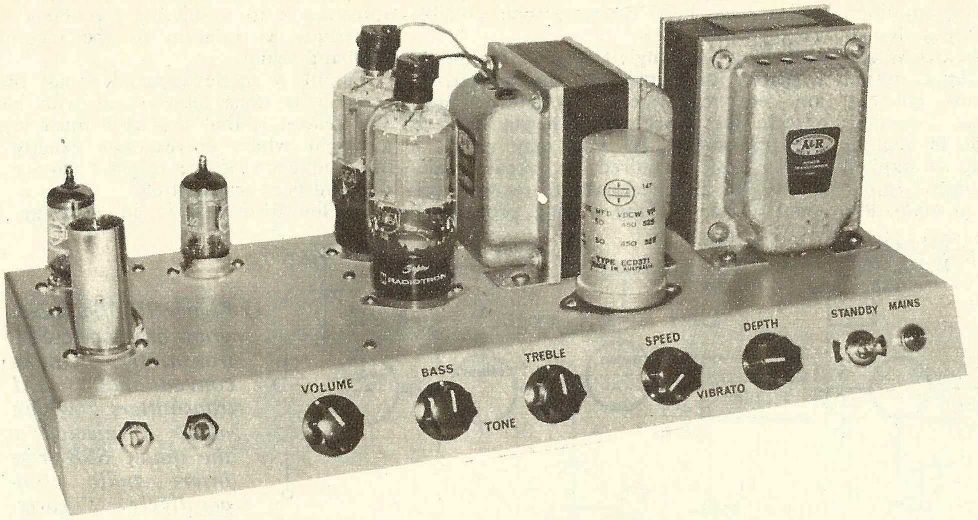


The preamplifier is in the left foreground, followed logically by other valves providing vibrato, voltage amplification and phase splitting to the two 6DQ6A output valves.

A Basic 40W Guitar Amplifier

Here is an amplifier that should meet many a need, particularly for readers with an interest in amplified musical instruments. With a power output of 40 watts RMS and full vibrato and tone control facilities, it can be used with bass, rhythm or lead guitars, electric bass or electronic organs. Alternatively, with the controls set for level response, it can double as a high-powered public address unit.

By Anthony Leo

While, as indicated, the new amplifier has been designed with a number of possible uses in mind, it will undoubtedly find its greatest application in connection with electric guitars, and this is the basis on which it is being presented.

Our last venture in this field was in the issues from October, 1962 to January, 1963. In this series, we presented a basic 12-watt guitar amplifier (the Playmaster 102) which was expanded to a two-channel 12 + 12 watt unit (the Playmaster 103).

Reflecting the whims of the market at the time, the 103 was a compact unit, of necessarily limited power output, but with vibrato facilities (tremolo would be the more correct word) plus a second channel which could be used for extra power output, reverberation, straight guitar or voice public address.

The 102/103 amplifiers met a particular need and are still being built in significant numbers. In fact, interest in them has persisted to the point that we will almost certainly have to up-date the designs and feature them again.

However, they have also prompted another and persistent demand for a higher-powered single-channel amplifier, suitable for use, if necessary, with a bass guitar. The incentive to build rather than buy has been strengthened by the fancy mark-ups which seem to apply to higher-powered amplifiers bought through "music" sources.

It is apparent also that many would-be constructors have put aside their one-time objections to the large loudspeakers and large enclosures which are necessary to handle power of 30 watts or more. In fact, an enclosure which needs to be trundled in on castors would seem almost to have reached the stature of a status symbol!

Perhaps it is only fair to observe that, along with the call for higher power, the basic instruments and group playing techniques have developed greatly in recent years and today's electric guitars are a far cry from the early units with a single pickup coil pushed under the strings.

The question of valves v. solid-state is also being debated by guitarists. Some prefer transistor equipment on the basis of its compactness, cool running, and reliability. Others stick to the "good old valves" which might get hot but don't blow up when the loudspeaker leads are accidentally broken or shorted. Price enters into it also, along with argument about "transistor tone" and "valve tone" which probably has more to do with different response contours selected by individual designers.

We used valves for this present amplifier, mainly because components were conveniently available and we had built up a background of suitable circuitry. Inevitably, at some future date, we will have to produce a solid-state equivalent, with appropriate effort to keep the cost down and to make it reasonably proof against the type of accident that blows up costly power transistors.

