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DIY: from vinyl to compact disk

with a PC and sound card

Nowadays, with the availability of personal computers and compact-disk (CD) writers, there is nothing in the way of transferring one's collection of vinyl records on to compact disks. All that may be needed in addition to the equipment already mentioned is a suitable preamplifier, such as the one presented in this article.

Brief parameters

Input sensitivity	
(moving-coil)	*2 mV*
(dynamic)	*about 0.2 mV*
Nominal output signal	*200 mV*
Signal-to-noise ratio	
(moving-coil)	*78 dBa (750 Ω in)*
	88 dBA (input short-circuited)
(dynamic)	*70 dBA (25 Ω in)*
	71 dBa (input short-circuited)

Design by T. Giesberts

INTRODUCTION

The DIY making of compact disks is rapidly becoming a commonplace. One of the applications that is particularly attractive to many people is the digitizing of their valuable collection of vinyl records. There are, of course, other advantages than creating space (CDs take much less storage space than vinyl records): a compact disk has a longer life than a vinyl record (although it is not, as some people believe, infinite), and it becomes possible to select and shuffle sections of the recording if and as desired.

When a personal computer is available that incorporates a CD recorder (many modern ones are) and a good-quality sound card, the copying of vinyl records is straightforward. All that is then required is a means of linking the pickup output to the sound card. When the record player is placed next to the computer, the line outputs of the amplifier may be used. When this is not possible, there are a few difficulties. The output voltage of a dynamic pickup is about 3 mV and that of a moving-coil type around 0.3 mV. Clearly, these potentials are insufficient to drive the line input of the sound card. Moreover, the frequency response of the signal must be corrected.

RIAA CORRECTION

A vinyl record is cut tangentially, that is, the cutter traverses the disk in a straight line from disk edge to centre. The cutter response is called constant velocity, which means that its velocity is the same for all frequencies. Therefore, the amplitude increases as the frequency drops (at a rate of 6 dB/octave). It would thus be 16 times greater at 30 Hz than at 15 kHz.

Large low-frequency stylus excursions during playback are avoided by cutting the bass and boosting the treble frequencies to improve the signal to noise ratio. These contours roll off at either side of a short flat region centred on 1 kHz to form the RIAA (Recording Industry Association of America) characteristic. The playback amplifier or preamplifier has a frequency response that is a mirror image of the RIAA characteristic (see Figure 1).

DESIGN

The design of the preamplifier allows the output of dynamic as well as moving-coil pickups to be connected to its input.

Although the preamplifier is intended primarily for use as a converter between record player and personal computer, it is equally suitable for use with a hi-fi amplifier that has no integral phone input.

The block schematic of the preamplifier is shown in **Figure 2**. Each of the two stereo channels is linked to an input amplifier for moving coil pickups, which can be taken out of circuit by a wire bridge, followed by a standard amplifier for dynamic elements. The RIAA frequency-correction circuit is incorporated in this latter amplifier.

Note that for cases where the record player is linked to the computer for long periods, the line input is retained for other applications. To avoid the cumbersome changing of plug-and-socket connections, there is a change-over relay at the output, which ensures that when the moving-coil preamplifier is not used, the line input is connected to the relevant terminal(s) on the computer.

The power supply provides the ±15 V lines for the operational amplifiers, as well as the single +20 V line for the relay. It is preceded by a filter to eliminate any mains hum and interference.

