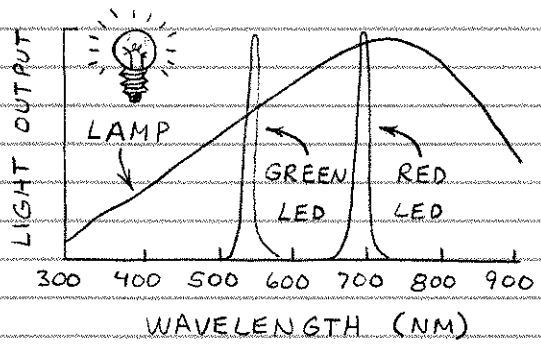
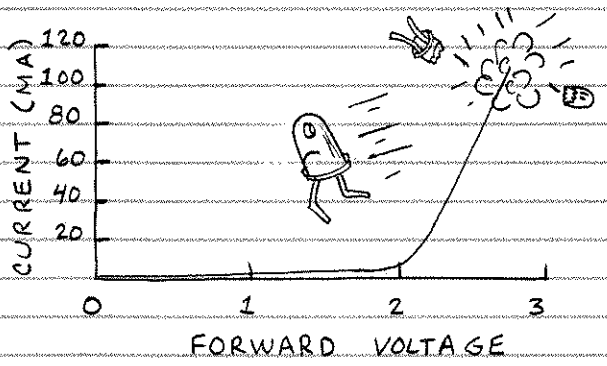
☐ MORE ABOUT LED OPERATION — HERE ARE SOME KEY ASPECTS OF LED OPERATION YOU SHOULD KNOW ABOUT:

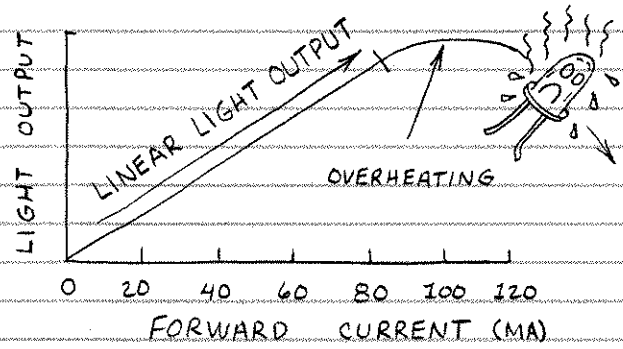
1. THE LIGHT EMITTED BY AN INCANDESCENT LAMP CONTAINS MANY WAVELENGTHS. THE LIGHT EMITTED BY AN LED HAS A NARROW WAVELENGTH RANGE. (THIS IS BECAUSE THE ELECTRONS IN THE LED ARE ALL EXCITED TO THE SAME LEVEL.)



2. WHEN AN LED BEGINS TO CONDUCT, THE VOLTAGE INCREASES GRADUALLY WHILE THE CURRENT INCREASES RAPIDLY. TOO MUCH CURRENT WILL OVERHEAT THE LED AND POSSIBLY SEPARATE THE LEADS OR MELT THE SEMICONDUCTOR CHIP.



3. THE LIGHT EMITTED BY AN LED IS DIRECTLY PROPORTIONAL TO CURRENT THROUGH THE LED. THIS MEANS LEDS ARE IDEAL FOR TRANSMITTING INFORMATION. THE LIGHT OUTPUT FROM AN OVERHEATED LED WILL SOON DECREASE. THE LED MAY EVEN BE DAMAGED.

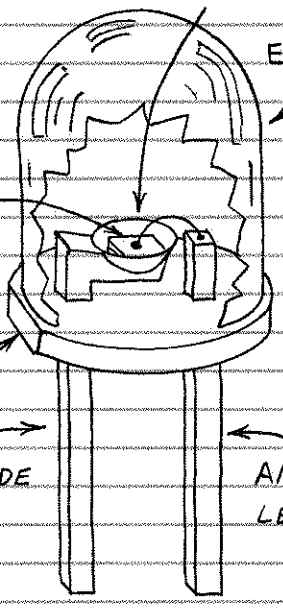


4. THE FORWARD VOLTAGE AND WAVELENGTH OF AN LED ARE DIRECTLY RELATED. THEREFORE IT'S NOT ALWAYS POSSIBLE TO SUBSTITUTE DIFFERENT LEDS WITHOUT CHANGING THE VOLTAGE AND CURRENT. MANY DIFFERENT SEMICONDUCTORS ARE USED TO MAKE VARIOUS LEDS.

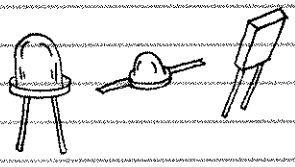
WAVELENGTH (NM)	VOLTAGE
565 (GREEN)	2.2 – 3.0
590 (YELLOW)	2.2 - 3.0
615 (ORANGE)	1.8 - 2.7
640 (RED)	1.6 - 2.0
690 (RED)	2.2 – 3.0
880 (INFRARED)	2.0 - 2.5
900 (INFRARED)	1.2 - 1.6
940 (INFRARED)	1.3 - 1.7

VISIBLE LIGHT EMITTING LEDs EMIT UP TO A MILLIWATT OR SO OF POWER. SOME INFRARED LEDs (LIKE 880 NM UNITS) EMIT 15 OR MORE MILLIWATTS! (A FLASHLIGHT EMITS 10 OR MORE MILLIWATTS.)

☐ KINDS OF LEDs — SINCE THE LED IS A LIGHT SOURCE, IT'S HELPFUL TO KNOW WHAT'S INSIDE THE PLASTIC OR METAL LED CASE. SHOWN HERE IS A TYPICAL LED. THE HEAVY LEADS HELP CONDUCT HEAT AWAY FROM THE CHIP. THE REFLECTOR COLLECTS LIGHT EMITTED FROM THE EDGES OF THE CHIP. THE EPOXY IS USUALLY COLORED WHEN THE LED IS A VISIBLE LIGHT EMITTER. LIGHT SCATTERING PARTICLES ARE OFTEN ADDED TO THE EPOXY. THIS DIFFUSES THE LIGHT AND CAUSES THE END OF THE LED TO APPEAR BRIGHTER.

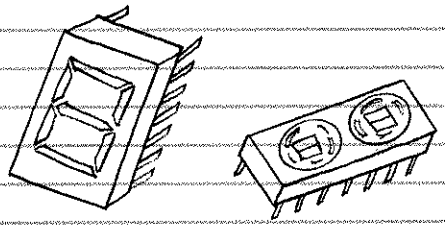


VISIBLE LIGHT LEDs.



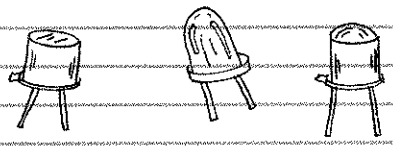
THESE INEXPENSIVE LEDs ARE USED AS INDICATOR LIGHTS. CERTAIN RED LEDs ARE USED TO TRANSMIT INFORMATION. MOST ARE ENCAPSULATED IN EPOXY.

LED DISPLAYS.



MANY KINDS OF LED READOUTS CAPABLE OF DISPLAYING DIGITS AND CHARACTERS ARE AVAILABLE. THEY ARE MORE RUGGED THAN LIQUID CRYSTAL DISPLAYS, BUT THEY USE MUCH MORE CURRENT.

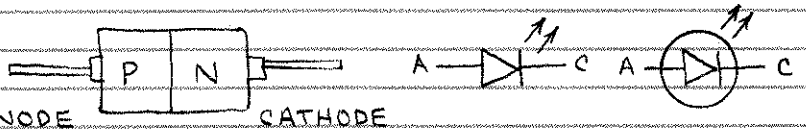
INFRARED LEDs.



INFRARED LEDs SHOULD BE CALLED INFRARED EMITTING DIODES. THEY ARE USED TO TRANSMIT INFORMATION. THEY ARE ALSO USED IN INTRUSION ALARMS, REMOTE CONTROL DEVICES, ETC. A SPECIAL KIND OF INFRARED LED IS THE DIODE LASER. SOME EMIT SEVERAL WATTS!

☐ LED SYMBOL.