In terms of power output, a more or less accepted "norm" appears to be about 40 watts RMS—a figure stemming partly from the economics of ordinary amplifier design and partly from what can be accommodated by practical "portable" loudspeaker systems.

In quoting this figure, we refer to actual constant-tone output over the fundamental musical range, measured across the load—a very practical figure for guitar applications.

How it relates to the published figures for commercial guitar amplifiers is another point. Actual measurements would suggest that these figures are sometimes "optimistic" as evidenced by one very large, very imposing 60-watt amplifier which, under test, yielded exactly 45 watts at the onset of clipping.

Our new amplifier, as shown, delivers a measured 40 watts RMS into a 15-ohm load. The output transformer secondary is tapped to provide a match to other load impedances as, for example, two 15-ohm loudspeakers in parallel. As such, it should meet most practical requirements.

For those who may want still higher power, and are prepared to provide loudspeakers to cope, we have in mind the possibility of substituting more expensive grain-oriented transformers and modifying the operating conditions to provide about 60 watts RMS. We do not expect the circuit or layout to be otherwise affected.

With powers of this order, it is usual to have the amplifier in its own carrying case, which sits piggy-back fashion on top of the loudspeaker enclosure. The chassis has been designed with this in view and is relatively compact, being little longer than is necessary to accommodate the front panel controls.

The amplifier itself may be suited for bass, rhythm or lead guitars by simply setting the tone controls for the desired bass/treble response contour. The ultimate result will be dependent, however, on the choice of loudspeaker system. Bass guitars need big, husky loudspeakers in big husky enclosures, with treble response of no great significance. At the other extreme, lead guitars can get by with less ponderous loudspeaker systems but treble response is a "must."

We may be able to say more about this, in a general way, later on.

Looking now at the circuit, it will be noted that the output valves, arranged in a "push-pull" configuration, are a type not normally found in an audio power application. The 6DQ6A is a power valve used primarily as a power amplifier for horizontal deflection in television receivers. Because of its volume of production, it is comparatively inexpensive.

As an output valve, the plate characteristics are not greatly different from those of the more familiar audio types, such as the EL34 and the 6CA7. Because of its television heritage, the valve has a high peak plate voltage rating, but this is of little consequence when the valve is used in a strictly audio application.

If anything, however, its "top cap" plate connection offers some advantage, in that it allows better isolation of the plate leads from the high sensitivity input stages of the amplifier.

A definite advantage of the 6DQ6A is that it is a good deal shorter than either the EL34 or 6CA7. As may be seen from the photograph, the overall height of the valve, including the insulated plate connecting caps, is about the same as that of the transformers, making for a clean profile.

The output valves operate under push-pull class AB1, fixed-bias conditions, a mode which avoids grid-drive problems, ensures good power supply economy, and which minimises cross-over distortion. The total harmonic distortion from the amplifier, incidentally, at 40 watts output, is less than 1 per cent.

