

WE LIVE SURROUNDED BY AN ENERGY FIELD OF EFFECTIVELY UNLIMITED POWER. WE CAN ACCESS THAT POWER FOR OUR OWN USE IN TWENTY DIFFERENT WAYS. A COPY OF THIS BRIEF INTRODUCTION CAN BE DOWNLOADED FREE FROM:

<http://www.free-energy-info.com/Lighting.pdf>

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FREE-ENERGY MEANS DRAWING POWER FROM SOURCES FOR WHICH WE DO NOT HAVE TO PAY. DAYLIGHT AND SUNSHINE ARE THOUGHT OF AS BEING “RENEWABLE” ENERGY AND THAT IS A COMMON ERROR AS THEY COME FROM THE ZERO-POINT ENERGY FIELD, OR AS SOME PREFER TO CALL IT “THE AMBIENT BACKGROUND ENERGY”.

A COMMON MISCONCEPTION IS THAT SOLAR PANELS ARE ONLY FOR RICH PEOPLE AS THE PANELS ARE VERY EXPENSIVE. WHILE THERE IS SOME TRUTH IN THAT, IT CERTAINLY DOES NOT MEAN THAT SOLAR PANELS ARE NOT VERY USEFUL, READILY AVAILABLE DEVICES.

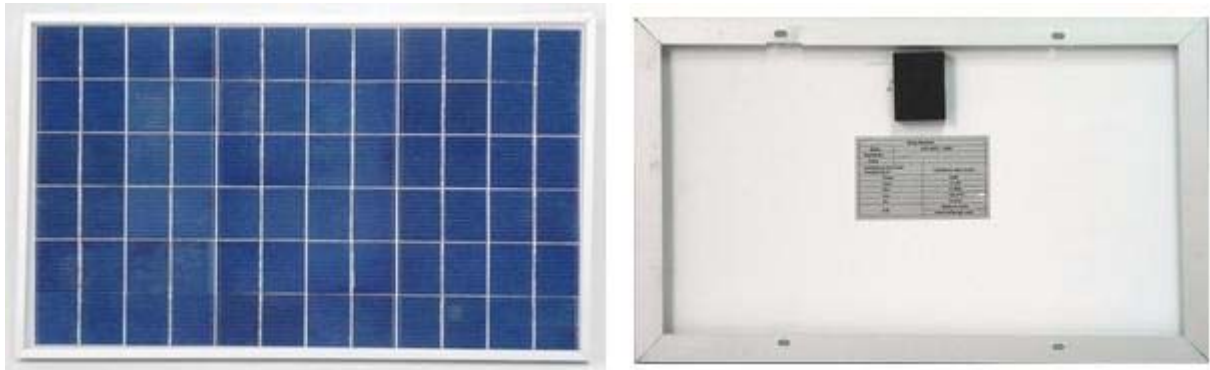


THIS SIMPLE INSTALLATION HAS 21 PANELS AND THE COST OF THOSE PANELS IS HIGH, NOT TO MENTION THE COST OF MOUNTING THEM AND WIRING THEM. HOWEVER, WE CAN DO A GOOD DEAL WITH A LOW-COST ALTERNATIVE.

A SOLAR PANEL IS A VERY LOW-EFFICIENCY DEVICE WITH THE BEST BEING ONLY 17% EFFICIENT – THAT IS, ONLY 17% OF THE LIGHT ENERGY REACHING THE PANEL IS CONVERTED TO ELECTRICITY. BUT FROM AN ENERGY POINT OF VIEW, THAT 17% EFFICIENT SOLAR PANEL HAS A COEFFICIENT OF PERFORMANCE (“COP”) OF INFINITY BECAUSE YOU DON’T HAVE TO SUPPLY ANY INPUT ENERGY SINCE THE LIGHT ARRIVES ALL ON ITS OWN AND DOES NOT DEPEND ON YOU.

SO, WE ARE BEING OFFERED SOLAR PANELS WITH INFINITE COP AND SOME OF THEM ARE VERY REASONABLY PRICED. HOWEVER, NOT ALL SOLAR PANELS ARE THE SAME EVEN THOUGH THE SELLERS MAY DESCRIBE THEM THE SAME WAY. THE DIFFERENCE IS THE NUMBER OF SOLAR CELL MODULES WHICH ARE CONNECTED TOGETHER TO GIVE THE OUTPUT. A GOOD PANEL WILL GIVE THE RATED OUTPUT IN POOR LIGHT WHILE A POOR PANEL HAS TO HAVE BRIGHT

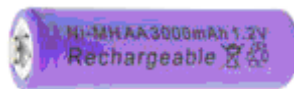
SUNLIGHT TO DO THAT, AND THAT IS A MAJOR DIFFERENCE WHEN YOU ARE USING THEM. THIS PANEL IS 337 x 205 x 18 mm IN SIZE AND IS A GOOD DESIGN :



THIS PRESENTATION IS ABOUT PRODUCING GOOD LIGHTING FROM A SOLAR PANEL. BUT UNFORTUNATELY, WE WANT LIGHTING WHEN THERE IS NO DAYLIGHT OR SUNSHINE. THEREFORE WE HAVE TO STORE ELECTRICAL ENERGY IN SOME FORM OF STORAGE DEVICE – SUPERCAPS OR BATTERIES. BECAUSE OF COST, WE WILL OPT FOR BATTERIES.

A VERY WELL KNOWN BATTERY IS THE LEAD-ACID BATTERY, BUT IT IS NOT A GREAT CHOICE FOR THIS TASK AS IT IS EXPENSIVE, VERY HEAVY AND IT IS ONLY 50% EFFICIENT, IN OTHER WORDS, IT WASTES HALF OF ALL OF THE ELECTRICITY THAT YOU PUT INTO IT, AND THAT IS PATHETIC.

