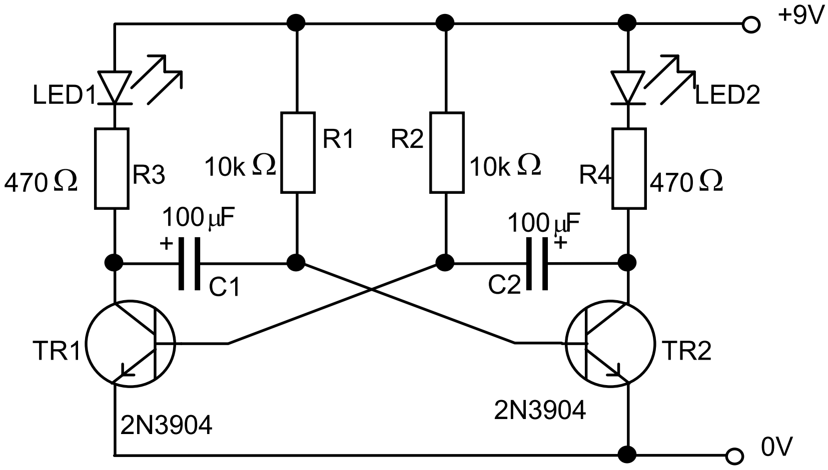
LED Flasher.

Specification
Operates from a 6 - 12V supply.
Alternately flashes two LEDs.
Flash rate adjustable by changing the capacitor values and the 10kΩ resistor values.

Circuit Diagram

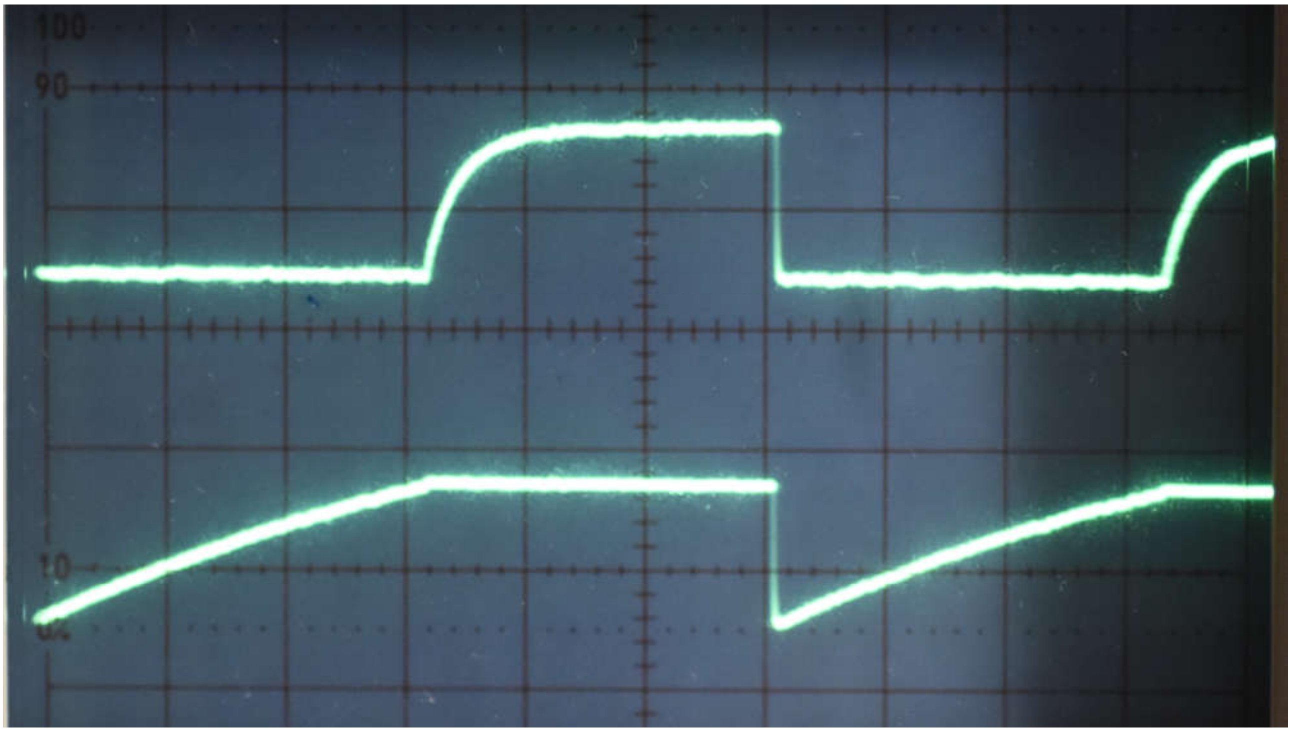


How it works
Although this looks to be a simple circuit, its operation is quite complex.
With fully matched components, the circuit does not naturally oscillate - it has two stable states - when either both transistors are switched off or both switched on.