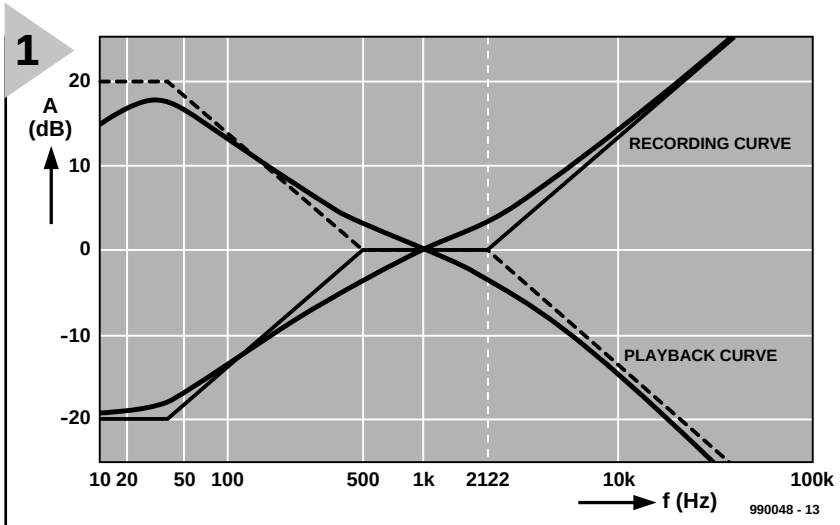
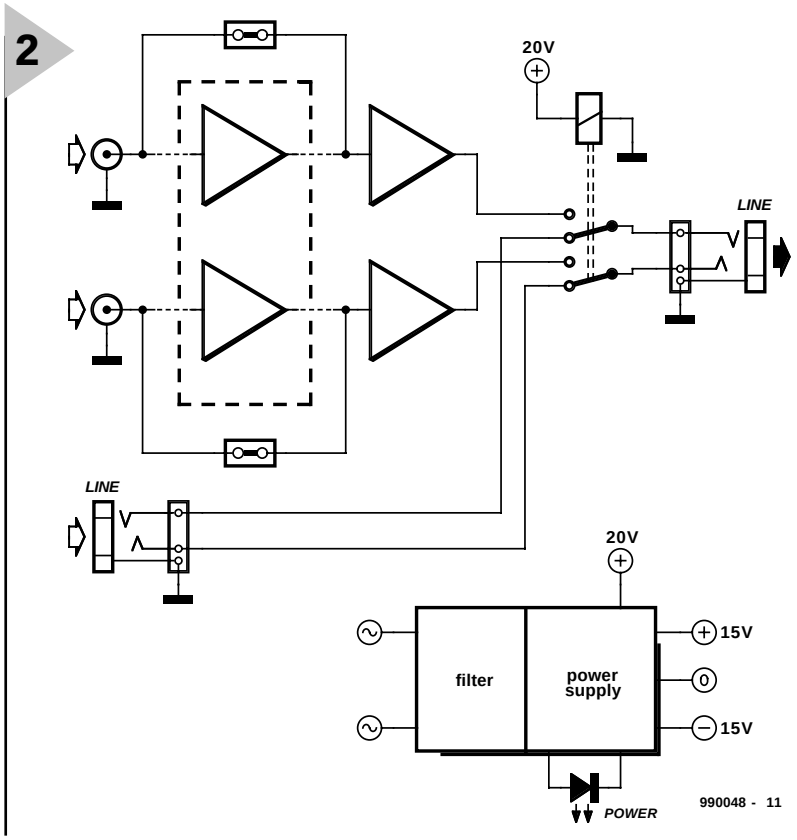


Figure 1. RIAA recording and playback characteristics.

Figure 2. Block schematic of the preamplifier.