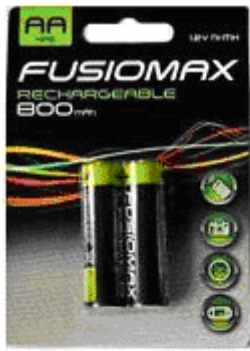
LITHIUM BATTERIES ARE EXCELLENT BUT THEY HAVE CHARGING PROBLEMS AND ARE TOO EXPENSIVE FOR THIS PROJECT. SURPRISINGLY, THE MOST SUITABLE BATTERY APPEARS TO BE THE SMALL, LIGHT, CHEAP NICKEL-MANGANESE (“NiMh”) BATTERY :



THESE ARE AVAILABLE IN CAPACITIES UP TO 2.85 AMP-HOURS, AND THEY CAN BE USED IN BATTERY BOXES LIKE THIS :



THESE BOXES ALLOW ALMOST ANY BATTERY VOLTAGE TO BE PROVIDED. HOWEVER, PLEASE DON'T BE FOOLED BY WHAT THE SELLER SAYS. I HAVE RUN TESTS ON THESE BATTERIES :



Fusiomax 800



Digimax 2850



Duracell 2400



SDNMY 3800

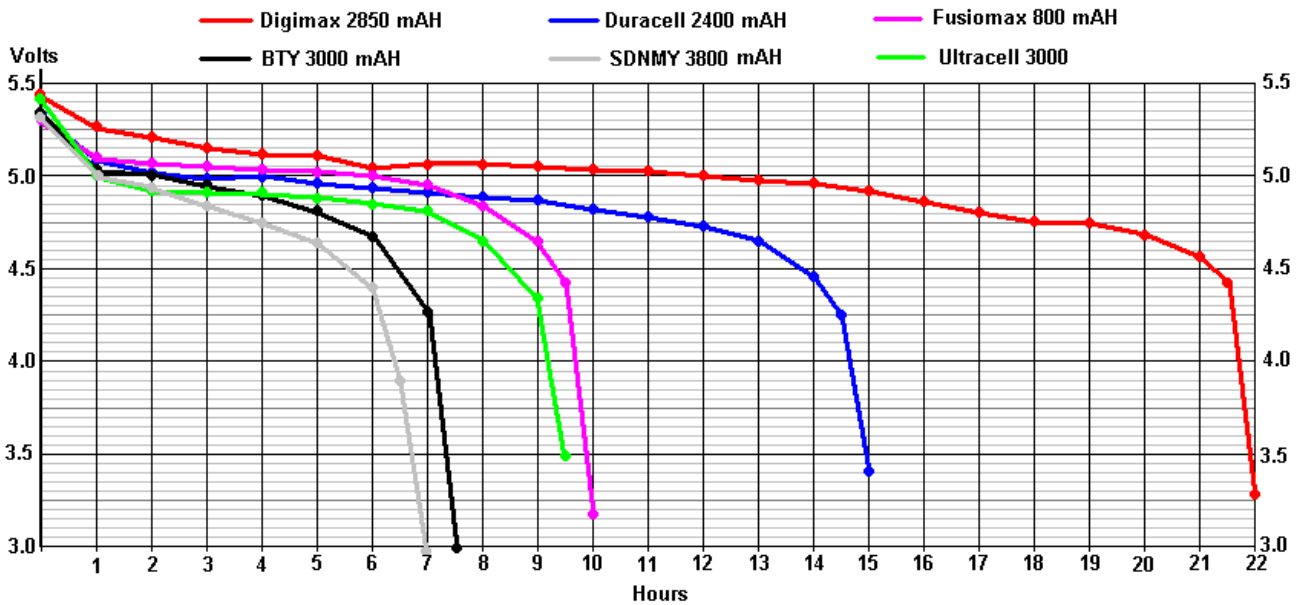


BTY 3000



Ultracell 3000

AND LOOKING AT THE PACKAGING, YOU WOULD EXPECT THE SDNMY 3800 TO BE THE MOST EFFECTIVE, BUT HERE ARE THE RESULTS OF A CONTINUOUS 50 MILLIAMPER CURRENT DRAW WITH A 4-BATTERY PACK :



THE VERY CHEAP 50-PENCE FUSIOMAX “800 MILLIAMPER-HOUR” BATTERIES FROM POUNDLAND REMAINED ABOVE 4.5 VOLTS FOR MORE THAN 9 HOURS WITH ONLY TWO OTHER BATTERIES DOING BETTER THAN THAT (THE DURACELL 2400 AND THE DIGIMAX 2850). THE IMPRESSIVELY PACKAGED “SDNMY 3000” BATTERIES WERE PATHETIC, NOT EVEN REACHING 6 HOURS. NONE OF THE BATTERIES MARKED “3000” WERE AS GOOD AS THE CHEAP 800 mAHr BATTERIES. SO, YOU NEED TO BE VERY CAREFUL WHAT BATTERIES YOU BUY.

NICKEL-MANGANESE BATTERIES ARE 66% EFFICIENT, THAT IS, THEY WASTE ONE THIRD OF THE ELECTRICITY THAT YOU FEED INTO THEM WHEN CHARGING THEM. ALSO, THE MAXIMUM RATE OF CHARGE FOR A 3000 mAhr NICKEL-MANGANESE BATTERY IS 300 MILLIAMPS, AND THAT NEEDS TO BE PAID ATTENTION TO WHEN DESIGNING A LIGHTING SYSTEM.

TESTS WHICH I HAVE RUN SHOW THAT A VERY REALISTIC LEVEL OF 1000-LUX LIGHTING CAN BE PROVIDED WITH JUST 1.5 WATTS OF ELECTRICAL INPUT. THE BEST SOURCE OF LIGHTING WHICH I HAVE FOUND IS THE G4 STYLE, LED ARRAYS OF THE "5050" CHIP TECHNOLOGY. THESE ARE CHEAP AND HAVE A VERY HEAVILY NON-LINEAR LIGHT OUTPUT FOR ANY GIVEN ELECTRICAL INPUT AND THAT IS A FACT THAT WE CAN USE TO OUR ADVANTAGE. THEY COME IN "COLD WHITE" OR "WARM WHITE" VERSIONS AND THOSE CAN BE MIXED TO GIVE A WIDER LIGHTING FREQUENCY IF YOU WISH. THEY LOOK LIKE THIS :



WITH A DIAMETER OF 30 mm AND PINS WHICH ARE EASY TO CONNECT TO, THESE ARE VERY CONVENIENT DEVICES WITH AN EXCELLENT LIGHTING ANGLE OF 160 DEGREES AND A LIGHT OUTPUT OF 165 LUMENS FOR 1.2 WATTS OF ELECTRICAL INPUT.

