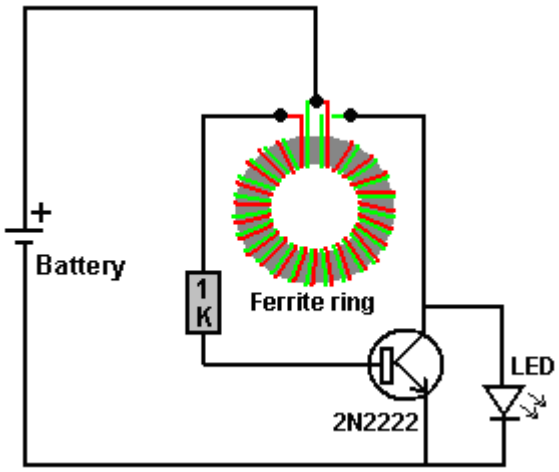
# *A Perpetual Light*

**PEOPLE ARE FAMILIAR WITH THE CONCEPT OF RUNNING A LIGHT FROM A BATTERY AND THEN RECHARGING THE BATTERY USING A SOLAR PANEL OR A WIND-POWERED GENERATOR. HOWEVER, WE REALLY WANT TO BE ABLE TO RECHARGE THE BATTERY WHEN THERE IS NO DAYLIGHT AND NO WIND.**

**WHAT I PERSONALLY WOULD LIKE IS A LIGHT WHICH SHINES WHENEVER I SWITCH IT ON AND WHICH USES A BATTERY WHICH I NEVER HAVE TO RECHARGE. WHILE THAT SOUNDS A BIT FAR FETCHED, IT IS ACTUALLY ACHIEVABLE IF THE BATTERY IS RECHARGED WHEN I AM ASLEEP. LET'S SEE WHAT CAN BE ACHIEVED USING THE KNOWLEDGE WHICH WE ALREADY HAVE.**

**IN THE NOVEMBER EDITION OF THE "EVERYDAY PRACTICAL ELECTRONICS" MAGAZINE, IN THE "INGENUITY UNLIMITED" SECTION, MR Z. KAPARNICK SHOWED ONE OF THE MOST SIMPLE AND ROBUST CIRCUITS EVER PRODUCED. THAT CIRCUIT IS CALLED THE "JOULE THIEF" AND ORIGINALLY IT WAS INTENDED TO LIGHT A 3-VOLT LIGHT–EMITTING DIODE USING A DRY CELL BATTERY WHICH HAD BEEN EXHAUSTED AND RUN DOWN TO 0.5 VOLTS OR SO.**

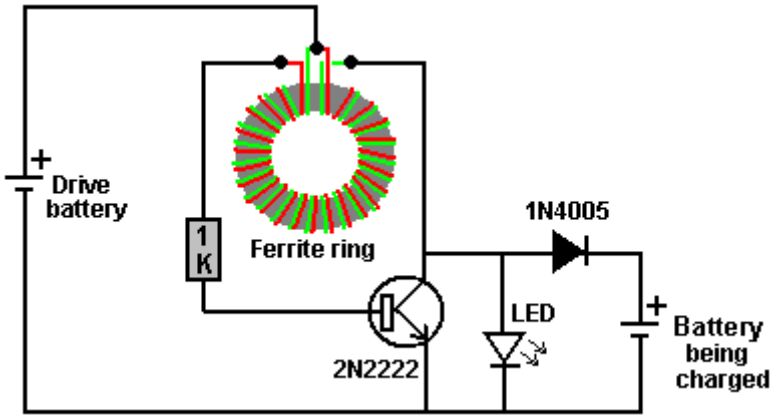
**THE JOULE THIEF CIRCUIT IS VERY, VERY SIMPLE USING JUST ONE TRANSISTOR, ONE RESISTOR AND ONE COIL. MR KAPARNICK WOUND HIS COIL WITH JUST A SHORT LENGTH OF WIRE MAKING JUST A FEW TURNS ON A TINY, SCAVENGED TOROID. THE CIRCUIT LOOKS LIKE THIS:**



