Cut the crackle and get rid of the rumble with our

Scratch and rumble filter

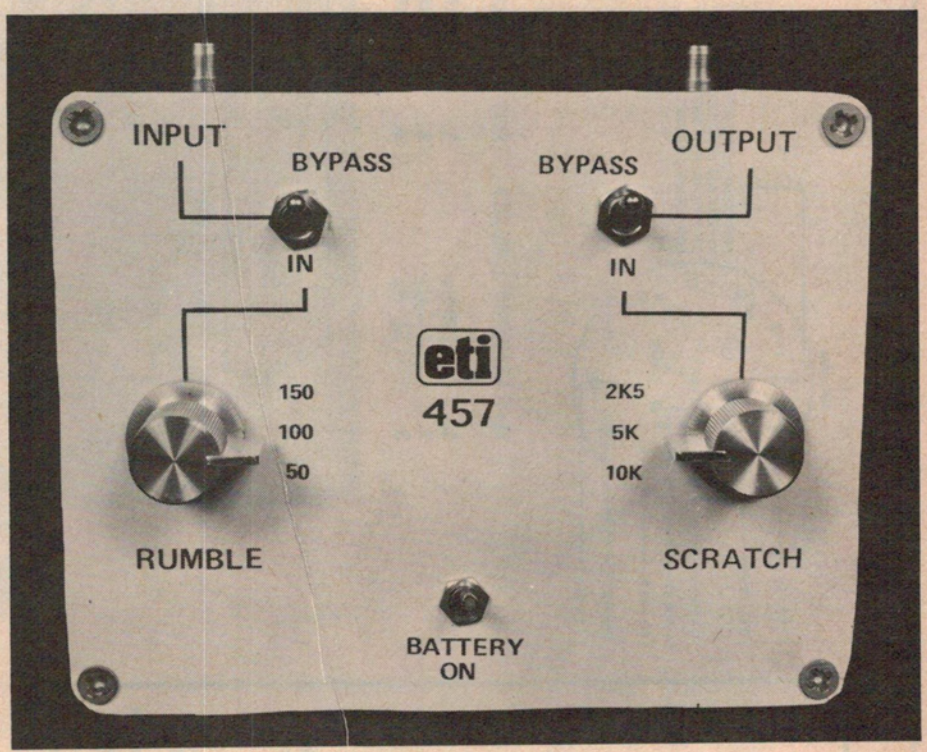
Staff

If many of your cherished older recordings are showing signs of old age and long use, or if you wish to transcribe your collection of 78s onto tape, this scratch and rumble filter project should help improve the sound quality.

SO YOU SAY you look after your records, but you probably have some that are scratched? Perhaps you lent them to someone who didn't care for them or they might be cherished rarities you picked up in a secondhand shop. Some of the best 'original' recordings are still on 78s especially if you're into jazz, bluegrass, blues or country music. Whatever the cause, clicks, pops and severe surface noise can spoil your listening pleasure, no matter how enthusiastic you are about the artist or the item recorded.

One other source of unwanted sound comes from the turntable in the form of rumble — a low frequency sound which can make your teeth grind in sympathy! If you look at the speaker cone whilst playing a turntable suffering from rumble, you may see it move in and out, although you may not hear anything. This is subsonic rumble and can be detrimental to the performance of the speaker system. The main cause of rumble is a less than perfect turntable transmitting vibration from the motor and bearings to the stylus. Rumble has almost been cured with the introduction of belt drive and good direct-drive turntables but these can suffer from wow and flutter. That's another story, though. Low frequency acoustic feedback from the speakers to the turntable can also occur if the acoustic mounting of the turntable is not up to scratch.

The high frequency surface noise on a recording can be removed with a 'high cut' filter. This will also cut the highs on the recording but on old records this will not be so noticeable. Likewise, low frequency noise can be removed with a 'low cut' filter and again, some of the low frequency information is lost.



