TALKING ELECTRONICS®

A NEW MAGAZINE FOR EXPERIMENTERS

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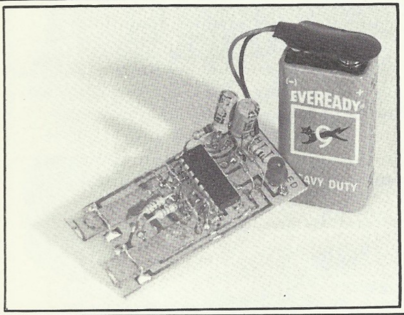
Build these...

Issue No1.

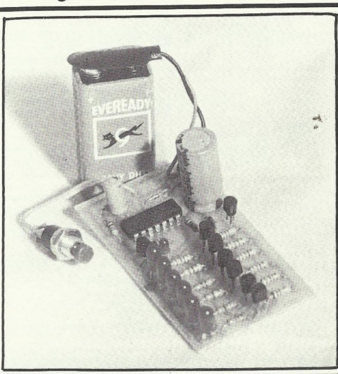


A game of patience...

Light the LED

LED Zeppelin

A game of skill...



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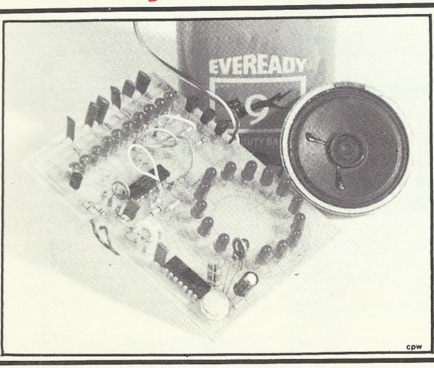

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TALKING ELECTRONICS

Vol.1 No.1

Welcome!

TALKING ELECTRONICS originates its name from the synthesised speech modules currently being incorporated into electronic games. These modules can speak hundreds of understandable words and will cause a revolution in electronics. In a few years a complete talking project will consist of one chip , a battery and switch — just like the calculator I bought last week. It contained no parts other than an MPS 7560 IC!

We want you to be ahead in the talking electronics field but to learn how these chips work you must begin at basics. This means making simple projects and becoming involved. This magazine will hep you do just that. To benefit you must promise me two things:

1. To build a project each issue.
2. Answer the quiz questions.

Only this way will you improve your knowledge of electronics to build the more complex projects in the future.

Good experimenting,

Colin Mitchell.

Editor

PUBLISHER

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*max. recommended retail price only

LIGHT THE LED

A game of patience.
Using just two switches, a pre-programmed combination has been set for this counting IC. I challenge anyone to break the combination within 30 minutes and repeat it!

Project cost: $5

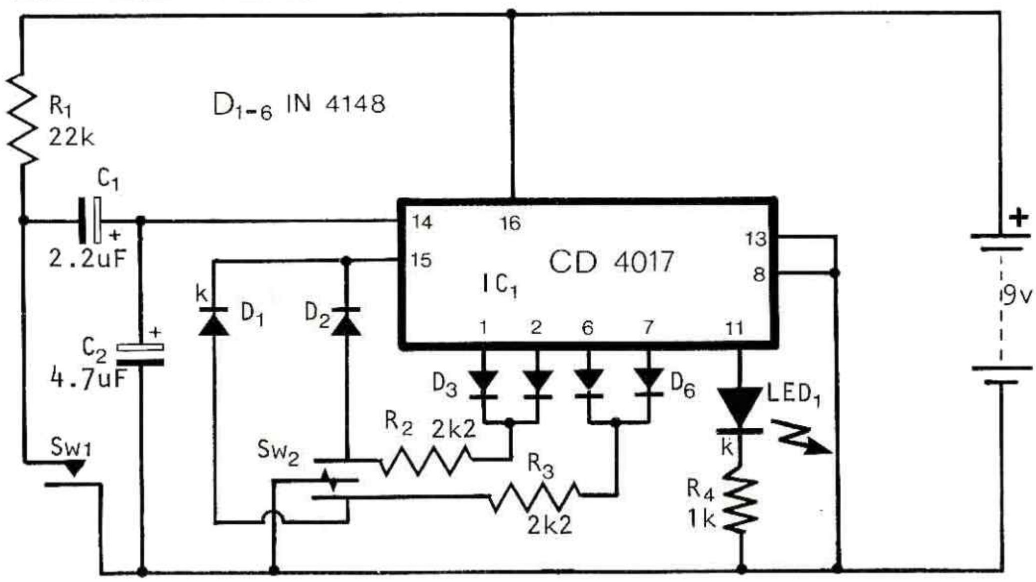


Fig. 1 **LIGHT THE LED**

Here is an ideal project if you are looking for something different in electronics. Many times I have wished I had an electronic brain teaser to try out on a witty friend or some small present to take to a sickie in hospital. Well here it is. Most of the games available on the market are too expensive or complex while others can be unravelled in a few minutes. With this game I think I have provided an ideal challenge. I like things which look easy but prove to be difficult.