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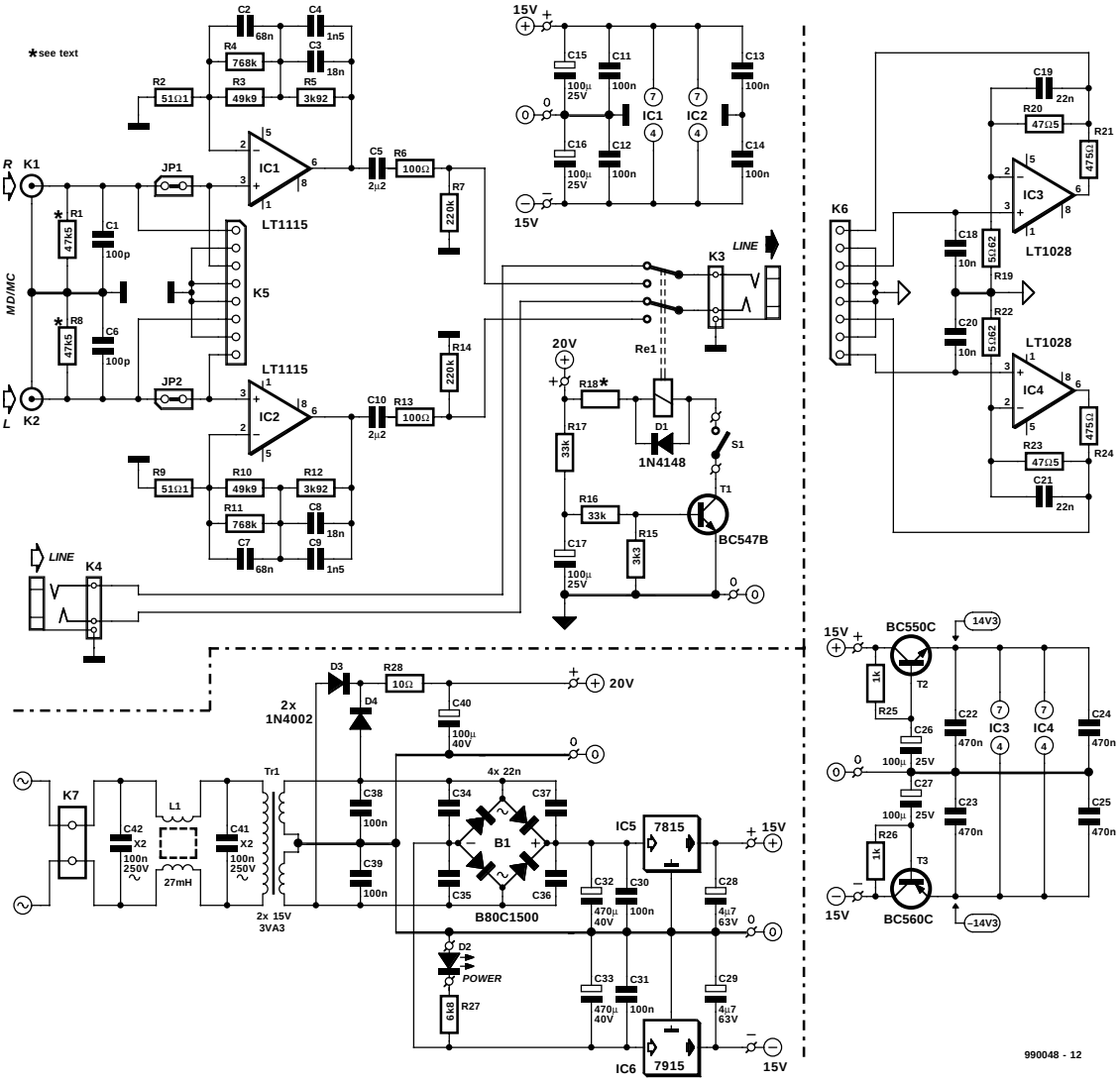

Figure 3. The circuit diagram may conveniently be split into three sections.

CIRCUIT DESCRIPTION

In **Figure 3**, the preamplifier for moving-coil elements is formed by IC_3 and IC_4, while the main amplifier is based on IC_1 and IC_2.

When the output of a dynamic pickup is linked to terminals K_1 and K_2, the input impedance has the standard value of 47 kΩ – determined almost exclusively by R_1 and R_8. Capacitors C_1 and C_6 determine the frequency response between 10 kHz and 20 kHz, which means that their value depends to some extent on the type of dynamic element used.

Operational amplifiers IC_1 and IC_2 are typified by a very low noise figure, a reasonably low bias current, and low input offset. When the output is 200 mV and the input is short-circuited, the amplifiers have a signal-to-noise ratio of 88 dB. In practical use, the noise of the amplifier is produced primarily by the pickup element. Note that the resistance and inductance of an average dynamic element are about 750 Ω and 450 mH respectively.

The gain of IC_1 and IC_2 is 40 dB at 1 kHz. The RIAA correction network is included in the negative-feedback loop between pins 2 and 6. Capacitors C_5 and C_{10} decouple any offset, while resistors R_6 and R_{13} protect the operational amplifiers against capacitive loads. Resistors R_7 and R_{14} ensure that C_5 and C_{10} are charged in the absence of a load, which helps to prevent switch-on phenomena.

When the power is switched on, relay Re_1 is energized, whereupon the output of the amplifiers is linked to terminal K_3. When the supply is switched off, the relay is disabled, whereupon the additional line input at terminal K_4 is linked to K_3.

To avoid switch-on clicks and plops, the relay is energized with some delay provided by capacitor C_{17} via transistor T_1. Resistor R_{15} ensures that the relay is deenergized rapidly to guarantee that the supply to the amplifiers is switched off instantly.

Switch S_1 serves to enable manual switching of the relay between amplifiers and line input terminal; K_4 without the need of switching off the supply.

When a dynamic pickup element is used, jumper terminals JP_1 and JP_2 are closed. The sections based on IC_3 and IC_4 are then not used and need not be built.

When a moving-coil pickup element is to be used, JP_1 and JP_2 must remain open and resistors R_1 and R_8 must be replaced by 100 Ω types. Amplifiers IC_3 and IC_4 are included in the signal path via terminals K_5 and K_6. These amplifiers provide an amplification of about ×10.