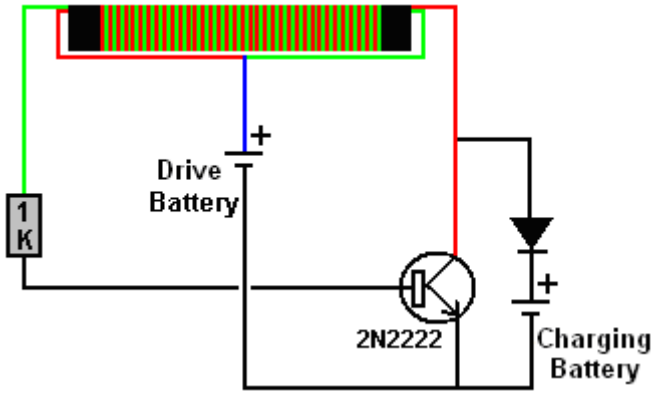

**THE CIRCUIT OSCILLATES AUTOMATICALLY AND GENERATES A MUCH HIGHER VOLTAGE THAN THAT OF THE SUPPLY BATTERY, AND WHILE IT CAN MOST CERTAINLY LIGHT AN LED WHICH CAN'T BE LIT BY THE BATTERY ON ITS OWN, THE CIRCUIT CAN DO MUCH MORE THAN THAT.**

**IT IS NOT NECESSARY TO WIND THE COIL ON A RING AS A SIMPLE PAPER CYLINDER IS PERFECTLY ADEQUATE, WITH A 1-VOLT BATTERY GENERATING A 19-VOLT OUTPUT.**

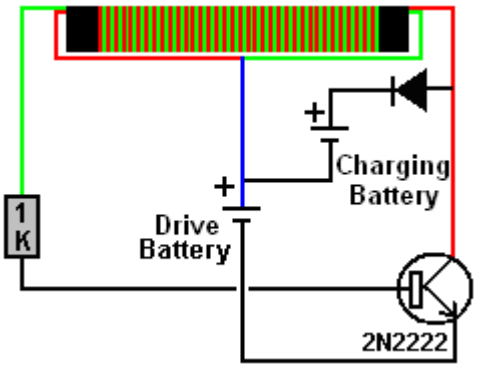
**THE CIRCUIT WAS THEN ADAPTED BY BILL SHERMAN TO CHARGE A SECOND BATTERY AS WELL AS LIGHTING A LIGHT-EMITTING DIODE. BILL ADAPTED THE CIRCUIT LIKE THIS:**




**I HAVE USED THIS TYPE OF CIRCUIT TO CHARGE A "1.2V NiMh" RECHARGEABLE BATTERY OF 2285 MaHr CAPACITY, FROM 0.6 VOLTS TO 1.34 VOLTS IN JUST ONE HOUR. THE DRIVE BATTERY STARTED WITH A VOLTAGE OF 1.34 VOLTS AND ENDED UP WITH A VOLTAGE OF 1.29 VOLTS (WHICH IS GENERALLY CONSIDERED TO BE FULLY CHARGED). THE EXTRA ENERGY FLOWED INTO THE CIRCUIT FROM THE EXCESS ENERGY OF THE LOCAL ENVIRONMENT. THE CIRCUIT IS LIKE THIS:**