It is desirable to only modify enough of the amplifier's frequency response to reduce the problems, therefore we have included switchable cutoff frequencies for each filter. High frequency hiss can usually be removed with the 10 kHz filter while cracks will probably need a lower frequency cutoff.

The unit uses two active filters in series, one a low cut for the rumble filter, the other a high cut for the scratch filter. The filters provide an attenuation of 12 dB per octave at frequencies past the cutoff point and can be switched in and out independently. The unit is battery operated and designed to go between the turntable and the preamplifier on older stereo systems, or between the preamplifier and the main amplifier on modern systems. We have built each channel on a separate pc board to allow the unit to be used for either mono or stereo systems. We have shown only one channel for simplicity. If you wish to build a stereo version you will need to duplicate all components except the switches and batteries, and of course, the box. ▶

Project 457 — scratch & rumble filter

PARTS LIST — ETI 457

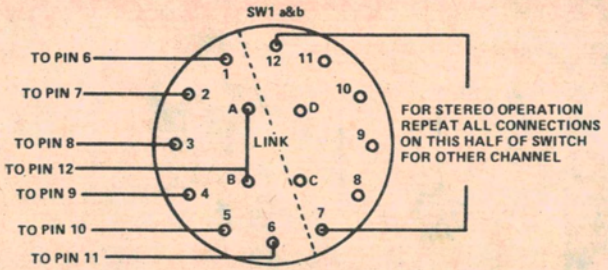
Resistors — all ½W, 5%
- R1 ..... 27k
- R2 ..... 12k
- R3 ..... 2k7
- R4,R5 ..... 15k
- R6 ..... 220k
- R7,R8 ..... 4k7
- R9 ..... 10k
- R10 ..... 820R

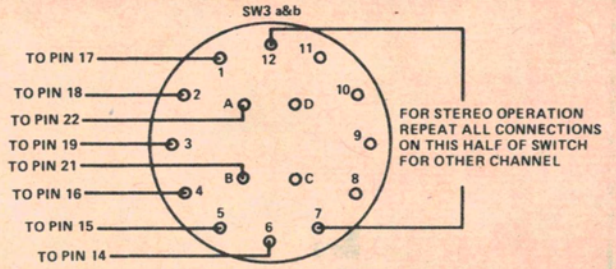
Capacitors
- C1,C4 ..... 68n greencap
- C2,C5 ..... 100n greencap
- C3,C6,C9 ..... 220n greencap
- C7,C8,C16 ..... 1u tantalum
- C10,C13 ..... 10n greencap
- C11 ..... 22n greencap
- C12, C15 ..... 4n7 greencap
- C14 ..... 2n2 greencap

Semiconductors
- Q1,Q2 ..... BC549, BC109 or sim.
- LED1 ..... red LED TIL220R or sim.

Miscellaneous
- SW1,SW3 ..... four pole, three-way wafer switches
- SW2,SW4,SW5 .... DPDT miniature toggle switches

ETI-457 pc board; two RCA phono sockets; box to suit (120 mm × 95 mm × 55 mm); knobs; 9V No. 216 battery and battery clip.