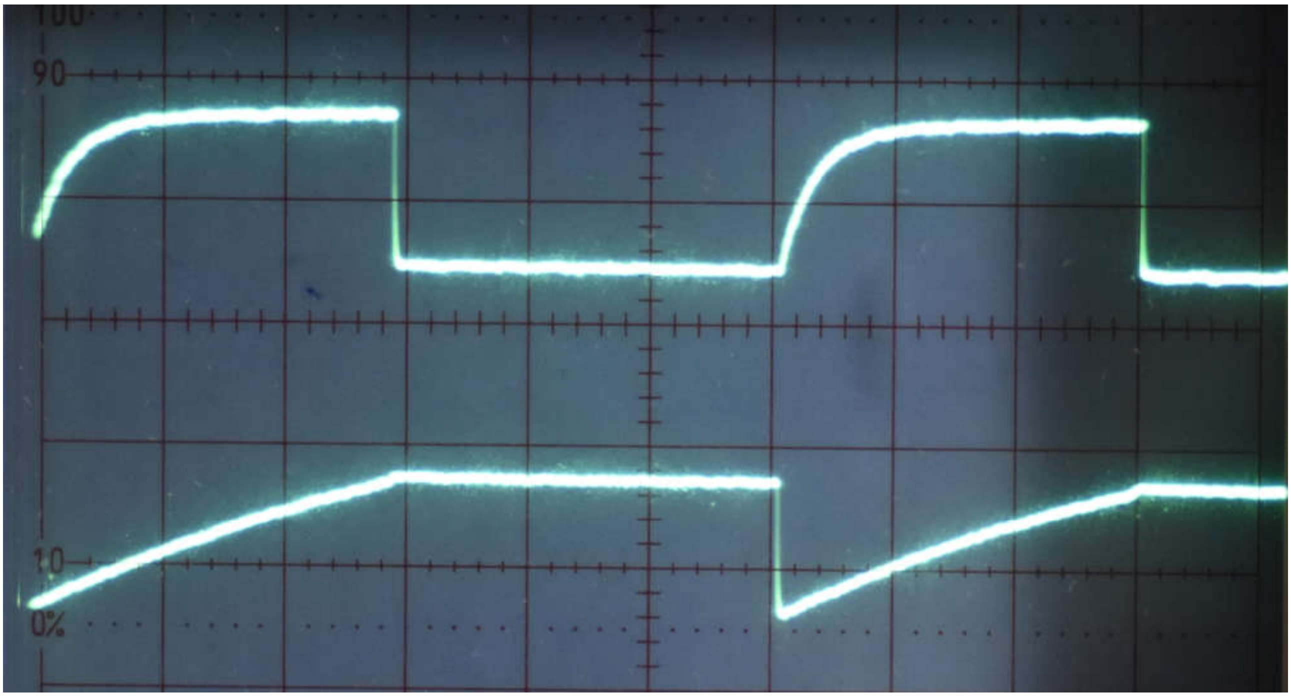
When the circuit is first switched on, one of the transistors will start to switch on before the other one since the components are not identical.

Consider TR1 switches on first. The collector voltage of TR1 will be low, capacitor C2 will be charging through the base of TR1, R4 and LED2.
In the meantime, capacitor C1 will also start to charge through TR1 and R1 and after a short time, the voltage at the base of TR2 will be sufficient to allow TR2 to start to turn on.
At this point, the voltage at the collector of TR2 starts to decrease. This decrease is transferred to the base of TR1 by the capacitor C2, making the base of TR1 negative and so switching off TR1.
When TR1 switches off, its collector voltage rises, which is transferred via the capacitor C1 to the base of TR2, switching TR2 on quickly.
The capacitor C2 now discharges via R2 until the base voltage of TR1 becomes sufficient for TR1 to start to switch on. This causesthe voltage at the collector of TR1 to decrease, which is passed through capacitor C1 to the base of TR2, so switching off TR2 and switching TR1 on fully.
C1 not discharges through R1 and the process repeats.