To ensure a low noise figure, the values of R_{19} and R_{22} are very low. To prevent this forming too large a load for the op amps, an additional resistor is used in the negative-feedback loop (R_{21} and R_{24} respectively). The resulting narrowing of the bandwidth is negated to a large extent by the use of very fast operational amplifiers.

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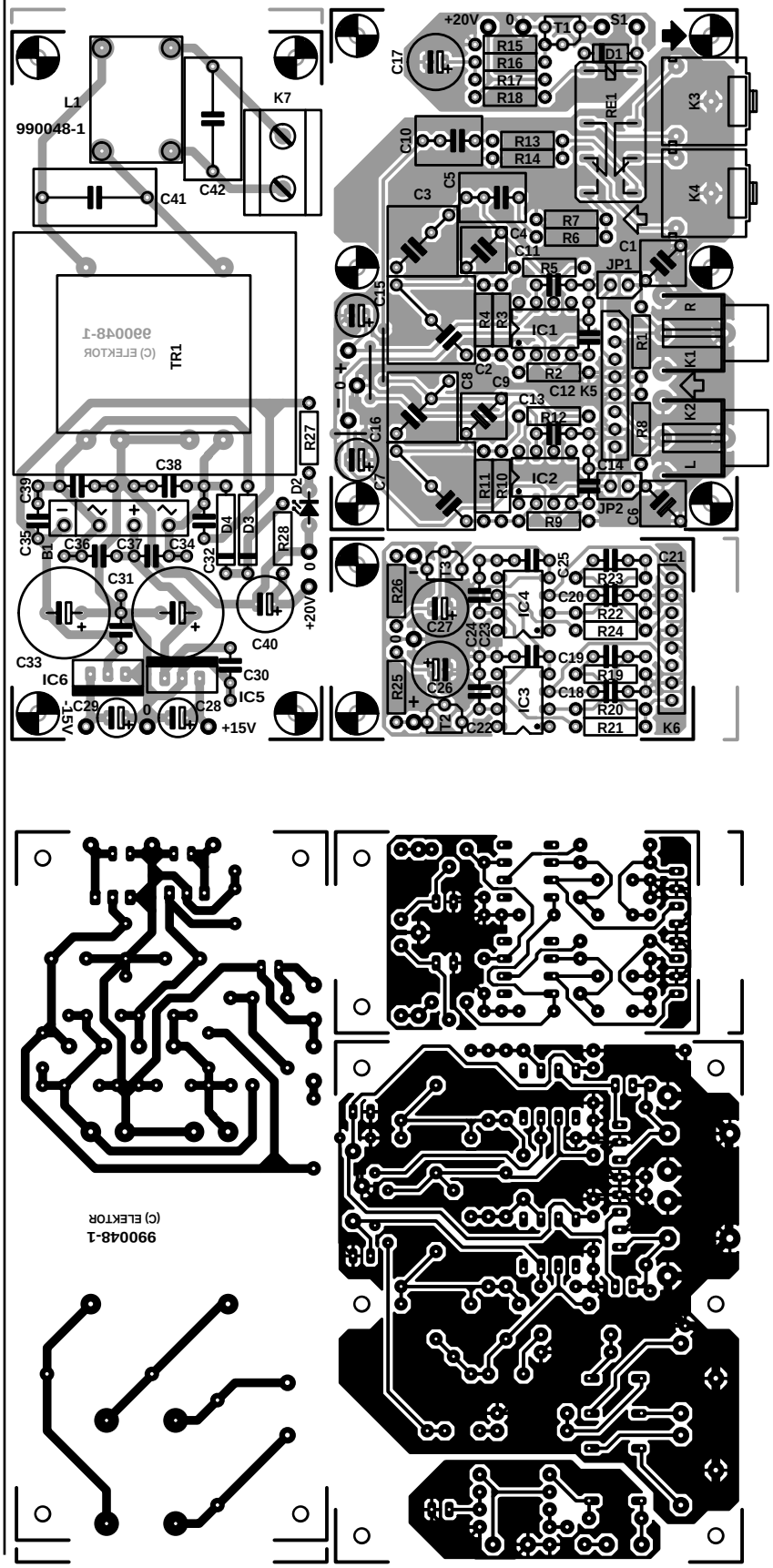

