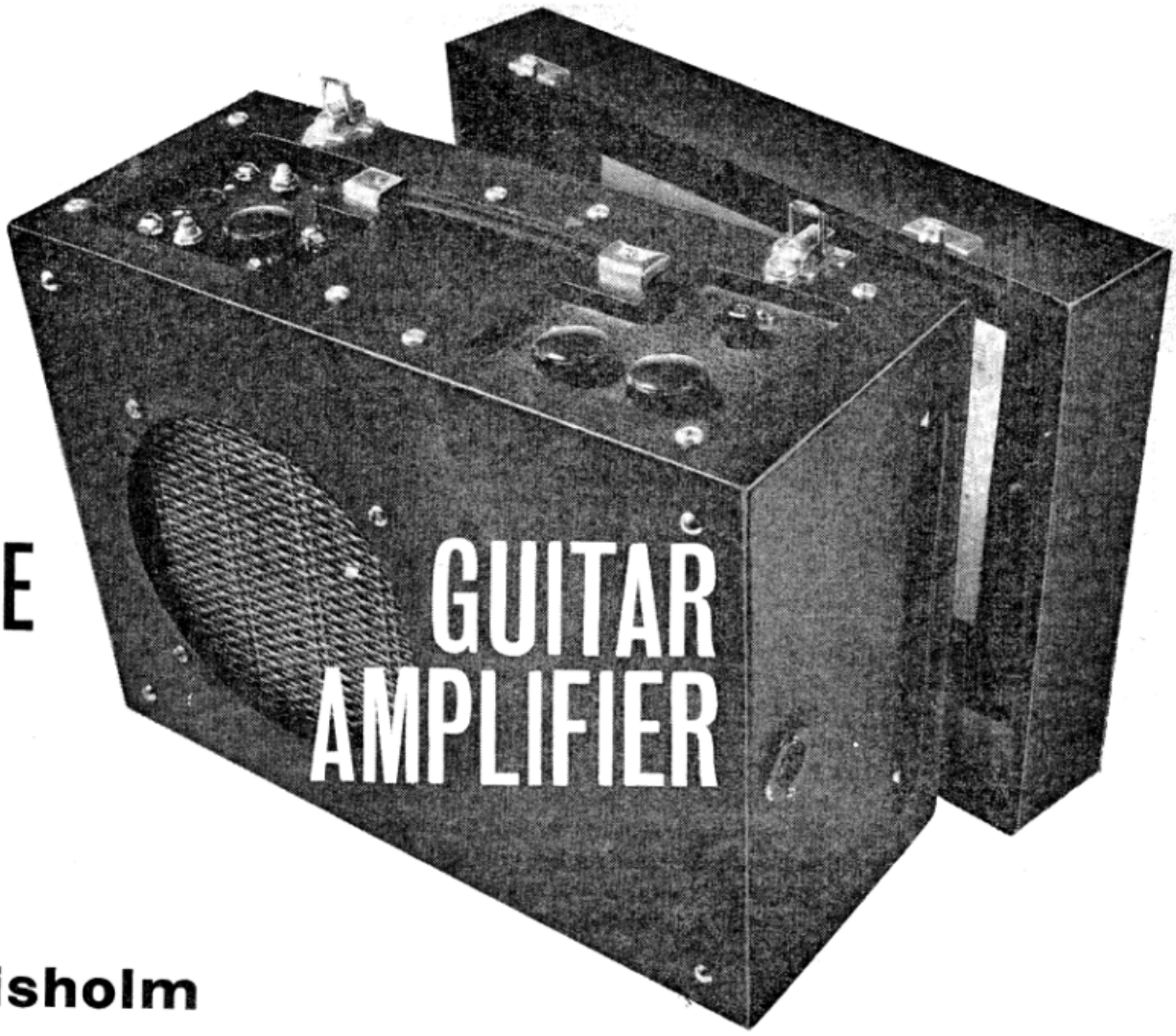


PART ONE GUITAR AMPLIFIER

By S. Chisholm

FOLLOWING last month's article on the tenor electronic guitar this article describes an integrated guitar amplifier with the facilities outlined in the specification.

Although it has been proved to be adequate for the purposes originally intended there are one or two limitations of which the prospective constructor should be aware before commencing the construction.

A tenor guitar has a wide frequency range but the bass notes are usually low level in comparison with the rest of the range. This amplifier copes very well with these conditions. On the other hand a bass guitar produces a relatively high amplitude at its lowest frequencies. The amplifier will handle this but if they are played strongly there is a risk of overloading the first stage. It was *not* intended to use the amplifier in a guitar group played before a large audience, but if the constructor wishes to do so he should be aware of the above limitations and use the channel volume controls, bearing in mind the power available at the output. It can give sufficient power to fill a large living room even when there is some room noise present.

Good earthing is essential to reduce hum to a minimum and provide a clean bass response.

SPECIFICATION

Although designed originally for use with the tenor electronic guitar described last month, this amplifier can be used with other musical instruments.

Input
Two channel input with independent volume controls.

Controls
Overall volume, tone and vibrato controls for local or remote operation.

Tone
Two alternative circuits described:
(a) Three position control with volume compensation simulating a three pickup guitar.
(b) Two position control uncompensated.

Vibrato
Optional two-speed constant depth.

Output
3½ watts driving one 8in energised and one 6in permanent magnet loudspeaker.

Frequency range
No audible loss over the entire range of a piano using a crystal microphone placed inside the piano cabinet.

Power Consumption
240 volts a.c. 70 watts (self-contained power unit).

Dimensions
18in wide, 14in high, 7½in deep. Wooden case with detachable lid containing the second loudspeaker and connecting cables.

