14. TWO-TRANSISTOR METRONOME

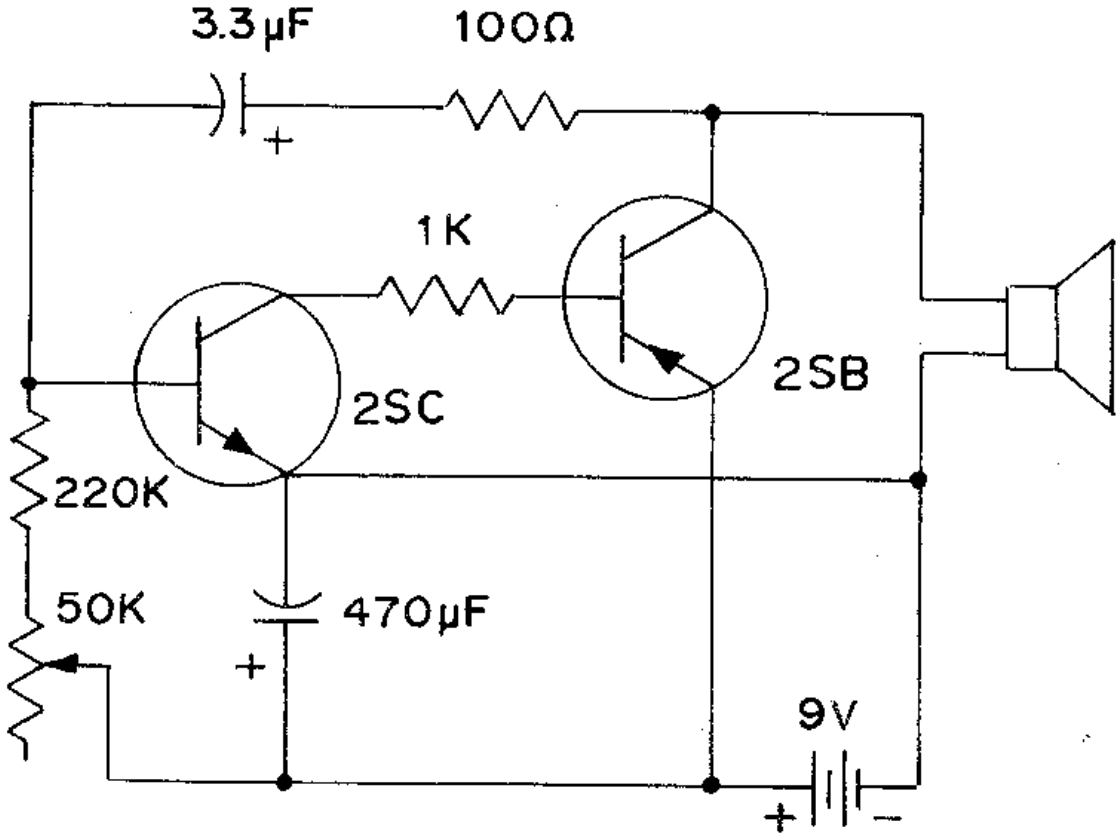
This project is a two-transistor metronome. The two Transistors are arranged in an oscillator circuit which is capable of driving the Speaker directly without a Transformer. A Control is provided to change the click rate. The 220K resistor may also be changed to 470K to obtain slower rates, or to 100K for faster rates.

The circuit is the same as Project 144 but with necessary changes to obtain clicks in the Speaker in place of the tone. You can use a Switch or Key as in Project 144.

This is a good project to check your circuit analyzing (circuit psyching) abilities also. Use the procedure described for Project 144. The only added circuit components are the 1K resistor (which is included to limit the 2SB base current to about 7 mA maximum) and the 470 μF Battery bypass capacitor which is included to make current pulse amplitudes less dependent on Battery characteristics. Of course a different schematic arrangement is used to give you some additional exercise.

Use the space below to outline circuit operation. A VOM or oscilloscope can be used to observe polarity of voltages across all circuit components to verify your current flow directions.