Parts list

Resistors:
R_1, R_8 = 47.5 kΩ or 100 Ω (see text)
R_2, R_9 = 51.1 Ω
R_3, R_{10} = 49.9 kΩ
R_4, R_{11} = 768 kΩ
R_5, R_{12} = 3.92 kΩ
R_6, R_{13} = 100 Ω
R_7, R_{14} = 220 kΩ
R_{15} = 3.3 kΩ
R_{16}, R_{17} = 33 kΩ
R_{18} = see text
R_{19}, R_{22} = 5.62 Ω
R_{20}, R_{23} = 47.5 Ω
R_{21}, R_{24} = 475 Ω
R_{25}, R_{26} = 1 kΩ
R_{27} = 6.8 kΩ
R_{28} = 10 Ω

Capacitors:
C_1, C_6 = 100 pF, 63 V, 1%
C_2, C_7 = 0.068 µF, 63 V, 1%
C_3, C_8 = 0.018 µF, 63 V, 1%
C_4, C_9 = 0.0015 µF, 63 V, 1%
C_5, C_{10} = 2.2 µF, metallized polyester, pitch 5 mm or 7.5 mm
C_{11}–C_{14}, C_{30}, C_{31}, C_{36}, C_{38} = 0.1 µF
C_{15}–C_{17}, C_{26}, C_{27} = 100 µF, 25 V, radial
C_{18}, C_{20} = 0.01 µF
C_{19}, C_{21} = 0.022 µF
C_{22}–C_{25} = 0.47 µF
C_{28}, C_{29} = 4.7 µF, 63 V, radial
C_{32}, C_{35} = 470 µF, 40 V, radial
C_{34}–C_{37} = 0.022 µF, ceramic
C_{40} = 100 µF, 40 V, radial
C_{41}, C_{42} = 0.1 µF, 250 VAC, Class X_2

Inductors:
L_1 = 2×27 mH, 400 mA, 250 VAC

Semiconductors:
D_1 = 1N4148
D_2 = LED, green, high efficiency
D_3, D_4 = 1N4002
B_1 = B80C1500 (straight)
T_1 = BC547B
T_2 = BC550C
T_3 = BC560C

Integrated circuits:
IC_1, IC_2 = LT1115CN6 (Linear Technology)
IC_3, IC_4 = LT1028CN8 (Linear Technology)
IC_5 = 7815
IC_6 = 7915

Miscellaneous:
JP_1, JP_2 = 2-way pin header and jumper
K_1, K_2 = audio socket for board mounting
K_3, K_4 = 3.5 mm PCB mounting audio socket
K_5, K_6 = 8-way SIL (see text)
K_7 = 2-way terminal block for PCB mounting, pitch 7.5 mm
S_1 = single-pole, single-throw switch
Re_1 = 24 V relay, 2.2 kΩ
Tr_1 = mains transformer, 2×15 V secondary, 3.3 VA

Figure 4. The printed-circuit board for the preamplifier is intended to be cut into two or three sub-boards.

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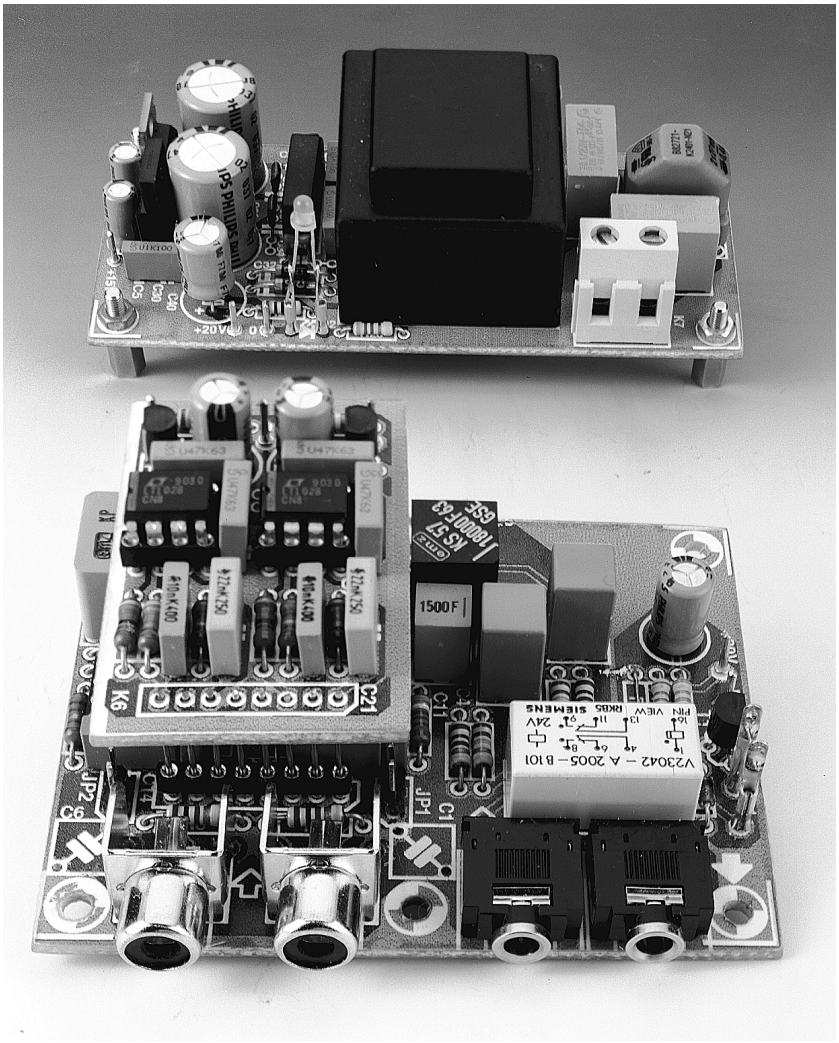
Figure 5. The completed prototype preamplifier for use with dynamic and/or moving-coil pickup elements.