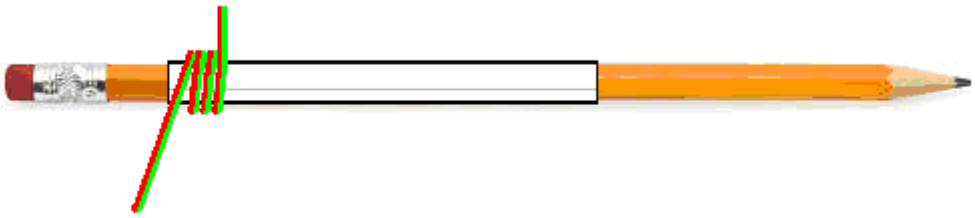

**HOWEVER, THE CIRCUIT HAS A MINOR WEAKNESS IN THAT IF THE DRIVE BATTERY HAS A VOLTAGE GREATER THAN THE CHARGING BATTERY VOLTAGE PLUS THE VOLTAGE DROP ACROSS THE DIODE, THEN THE DRIVE BATTERY FEEDS CURRENT DIRECTLY TO THE CHARGING BATTERY THROUGH THE COIL WINDINGS AND WE DON'T WANT THAT TO HAPPEN AS IT JUST WASTES POWER. THAT WEAKNESS CAN BE OVERCOME BY PUTTING THE BATTERIES IN SERIES LIKE JOHN BEDINI DID:**



**A SUITABLE COIL CAN BE WOUND QUITE EASILY. A PENCIL MAKES A GOOD FORMER FOR A COIL, SO A 100 mm WIDE STRIP OF PAPER CAN BE WRAPPED AROUND A PENCIL TO FORM A CYLINDER SEVERAL LAYERS THICK AND SEALED CLOSE WITH SELOTAPE:**

**MAKE SURE THAT THE PAPER IS NOT STUCK TO THE PENCIL AND THE CYLINDER IS NOT SO TIGHT THAT IT CAN'T BE SLID OFF THE PENCIL WHEN THE COIL HAS BEEN WOUND. THERE IS A WIDE SCOPE FOR EXPERIMENTATION WITH THE NUMBER OF TURNS IN THE COIL AND THE WIRE DIAMETER USED. I USED 0.375 mm DIAMETER SOLID ENAMELLED COPPER WIRE.**

**THERE ARE MANY DIFFERENT WAYS TO WIND A COIL. THE METHOD WHICH I USED IS TO LEAVE MORE THAN 100 mm OF WIRE BEFORE THE START OF THE COIL AND THEN MAKE THREE OR FOUR TURNS LIKE THIS:**



**THEN THOSE TURNS ARE HELD IN PLACE WITH SELOTAPE BEFORE WINDING THE REST OF THE COIL IN A SINGLE SIDE-BY-SIDE LAYER USING TWO WIRES TO FORM A BI-FILAR COIL. THEN BOTH ENDS ARE COVERED WITH ELECTRICAL TAPE AS SELOTAPE DETERIORATES WITH TIME. ONE SINGLE LAYER OF WIRE IS ADEQUATE, AND THEN THE COMPLETED COIL IS SLID OFF THE PENCIL.**

**WHILE THE DIAGRAMS ABOVE SHOW THE STRANDS OF WIRE IN TWO COLOURS, THE REALITY IS THAT BOTH WIRES WILL BE THE SAME COLOUR AND SO YOU END UP WITH A COIL WHICH HAS TWO IDENTICAL LOOKING WIRES COMING OUT OF EACH END. BE SURE TO LEAVE MORE THAN 100 mm OF WIRE AT THE FINISHING END SO THAT THERE IS ENOUGH TO MAKE THE FINAL CONNECTIONS LATER ON. USE A MULTIMETER (OR BATTERY AND LED) TO IDENTIFY A WIRE AT EACH END WHICH CONNECTS ALL THE WAY THROUGH THE COIL. THEN, CONNECT ONE END OF THAT WIRE TO THE OTHER WIRE AT THE OTHER END. THAT MAKES THE CENTRAL TAP "B" OF THE COIL:**

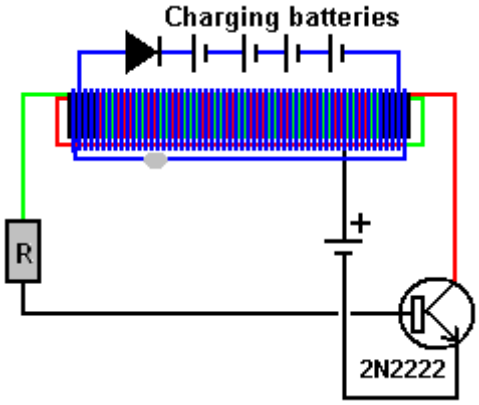
**THE COIL NEEDS TO BE CHECKED CAREFULLY BEFORE USE. IDEALLY THE CENTRAL JOINT IS SOLDERED AND IF THE WIRE IS THE "SOLDERABLE" WIRE (WHICH IS THE MOST COMMON TYPE NOWADAYS) THEN THE SOLDERING IRON HEAT WILL BURN THE ENAMEL AWAY AFTER A FEW SECONDS, MAKING A GOOD QUALITY SOLDERED JOINT ON WHAT USED TO BE ENAMELLED WIRES.**

