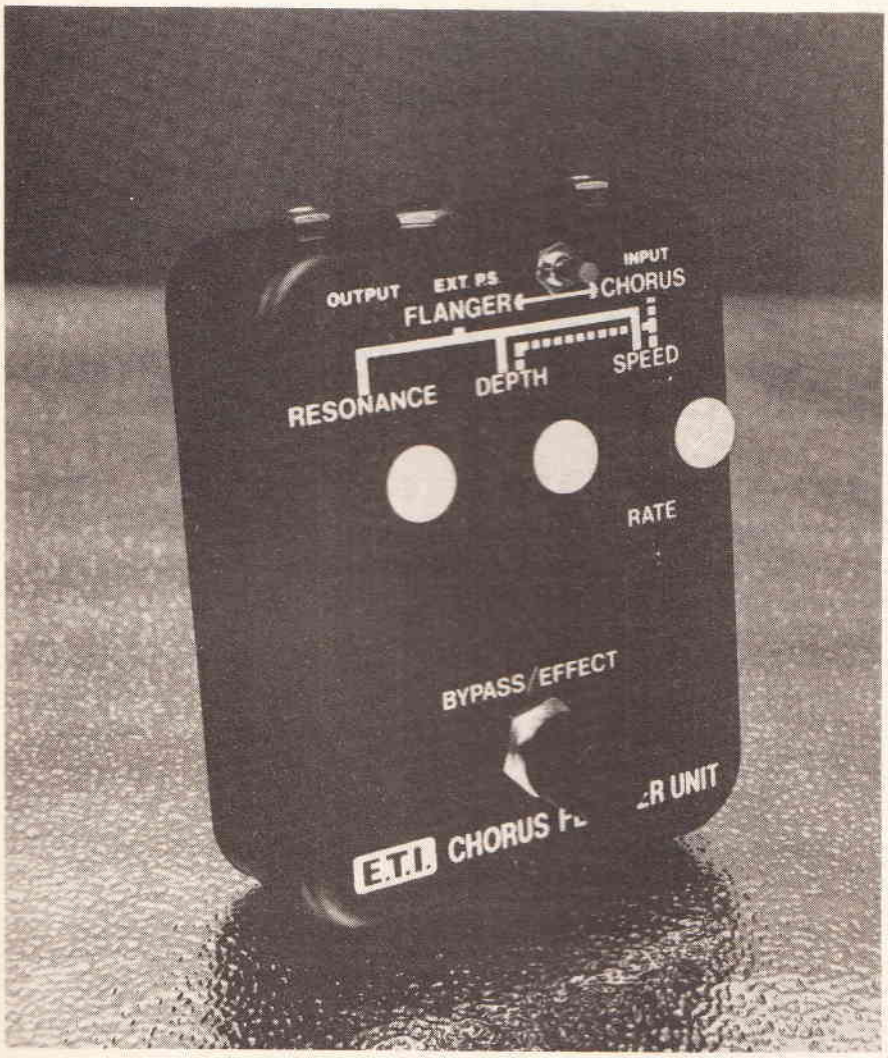
CHORUS/ FLANGER UNIT

Tim Orr returns to the pages of ETI with a project to make your amplifier see double — a chorus/flanger.



The Chorus/Flanger unit is a device for processing musical and other signals to produce a wide range of effects. The electronics have been optimised for an electric guitar input but the unit can run equally well from line level signals (−6dBm) and high output microphones.

The chorus effect simulates a second instrument, which is producing the same sound as the input signal, but which is slightly delayed in time. This tends to generate the illusion of a second instrument and also enriches the overall sound quality. If a relatively fast (10Hz) time modulation is used, then genuine vibrato is generated. Flanging is a very dramatic colouration of the input sound. An instrument played through a flanger sounds like it is being heard in a drain pipe, the size of which is changing!

Flanging, chorus and vibrato are all time delay effects, and so their implementation is relatively simple if we use a bucket brigade delay line, Fig. 1. Voltages presented to the input of the delay line are sampled and then converted into small quantities of charge. These charges are passed along several hundred electronic 'buckets' until they reach the output, whereupon they are reconverted back into the original voltage. This process takes time, in fact the time delay is equal to the number of buckets divided by the speed at which the charge is passed along the line. The signal recovered at the other end very closely resembles the input signal except for a small amount of noise and distortion (it's an imperfect world).