NOTES


3.3μF
100Ω
+
1K
2SC
2SB
220K
50K
470μF
+
9V
+
−

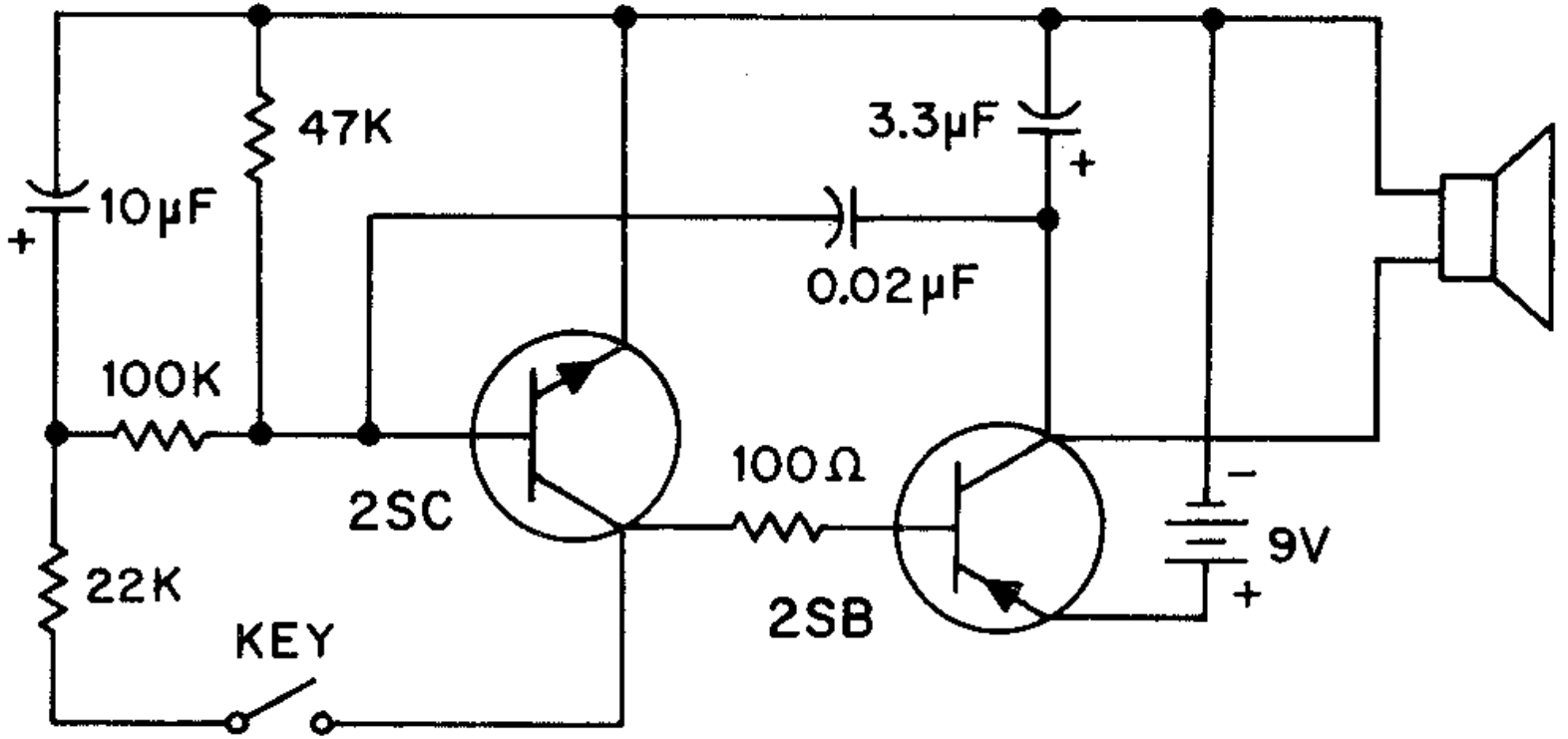
12. ELECTRONIC SIREN

Don't be surprised if this becomes the most popular circuit in this entire kit! This circuit sounds so much like a real siren used on some police cars and ambulances you may **have** to modify the circuit or risk being arrested for impersonating a police car!

Some of the modifications you will want to try are listed below:

1. Change the 10 μF to a 100 or 470 μF. This gives a very long delay for both turn-ON and turn-OFF.
2. Change the circuit to eliminate the ON-OFF delays by replacing the 10 μF with an open circuit. (Sounds dead in comparison doesn't it!)
3. Change the 0.02 μF to a 0.01 and then a 0.05.
4. Try it with the 3.3 μF removed temporarily.
5. Change the Battery to 3V.
6. Change to a fresh 9V Battery. Yes, sad to say, this circuit is hard on batteries. The current drain is about 50 mA. This is three or four times as high as the normal transistor radio operating at a low volume.

You should be able to determine how this circuit works by comparing it to the circuit of Project 144. Actually the changes are few so if you use the same method of following the currents around you can do it. Start by considering this circuit without the 10 μF and 47K. Without these components the operating characteristics are virtually identical to the other project. After obtaining an understanding without the 10 μF and 47K, try including these in your analysis. Remember, with these in the circuit the turn-ON is delayed and the turn-OFF is delayed.


47K
3.3μF
+
10μF
+
0.02μF
100K
100Ω
2SC
2SB
9V
−
+
22K
KEY

19. ELECTRONIC THERMOMETER

The purpose of this project is to study the basic bridge circuit which is used in virtually every electronic thermometer. The temperature sensitive element is a common germanium (Ge) transistor, 2SB. You may have seen or used an electronic thermometer in the hospital or in a doctor's office. If so, you have seen this concept developed to its practical end – an accurate, quick reading thermometer.