**A RESISTANCE TEST NEEDS TO BE CARRIED OUT TO CHECK THE QUALITY OF THE COIL. FIRST, CHECK THE DC RESISTANCE BETWEEN POINTS"A" AND "B". THE RESULT SHOULD BE BETWEEN 1 AND 2 OHMS. THEN CHECK THE RESISTANCE BETWEEN POINTS "B" AND "C" AND THAT SHOULD BE EXACTLY THE SAME VALUE.**

**FINALLY, CHECK THE RESISTANCE BETWEEN POINTS "A" AND "C" AND THAT VALUE MUST BE TWICE THE "A" TO "B" RESISTANCE. IF IS ISN'T, THEN THE SOLDERED JOINT IS NOT MADE PROPERLY AND NEEDS TO BE HEATED UP AGAIN, AND THE RESISTANCE MEASUREMENTS MADE AGAIN.**

**THE SIMPLE CIRCUIT SHOWN CAN CHARGE FOUR AA-SIZE BATTERIES IN SERIES WHEN THE CIRCUIT IS DRIVEN WITH JUST ONE AA-SIZE BATTERY. IT IS GENERALLY THOUGHT THAT USING THREE DIODES IN PARALLEL TO FEED THE BATTERY BEING CHARGED IS HELPFUL AS IT REDUCES THE RESISTANCE TO CURRENT FLOW.**

**A METHOD OF RAISING THE EFFICIENCY OF THE CIRCUIT IS TO ADD A SECOND BI-FILAR WINDING TO THE COIL AND TAKING THE CHARGING CURRENT FROM THE SECOND WINDING. THAT MAKES THE CIRCUIT LAWRENCE TSEUNG'S "F.L.E.E.T." CIRCUIT:**

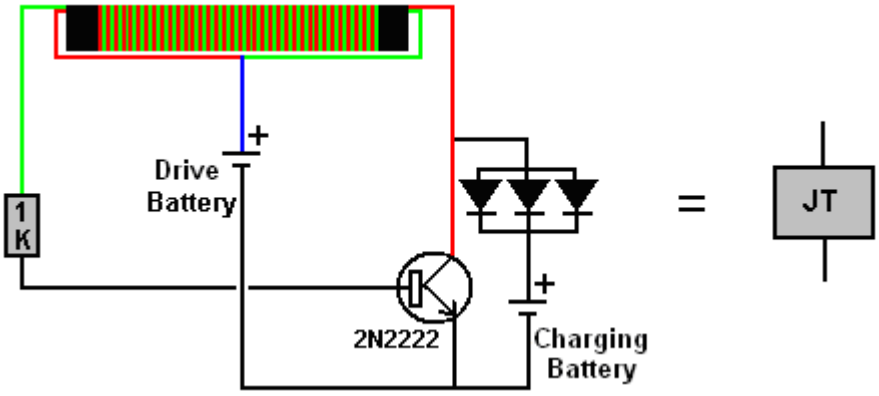



**CURRENT DRAWN FROM THE SECOND WINDING DOES NOT AFFECT THE CURRENT DRAW OF THE DRIVE BATTERY WHICH IS RUNNING THE JOULE THIEF CIRCUIT.**

**IF YOU HAVE AN OSCILLOSCOPE, THEN THE CIRCUIT CAN BE TUNED FOR OPTIMUM PERFORMANCE BY PLACING A SMALL CAPACITOR ACROSS THE RESISTOR "R" AND FINDING THE VALUE OF CAPACITOR WHICH GIVES THE HIGHEST RATE OF PULSING WITH YOUR PARTICULAR COMPONENTS. THE CAPACITOR IS NOT ESSENTIAL AND I HAVE NEVER USED ONE, BUT VALUES SUCH AS 2700 pF ARE SOMETIMES SHOWN.**