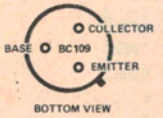


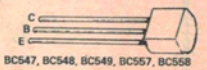
SW1 LOW CUT RANGES

1	150 Hz
2.	100 Hz
3.	50 Hz

SW3 HIGH CUT RANGES

1.	10 kHz
2.	5 kHz
3.	2.5 kHz





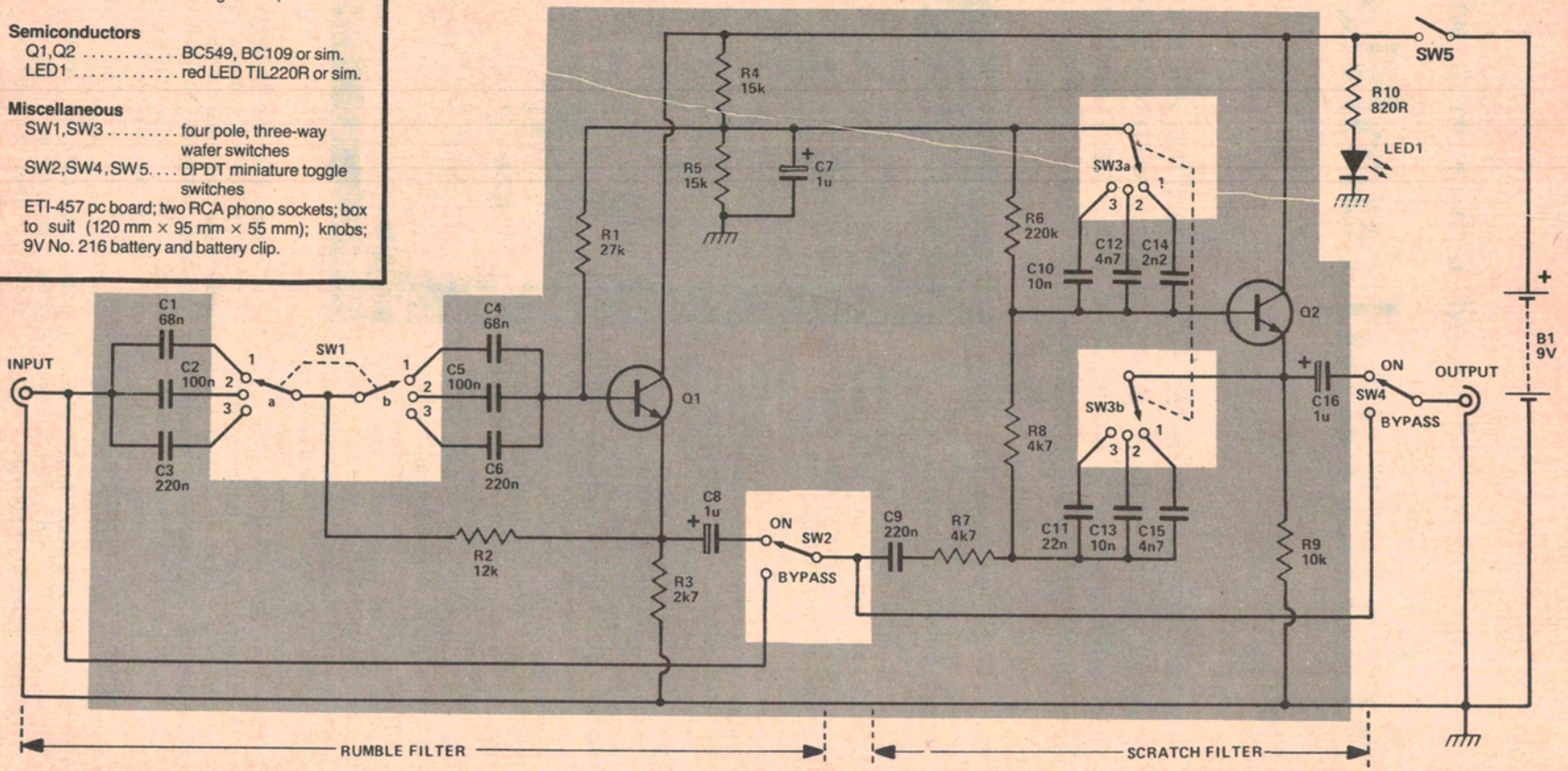


Figure 1 shows the block diagram of the mono version of the scratch and rumble filter. The input signal (from the turntable pick-up) is first fed through a high-pass filter, which rejects unwanted low-frequency rumble signals, and is then fed through a low-pass filter which rejects unwanted high-frequency scratch signals. Each filter can be bypassed via a simple switch if required, so the input signal can be passed through either one, both, or neither of the filters.

