part 1

# tap preamp

**In a previous issue (elektor no. 2), in the article entitled 'Sonant', a new design of audio preamplifier and control unit was discussed, which would complement the power amplifier/loudspeaker combination of the Sonant. This article describes the design and construction of such a 'Pre-sonant', which combines high performance with simplicity of operation.**

Elektor readers will by now be familiar with the TAP or Touch Activated Programmer. For reliability and ease of operation all the preamplifier functions are controlled by TAP's and mechanical switches and potentiometers are eliminated. This necessarily leads to some simplification of control functions, as such things as volume and tone control can now be implemented only in discrete steps. This is perhaps no bad thing, as the front panels of some modern amplifiers look like something from 'Star Trek' and one wonders if a training course is necessary to operate them. This design is, therefore, not suitable for the dedicated knob twiddler!

Assuming that the recording engineer has done his job properly, many control functions may be removed from the front panel of the preamp and may be replaced by internal presets. This applies to balance and tone controls, which may be adjusted to suit room acoustics and personal taste, after which no further adjustment should be necessary. The number of control functions was thus reduced to the following:

| | |
|---|---|
| Input Selection: | Disc, Radio, Tape, Auxiliary. |
| Volume: | Four preset levels. |
| Image Width: | Four settings from mono to 'extreme stereo'. |
| Tone: | Bass lift, 'Presence', Flat, Treble cut. |

It is hoped in a later article to include a touch station selector for radio. The layout of the touch panels is shown in figure 1. These are available from the Elektor Print Service.

## Four Position TAP

All the controls mentioned above are based on the four-position TAP shown in figure 2, which is designed around an RCA COSMOS IC type CD4011AE, a quad two-input NAND gate. The circuit operates as follows:

When the circuit is first switched on the output of one of the gates will set to '1' and all the others are held at '0' since a '1' is applied to their inputs via the input

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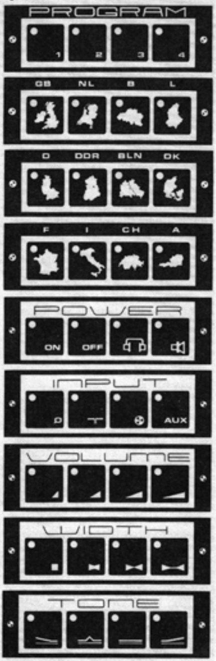


**Figure 1. Touch panels for the TAP's. The contact surfaces and legends are nickel plated with a black background.**

**Figure 2. The circuit of the four-position TAP. Touching one of the input contacts causes the corresponding output to become '1' and all other outputs to become '0'.**

**Figure 3. Circuit to show the principle of an electronic 'make' contact. The LED indicates that the contact is 'closed'.**

**Figure 4. Extension of the circuit of figure 3 to control two channels.**

**Figure 5. The make contact applied to a four-preset-level volume control. The values of $R_{15}$-$R_{22}$ determine the four preset volume levels.**

**Figure 6. The electronic 'break' contact. When a '1' appears at input $Q_x$ $T_1$ and $T_2$ are cut off and the LED lights to show that the contact is 'open'.**

resistors connected to $+V_b$ and via the diodes from the output of the gate whose output is '1'. Which output sets to '1' on initial switch on is determined by the switching speed of the individual gates and the various resistor tolerances.

Suppose now that input 1 is touched. Pin 1 of gate $N_1$ is now held at '0' by the skin resistance, the output therefore becomes '1'. This '1' is applied to the inputs of the other three gates via $D_4$, $D_7$ and $D_{10}$ respectively. Since the other input of each of these gates is already at '1' via the input resistors $R_4$, $R_5$, $R_7$, $R_8$, $R_{10}$ and $R_{11}$ the output of $N_2$-$N_4$ becomes '0'. The logic level on the anodes of $D_1$, $D_2$ and $D_3$ becomes '0' and pin 2 of $N_1$ is held at '0' by $R_3$. Thus when input 1 is released the output of $N_1$ remains at '1'. This explanation applies for all the other inputs. Only one output can be a '1' at any time.