As this is a sampled information system we must sample the input signal much more frequently than the highest frequency compon-

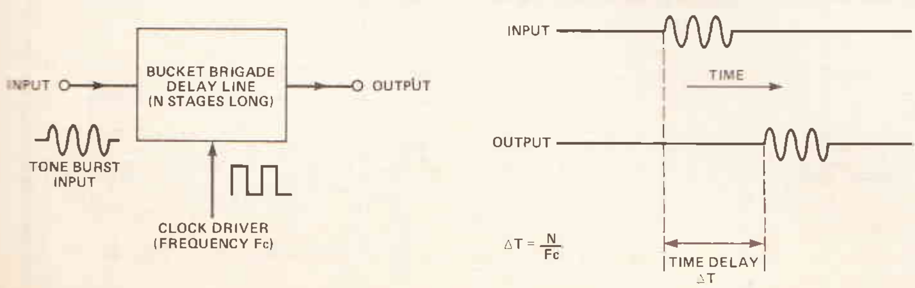
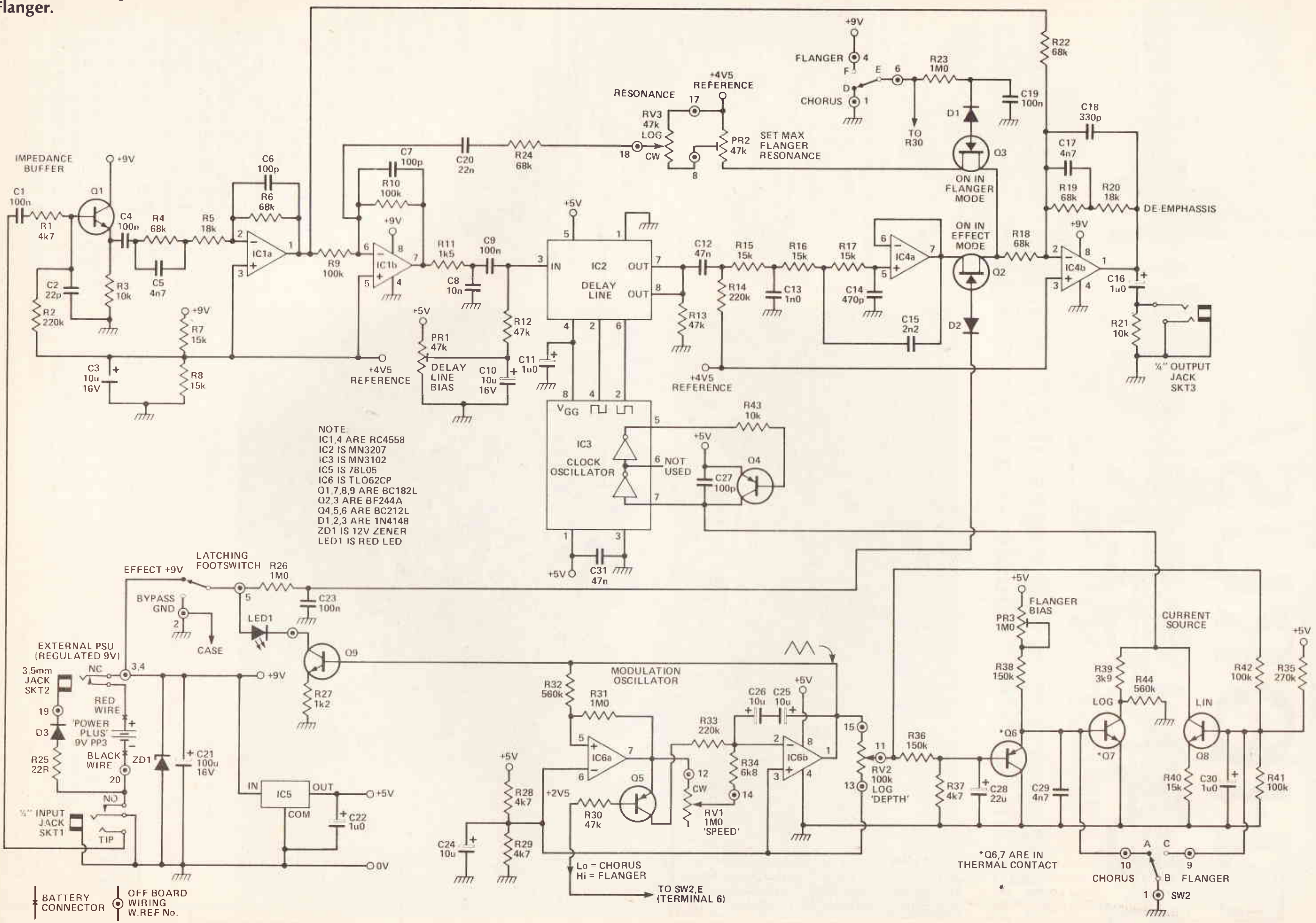


Fig. 1 The basic principle of producing a time delay.

Fig. 5 Circuit diagram of the Chorus/ Flanger.