HUMAN EYES ARE VERY BAD AT ASSESSING LIGHTING LEVELS AS THEY HAVE AUTOMATIC LIGHT SENSITIVITY ADJUSTMENT. USING TWO LED ARRAYS SIDE BY SIDE IN A LIGHT BOX CONTAINING A LIGHT METER GIVES SOME VERY INTERESTING, VOLTAGE/CURRENT DRAW/ LIGHT PRODUCED RESULTS WHEN USING 1.2 VOLT NiMH BATTERIES :

9 batteries 11.7V 206 mA 1133 lux: 2.41 watts 470 lux per watt
(the manufacturer's intended performance)

8 batteries 10.4V 124 mA 725 lux 1.29 watts 562 lux per watt

7 batteries 9.1V 66 mA 419 lux 0.60 watts 697 lux per watt (a very realistic performance level)

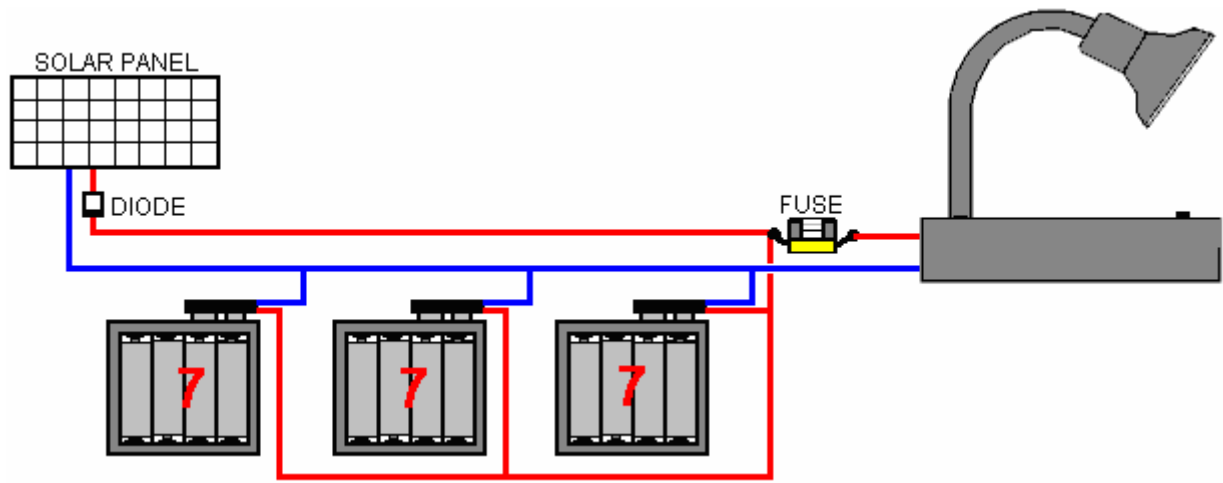
6 batteries 7.8V 6 mA 43 lux 0.0468 watts 918 lux per watt

THIS SHOWS THAT ONE OF THESE LED ARRAYS FED WITH JUST 33 MILLIAMPS CAN PRODUCE VERY IMPRESSIVE 210 LUX LIGHTING AT A WIDE ANGLE OF ILLUMINATION. TO PUT THAT ANOTHER WAY, FEEDING FIVE LED ARRAYS WITH 9 VOLTS GENERATES A VERY ACCEPTABLE 1000 LUX LIGHTING LEVEL FOR JUST 165 MILLIAMPS, WHICH IS ONLY 1.5 WATTS. THAT IS SPECTACULAR PERFORMANCE.

EQUALLY IMPRESSIVE IS THE FACT THAT AS THE BATTERY VOLTAGE DROPS, THE LED ARRAY LIGHT OUTPUT EFFICIENCY RISES AND EVEN AT THE RIDICULOUSLY LOW 3 MILLIAMP INPUT CURRENT THE ARRAY PUTS OUT 21 LUX, SO IF THE BATTERIES STARTS TO RUN DOWN, THE LIGHTING DOES NOT DROP AS FAST AS WOULD BE EXPECTED.

TO AVOID CHARGING THE BATTERIES TOO FAST, WE NEED TO USE THREE SETS OF BATTERIES CONNECTED IN PARALLEL, AND THAT GIVES EIGHT HOURS OF 1000 LUX LIGHTING EVERY NIGHT FOR JUST TWO HOURS FORTY MINUTES OF GOOD LIGHTING DURING THE DAY, EVEN WITH 66% EFFICIENT BATTERIES.

SO, USING SETS OF 7 BATTERIES, THE ONLY MOVING PART IS THE ON/OFF SWITCH AND THE CIRCUIT COULD NOT BE ANY MORE SIMPLE THAN THIS :



ALL SOLAR PANELS NEED A DIODE TO PREVENT THE PANEL DRAWING CURRENT FROM THE BATTERIES DURING THE HOURS OF DARKNESS. MOST PANELS HAVE A DIODE ALREADY FITTED. PERSONALLY, I WOULD CONSIDER THE FUSE SHOWN TO BE UNNECESSARY, BUT IT IS STANDARD PRACTICE TO FIT ONE.

THE BATTERIES ARE INSTALLED IN A BASE BOX WHICH SUPPORTS THE SOLAR PANEL AND THEIR WEIGHT MAKES FOR A VERY STABLE LAMP. FIVE LED ARRAYS ARE WIRED IN PARALLEL AND FITTED INTO A SUITABLE LAMP HOUSING SUCH AS THIS ONE :

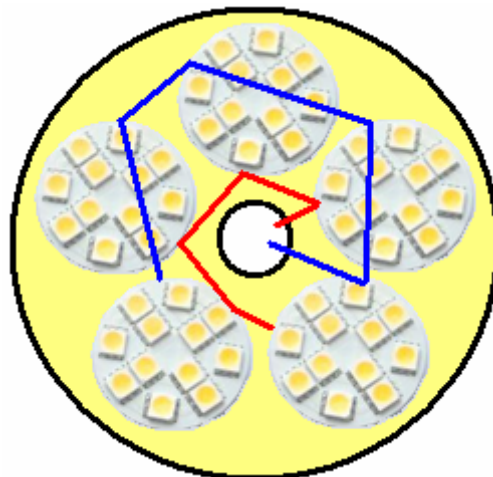


ONLY THE FLEXIBLE STEM, 120 mm DIAMETER LAMPSHADE AND THE ON/OFF SWITCH ARE USED. THIS IS AN EXCEPTIONALLY SIMPLE AND ROBUST DESIGN WHICH IS AN AFFORDABLE UNIT WHICH CAN GIVE YEARS OF COST-FREE LIGHTING AT A VERY SATISFACTORY LEVEL. THE PROTOTYPE LOOKS LIKE THIS :



THIS IS, OF COURSE, A PERFECTLY ORDINARY AND QUITE STANDARD TYPE OF A SOLAR POWERED LIGHT. THE DIFFERENCE HERE IS THAT THE LIGHT LEVEL IS GOOD AND LASTS FOR MANY HOURS EVERY NIGHT.

