Most of us have heard the stereo effect of an express train, a gale force wind, or perhaps an artificially created sound transferring from the right-hand to the left-hand speaker. It's just as impressive when the sound returns from the left-hand to the right-hand speaker, as when, for instance, a train from the opposite direction passes by. The circuit described in this article makes it possible for both effects to happen simultaneously: creating a sound very much like that of a Lesley rotating speaker system.

gyrophone...

. . . to make your stereo wander

Before we go any further, there is one thing to be borne in mind: the contents of the two stereo channels must be quite distinct from one another if the effect is to be realized. A short listening test will soon show which type of recording is suitable: listen to it and then turn one of the speakers off. If half of the sound just 'dies', the recording is usable. Stereo records produced ten years or more ago are particularly suitable.

The circuit is not really an electronic version of a Lesley because phase shifts are not catered for, but its action is none the less remarkable. Briefly, the right-hand signal 'wanders' to the left-hand channel, and vice versa. Shortly afterwards, the two sounds revert to their original channel. This effect is achieved by periodically inverting the two channels.

The block diagram in figure 1 shows that the signals from the two channels are split and applied to four operational transconductance amplifiers (OTAs). However, although both OTA1 and OTA3 are fed with the left-hand signal (and OTA2 and OTA4 with the right-hand signal), they are not controlled by the same sawtooth voltage. The low-frequency oscillator (LFO) drives OTAs 1 and 4 directly and OTAs 2 and 3 via an inverter. This means that OTAs fed with the same stereo signal have opposing control signals. The left-hand information is therefore amplified in OTA1 but attenuated in OTA3 and consequently appears in the left-hand but not in the right-hand output. From time to time, however, the control signals are such that the left-hand information appears in the right-hand but not in the left-hand output. The right-hand input signal is treated in an identical manner. The whole process is continuous and therefore causes the characteristic swelling and fading of the loudspeaker outputs. In contrast to a real Lesley, our circuit creates the effect only by differences in volume in each individual channel.

A low-frequency oscillator consisting of integrator A1 and trigger A2 (see figure 2) generates a sawtooth voltage. This voltage should not go negative because that would block the OTAs, and a diode, D1, is therefore included in the feedback path of A2. The sawtooth voltage is fed to A3 and to inverter IC2. The output of IC2 is applied to the inverting input of A4. Opamps A3 and A4 drive transistors T1 and T2 and these in turn feed the four OTAs.

As already explained, the signals from the two channels are split and the parts are amplified in different OTAs. Output channel L contains a mixture of the signals

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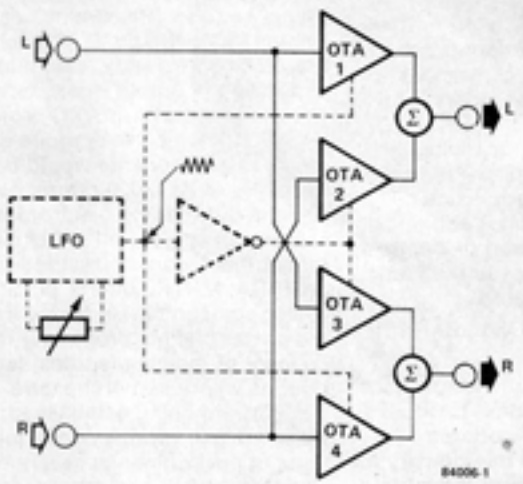

Figure 1. Block schematic of the gyrophone. The signal and control paths (the latter in dashed lines) are shown separately to clarify the operation of the gyrophone.