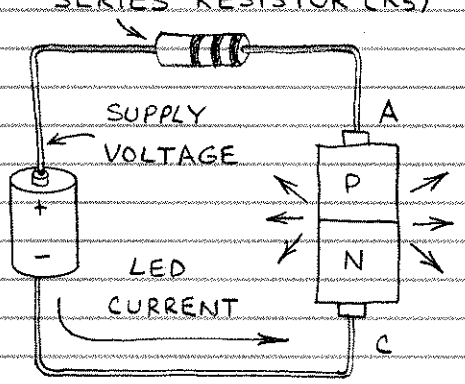
BOTH SYMBOLS SHOWN HERE ARE USED.



HOW LEDs ARE USED

LEDs CAN BE POWERED BY CONTINUOUS CURRENT OR BY BRIEF PULSES OF CURRENT. WHEN OPERATED CONTINUOUSLY, THE CURRENT CAN BE VARIED TO CHANGE THE LIGHT OUTPUT.

☐ LED DRIVE CIRCUIT — BECAUSE LEDs ARE CURRENT DEPENDENT, IT'S USUALLY NECESSARY TO PROTECT THEM FROM EXCESSIVE CURRENT WITH A SERIES RESISTOR. SOME LEDs INCLUDE A BUILT-IN SERIES RESISTOR. MOST DO NOT. IT'S IMPORTANT TO KNOW HOW TO DETERMINE THE REQUIRED SERIES RESISTANCE (R_S). THE FORMULA IS:



$$R_S = \frac{\text{SUPPLY VOLTAGE} - \text{LED VOLTAGE}}{\text{LED CURRENT}} \quad \text{OR} \quad R_S = \frac{V - V_{LED}}{I_{LED}}$$

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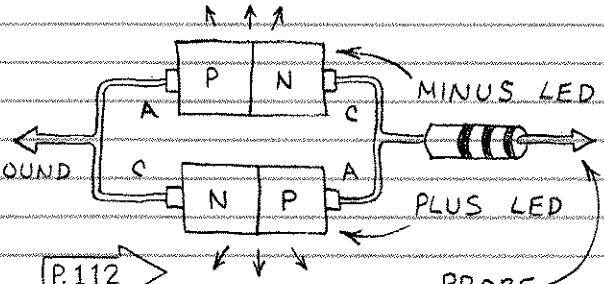
EXAMPLE: SUPPOSE YOU WANT TO OPERATE A RED LED AT A FORWARD CURRENT (I_{LED}) OF 10-MILLIAMPERES FROM A 5-VOLT SUPPLY (V). V_{LED} IS 1.7-VOLTS (FROM DATA SHEET). THEREFORE R_S IS (5 - 1.7)/0.01 OR 330-OHMS.

☐ LED POLARITY INDICATOR — TWO REVERSE-PARALLEL LEDs FORM A POLARITY INDICATOR. BOTH LEDs GLOW IF THE TESTED VOLTAGE IS AC. THE SERIES RESISTOR MUST BE USED!



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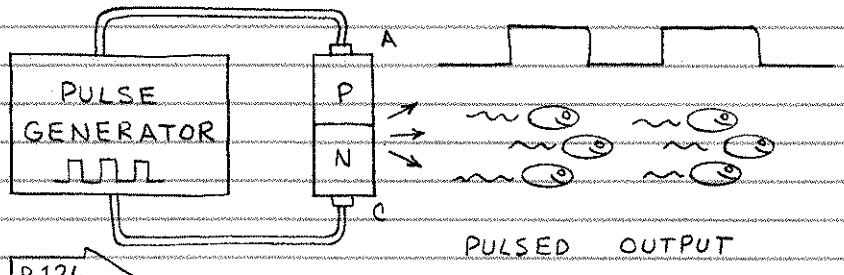
☐ PULSED LED — WHEN OPERATED CONTINUOUSLY, AN INFRARED LED MIGHT HAVE A MAXIMUM CURRENT OF 100-MILLIAMPERES. WHEN DRIVEN BY BRIEF PULSES OF CURRENT, THE SAME LED MAY SAFELY ACCEPT HUGE 10-AMPERE PULSES!

NOTE: A SERIES RESISTOR MAY NOT BE REQUIRED IF THE PULSES DO NOT EXCEED THE MAXIMUM LEVELS SPECIFIED FOR THE LED.



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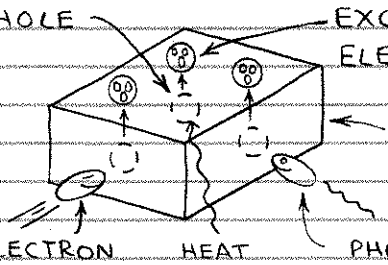
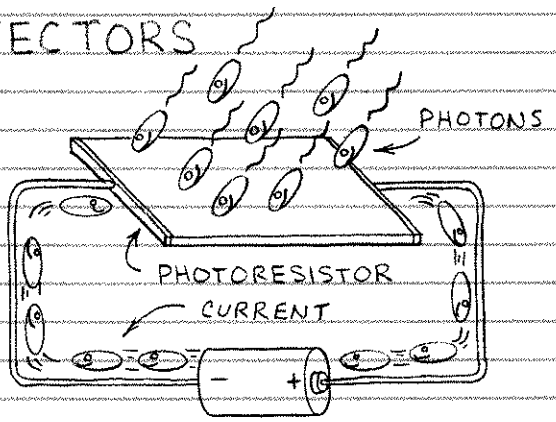
SEMICONDUCTOR LIGHT DETECTORS

ENERGY ENTERING A SEMICONDUCTOR CRYSTAL EXCITES ELECTRONS TO HIGHER LEVELS, LEAVING BEHIND HOLES. THESE ELECTRONS AND HOLES CAN RECOMBINE AND EMIT PHOTONS, OR THEY CAN MOVE AWAY FROM ONE ANOTHER AND FORM A CURRENT. THIS IS THE BASIS OF SEMICONDUCTOR LIGHT DETECTORS. THERE ARE TWO MAJOR CLASSES OF SEMICONDUCTOR LIGHT DETECTORS, THOSE WITH AND THOSE WITHOUT PN JUNCTIONS.

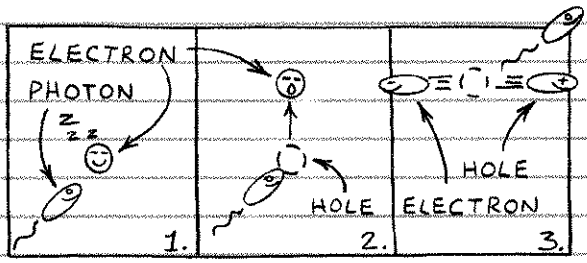


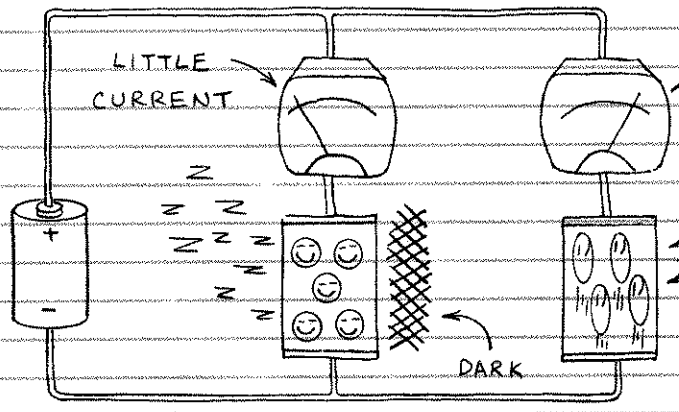
PHOTORESISTIVE LIGHT DETECTORS

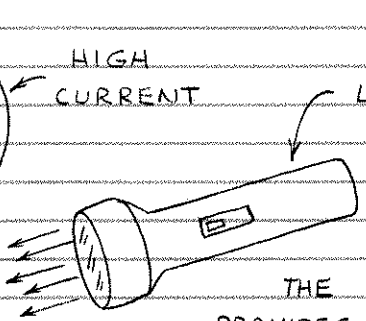
PHOTORESISTORS ARE SEMICONDUCTOR LIGHT DETECTORS WITHOUT A PN JUNCTION. THEIR RESISTANCE IS VERY HIGH (UP TO MILLIONS OF OHMS) WHEN NO LIGHT IS PRESENT. WHEN ILLUMINATED, THEIR RESISTANCE IS VERY LOW (HUNDREDS OF OHMS).



☐ PHOTORESISTOR OPERATION. THIS PANEL SHOWS HOW A PHOTON CREATES A HOLE-ELECTRON PAIR. AN EXTERNAL VOLTAGE WILL FORCE THE HOLE AND ELECTRON TO MOVE.





