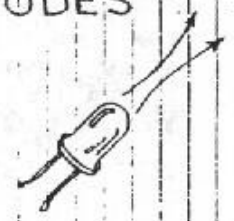
The following information is designed to help you get a feel for some of the sensors and electronics available for improving your tutebot.

All of the material came from Radio Shack®'s series of pamphlets called Engineer's Mini Notebook, all written by Forrest M. Mims III. The following titles were used here:

- Basic Semiconductor Circuits
- Op Amp IC Circuits
- Optoelectronics Circuits
- Sensor Projects

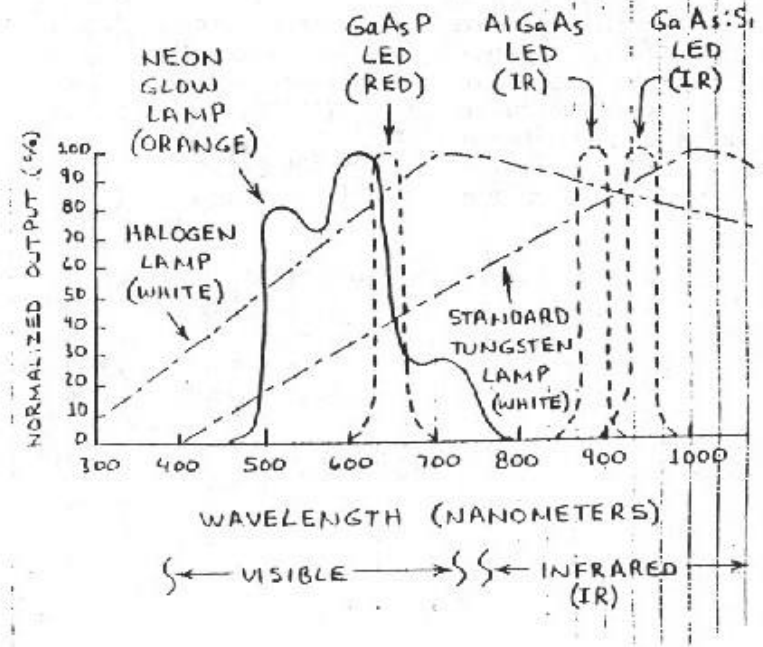
For more information and ideas, refer to the books themselves, as well as other books in the series.

LIGHT-EMITTING DIODES



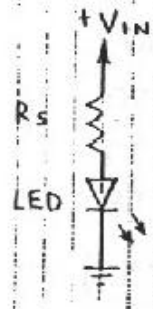
THE LIGHT-EMITTING DIODE (LED) IS A SEMICONDUCTOR PN JUNCTION DIODE THAT EMITS VISIBLE LIGHT OR NEAR-INFRARED RADIATION WHEN FORWARD BIASED. VISIBLE LEDs EMIT RELATIVELY NARROW BANDS OF GREEN, YELLOW, ORANGE, OR RED LIGHT. INFRARED DIODES EMIT IN ONE OF SEVERAL BANDS JUST BEYOND RED LIGHT. LEDs SWITCH OFF AND ON RAPIDLY, ARE VERY EFFICIENT, HAVE A VERY LONG LIFETIME, AND ARE EASY TO USE. LEDs ARE CURRENT DEPENDENT SOURCES, AND THEIR LIGHT OUTPUT IS DIRECTLY PROPORTIONAL TO THE FORWARD CURRENT.

LIGHT SOURCE SPECTRA



HOW TO USE LEDs

USE A SERIES RESISTOR (R_S) TO LIMIT THE CURRENT THROUGH AN LED TO A SAFE VALUE.



USE THIS FORMULA TO DETERMINE THE RESISTANCE OF R_S:

$$R_S = \frac{V_{IN} + V_{LED}}{I_{LED}}$$

I_{LED} IS THE SPECIFIED FORWARD CURRENT.

V_{LED} IS THE LED VOLTAGE DROP. IT RANGES FROM ABOUT 1.3 VOLTS (940nm INFRARED EMITTERS) TO ABOUT 2.5 VOLTS (GREEN EMITTERS).

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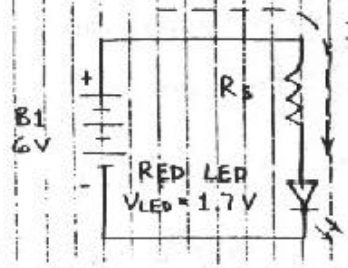
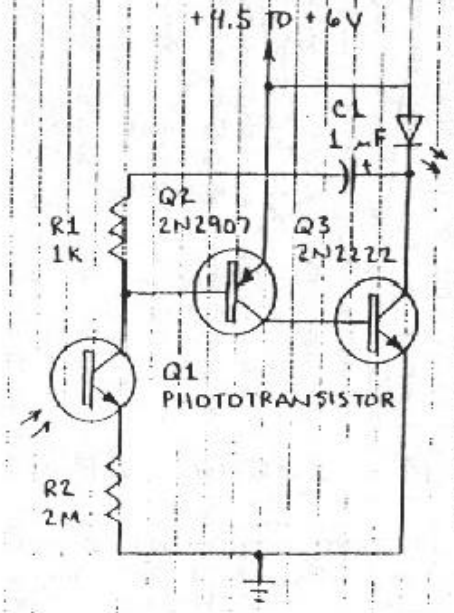
SAMPLE LED CIRCUIT