The TAP is used to control two types of electronic switch, a make contact, as shown in figure 3 and a break contact as shown in figure 6. When a '1' is applied to the $Q_x$ input in figure 3, $T_1$ is turned on. Current flows through the LED and resistor into the base of $T_2$, which is also turned on. The LED lights to indicate that this switch position is activated. The modifications necessary to switch two channels are shown in figure 4. $T_1$ is now used to switch two transistors and the base resistors are doubled in value (within the limits of preferred resistor values) to keep the LED current the same.

## The Break Contact

The circuit of figure 6 operates in an inverse manner to that of figure 4. When the $Q_x$ input is at '0' $T_1$ is turned off. However, $T_2$ and $T_3$ are turned on by current flowing into their bases via the LED, $R_2$, $R_3$ and $R_4$. The 'contact' is thus normally 'closed'. When a '1' is applied to the $Q_x$ input $T_1$ is turned on thus grounding the bases of $T_2$ and $T_3$ and turning them off. Current flows through the LED via $R_2$ and $T_1$ so that it lights.

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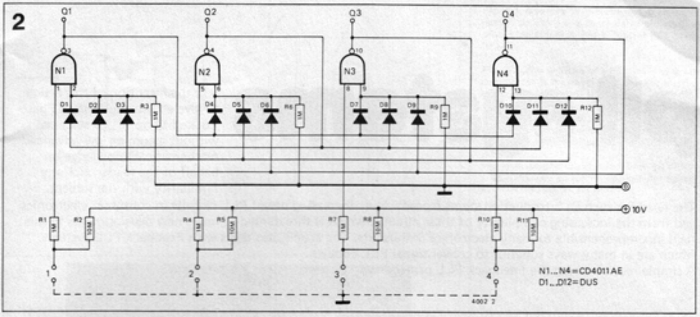


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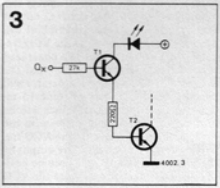


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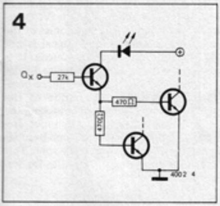


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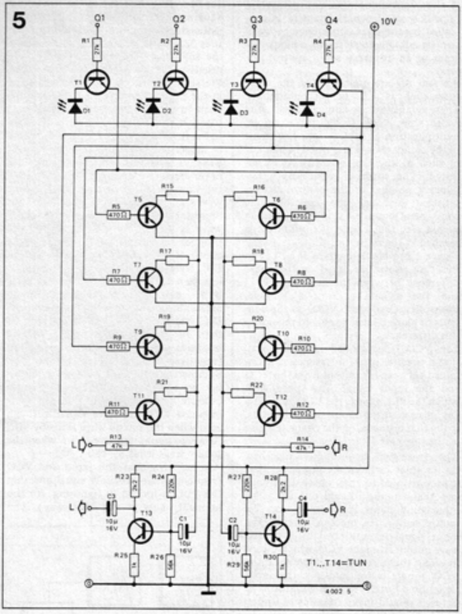


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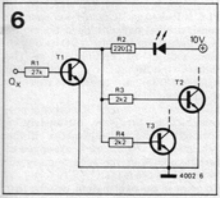



As an example of the use of the make contact a four-setting volume control is shown in figure 5. For the left channel $R_{13}$ and $R_{15}$-$R_{21}$ comprise a potentiometer, likewise $R_{14}$ and $R_{16}$-$R_{22}$ for the right channel. When one of the inputs $Q_1$-$Q_4$ is high then the corresponding transistors $T_5/T_6$-$T_{11}/T_{12}$ are turned on, grounding one end of the corresponding collector resistor $R_{15}/R_{16}$-$R_{21}/R_{22}$. The attenuation depends on the value of the resistor that is grounded and may be varied to suit personal taste. After attenuation the signal is fed into the base of $T_{13}$ ($T_{14}$) and the output is taken from the collector. This and the other control circuits will be discussed in greater detail in next month's article.

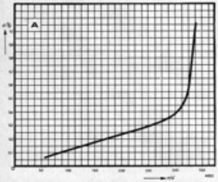
**part 2**

# tap preamp

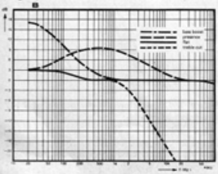
The first part of this article discussed an audio pre-amplifier and control unit operated entirely by TAP's and dealt with the design of the TAP and the electronic switching controlled by the TAP. This month's article deals with the application of these circuits to a complete touch-controlled preamp with the facilities already described.