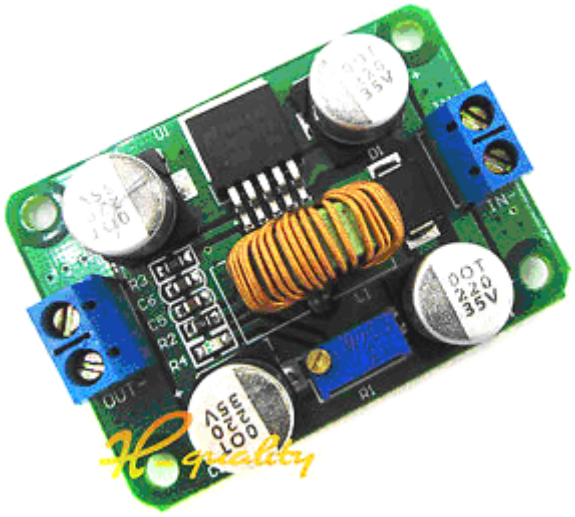
**I HAVE USED THE "FLEET" CIRCUIT TO CHARGE TWO IDENTICAL LEAD-ACID BATTERIES, USING ONE BATTERY TO POWER THE CIRCUIT WHICH CHARGED THE OTHER BATTERY. THEN, SWAPPING THE BATTERIES OVER AND REPEATING THE PROCESS A COUPLE OF TIMES, ENDED UP WITH BOTH BATTERIES HAVING MORE GENUINE, USABLE POWER THAN WHEN THEY STARTED. SINCE A LEAD-ACID BATTERY HAS ONLY A 50% EFFICIENCY AND LOSES HALF OF THE CHARGING CURRENT WHICH YOU FEED INTO IT, MY TEST DEMONSTRATED THAT THE "FLEET" PERFORMED FOR ME WITH MORE THAN TWICE THE OUTPUT POWER WHEN COMPARED TO ITS INPUT POWER. THE ADDITIONAL POWER COMES FROM THE LOCAL ENVIRONMENT.**

**HOWEVER, KEEPING THINGS SIMPLE AND CONCENTRATING ON THE JOULE THIEF CIRCUIT, IF WE REPRESENT THE MOST SIMPLE VERSION WITH THREE OUTPUT DIODES CONNECTED IN PARALLEL, LIKE THIS:**