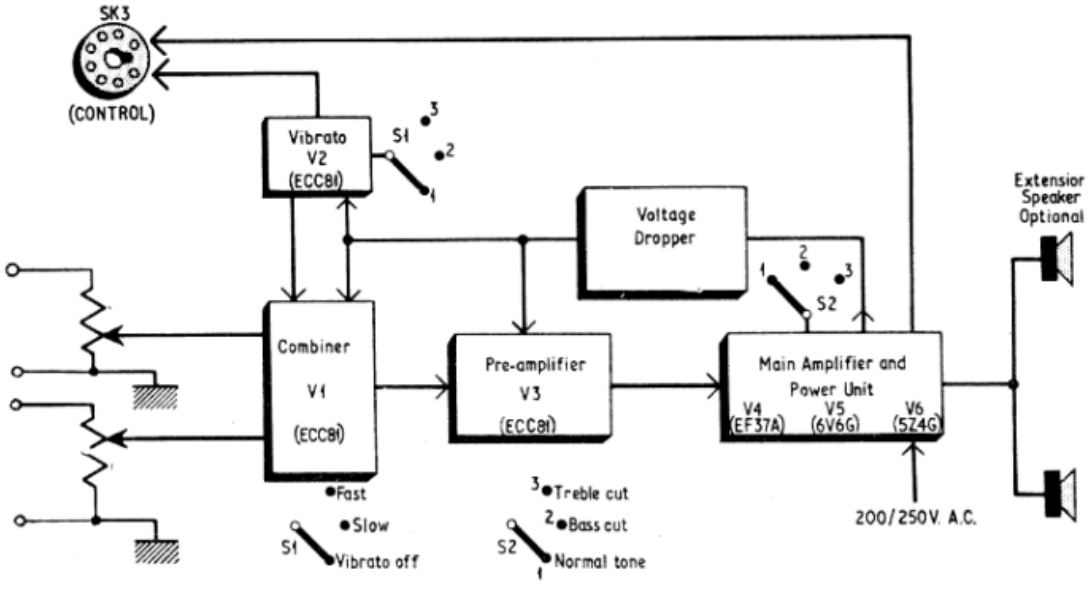


Fig. 1. Block diagram of the complete amplifier

CIRCUIT

The block digram of the complete amplifier is shown in Fig. 1. The two input sockets are suitable for high impedance signals from a microphone and pick-up. Each channel has its own volume control to match the two signals and prevent possible overloading of the first stage. Vibrato effect can be switched to channel 1 signal before the two signals are mixed and fed to V3a (see Fig. 3). V3 and V4 amplify the combined signal. RLA1 in the cathode of V4 is normally closed. Switch S2 (situated on the guitar itself) can operate the relay to bring the cathode bypass capacitor into circuit to increase the bass response. A certain degree of top cut is provided by R26 and C17 across the primary of the output transformer.

Although an 8in energised loudspeaker is specified (part of the winding being used as a smoothing choke), there is no reason why this should not be replaced by a moving coil loudspeaker and separate choke as shown in Fig. 3.

The power unit is designed for a.c. operation only. Universal (a.c./d.c.) operation is unsuitable because of shock risks on the instrument. The amplifier should be earthed.

TONE CONTROL

One of two systems can be adopted; both provide instantaneous preset change of tone. The first (R24 and C16 in Fig. 3) will give a slight drop in volume. The second (Fig. 4) provides a more flexible arrangement controlling both treble and bass.

In the simple circuit the guitar switch S2 supplies a d.c. voltage to relay RLA from the h.t. line. The

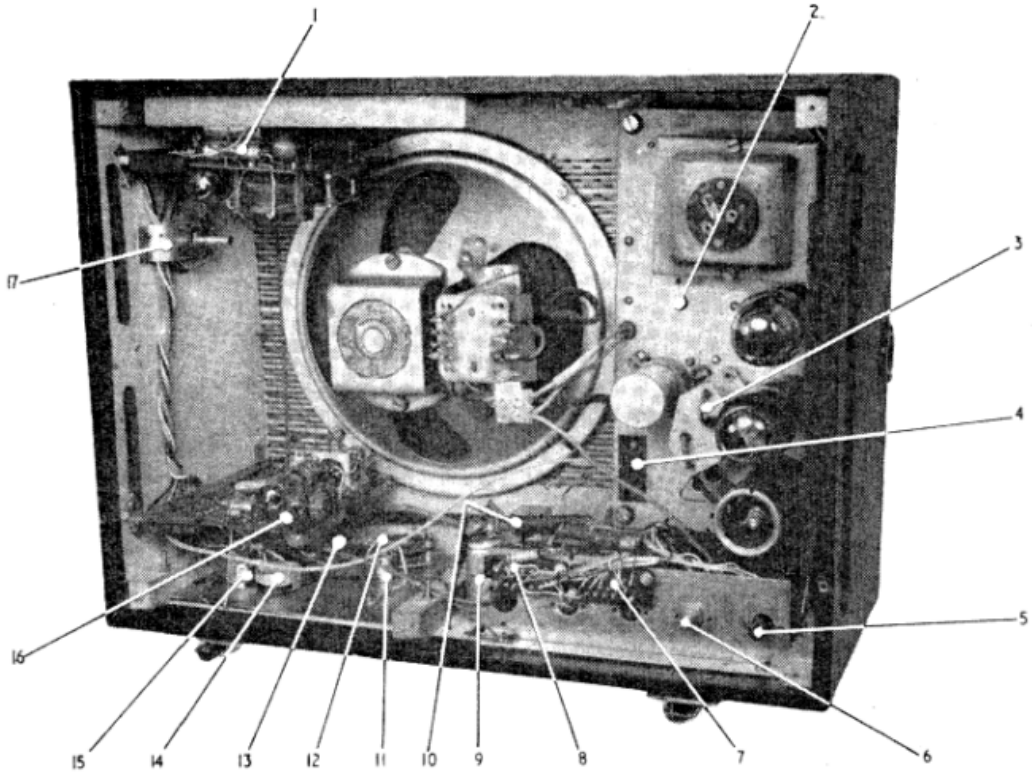


Fig. 2. Interior of the prototype model

1. Vibrato unit
2. Main amplifier
3. Bass inductor L4
4. Input to main amplifier
5. Treble volume control VR5
6. Bass volume control VR4
7. Relay RLB
8. Relay RLA
9. Smoothing capacitor C8
10. Smoothing choke L2
11. Vibrato indicator lamp LP1
12. Vibrato control switch S1
13. Input volume control VR2
14. Input volume control VR1
15. Input socket SK1
16. Preamplifier unit
17. Vibrato speed control VR3