The secret combination (actually it should be called permutation) is locked into the game's CD 4017 IC via the gating diodes D_3 D_4 D_5 and D_6 so that when any of the outputs go high, the switch Sw_2 must be in a position so that it earths the signal and prevents it resetting the IC via either diode D_1 or D_2 (which feeds the reset pin 15). The object of the game is to light the red LED. With only two switches this looks at first to be an easy matter. Why, you may think, "I'll just have to push the switches randomly a few times and eventually I must strike the right combination." Well, chances are you won't, and secondly, you will not be able to repeat your effort again if you did happen to strike it after hours of trial.

I would prefer to give you no clues at all on solving the combination however you will need to test the unit and thereby I lose my strategy. Without divulging too much I'll release two small clues. 1. Connecting the battery resets the IC. 2. The first switch (called the "clocking" switch) must be pushed nine times in total and

COMPONENTS YOU WILL NEED:

R_1 resistor 22k ¼ watt 5%
R_2 resistor 2k2 ¼ watt 5%
R_3 resistor 2k2 ¼ watt 5%
R_4 resistor 1k0 ¼ watt 5%

C_1 electrolytic 2.2 mfd 10v
C_2 electrolytic 4.7 mfd 10v

D_1 – D_6 1N 914 or 1N 4148

LED_1 Light Emitting Diode

IC_1 counter IC CD 4017

.01" thick springy brass strip
Battery Clip
9v Battery
"Light the LED" PC Board

the second switch must be pushed twice. May I suggest you try random selections for 30 minutes to satisfy yourself that even with two major facts known, the combination is still securely locked into the puzzle. After tiring of this, settle down and compile a table showing all the possible combinations. Using this table will remove repetitive operations and you will most probably light the LED.

red LED. This may look simple but believe me, if someone handed you the finished project and asked you to decipher the combination you would be at a loss completely. I have another project at a later date in which the timing is absolutely critical and yet another which has high cycling on each switch, so an outsider doesn't know which variables are important and it is left for him to show his ability.

The output pins turn on and off sequentially according to this pin order: 3-2-4-10-1-5-6-9-11. This can be quite confusing as it is not in order of the pin numbering on the IC! This unfortunate sequence has come about in the designing process and it sometimes makes printed circuit construction very difficult. For this project I have used some of the printed circuit as a platform for the switches. Utilizing the copper as a base makes the switch rigid and integral with the board and saves about $1. By using the PC board upside down the IC and

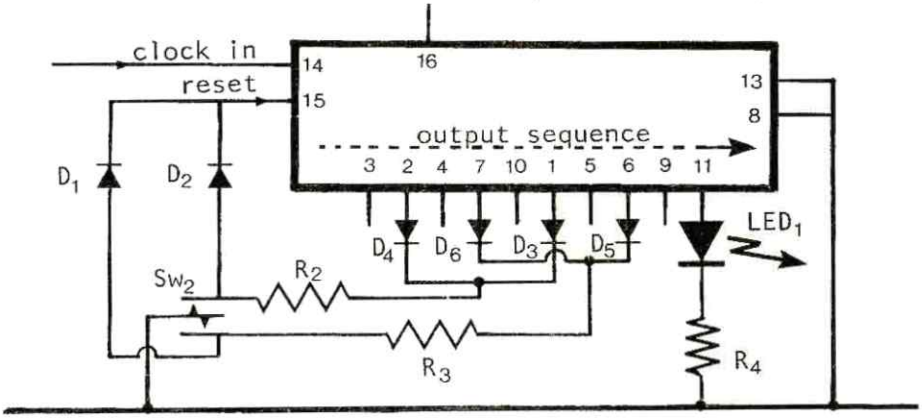


Fig. 2 Circuit showing the output sequence.

HOW DOES IT WORK?

Fig. 1 gives you no idea of the operation of the circuit. I have drawn it this way for two reasons. Firstly, it makes the circuit very simple (which it is) and secondly, if someone asks you to see the circuit to try and work out the combination, he will be completely lost.

Connecting the battery will reset the counter so that output pin 3 will have a high voltage on it. Pressing the "clock" switch Sw_1 will make pin 3 go low and pin 2 high. The high will pass through D_4 and into the 2k2 load R_2 if switch Sw_2 is in the up position. If Sw_2 is pressed at any time pin 2 is in a high state, the voltage will pass through D_2 and reset the counter back to pin 3. There are four such hidden reset paths which have to be correctly manipulated for the signal to make 9 jumps and finally light up the

The main reason we draw the IC as a vacant block (apart from simplifying the schematic) is due to the manufacturer rarely releasing the circuitry. Of those schematics which have been released the circuitry is so complex that it would fill up an entire page of this magazine. The internal workings of an IC is of little importance to us. We are mainly concerned with the function of each pin and the overall capability of the little 14 pin wonder. We can let you into a little more detail, however, and reproduce all the IC pins to show how the 10 outputs are turned on and off one at a time, each time the input pin is "clocked". Clocking means applying a pulse to the input pin 14.

the parts can be mounted on top of the solder-lands quite easily. There is no need to drill any holes and this is an additional saving. The third and most important reason for using an undrilled board is the ease of removing the parts once the project is no longer required. I hope this will never be the case!

