be varied in value from those shown.

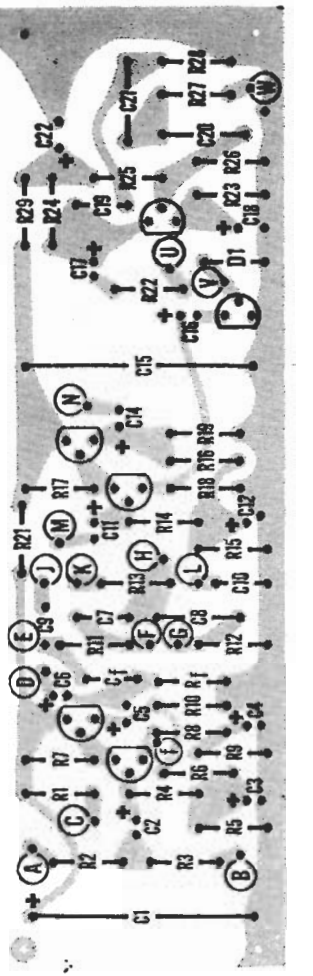


Fig. 6. Actual-size printed board for assembly of instrument preamplifier. The preamp can also be used independently with any instrument audio system.

The signal from *Q2* is then passed through a bass and treble tone control circuit (15 dB cut or boost) before it is further amplified by *Q3*. There is one unique feature about the treble control used here. When switch *S2* is activated, capacitor C_b is introduced to bypass the high-frequency sound around volume control *R32*. Introducing this capacitor in the circuit produces a "bright" signal that is a type of fixed treble boost. Although switch *S2* is shown coupled to *R34*, it can be an independent switch.

The output signal at the collector of *Q3* is directly coupled to emitter-follower *Q4*, from which it is fed to the power amplifier. However, the built-in tremolo is introduced at the emitter of *Q3*.

The tremolo circuit consists of *Q3*'s emitter bypass capacitor (*C16*) in se-

(*Continued on page* 99)

INSTRUMENT AMPLIFIER

(*Continued from page 47*)

ries with a FET (*Q5*) acting as a voltage-variable resistor. As the voltage to the FET gate is varied, more or less bypass is introduced into the *Q3* circuit. This, in turn, will vary the gain of the output signal, producing tremolo (signal level variation).

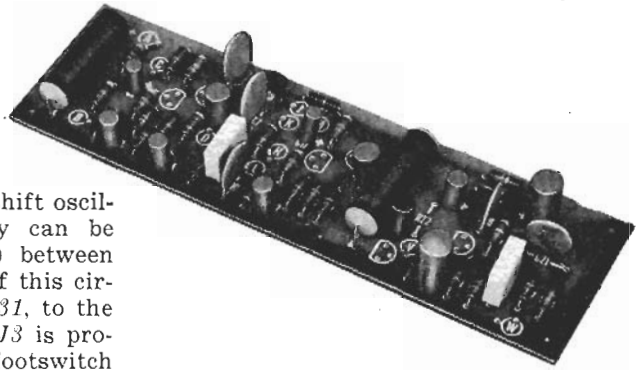


Fig. 8. Completed instrument preamplifier on printed board before installation of the transistors.

Transistor *Q6* is in a phase-shift oscillator circuit whose frequency can be varied (by speed control *R30*) between 4 and 15 Hz. The a.c. output of this circuit is fed, via level control *R31*, to the gate of *Q5*. Open-circuit jack *J3* is provided so that an external footswitch can be used to turn on the tremolo if desired.