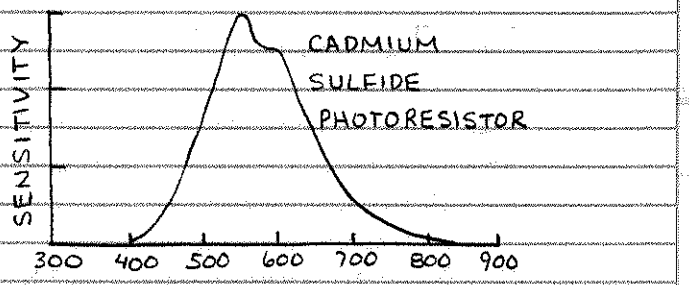


THE BATTERY PROVIDES THE FORCE TO MOVE THE ELECTRONS AND FORM A CURRENT.

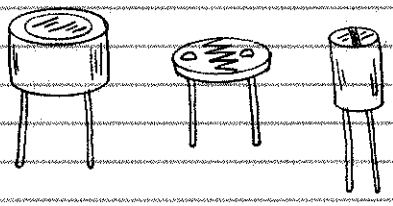
☐ MORE ABOUT PHOTORESISTOR OPERATION — HERE ARE SOME IMPORTANT ASPECTS OF PHOTORESISTOR OPERATION:

1. PHOTORESISTORS MAY REQUIRE A FEW MILLISECONDS OR MORE TO FULLY RESPOND TO A CHANGE IN LIGHT INTENSITY (THAT'S PRETTY SLOW). THEY MAY REQUIRE MANY MINUTES TO RETURN TO THEIR NORMAL DARK RESISTANCE WHEN LIGHT IS REMOVED (THE MEMORY EFFECT).

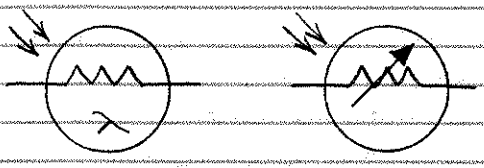
2. THE SEMICONDUCTOR MOST OFTEN USED IN PHOTORESISTORS IS CADMIUM SULFIDE. ITS SENSITIVITY TO LIGHT IS VERY SIMILAR TO THAT OF THE HUMAN EYE! LEAD SULFIDE IS USED TO DETECT INFRA-RED (OUT TO 3-MICROMETERS).



☐ KINDS OF PHOTORESISTORS — MANY DIFFERENT KINDS ARE AVAILABLE. IN MOST THE LIGHT SENSITIVE SEMICONDUCTOR IS COATED BETWEEN INTERLEAVED ELECTRODES TO INCREASE THE EXPOSED SURFACE. A PLASTIC OR GLASS WINDOW MAY OR MAY NOT BE USED.



☐ PHOTORESISTOR SYMBOL. BOTH SYMBOLS SHOWN HERE ARE USED.



HOW PHOTORESISTORS ARE USED

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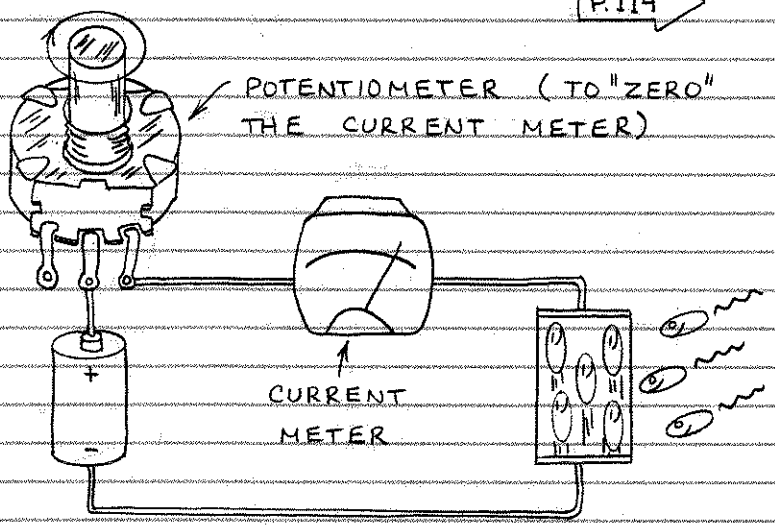
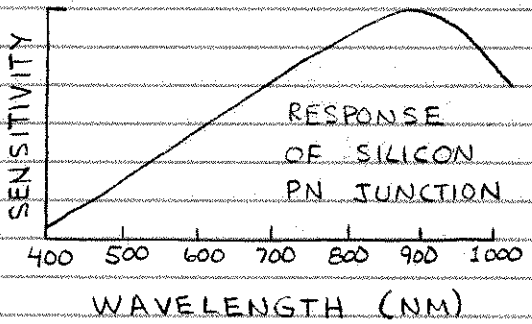
PHOTORESISTORS ARE USED IN LIGHT CONTROLLED RELAYS AND LIGHT METERS.



☐ LIGHT METER. THE ARRANGEMENT SHOWN HERE INDICATES ON A CURRENT METER THE INTENSITY OF LIGHT ILLUMINATING A CADMIUM SULFIDE PHOTORESISTOR.

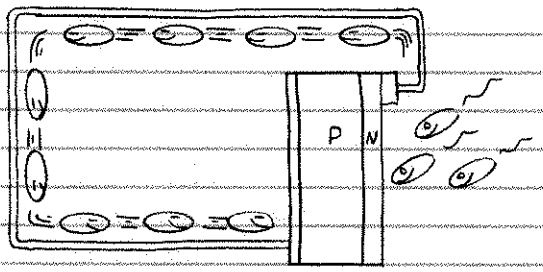
PN JUNCTION LIGHT DETECTORS

PN JUNCTION LIGHT DETECTORS FORM THE LARGEST FAMILY OF PHOTONIC SEMICONDUCTORS. MOST ARE MADE FROM SILICON AND CAN DETECT BOTH VISIBLE LIGHT AND NEAR-INFRARED.

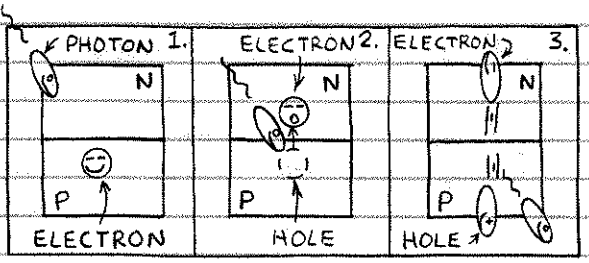


PHOTODIODES

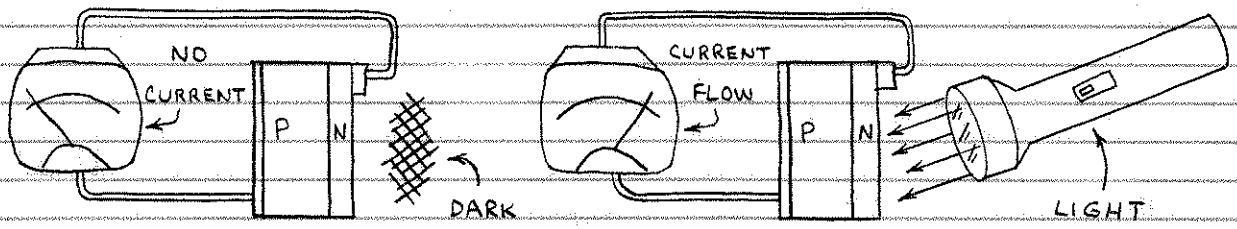
ALL PN JUNCTIONS ARE LIGHT SENSITIVE. PHOTODIODES ARE PN JUNCTIONS SPECIFICALLY DESIGNED FOR LIGHT DETECTION. THEY ARE USED IN CAMERAS, INTRUSION ALARMS, LIGHTWAVE COMMUNICATORS, ETC.