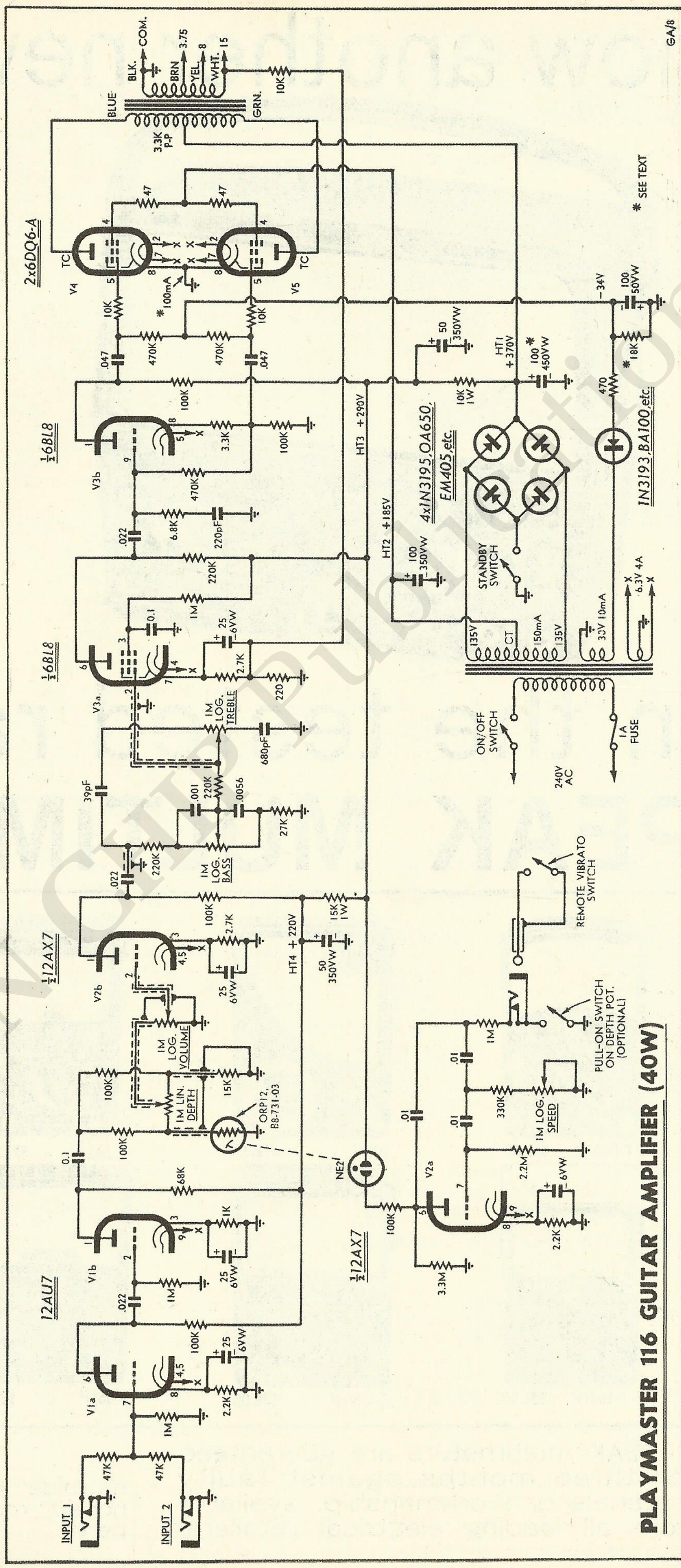
Class AB2 or class B operation would have posed additional grid-drive, power supply and distortion problems and, fortunately, are not necessary for the orders of power output required and achieved.

As it is, the valves operate with a total standing current of about 100 milliamps, rising to more than double this figure with sustained signal. "Stopper" resistors are included in series with each grid to inhibit oscillation during any part of the signal cycle.

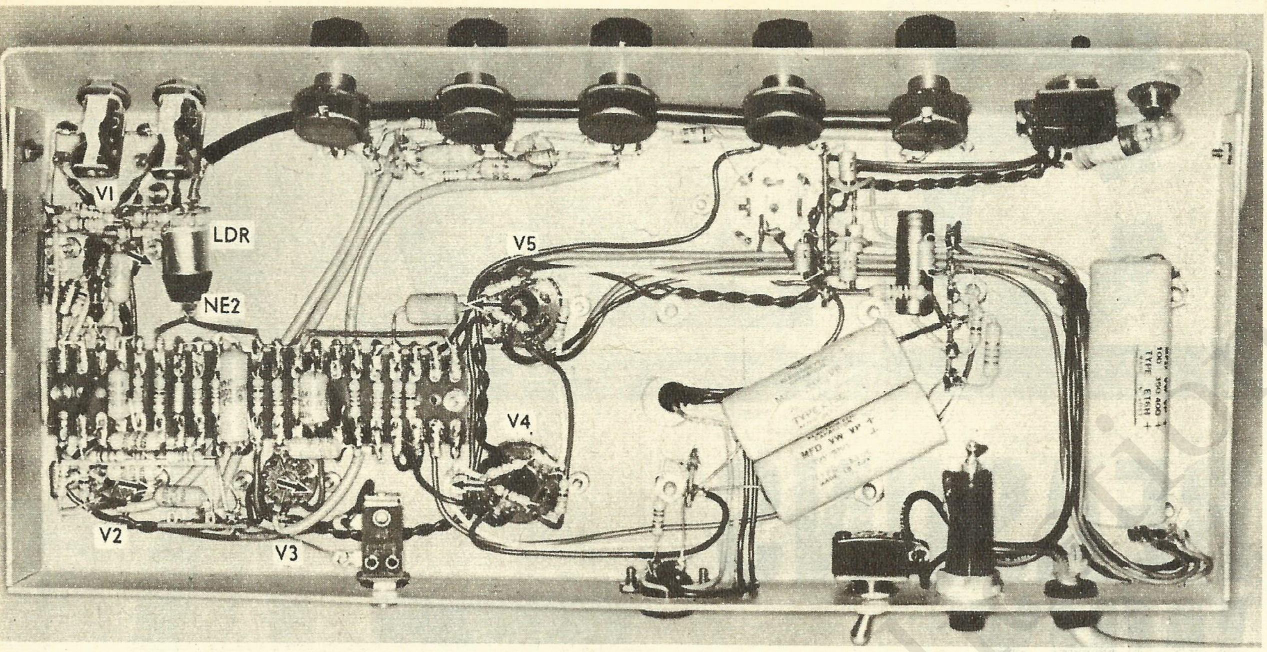
Three voltages have to be supplied to the power stage—a nominal 370 volts for the plates, 185 volts for the screens and —34 volts for the grids. This latter is probably the most critical of the three, for on it depends the quiescent current of the output valves and therefore their quiescent plate and screen dissipation.