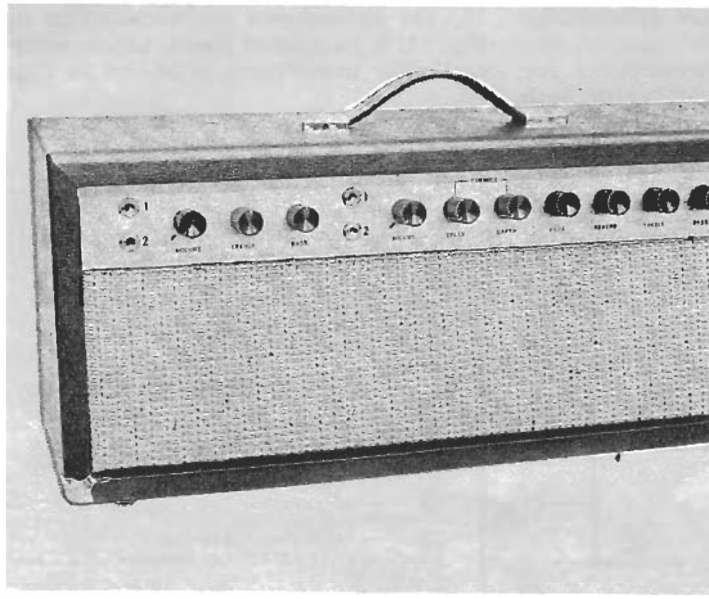
PC BOARDS AND PARTS KITS

The following are available from Southwest Technical Products: etched and drilled PC board for instrument preamplifier (#141), $3.00; straight preamplifier (#141P), $2.50; reverb unit (#141R), $2.10; and power amplifier (#141A), $2.10. A complete amplifier kit including all parts and punched chassis, less cabinet and panel markings (#MMC141) is $85.00. Send self-addressed envelope for price list on separate parts kits for each portion of the system to Southwest Technical Products Corp., 219 W. Rhapsody, Box 16297, San Antonio, Texas 78216.

The actual-size printed board for the instrument preamplifier is shown in Fig. 6 with the components mounted as in Fig. 7. A completed board, before the semiconductors are installed, is shown in Fig. 8. This board was made from the kit.

Part 2 of this article (to appear next month) will contain the construction details for a straight preamplifier that can be used for announcements, vocals, or instruments not requiring signal conditioning; an adjustable reverberation system that has no signal loss, including some methods of installing it in any audio system; a power supply capable of operating either the entire M/M/M Instrument Amplifier, or any portion of it; and the interconnection details for assembling the entire instrument amplifier system in one package.

Incidentally, the straight preamplifier will also make an excellent hi-fi preamplifier for any audio system. It incorporates adjustable bass and treble controls —15 dB boost or cut—and an independent volume control. —30—