Figure 2 shows the circuit (a) and performance graph (b) of a simple single-stage passive high-pass filter. At low frequencies, capacitor C1 presents an impedance that is high relative to R1 so a lot of signal attenuation occurs between the input and output terminals. At high frequencies C1 presents an impedance that is low relative to R1, so negligible signal attenuation occurs between input and output.

The frequency at which the output signal is 3 dB down on the input signal is conventionally known as the BREAK frequency.

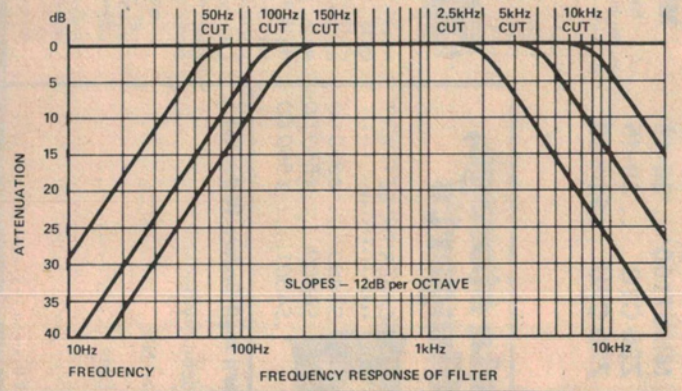
Note in Figure 2(b) that the graph shows a smooth roll-off or slope up to the break frequency point: a single stage filter has a slope or roll off of 6 dB/octave, i.e: the signal output level doubles if the input frequency is doubled.

A number of filter stages can be cascaded to give a roll-off of greater than the basic 6 dB/octave: usually, some kind of electronic buffering or feedback is used between the individual sections of a multi-stage pass filter system.

Figure 3 shows the circuit (a) and performance graph (b) of a two-stage high-pass filter. This design is known as a Butterworth filter, and is the type used as the rumble filter section of our project: It has a sharp break frequency, and gives a slope or roll-off of 12 dB/octave.

The basic high-pass filter of Figure 2 can be made to act as a low-pass type by simply transposing the positions of C1 and R1, as shown in Figure 4. Figure 5 shows the two-stage (second order) Butterworth version of the low-pass filter. This is the design that is used as the scratch filter in our project.

In the complete project (see main diagram) the high-pass or rumble filter is designed around Q1 and R1, R2 and C1 - C6, and the low-pass or scratch filter is designed around Q2 and R6 - R8 and C10 - C15. Resistors R4, R5 and bypass capacitor C7 provide the low-Z bias point for the two transistors. The low-frequency break point of the rumble filter can be varied via three-way switch S1, and the high-frequency break point of the scratch filter can be varied via S3.



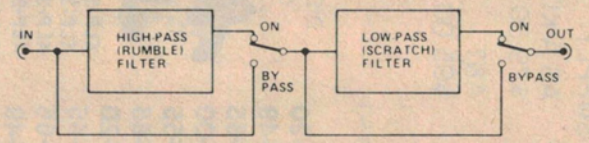


Figure 1. **Block diagram, scratch and rumble filter.**

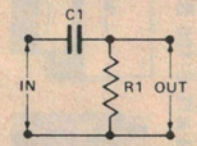


Figure 2 (a). **Simple passive high-pass filter.**

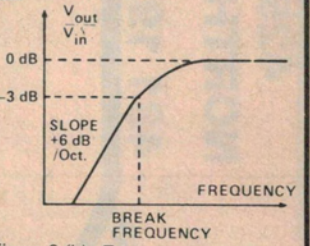
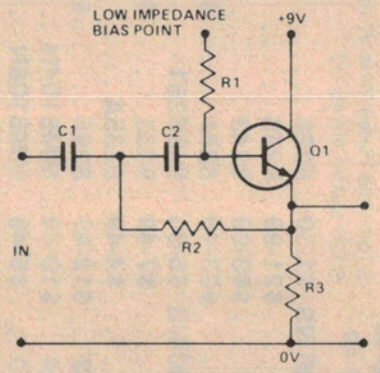