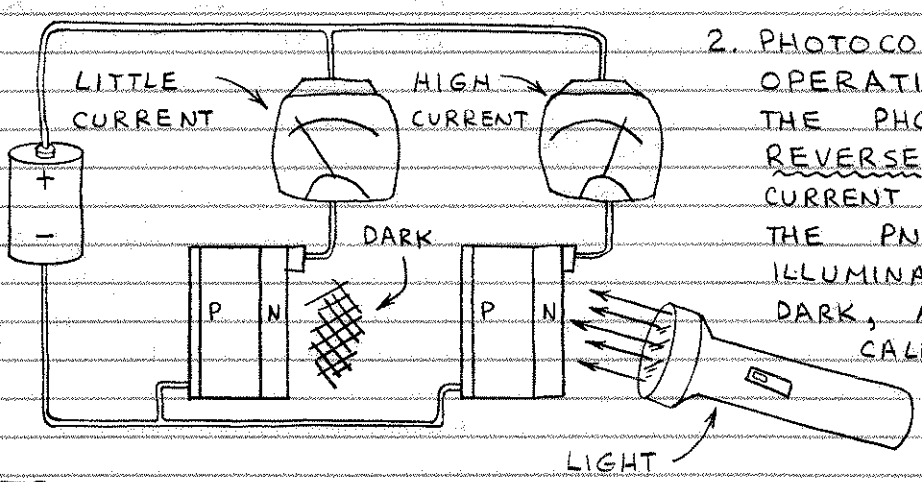


☐ PHOTODIODE OPERATION. A PHOTON WILL CREATE A HOLE-ELECTRON PAIR AT A PN JUNCTION. A CURRENT WILL FLOW IF THE TWO SIDES OF THE JUNCTION ARE CONNECTED. TWO OPERATING MODES ARE POSSIBLE:



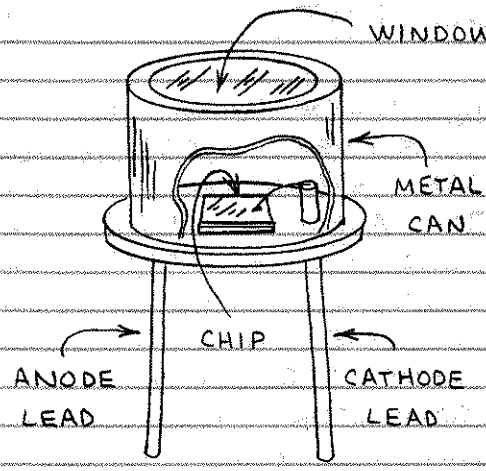
1. PHOTOVOLTAIC OPERATION — HERE THE PHOTODIODE BECOMES A CURRENT SOURCE WHEN IT IS ILLUMINATED.





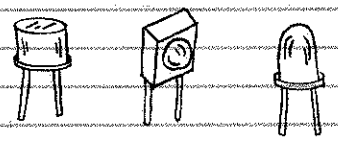
2. PHOTOCONDUCTIVE OPERATION — HERE THE PHOTODIODE IS REVERSE-BIASED. A CURRENT FLOWS WHEN THE PN JUNCTION IS ILLUMINATED. (WHEN DARK, A TINY CURRENT CALLED THE DARK CURRENT WILL FLOW.)

☐ KINDS OF PHOTODIODES.
SHOWN HERE IS A TYPICAL PHOTODIODE. MANY OTHER CASE STYLES ARE ALSO USED (PLASTIC HOUSING, BUILT-IN LENSES AND FILTERS, ETC.). THE MOST IMPORTANT DISTINCTION IS THE SIZE OF THE SEMICONDUCTOR CHIP. SPECIALIZED CHIP DESIGNS MAY BE USED TO GIVE BETTER RESPONSE TO CERTAIN WAVELENGTHS OF LIGHT.



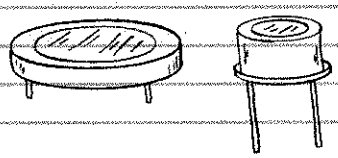
FAMOUS FACT: LEDs CAN BOTH EMIT AND DETECT LIGHT!

SMALL AREA PHOTODIODES.



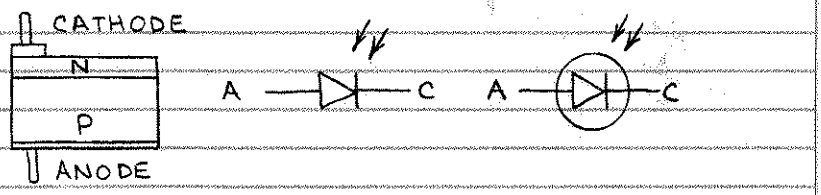
THESE PHOTODIODES HAVE VERY FAST RESPONSE TIMES WHEN USED IN THE REVERSE-BIASED PHOTOCONDUCTIVE MODE.

LARGE AREA PHOTODIODES.



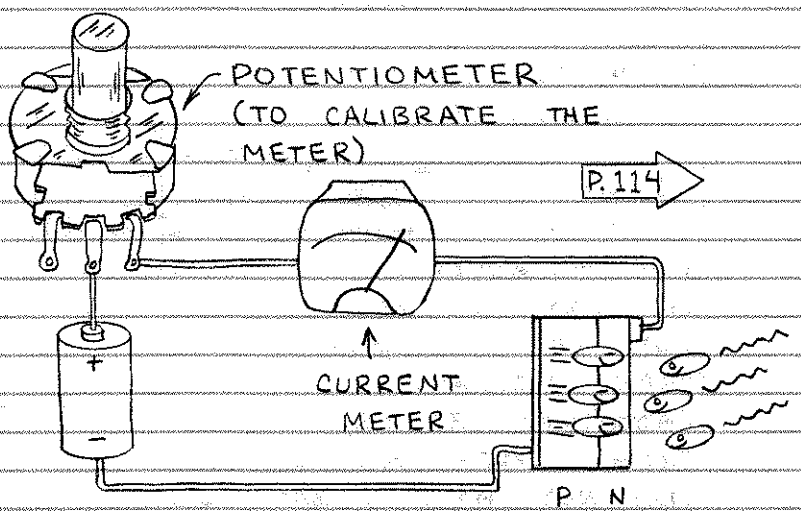
THOUGH SLOWER RESPONDING THAN SMALL AREA PHOTODIODES, THEIR LARGE AREA PROVIDES HIGH SENSITIVITY.

☐ PHOTODIODE SYMBOL.
BOTH SYMBOLS SHOWN HERE ARE USED.



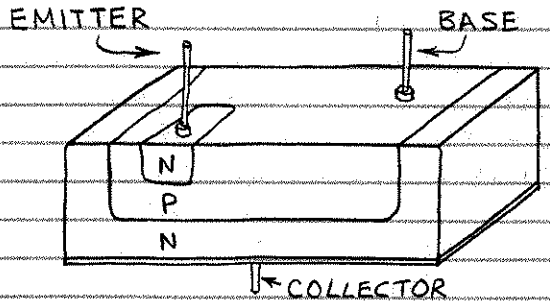
HOW PHOTODIODES ARE USED

PHOTODIODES ARE COMMONLY USED TO DETECT FAST PULSES OF NEAR INFRARED (AS IN LIGHTWAVE COMMUNICATIONS).

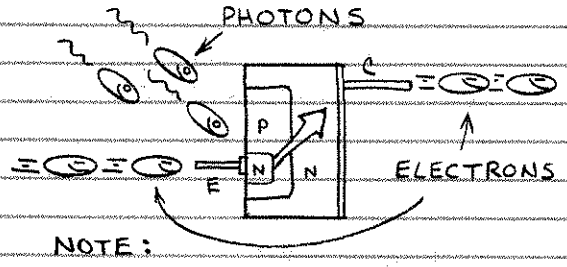


☐ LIGHT METER.
THIS ARRANGEMENT PROVIDES A BASIC PHOTOCONDUCTIVE MODE LIGHT METER. ITS RESPONSE IS VERY LINEAR.