BUILD THE

M/M/M Instrument Amplifier

60-WATT SOLID-STATE GUITAR AMPLIFIER WITH TREMOLO, REVERB, AND FUZZ

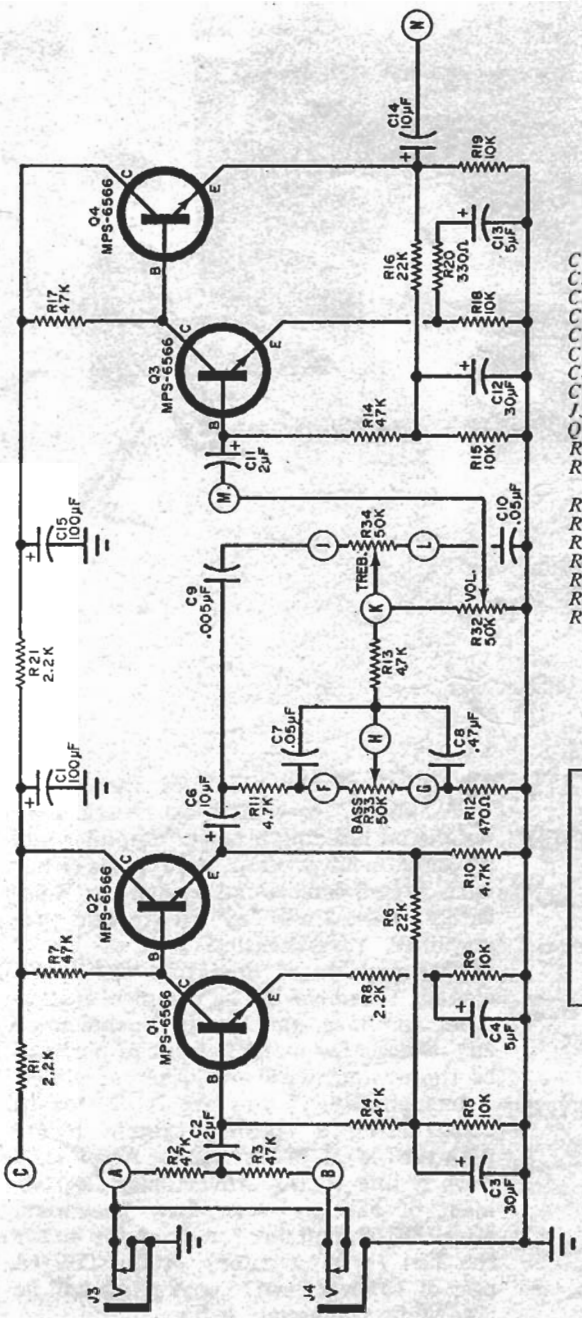
BY DANIEL MEYER

PART 1 of the "M/M/M Instrument Amplifier," presented last month, gave details on building a power amplifier and an instrument preamplifier for use either with a complete sound system or separately. Part 2 will cover a straight preamplifier, reverberation unit, a power supply capable of operating the entire system, assembly of the complete instrument amplifier, and it will provide some suggestions for using individual portions of the system with any other amplifier.

Incidentally, if you are interested in constructing a speaker system to go with the "M/M/M Instrument Amplifier," drop a line to the Advertising Department of Electro-Voice, Inc., Buchanan, Mich. 49107, and ask for plans for either the TB1 (a 30″ woofer), or the TB2 (a pair of 15″ woofers). These plans will be free while the supply lasts.

Straight Preamplifier. The circuit for the conventional straight preamplifier, useful for vocals or general announcement purposes, is shown in Fig. 9. It is basically similar to the instrument preamplifier without the special effects circuitry, and can make an excellent preamplifier for any hi-fi system. It incorporates both bass and treble tone controls and has its own volume control.

An actual-size printed board for the straight preamplifier can be seen in Fig. 10; the components are installed as in Fig. 11. A completed board, before semiconductor installation, is shown in Fig. 12.



STRAIGHT PREAMPLIFIER PARTS LIST

C1, C15—100-µF, 50-volt electrolytic capacitor
C2, C11—2-µF, 15-volt electrolytic capacitor
C3, C12—30-µF, 15-volt electrolytic capacitor
C4, C13—5-µF, 15-volt electrolytic capacitor
C6, C14—10-µF, 25-volt electrolytic capacitor
C7, C10—0.05-µF capacitor
C8—0.47-µF capacitor
C9—0.005-µF capacitor
J3, J4—Closed-circuit phone jack
Q1, Q2, Q3, Q4—MPS6566 transistor (Motorola)
R1, R8, R21—2200 ohms
R2, R3, R4, R7, R14, R17—47,000 ohms
R5, R9, R15, R18, R19—10,000 ohms
R6, R16—22,000 ohms
R10, R11, R13—4700 ohms
R12—470 ohms
R20—330 ohms
all ½-watt resistors
R32—50,000-ohm audio taper potentiometer
R33, R34—50,000-ohm linear potentiometer

The author's M/M/M Instrument Amplifier, shown on page 31, is assembled in a leatherette-covered, sloping-front wooden case measuring 25" long, 10" high, and 7" deep. The various electronic assemblies are mounted on a metal chassis as shown on page 40, running the length of the case, and the reverb spring unit is secured to the bottom of the case.

Fig. 9. The straight preamplifier is a high-quality unit having its own bass, treble, and volume controls. Components C5, J1, J2, and R22 through R31 are omitted from schematic and Parts List since they are not used here but in the instrument preamplifier (presented last month) which is built on a similar PC board.

