When the **Enigma-E** is tranmitting, the PIC will produce negative pulses which will cause **T5** to open, raising the voltage at **TWP22**. For this, it uses -via **R7**- the charge stored in **C29**.

For the technically minded: the serial port operates at a speed of 9600 baud, the data protocol is 8N1 (8-bits, no parity and 1 stop-bit) and no handshaking is used. If you want to use the serial port, an optional 9-pin sub-D female socket should be connected to terminals **TWP22**, **TWP23** and **TWP24**. Alternatively you may use these terminals to connect a buzzer, so that the encrypted text is converted into morse code as you type. For this you need an extra buzzer (not supplied in the kit). Additional information can be found in the paragraph 2.7 *Wiring Diagram*, 3.9 *Using morse code* and 3.10 *Using the Serial Port*.

4.4 Buzzer

T6 drives the buzzer, which is used to 'simulate' the key-click sound of the Enigma. The buzzer contains some internal electronics that produces the sound. Of course, the buzzer is far too small to generate the real key-clunck as can be experienced on a real Enigma, but by rapidly turning the buzzer on and off, we've tried to implement some kind of key-click. The buzzer may be turned *off* completely by placing jumper ① on header J1.

4.5 Steckerbrett

The Stecker board can be explained best as a matrix. HEF4094 ICs are used to convert a serial signal from the PIC into a series of outputs. A HEF4021 is used to do the opposite: it converts inputs into a serial signal that can be read by the PIC. The software inside the PIC plays a crucial role here. Pins 12, 23 and 24 of the PIC carry the signals to drive the HEF4094s. The PIC will now drive the HEF4094s in such a way, that only a single output will be active at any one time. All other outputs of the four ICs will stay low. Next, the PIC reads, via pin 23, 13 and 7, the inputs of the HEF4021 ICs, one by one.

If only a single match is found, the letter is not 'Steckered'. However, if another match is found, the letter is assumed to be swapped with the letter corresponding to that input. In its memory, the PIC builds a table of all known connections. This technique is called 'scanning' and has the advantage that only single wires are needed to create the patch cables. Scanning the Steckerbrett is done in the background and is so fast, that any changes are spotted by the software instantly.

The Steckerbrett is a separate part of the PCB and can be removed. Without the Steckerbrett, the **Enigma-E** can be used as normal. However, the extra permutations introduced by the Steckerbrett will be lost, and you won't be able to use the jumpers.

4.6 Displays

The **Enigma-E** caries four large alpha-numerical LED displays. These displays replace the mechanical wheels (Walze) of a real Enigma. **IC1** and **IC2** are two HEF4094s. Each output of these ICs is connected to a single segment of these displays. The PIC scans **T1**, **T2**, **T3** and **T4** and drives the LED displays one-by-one. This technique is called 'multiplexing' and it happens so fast, that the human eye can't see it.

4.7 Lamp panel

At the centre of the PCB are the 26 LEDs that simulate the 26 lamps of a real Enigma. All LEDs are connected in a matrix, just like on the Steckerbrett. Again HEF4094 ICs are used to muliplex the LEDs. Transistors **T1**, **T2**, **T3** and **T4** (also used for multiplexing the displays) allow the LEDs to be 'selected' one group at a time. The configuration LEDs (mounted left of the displays) are also driven by these transistors.

4.8 Keyboard

Like the lamp panel, the keyboard is divided into groups. The PIC drives a single HEF4094 (**IC4**), which in turn selects a group of four keys on the keyboard. The four signals **CharInt1...CharInt4** are directly read by the PIC. The up/down keys of the displays, are scanned at the same time. The input '**WheelInt**' of the PIC is used to read the state of these keys.