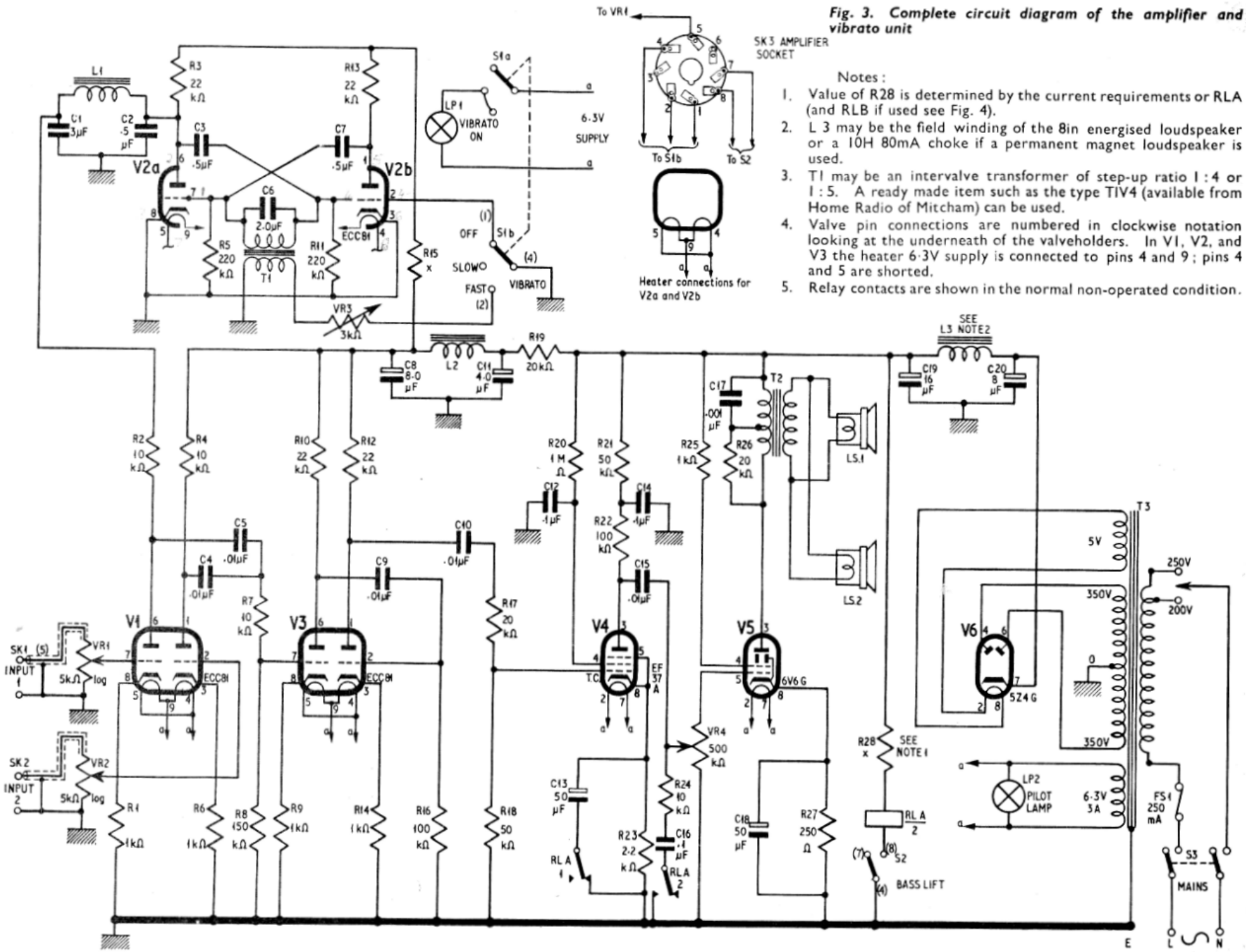


Fig. 3. Complete circuit diagram of the amplifier and vibrato unit

Notes :

1. Value of R28 is determined by the current requirements or RLA (and RLB if used see Fig. 4).
2. L 3 may be the field winding of the 8in energised loudspeaker or a 10H 80mA choke if a permanent magnet loudspeaker is used.
3. T1 may be an intervalve transformer of step-up ratio 1 : 4 or 1 : 5. A ready made item such as the type TIV4 (available from Home Radio of Mitcham) can be used.
4. Valve pin connections are numbered in clockwise notation looking at the underneath of the valveholders. In V1, V2, and V3 the heater 6·3V supply is connected to pins 4 and 9 ; pins 4 and 5 are shorted.
5. Relay contacts are shown in the normal non-operated condition.

value of Rx is arranged to suit the current required to operate RLA (see a later paragraph). Contacts RLA1 disconnect C13 from the cathode of V4 and RLA2 introduces the top cut circuit (R24 and C16) across the output of V4.

The complex circuit (Fig. 4) involves more components but it is well worth adopting. A second relay is connected in the h.t. circuit as shown, with S2 changed to a three-way switch to give bass lift, treble lift or neither. We now have two sets of relay contacts RLA and RLB. The positions of the contacts shown in the circuit indicate their function in the non-operated condition.

Operation of the tone switch S2 to the bass lift position operates RLA. RLA1 disconnects the cathode bypass capacitor C13 from earth and inserts the top cut circuit R24 and C16 and the bass control VR5. The volume control VR4 and treble control VR5 are not in use. The values of R24 and C16 can be adjusted to provide top cut to suit the user.

When S2 is set to treble lift, RLB operates and RLA releases. All circuits associated with RLA are now restored to normal. RLB1 and RLB2 connect the treble control VR5 and disconnect VR4. RLB3 inserts C21 and L4 in the grid circuit of V5. The values of C21 and L4 may be chosen to suit the user's preference, and may be determined from published nomograms to give a bass cut below about middle C (256c/s). VR5 can be adjusted to compensate for the general loss of volume due to C21 and L4.

In the prototype a 60 : 1 microphone transformer was used for L4. The primary (low impedance) winding was left open circuit. C21 was initially 150pF, then by experimenting a suitable value was found to give the required amount of bass cut. Too small a value for C21 can cause a.f. oscillation when VR5 is adjusted. Relays RLA and RLB should be capable of operating at about 10mA, the lower the current demand the better. They should have at least three changeover sets of contacts.

VIBRATO

The vibrato circuit (V2a and V2b in Fig. 3) is basically a multivibrator. The operating frequency is governed by T1, C6 and VR3. The LC circuit (L1, C1, C2) rounds off the spiky waveform of the multivibrator. The value of C6 is chosen in conjunction with the inductance of T1 by connecting a preset potentiometer VR3 across the primary when required. Depth of vibrato is preset by R15.

The h.t. supply to V1a anode is taken from the anode load resistor R3 via a low-pass filter L1, C1 and C2. This filter removes practically all trace of multivibrator waveform and provides a smoothly alternating waveform to V1. Inductor L1 is a Mullard ferroxcube (type LA7) filled with 30 s.w.g. enamelled wire but any form of a.f. choke should be suitable provided it can be mounted on Veroboard.

Vibrato is introduced to the guitar signal by operating S1 which also switches on the vibrato indicating lamp. When S1 is switched off V2B grid is earthed, thus preventing modulation of the h.t. supply to V1a. The "slow" setting releases the grid; vibrato frequency is then determined by the LC circuit only.

The "fast" setting introduces preset VR3 effectively reducing the inductance of T1 primary. Vibrato tends to affect V1b, but to a lesser degree than in V1a, and is not considered to be objectionable. Socket SK3 provides connection to remote controls on the guitar.