$$R_S = \frac{6 - 1.7}{.02} = 215 \text{ OHMS}$$

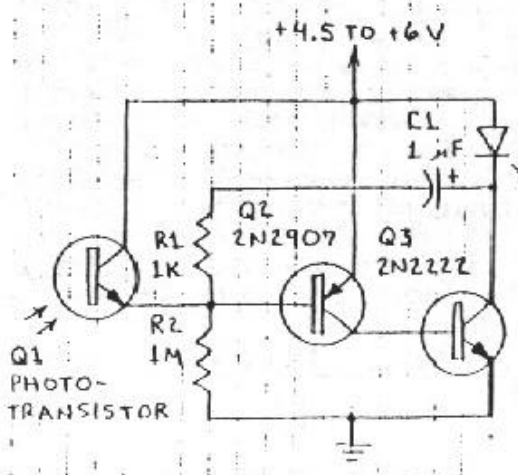
220 Ω IS CLOSEST STANDARD VALUE.

LIGHT-ACTIVATED FLASHER



THE LED FLASHES WHEN Q1 IS ILLUMINATED BY SUNLIGHT OR ARTIFICIAL LIGHT. WHEN Q1 IS DARK, THE FLASHER IS DISABLED. C1 CONTROLS THE FLASH RATE.

DARK-ACTIVATED FLASHER



THIS CIRCUIT CAN BE USED AS A WARNING FLASHER THAT TURNS ON AT NIGHT. C1 CONTROLS FLASH RATE.

ANALOG SENSORS

MANY KINDS OF ANALOG SENSORS ARE READILY AVAILABLE. SOME OF THE MOST COMMON ARE DESCRIBED HERE.

PHOTORESISTOR

LIGHT-SENSITIVE RESISTOR WHOSE RESISTANCE CHANGES WITH LIGHT.

PHOTODIODE

LIGHT-SENSITIVE DIODE WHICH PRODUCES A CURRENT IN RESPONSE TO LIGHT.

THERMISTOR

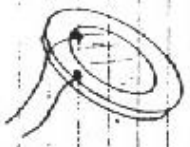
TEMPERATURE-SENSITIVE RESISTOR WHOSE RESISTANCE CHANGES WITH TEMPERATURE.

MICROPHONE

SOUND-SENSITIVE SENSOR WHICH PRODUCES A VOLTAGE OR CHANGES A CAPACITANCE AS THE SOUND LEVEL CHANGES.

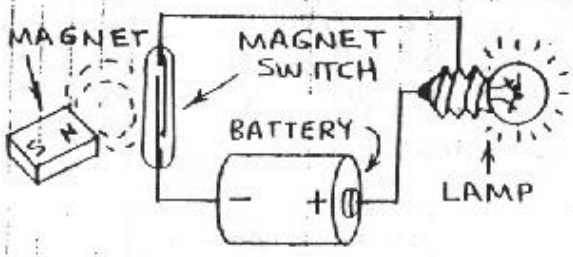
PIEZOELECTRIC

VARIOUS CRYSTALS OR CERAMICS WHICH PRODUCE A VOLTAGE WHEN BENT, VIBRATED OR SUBJECTED TO MECHANICAL SHOCK.

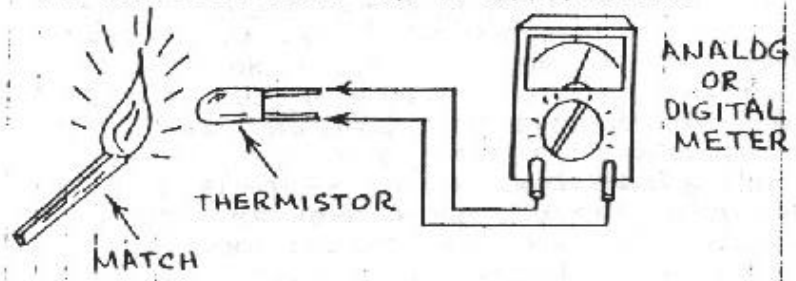


BASIC SENSOR CIRCUITS

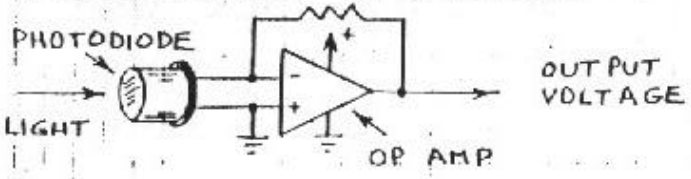
ELECTRONIC SENSORS REQUIRE A DEVICE THAT INDICATES WHEN SOMETHING HAS BEEN SENSED. THE INDICATOR FOR A SIMPLE GO-NO GO SENSOR SUCH AS A MAGNET SWITCH CAN BE A LAMP, LED OR BUZZER.