The pictures below are oscilloscope traces which may make the above explanation clearer.

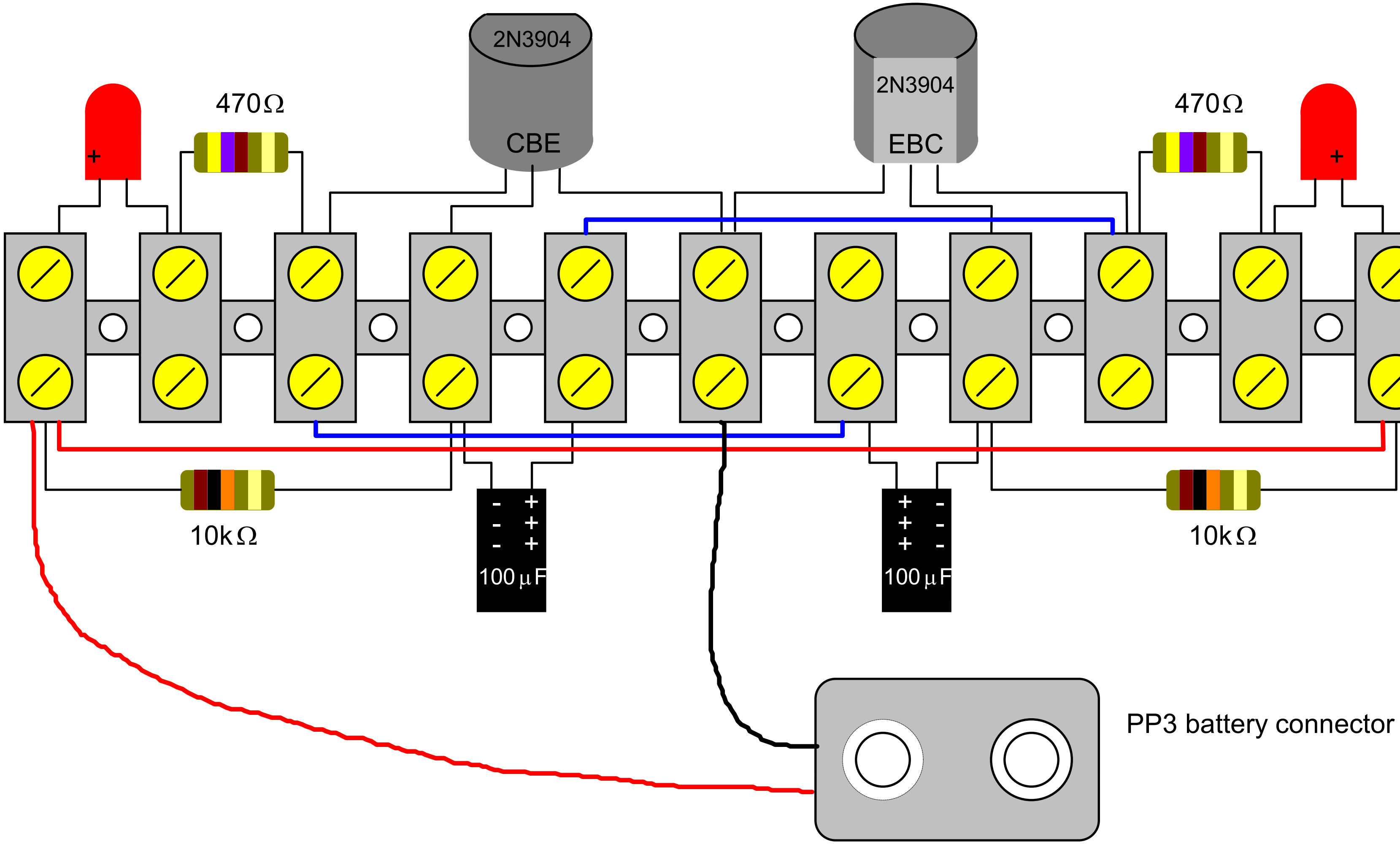


The picture above shows the collector voltage of TR1 (top) and the base voltage of TR2 (bottom). When TR1 is switched on (low voltage), the base voltage of TR2 can be seen to slowly increase from a negative value until it reaches ≈0.7V, at which time TR1 starts to switch off and the voltage becomes high.