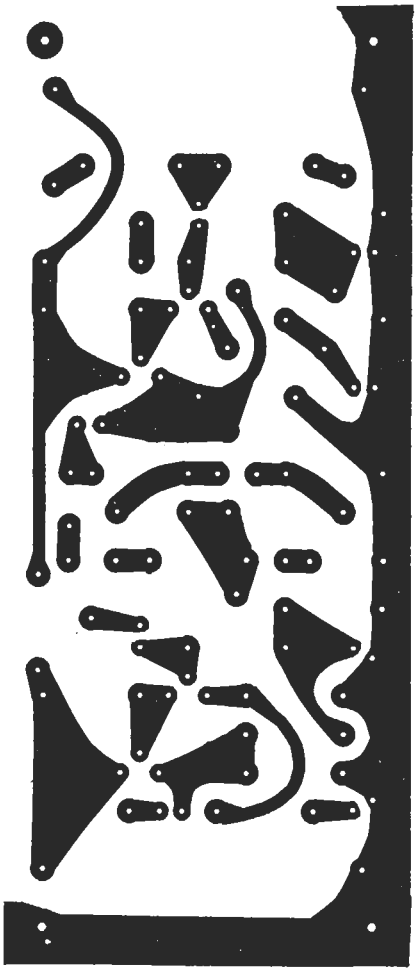


Fig. 10. You can make this actual-size printed board for the straight preamplifier yourself, or buy it etched and drilled.

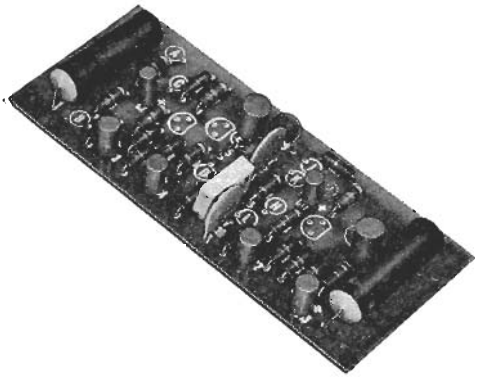


Fig. 12. The author's prototype of the straight preamplifier before installation of transistors.

Reverberation Unit. This unit consists of a two-transistor driver for a spring-type reverb unit, and another two-transistor amplifier to make up the signal loss (typically about 40 dB) encountered in the spring unit. See Fig. 13.

The input signal for the reverb unit is taken from the output of the preamplifier. Because it is desirable to have as high an input signal to the spring unit as possible in a reverb system (to reduce hum and vibration noise), the input signal is amplified by *Q1*, while *Q2* is an impedance matcher used to drive the reverb spring unit. The echo signal at the other end of the spring is amplified by *Q3* and passed via emitter follower *Q4* as the output. Open-circuit jack *J1* is provided so that an external footswitch can be used to activate the reverb as desired.

An actual-size printed board for the reverb unit is shown in Fig. 14; the as-

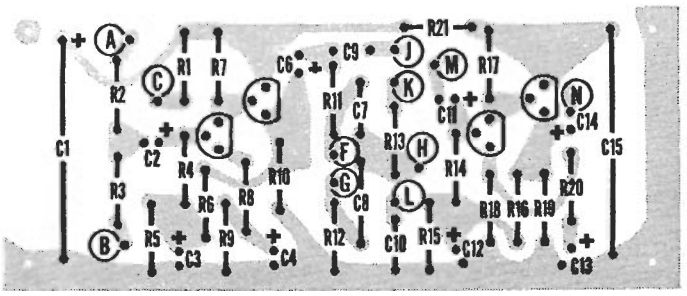
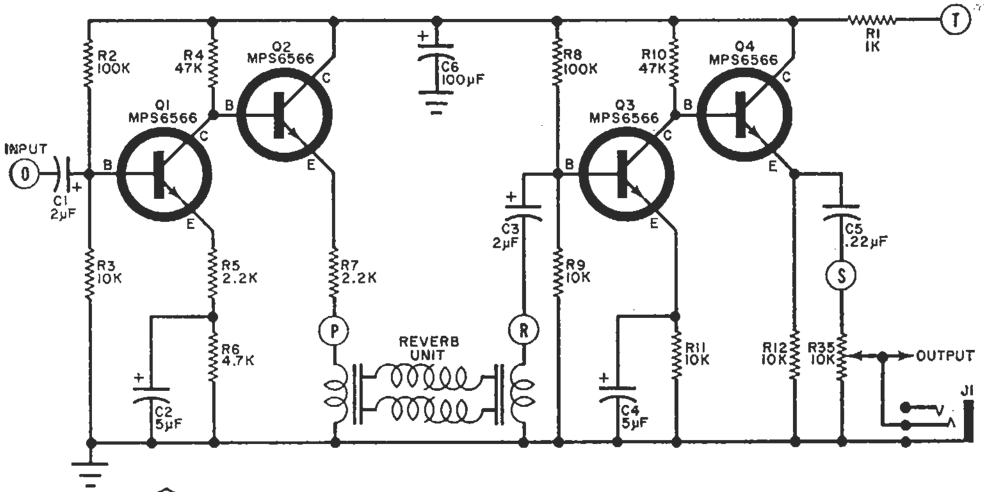