## measurement results

Input impedance: 60 ... 160 kΩ, depending on
Input sensitivity: 70 ... 170 mV (adjustable)
Output impedance: 1kΩ or up to 4k7, depending on
Maximum output level: 180 mV (or up to 850 mV)
S/N ratio: better than 60 dB
Input selector: suppression of unwanted inputs: better than 60 dB
Crosstalk: adjustable;
in stereo position: −40 ... −50 dB, 100 Hz ... 10 kHz
Current consumption: approx. 200 mA (10 V)
Distortion, as a function of the output voltage from the input selector stage: see graph A




Tone control characteristics: see graph B



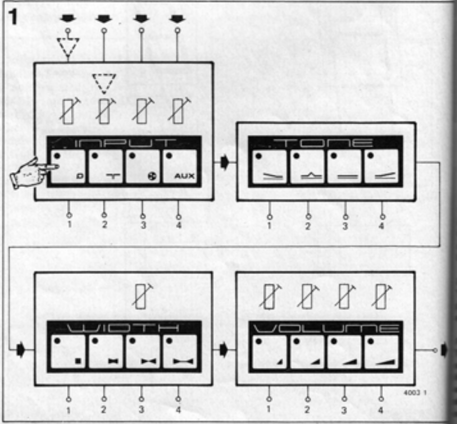

A block diagram of the preamp and control unit is given in figure 1. The input selector, with inputs for four signal sources, is followed by a tone control that provides bass lift, presence (middle lift), treble cut, or a flat response. (It should be noted that the touch control panel shows a symbol which could be interpreted as 'treble lift' in the fourth position.) The signal is then fed into a circuit that controls the image width from mono to 'enhanced stereo' by introducing crosstalk between the channels. The signal is fed finally to a volume control that provides four preset gains.

The disc input must be preceded by a suitable RIAA-equalised preamplifier, which may be mounted in the control unit, but preferably in the record deck as this will give better hum figures and (provided the disc preamp has a low output impedance) the frequency response will be unaffected by cable capacitance.

The TAP, which controls all the functions, is shown in figure 2. Its operation was described in detail in last month's article, but basically, touching any one of the inputs causes the corresponding Q output to become '1' and all the other outputs to become '0'. Only one Q output can be '1' at any time. The Q outputs of the TAP are connected to the corresponding Q inputs of the input selector, tone, width and volume controls.

### The Input Selector

The input selector of figure 3 makes use of the electronic 'break contact' de



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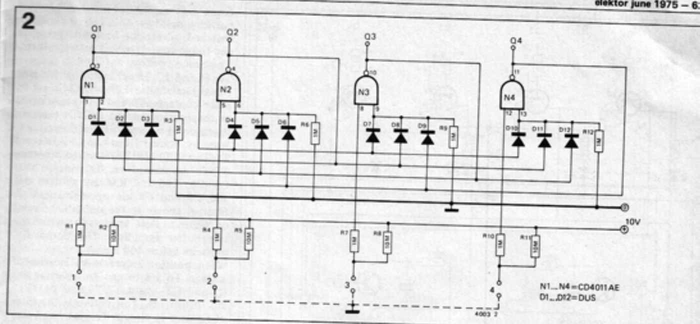


scribed in last month's article to short out the unwanted signals. When one of the inputs 1-4 is selected the corresponding transistor (T1-T4) is turned on. The corresponding pair of transistors for left- and right-hand channels (T5/T6-T11/T12) are turned off so that the desired signal can reach the base of T15 and T16. All the other pairs of transistors are turned on and short the unwanted signals to ground.

The presets on each input allow adjustment of input sensitivity and channel balance to correct channel imbalance in the signal sources. The channel balance of the preamplifier itself may be adjusted by presets in the volume control stage.