Figure 2 (b). **Frequency response.**



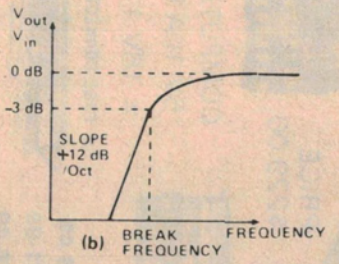


Figure 3 (a). **Two-stage active high-pass filter.** *Figure 3 (b).* **Frequency response.**

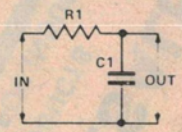


Figure 4 (a). **Simple passive low-pass filter.**

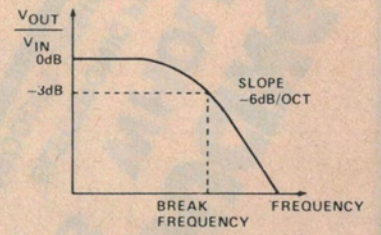


Figure 4 (b). **Frequency response.**

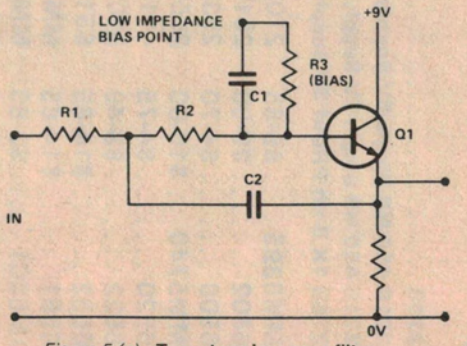


Figure 5 (a). **Two-stage low-pass filter.**

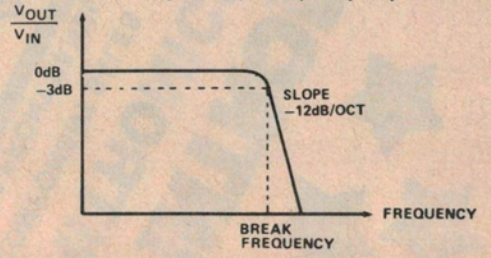
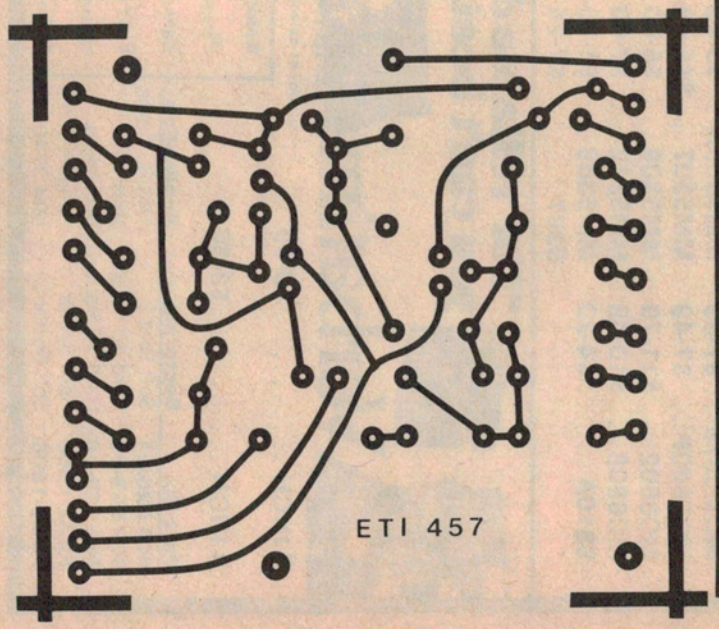


Figure 5 (b). **Frequency response.**



Construction

This description is confined to the mono version. A stereo version is readily assembled from two pc boards. As the switches are all available with a complete extra set of poles and contacts, these components need not be duplicated in a stereo version. Wiring will follow much the same course as described here.