THE OUTPUT DEVICE FOR AN ANALOG SENSOR CAN BE AN ANALOG OR DIGITAL METER, AN OSCILLOSCOPE OR A COMPUTER.



MANY ANALOG SENSORS REQUIRE A CIRCUIT TO PREPARE THE SIGNAL FOR AN OUTPUT INDICATOR. AN ESPECIALLY USEFUL CIRCUIT IS THE OPERATIONAL AMPLIFIER (OP AMP). THE OP AMP CAN TRANSFORM THE TINY CURRENT FROM A PHOTODIODE INTO A VOLTAGE THAT IS EASILY INDICATED BY A METER.



LIGHT SENSORS

MANY LIGHT SENSORS ARE AVAILABLE FOR OPTOELECTRONIC PROJECTS. THE MOST COMMONLY USED SENSORS INCLUDE:

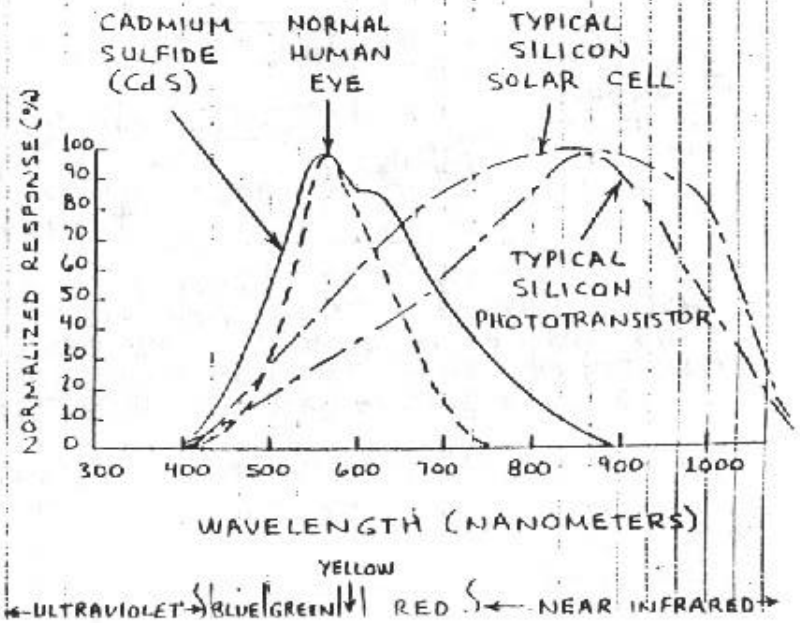
PHOTORESISTORS

THE ELECTRICAL RESISTANCE OF A DARK PHOTORESISTOR IS ORDINARILY VERY HIGH, UP TO 1,000,000 OHMS OR MORE. THE RESISTANCE MAY FALL TO AS LITTLE AS A FEW HUNDRED OHMS WHEN THE PHOTORESISTOR IS ILLUMINATED. THE MOST COMMON SEMICONDUCTOR USED TO MAKE PHOTORESISTORS IS CADMIUM SULFIDE (Cd S). IT IS PRIMARILY SENSITIVE TO GREEN LIGHT. PHOTORESISTORS EXHIBIT A "MEMORY EFFECT" IN THAT THEY MAY REQUIRE A SECOND OR MORE TO RETURN TO THEIR HIGH-RESISTANCE STATE AFTER A LIGHT SOURCE IS REMOVED. THOUGH THIS SLOWS THEIR RESPONSE TIME, THEY ARE VERY

PHOTOTRANSISTORS

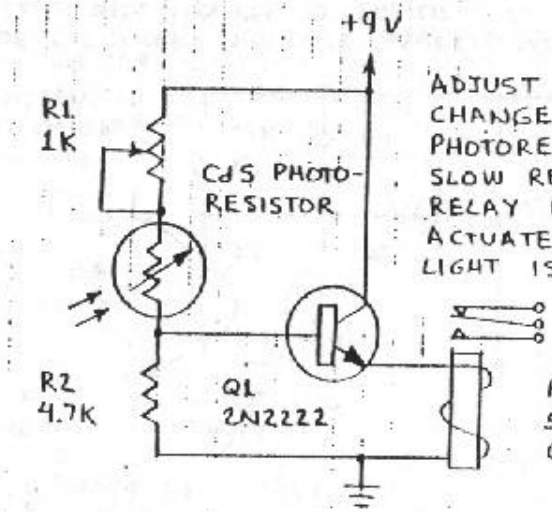
ALL TRANSISTORS ARE LIGHT SENSITIVE. PHOTOTRANSISTORS ARE DESIGNED TO EXPLOIT THIS PHENOMENON. THOUGH A BIPOLAR TRANSISTOR HAS THREE LEADS, A PHOTOTRANSISTOR MAY NOT HAVE A BASE LEAD. MOST PHOTOTRANSISTORS ARE NPN DEVICES WITH A BASE REGION MUCH LARGER THAN THAT OF A STANDARD NPN TRANSISTOR. THEY HAVE A RESPONSE TIME OF 1 MICROSECOND IN SOME CIRCUITS. THE DARLINGTON PHOTOTRANSISTOR INCLUDES A SECOND ON-CHIP TRANSISTOR TO AMPLIFY THE SIGNAL GENERATED BY THE PHOTOTRANSISTOR. IT GIVES MORE SENSITIVITY BUT IS SLOWER.