While we have suggested a figure of —34 volts, and while the bias network should give something very close to this figure, the quiescent current in the

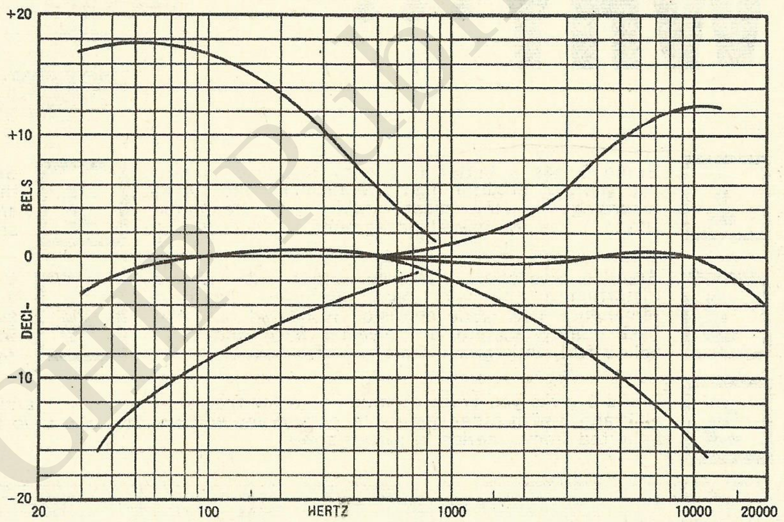
Apart from the rather unusual configuration of the power supply, the circuit follows well proven techniques. Of particular interest is the vibrato system, which we developed some years ago, and which gives a wide range of speed and depth without any tendency to cone "pumping." The gain is ample for typical commercial guitars, most of which deliver signal levels of at least 30mV RMS.



PLAYMASTER 116 GUITAR AMPLIFIER (40W)



The underside of the new guitar amplifier has space to spare, apart from the "busy" area around the low-level stages. Along the rear lip of the chassis is a jack for vibrato foot control, the loudspeaker socket, mains switch and mains fuse. At the time the photograph was taken we had not installed the clip to secure the mains lead.



Typical contours, with the tone controls set approximately level, as per the centre curve, and for maximum and minimum bass and treble. Note that the maximum bass/minimum treble curves, and their converse, tend to merge into continuous slopes, suiting the amplifier for either bass or lead guitars, as required.

common cathode lead to the output valves should be checked to see that it does not exceed 100 milliamps, representing full rated dissipation. The bias can be varied, if necessary, by varying the 18K shunt resistor.

A single electrolytic capacitor serves to filter the bias voltage, partly because of the high impedance of the circuit and partly because residual hum tends to be cancelled, anyway, by the push-pull connection of the output valves.

The main HT power supply is of rather unusual configuration, supplying separate and appropriate voltages to the output valve plates and screens.

The main secondary winding of the power transformer is wound for 135 volts on either side of a centre-tap, with a nominal current rating of 150mA.