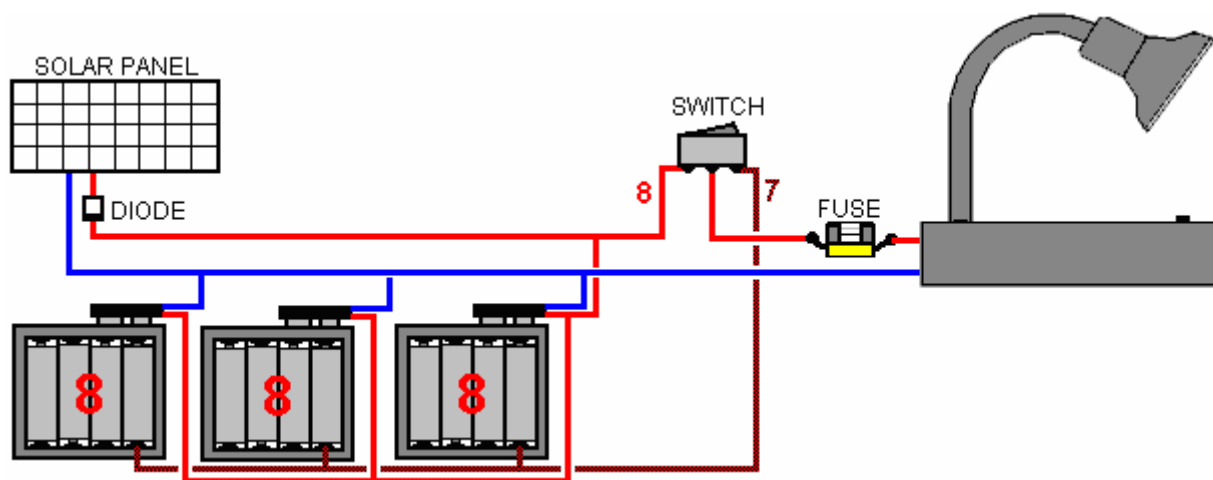
AT THE HIGHER VOLTAGES, THE LED ARRAYS ARE DAZZLINGLY BRIGHT, AND SO IT IS ADVISABLE TO USE A LAYER OF 'FROSTED PERSPEX' PLASTIC TO COVER THEM. SUPPLIERS CAN BE FOUND ON EBAY. THE ARRAYS ARE MOUNTED ON A CIRCULAR PIECE OF 3 mm THICK MDF (OR SIMILAR) MATERIAL, WITH THE DIAMETER BEING SLIGHTLY LESS THAN THE LAMPSHADE SO THAT IT CAN BE GLUED JUST INSIDE THE LIP OF THE LAMPSHADE :



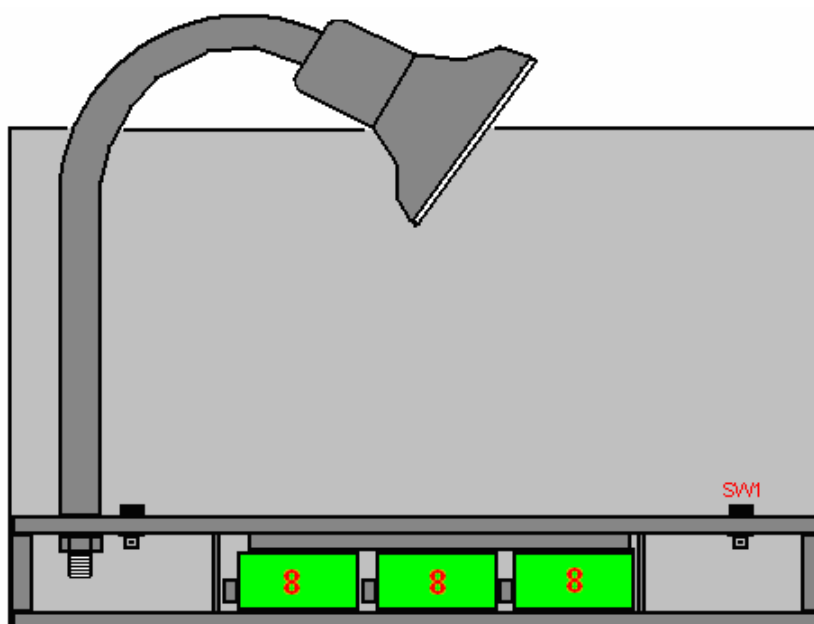
THE WIRES FROM THE LED ARRAYS RUN UNDERNEATH THE LEDS RATHER THAN ABOVE THEM AS SHOWN FOR CLARITY, AND THEY ARE FED DOWN THROUGH THE FLEXIBLE SHAFT OF THE LAMP, READY TO BE CONNECTED IN THE BASE OF THE UNIT AFTER THE LAMP STEM IS FITTED TO THE BASE BOX.

THE LIP OF THE LAMPSHADE IS USED TO MARK AROUND ON THE FROSTED PLASTIC BEFORE CUTTING IT OUT WITH A COPING SAW AND GLUING IT TO THE LAMPSHADE.

IT IS ALSO POSSIBLE TO EXTEND THE DESIGN VERY SLIGHTLY TO PROVIDE AN EVEN LONGER PERIOD OF LIGHTING, OR IF PREFERRED, A PERIOD OF EVEN BRIGHTER LIGHTING BY USING EIGHT BATTERIES IN EACH HOLDER. A CHANGEOVER SWITCH CAN BE USED TO SWITCH IN THE EXTRA BATTERIES WHENEVER THE USER CHOOSES. THE CIRCUIT THEN BECOMES :

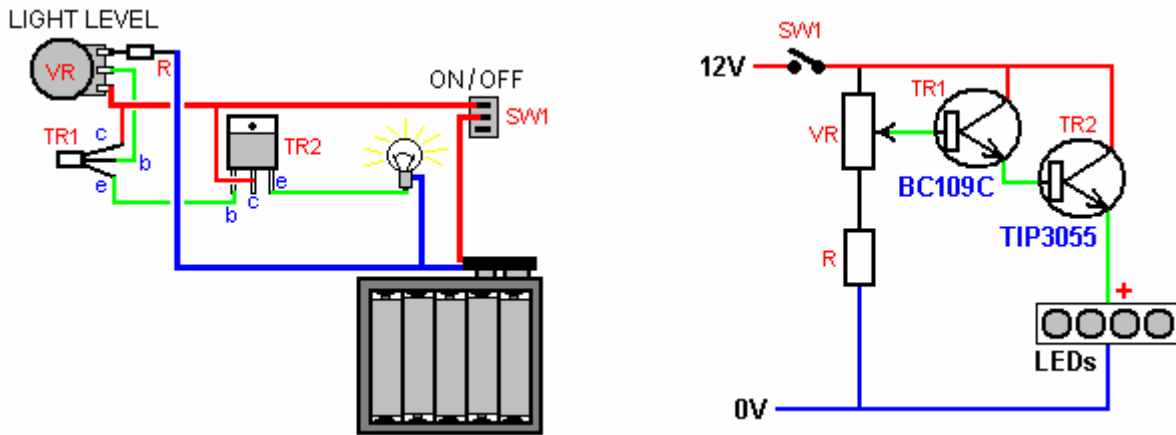


WHEN THE BATTERIES ARE BEING CHARGED, ALL EIGHT BATTERIES IN EACH BATTERY BOX ARE CHARGED, NO MATTER WHAT POSITION THE CHANGEOVER SWITCH IS IN. THE PROTOTYPE LOOKS LIKE THIS :