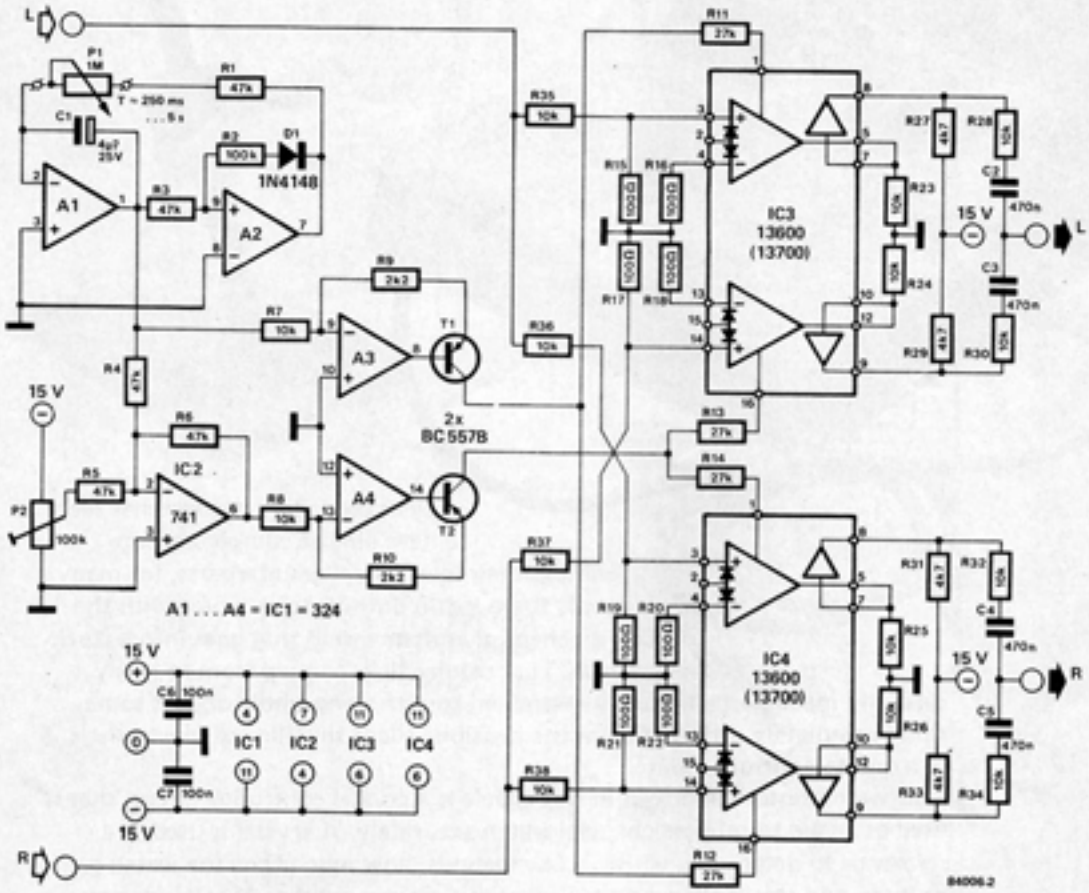

Figure 2. It is clear from this circuit diagram that only inexpensive and easily available components have been used. Only the setting of P2 may test your patience (and your hearing!).

fed to OTAs 1 and 2 and, similarly, output channel R a mixture from OTAs 3 and 4. The mixing elements are formed by two resistors and a capacitor (for instance, R27/R28/C2).
The buffers contained in IC3 and IC4 (pins 7, 8 and 9, 10 respectively) must not be used in this application.

Construction and calibration

The design has been kept as simple and inexpensive as possible and its construction on a prototyping (Vero)board should not present any trouble to the hobbyist with some experience.
Preset P1 enables the frequency of the sawtooth generator to be set to your own individual taste. The frequency, f, is given by $f = 1/[C1(P1 + R1)]$Hz. With values shown, the frequency can be set anywhere between 0.2 Hz and 4 Hz, corresponding to periods of 5 s and 250 ms respectively.
Because IC2 inverts the sawtooth waveform, its output would normally be mostly negative. As stated, this cannot be tolerated as it would block the OTAs. Therefore, the inverted sawtooth voltage is superimposed on a d.c. voltage, the level of which is preset by P2. If an oscilloscope is not available, the presetting can be done by ear. Apply a signal to one of the input channels and set the LFO to a low-frequency output. If P2 has been set correctly, the loudspeaker volume should gradually fade away and then gradually swell again. If not, limiting is taking place and this is indicated by an absence of sound for some time followed by a sudden burst of volume.
The audio input signals to the circuit may lie between 0.7 V and 10 V. However, when you use inputs of just about 0.7 V and have a powerful main amplifier connected to the output of the gyrophone, it may happen that the maximum and minimum values of the sawtooth voltage become audible in the loudspeakers. This can be prevented by increasing the signal input by, for instance, inserting an additional amplifier between the signal source and the inputs to the gyrophone.
We shall be very brief about the required mains supply: the current consumption of the gyrophone is around 50 mA per channel at ± 15 V.