The full secondary voltage is applied across a conventional bridge rectifier configuration, with one side of the bridge taken to earth through the "Standby" switch. From the other side of the bridge comes the main HT supply for the plates, just a trifle less than the peak value of the AC input.

The screen supply is the less obvious part of the arrangement, the positive screen supply potential being derived from the secondary centre tap. However, examination of the circuit will show that the two diodes connecting to earth through the "Standby" switch, and which form half of the main bridge, represent a back-to-front full-wave rectifier system, with the centre tap at a positive potential, rather than negative as in a more conventional system.

Filtering for the main HT supply could hardly be more straightforward, since it comprises a single effective 100uF capacitor, rated at 450VDCW; in fact, we used an available unit containing two 50uF capacitors, and connected them in parallel. This single large capacitor not only provides the requisite hum filtering but also serves as an effective reservoir for peak signal current demand.

From it also is derived supplementary supplies for the earlier stages through a cascaded decoupling network, using ordinary small resistors and pigtail electrolytics.

The phase splitter is the triode section of a 6BL8, another valve widely used in television receivers. Equal loads in the plate and cathode circuits ensure balanced signal to the output valves, each signal being about 0.9 times the amplitude of signal fed to the phase splitter grid. Due to cathode circuit degeneration, the input impedance to the stage is many times the value of the .47meg grid resistor and this has a bearing on the gain which can be expected from the preceding stage.

We gave some thought to the use of a "long-tailed pair" type of phase inverter but to be tied to a twin triode would have dictated much lower gain in this portion of the circuit than we were prepared to accept.

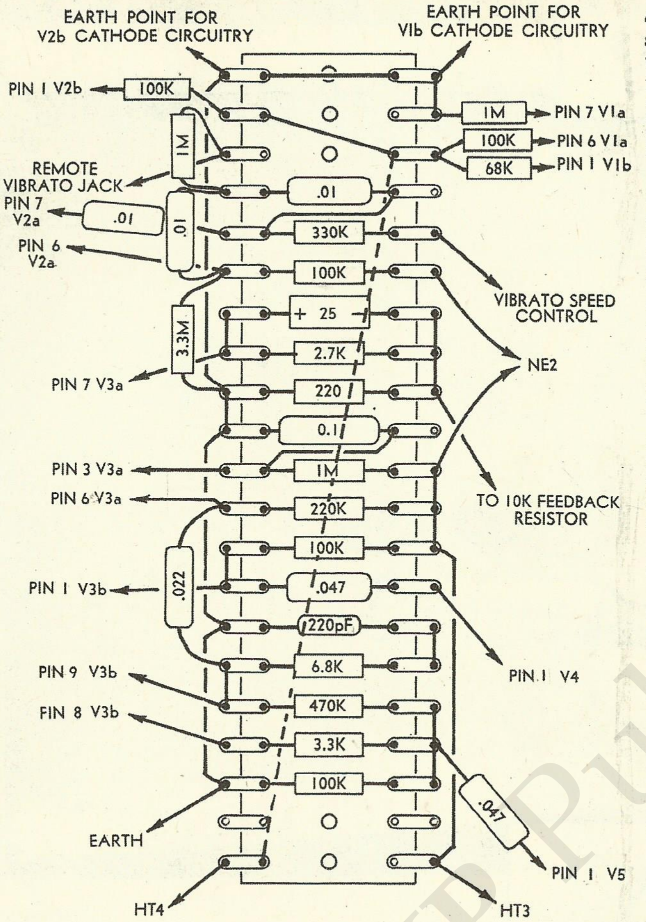
In designing an amplifier such as this, it is important to envisage, not only the overall gain, but also the distribution of gain between the stages and relative to the control functions.

Too little gain after the controls would necessitate multiple high-gain input stages and a "front-end" which could too easily be over-loaded by unexpectedly large input signals.

Too much gain after the controls could magnify the unwelcome sound of "noisy" potentiometers and dictate the use of a premium quality audio valve in the voltage amplifier stage to minimise risk of hum and microphony.

Microphony is an important consideration in connection with guitar amplifiers. Close proximity to the speaker system may introduce acoustic feedback, particularly in the case of a bass-guitar amplifier, since the frequencies are such that the vibration is easily transmitted through solid objects.