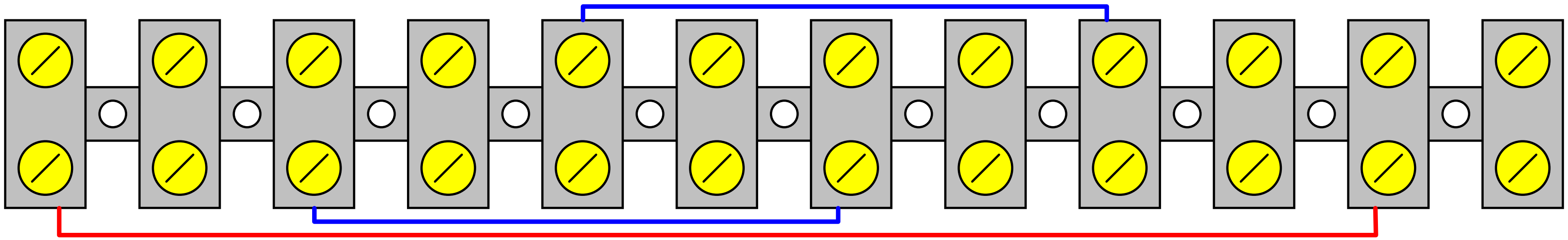
The picture above shows the collector voltage of TR1 (top) and the base voltage of TR1 (bottom). When TR1 is switched off (high voltage), the base voltage can be seen increasing slowly from a negative voltage to ≈0.7V, at which time TR1 can be seen to quickly switch on (voltage goes low).

Terminal Strip Layout

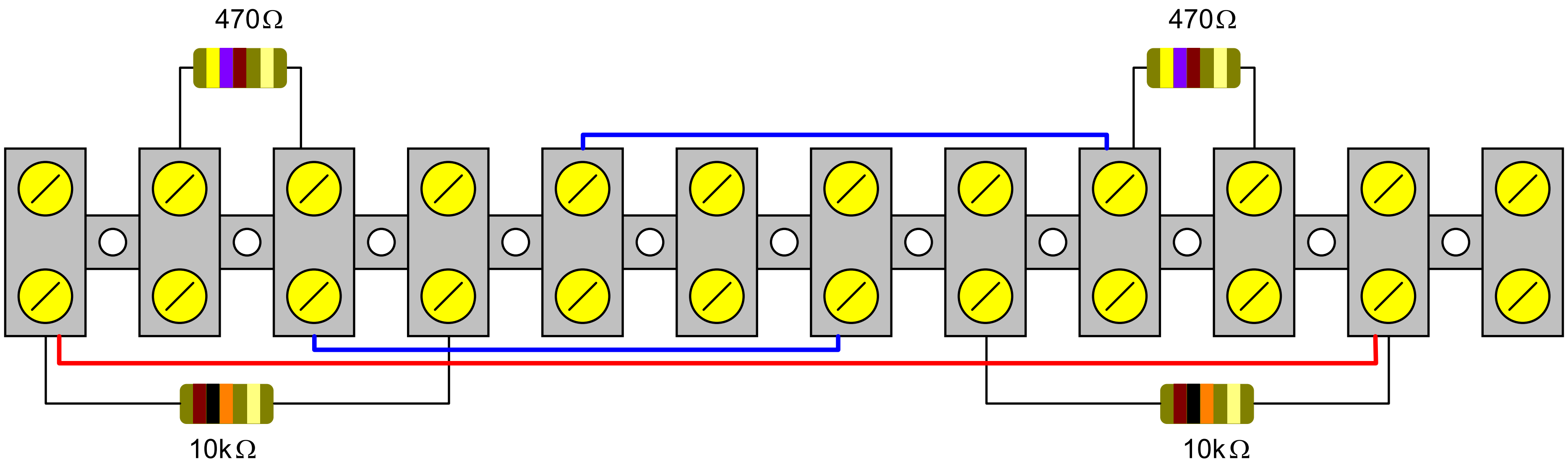


Step by step construction.