GUITAR WIRING NOTE

In last month's article on the "Electronic Guitar" (see Fig. 6) the connections of terminals 4 and 5 on the guitar plug, amplifier plug and jack plug were incorrect. The screen should be connected to pins 4 on both 8-pin plugs and to the sleeve of the jack plug; the centre conductor should be connected to pins 5 and the tip of the jack plug.

Next month: Full constructional details will be given with a few details on maintenance and use of the amplifier and guitar.

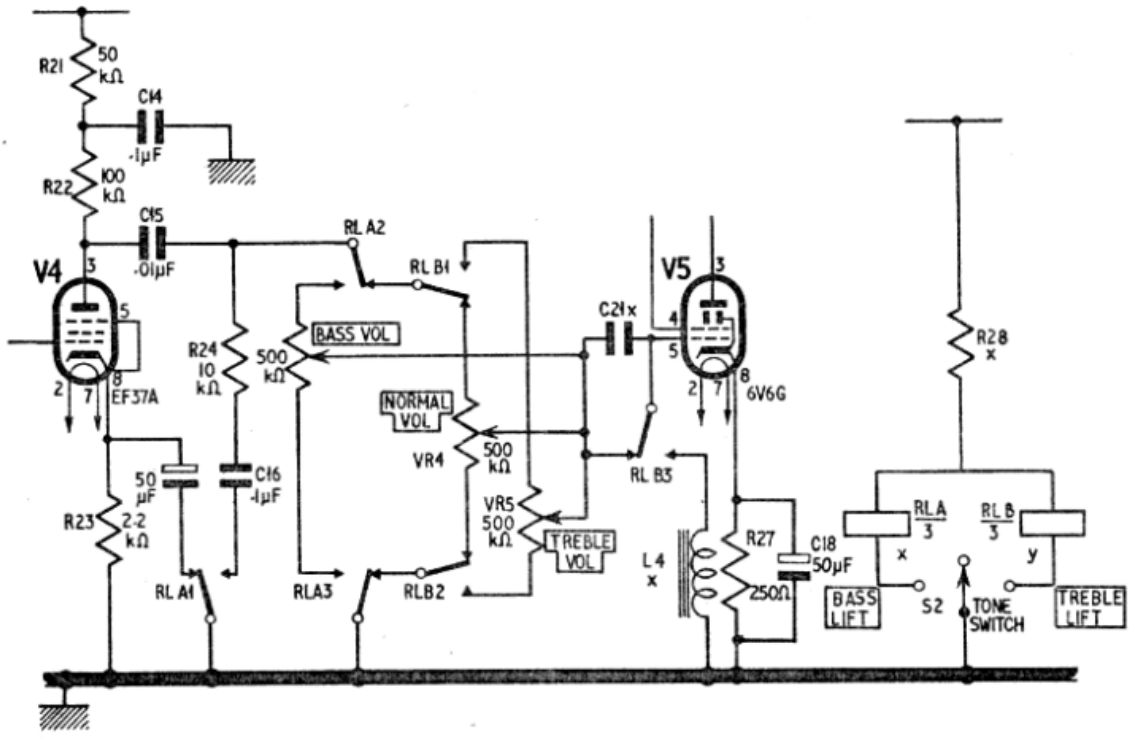


Fig. 4. Alternative complex tone control circuit between V4 and V5

COMPONENTS . . .

INPUT CONTROL PANEL

Potentiometers

VR1 and VR2 5kΩ log.

Sockets

SK1 and SK2 Two-terminal jacks
SK3 International octal valveholder

Switch

S1 2-pole, 3-way, centre off, toggle switch

Lamp

LP1 Indicator lampholder and 6·3V 0·05A m.e.s. bulb.

Note: VR1 and VR2 are connected to the pre-amplifier S1 and LP1 are connected to the vibrato circuit

MIXER AND PRE-AMPLIFIER UNIT

Resistors

R1	1kΩ	1W	R9	1kΩ	1W
R2	10kΩ	1W	R10	22kΩ	1W
R4	10kΩ	1W	R12	22kΩ	1W
R6	1kΩ	1W	R14	1kΩ	1W
R7	10kΩ	¼W	R19	20kΩ	3W
R8	150kΩ	¼W			

Capacitors

C4	0·01μF	350V paper	C9	0·01μF	350V paper
C5	0·01μF	350V paper	C10	0·01μF	350V paper
C8	8μF	350V elect.	C11	4μF	350V elect.

Valves

V1 ECC81 V2 ECC81

Choke

L2 10H 30mA

VIBRATO UNIT

Resistors

R3	22kΩ	1W	R11	220kΩ	¼W
R5	220kΩ	¼W	R13	22kΩ	1W
R15		3W resistor (resistance determined by vibrato depth required)			

Potentiometer

VR3 3kΩ log

Capacitors

C1	3μF	150V paper (can be 2 + 1μF in parallel)
C2	0·5μF	150V paper
C3	0·5μF	150V paper
C6	2μF	150V paper
C7	0·5μF	150V paper

Choke

L1 Ferroxcube type LA7 filled with 30 s.w.g. enamelled wire, or any a.f. choke

Transformer

T1 Type TIV4 (Home Radio)

Valve

V2 ECC81

MAIN AMPLIFIER

Resistors

R17	20kΩ	¼W	R23	2·2kΩ	1W
R18	50kΩ	¼W	R24	10kΩ	½W
R20	1MΩ	½W	R25	1kΩ	1W
R21	50kΩ	1W	R26	20kΩ	½W
R22	100kΩ	1W	R27	250Ω	1W

R28 to suit current through RLA (see text)

Potentiometer

VR4 500kΩ log. carbon

Capacitors

C12	0·1μF	350V paper
C13	50μF	25V elect.
C14	0·1μF	350V paper
C15	0·01μF	350V paper
C16	0·1μF	150V paper
C17	0·001μF	350V paper
C18	50μF	50V elect.
C19, 20	16μF + 8μF	350V elect.

Valves

V4 EF37A V5 6V6G V6 5Z4G

Switches

S2 Single-pole, on-off toggle switch
S3 Double-pole, on-off toggle switch

Transformer

T2 Output transformer to match 6V6 to two loudspeakers in parallel
T3 Primary 200-250V a.c.
Secondary 350-0-350V 70mA, 6·3V 3A, 5V 2A

Choke

L3 L.F. choke 10H 80mA (required only if p.m. loudspeaker is used)

Miscellaneous

FS1 Fuseholder and 250mA fuse
LP2 Indicator lampholder and 6·3V 0·3A bulb
RLA Relay (see text)

COMPENSATED TONE CONTROL

The following is a list of additional or replacement components. See text and Fig. 4 for details.