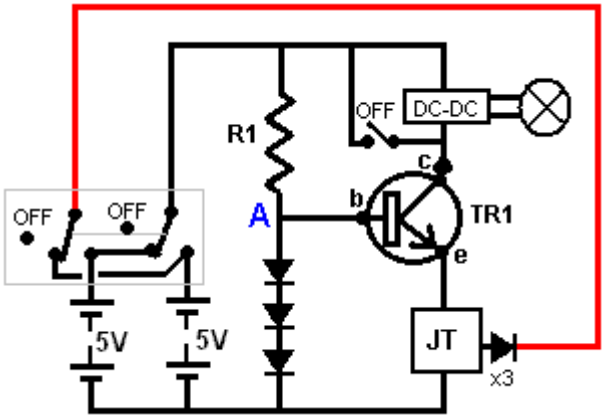



**FOR EXAMPLE, IF WE DECIDE TO PRODUCE A SERIOUS LEVEL OF LIGHTING USING THE 24-LED, 12-VOLT ARRAYS:**

**THEN WE MIGHT CHOOSE TO USE A COMMERCIAL DC-TO-DC CONVERTER LIKE THIS ONE:**



**AND THE CIRCUIT ARRANGEMENT MIGHT BE LIKE THIS:**

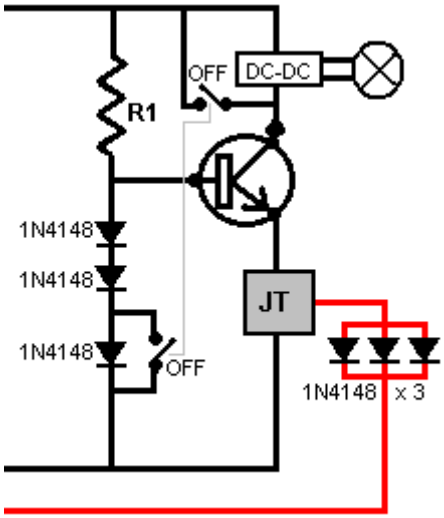



**THIS CIRCUIT WORKS REALLY WELL. THE CURRENT FED TO THE DC-DC STEP-UP CONVERTER IS CONTROLLED BY THE VOLTAGE AT POINT "A" COMBINED WITH RESISTANCE OF THE JOULE THIEF CIRCUIT AS THE TRANSISTOR IS OPERATING IN EMITTER-FOLLOWER MODE. CONSEQUENTLY, THE VOLTAGE SUPPLIED TO THE JOULE THIEF CIRCUIT WILL BE ABOUT 0.7 VOLTS LOWER THAN THE VOLTAGE AT POINT "A".**

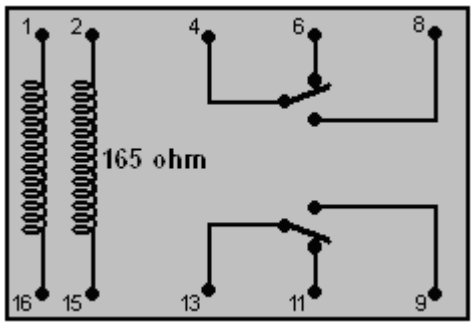
**THE STRATEGY FOR THIS LIGHTING SYSTEM IS TO PROVIDE LIGHTING DURING THE HOURS OF DARKNESS WHEN THE USER IS NOT ASLEEP, AND WHEN THE LIGHT IS OFF AND THE USER IS SLEEPING, THE BATTERY GETS RECHARGED. LIVING AT THE LATITUDE OF IRELAND, THE LONGEST THAT I USE LIGHTING IS SEVEN HOURS IN MID WINTER AND FAR, FAR LESS IN SUMMER. A STUDY CARRIED OUT IN AFRICA WHERE THERE IS NO ELECTRICAL SERVICE, STATES THAT PEOPLE REQUIRE LIGHTING FOR 4 HOURS AT NIGHT AND 2 HOURS IN THE MORNING. SO, WITH SAY, SEVEN HOURS OF LIGHTING, THAT LEAVES 17 HOURS DURING WHICH THE BATTERY CAN BE RECHARGED.**

**AS SHOWN, THE CIRCUIT DRAWS ABOUT 70 MILLIAMPS AND LIGHTS TWO OR MORE LED ARRAYS BRIGHTLY FOR SEVEN HOURS WHEN POWERED BY ONE SET OF FOUR AA-SIZE DIGIMAX BATTERIES OF THE 2850 MILLIAMP-HOUR SIZE.**

**DURING THE PERIOD OF LIGHTING, ALL OF THE LIGHTING CURRENT IS FED INTO THE JOULE THIEF CIRCUIT AND THAT ALLOWS IT TO CHARGE A SECOND SET OF FOUR BATTERIES. THE MANY EXTRA HOURS DURING EACH DAY ALLOWS A VERY MUCH GREATER PERIOD OF RECHARGING. WHILE THE CIRCUIT SHOWS THE OFF SWITCH SHORT-CIRCUITING THE LIGHTING LEDs, THERE IS NO NEED FOR ANYTHING REMOTELY LIKE 70 MILLIAMPS OF CURRENT DRAW AND SO THE SWITCH COULD DROP THE JOULE THIEF CURRENT DOWN TO JUST A FEW MILLIAMPS WITHOUT LOWERING THE CHARGING RATE. THAT WOULD LOOK LIKE THIS:**