## The Tone Control

The tone control circuit is shown in

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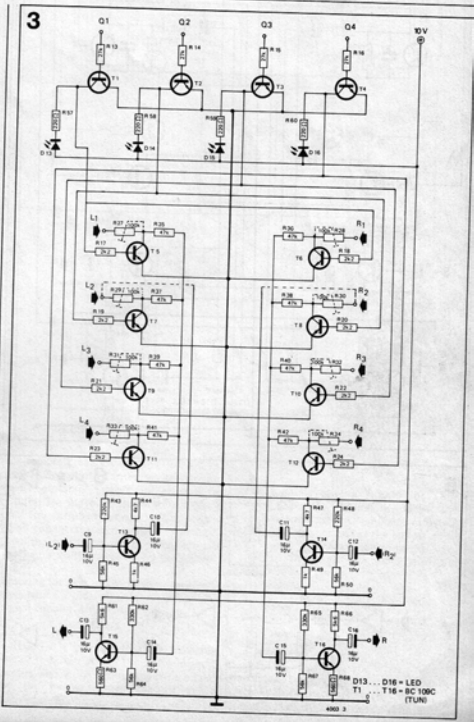


**Figure 1. Block diagram of the complete touch-controlled preamplifier consisting of input selector, tone, stereo image width and volume controls. The four units each have a nominal gain of one, so any unit or units may be omitted without affecting the sensitivity.**

**Figure 2. Circuit of the four-position TAP. Touching one of the inputs causes the appropriate output to become '1'. The Q outputs are used to control the preamplifier functions.**

**Figure 3. Circuit of the input selector. T13 and T14 provide additional amplification for low-output tuners and can be dispensed with if not required. Presets R27-R34 are used to adjust for the same nominal output for all signal sources. For high-level inputs the value of these presets can be increased to 1 MΩ.**

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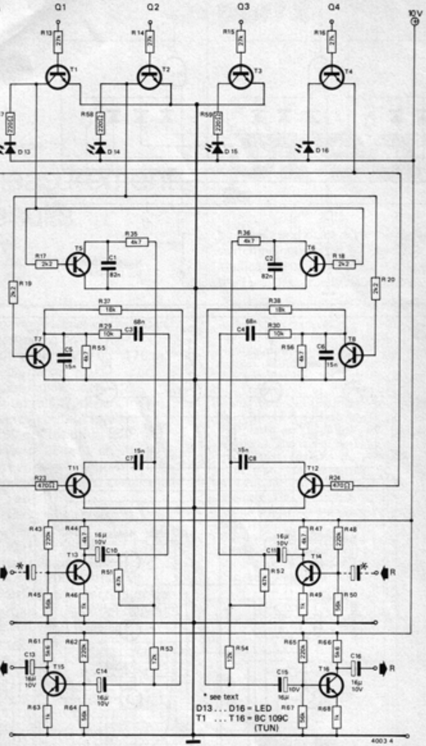


figure 4. It consists of input and output buffer amplifiers T13-T16 with three switched filters for bass lift, presence and treble cut interposed between them. The circuit operates as follows:

T5/T6 and T7/T8 act as normally closed (break) contacts. T11 and T12 act as make contacts. T9 and T10 are omitted as they correspond to the flat position (position 3) where no filter is in circuit. When position 1 (bass boost) is selected T5/T6 and T11/T12 are turned off while T7/T8 are turned on. This means that C5, C6, R55 and R56 are shorted out and C7 and C8 are open-circuited. A filter as shown in the simplified circuit of figure 5 thus appears between the two buffer amplifiers. This boosts frequencies below 400 Hz.

When position 2 (presence) is selected T5 and T6 are turned on, shorting out C1 and C2, whilst T7/T8 and T11/T12 are turned off. This connects the filter of figure 6 in circuit. This is a band-pass filter, which boosts the signal over the range 200 Hz to 4 kHz, with a maximum mid-band boost of about 10 dB. Position 3 is the flat position with T5/T6 and T7/T8 turned on and T11/T12 turned off. The circuit of figure 7 therefore results, which is of course simply an attenuator with no frequency-dependent characteristics. In position 4 (treble cut) all the transistors T5-T12 are turned on and the circuit of figure 8 results. At frequencies away from those at which the filters have their effect the nominal gain is one in all positions. This ensures that switching from one filter position to another does not result in large changes in volume.