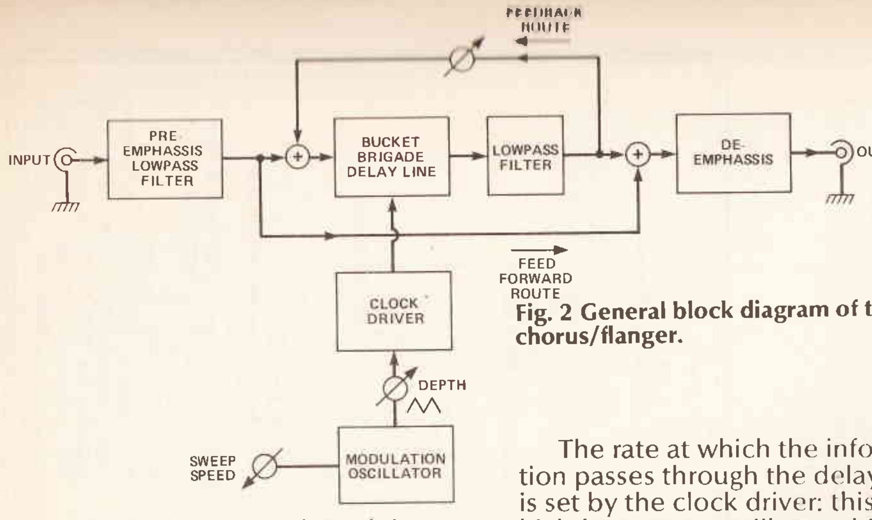


Fig. 2 General block diagram of the chorus/flanger.

nents of the input signal. By doing this, we can avoid the dreaded aliasing distortion (which sounds like ring modulation) and hope to recover the input signal with some degree of integrity.

The general block diagram of the chorus-flanger unit is shown in Fig. 2. The low-pass filter at the front end of the unit limits the input bandwidth and so helps to avoid any aliasing problems. The low-pass on the output recovers the delayed signal and rejects unwanted high frequency clock and noise signals.

The audio signal is given a treble lift (pre-emphasis) at the front end of the unit and a treble cut (de-emphasis) at the output. This helps to produce a better signal to noise ratio throughout the unit: most natural sounds have an energy spectrum that drops off very rapidly with increasing frequency, so by giving a frequency lift to these parts of the spectrum, more information can be elevated above the noise floor of the delay line. At the output end of the system, the de-emphasis restores the overall frequency response back to a flat one, but also suppresses high frequency noise from the delay

The rate at which the information passes through the delay line is set by the clock driver: this is a high frequency oscillator which can be frequency modulated. The delay line (MN3207) has a delay length of 512 buckets, so a clock frency of 512 kHz will produce a delay time of 1 millisecond. The modulation oscillator is used to produce slowly-varying time delays of variable speed and depth.

The chorus-flanger unit has been configured to look like a comb filter, Fig. 3. This is a filter with a frequency response that is full of notches, and which looks like the teeth of a comb! When the delayed signal is 180° out of phase with the direct signal, then cancellation will occur and a notch in the frequency response is generated. These notches are linearly spaced with a separation of 1/(the time delay). Feedback around the delay line (used in flanging) makes the comb response much more peakey when the phase shift around the delay line is zero. Short time delays produce few notches and long time delays produce several, Fig. 4. Note that the frequency separation of the notches is linearly proportional to the clock frequency.

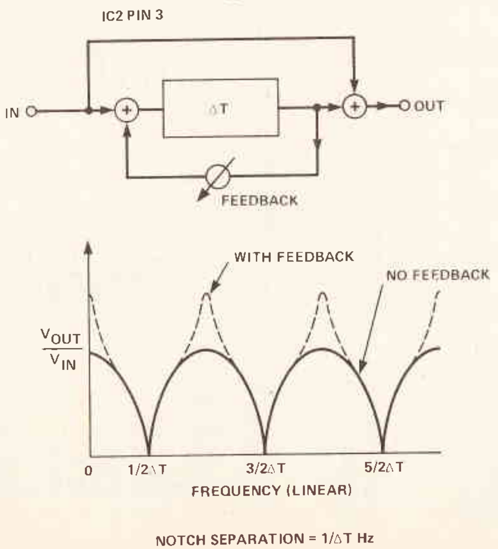


Fig. 3 A basic time delay comb filter.