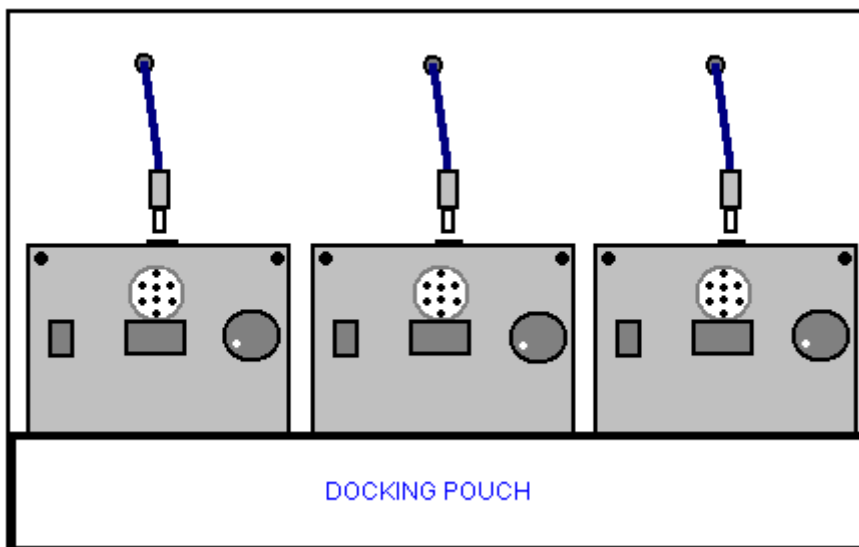


www.free-energy-info.com/PJKbook.pdf HAS FULL CONSTRUCTIONAL DETAILS WITH DIMENSIONS, ETC.

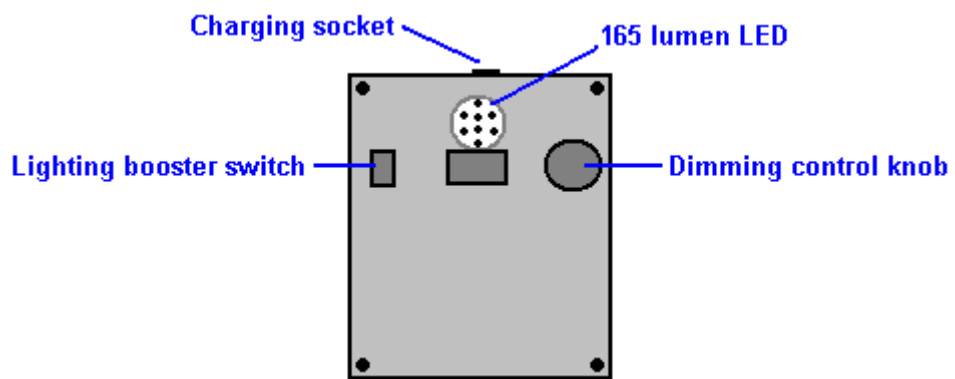
IF YOU WANT TO BE FANCY, YOU CAN USE VERY SIMPLE CIRCUITRY TO GIVE FULLY DIMMABLE LIGHTING WITH EITHER FIVE OR PERHAPS TEN LED ARRAYS :



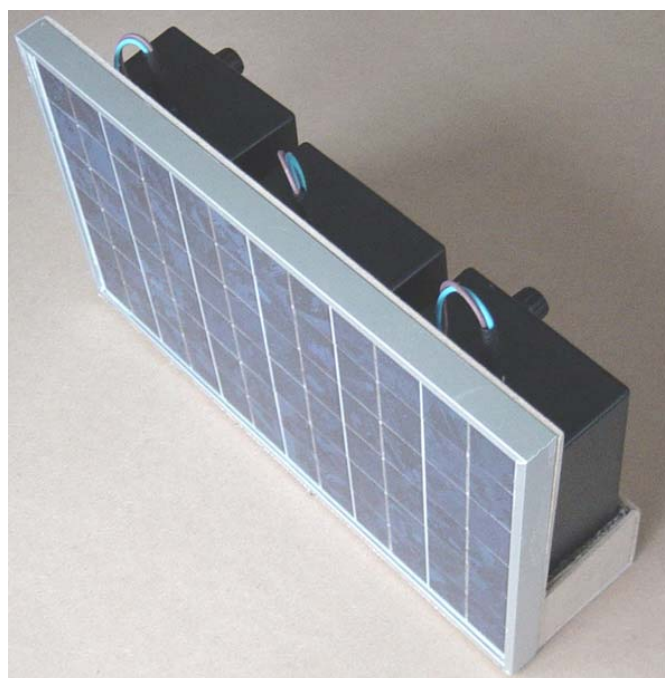
HOWEVER, WITH OR WITHOUT DIMMING, THERE ARE OTHER WAYS OF MAKING A VERY USEFUL SOLAR LIGHT. INSTEAD OF CONNECTING THE THREE BATTERY PACKS TOGETHER WHEN LIGHTING IS BEING USED (BUT NOT WHEN CHARGING) ALLOWS THREE SEPARATE LIGHTS TO BE USED AT DIFFERENT POINTS IN A ROOM OR IN DIFFERENT ROOMS :