PHOTOTRANSISTORS



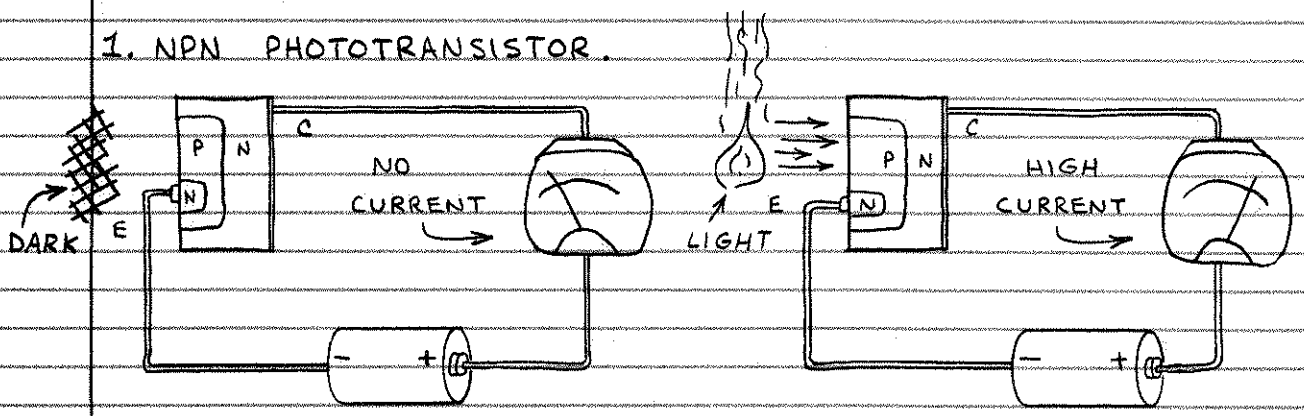
ALL TRANSISTORS ARE LIGHT SENSITIVE. PHOTOTRANSISTORS ARE SPECIFICALLY DESIGNED TO TAKE ADVANTAGE OF THIS IMPORTANT PROPERTY. LIGHT SENSITIVE FETs ARE AVAILABLE, BUT THE MOST COMMON PHOTO-TRANSISTOR IS AN NPN JUNCTION TRANSISTOR WITH A LARGE, EXPOSED BASE REGION. PHOTONS ENTERING THE BASE REPLACE THE BASE-EMITTER CURRENT OF ORDINARY NPN TRANSISTORS. THEREFORE A PHOTOTRANSISTOR DIRECTLY AMPLIFIES VARIATIONS IN THE NUMBER OF PHOTONS.



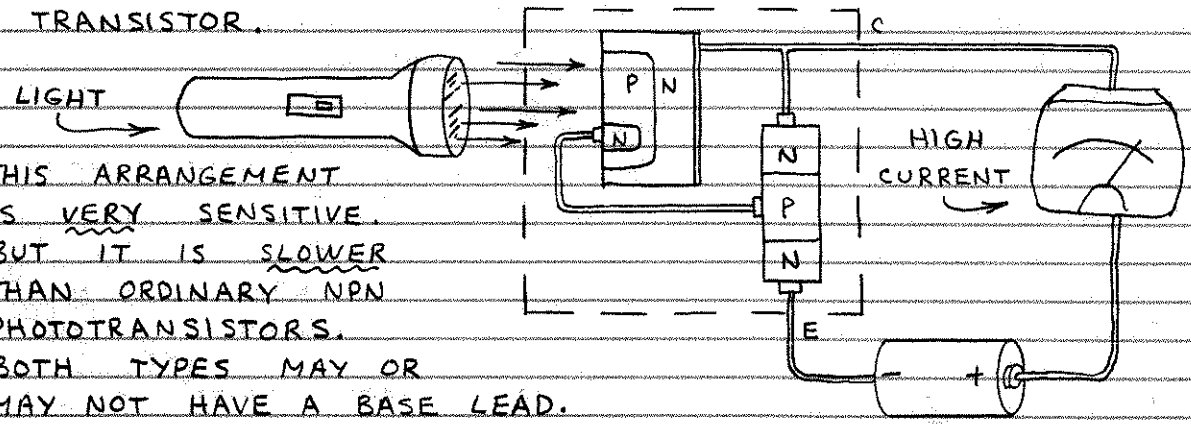
NOTE:
BASE LEAD IS OPTIONAL.

☐ NPN PHOTOTRANSISTOR OPERATION— TWO TYPES OF NPN PHOTOTRANSISTORS ARE AVAILABLE. ONE IS AN NPN TRANSISTOR AS SHOWN ABOVE. THE OTHER INCLUDES A SECOND NPN TRANSISTOR TO PROVIDE MORE AMPLIFICATION.

1. NPN PHOTOTRANSISTOR.

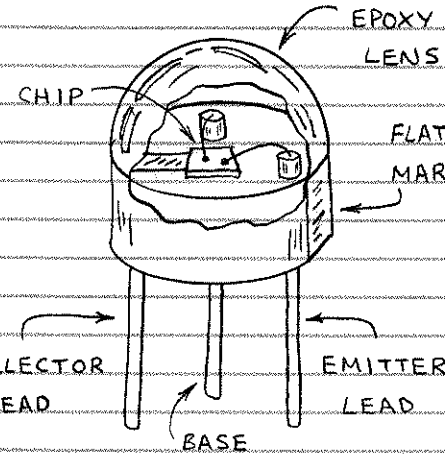


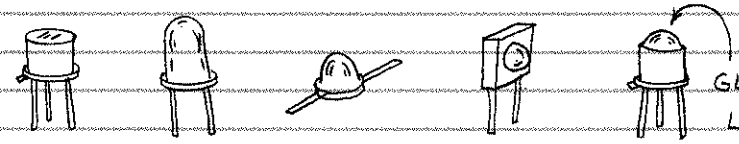
2. PHOTODARLINGTON TRANSISTOR.



THIS ARRANGEMENT IS VERY SENSITIVE. BUT IT IS SLOWER THAN ORDINARY NPN PHOTOTRANSISTORS. BOTH TYPES MAY OR MAY NOT HAVE A BASE LEAD.

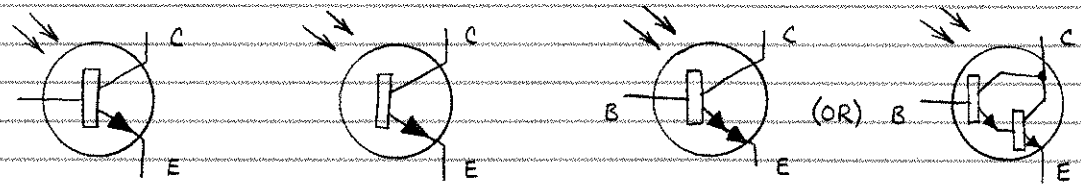
☐ KINDS OF PHOTOTRANSISTORS. SHOWN HERE IS A TYPICAL LOW COST NPN PHOTOTRANSISTOR. MANY OTHER CASE STYLES ARE ALSO USED (METAL CANS, GLASS LENSES, FLAT WINDOWS, ETC.). IMPORTANT: THE BASE LEAD MAY OR MAY NOT BE PRESENT. MANY PHOTOTRANSISTOR CIRCUITS DO NOT USE THE BASE CONNECTION.





THESE ARE TYPICAL PHOTOTRANSISTORS.

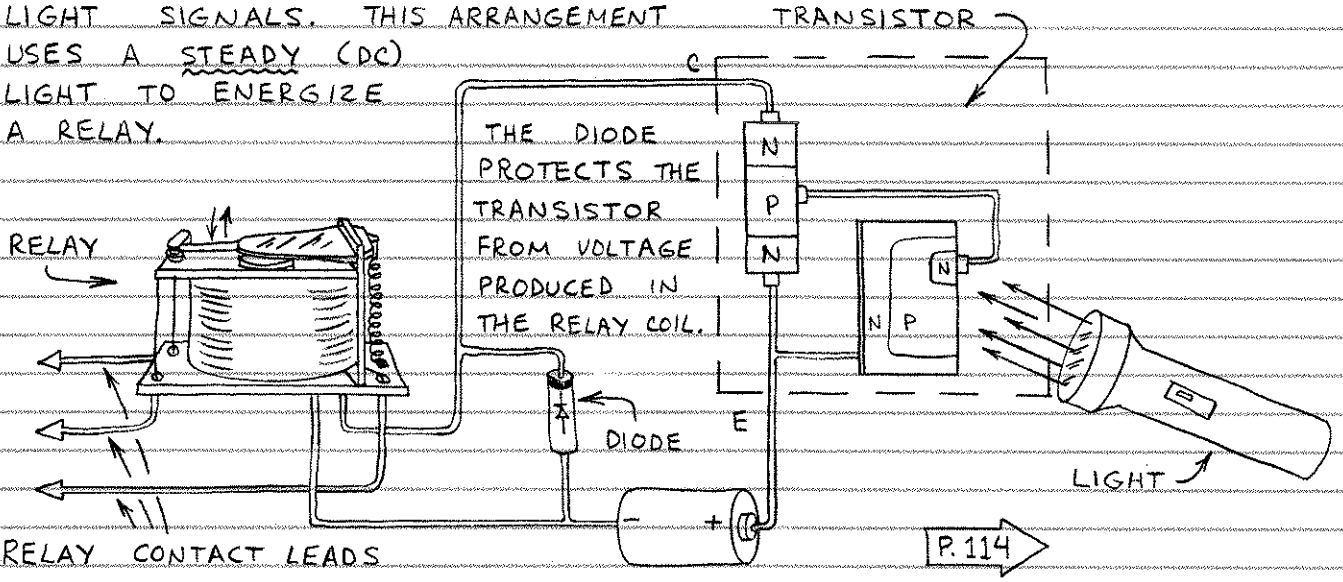
☐ PHOTOTRANSISTOR SYMBOLS.