SENSOR SPECTRAL RESPONSE



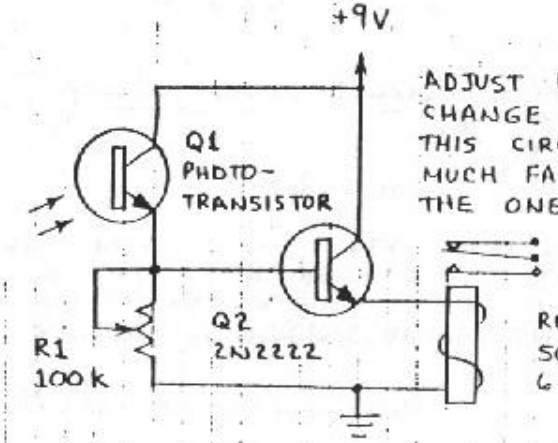
LIGHT-ACTIVATED RELAYS

PHOTORESISTOR



ADJUST R1 TO CHANGE SENSITIVITY. PHOTORESISTORS HAVE SLOW RESPONSE, SO RELAY WILL REMAIN ACTUATED BRIEFLY AFTER LIGHT IS REMOVED.

PHOTOTRANSISTOR

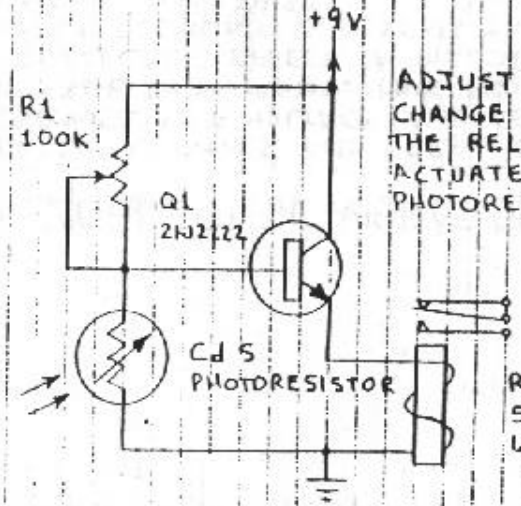


ADJUST R1 TO CHANGE SENSITIVITY. THIS CIRCUIT RESPONDS MUCH FASTER THAN THE ONE ABOVE.

NOTE: USE LIGHT SHIELD AT DETECTOR OF BOTH CIRCUITS TO PREVENT FALSE TRIGGERING.

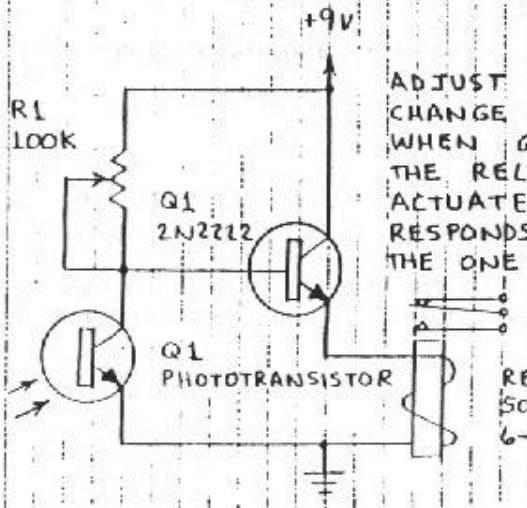
DARK-ACTIVATED RELAYS

PHOTORESISTOR



ADJUST R1 TO CHANGE SENSITIVITY. THE RELAY WILL BE ACTUATED WHEN THE PHOTORESISTOR IS DARK.