This circuit doesn't have all the refinements of the hospital type thermometer, but it can demonstrate some basic principles. The basic circuit type is the Wheatstone bridge (see also Project 129). This bridge is composed of four resistances connected in a continuously closed loop or circle. In this project the resistance between collector and emitter of the 2SB is used as one of the four resistances. The source of voltage (Battery) is connected across two opposite corners of the bridge, and the detector is placed across the remaining two corners of the bridge.

The bridge is said to be "balanced" when the ratio of resistances in adjacent arms of the bridge is equal. For this project the adjacent 10K resistors are two arms of the bridge and the 50K and 2SB are the other adjacent arms. Because the 10K resistors are equal in value (a ratio of one to one), the resistances of the 50K and 2SB must also be equal in value (a ratio of one to one) in order for this bridge to be balanced.

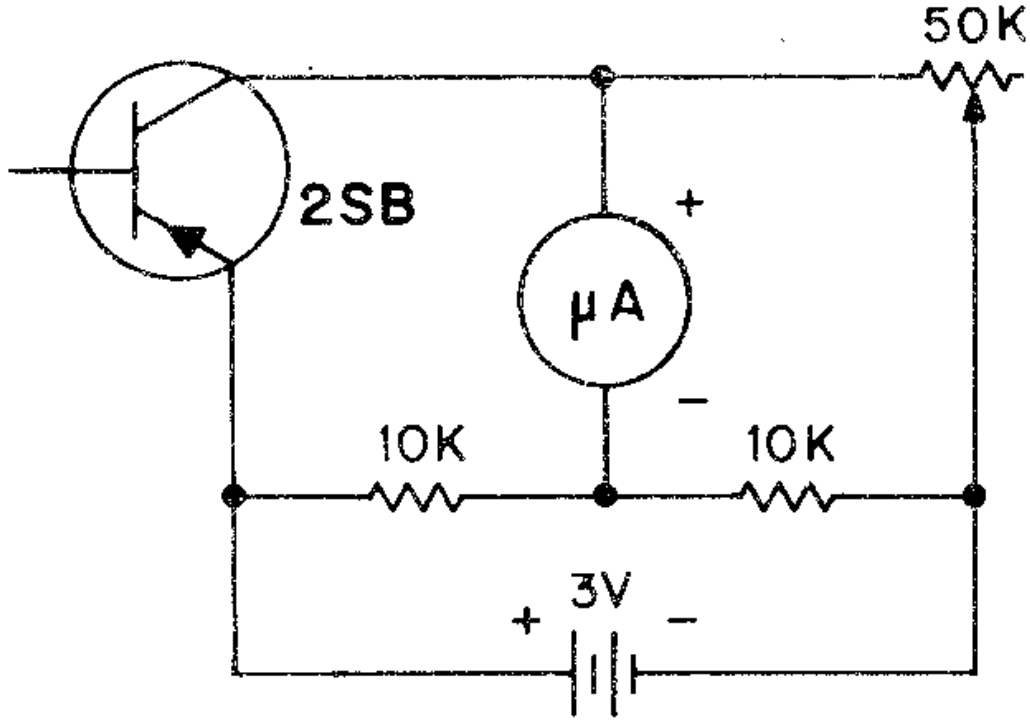
When the bridge is balanced, no current will flow through the meter. This is the starting condition for comparing temperature changes with this circuit. The procedure is as follows:

1. Keep the 2SB in the **lower** of the two temperatures to be measured for a few minutes – to stabilize this condition as the balanced-bridge reference condition. Keep the Meter on zero during this time by adjusting the 50K Control as required. When you no longer need to make adjustments of the Control to maintain a zero reading, the circuit is stabilized. Leave the control at this setting for the following.
2. Place the 2SB in the **higher** of the two temperatures and allow the Meter to come to rest at some up-scale reading. The amount of meter deflection above zero is an indication of the increase in temperature (temperature differences between the high and low temperatures).

Try measuring such temperature differences as room-temperature to outside-temperature, room-temperature to body-temperature (fingers gripping the 2SB), and shade-temperature to sunshine-temperature.

Battery current drain is very low for this circuit so hours of use make little change in battery life.

The characteristic of the Transistor which provides the resistance change is basic to all semiconductor devices, especially germanium. The resistance used in this project is that caused by the leakage between collector and emitter of the Transistor when it is in the OFF state. This leakage is usually measured in terms of the current which will flow with 2V applied. This current is called the I_{CEO} leakage current. Below about 10°C this leakage is very small and may be neglected, but as temperature increases (especially above 50°C) this leakage doubles for each 10°C or so increase in temperature and makes the device usable in circuits which are unable to cope with the excessive leakage current.


50K
2SB
+
μA
−
10K
10K
+
3V
−