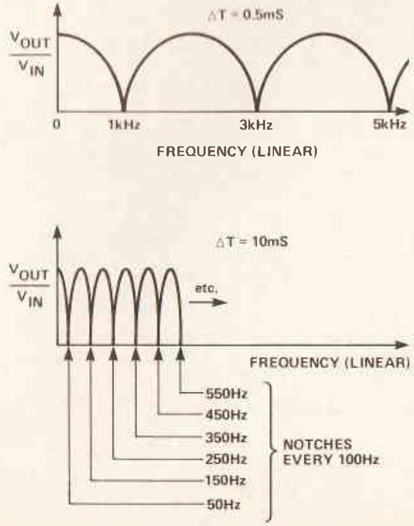


Fig. 4 Comb filter frequency responses for different time delays.

HOW IT WORKS

Q1 forms a conventional high-impedance buffer: experience has shown that electronic guitars sound better when presented with a fairly high input impedance.

IC1a performs signal pre-emphasis, lifting all frequencies above about 500 Hz; IC1b performs the low-pass anti-aliasing filtering, as well as mixing the fed-back proportion of the delayed output (which comes in via RV3, R24 and C20).

PR1 sets the DC bias level of signal going to the input of the bucket-brigade device; this is needed to obtain minimum signal distortion. The output from IC2 is recovered by the low-pass filter around IC4a, and passed to the FET signal switch, Q2 (FETs are used rather than mechanical switches to save loudspeaker cones!). Q2 allows the signal to pass except when the unit is in the bypass mode.

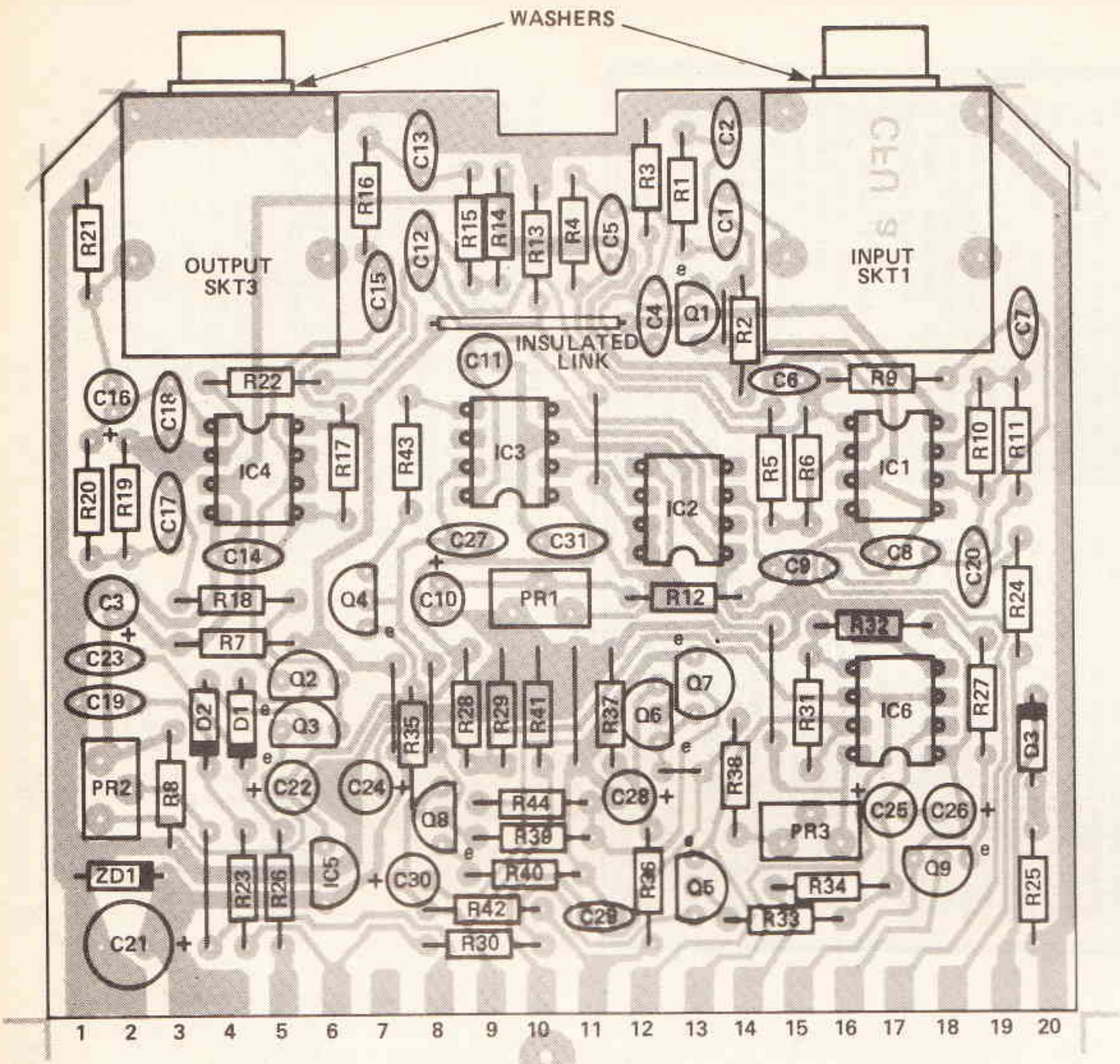
Q3 is another FET signal switch, and when the unit is in the flanging mode, this feeds a proportion of the delayed signal back to the input via PR2, the resonance control RV3,R24 and C20. At the same time, the fed-forward signal and the delayed signal are combined by IC4b, which also performs the de-emphasis. From here the signal is passed to the output.

