Twin tremolo for organs/stage amps

an alternative to rotating speaker systems

This new twin tremolo unit should be of considerable interest to anyone wishing to expand the facilities on an existing electronic music system. As applied to an organ, it could provide simple tremolo for the respective manuals, or it could process the total signal as an alternative to — or substitute for — a rotating loudspeaker system.

by IAN POGSON AND NEVILLE WILLIAMS

To forestall any possible confusion in the meaning of terms, we use the word "tremolo", to signify a periodic variation in the level or loudness of the sound. For popular or "theatre" style organ music, the frequency of the tremolo effect is usually set at about 7Hz. For "church" type organ sound, a frequency of about 1Hz is more appropriate.

The tremolo effect was widely used in early electronic organs but it gradually gave place to "vibrato" – a periodic variation in the pitch or frequency of the notes. In fact, vibrato does produce a subjective variation in loudness, as well because of the changing pattern of echoes or "standing waves" in the listening room. It can be achieved by modulating the operating conditions of the tone generators or by incorporating a phase modulating system in the subsequent signal path.

Rotating loudspeaker systems, of which the "Leslie" is the best known example, also tend to produce a mix of loudness and frequency variation because of the changing pattern of standing waves, and also because of phase or "Doppler" modulation as the sound source moves in relation to the listening position.

By comparison to these effects, pure tremolo is commonly regarded as being somewhat bland.

Vibrato, as effected in the generator or amplifier circuits, is subjectively more complex and more "interesting". However, too much vibrato can also have the subjective effect of changing the overall pitch of the melody – distressing to pitch-sensitive listeners.

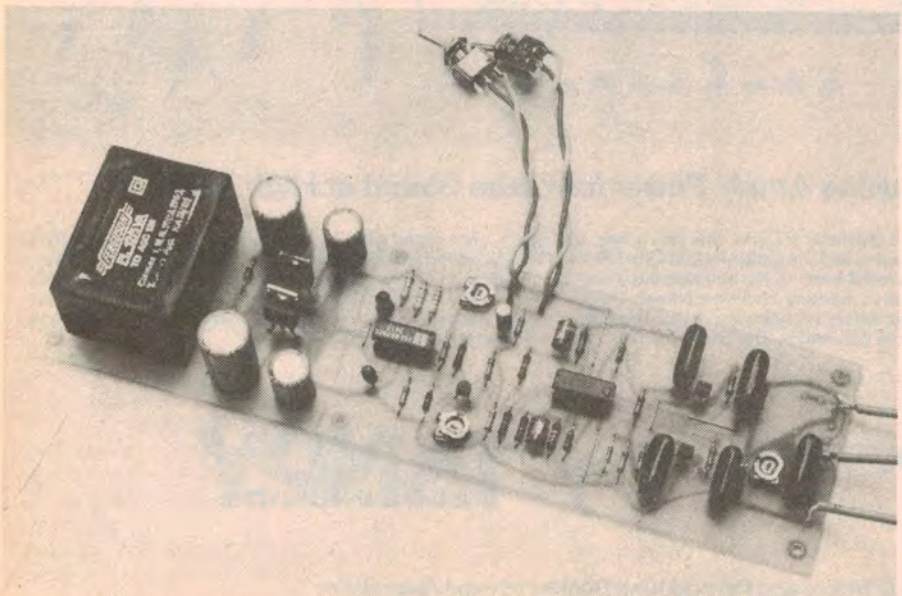
Rotating loudspeakers are effective musically – but they also have their problems: mechanical noise, especially when used at 7Hz in a home situation, and limited power handling capacity. Periodic maintenance is a further liability.

Our attention was focussed on other possible approaches by recent experience with the Technics SX-7700G organ, reviewed in the June 1980 issue. While it included vibrato as a normal facility, it also closely simulated a fast and slow mode rotating loudspeaker, without actually using one. We did not see a circuit or block diagram but we reckoned that Technics achieved the end result by effectively cycling the sound between two (or more) channels. There may have been more to it than this but it was certainly very effective.