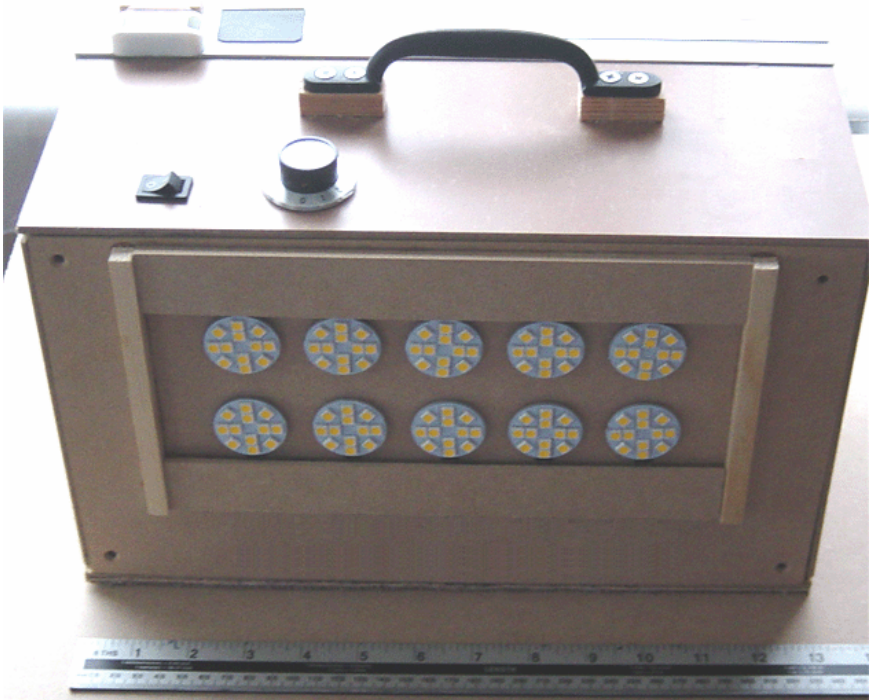
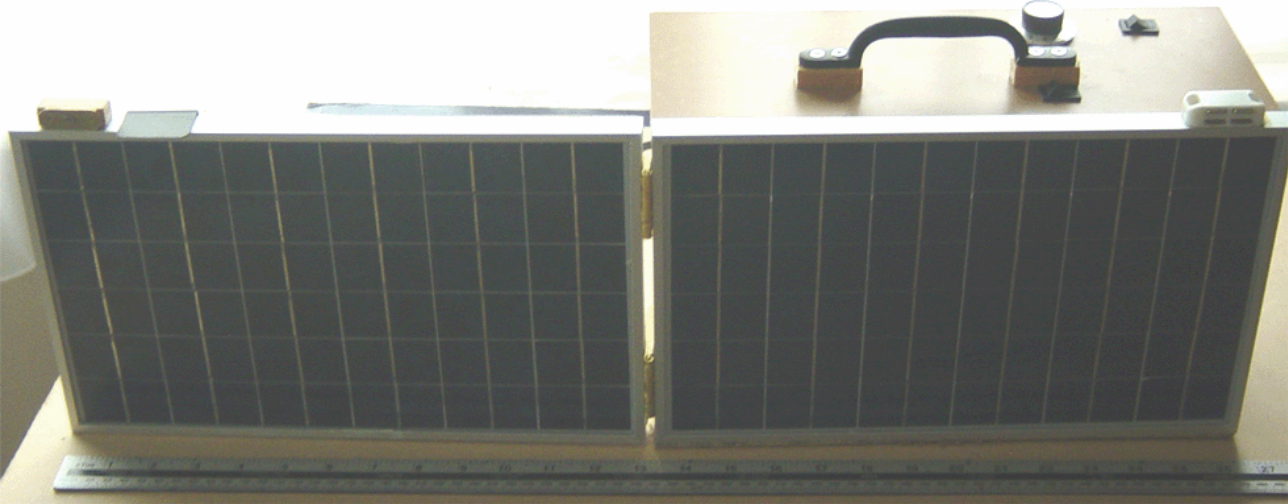
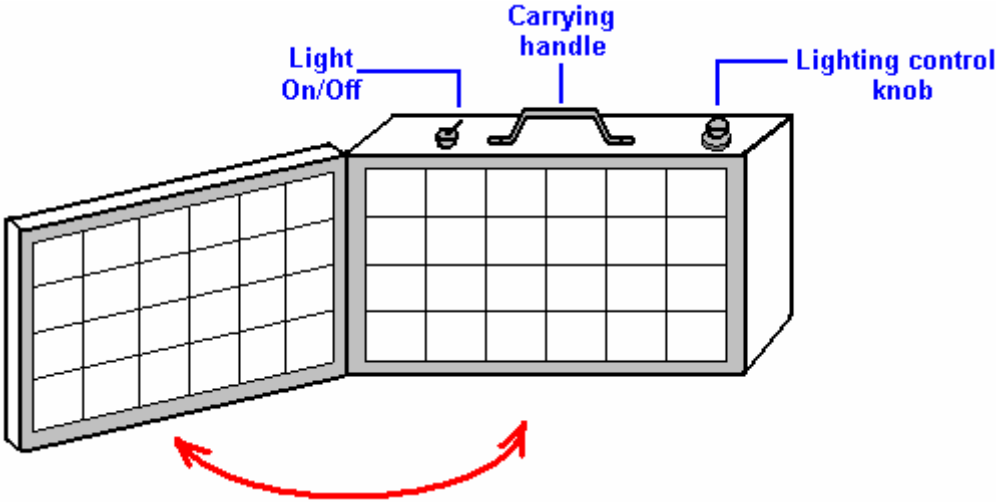
THE THREE IDENTICAL UNITS ARE EFFECTIVELY JUST SOPHISTICATED SOLAR TORCHES WITH ADJUSTABLE, WIDE ANGLE BEAMS. ALL THREE ARE CHARGED SIMULTANEOUSLY FROM A SINGLE 10-WATT SOLAR PANEL. EACH UNIT CAN STAND SECURELY DUE TO THE BATTERY WEIGHT AND IS ROBUST IF KNOCKED OVER OR DROPPED.



THE PROTOTYPE LOOKS LIKE THIS:



THESE SINGLE UNITS WORK VERY WELL AND LIGHT A ROOM TO A GOOD LEVEL. IT IS ALSO POSSIBLE TO MAKE A TWIN SOLAR PANEL UNIT WHICH DRIVES TEN LED ARRAYS :



WITH FULLY CHARGED BATTERIES, THIS UNIT PUTS OUT MORE LIGHT THAN A MAINS-POWERED 100 WATT BULB AS THIS POTENTIAL USER DISCOVERED IN DAYLIGHT :



THIS UNIT GIVES EXCELLENT WIDE-ANGLE ILLUMINATION FOR WALKING ALONG AN UNLIT, UNFAMILIAR ROAD AT NIGHT.