Should you wish to "borrow" the IC at a latter date for another project all you need do is sit the board upright, hold the ends of the IC with your fingers and run the soldering iron down a row of pins. This will make the IC come partly off the board and by running the iron down the other pins the IC will come away cleanly. What a contrast to removing an IC from a normal PC board. Usually it's an almost impossible task without a solder sucker or desoldering iron and plenty of patience.

light the led

MOUNTING THE PARTS

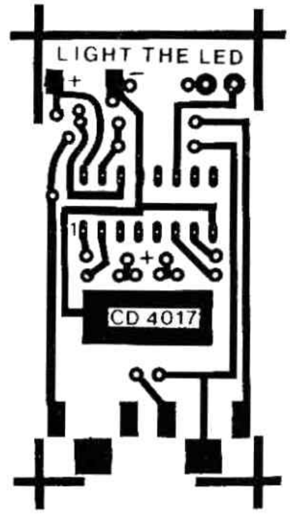
The two switches are fabricated. This means you will be making the switches yourself from two pieces of springy brass and two saddles cut from resistor wires. Cut two pieces of brass 2.5cm long x .7cm wide (1" x ¼") from .010" brass sheet. Tin one end of each strip and solder it onto the large copper land on the printed circuit board. Make sure they are parallel to each other and come right down to the bottom edge of the board. Curve them upwards so they have a 1cm travel to the PC board. Make two staple-looking saddles from wire cut off a resistor and trim the legs short so that when you place them over the brass strips they press fairly hard on the brass. Solder them in position making sure the strips still have some travel left to touch the printed circuit contacts below. Dimple the centre of each saddle to make a point contact. Mount all the other components as shown in the layout diagram except the two top diodes D_1 and D_2. These will be soldered in after the unit has its pre-test. The other diodes and resistors can be left standing up from the board to reduce congestion. Hold each part in your fingers as you solder it. If you find the parts getting too hot, you are taking too long to solder them. This is the easiest way to judge if you are good at soldering.

Here are three tips to speed up your soldering:

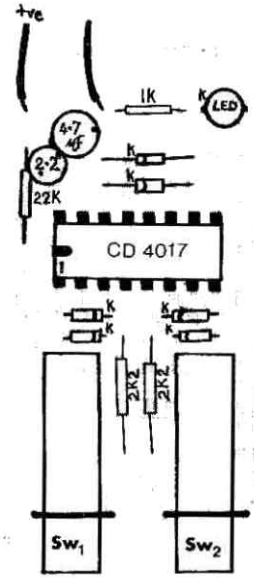
1. Tin each lead of the component first. This is a must. I always do this before soldering any parts into a project.
2. Use only a fine tip soldering iron. Preferably use a constant temperature soldering iron for fine work like this.
3. Use FINE solder. Old fashioned 16 and 18 gauge solder is OUT.

TESTING THE UNIT

All the parts should be soldered in place as shown in the diagram except the two top diodes D_1 and D_2. Connect only their cathodes (marked with a band) to pin 15. Connect the other end of D_1 via a jumper lead to the negative lead of the battery. The reset pin must not be left open or floating as this will prevent the IC from clocking. Connect a 9v battery to the battery clip. Push Sw_1 ten times and the LED will light up. Try this a number of times. You are cycling the Decade Counter. Notice you must push the switch slowly and firmly as any contact bounce will register on the IC very easily and the LED will light up after pushing the switch only 6, 7 or 8 times. A considerable amount of contact bounce has been eliminated by the inclusion of the 2.2mfd and 4.7mfd electrolytics. Without them the bounce from five pushes will register as a count of ten. Disconnect the battery and solder D_1 into circuit Connect the battery and cycle the counter via Sw_1 The LED should not light up even after 50 pushes. If it does light up, Sw_2 is not making connection at its upper contact. Press Sw_2 down any cycle the IC. After each ten clocks the LED should light up. Disconnect the battery and solder D_2 onto the board. Make sure Sw_2 lower contact is working by soldering a bump of solder onto each surface and cleaning with a small file. Now try to light the LED!



FULL-SIZE LAYOUT
DO NOT drill the board. All the parts are mounted on the copper side.



MAKE YOUR OWN PC BOARDS

It's fun
It's economical

Making your own Printed Circuit Boards is fun and economical and I can almost guarantee you will get a perfect result. I have never lost a board yet and if a mistake occurs you can remove it from the board and start again.
This article may seem technical and complicated but after reading it through twice and at least attempting the procedure, you find it impossible to get good results, I will give you a refund out of my own pocket! This is how foolproof I think it is. The procedure is about as complicated as making a cake and requires no special tools. There is one kit available containing all the chemicals you will need or most of them can be bought separately from large electronics shops or Dick Smith Stores. Here is a list of the items I bought:

1 blank fibreglass board 150mm x 75mm (6" x 3")	H5540	$1.45
1 blank fibreglass board 150mm x 150mm (6" x 6")	H5545	$2.90
1 bottle positive resist CCPR12	H5720	$3.75
1 bottle positive developer crystals CCPD16	H5724	$1.85
1 bottle Ferric Chloride etching solution	H5652	$1.90
post & pack		$3.50
TOTAL:		$15.35