IC6 forms a simple triangle/squarewave oscillator. RV1 controls the oscillation speed. Q5 is used to limit the low frequency range of the oscillator when in the chorus mode.

Q9 is used to drive the panel LED. When the effect is selected (via the footswitch) the LED will light up and flash at the modulation rate.

IC3 and Q4 form the clock oscillator for the delay line. C27 is charged up by either Q7 or Q8, both of which act as current sources. When pin 7 of IC3 drops below about +2.5 V, pin 5 of the same IC goes low, which turns on Q4, which discharges C27 back up to +5V. Thus the circuit oscillates at a rate determined by the size of the current sink from either Q7 or Q8. In the chorus mode Q8 generates a linearly varying current over a maximum two-to-one range. C30 limits this sweep at faster rates. In the flanger mode, Q6 and Q7 generate an exponentially varying current over a seven-to-one range. Again the modulation depth is limited at fast rates by a capacitor, C28.

IC5 provides a stable +5V power supply for the modulation oscillator, clock oscillator and the delay line. Battery voltages droop with time! The battery starts life at about +9.5 V and has an end of useful live at about 6.5 V. For maximum battery life, plug in the effect unit only when it is needed and never leave it on over night. The ON/OFF switch is the input jack which has a switched earth pin. For infinite battery life use a mains power supply (a PP3 eliminator)!



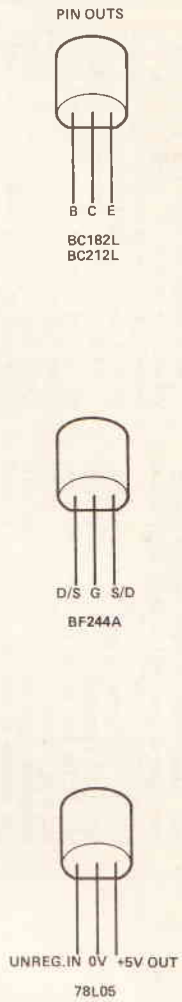


Fig. 6 Overlay diagram of the PCB for the Chorus/Flanger

PARTS LIST

RESISTORS (all ¼W 5%)

R1	4k7
R2	220k
R3	10k
R4,6	68k
R5	18k
R7,8	15k
R9,10	100k
R11	1k5
R12,13	47k
R14	220k
R15,16,17	15k
R18,19,22,24	68k
R20	18k
R21	10k
R23,26,31	1M0
R25	22R
R27	1k2
R28,29,37	4k7
R30	47k
R32	560k
R33	220k
R34	6k8
R35	270k
R36,38	150k
R39	3k9
R40	15k
R41,42	100k
R43	10k
R44	560k

POTENTIOMETERS

RV1	1M0 reverse logarithmic
RV2	100k logarithmic
RV3	47k reverse logarithmic
PR1,3	47k preset
PR2	1M0 preset

CAPACITORS

C1,4,9	100n polyester
C2	22p ceramic
C3,10	10µ 16V PCB electrolytic
C5	4n7 polyester
C6,7	100p ceramic
C8	10n ceramic
C11,16	1µ0 63V PCB electrolytic
C12	47n polyester
C13	1n0 polyester
C14	470p ceramic
C15	2n2 polyester
C17	4n7 polyester
C18	330p ceramic
C19	100n polyester
C20	22n polyester
C21	100µ 16V PCB electrolytic
C22,30	1µ0 63V PCB electrolytic
C23	100n polyester
C24,25,26	10µ 16V PCB electrolytic
C27	100p ceramic
C28	22µ 16V PCB electrolytic
C29	4n7 ceramic
C31	47n polyester

SEMICONDUCTORS

IC1,4	RC4558
IC2	MN3207
IC3	MN3102
IC5	78L05
IC6	TL062CP
Q1,7,8,9	BC182L
Q2,3	BF244A
Q4,5,6	BC212L
D1,2,3	1N4148
ZD1	BZY88-12V zener
LED1	0.2" red LED

MISCELLANEOUS

SKT1,3	¼" mono switched jack sockets
SKT2	3.5 mm mono jack socket
SW1	latching footswitch SPCO plus cap
SW2	DPDT switch

PCB; knobs; PP3 battery connector; case; self-adhesive foam strip (for securing the PCB); 8-pin IC sockets (5 off); holder for LED; wire, solder, Gibson Les Paul Special, etc.