NPN NPN (NO BASE LEAD) PHOTODARLINGTONS

HOW PHOTOTRANSISTORS ARE USED

PHOTOTRANSISTORS ARE OFTEN USED TO DETECT FLUCTUATING (AC) LIGHT SIGNALS. THIS ARRANGEMENT USES A STEADY (DC) LIGHT TO ENERGIZE A RELAY.



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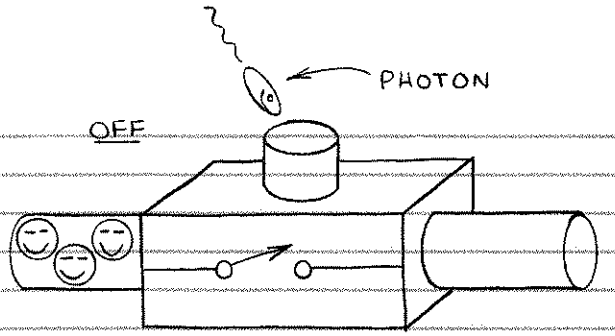
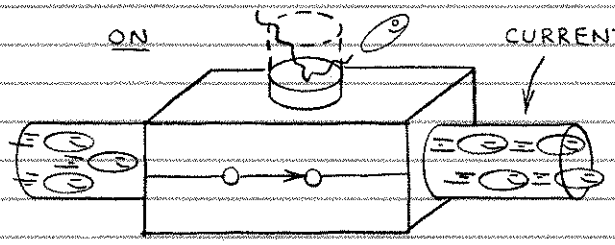
PHOTOTHYRISTORS

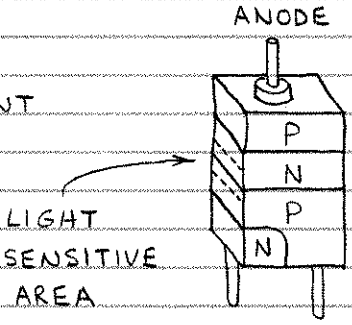


PHOTOTHYRISTORS ARE VARIOUS KINDS OF LIGHT-ACTIVATED THYRISTORS. YOU CAN THINK OF THEM AS LIGHT-ACTIVATED SWITCHES. THE MOST IMPORTANT MEMBER OF THE FAMILY IS THE LIGHT-ACTIVATED SILICON CONTROLLED RECTIFIER (LASCR). LIGHT ACTIVATED TRIACS ARE ALSO MADE. NEITHER CAN SWITCH AS MUCH CURRENT AS CONVENTIONAL THYRISTORS.

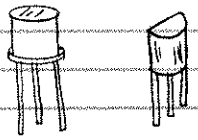


LIGHT ACTIVATED SCRs (LASCRs)

TO IMPROVE THEIR SENSITIVITY TO LIGHT, THE LASCR IS MADE THINNER THAN STANDARD SCRs. THIS LIMITS THE AMOUNT OF CURRENT THEY CAN SWITCH. FOR HIGH CURRENT APPLICATIONS A LASCR CAN BE USED TO TRIGGER A CONVENTIONAL SCR.

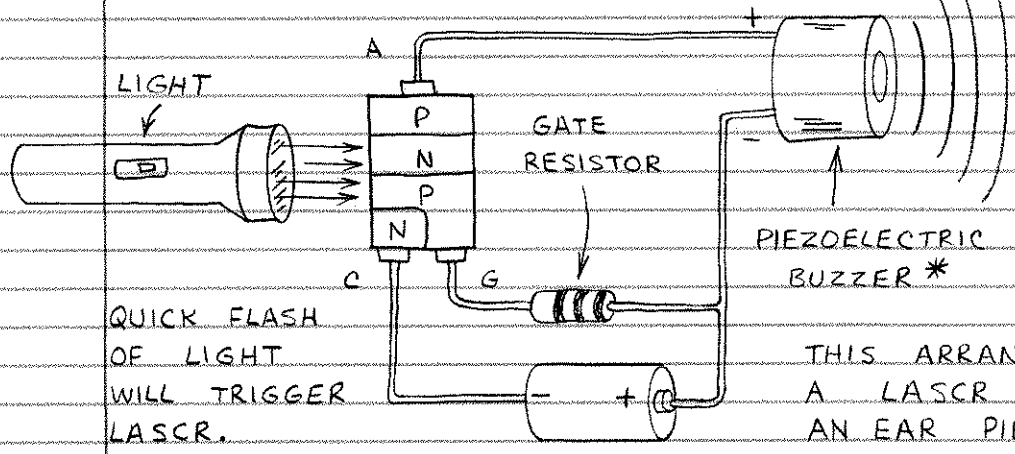


☐ KINDS OF LASCRs.



MOST LASCRs CAN SWITCH UP TO A FEW HUNDRED VOLTS. MAXIMUM CURRENT IS ONLY A FEW TENTHS OF AN AMPERE.

HOW LASCRs ARE USED



* ONCE TRIGGERED, BUZZER REMAINS ON UNTIL POWER IS INTERRUPTED.

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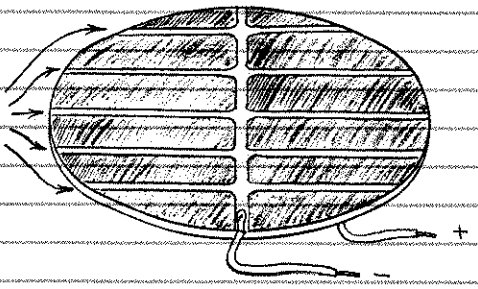
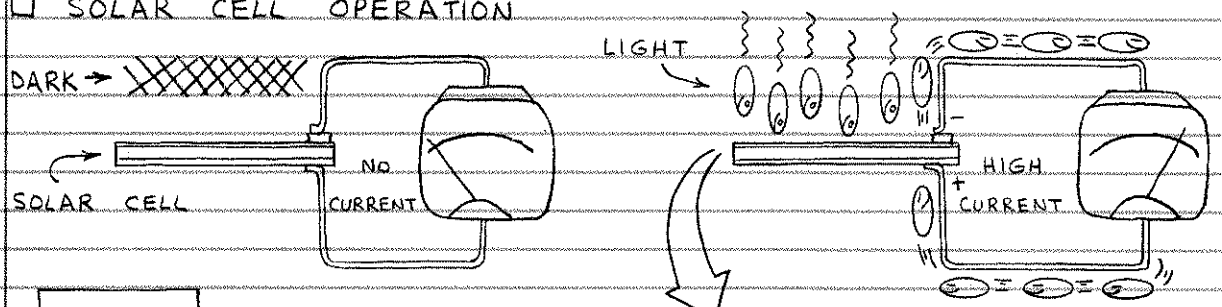
SOLAR CELLS

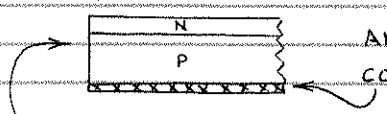
SOLAR CELLS ARE PN JUNCTION PHOTODIODES WITH AN EXCEPTIONALLY LARGE LIGHT SENSITIVE AREA. A SINGLE SILICON SOLAR CELL GENERATES 0.5 VOLT IN BRIGHT SUNLIGHT.



☐ SOLAR CELL OPERATION

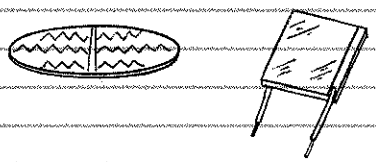


A CELL THIS SIZE GENERATES 0.1 AMPERE* * IN BRIGHT SUNLIGHT.