I also bought a complete kit of parts from EXPERIMENTER PARTS CO, which contained a smaller quantity of the above chemicals and a few extra necessary components.
This is what the kit contained:

5 small blank PC boards ranging from 40mm x 75mm to 100mm x 75mm
1 plastic bag containing cleaning powder
1 small bottle of positive resist, enough for 10 boards
1 packet of developer crystals, enough for 10 boards
1 bottle of ferric chloride solution for 10 boards
1 No 60 drill

Complete kit $7.00 P & P $2.00

Note: The two main chemicals CCPR12 and CCPD16 are a product of Circuit Components of Bexley NSW and carry their code, namely: Circuit Components Positive Resist 12 or CCPD16.

The following notes are compiled from my experience in making "one-off" boards for the magazine using instructions supplied with the chemicals. I have updated the instructions slightly to make them a little simpler to understand.

GENERAL

CCPR12 Photo Resist is a positive working Polyvinyl compound which, when exposed to ultra violet light through an artwork made from dense black tape and circles, on a clear or translucent film, will leave the black areas as a pattern on the laminate when developed. The clear or translucent area exposed to ultra violet light will break down and wash away during development leaving an image which will offer strong resistance to a veriety of etching solutions. This process uses "contact printing" and requires size/size artwork such as that found in magazines or from Talking Electronics Magazine Art Dept.

ITEMS YOU WILL NEED

A small oven or frypan which can be set at 90°C (194°F)
2 small plastic trays - similar to those from take-away food shops
1 small paint brush 3cm (1")
2 small wooden sticks - similar to ice-cream sticks
1 sheet of glass - enough to cover the PC board plenty of paper towels
1 new piece of CHUX Superwipe or CHUX nappy-liner
1 kit of chemicals as per above list

PREPARATION

The kitchen sink is an ideal place for preparing the boards as it is near the oven, has plenty of running water and is not exposed to direct sunlight. Place the chemicals on a WHOLE newspaper and use plenty of water whenever the chemicals are splashed. The chemicals will not attack your fingers harshly however the Ferric Chloride and Resist will stain.

LAMINATE PREPARATION

Select a board larger than the required size so that an allowance of at least ¼" is left all round. Clean the board with the cleaning powder or use Ajax or Bon Ami. Add a few drops of water to the powder and rub well into the board with your finger then finish with a slightly damp Chux superwipe cloth. (Do not use sponge-type kitchen pads or STEEL WOOL, due to their ability to hold grease).

Hold the scrubbed laminate under running water and be sure the copper surface "wets" evenly all over. If a break appears in the surface tension of the water, rescrub and re-test. Dry both sides with a clean piece of paper towel, being particularly careful not to touch the prepared surface of the laminate with the fingers. (Skin oils will contaminate the surface and nullify the preparation). Then brush the surface with a soft clean brush to free the surface of lint and dust. The finished laminate must be dust free for best results.

COATING THE LAMINATE

Pour a small pool of resist in the centre of the prepared laminate and thinly smooth over the surface with a 3cm paint brush. (Use a NEW brush and keep it for use with the resist only). Wash brush in Methylated Spirits, then in soap and water. A"streaky" appearance when wet usually settles down during the drying process. An equally successful method is to pour a little resist on the board and tilt it to flow all over the board. Allow excess to drip off. The coating should be of medium density. Too thick gives difficult drying/developing, too thin could result in "pin holing".

OVEN TEMPERATURE

This is a critical stage in the process. The oven temp/time combination must be correct. The CCPR12 resist cannot be air dried at ambient temperature due to some of the solvents requiring high temperature to remove them. The shelf should be set in the centre of the oven and the oven pre-heated to 80°C(176°F) or 90°C(194°F). When up to temperature, place the coated laminate on the shelf and allow to bake for 10 to 12 minutes. For a small laminate, a FRYPAN may be used if set up in the following manner: Place a wire grid such as a cake cooling stand (see I told you it's as easy as baking a cake) in the frypan. Set the control to 340° on the thermostat. Open the vent in the vent in the lid and set the lid on the frypan furthest from the thermostat side. Place a piece of scrap laminate flat between the lid and base at the thermostat side to allow a ventilation air flow. Let this arrangement stand, turned on for approx 25 - 30 minutes to preheat. Once it has completely warmed up, switch the frypan off and place the board inside and bake for 10 - 12 minutes. Be sure to replace the lid as described above.

Note: It is recommended that ovens using exposed or infra-red elements NOT be used as the red colour rays may prevent the photo sensitivity from functioning. Where these and gas ovens are employed, bring the oven up to temperature and switch off, then place the prepared laminate in the upper section of the oven for 15 to 20 minutes.

ARTWORK

The printed circuit artwork should be on film for best results however drawings from magazines or good photocopies will work provided they have no black printing on their reverse side. Place the artwork face up on the copper side of the board and tape in position. Place the sheet of glass over this and also tape in position.