Assembly And Setting Up

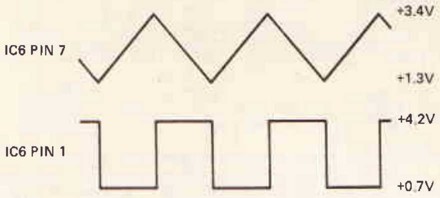
Assemble the PCB and connect to the controls as shown in Figs. 6 and 7. When testing is complete, the PCB is mounted in the box, supported by the jack sockets, with the foil side to the case bottom. Put some thin sticky-backed foam rubber on the inside of the case bottom to prevent shorts.

Table 1 shows various DC test voltages around the circuit and Fig. 8 shows some of the waveforms you should find using an oscilloscope. As regards the setting of the presets, you *can* just plug in, switch on and hope for the best and set the presets by trial and error, but if you do have access to some test gear, here is the proper way to set up the unit.

IC1,4, PIN 8	+9V (FOR BATT. OPERATION)
IC1, PINS 3,5	+4.5V APPROX
IC1, PINS 1,7	+4.5V APPROX*
Q1 EMITTER	+3.8V APPROX*
IC2, PIN 5	+5V
IC3, PIN 1	+5V
IC3, PIN 8	+4.67V
IC4, PINS 1,7	+4.5V APPROX*
IC6, PIN 8	+5V
IC6, PIN 3,6	+2.5V

* VOLTAGE WITH NO INPUT SIGNAL

Table 1 DC test voltages.



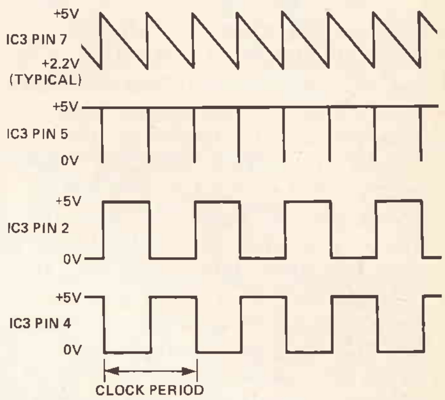
TYPICAL SPEEDS	MAX	MIN
CHORUS	10Hz	0.33Hz
FLANGER	10Hz	0.06Hz

Fig. 8a Waveforms for the modulation oscillator; note that the voltage levels for IC6 are only approximate, as are the oscillator frequencies.

Inject a 2.0 V peak-to-peak 500 Hz sinewave into the input socket, and select chorus on SW2 with the footswitch, SW1, set to effect. Set the rate control to maximum and the depth control to minimum. Using an oscilloscope, check that the undistorted signal is present at Q1 emitter, IC1 pins 1 and 7 and IC2 pin 3.

Set PR1 to its mid-way position and look at the signal present on IC2 pin 8; adjust PR1 until the signal is clipping symetrically (see Fig. 9). Note that this signal will have a lot of high-frequency clock signal breakthrough: this is normal.

Examine the output at IC4 pin 7; this should be the same signal without the HF breakthrough. Reduce the input signal level to remove the clipping on this signal. Turn the depth control to maximum and the sinewave at IC4 pin 7 will be frequency modulated by the modulation oscillator; a mixture of this signal plus the direct signal should appear at IC4 pin 1.



CLOCK PERIOD	MIN	MAX
CHORUS	7.0uS	12uS
FLANGER	3.5uS	22uS

Fig. 8b Waveforms for the clock oscillator; select minimum depth (RV2) for these waveforms. The table shows the limits of the clock period for depth set to maximum and rate set to minimum; the preset PR3 should be adjusted to bing the oscillator into the range given for the flanger mode (with the flanging effect selected).