## Stereo Image Width Control

This control alters the separation between channels by introducing crosstalk from one channel into the other. The image width may be varied from a mono signal, where each output channel contains an equal proportion of left and right inputs, to 'enhanced stereo', where crosstalk is introduced in antiphase to increase the image width beyond that of normal stereo. The circuit (shown in figure 9) operates in the following manner:

T13 and T14 function as a difference amplifier. That is to say that the signal

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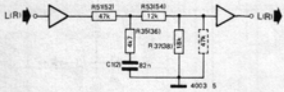


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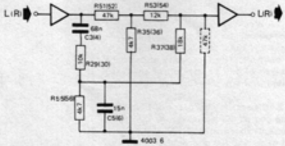


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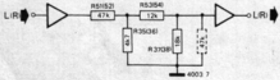


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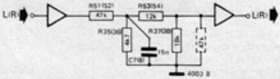

appearing across their collectors is proportional to the difference between the left and right input signals to their bases. If, for example, the right input is grounded and the left input is fed with a signal then the signal on the collector of T14 is proportional to the left input and 180° out of phase with the signal on the collector of T13. The same argument holds true if the left input is grounded. When both inputs are driven the outputs at the collector of T13 and T14 consist of left channel with a proportion of antiphase right channel and right channel with a proportion of antiphase left channel. That is to say, the crosstalk appearing in the signal at the collector of T13 is 180° out of phase with the right channel signal appearing at the collector of T14 and vice versa.

In-phase crosstalk may be introduced into these signals by mixing with the opposite channel at the base of T15 and T16 respectively. When no in-phase crosstalk is introduced the signals appearing at the collectors of T15 and T16 consist of the original signal plus the antiphase crosstalk and the image width is increased. When the proportion of in-phase crosstalk is the same as the proportion of antiphase crosstalk the two cancel and only the original signal remains. This is normal stereo. When the in-phase crosstalk exceeds the antiphase crosstalk the net result is a proportion of in-phase crosstalk and the stereo image width is reduced; finally, when the crosstalk equals the signal a mono output results.

When position 1 (mono) is selected transistors T7-T12 are cut off. This means that crosstalk from the collector of T14 is fed into the base of T15 together with the left channel signal from the collector of T13 and vice versa. When position 2 (reduced width stereo) is selected T9 and T10 are turned on, grounding R37 and R38 respectively. R51, R37 and R52, R38 thus form attenuators that reduce the amount of in-phase crosstalk. The same applies to position 3 (normal stereo) when T9 and T10 are turned on, but R39 and R40 are chosen so that the in-phase crosstalk equals the antiphase crosstalk and the two cancel. R39 and R40 may be replaced by presets so that the circuit can be trimmed to cancel the crosstalk exactly. In position 4 T11 and T12 are both turned on and the in-phase crosstalk signals are shorted to ground leaving only the original signals plus the antiphase crosstalk. This results in an enhanced stereo image width.

Looking at the operation of the circuit mathematically we can derive the following:

ignoring the gain of the difference amplifier, which affects all components of the signal equally, we can say that

$$L_c = -L + k_1 R$$

where $L_c$ is the signal at the collector of T13, L and R are the left and right inputs and $k_1$ is a constant determined by the parameters of the difference amplifier. Similarly

$$R_c = -R + k_1 L$$

The minus signs are due to the 180° phase change in T13 and T14 respectively. After mixing with in-phase crosstalk the signals appearing at the collectors of T15 and T16 (again ignoring the gain, which affects all components of the signal equally) are

$$L_o = -L_c - k_2 R_c,$$

and

$$R_o = -R_c - k_2 L_c$$

where $k_2$ is a constant whose value is selected by switching in the different attenuators that introduce varying proportions of in-phase crosstalk.

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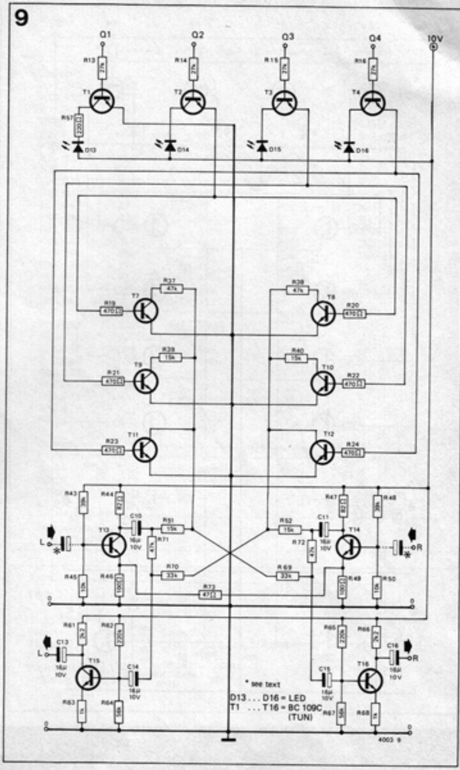