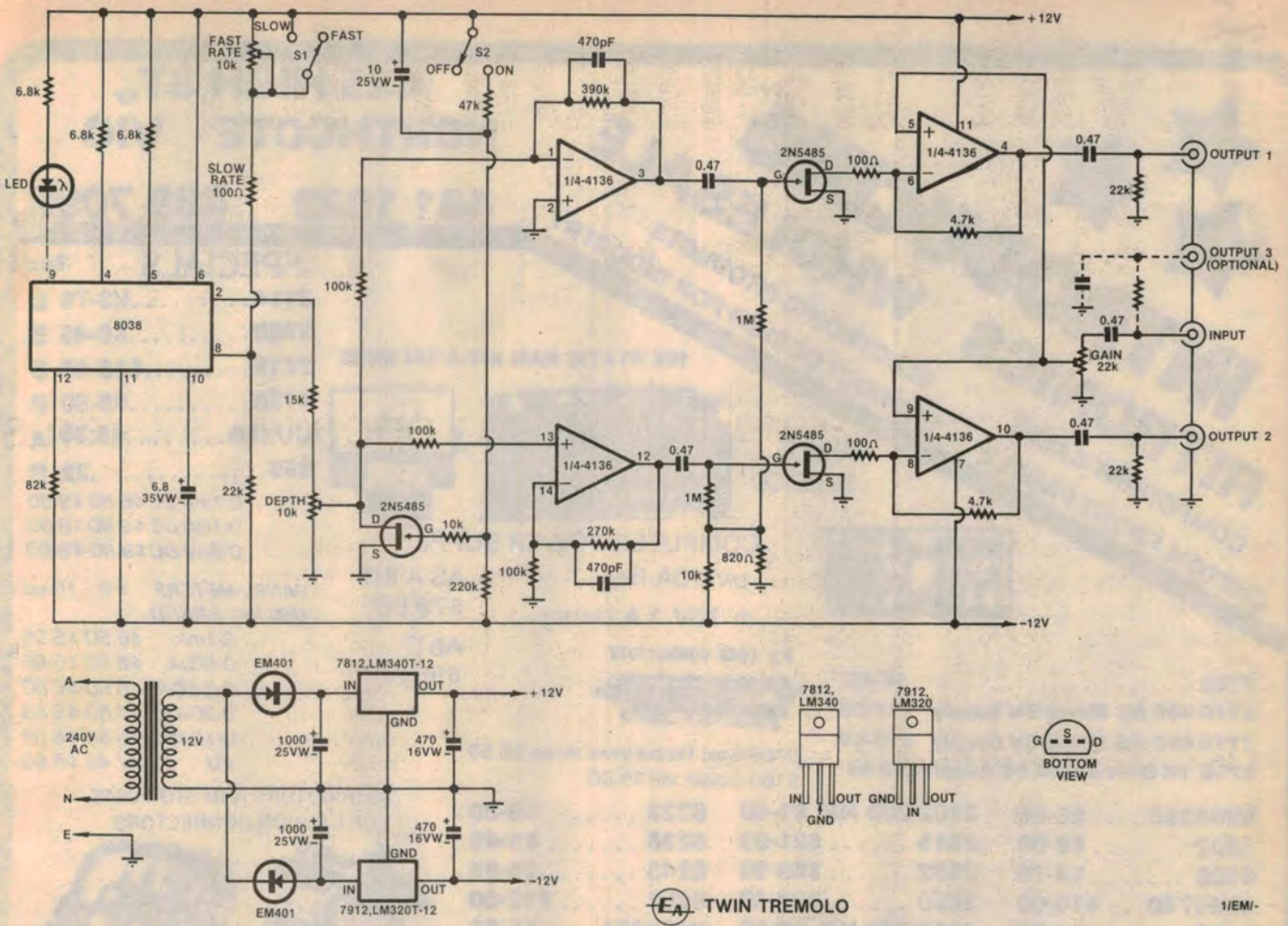
About the same time, we noticed a circuit for a "Split-Phase Tremolo" unit in the May 1980 issue of the English magazine "Practical Electronics". While they saw it as an adjunct to any stage music system – even a vocal channel – it had obvious potential for an electronic organ. It, too, served to quicken our interest.

Thinking back over add-on units that we have described previously, there was the "Phase-shift Vibrato Unit for Electronic Organs" featured in the October '74 issue. It offered the interesting potential of being "fiddled" to produce a mix of vibrato and tremolo but, by present day standards, its use of LDR technology is somewhat "old hat".

More recently, in the November '77



A single PC board accommodates all components, including the power supply. Signal pick-up for the unit can take place after the volume or "Expression" control.