EXPOSING

This stage is fairly critical. Two types of exposure are ideal:

1. UV LAMPS. Two 20 watt Sylvania type F20T12-BL fluorescent tubes (or Philips Actinic Blue fluorescent tubes, both makes being 3,900 Angstroms) are mounted on a twin batten unit. This should be positioned 3cm (1") from the PC board and requires an exposure verying according to the artwork.
   Typically these are: 2 minutes for clear film
   4 minutes for matte film
   8 mins for magazine page

2. DIRECT SUNLIGHT. This is the cheapest and works very well. Pick a bright sunny day. The exposure times will be:
   4 minutes for clear film
   5 minutes for matte film
   8 minutes for magazine page

Note: Suntan lamps can be used but are not recommended. Safelights are not needed. The entire operation can be carried out in LOW LEVEL incandescent ambient light. Special dark-room facilities are not essential, but keep clear of direct or reflected sunlight, fluorescent or red lighting. When using double-sided material, make up a stand using 1cm thick particle board with four 2-inch nails protruding through, just outside the artwork area but smaller than the PC board. Coat both sides of the laminate and stand it on the nail points. Place it in the centre of the oven. When dry, clamp the laminate and both artworks between two sheets of glass and expose each side in turn. Develop both sides at once.

DEVELOPMENT

To 300 ml of water (½ pint) add one heaped teaspoon (10 gm) of CCPD16 Developer Crystals. This will be enough for 10 small PC boards. The next stage is the MOST IMPORTANT step of the whole job.

Immerse the exposed laminate in the developer and move it about in the solution gently avoiding splash, I suggest a wooden stick or better still, use a clip to keep full control. In a few seconds the image will appear. Keep washing away the resist for a few more seconds until it has been removed from the unwanted areas. Watch carefully that the pattern doesn't start to disappear too! Take the board out and wash it under running water. If you make a mistake you can dip it back into the developer or even wash it all off and start again.

Notes: If, in the prebaking stage, the oven was not up to temperature, the image will appear very quickly and then wash away completely. On the other hand, if the baking were overdone, the strength of the developer may be increased very slightly by dissolving more crystals in the solution. (Remove the coated laminate FIRST). If this is done, be careful not to use for subsequent boards which may have been baked correctly. This developer is not flammable but should be treated with care as should all chemicals. Always wash from hands or other exposed skin as soon as possible after contact. Rinse the developed laminate under running water and dry off with a cloth, then allow to cool in free air for 30 minutes to stabilize.

Post bake at 100°C (212°F) for 30 minutes is recommended. Allow the laminate to fully cool before etching.

ETCHING

Three forms of Ferric Chloride are available:

1. YELLOW LUMP (Hydrated) Mix 200gm (7oz) with 200ml of water in the plastic tray and stir until dissolved.
2. ANHYDROUS Mix 100 gm with 300ml of cold water. Note: Add the powder to the water slowly stirring continuously as this process will generate extreme heat.
3. FERRIC CHLORIDE SOLUTION 42% Mix 50ml (1/5th bottle) with 100ml of water.

AMMONIUM PERSULPHATE Dissolve 100gm in 250ml of water. This solution should be heated to 40°C(100°F) but not above 50°C(120°F) for etching. Form a "basket" of plastic tubing and use a continuous "dunking" action until fully etched. Constant agitation is essential and a fresh solution should etch in 5 to 7 minutes. This is a perticularly clean etchant but does not etch as much area as the same volume of Ferric Chloride.

The Ferric Chloride solution should be pre-warmed by immersing the tray in warm water for 10 minutes. Place the board in the solution and rock gently. Remember, the etching is faster with agitation and you should be able to see immediately where the copper is being eaten away. Keep rocking and watching the process. It should take about 10 minutes to completely etch through the copper sheet and you will see the green of the fibreglass begin to show through. By holding the board up to the light you will see when it is finished. Wash the board under running water. If some of the copper has been left in unwanted places within the artwork area, it can be removed by using a brush or stick containing some developer, to remove the resist. In some cases I have replaced it into the developer to remove the final traces of unwanted resist without losing the copper-lands. The board is then placed in the ferric chloride solution for final etching.

It's a fun process and most gratifying. I hope you enjoy it as much as I do.

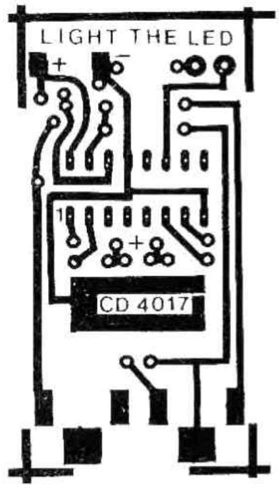
WARNING

Exercise caution when using chemicals. Do not smoke. Do not use the resist, thinners or methylated spirits near naked flame and on no account use any utensil which has been used with chemicals for food or drinking purposes. Good housekeeping is essential for good results - keep all utensils clean and dust free.

Note; The resist is not a flux, however it does not hinder soldering and can be left on the board to keep the soldering neat and professional-looking. Use fine cored solder when making up the circuit as this has plenty of flux. Pack away all the chemicals after use. The developer should be placed in an air-tight jar where it will last for many months.