Potentiometers

VR5 and VR6 500 kΩ log. (additional)

Switch

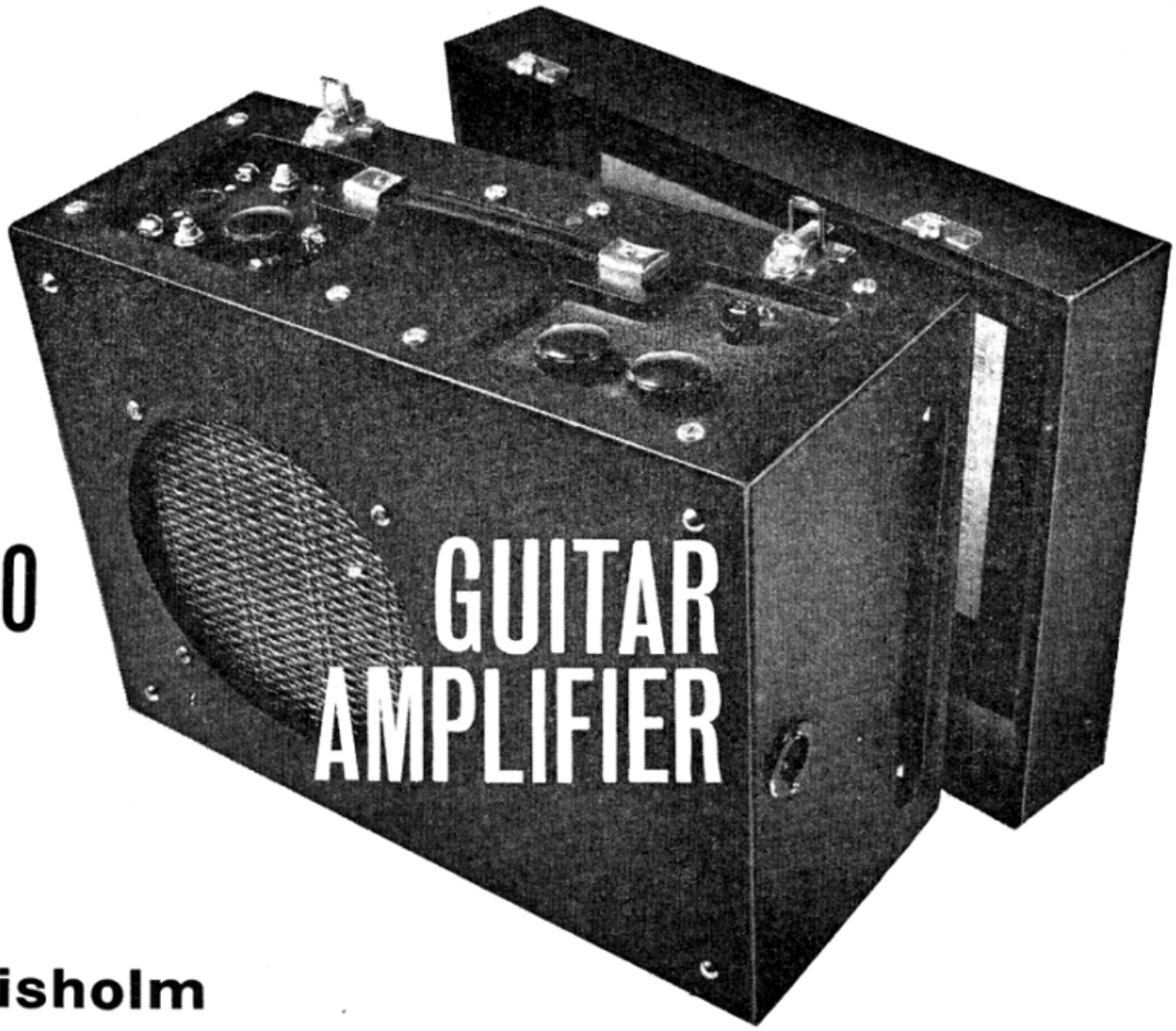
S2 single-pole, 3-way, centre off, toggle switch replaces the single-pole, on-off switch given in main amplifier components list

Miscellaneous

L4 Choke
C21 Capacitor
RLB Relay
} additional (see text)

OTHER MISCELLANEOUS ITEMS

2 Veroboard panels
1 8in loudspeaker, permanent magnet (if an energised loudspeaker is used, the field winding should withstand 80mA at 350V and take the place of L3)
1 6½in permanent magnet loudspeaker
Screened wire, connecting wire, cleats, nuts, bolts, wood screws, sheet aluminium (see next month's article)



PART TWO GUITAR AMPLIFIER

By S. Chisholm

THE information which follows describes the prototype, which employed complex tone control. As the equipment is not frequency-conscious, rigid adherence to component values and dimensions is not essential and the prospective constructor will probably find some of the material on his spares shelf already.

It must be realised, however, that there is a very high gain between input and output; when designing layout, cross-coupling between grid and anode circuits due to close proximity of wiring will cause instability. Also, because of the high gain, the main amplifier must be effectively earthed if hum is to be reduced to a minimum. The earthing arrangements must be adhered to in the sub-units and input circuit screening.

MAIN AMPLIFIER

Fig. 5 shows the drilling details of the main amplifier using international octal valve bases. It does not show drilling details for component assembly strips, T3, L3 and L4 as these will depend on what is available. Fig. 6 shows a representative component layout when a smoothing choke is to be used instead of an energised loudspeaker. The location of the transformer (T3) is shown dotted, also the position of L4. Approximate cable entry positions are given.

As much as possible of the wiring to the grid circuit of V3 and to the compensating volume controls mounted on the relay sub-assembly should be in screened cable. The screens are earthed.

A word of caution here: in some screened cable (particularly coaxial cable) with p.v.c. or polythene insulation, the insulation will melt at fairly low temperatures. It is best to tin the screen and centre conductor with solder before final connection. In all cases, check the insulation between the internal lead and its screen after completing the joint, making sure that no resistors are in circuit.

When wiring, do not forget the h.t. and l.t. connections for the sub-units. These can be formed into a cable, in which the heater leads should be a twisted pair. Finally, ensure all joints are sound. One poor connection can cause a great deal of annoyance and partial dismantling of the assembly. A good test for "dry" joints is to give the soldered wire a gentle tug with a pair of pliers.

COMPONENTS

Details of components were given last month but it may be worth mentioning here that if R28 is too low in value the vibrato speed may be affected.

Relays RLA, RLB are mounted on a sub-panel which also carries the compensating volume controls. The flexible wiring from the relay contacts to the amplifier must be low loss screened cable in anode and grid circuits and may be laced into a cable form which enters the amplifier through a suitable grommet. Wiring between the relays can be single strand p.v.c. covered wire.