Fig. 11. Mount the components used in the straight preamplifier on the PC board as shown. The letter designations correspond to those in the schematic.



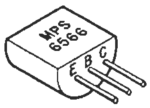
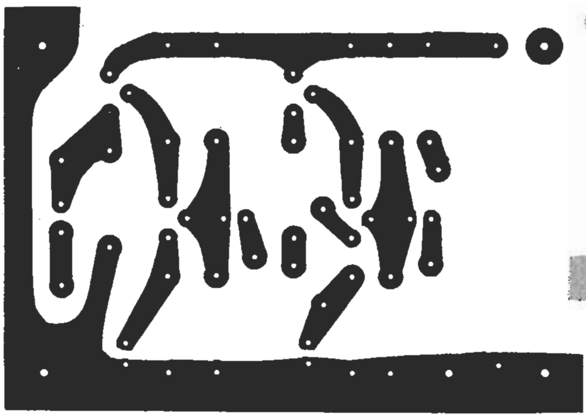


Fig. 13. Jack J1 connects to an external footswitch to turn the reverb on and off. Reverberation gain control R35 is not on the PC board but on the front panel.

REVERBERATION UNIT PARTS LIST

C1, C3—2-μF, 15-volt electrolytic capacitor
C2, C4—5-μF, 15-volt electrolytic capacitor
C5—0.22-μF capacitor
C6—100-μF, 50-volt electrolytic capacitor
J1—3-conductor phone jack
Q1, Q2, Q3, Q4—MPS6566 transistor (Motorola)
R1—1000 ohms
R2, R8—100,000 ohms
R3, R9, R11, R12—10,000 ohms
R4, R10—47,000 ohms
R5, R7—2200 ohms
R6—4700 ohms
(all ½-watt resistors)
R35—10,000-ohm linear potentiometer
1—Gibbs Type 1V-C reverberation spring unit



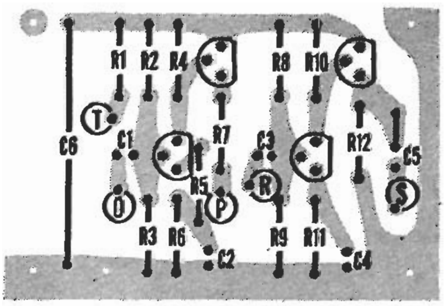


Fig. 15. Assemble the components on the printed circuit board as shown above.

Fig. 14. Actual-size PC board (left) contains the entire reverberation circuit.

sociated components are added as per Fig. 15. The completed board, before semiconductor installation, appears in Fig. 16.