SUMMARY

- Turn on oven
- Clean laminate
- Coat laminate with resist
- Turn off oven
- Bake laminate for 10 mins
- Heat Ferric Chloride solution
- Fix artwork and laminate to glass
- Expose in sunlight for 5 mins
- Remove resist in developer 5 secs
- Wash board
- Etch board in Ferric Chloride solution
- Wash board
- Drill all holes with No 60 drill



Start with this....

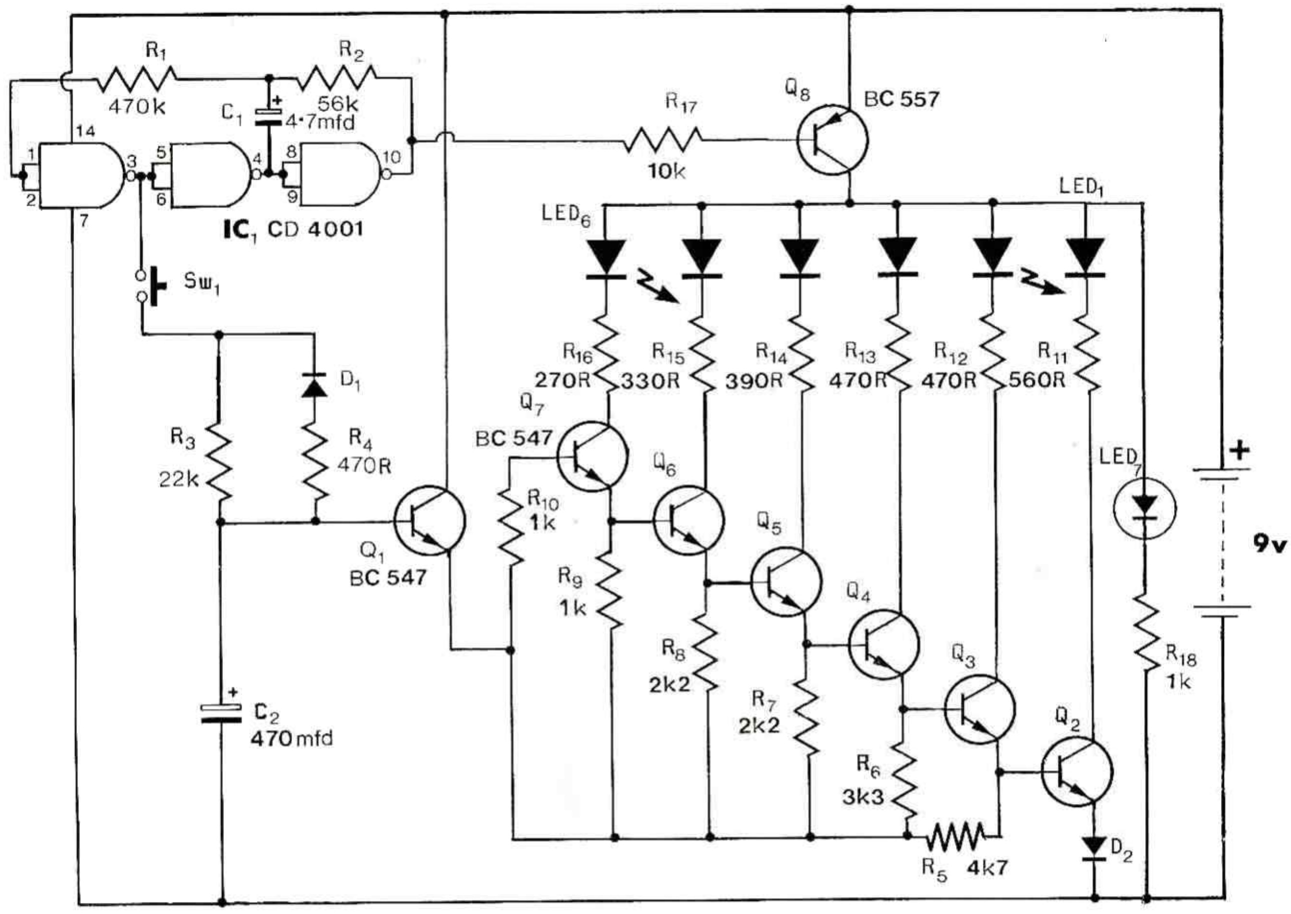
ANSWER TO LIGHT THE LED

Switch on. IC will reset. Left hand button: clock; clock. Right hand button down and kept down while: clock; clock. Right hand button up; clock; clock. Right hand button down; clock; clock; clock. Red LED will glow.

LED ZEPPELIN

Led Zeppelin is a game of patience. It's like getting a kite into the air. It goes up slowly but the slightest mistake will bring it down like a lead balloon.

PROJECT PRICE
Approx: **$8.00**



LED ZEPPELIN

Our game name, LED ZEPPELIN, is a play on words. It comes not from the pop group but from Graf Von Zeppelin, a german army officer who invented the first rigid air ship in 1900. The association fits perfectly with this project.