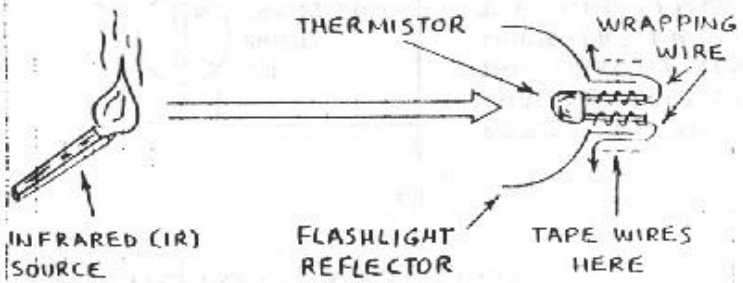
PHOTOTRANSISTOR



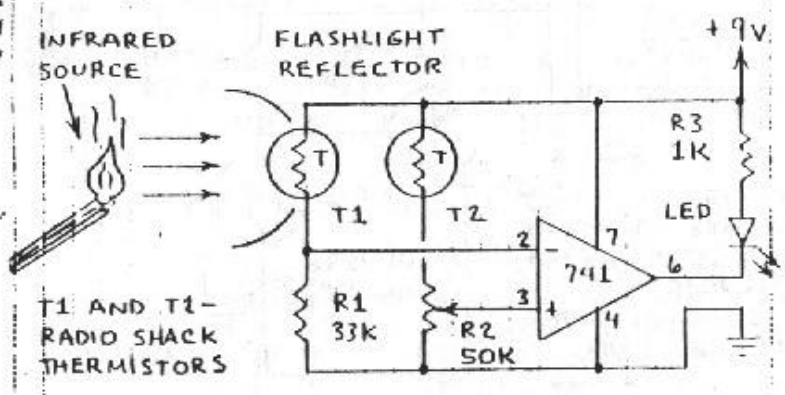
ADJUST R1 TO CHANGE SENSITIVITY. WHEN Q1 IS DARK THE RELAY IS ACTUATED. THIS CIRCUIT RESPONDS FASTER THAN THE ONE ABOVE.

INFRARED SENSOR

A THERMISTOR IS A TEMPERATURE-SENSITIVE RESISTOR. INSTALL A THERMISTOR AT THE FOCAL POINT OF A FLASHLIGHT REFLECTOR TO DETECT INFRARED RADIATION FROM HEAT SOURCES.



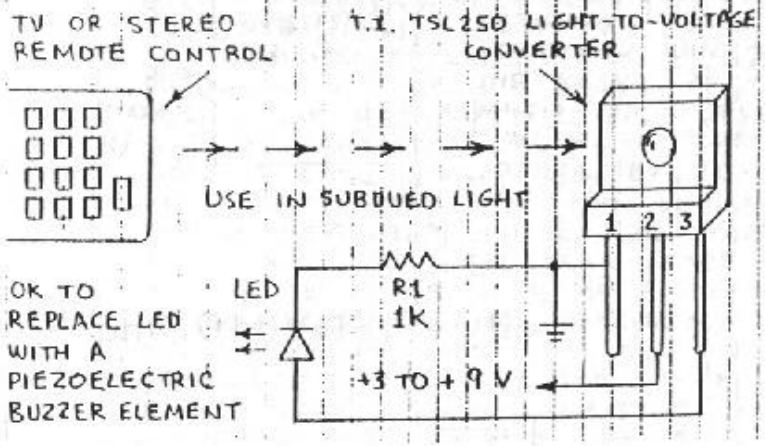
INFRARED SWITCH



CONNECT BATTERY AND WAIT SEVERAL SECONDS TO ALLOW THERMISTORS TO STABILIZE. ADJUST R2 UNTIL LED JUST SWITCHES OFF. PLACE YOUR HAND NEAR REFLECTOR AND LED SHOULD TURN ON. A MATCH WILL TRIGGER THE CIRCUIT FROM UP TO 1 METER (ABOUT 3 FEET) OR MORE. NOTE THAT CHANGES IN AIR TEMPERATURE CAUSE EQUAL CHANGES IN T1 AND T2. BUT AN INFRARED SOURCE AFFECTS ONLY T1. TO ADD RELAY SEE SIMILAR CIRCUITS IN THIS BOOK.

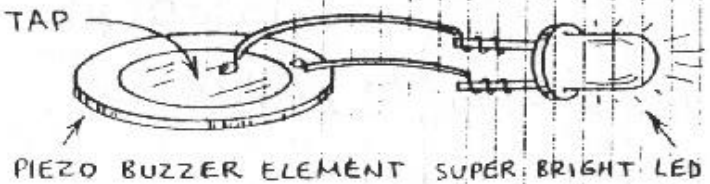
IR REMOTE CONTROL SENSOR

LED WILL GLOW OR PULSATE IF IR REMOTE CONTROL TRANSMITTER IS TRANSMITTING.