PRE-AMPLIFIER

A typical layout for this sub-unit is shown in Fig. 7 and needs little explanation. Heater wiring should again be in twisted pair. Grid inputs, and anode output leads to the main amplifier, should be in screened

wiring, the screen being well earthed. Remember to leave sufficiently lengthy leads for inter-wiring between the pre-amplifier, the vibrato panel, and to the input control panel. These can be laced after the units have been fitted into the cabinet and the connections soldered.

A word of caution regarding valves. It is advisable to use new valves if possible. The reason is that some "used" but "good" valves are too noisy for those stages where high gain is required. A cathode to heater leak is one source of noise here, whereas it may not matter so much in later stages of the amplifier. The valveholders should be skirted, and have clip-on screening cans both to prevent hum pick-up and to prevent the valves becoming dislodged during transit. A small bracket, bolted to the skirt, provides a simple means of attaching the holder to the sub-unit panel.

VIBRATO UNIT

This unit is shown in Fig. 8. The capacitors in the prototype were physically rather large and a suggested alternative layout is shown in view of this. Construction is on similar lines to the method described for the pre-amplifier.

Transformer T1 is an intervalve transformer whose secondary d.c. resistance is approximately 2,000 ohms, and primary resistance about 500 ohms. Other step-up transformers have been tried and worked quite well, but the one specified above proved most effective. Its function is to control the vibrato "slow" frequency, thus a small amount of experimenting with readily available transformers and capacitors may be necessary. If a selection of transformers is not available, a 4:1 step-up intervalve transformer should be obtained.

The resistor R15 will determine the amplitude (depth) of vibrato; try 20 kilohms for a starting point. If "puffing" (over-modulation) of the vibrato occurs, raise the value in 5 kilohm steps until the puffing clears.

INPUT CONTROL PANEL

The component layout of the input control panel is shown in Fig. 9. Physically small potentiometers are required in order to clear the sockets SK1, SK2 and the control socket SK3. Wiring between the panel and the sub-units is made up into a cable form, which includes screened leads from VR1 and VR2, and is secured against vibration by the insulated cleat; other leads are clamped to the interior of the cabinet.

The h.t. and l.t. supply leads coming from the main amplifier are also assembled into the cable form, but remember to twist the l.t. leads. Lamp LP1 is a 6·3V 0·05A, or 0·3A if the transformer can handle the total load quite safely, and indicates when vibrato is in use.

GENERAL ASSEMBLY

The overall assembly of the complete amplifier was shown in Fig. 2 (last month). Note the positions of the vibrato speed control VR3, the smoothing choke

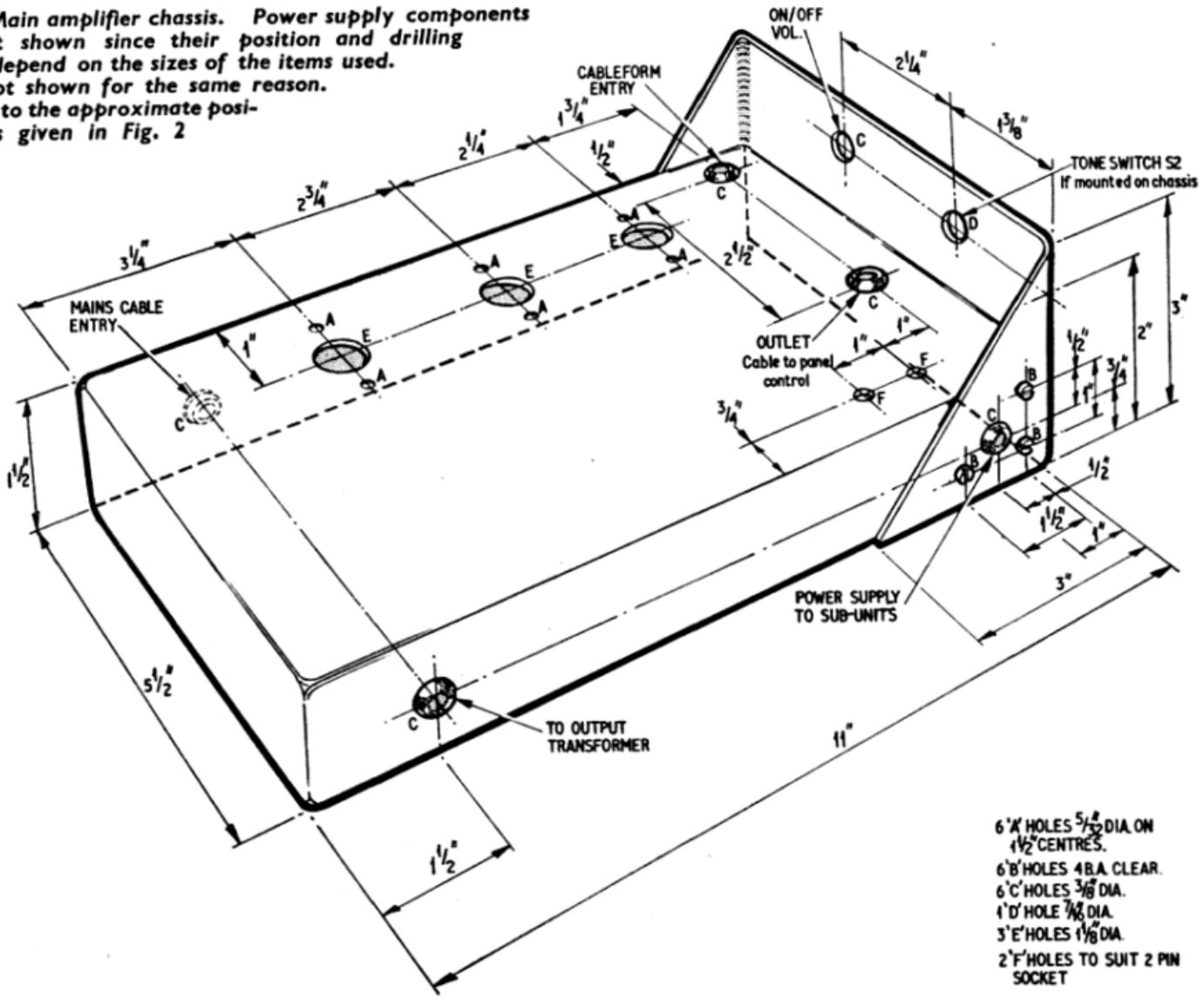


Fig. 5. Main amplifier chassis. Power supply components are not shown since their position and drilling details depend on the sizes of the items used. L3 is not shown for the same reason. A guide to the approximate positions is given in Fig. 2