With the phase-splitter and output



A wiring diagram of the miniature resistor-panel unit is shown at right. Elsewhere two tag strips are used to mount the components for the first and second stages, together with the "modulator" network components. An additional two tag strips are used for the rectifier diodes and decoupling resistors.

valves involved in this amplifier, we were glad to take advantage of the 6BL8 pentode section for the main voltage amplifier without, however, getting down to a level where microphony in the stage was likely to be a problem.

The 6BL8 pentode stage has an overall gain of about 150 times, without external feedback, allowing for a small amount of degeneration from the 220-ohm resistor, across which the external feedback voltage is applied. The total feedback, using the constants specified, is about 16dB, a figure which we consider to be an advisable maximum, to minimise the risk of instability due to phase change within the output transformer.

The circuit, as drawn, shows the "Common" end of the output transformer secondary as being earthed and feedback taken from the 15-ohm connection back to the cathode circuit of the 6BL8 pentode, through a 10K resistor.

The colour coding on the circuit and the identification of the output valves should allow the feedback to be wired in correct polarity for the A&R output transformer type 2843, as used in our prototype.

With other types of output transformer, it may be necessary to establish the polarity of the feedback by trial and error. In this case, it would be logical to complete the wiring of the basic amplifier section but to leave the feedback initially unconnected.

After switch-on and with this portion of the amplifier operating normally, the feedback connection can be made. If the amplifier remains stable and/or there is a drop in the level of any test signal which is being fed through it, the feedback is negative and all is well. If the gain increases, however, and/or the amplifier howls, it is a sure sign that the feedback is positive.

Since it is logical to leave the "Common" end of the secondary earthed and not to cross over the flying leads to the output valve plates, the simplest modification is to swap over the leads from the component board to the grids of the two output valves.

It will be noted that no phasing capacitor is shown across the feedback resistor. Such a capacitor is frequently used in valve amplifiers to offset the phase rotation which commonly occurs in output transformers at supersonic frequencies and which can cause supersonic oscillation in isolated cases.

While phasing capacitors can be very effective for this purpose, they should really be selected for the particular circuit and output transformer type with the aid of an oscilloscope and square-wave generator. Any value which we might specify would not necessarily be optimum for an amplifier built up with a different brand or type of output transformer.

As an alternative measure, we have specified a "step" circuit comprising a 6.8K resistor and a 220pF capacitor in series, from the phase splitter grid to chassis. The effect of this circuit is to produce a sharp step or reduction in the gain of the amplifier above a certain frequency, normally selected to be just outside the audible range. Because of reduced response in the supersonic region, an amplifier with such a step circuit is most unlikely to become actively unstable, even with considerable phase rotation in the output transformer and feedback system.

The tone control network which precedes the 6BL8 pentode is a passive system very similar in configuration to the controls used in our various valve-type Playmasters intended for use with pickups and radio tuners. The curves have been manipulated, however, to suit them better to the present purpose.

With amplifiers intended for reproduction from tuners and records, there is a tendency to make the bass control most effective in the general region of 50Hz and to look for full treble control in the region of 10KHz. The treble control therefore has its greatest effect on musical "overtones" rather than fundamentals, tending to make the sound more or less "bright," according to the preference of the listener.

Guitarists, however, seem to want to operate on the fundamentals and low order overtones and therefore prefer a treble control which functions much lower down into the range than is common with ordinary hi-fi amplifiers. More appropriate adjectives would be "strident" and "piercing."

At the bass end, they look for copious control over frequencies in the 70-100Hz region.

The chase after sensational effects has, in fact, produced commercial amplifiers with huge orders of boost and cut over various parts of the spectrum and controls which interact so much, or so lack a balance position, that it is difficult to achieve anything like a level response.

To talk to guitarists is to realise how confused is the whole control situation and how subjective the preference for different kinds of sound.

In our case, we have tailored the constants so that the amplifier can be set up for a substantially level response, allowing it to be used for other electronic instruments, for public address or for two dissimilar guitars, each using their own in-built tone facilities.

On the other hand, maximum bass and minimum treble will give steep slope eminently suitable for a bass guitar, while rhythm and lead guitars can boost the treble to maximum and cut the bass back as necessary.

For the rest, as we said earlier, it is a matter of choosing the appropriate type of loudspeaker and enclosure.