PIEZOELECTRIC VIBRATION SENSOR

CERTAIN CRYSTALS AND CERAMICS BEND IN RESPONSE TO A VOLTAGE AND GENERATE A VOLTAGE WHEN BENT. THIS PROPERTY IS THE PIEZOELECTRIC EFFECT. A PIEZOELECTRIC BUZZER ELEMENT IS A SENSITIVE VIBRATION SENSOR. TRY THIS:



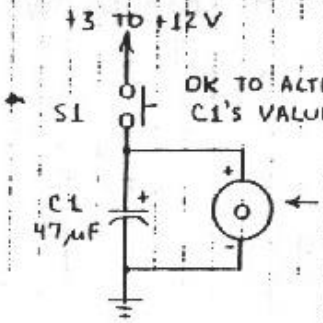
TAP THE PIEZO ELEMENT WITH A PENCIL WHILE LOOKING INTO THE END OF THE LED. EACH TAP

PIEZOELECTRIC BUZZERS

PIEZO BUZZERS DELIVER EAR-PIERCING TONE AT LOW DRIVE CURRENT AND VOLTAGE.

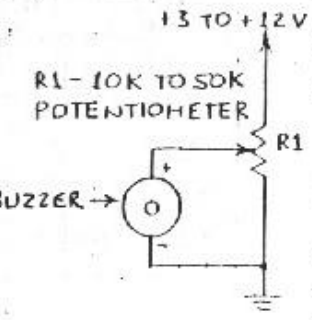
CAUTION: USE EAR PROTECTORS WHEN EXPERIMENTING WITH PIEZO BUZZERS AT CLOSE RANGE FOR MORE THAN BRIEF INTERVALS.

BELL



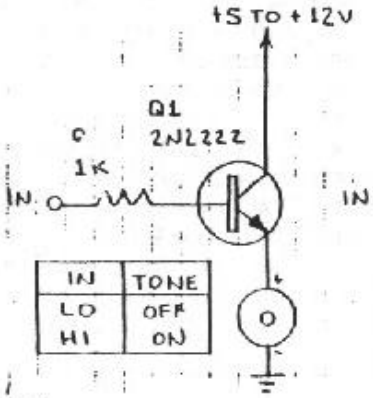
PRESS AND RELEASE S1 TO SIMULATE BELL.

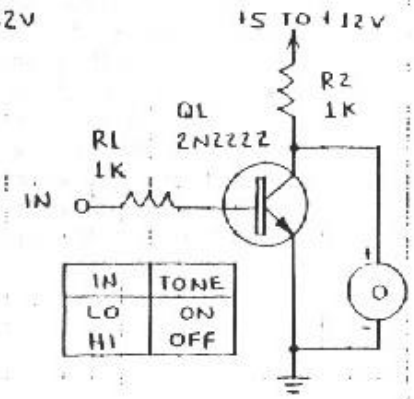
VOLUME CONTROL



R1 CONTROLS VOLUME.

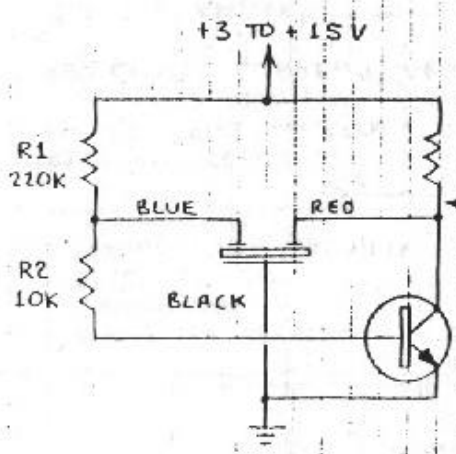
LOGIC INTERFACES





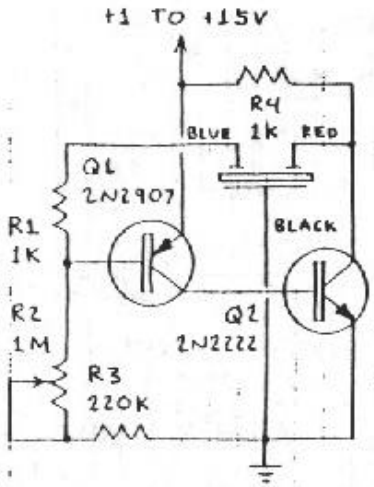
PIEZO-ELEMENT DRIVERS

FIXED TONE

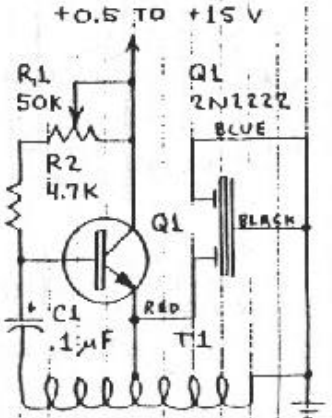


CONNECT CdS CELL ACROSS R1 FOR DARK-ACTIVATED TONE OR HERE FOR LIGHT-ACTIVATED TONE.