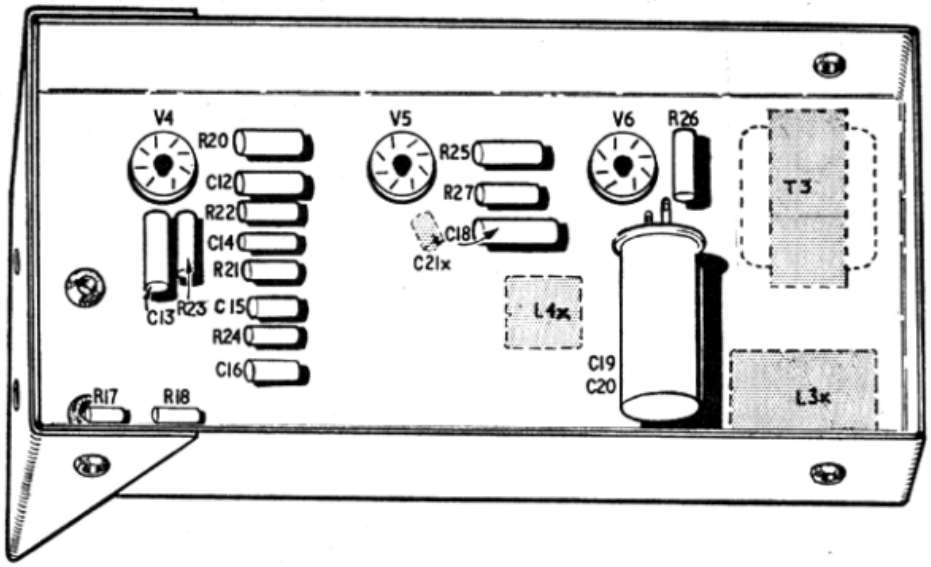


Fig. 6. Approximate layout guide to components on the underside of the main amplifier chassis. L4 and C21 are fitted only if the complex tone control circuit (described last month) is used. The approximate positions of T3 and L3 are shown; they are mounted on the top of the chassis. The cores should be arranged at right angles to each other to reduce hum

L2 and associated capacitors C8 and C11. These items (including R19) cannot be fitted into the sub-units or main amplifier without overcrowding or risk of hum due to coupling. The terminal strip secured to the loudspeaker carries the wiring to the h.t. fuse mounted on the main amplifier control panel.

The relay sub-assembly can be conveniently fitted above the top edge of the amplifier control panel. From this point, the wiring (in the cable form) to the main amplifier is quite short and, if handled carefully, the relay sub-assembly and main amplifier can be withdrawn for inspection without unsoldering.

Security of the sub-assemblies can be obtained by fitting a wood or metal pillar to the cabinet adjacent to the side of the sub-assembly concerned, and then securing the sub-assembly panel to the pillar by a screw passed through the panel. This precaution is worth taking if the amplifier is to be transported frequently.

The vibrato and tone controls shown on the guitar (January issue) are S1 and S2 respectively (see the components list last month). If desired S1 can be mounted on the control panel of the amplifier as shown in Fig. 9. S2 can be mounted on the main amplifier chassis as indicated in Fig. 5. In this case the international octal control sockets can be eliminated so that only one screened cable is left to link the guitar volume control with the amplifier.

EXTENSION LOUDSPEAKER

If the lid of the cabinet is used to house an extension loudspeaker, it will be necessary to fit a hardboard panel over the interior of the amplifier to guard against damage when the extension speaker is in use.

TRYING OUT THE GUITAR

Fit the guitar plug into the guitar socket, and the control plug and input plug into the amplifier sockets. Switch the amplifier on and allow time to warm up.

Set the amplifier volume control to about mid-travel. Set the tone switch to normal, and the gain controls to two-thirds of full travel. Set the vibrato switch to off. Set the guitar volume control about mid-way and the tone switch to the central position (normal tone). Set the vibrato switch (S1) to "off". The central position gives slow speed; downward gives fast speed.

Now pluck the strings and adjust the volume control to the required level. If insufficiently loud, increase the input gain control (VR1) on the amplifier or, if this is already at maximum, set the main amplifier volume control to a higher level. Check the effect of the tone control and note the switch positions. Check the vibrato circuit at low speed and high speed and note the switch positions. Adjust the bass and treble gain to balance volume when using normal tone.

USING THE AMPLIFIER

(1) Ensure the amplifier is efficiently earthed by as short a lead as is practicable.

(2) Switch on 10 minutes before requiring to use the amplifier to allow it to settle down.

(3) If using only one input, turn the unused input volume control to minimum otherwise hum may be picked up. This effectively shorts the grid of the other half of V1 to earth.

(4) Vibrato is most effective on sustained notes. Do not try to use it on fast moving music.

(5) To prevent excessively noisy operation, use no more *input* gain than is necessary.

(6) When using a microphone, which must be a high impedance type, or a low impedance type coupled through a transformer, guard against acoustic feedback, especially if two speakers are in use,

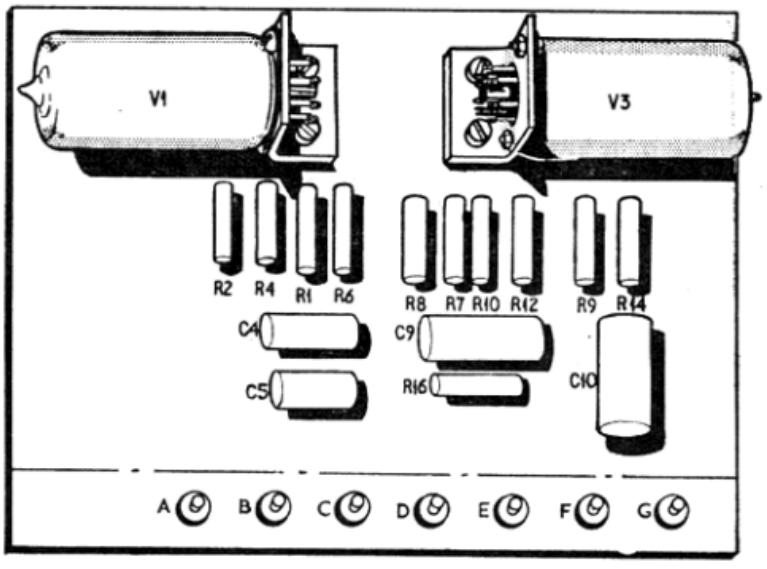


Fig. 7. Pre-amplifier unit built on Veroboard. Terminal connections are as follows (see also Figs. 6, 8, and 9): A to L1, C1; B to R15 (and L2 see text); C—coaxial to R17; D and E to heater supply; F—coaxial to VR1; G—coaxial to VR2

otherwise the loudspeaker may be damaged. For high quality, a crystal microphone should be connected through a matching circuit to suit a 50 kilohm input impedance.