The tone control network is preceded by three triode stages of amplification with the vibrato "modulating" circuit and volume control intermediate between the 12AU7 and the 12AX7. This vibrato circuit, based on a circuit which we published in August, 1964, gives full speed and depth control by employing a light dependent resistor (LDR) in a balanced resistance network.

Electrically, the system has the same effect as if one were to turn the volume control rapidly up and down varying the signal level without changing any DC potentials in the amplifier. This being so, here is no tendency to "pump" the loudspeaker cones in and out and no sound to be heard other than the modulation of the signal itself. Guitarists who checked the amplifier during its development voted it as about the best vibrato (or tremolo) that they had ever used.

Another feature of the circuit is that switching the vibrato in and out, or changing the depth, does not materially alter the average loudness of the signal.

A small neon tube is used as the light source and is wired in series with the plate circuit of the oscillator. A 3.3M resistor shunts the plate of the triode to prevent the neon "going out" on the positive excursion of the plate voltage. The inclusion of the resistor thus prevents irregularities appearing in the "modulating" waveform which would produce unwanted clicks from the amplifier. Further filtering of the "modulating" signal is afforded by virtue of the natural time constant of the light dependant resistor.

The vibrato or "modulating" signal is derived from a phase-shift oscillator, which consists of the second half of a 12AX7. A high-mu triode is required in this application because a phase-shift oscillator is rather critical as to gain. The oscillator frequency is varied by means of a 1M potentiometer included in the phase-shift network.

A facility for remote control of the vibrato has been provided, by way of a "shorting" type telephone-jack on the back panel. The remote control usually consists of a foot-switch which can be either of two types, a push-on and push-off type or push-on type with a self returning spring action. Either way, they must be of such construction as to stand up to the pressure of a somewhat large, heavily clad foot!

In certain instances it may be inconvenient to use a foot-switch, particularly where a number of guitars are involved. In such cases a player may desire the vibrato switch to be on the amplifier within easy reach and with a convenient switch action. An optional vibrato "hand" switch has been shown on the circuit as being part of the depth control potentiometer, and is wired in series with the "remote" telephone jack. Potentiometers incorporating "pull - on" switches are readily available, being commonly used in television receivers.

The preamplifier valve, shown in the left foreground of the photograph, is a 12AU7A medium-mu twin triode. The valve was selected for its ruggedised construction, which makes it useful in situations critical to microphonics. The input has a low impedance network with "shorting" type jacks which tends to present a constant load to the guitars regardless of whether there are two guitars or only one. Having the jacks shorted when there are no input connections also prevents "stray" signal pic-up.

Construction might well begin with the mounting of the "hardware" with power and output transformers first, followed by the can-type electrolytic and valve sockets, using the various mounting screws to secure the tag strips where required. Orientation of the valve sockets is indicated on the under-chassis photograph.

As will be apparent from the photograph, the potentiometers were set back inside the front panel with 3/16in spacers, which we managed to obtain from a parts supplier. By using these spacers, or an equivalent thickness of washers, only enough thread need protrude to accommodate the locking nut, thus allowing the control knobs to locate fairly close to the panel.

Our own prototype chassis was handmade, sprayed and the panel lettered with adhesive transfers. We imagine, however, that suppliers will organise to make available pre-punched chassis to our specifications and lettered panels to suit.

As a next step, it is probably logical to lay in the twisted leads to the heaters and to the 6.3V pilot lamp.

Wiring of the power supply could begin with the "pigtail" electrolytics, the decoupling electrolytics mounting obliquely as a matter of convenience. The two-lug tagstrip which secures the earthed end of these electrolytics and the associated decoupling resistors is also used to mount the 10K feedback resistor from the loudspeaker socket.

The power diodes are mounted on a tag strip adjacent to the can-type electrolytic, with the positive end of the bridge supporting the 10K decoupling resistor. The other end of the bridge is connected to the "Standby" switch which is mounted on the front panel. The mains off-on switch is mounted on the back panel, adjacent to the fuse holder. Note that the power cord should be passed through a chassis grommet and secured by a suitable clip to obviate stress on the internal connections.

The next logical step is to wire the power output stage, having in mind earlier remarks about polarity of the feedback.

As can be seen from the photograph, the screen and grid resistors of the output valves have been wired across the sockets using the vacant lugs as anchor points. Connection to the grid and circuit of one of the output valves is made by the coupling capacitor from the main component panel, while the other grid circuit is connected via a lead.