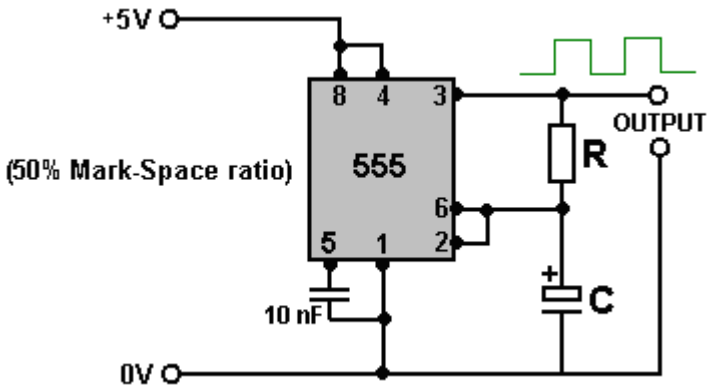



**THE CIRCUIT SHOWN SO FAR HAS TWO SETS OF FOUR BATTERIES. IT WOULD BE NICE TO SWAP BETWEEN THEM EVERY FEW MINUTES. BATTERIES WHICH ARE POWERING A LOAD DON'T CHARGE NEARLY AS WELL AS UNLOADED BATTERIES WHICH ARE BEING CHARGED. HOWEVER, THE MECHANISM WHICH SWITCHES BETWEEN THE TWO SETS OF BATTERIES NEEDS TO HAVE EXTREMELY LOW CURRENT DRAW IN ORDER NOT TO WASTE CURRENT. ONE POSSIBILITY FOR THAT WOULD BE TO USE A 5-VOLT LATCHING RELAY LIKE THIS:**

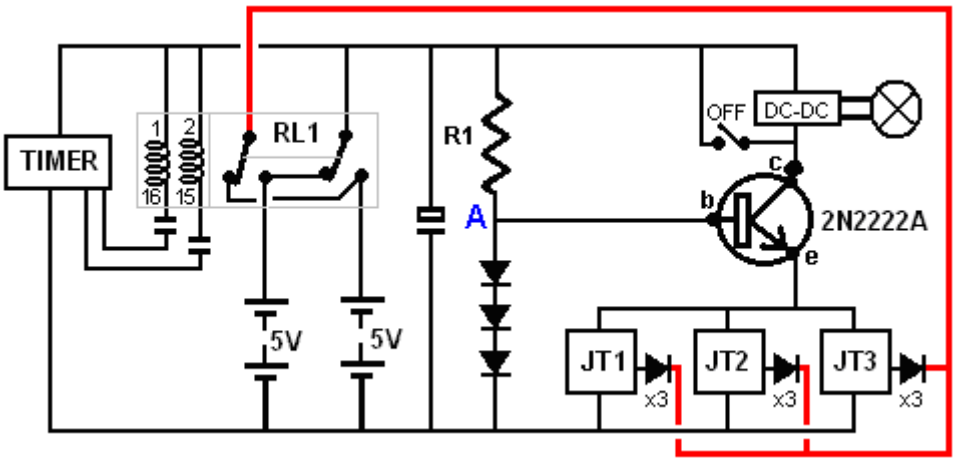

**THIS IS THE ELECTRONIC VERSION OF A MECHANICAL TWO-POLE CHANGEOVER SWITCH. A BRIEF PULSE OF CURRENT THROUGH THE RELAY COIL CONNECTED BETWEEN PINS 1 AND 16 LOCKS THE SWITCH IN ONE POSITION, WHILE A BRIEF PULSE THROUGH THE COIL BETWEEN PINS 2 AND 15 LOCKS THE SWITCH IN THE OTHER POSITION. THE CURRENT DRAIN ON THE CIRCUIT WOULD BE ALMOST ZERO.**