ADDITIONAL GUITAR DETAILS

The following notes may help readers who are constructing the guitar described in the January issue.

Head Matching Transformer

This component is mounted in the body of the guitar, so the most critical feature is its physical size determined by the space available. It should preferably have a voltage ratio 30 : 1; a microphone transformer should serve the purpose. Alternatively, a loudspeaker output transformer with a 3 ohm low impedance winding can be used provided the impedance of the other winding is at least 2,700 ohms.

It may be worthwhile providing one channel of the amplifier to take a high impedance input while the other channel can be low impedance. This transformer can then be mounted on the amplifier chassis and wired to one channel only, keeping the same physical connections as described earlier. This means that the "sound" lead from the guitar will be low impedance and reduce the likelihood of hum being picked up. The restriction of physical size is also overcome.

Guitar Volume Control

This is a miniature carbon potentiometer either 25 kilohms or 50 kilohms. Here again the physical size is important. The higher resistive value will give a coarse control, i.e. a faster reduction of volume.

Strings and Winders

The strings used are standard taped strings specially made for electronic guitars (they must be steel) and are readily obtainable in sets of six from music shops dealing in guitars. The winders or "machine heads" are single units secured to the instrument as described in the article. The string is passed through the hole in the winder pin which is attached to the spur wheel. There should be sufficient slack in the string to give at least two turns around the pin before the strings become taut. The turns should be low down on the pin.

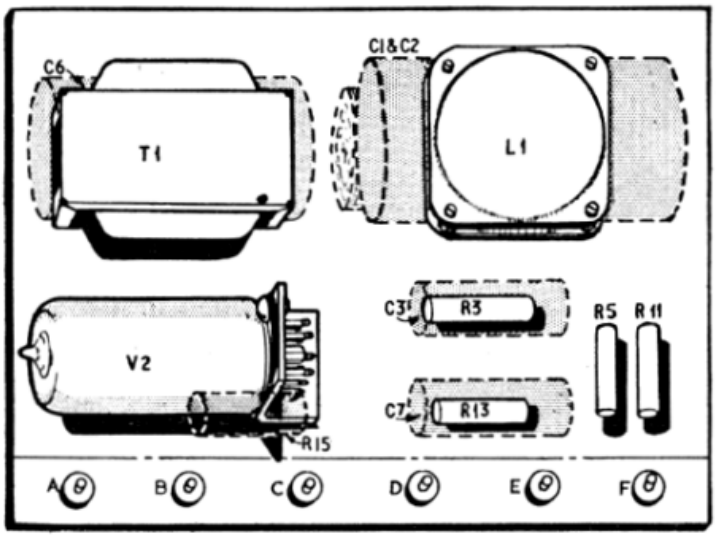


Fig. 8. Vibrato unit built on Veroboard. Terminal connections are as follows (see also Figs. 6, 7 and 9): A to R2; B to R4, R10, R12; C—coaxial to S1b (1); D and E to heater supply; F to VR3 (mounted on cabinet). Screen of coaxial cable to chassis

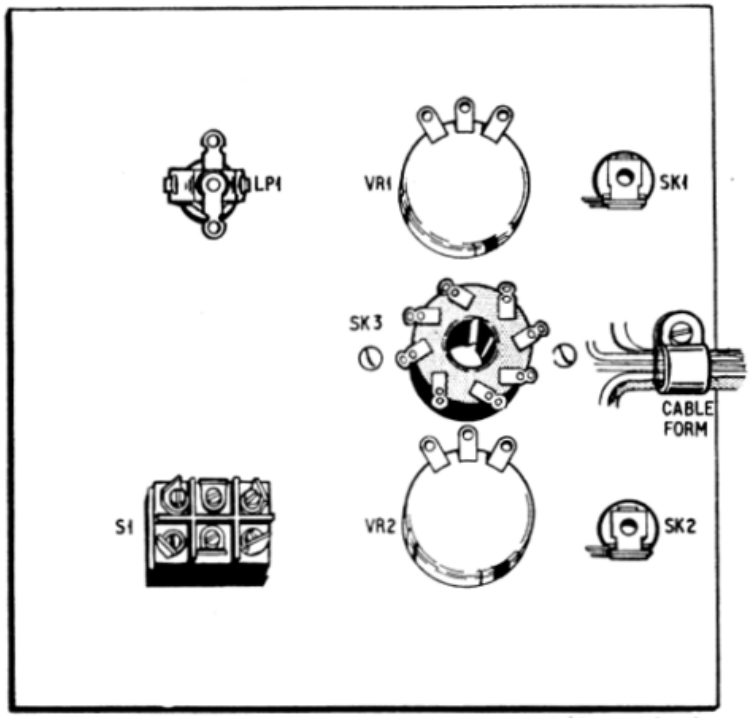


Fig. 9. Control panel layout. Socket SK3 links with the remote controls on the guitar. Sockets SK1 and SK2 are the signal input jacks

GUITAR FAULT ANALYSIS

One or two points may be mentioned in conclusion, and may help a constructor to overcome difficulties or avoid pitfalls when using the guitar.

Falling Out of Tune. Check the condition of storage; a damp room will cause this. Check for curvature of stem due to soft wood; check the movement of the stem due to insecure fixing screws or to very soft shim material. Check for movement of tailplate; the body *must* be very sound hardwood otherwise it will allow the tailpiece to drag its screws.

Inaccurate Tuning Over the Range of Frets. This is due to (a) use of incorrect string for the position, or (b) inaccurate measurement and placing of frets. Try moving the bridge block to correct mistuning.

Low Sensitivity Over-all. Check that the strings are *steel* strings (internally, if wrapped) as used in electronic guitars. Nylon strings are useless with a pick-up.

Low Sensitivity at One String. This is likely to be due to a short circuit when winding the pick-up limb concerned. It will require rewinding.

No Output. Pick-up winding broken, or circuit to transformer broken or short-circuited. Check from transformer by removing fingerboard, connecting up the amplifier in the usual way, and with the volume control set high, touch the transformer terminals. Touching one terminal should produce a loud hum. If this is not so, check the wiring to the volume control, the connector cable and the input plug.

Greater Sensitivity at Low Notes. This is probably due to the string material, but may be partly or wholly overcome by increasing the height of the affected string above the pick-up. The height may be increased by alteration to the bridge slot.

Feedback. A sensitive guitar, played very near to its loudspeaker, will pick up notes to which the "open" strings will respond. This causes the strings to vibrate and produce a continuous, often unpleasant, note. The volume control should be decreased or the loudspeaker may be placed further away from the guitar and facing away from it. ★