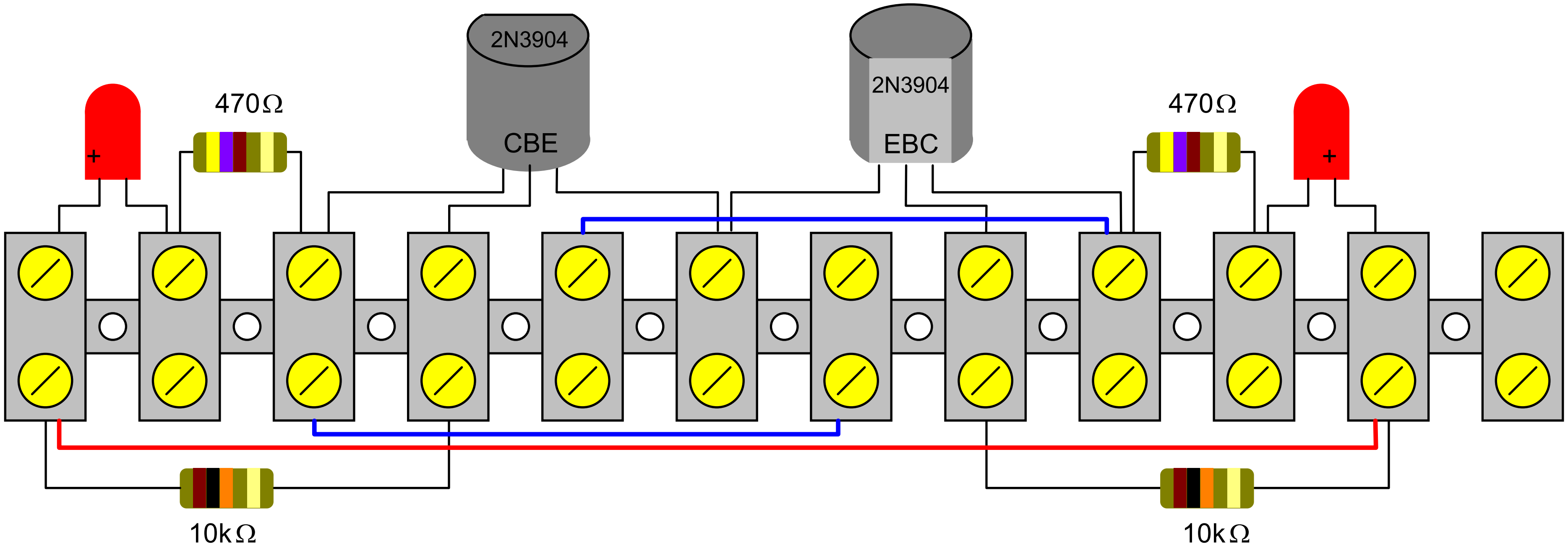
1). Cut two pieces of insulated wire approximately 5cm long and strip both ends. Bend the ends of the wires so that it will fit where the blue wires are in the diagram below. Cut a piece of insulated wire approximately 10cm long and strip both ends. Bend the ends of the wire so that it will fit where the red wire is in the diagram below.