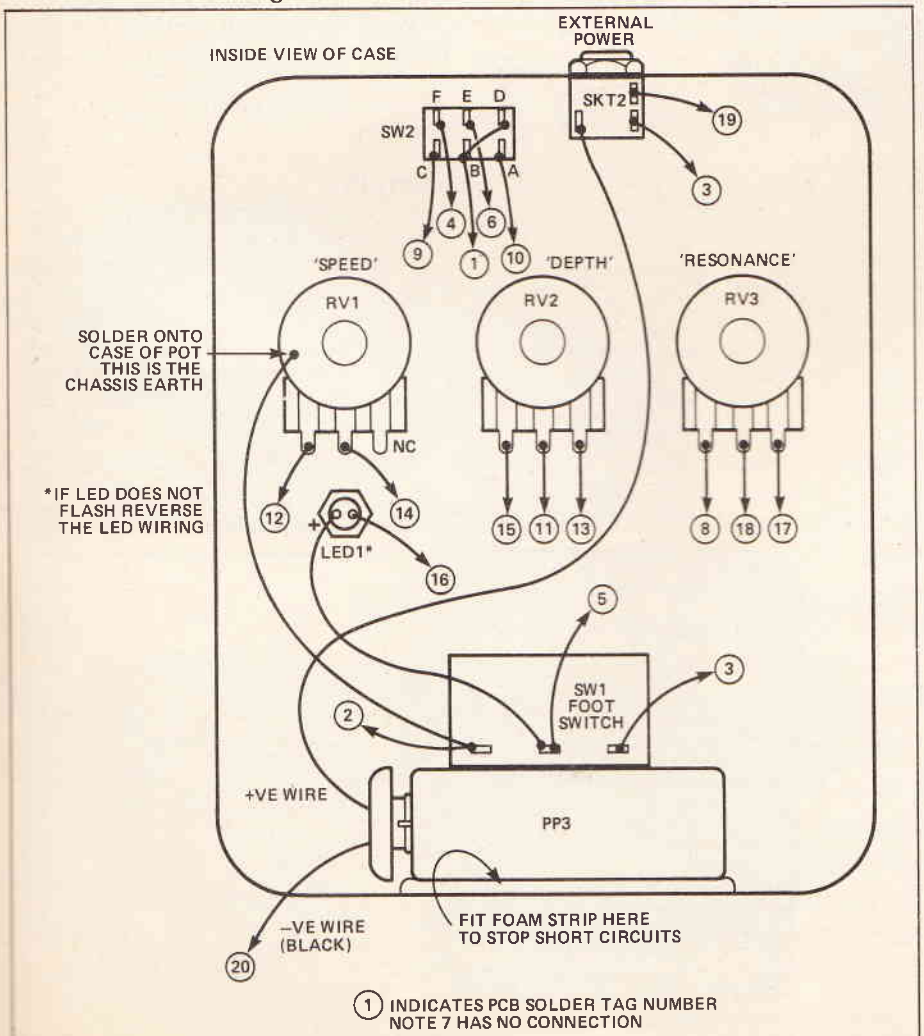


Fig. 7 Inside view of the case and interconnections.

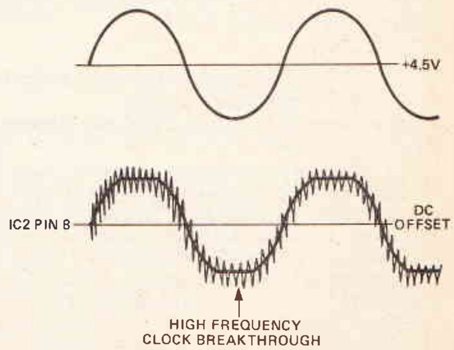


Fig. 9 Waveforms at the input and output of IC2.

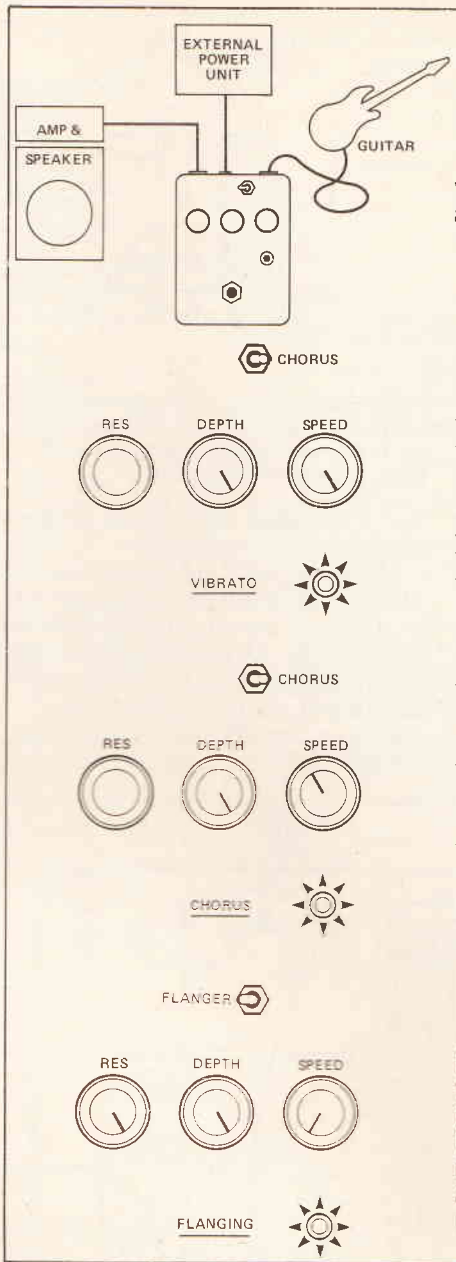
The flanging effect is best tested with a 200 mV P-P square wave oscillating at 2 Hz. This excites the unit with two clicks per second. Set resonance to maximum, speed to minimum and SW2 to the flanger position (footswitch SW1 should still be set to effect and not bypass). Listen to the output from the unit via a suitable amplifier, and adjust PR2 so that the output is a rich 'drainpipe' sound (you'll hear what we mean). If PR2 is set for too much feedback, the unit will oscillate; if this occurs back off the control a little.