The game consists of six LEDs which flash at 2 cycles per second. A push button is the "Operations Control" and by carefully pushing the button in synchronization with the flashes, the row of LEDs will gradually light up but the slightest mistake will immediately extinguish one, two or three LEDs.

HOW THE CIRCUIT WORKS

The circuit consists of a three-inverter CMOS clock oscillator driving Q_8 which flashes the LEDs on and off. The other output from the oscillator is used to charge up the 470mfd electrolytic C_2, via R_3. The output from pin 3 is in the form of a square wave only slightly less than the supply voltage and is about 7.5v to 8v. The frequency of oscillation is governed by R_1, R_2 and C_1 and is approximately 2Hz. Charging of the 470mfd electrolytic is exponential so that initially the voltage increments on the capacitor will be greatest when it is beginning to charge. Each time the button is pressed a small amount of energy is fed into C_2. This voltage appears at the base of Q_1 which is connected as an emitter-follower and the voltage will appear proportionally at the emitter, less the .6v base-emitter voltage drop of Q_1. This voltage is then fed to the base of six transistors Q_2 to Q_7 which drive LEDs 1-6 via current limiting resistors. Each of these transistors will turn on according to the voltage on the 470mfd electrolytic. As the voltage rises to .6v, Q_1 will turn on. For Q_2 to turn on its base must be .6v highet than the emitter. Now Q_2 has a forward-biased diode in its emitter lead and the voltage drop across it will be .6v. The base of Q_2 must be .6v above the emitter, making it .6 plus .6 or 1.2v This means the voltage on C_2 will be .6v plus .6v plus .6v or 1.8v for the first LED to be fully lit. The emitter of Q_3 is connected to the base of Q_2 so that a further .6v will turn it on. At each successive .6v rise the next transistor in the chain will turn on until finally Q_7 will switch on. This transistor drives the top LED which is the highlight of the game. When you have LED 6 pulsating you really feel a sense of achievement.

Should the button be pressed when the oscillator is low, the diode D_1 is forward biased and the charge on C_2 will rapidly discharge through R_4. Since the voltage increments become smaller as the 470mfd becomes fully charged, to light the top LED requires significantly more pushes than LEDs 1 and 2. If, however, the button is pushed too long, the discharge will be greatest when the capacitor is nearing full charge and an error here will lose the gain made by many pushes. This is where the skill of the game comes in.

The charging of the capacitor is "out of phase" with the flashing of the LEDs. This means the button must be pressed when the LEDs are extinguished. To turn the game off, push the button when the LEDs are lit. This will remove the charge on C_2 and eventually every LED will go out.

CONSTRUCTION

All the components are mounted on the Printed Circuit Board. Follow the layout diagram for the identification of each part. You will notice all the components are placed neatly on the board with Q_2 - Q_7 fitted the same way around and all LEDs mounted the same way. For the transistors a dot on the PC board signifies the collector lead. Both electrolytics are identified with their positive lead. The IC has pin 1 shown and the switch connections are also identified.

PARTS LIST

R1	resistor	470k	¼watt 5%
R2	"	56k	"
R3	"	22k	"
R4	"	470R	"
R5	"	4k7	"
R6	"	3k3	"
R7	"	2k2	"
R8	"	2k2	"
R9	"	1k0	"
R10	"	1k0	"
R11	"	560R	"
R12	"	470R	"
R13	"	470R	"
R14	"	390R	"
R15	"	330R	"
R16	"	270R	"
R17	"	10k	"
R18	"	1k0	"

C1 electrolytic 4.7mfd 16v
C2 " 470mfd 16v

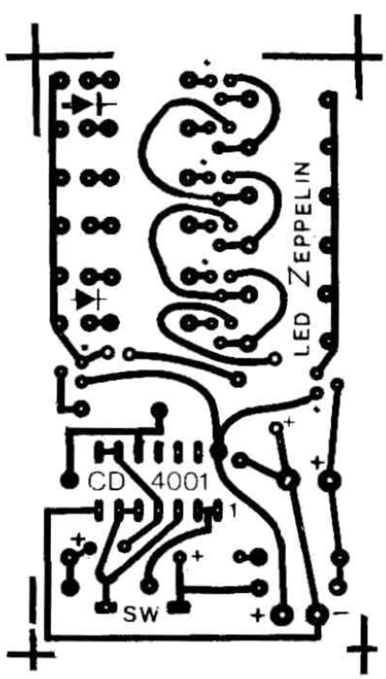
Q1 - Q7 transistors BC 547
Q8 " BC 557

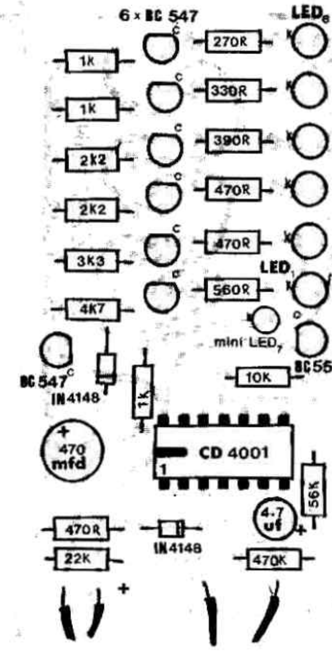
IC_1 CD 4001

LED_1 - LED_6 Large Red LEDs
LED_7 miniature red Light-Emitting Diode

$D_1 D_2$ diodes 1N914 or IN 4148

Sw_1 push button
battery clip
9v battery
"Led Zeppelin" PC Board





The last two items to connect are the two wires for the switch and the battery clip. Check all soldering and the orientation of the transistors. I always connect a milliammeter in one battery line whenever I switch on a project for the first time to check if a short-circuit is present or excessive current is being drawn - you should do this if you have a multimeter.