**Figure 4. The tone control unit. The four positions give bass boost, middle lift (presence), flat response and treble cut respectively.**

**Figures 5-8. Simplified equivalent circuits of the tone control in the four positions mentioned.**

**Figure 9. Circuit of the stereo image width control. This has four positions from mono to enhanced stereo with different amounts of crosstalk introduced between the channels to vary the separation.**

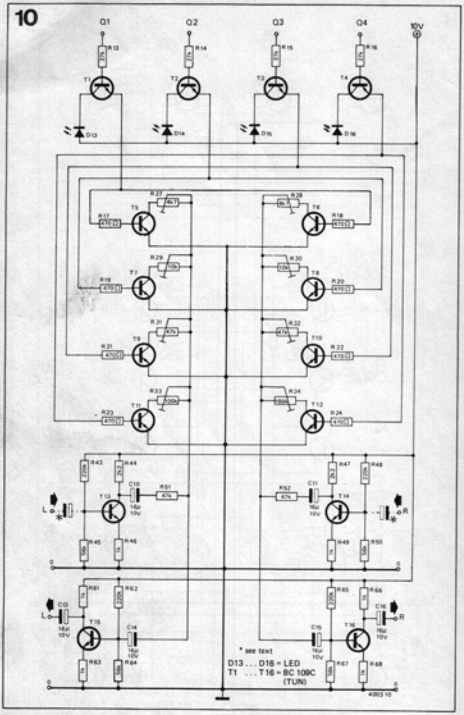


**Figure 10. The four-level volume control, which may be preset to the desired listening levels and may be used to adjust channel balance.**

**Figure 11. Pattern of the universal p.c. board used for each of the four units of the preamplifier.**

Therefore

$$L_o = L - k_1 R + k_2 R - k_1 k_2 L$$
$$= L(1 - k_1 k_2) + (k_2 - k_1)R$$

$k_1$ was chosen subjectively and it was found that a value of 6 dB (× ½) of antiphase crosstalk gave the best results. This immediately gives some of the values for $k_2$.

For a mono signal the proportions of L and R in the output must be equal i.e.

$$1 - k_1 k_2 = k_2 - k_1$$

which means that $k_2 = 1$.

For a normal stereo signal the crosstalk must be zero i.e.

$$k_2 - k_1 = 0$$

which means that $k_2 = ½$.

For enhanced stereo there must be only antiphase crosstalk i.e.

$$k_2 = 0.$$

The value of $k_2$ for a reduced width stereo signal (position 2) is purely a mat-

ter of personal taste depending on the image width required and may be adjusted by changing R39 and R40 in figure 9.

## Volume Control

This was discussed briefly in last month's article and the complete circuit is given in figure 10. Selecting one of the positions turns on the corresponding pair of transistors T5/T6-T11/T12, grounding the potentiometers connected to each collector. These form attenuators with R51 and R52 which control the levels of the signals fed into the bases of T15 and T16 respectively. The degree of attenuation produced in each position may be altered by the potentiometers to suit personal taste and to adjust the channel balance.

## Construction and Adjustment

The four units described are each constructed on a universal printed circuit board, the pattern for which is given in figure 11. The component layouts for the different units are detailed in figures 12-15 and the parts lists are given in the tables 1 and 2. The components common to every board are given in table 1 and those particular to one unit are given in table 2. The capacitors marked * in figures 4, 9, and 10 may be omitted if all 4 boards are used together but should be included if any board is used on its own.