For both chorus and flanging effects, the time modulation depth reduces as the modulation speed increases. The modulation depth at 10 Hz should produce a pleasant vibrato effect, caused by a small time delay sweep.

Power Supply

The unit consumes about 1 mA. Using an Ever Ready PP3PP (power plus) for two hours per day, the expected battery life will be about 20 hours. If you leave the unit turned on over night, you will exhaust the battery. It is possible to use a rechargeable Nickel Cadmium PP3 battery. This has a shorter discharge life time of about 7 hours, but can be reused (charged/discharged) about 600 times! The purchase price of Nickel Cadmium batteries is about six times that of a standard PP3, and also you will need a charger unit. A non rechargeable alkaline PP3 battery (eg Duracell type) gives about four times the energy content of a zinc carbon PP3 but costs about twice as much.

A 9V battery eliminator can be used, the operating power is then derived from the mains. Note that the inner connection is +9V and the outer is 0V; if the polarity is reversed, D3 should prevent any damage to the chorus flanger, but the unit will not work.



User Guide

Plug in the guitar and the amplifier. Press the footswitch so that the LED is off. Turn up the guitar volume, set up the amplifier level and tune the guitar. This is the BYPASS mode.

Vibrato

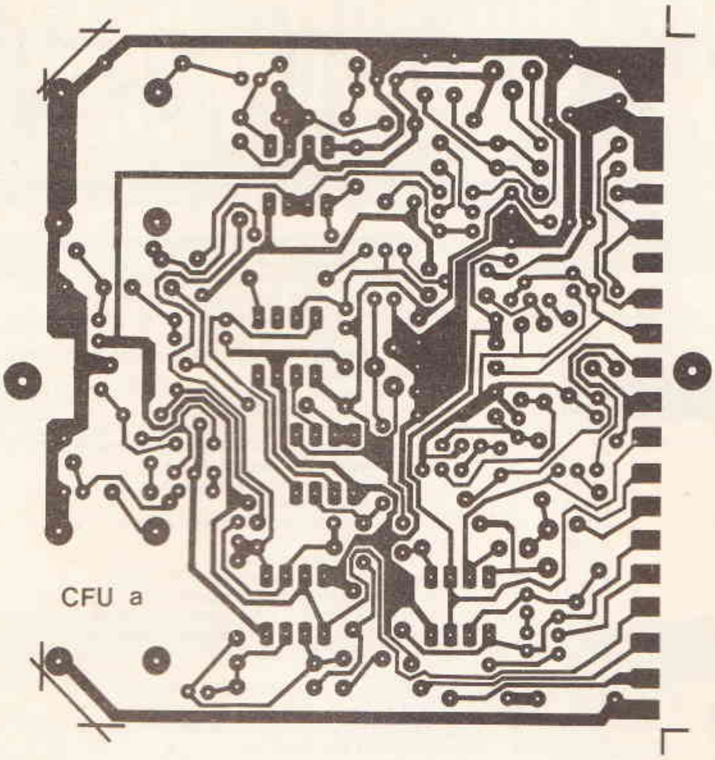
Set up the controls as shown, with SPEED and DEPTH at maximum. RESONANCE is inoperative. Press the footswitch so that the LED is flashing. Play the guitar. A fast (10Hz) vibrato will be heard. If necessary alter the guitar and amplifier levels. Adjust both controls for less depth and different vibrato rates.

Chorus

Set up the controls as shown, with the DEPTH set to maximum and a SPEED setting of about 1 flash per second. RESONANCE is inoperative. Play the guitar. A "creamy" sound will be heard. Press the BYPASS footswitch and see how flat the original signal sounds. Go back to the effect and try some different SPEED and DEPTH settings.

Flanging

Set up the controls as shown with DEPTH and RESONANCE to maximum and SPEED to minimum. Tap the guitar strings. A slowly sweeping "drain pipe" resonance will be heard. Try playing a melody with a rhythm that has the same period as the sweep time. Try other control settings.



The Chorus/Flanger Board