An 8038 waveform generator, a 4136 quad op-amp and three junction FETs form the basis of the circuit (see text re dotted components).

issue, we described an "Electronic Scanner for Organs" – a potential substitute for a rotating loudspeaker system but assuming the use of three separate channels.

Looking afresh at the proposition, we reckoned that it should now be possible to come up with a unit, much simpler than the above-mentioned scanner, using two channels and hopefully showing the way to a smooth, non-mechanical 'Leslie" effect.

The basic idea would be to break into the signal path of an existing organ – or other stage music system – at a point where the level is being controlled by the volume or "expression" pedal. The controlled signal would then be fed into the proposed add-on unit, split into two channels and fed thence into two separate power amplifiers and two separate loudspeakers. This would involve the provision of an extra single-channel amplifier, or the use of an entirely separate stereo power amplifier.

If nothing else were to happen, the organ (or other instrument) would behave much as before, except for the doubling up of the power amplifier system. However, the proposed add-on unit would include provision whereby the sound would effectively be cycled from one amplifier to the other, as the tremolo circuitry smoothly increased and decreased the relative gains of the two channels.

Subjectively, and as far as standing waves were concerned, the sound would appear to oscillate smoothly from one speaker to the other, thereby creating an effect not unlike that of a physically moving sound source. A slow movement (eg 1Hz) would produce a "church" or "celeste" effect; faster movement (eg 7Hz) would produce "theatre" sound.

The "Practical Electronics" unit used a function generator chip to produce the slow or fast modulating frequency and a FET to provide "soft" electronic on-off switching; so far so good. However, they then used a separate transistor as a tremolo phase splitter, a couple of 741 ICs as tremolo amplifiers and a 3340 IC in each channel to effect amplitude modulation of the music signals. A point was made about the modulation being desirably logarithmic.

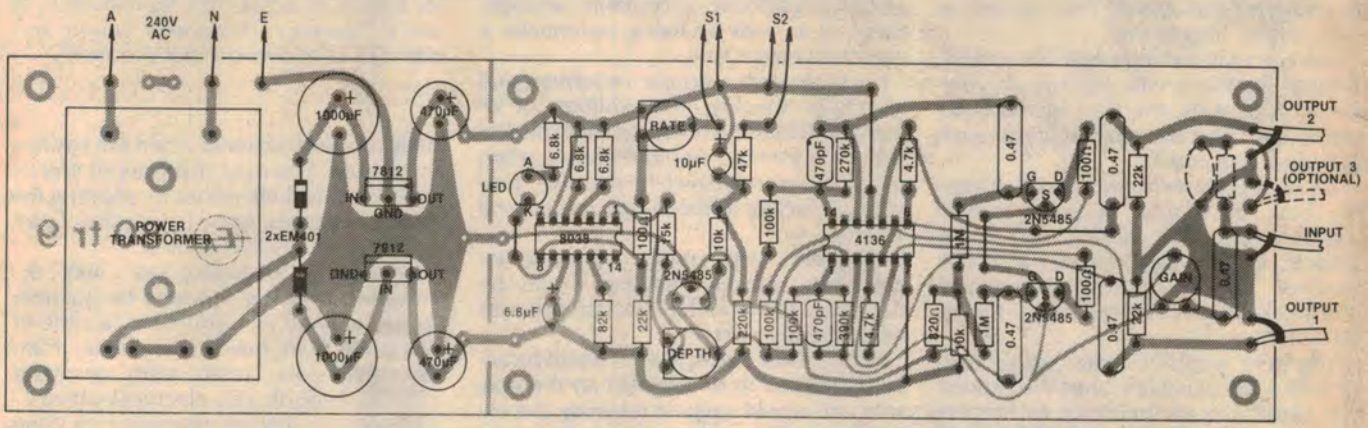
We opted for a completely different approach in this area, using a single 4136 quad op-amp and a couple of JFETs, with the aim of achieving as close as possible to a classical linear modulation envelope. And we produced an appropriate PC board pattern.

Let's look in more detail at our suggested circuit:

The modulating signal is derived from an 8038 waveform generator, which is capable of operating over a very wide frequency range and which gives separate sine wave, square wave and triangular wave outputs. The sine wave is used for modulation and the square wave is used to drive a LED, which serves to indicate the mode of operation. The LED current is limited by the 6.8k series resistor.