Setting up of the units is a simple matter. The input potentiometers of the input selector stage are adjusted so that the output of this stage is about 100 mV when fed with the nominal signal level of each source. Thus, if the system is to be used with a tuner of nominally 100 mV output the tuner input should be adjusted with 100 mV input signal from an oscillator. If no test equipment is available the circuit may be adjusted using the actual signal sources (disc, radio, tape etc.) and listening on headphones each input potentiometer may be adjusted to give approximately the same volume level. Balance between channels should also be adjusted to compensate for im-

**Table 1**

| | Figures 3, 12 | Figures 4, 13 | Figures 9, 14 | Figures 10, 15 |
|---|---|---|---|---|
| Resistors: | | | | |
| R17,R18 | 2k2 | 2k2 | X | 470Ω |
| R19,R20 | 2k2 | 2k2 | 470Ω | 470Ω |
| R21,R22 | 2k2 | X | 470Ω | 470Ω |
| R23,R24 | 2k2 | 470Ω | 470Ω | 470Ω |
| R27,R28 | 100 k preset | X | X | 4k7 preset |
| R29,R30 | 100 k preset | 10k | X | 10k preset |
| R31,R32 | 100 k preset | X | X | 47k preset |
| R33,R34 | 100 k preset | X | X | 100k preset |
| R35,R36 | 47k | 4k7 | X | X |
| R37,R38 | 47k | 18k | 47k | X |
| R39,R40 | 47k | X | 15k | X |
| R41,R42 | 47k | X (C7,8) | — | X |
| R43,R48 | 220k | 220k | 39k | 220k |
| R44,R47 | 4k7 | 4k7 | 82Ω | 2k2 |
| R45,R50 | 56k | 56k | 10k | 56k |
| R46,R49 | 1k | 1k | 100Ω | 1k |
| R51,R52 | X | 47k | 15k | 47k |
| R53,R54 | — | 12k | X | — |
| R55,R56 | X | 4k7 | X | X |
| R57 | 220Ω | 220Ω | 220Ω | — |
| R58,R59 | 220Ω | 220Ω | — | — |
| R60 | 220Ω | — | — | — |
| R61,R66 | 5k6 | 5k6 | 2k2 | 1k |
| R62,R65 | 330k | 220k | 220k | 220k |
| R63,R68 | 560Ω | 1k | 1k | 1k |
| R64,R67 | 56k | 56k | 56k | 56k |
| R69,R70 | X | X | 33k | X |
| R71,R72 | X | X | 47k | X |
| R73 | X | X | 47Ω | X |
| Capacitors: | | | | |
| C1,C2 | X | 82n | X | X |
| C3,C4 | X | 68n | X | X |
| C5,C6 | X | 15n | X | X |
| C7,C8 | (R41,R42) | 15n | — | (R41,R42) |
| C9,C12 | 16µ/10 V | — | — | — |

(X = omitted; — = wire link)

**Table 2**

| Resistors: | Capacitors: | Semiconductors: |
|---|---|---|
| R1,R4,R7,R10 = 1 M | C10,C11,C13,C14,C15,C16 = 16µ/10 ... 16 volt | D1 ... D12 = DUS |
| R2,R5,R8,R11 = 10 M | | D13 ... D16 = LED |
| R3,R6,R9,R12 = 1 M | | T1 ... T16 = BC109C or equ. |
| R13,R14,R15,R16 = 27k | | IC1 = CD4011AE |

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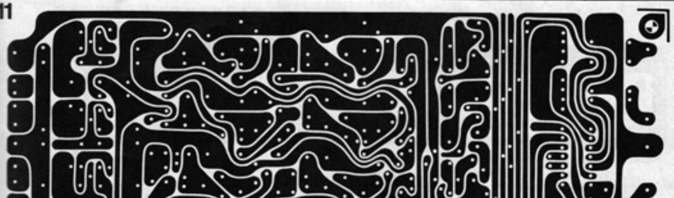

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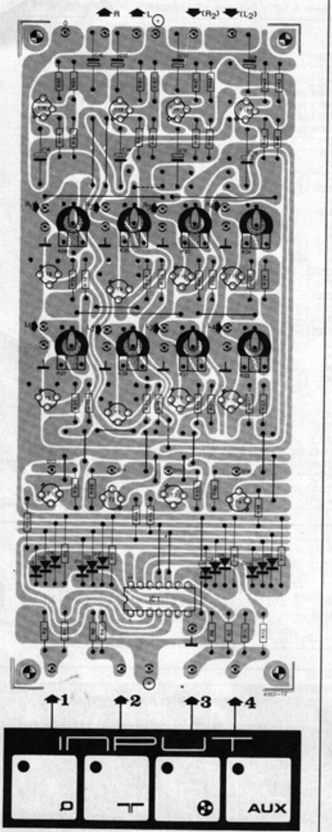


Figure 12. Component layout for the input selector (figure 3).