THESE UNITS ARE NOT DIFFICULT TO BUILD NOR ARE THEY PARTICULARLY EXPENSIVE. HOWEVER, IF LIKE ME, YOU LIVE WELL AWAY FROM THE EQUATOR, THE TENDENCY IS TO THINK IN TERMS OF LIVING IN A TYPICAL HOUSE WITH GLASS WINDOWS. THIS IS NOT THE CASE FOR A LARGE PERCENTAGE OF WORLD POPULATION. FOR EXAMPLE, TAKE AFRICA :

Anna Brüderle's "Solar Lamps – Africa" MARKETING RESEARCH PUBLISHED BY GIZ GmbH UGANDA HAS RAISED MANY FACTS WHICH SUGGEST PHYSICAL CHANGES IN CONSTRUCTION :

- 1. USING A SOLAR PANEL INDOORS IS NOT POSSIBLE DUE TO LACK OF WINDOWS AND MAJOR ROOF OVERHANG.**
- 2. USING A SOLAR PANEL OUTDOORS FOR RECHARGING IS LIKELY TO HAVE IT STOLEN.**
- 3. USING AN OUTSIDE SOLAR PANEL CONNECTED BY A WIRE IS LIABLE TO BE DAMAGED AND/OR CAUSE CHILD INJURY WHEN CHILDREN ARE PLAYING.**

LIFESTYLE IN THE SURVEY AREA HAS THE FOLLOWING CHARACTERISTICS :

- 1. SEVEN PEOPLE LIVING IN ONE BUILDING IS NOT UNUSUAL AND SO, 360-DEGREE LIGHTING IS PREFERRED.**
- 2. THE KITCHEN IS NORMALLY SEPARATE AND HAS NO WINDOWS AND YET NEEDS MEAL-PREPARATION LIGHTING.**
- 3. BURNING A FUEL FOR LIGHTING IS LIABLE TO CAUSE POOR HEALTH FROM THE FUMES PRODUCED.**
- 4. CHILD EDUCATION IS HINDERED BY LACK OF LIGHTING.**
- 5. LIGHT USAGE IS USUALLY 3 OR 4 HOURS AT NIGHT PLUS 2 HOURS IN THE MORNING.**
- 6. TESTS WITH 100 LUMEN LIGHTING HAVE BEEN CONSIDERED TO BE SATISFACTORY.**
- 7. LAMPS ARE NORMALLY PLACED ON THE DINING TABLE DURING MEALS AND HUNG FROM THE CEILING AT OTHER TIMES.**
- 8. WHEN CARRIED OUTSIDE, A NARROW FORWARD LIGHTING ARC OF SAY, 90 DEGREES, IS PREFERRED FOR SAFETY.**

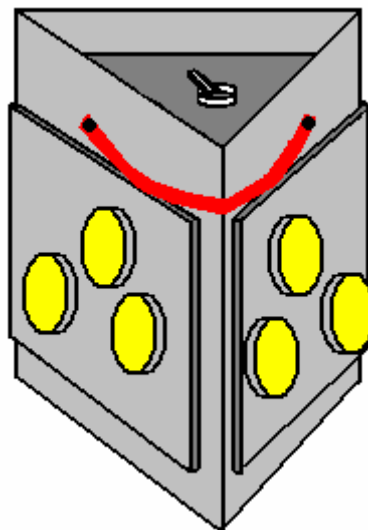
9. UNITS WITH VARIABLE LIGHTING LEVELS ARE PREFERRED BUT WHY IS NOT SPECIFIED – PROBABLY LIGHT DURATION.

IN THESE HOUSES, THERE CAN BE INTERNAL WALLS WHICH DO NOT REACH THE CEILING AND SO, LIGHT IN THE CENTRAL ROOM SPILLS OVER INTO THE ADDITIONAL ROOMS.

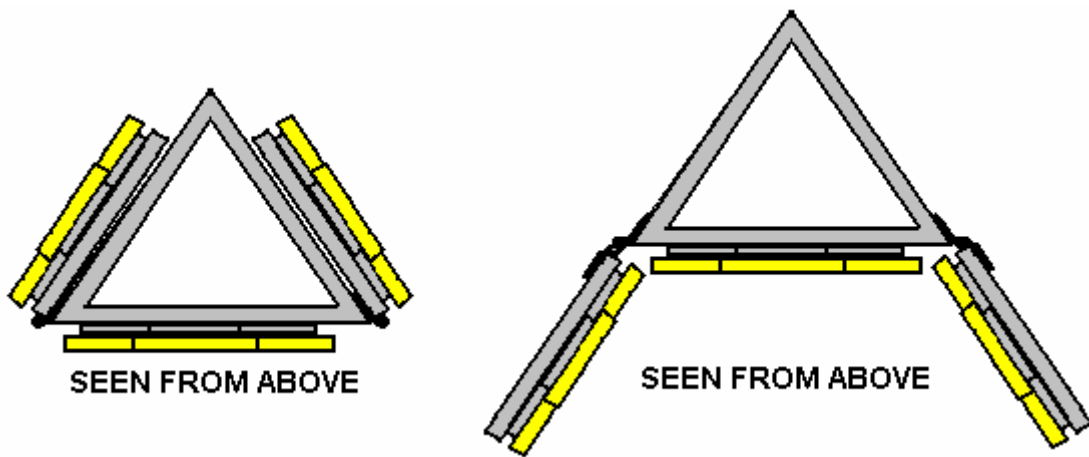
THESE FEATURES CALL FOR A LIGHTING UNIT WHICH IS :

1. ABLE TO PROVIDE 360-DEGREE ILLUMINATION.
2. ABLE TO GIVE A RESTRICTED 90-DEGREE LIGHTING ARC WHEN USED OUTSIDE.
3. STABLE WHEN STANDING ON A HORIZONTAL SURFACE.
4. ABLE TO BE CARRIED COMFORTABLY.
5. ABLE TO BE SUSPENDED FROM A CEILING.
6. ABLE TO PROVIDE CONSIDERABLY MORE THAN 100 LUMENS FOR THE LIGHTING PERIOD USED.
7. IS CHEAP ENOUGH TO BE BOUGHT.
8. IS VERY ROBUST.
9. IS FREE OF ANY GLASS COMPONENTS AS HURRICANE LAMP ACCIDENTS ARE MAINLY CUTS FROM BROKEN GLASS.