ADJUSTABLE FREQUENCY

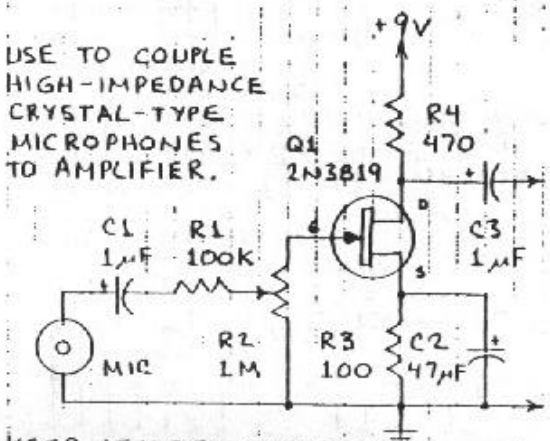


THIS CIRCUIT CAN BE EASILY MINIATURIZED. R2 CONTROLS FREQUENCY.



T1 IS PRIMARY OF CENTER-TAPPED AUDIO TRANSFORMER (RADIO SHACK 273-1380). R1 CONTROLS FREQUENCY.

HI-Z MICROPHONE PREAMPLIFIER

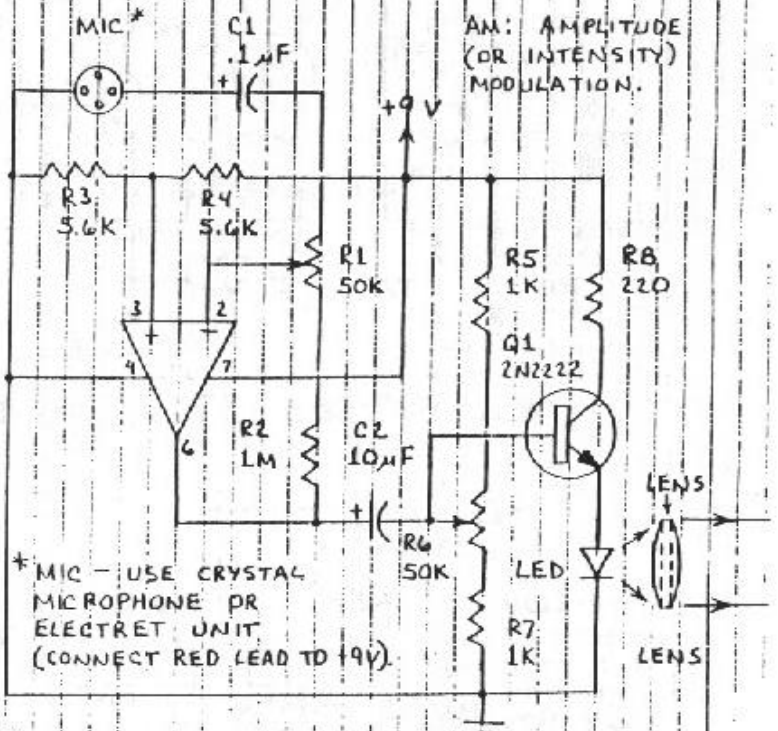


USE TO COUPLE HIGH-IMPEDANCE CRYSTAL-TYPE MICROPHONES TO AMPLIFIER.

R2 IS GAIN CONTROL.

KEEP LEADS TO MICROPHONE

AM LIGHTWAVE TRANSMITTER



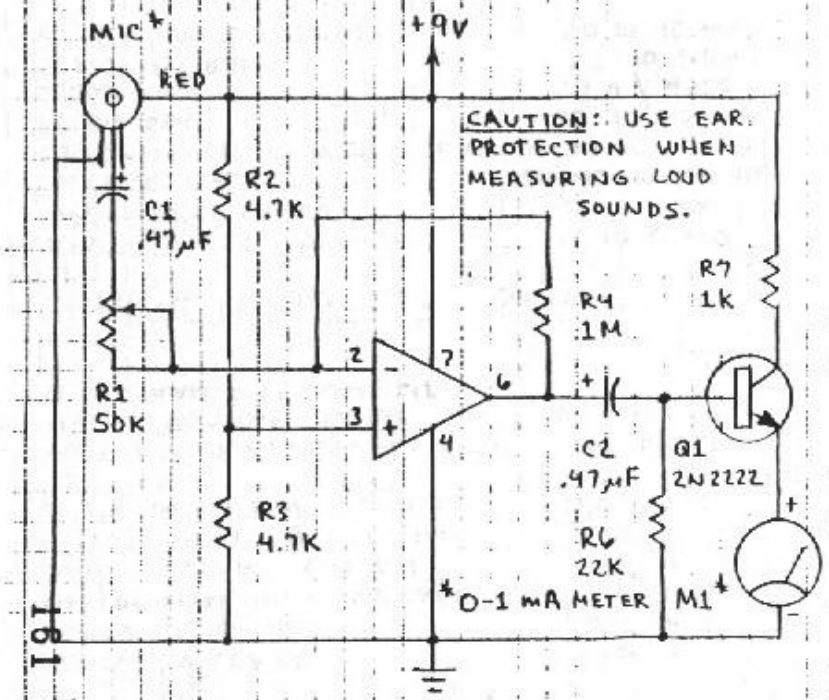
AM: AMPLITUDE (OR INTENSITY) MODULATION.