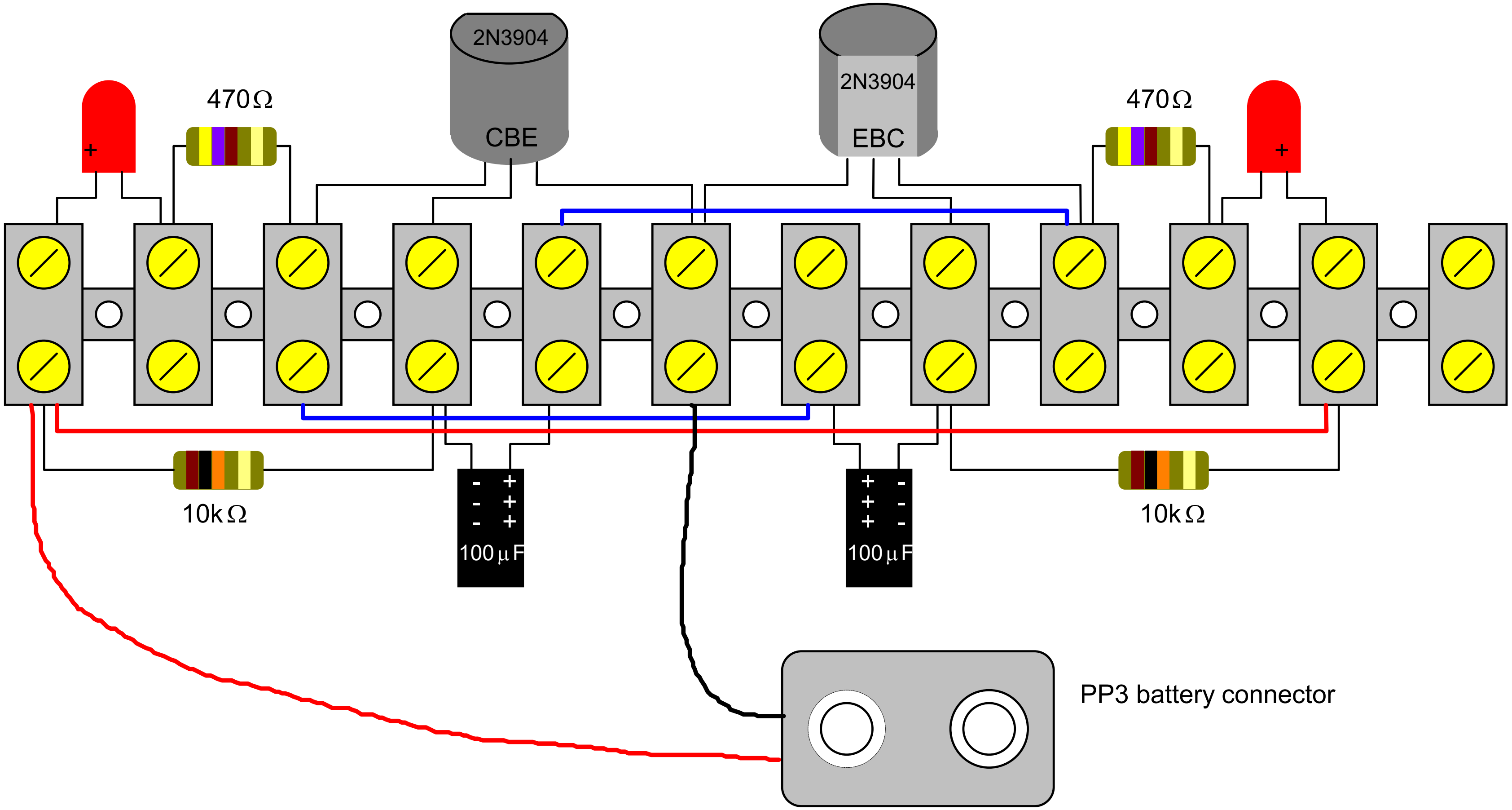
2). Take the two 470Ω resistor (yellow, violet, brown and gold) and the two 10kΩ resistor (brown, black, orange and gold). Carefully bend the leads so that they will fit as in the diagram below. Trim the leads if necessary. It does not matter which way round they are connected.



3). Take the two 2N3904 transistors - carefully spread out the leads so that it will fit as in the diagram below. Trim the leads if necessary.
Ensure that the transistors are connected the correct way round.
Take the two LEDs - carefully spread out the leads so that it will fit as in the diagram below. Trim the leads if necessary.
Ensure that the LEDs are connected the correct way round - the flat on the side of the LED body is the negative side.



4). Take the two 100µF capacitors. Carefully bend the leads so that they will fit as in the diagram below. Trim the leads if necessary.
Ensure that they are connected the correct way round.
Finally connect the battery connector - ensure that the red and black wires are connected to the correct terminals.



Connect the battery. If all is well, the LEDs will alternately light up. Secure your circuit and battery to the cardboard base with Sticky Tac to prevent it being damaged by being moved. If your circuit does not work, carefully check that there are no wiring errors and that all of the wires are secure in the terminal strip.

Further experiments

1). Increase the values of R1 and R2 and note what happens.

Decrease the values of R1 and R2 and note what happens. (**NOTE** - do not make the values smaller that 4.7kΩ or you may damage the transistors!)

2). Investigate what happens if the values of R1 and R2 are different.

3). Increase the values of C1 and C2 and note what happens.
Decrease the values of C1 and C2 and note what happens.
What happens to the LEDs if C1 and C2 and made very small?

4). Investigate what happens if the values of C1 and c2 are different.

5). Summarise your results.