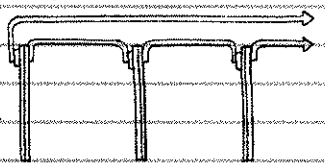
SILICON CELLS MAY BE P ON N.

☐ KINDS OF SOLAR CELLS.

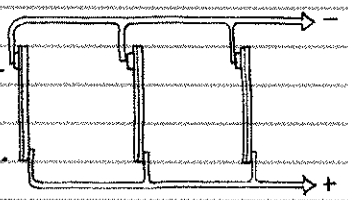


MANY DIFFERENT KINDS OF SILICON SOLAR CELLS ARE MADE. OFTEN INDIVIDUAL CELLS ARE CONNECTED IN SERIES OR PARALLEL.

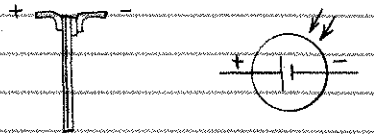
SERIES: OUTPUT VOLTAGE IS SUM OF CELL VOLTAGES.



PARALLEL: OUTPUT CURRENT IS SUM OF CELL CURRENTS.



☐ SOLAR CELL SYMBOL.



REMEMBER, CELLS MAY BE P ON N.

HOW SOLAR CELLS ARE USED

ARRAYS OF SOLAR CELLS CAN CHARGE RECHARGEABLE CELLS AND BATTERIES.

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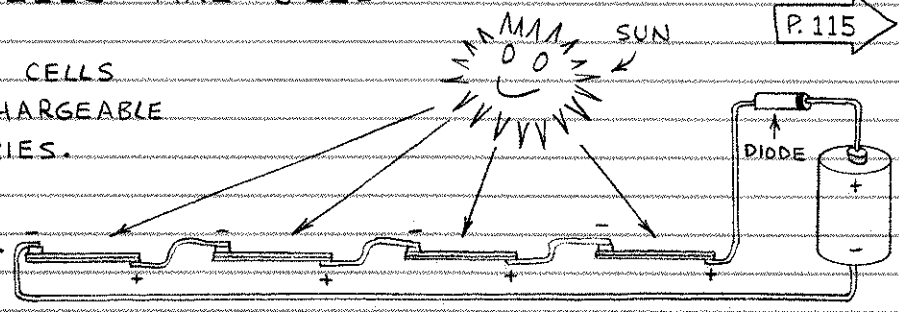
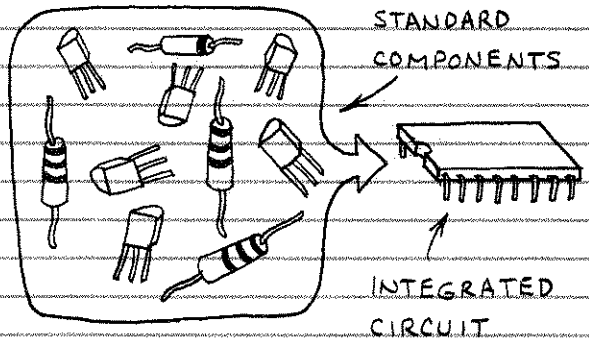


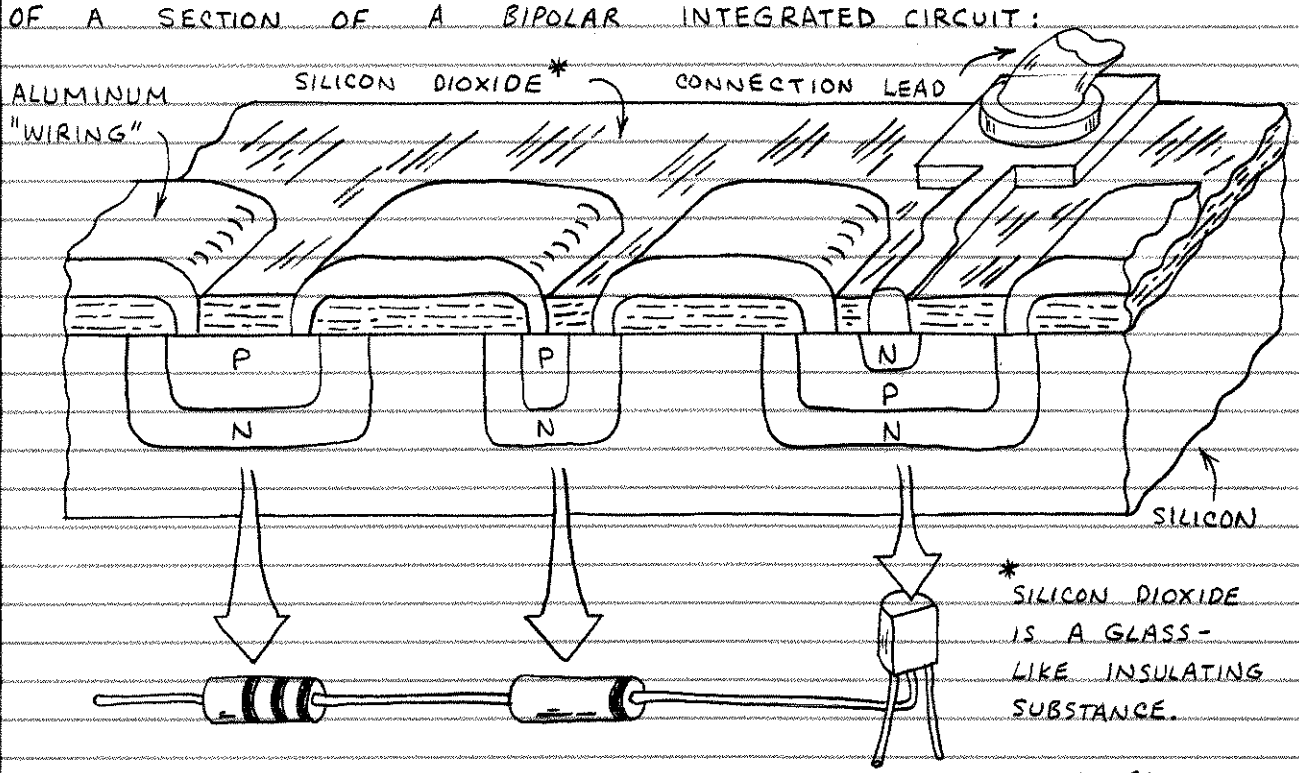
SERIES CONNECTED SOLAR CELL ARRAY

5. INTEGRATED CIRCUITS

ELECTRONIC CIRCUITS CAN BE MADE BY SIMULTANEOUSLY FORMING INDIVIDUAL TRANSISTORS, DIODES AND RESISTORS ON A SMALL CHIP OF SILICON. THE COMPONENTS ARE CONNECTED TO ONE ANOTHER WITH ALUMINUM "WIRES" DEPOSITED ON THE SURFACE OF THE CHIP. THE RESULT IS AN INTEGRATED CIRCUIT.



INTEGRATED CIRCUITS (OR IC's) CAN CONTAIN AS FEW AS SEVERAL TO AS MANY AS HUNDREDS OF THOUSANDS OF TRANSISTORS. THEY HAVE MADE POSSIBLE VIDEO GAMES, DIGITAL WATCHES, AFFORDABLE COMPUTERS AND MANY OTHER VERY SOPHISTICATED PRODUCTS. HERE'S A SIMPLIFIED AND HIGHLY MAGNIFIED VIEW OF A SECTION OF A BIPOLAR INTEGRATED CIRCUIT:



*SILICON DIOXIDE IS A GLASS-LIKE INSULATING SUBSTANCE.

RESISTOR — A SMALL SECTION OF P-TYPE SILICON FORMS A RESISTOR.

DIODE — A PN JUNCTION FORMS A DIODE.