* MIC – USE CRYSTAL MICROPHONE OR ELECTRET UNIT (CONNECT RED LEAD TO +9V).

R1 – GAIN CONTROL.
R6 – LED BIAS CONTROL. ADJUST R6 FOR BEST SOUND QUALITY.
R8 – LIMITS CURRENT APPLIED TO LED.

THE 741 AMPLIFIES VOICE SIGNALS FROM THE MICROPHONE AND COUPLES THEM THROUGH C2 TO MODULATOR TRANSISTOR Q1. USE A HIGH-BRIGHTNESS RED OR HIGH-POWER INFRARED LED FOR BEST RESULTS. FOR A FREE-SPACE RANGE OF UP TO 1,000 FEET (AT NIGHT), USE A LENS TO COLLIMATE THE LED BEAM. OR USE THIS CIRCUIT AS AN OPTICAL FIBER TRANSMITTER.

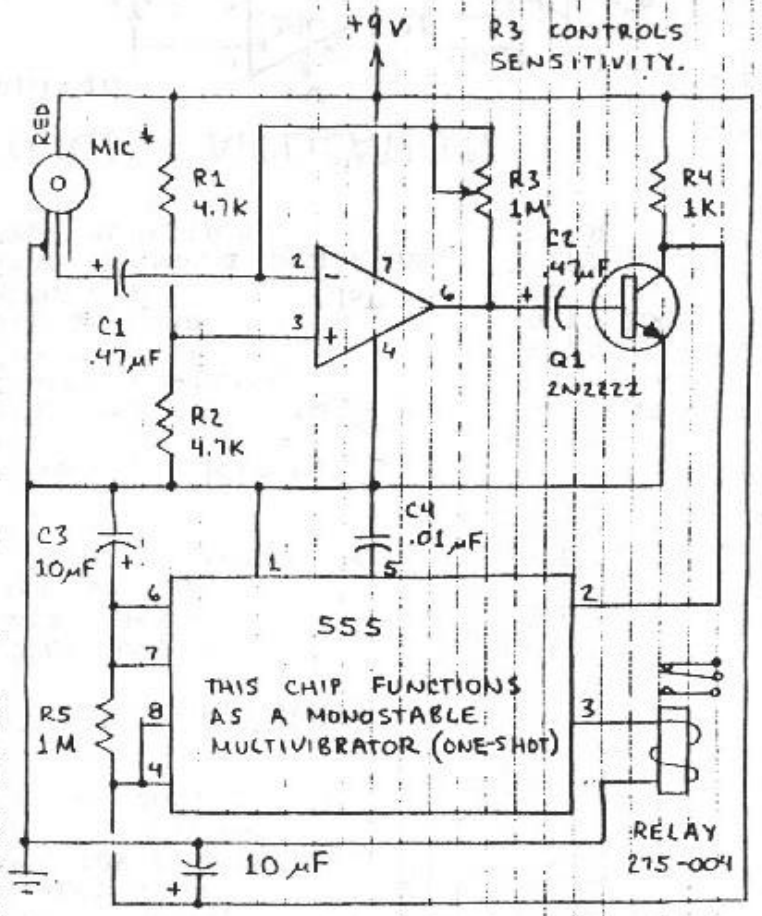
SOUND-LEVEL METER



*MICROPHONE (RADIO SHACK 270-092 OR SIMILAR).

THIS SIMPLE CIRCUIT IS AN EFFECTIVE SOUND-LEVEL METER. R1 CONTROLS THE GAIN OF THE 741 OP-AMP, HENCE THE SENSITIVITY OF THE CIRCUIT. THE METER CAN BE A PANEL METER OR A MULTIMETER SET TO READ CURRENT. THE CIRCUIT WAS TESTED WITH A PIEZO [illegible]ER THAT EMITTED A 6.5 KHz TONE AT A [illegible]D PRESSURE OF 90 dB. WHEN THE BUZ[illegible] WAS 2" FROM THE MICROPHONE AND [illegible] WAS SET FOR MAXIMUM GAIN, THE METER INDICATED 1 mA. AT 12" THE OUTPUT FELL TO 0.4 mA. NORMAL SPEECH AT 12" GAVE FLUCTUATING SIGNAL UP TO 10 μA.

SOUND-ACTIVATED RELAY



*MICROPHONE (RADIO SHACK 270-092 OR SIMILAR).

THIS CIRCUIT TRIPS RELAY IN RESPONSE TO LOUD SOUND (VOICE, CLAP, ETC.). R5 AND C3 CONTROL TIME RELAY STAYS PULLED IN (VALUES SHOWN GIVE ~12 SECONDS). IMPORTANT: USE 0.1μF CAPACITOR ACROSS POWER SUPPLY PINS OF BOTH THE 741 AND 555. REDUCE RESISTANCE OF R3 TO REDUCE SENSITIVITY.