The rate of oscillation is determined by the 6.8uF capacitor and the resistor chain associated with pin 8. The fast rate is adjustable and preset by the 10k trimpot. The slow rate is set by the 100 ohm resistor and this may be altered to suit individual tastes. (The more resistance between pin 8 and the +12V rail, the faster the rate of oscillation.)

The sine wave output from pin 2 is taken via a 15k resistor in series with a 10k trimpot which functions as a modulation depth control. Output from the rotor of the trimpot is fed via two 100k resistors to two sections of a 4136 quad op amp. The op amps are connected such that one is non-inverting and the other inverting, thus obviating



The component overlay. Note that the two ICs are oriented in opposite directions.

the need for a separate phase inversion stage.

The modulation process is achieved with two 2N5485 junction FETs in the negative feedback networks associated with the other two sections of the 4136 quad op amp.

Modulating drive from the first two op amps is fed to the gates of the two JFETs and the variation in the effective resistance of the JFETs, in turn, varies the gain of the op amps.

The signal to be modulated is fed into the board via a 22k trimpot; it is then split and the two signals are fed through the modulating op amps. The resulting modulated signals emerge from the op amp outputs, modulated in opposite phase – one passing through a peak as the other passes through a trough.

In order to get proper modulating action of the op amps, it is necessary to set them up with a reasonable amount of gain. When actually coupled into an amplifier chain, the tremolo device is most likely to be operated under unity gain conditions and the 22k input trimpot can be used to set the overall gain accordingly.

Fixed negative bias for the two modulating JFETs is obtained by a voltage divider consisting of a 10k resistor from the −12V rail and an 820 ohm resistor to the 0V line.

Fast/Slow switching is done by a simple toggle switch across the 10k fast rate trimpot.

On/Off switching is rather more involved. A similar toggle switch is used to switch bias to a JFET via a voltage divider consisting of a 47k and a 220k resistor across the +12 and −12V rails. A 10uF electrolyic capacitor is also connected between the +12V rail and the junction of the voltage divider.

With the switch in the open circuit position, a negative bias of several volts is applied to the gate of the JFET, cutting it off; it looks like a very high resistance and so allows the modulating signal to pass, to the two op amps.

When the toggle switch is closed, a positive bias is applied to the gate of the JFET. This has the effect of making it look like a very low resistance, thereby short circuiting the modulating signal and preventing it from being passed on to the two op amps. The 10uF capacitor acts as a time constant, making the switching between on and off a gradual rather than a sudden transition.

The power supply consists of a Ferguson PL12/5VA transformer in a centre-tapped voltage doubler arangement. The DC output is split and feeds two 3-terminal regulators, to give plus and minus 12V output, referred to a 0V line.

With the exception of the two toggle switches, all of the components are mounted on a PCB, measuring 254mm x 72mm and coded 80tr9. The board should be available from the usual places by the time this appears in print.

While most will probably prefer to incorporate the power supply as shown, there may be situations in which the requisite source voltages would be available from the associated amplifier, either directly or in association with 12V regulators. With this possibility in mind, the PC board has been designed so that the power supply section can be sliced off, to conserve space.

The remainder of the components should be readily available. However, if any problem should arise in obtaining the 8038 or the 4136 ICs, we suggest that you try Radio Despatch Service, 869 George Street, Sydney 2000, for the former and any Dick Smith Store for the latter.

Because of the nature of the tremolo unit and the varied applications for it, we have not fitted it to a box of any sort. Where it is likely to be used in conjunction with an electronic organ, more than likely it will be fitted inside the cabinet and so it would not need a box. This matter is left to the builder to decide for himself.

It is usually best to start the board assembly by first fixing the smallest components. There are five jumpers on the board and they should be fitted using tinned copper wire. These may be followed by the resistors, small capacitors, diodes, ICs or sockets, checking carefully for dry joints. Care should be taken to observe the polarity of components where this applies.

More than that need hardly be said as far as the actual construction is concerned.

We do, however, need to add something about possible uses for the twin tremolo unit and your expectations of it, especially in relation to electronic organs.

First off, if you can gain access to a CRO and any kind of an audio source, set the unit up for unity gain and for full modulation, with the envelope just tipping the zero line, without obvious flattening.