We built our filter into a diecast box, but you may have something else in mind. A diecast box is very robust and provides generally good shielding, although a steel box would further reduce possible hum pickup.

All the switches are mounted on the lid of the diecast box. The pc board is 'hung' off the rotary switches and supported by tinned copper wire from the switch tags. This makes quite a rigid assembly and ensures short wiring to the switches. For a stereo version, the second channel pc board may be mounted behind the first, wired to the switches in a similar fashion.

The input and output sockets are mounted on one wall of the box and wired to the pc board with shielded cable. The bypass toggle switches are wired with hookup wire.

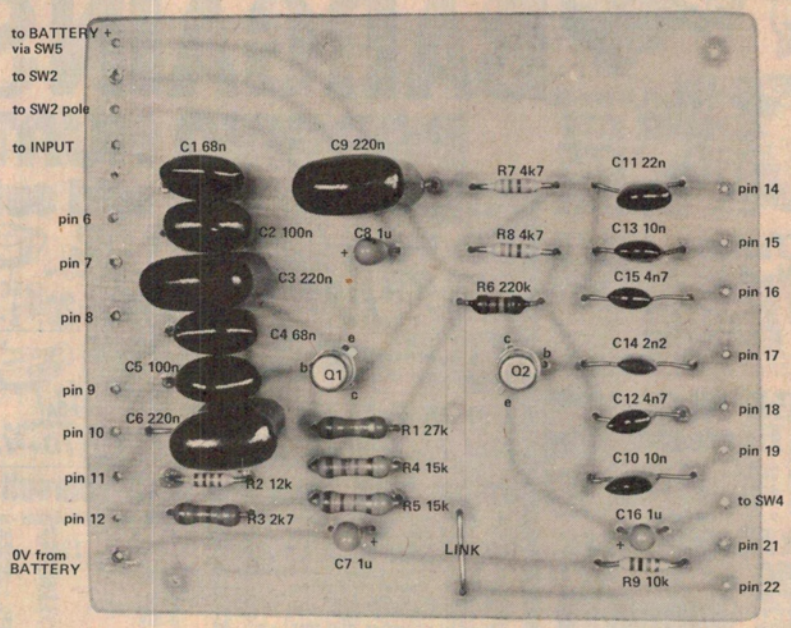
When assembling the pc board, watch out for the polarity of the tantalum capacitors and the orientation of the transistors, otherwise assembly is quite easy. With the components mounted in the board, the next step is to solder 50 mm lengths (longer for the second channel in a stereo version) of tinned copper wire to the lugs on the rotary switches.

Solder suitable lengths of insulated hookup wire to the points on the pc board that lead out to the toggle switches SW2, SW4 and SW5.

Carefully insert the tinned copper wires into their respective holes on the pc board and push the board up the wires to within about 15 mm or so of the switches. Take care not to bend any of the wires. Solder all the wires in place and cut off the excess. If building a stereo version, repeat this, taking care not to get the two channels' switch wiring tangled, pushing the second channel board to within 15 mm of the first.

Wire all the toggle switches input and output leads and you're ready to try it out.

We used a No.216 9 V battery. This is quite sufficient for the mono or stereo versions as current drain is only two milliamps per channel.



Component overlay for the pc board. Note that pin numbers 1 to 5, plus 13 and 20 , are not used. Resistor R10 and the indicator LED1 are mounted off the pc board (we have not used these).

Operation

Operation is quite simple. With the unit's switches set for bypass, put on a record known to suffer from surface noise problems. Switch the unit on and put the scratch filter in circuit. Adjust the rotary switch and note the effect of the different filter frequencies. Do the same for the rumble filter.

A little experimentation should show up the best setting for each recording. It's worthwhile keeping a note of the setting with each record. The Scratch and Rumble filter is also a great aid when making tape recordings of old discs, particularly 78s.

With this unit, those old discs will find a new lease of life! ●

Internal view of the completed project showing the location of the input and output RCA sockets and the pc board 'hung' from the rear of the switches. Note that this is a mono version.