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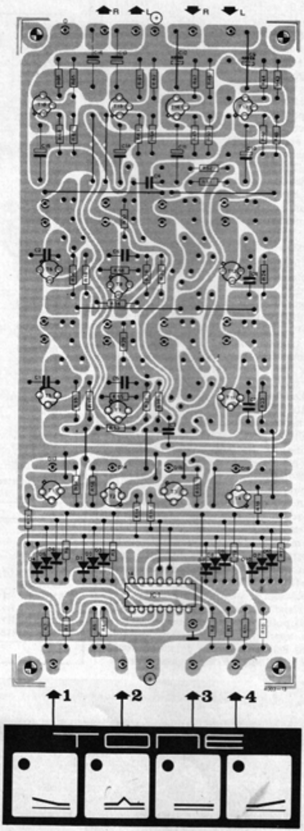


Figure 13. Component layout for the tone control stage (figure 4).

balance in the signal sources. The volume control settings are next adjusted to give the desired listening levels. Channel balance may also be adjusted to compensate for any imbalance in the preamplifier itself or in the power amplifier and loudspeakers. The unit is now ready for use.

The output level is 200 mV; if this is insufficient for full drive of the power amplifier, R61 and R66 (figures 10 and 15) can be increased to 4k7. The output level then becomes 1000 mV.

## Conclusion

All the units in the touch-controlled preamplifier have a nominal gain of unity and so may be used in any combination without affecting the performance, or they may be used in conjunction with other equipment. It is

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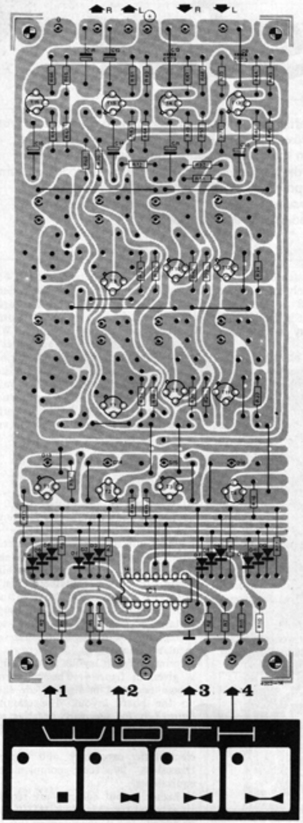


**Figure 14. Component layout for the stereo width control (figure 9).**

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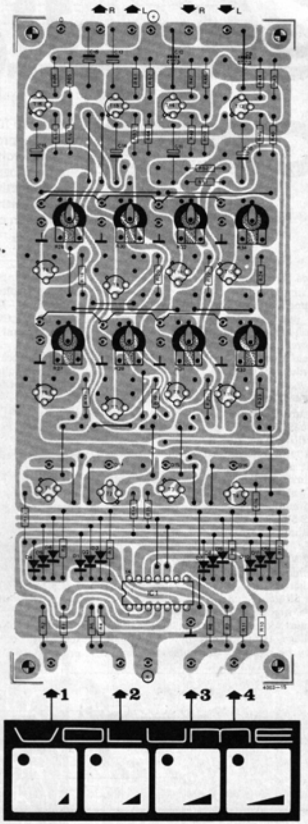


**Figure 15. Component layout for the volume control (figure 10).**

hoped in a later article to publish details of a touch station selector for radio and other additions to the system.

## Design Modification

A small modification has been made to the portions of the circuit using the 'break contact'. Referring to figure 6 of last month's article, when T1 is turned off there is still a residual current of about 6 mA flowing through the LED via R3, R4 and the base-emitter junctions of T3 and T4. With certain types of LED, notably those with a clear plastic encapsulation, this may give rise to a noticeable glow. This can be eliminated by connecting a 220 Ω resistor across the LED. Current will flow through this resistor but the voltage drop across it will be less than the turn-on voltage of the LED. This modification applies to the following: figure 3, D13-D16; figure 4, D13 and D14.