**WE COULD USE A 555 TIMER CHIP TO DO THE TIMED SWITCHING. WHILE STANDARD NE555 INTEGRATED CIRCUITS CAN GENERALLY OPERATE WITH A SUPPLY VOLTAGE AS LOW AS 4.5 VOLTS, THERE ARE SEVERAL MUCH MORE EXPENSIVE 555 TIMERS WHICH ARE DESIGNED TO WORK AT MUCH LOWER SUPPLY VOLTAGES. ONE OF THESE IS THE TLC555 WHICH HAS A SUPPLY VOLTAGE RANGE FROM JUST 2 VOLTS RIGHT UP TO 15 VOLTS, WHICH IS A VERY IMPRESSIVE RANGE. ANOTHER VERSION IS THE ILC555N WITH A VOLTAGE RANGE OF 2 VOLTS TO 18 VOLTS. COMBINING ONE OF THOSE CHIPS WITH A LATCHING RELAY PRODUCES A VERY SIMPLE CIRCUIT:**

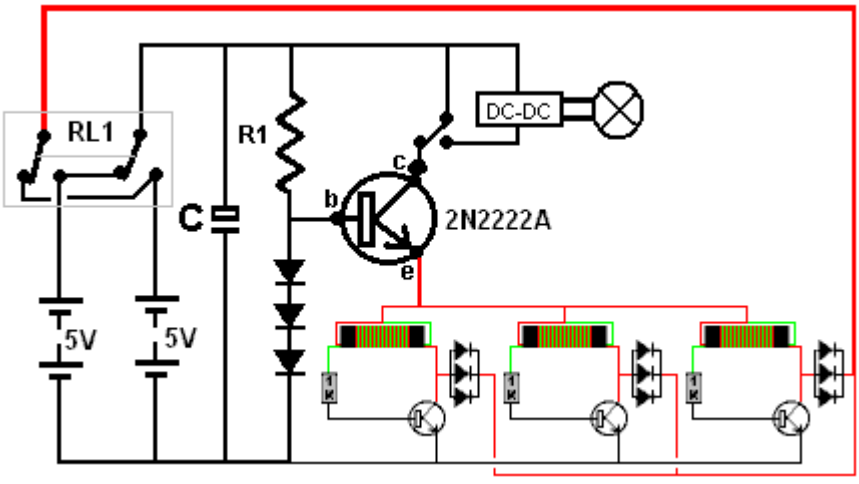



**THE CAPACITOR HAS TO BE HIGH QUALITY WITH VERY LOW LEAKAGE IN ORDER TO GET THE OFF TIME TO EXACTLY MATCH THE ON TIME, AND WE WOULD LIKE THAT SO THAT THE TWO BATTERY PACKS GET IDENTICAL PERIODS OF RECHARGING.**

**JOULE THIEF CIRCUITS DO NOT NEED ANYTHING REMOTELY LIKE 70 MILLIAMPS OF INPUT CURRENT IF THEY ARE TO CHARGE A BATTERY PACK WELL. CONSEQUENTLY, WE CAN USE TWO OR MORE JOULE THIEF CIRCUITS TO SHARE THE CURRENT FLOWING THROUGH THE LIGHTING LED ARRAYS.**
**ONE ADDITION WHICH IS HELPFUL IS THE CAPACITOR WHICH HAVING A FAIRLY LARGE CAPACITANCE, SUPPLIES THE CIRCUIT DURING THE FRACTION OF A SECOND WHEN THE RELAY CONTACTS ARE SWITCHING OVER:**




Or :



**HERE IS A POSSIBLE PHYSICAL LAYOUT FOR A THREE JOULE THIEF CIRCUIT VERSION. IT USES A 125 mm X 35 mm PIECE OF STRIPBOARD, THAT IS, A PIECE WHICH HAS 14 HORIZONTAL COPPER STRIPS AND EACH STRIP HAS 49 HOLES IN IT. WHY THAT ODD SIZE? BECAUSE A PIECE WAS AVAILABLE AS AN OFFCUT WHEN THE PROTOTYPE WAS BEING BUILT. THE PROTOTYPE LAYOUT IS LIKE THIS:**

**THE RED DOTS IN THE SUGGESTED PHYSICAL LAYOUT INDICATE PLACES WHERE THE COPPER STRIP ON THE UNDERSIDE OF THE BOARD IS BROKEN.**

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