Capacitors C_{18} and C_{20} suppress any r.f. radiation. Since the impedance of moving-coil pickup elements is very low, the values of C_1 and C_6 are too low, which results in too wide a bandwidth. This is, therefore, narrowed by capacitors C_{19} and C_{21}.

Any interference on the supply lines to IC_3 and IC_4 is additionally decoupled by gyrators T_2 and T_3.

Regulators IC_5 and IC_6 provide stabilized ±15 V lines from a traditional power supply. The 20 V supply for the relay is separately rectified and smoothed. Resistor R_{28} provides some filtering of the line.

Note that, because of the small signal voltages, the supply contains rather more r.f. decoupling than usual. Since the mains voltage in the vicinity of a personal computer often is not too 'clean', mains filter L_1-C_{42} is provided at the primary of mains transformer Tr_1.

Diode D_2 is the obligatory on/off indicator.

CONSTRUCTION

The preamplifier is best built on the printed-circuit board shown in **Figure 4**. The board consists of three sections, which may be cut apart. This is highly advisable as far as the power supply is concerned, since, in view of stray fields around the mains transformers, this is best kept as far away as possible from the amplifier section(s).

Construction should present no problems provided it is done with constant and careful reference to the circuit diagram and the parts list. There are, nevertheless, a few points that need special mention.

The output of the pickup element is linked to the preamplifier via audio terminals K1 and K_2. For best, long-life performance, use gold-plated types.

The line input and output terminals, K_3 and K_4, are standard 3 mm audio sockets.

Note that a 24 V relay has been used, since this draws a smaller current than a 12 V type, which means that the (adverse) effect on the preamplifier of the ripple superimposed on this current is smaller.

The relay needs an energizing voltage of not less than 18 V, so that the 20 V provided in the present design is more than adequate. If a relay other than that specified is used, it may be possible to lower the current drawn by it by altering the value of R_{18}. Note that this resistor is not needed when the specified relay is used.

Table 1.
To lower the gain to 30 dB, alter the values of the following components as indicated.

R_2, R_9	=	162 Ω
R_3, R_{10}	=	49.9 kΩ
R_4, R_{11}	=	845 kΩ
R_5, R_{12}	=	3.83 kΩ
C_3, C_8	=	0.02 µF
C_4, C_9	=	0.0012 µF

Table 1 shows the values of which components need to be altered if the line input of the sound card in the computer needs a lower level.

The board for the moving-coil type pickup element is linked to the main amplifier board via an 8-way single-in-line (SIL) connector, K_5, which is in essence a half IC socket. This, as well as the corresponding connector K_6, may also consist of an 8-way terminal strip. The two connectors or strips are linked by eight 15 mm lengths of 0.8 mm dia. insulated circuit wire. See the photograph in **Figure 5**.

To avoid any interference between the signal lines and the supply lines of the moving-coil board, the latter do not enter via K_6, but via three additional solder pins at the back of the board.

As mentioned earlier, the interior of a personal computer, and the space immediately surrounding it, are not exactly free of interference. It is, therefore, highly advisable to house the preamplifier in a well-screened metal enclosure.

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