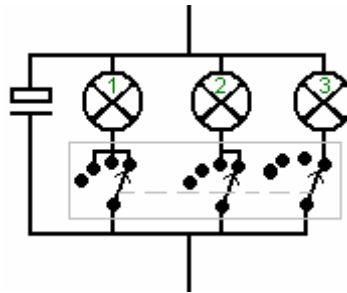
IT IS POSSIBLE TO DESIGN A LAMP WHICH MEETS ALL OF THESE REQUIREMENTS ALTHOUGH LOW COST IS THE MOST CHALLENGING REQUIREMENT. TO MEET THE USER'S NEEDS, IT MIGHT BE POSSIBLE TO USE A HOUSING LIKE THIS :



THE TRIANGULAR SHAPE MAKES FOR EASY CONSTRUCTION AND IS VERY ROBUST FROM AN ENGINEERING POINT OF VIEW. IT ALSO CUTS DOWN THE NUMBER OF FACES NEEDED FOR 360-DEGREE LIGHTING TO JUST THREE. THE VERSATILITY IS INCREASED GREATLY IF TWO FACES ARE HINGED :

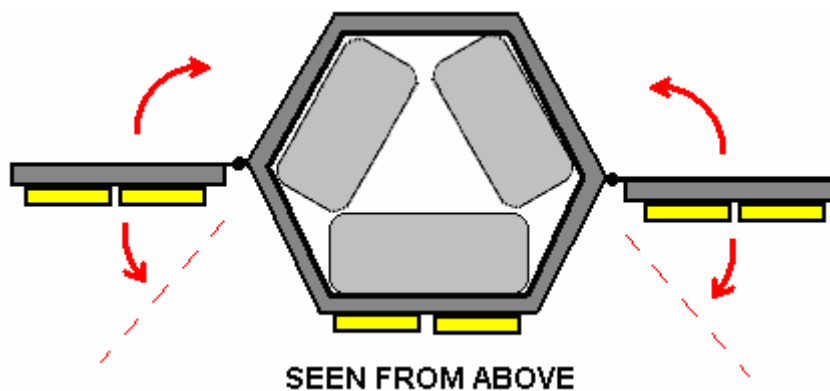


THIS ARRANGEMENT ALLOWS TWO FACES TO BE ALIGNED WITH THE FIXED FRONT FACE GIVING A VERY BRIGHT ARRANGEMENT WITH ALL OF THE LIGHT GOING IN ONLY ONE DIRECTION. THE TWO FACES CAN BE MOVED FURTHER AROUND TO GIVE THE NARROW FORWARD BEAM WANTED FOR WALKING OUTSIDE AT NIGHT. IF WANTED, THE LIGHTING LEVEL CAN BE CONTROLLED BY MAKING THE ON/OFF SWITCH A THREE-POLE FOUR-WAY ROTARY SWITCH :

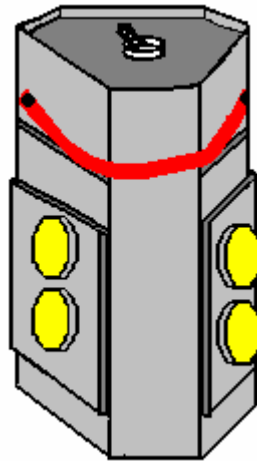


THIS ARRANGEMENT GIVES OFF, ONE PANEL, TWO PANELS, OR THREE PANELS OF ILLUMINATION, BUT IT COULD EQUALLY WELL BE CHANGED TO GIVE ONE LED LIT PER PANEL, TWO LEDs LIT PER PANEL, OR THREE LEDs LIT PER PANEL.

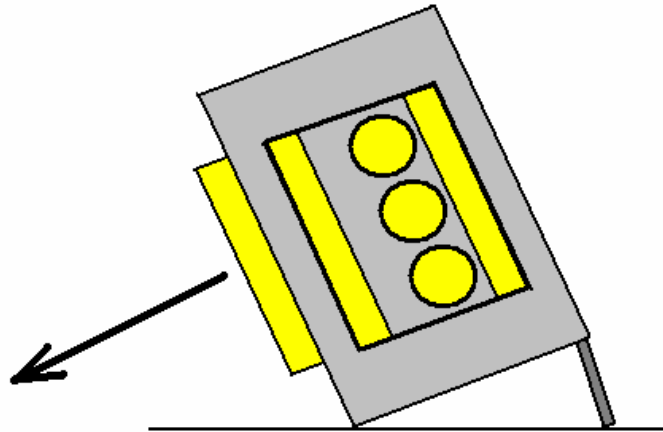
IF ORDINARY 10-BATTERY HOLDERS ARE USED, THEN THE LAMP HOUSING CAN BE MADE MORE COMPACT AS THE CORNERS OF THE TRIANGLE ARE NOT NEEDED. THE BATTERY PACKS FIT IN LIKE THIS :



THIS GIVES A COMPACT HEXAGONAL SHAPE WHICH IS STRONG AND WHICH HAS THE SAME VERSATILE LIGHTING CAPABILITIES. THE SIDES EXTEND ABOVE THE TOP AND BELOW THE BASE SO THAT THE UNIT CAN STAND SECURELY EITHER WAY UP ON A FLAT HORIZONTAL SURFACE. THE HINGES NEED TO BE STIFF SO THAT THEY HOLD THEIR POSITION WHEN SET TO THE DESIRED ANGLE. EACH PANEL CAN HAVE ONE, TWO OR THREE LED ARRAYS MOUNTED ON IT.



THE ADDITION OF A SIMPLE HINGED FLAP TO THE BASE ALLOWS A TILTED POSITION WHICH IMITATES THE DOWNWARD LIGHTING STYLE OF A DESK LAMP :



IT MAY WELL BE POSSIBLE TO CHARGE AN EXTRA BATTERY WHEN THE LIGHTS ARE ON AND THEN, WHEN THE LIGHTS ARE OFF TO RECHARGE THE MAIN BATTERY PACKS – THIS CALLS FOR A COP>>1 CHARGING CIRCUIT. ALTERNATIVELY, A 10-WATT SOLAR PANEL CAN BE USED THROUGH A LENGTH OF LOW-RESISTANCE CABLE TO RECHARGE THE BATTERIES VIA A PLUG AND SOCKET.

THERE IS ALSO THE POSSIBILITY OF PROVIDING A USB SOCKET FOR RECHARGING MOBILE PHONES WHEN THE BATTERIES ARE BEING CHARGED. THE PROTOTYPE WORKED VERY WELL INDEED WHEN CARRIED OUT OF DOORS IN A TOTALLY UNLIT AND UNFAMILIAR PLACE.

IF THE SUSPENSION CORD IS MADE LONGER AND AN ADDITIONAL HOOK IS PROVIDED NEAR THE BASE, THEN THE UNIT CAN BE SUSPENDED INDOORS WITH ALL OF THE LED ARRAYS FACING DOWNWARDS, WHICH WITH THEIR 160-DEGREE ANGLE OF ILLUMINATION GIVES GOOD 360-DEGREE LIGHTING.

VIDEO : https://youtu.be/j3_AWHfn5ow