TRANSISTOR — A PAIR OF PN JUNCTIONS FORMS AN NPN TRANSISTOR

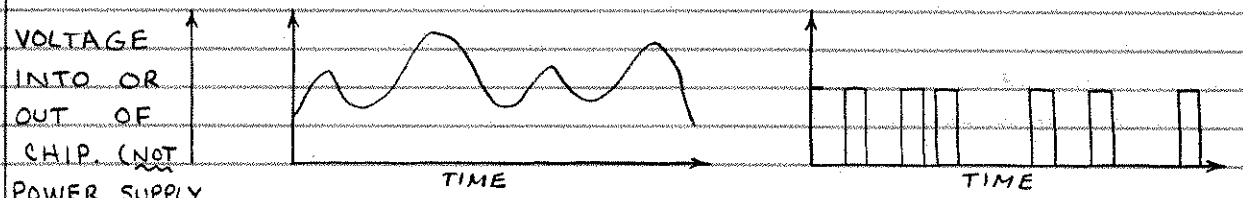
OF COURSE THE CONVENTIONAL COMPONENTS SHOWN BELOW THE HIGHLY MAGNIFIED SECTION OF THE IC ARE NOT DRAWN TO THE SAME SCALE. FOR EXAMPLE, ONE KIND OF IC INCLUDES 262,144 TRANSISTORS ON A SILICON CHIP ONLY ABOUT 1/4 INCH SQUARE!

☐ KINDS OF INTEGRATED CIRCUITS — INTEGRATED CIRCUITS ARE GROUPED INTO TWO MAJOR CATEGORIES:

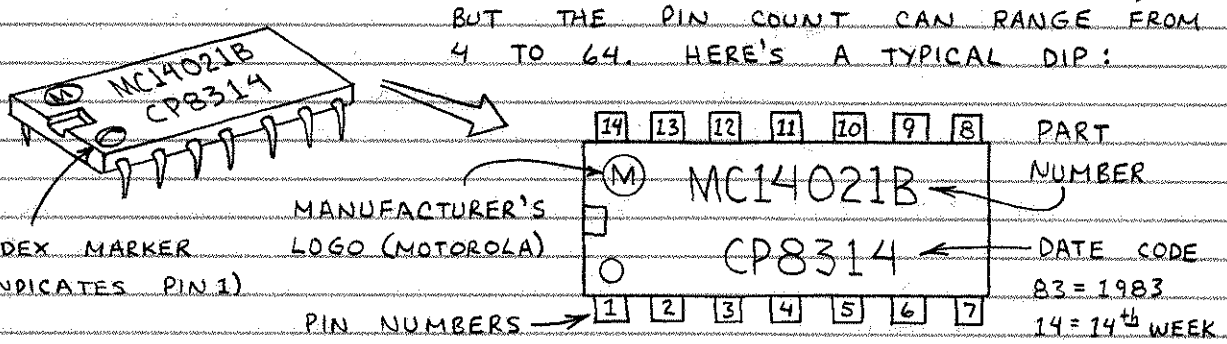
1. ANALOG (OR LINEAR) IC's PRODUCE, AMPLIFY OR RESPOND TO VARIABLE VOLTAGES. ANALOG IC's INCLUDE MANY KINDS OF AMPLIFIERS, TIMERS, OSCILLATORS AND VOLTAGE REGULATORS.

2. DIGITAL (OR LOGIC) IC's RESPOND TO OR PRODUCE SIGNALS HAVING ONLY TWO VOLTAGE LEVELS. DIGITAL IC's INCLUDE MICROPROCESSORS, MEMORIES, MICROCOMPUTERS AND MANY KINDS OF SIMPLER CHIPS.

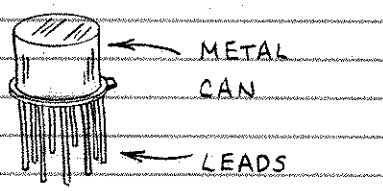
SOME IC's COMBINE ANALOG AND DIGITAL FUNCTIONS ON A SINGLE CHIP. FOR EXAMPLE, A DIGITAL CHIP MAY INCLUDE A BUILT-IN ANALOG VOLTAGE REGULATOR SECTION. AND AN ANALOG TIMER CHIP MAY INCLUDE AN ON-CHIP DIGITAL COUNTER TO GIVE MUCH LONGER TIME DELAYS THAN POSSIBLE WITH THE TIMER ALONE.



☐ KINDS OF INTEGRATED CIRCUIT PACKAGES — IC CHIPS ARE SUPPLIED IN MANY DIFFERENT PACKAGES. BY FAR THE MOST COMMON ARE VARIATIONS OF THE DUAL IN-LINE PACKAGE (OR DIP). THE DIP IS MADE FROM PLASTIC (CHEAP) OR CERAMIC (MORE ROBUST). MOST DIPs HAVE 14 OR 16 PINS, BUT THE PIN COUNT CAN RANGE FROM 4 TO 64. HERE'S A TYPICAL DIP:



ANOTHER IC PACKAGE IS THE TO-5 METAL CAN. THOUGH VERY STURDY, IT'S BEING REPLACED IN MANY CASES BY CHEAPER PLASTIC DIPs.



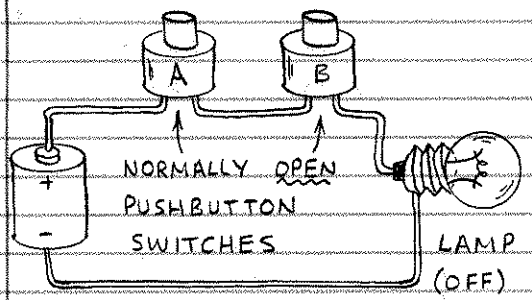
6. DIGITAL INTEGRATED CIRCUITS

NO MATTER HOW COMPLICATED, ALL DIGITAL INTEGRATED CIRCUITS ARE MADE FROM SIMPLE BUILDING BLOCKS CALLED GATES. GATES ARE LIKE ELECTRONICALLY CONTROLLED SWITCHES. THEY ARE EITHER ON OR OFF. HOW DO GATES WORK? LET'S START WITH THE BASICS...

MECHANICAL SWITCH GATES

THE THREE SIMPLEST GATES CAN BE DEMONSTRATED WITH SOME PUSHBUTTON SWITCHES, A BATTERY AND A LAMP.

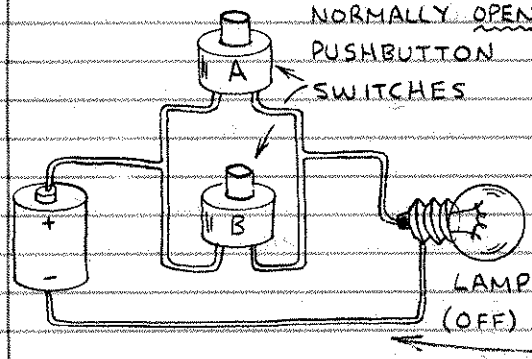
☐ SWITCH "AND" GATE.



THE LAMP GLOWS ONLY WHEN SWITCHES A AND B ARE CLOSED. THE TABLE SUMMARIZES THE GATE'S OPERATION. IT'S CALLED A TRUTH TABLE.

	A	B	OUT
OPEN SWITCH = OFF	OFF	OFF	OFF
CLOSED SWITCH = ON	OFF	ON	OFF
	ON	OFF	OFF
ALL POSSIBLE	ON	ON	ON
ON-OFF COMBINATIONS			

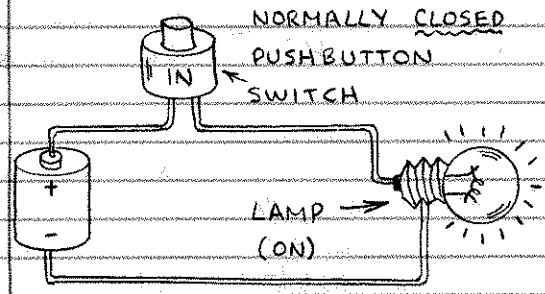
☐ SWITCH "OR" GATE.



THE LAMP GLOWS ONLY WHEN SWITCH A OR SWITCH B OR BOTH SWITCHES A AND B ARE CLOSED. HERE'S THE TRUTH TABLE:

THE SWITCHES	A	B	OUT
ARE THE GATE'S	OFF	OFF	OFF
INPUTS. THE LEAD	OFF	ON	ON
WITHOUT SWITCHES	ON	OFF	ON
IS THE COMMON	ON	ON	ON
OR GROUND LEAD.			

☐ SWITCH "NOT" GATE.



THE LAMP NORMALLY GLOWS. ONLY WHEN THE SWITCH IS OPENED IS THE LAMP OFF. IN OTHER WORDS, THE "NOT" GATE REVERSES (INVERTS) THE USUAL ACTION OF A SWITCH. HERE'S THE TRUTH TABLE:

THE "NOT" GATE IS	IN	OUT
USUALLY CALLED THE	OFF	ON
INVERTER.	ON	OFF