Without a CRO, turn the modulation right off and adjust the input pot so that the unit does not add or detract noticeably from the natural gain through the organ amplifier. Then turn the modulation up until further rotation yields no obvious benefit. Do not turn up the modulation to the point where the modulation sounds rough or seems to

We estimate that the current cost of parts for this project is approximately

$40

This includes sales tax.

be chopping the sound. That, in fact, is what will be happening!

How the twin tremolo unit fits into individual situations will depend on your needs, your skills, the time available to experiment, and the adaptabiity of each individual instrument.

Our own tests were done with an ageing but reasonably complex spinet organ, with in-built vibrato and Leslie speaker, and a single channel amplifier feeding three parallel-connected loudspeakers across the front of the instrument.

Consistent with our earlier suggestion, we broke the signal line after the expression pedal and at the input to the existing amplifier. We coupled in the twin-tremolo unit and fed it to the AUX terminals of an external stereo amplifier and thence to a pair of stereo loudspeakers. (Since they were wide-range units, we turned the stereo amp treble control down to simulate the limited top response of the average organ console speaker.)

It was immediately apparent that the twin tremolo did provide the kind of result that we had been seeking – a well modulated, spacious kind of sound. It was far more satisfying than simple tremolo, which could be achieved simply by turning off either channel by means of the amplifier balance control.

As a matter of interest, we tried moving the stereo loudspeakers well apart but, overall, the result seemed unpromising. The dominant effect seemed to be of simple tremolo via the speaker that happened to be the closer of the two. In fact, we finished up wiring the stereo amplifier to the two outermost speakers in the console and that seemed to be a perfectly acceptable arrangement – as well as being potentially a very convenient one.

For those with a simple instrument and no Leslie speaker, the addition of an extra amplifier channel and loudspeaker with twin tremolo would therefore seem to be a very worthwhile exercise, providing a facility additional to the normal vibrato.

However, with more complex instruments, careful planning would be necessary to blend the new facilities with what already exists.

Where three loudspeakers could be accommodated in or adjacent to the console, we would suggest retaining the existing amplifier and a centre speaker to carry the lower frequencies and particularly the pedals. This could be done by taking the signal into the tremolo unit and then out again via output 3. There is space on the board to allow for a series resistor and a bypass, which could be chosen to roll off the response through the main amplifier above about 200Hz. By limiting the output of the main amplifier in the melody area, the tremolo effect would from the additional speakers would not be swamped.

We would also suggest reducing from 0.47 to about 0.1uF the capacitors to do with the tremolo unit "Input" and "Output" 1 & 2. This will keep the lower frequency signals out of the modulated amplifiers and also make it practical to get by with a less powerful stereo amplifier and smaller speakers.

If the organ already includes a Leslie system, and you logically want to retain it, the same general course could be followed but with provision to switch out the high frequency bypass on the main amplifier channel when the Leslie is to be used. You may also want to silence the trem channels, either by shorting the input or outputs, or by having the "Gain" pot as an accessible control.

At right is an actual size reproduction of the PC pattern. The power supply section can be deleted if not required.

Indeed, with appropriate and accessable switching, it would be possible to end up with an instrument capable of operating solo main, solo Leslie, trem fast and slow, multi trem or multi celeste. And, oh yes, electrical vibrato!

Hence our earlier reference to time and initiative.

To go beyond that would be to provide separate twin tremolo on the two manuals and we have thought of that possibility by providing holes whereby you can piggy-back two trem units with spacers. But, be warned:

The output from each manual would automatically become 2-channel rather than 1-channel (virtual stereo), requiring a ganged inter-manual balance pot and an expression pedal with two symmetrical signal circuits. It's possible, it's rewarding and Technics did something like this (and more) in their 7700-G, mentioned earlier. But you have to be prepared to dive in with iron smoking!

One final suggestion, which may not be quite so daunting: In many spinets, there is no way of doing different things with the two manuals. Vibrato and Leslie affect both and there is no way of splitting them.

It would be possible to wire one channel of the twin tremolo unit into the signal line for the lower manual and at least have simple trem available to accompany a straight upper manual instrumental sound.

You could go one step further and, by cutting the copper track, wire the other channel into the upper manual. Duplicate the switching circuit on a scrap of tag and you can have simple trem separately available on the upper manual. With both manuals on simple trem and operating out of phase, the result could be sonically quite interesting.