Because the top caps of the 6DQ6A's are exposed and at full plate potential, the connectors should be of the protected type, as used in TV receivers.

The main component panel may be wired as a unit and secured in position, using long screws with nuts as spacers. With the panel in position the various connections can be made to the adjacent valve sockets.

The earthed lugs at one end of the panel have been used to secure the earthed ends of the cathode resistors and their bypass capacitors, belonging to the first two valves. Similarly, the lugs carrying the HT have been used to terminate one end of the load resistors to the same valves.

Mounting the light dependant resistor and the neon posed a small problem. In some commercial guitar amplifiers, the light dependant resistor and neon are simply mounted adjacent to but separate from one another, on an open tagstrip. Without shielding, however, any spurious light which may fall on the light dependant resistor will affect the modulation characteristic of the vibrato circuit.

We mounted our modulating assembly in a small can which was obtained by "butchering" a discarded electrolytic capacitor. A scrap of tinplate would do just as well. A rubber grommet retains the neon lamp while the light dependant resistor is a neat fit in the tube.

As will be evident from the under-chassis picture, the components in the LDR circuit are mounted on a tag strip adjacent to the input jacks, with a twin core shielded cable to the outside lugs of the vibrato "Depth" potentiometer. A separate shielded lead is used to connect the centre lug of the same potentiometer, to the volume control.

Having completed the input circuitry, the amplifier should be ready for operation.

> POWER: 40 watts RMS output.
> DISTORTION: Total harmonic distortion at 40 watts output is 0.8 per cent.
> INPUT SENSITIVITY: 15mV for 40 watts output at 500Hz.
> LOAD IMPEDANCE: 3.75, 8 or 15 ohms.

PARTS LIST

1 Chassis 16in x 7in x 1½in with outward sloping front panel.
1 Power transformer 240V to 270V at 150mA with centre tap, 30V bias winding, and 6.3V at 4A with centre tap. A&R Transformer type PT5892, or similar.
1 Output transformer 3.3Kohms plate to plate with 3.75, 8 and 15 ohm secondary taps. A&R transformer type OT2843, or similar.
2 Octal valve sockets.
1 9-pin shielded valve socket.
2 9-pin valve sockets.
2 6DQ6A valves, 1 6BL8 valve, 1 12AX7 valve, 1 12AU7A valve.
4 Power diodes, types EM405, 1N3195, OA650 or similar.
1 Bias supply diode, types, BA100, 1N3193, or similar.
1 LDR, type ORP12, B8-731-03 etc.
1 Neon lamp, type NE2.

RESISTORS

½-watt, 10 percent, unless specified.
1x3.3M, 1x2.2M, 1x1M, 3x470K, 1x330K, 3x220K, 7x100K, 1x68K, 2x47K, 1x27K, 1x18K, 1x15K, 1x15K 1 watt, 3x10K, 1x10K 1 watt, 1x6.8K, 1x3.3K, 2x2.7K, 2x2.2K, 1x1K, 1x470 ohms, 1x220 ohms, 2x47 ohms.

POTENTIOMETERS

4 1M log. (C-taper).
1 1M linear (A-taper).

CAPACITORS

1 100uF 450VW electrolytic.
1 100uF 350VW electrolytic.
2 50uF 350VW electrolytic.
1 100uF 50VW electrolytic.
5 25uF 6VW electrolytic.
2 0.1uF 400V plastic.
2 .047uF 400V plastic.
3 .022uF 400V plastic.
3 .01uF 400V plastic.
1 .0056uF L.V. plastic.
1 .001uF L.V. plastic.
1 680pF L.V. plastic.
1 220pF L.V. ceramic
1 39pF L.V. ceramic.

MISCELLANEOUS

2x6-way tag strips, 3x4-way tag strip, 3x2-way tag strips, 21 lug length of miniature resistor panel.
2 single pole toggle switches.
1 pilot lamp assembly.
1 fuse holder.
3 "shorting" type jack sockets and plugs.
1 4-pin speaker socket and plug.
Power flex and plug, clamp and rubber grommet, knobs, shielded cable, hookup wire, nuts, bolts, washers, solder, etc. Remote foot switch and mounting, if desired.