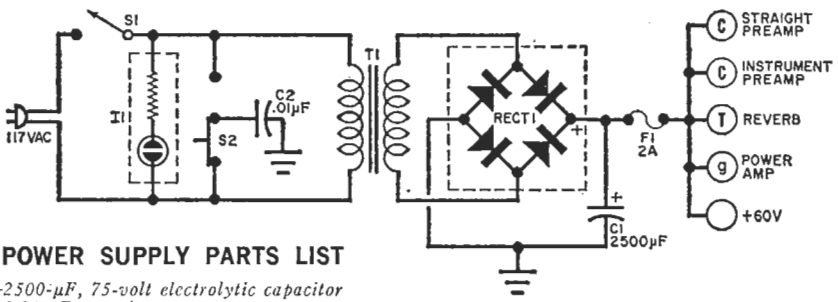
Power Supply. The circuit for a power supply capable of driving the complete system is shown in Fig. 17. It is a conventional full-wave rectifier and filter capacitor combination that will deliver 60 volts at the required current. Indicator *I1* tells when the power has been applied to the system, while *S2* is placed in the position that produces the lowest hum level (if any).

Assembling Complete System. The various components are interconnected as

Fig. 16. The reverberation PC board should look like this before you install the four transistors.

shown in Fig. 18. As shown in the photograph on page 31, the entire system can be mounted within a suitable case (partially sloping front), with the electronics all supported on a single cabinet-length metal chassis and with the reverb spring unit secured to the bottom of the case. The various potentiometers and switches can be mounted on the front apron of the chassis and transfer decals used to identify them. See Fig. 19 for the chassis arrangement used by the author; any other arrangement will suffice.

(*Continued on page* 40)



POWER SUPPLY PARTS LIST

C1—2500-μF, 75-volt electrolytic capacitor
C2—0.01-μF capacitor
F1—2-ampere fuse
I1—Neon lamp and limiting resistor
RECT 1—2-ampere silicon rectifier bridge, 100-PIV (Varo VS148 or similar)
S1—S.p.s.t. switch
S2—S.p.d.t. switch
T1—Power transformer: secondary, 45 volts at 2 amperes

Fig. 17. This power supply is capable of operating the entire instrument amplifier, or any one unit.

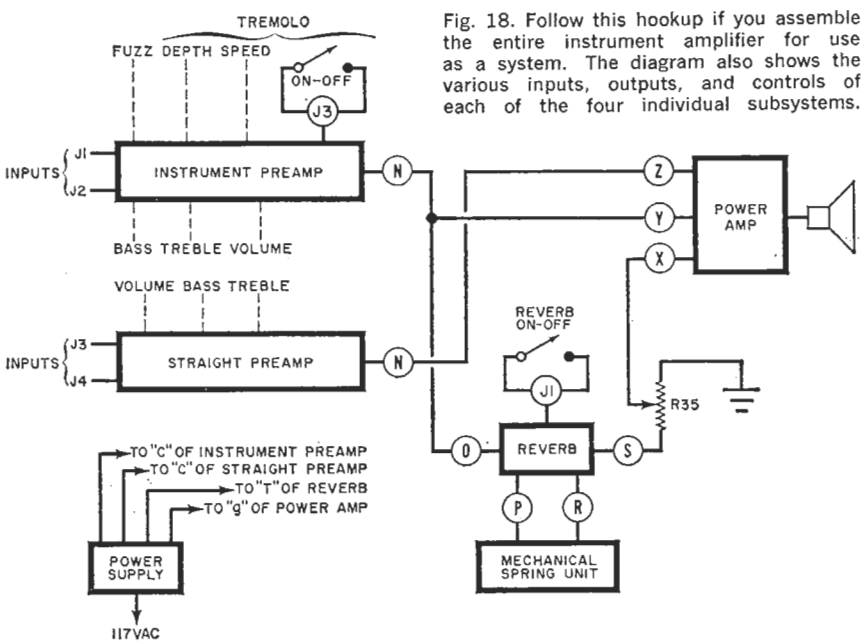


Fig. 18. Follow this hookup if you assemble the entire instrument amplifier for use as a system. The diagram also shows the various inputs, outputs, and controls of each of the four individual subsystems.