You try it: we didn't have time to experiment with everything!

One final point: when you are interconnecting amplifiers and speakers to operate side by side, keep in mind the matter of loudspeaker phasing. If introduction of the extra amplifier(s) appears to diminish the bass in particular, try reversing the connections to the extra speaker(s). If you are not able to precheck the phasing in the amplifier chains, there is a 50/50 chance that it will be wrong.

PARTS LIST:

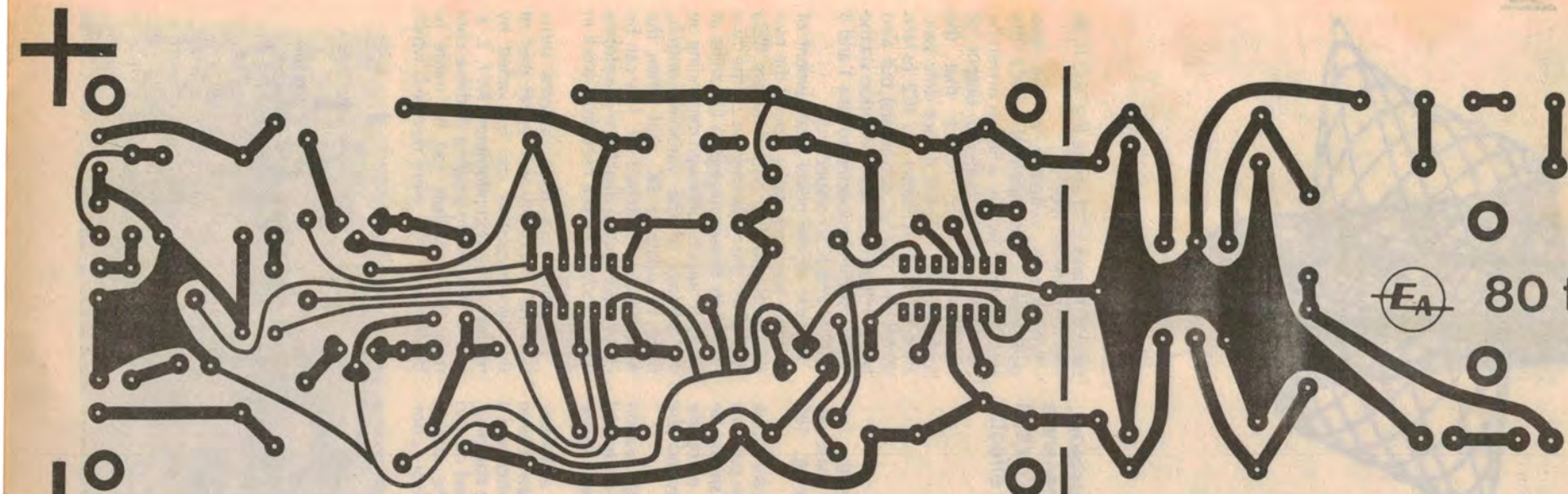
1 PC board 254mm x 72mm code 80tr9
1 Ferguson transformer PL12/5VA
2 10k miniature horizontal trimpots
1 22k miniature horizontal trimpot
2 14-pin DIL sockets
2 miniature toggle switches SPDT
2 EM401 or similar rectifier diodes
1 red LED
1 LM340-12, uA7812 12V 3-terminal regulator
1 LM320T-12, uA7912 –12V 3-terminal regulator
3 2N5485 JFETs
1 8038 waveform generator
1 4136 quad op amp

RESISTORS
(5% tolerance, ¼ or ½W rating)
3 x 100 ohms, 1 x 820 ohms, 2 x 4.7k, 3 x 6.8k, 2 x 10k, 1 x 15k, 3 x 22k, 1 47k, 1 82k, 3 100k, 1 220k, 1 270k, 1 390k, 2 1M.

CAPACITORS
2 470pF polystyrene
5 0.47uF/250V metallised polycarbonate (greencap)
1 6.8uF/35VW tantalum electrolytic
1 10uF/25VW electrolytic
2 470uF/16VW electrolytics
2 1000uF/25VW electrolytics

MISCELLANEOUS
Hookup wire, shielded audio cable, 3-core power flex, 3-pin plug, solder, hookup wire.

NOTE: Ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible.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