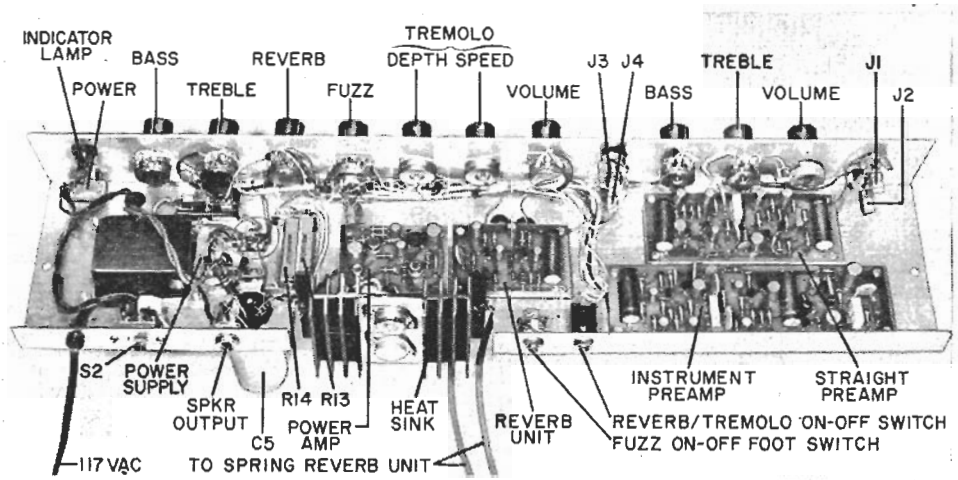


Fig. 19. The M/M/M Instrument Amplifier can be mounted on one long metal chassis. Note (below) that a complete amplifier kit is available as well as individual unit kits. All you need is a 60-watt speaker.

PC BOARDS AND PARTS KITS

The following are available from Southwest Technical Products: etched and drilled PC board for instrument preamplifier (#141), $3.00; straight preamplifier (#141P), $2.50; reverb unit (#141R), $2.10; and power amplifier (#141A), $2.10. A complete amplifier kit including all parts and punched chassis, less cabinet and panel markings (#MMC141) is $85.00. Send self-addressed envelope for price list on separate parts kits for each portion of the system to Southwest Technical Products Corp., 219 W. Rhapsody, Box 16297, San Antonio, Texas 78216.

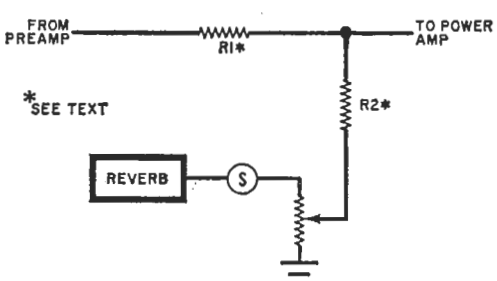


Fig. 20. Method of connecting reverb unit to any amplifier. See text at right for resistance values.

The speaker is connected to the amplifier via a telephone-type jack, as are the on-off footswitches that control fuzz, reverb, and tremolo circuits. The on-off footswitches are conventional instrument switches, available wherever electronic musical instruments are sold.

When the complete system is used, do not place it on a speaker enclosure as acoustic feedback can cause the reverb spring to produce a disturbing howl. Also, make sure that the speaker used can take the full 60-watt output of the power amplifier.

Set the guitar output control to maximum, plug it into the instrument preamplifier and make the desired volume, bass, and treble adjustments. Then set in the desired amount of fuzz, reverb, or tremolo, and use the external footswitches to turn them on or off as desired.

Individual Use. Either preamplifier can be used with any power amplifier merely by applying the correct d.c. voltage, and using the signal from terminal "N" of each printed board as the output.

The reverb unit can be installed in any audio system by following the arrangement in Fig. 20. In vacuum-tube systems, *R1* and *R2* will be between 47,000 and 100,000 ohms, with the exact values determined by tests; start with a 47,000-ohm unit, remembering that there will be some signal loss. In transistor circuits, *R1* and *R2* will be between 1000 and 4700 ohms (a good compromise is 2200 ohms); again remember that some signal loss will be introduced by these two resistors. —30—