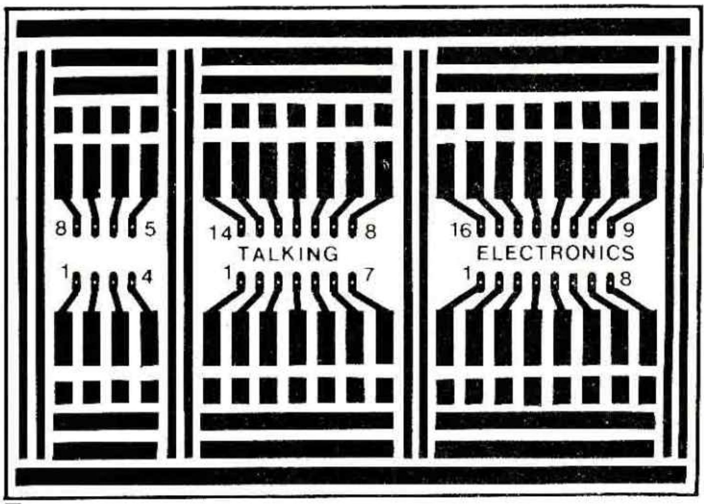
TO PLAY

The miniature LED begins to flash when the battery is connected. This indicates the flash rate. To start the chain of LEDs flashing, push the switch a number times when the LED is extinguished and eventually you will see the first LED flash faintly. Keep in harmony with the off periods and you will gradually increase the illumination. The rest is up to you.

The LED ZEPPELIN game can be played a number of ways. The most popular is to count the number of pushes required to get the top LED flashing with reasonable brightness. The player with the least number of pushes wins. Another variation is to cover the six LEDs with black tape leaving just the indicator LED flashing. The object of the game is to see how many LEDs can be set flashing with a certain number of pushes. Start with 50 pushes per player. Push the button 50 times then remove the tape and read your score. You can make certain adjustments such as 3½ or 2¼ LEDs flashing. When used competitively, like this, the game provides a means of assessing your reflex time and co-ordination.

Designed for:
TALKING ELECTRONICS

INTRODUCING THE....



A PC board you can use again and again......

This series of articles is designed around the TALKING ELECTRONICS IC EXPERIMENTER BOARD. This PC board is made for these 3 IC's:
8 pin IC
14 pin IC
16 pin IC

All the components including the IC's are mounted on TOP of the board. This type of construction is called "bread-boarding" and has 3 major advantages for the experimenter:

1. The board can be used again and again.
2. The parts – including the IC's – can be easily removed.
3. The board is very easy to use – it doesn't have to be turned over to follow the copper tracks.

All this adds up to an inexpensive way to produce quick projects which can be transferred to a home-made PC board if the circuit needs to be kept or made to look more professional, if not they can be removed.

The IC EXPERIMENTER BOARD has been specially designed for newcomers unaccustomed to soldering integrated circuits or in fact anyone wishing to use the same components in future projects. The .1" matrix which is now universally used for all electronic components has been enlarged a little to make soldering easier. This is why the solder lands for the IC's have been spread out from the socket. Interconnection between IC's has been provided by the double copper tracks at the top and bottom. The extreme outside tracks from the positive and negative rails.

You shouldn't have any difficulty following the simple projects in this series. The layout diagrams will help you to position the parts accurately.

USING IC's

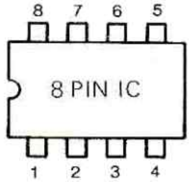
For those who have never handled IC's, there are basically two types of IC which we will be using in these projects. The older type called TTL stands for Transistor-Transistor-Logic. They are quite robust and can be soldered into circuit without any fear of damaging them provided you keep your fingers on the body of the IC as a heat-sink while soldering the pins.

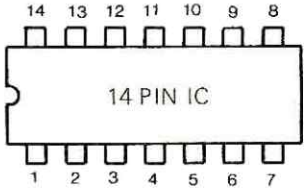
The second type is CMOS, standing for Complementary-Metal Oxide Semiconductor. These types are sold to you with their leads fitted through tin-foil to prevent any static electricity build-up damaging their input gates. Once you remove the foil, solder them into circuit making sure the IC is heat-sinked with your fingers.

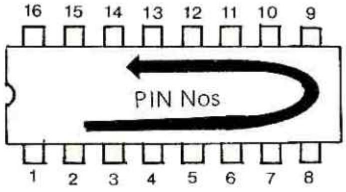
PIN NUMBERING

All IC's are numbered in an anticlockwise direction when looking at them soldered onto a printed circuit board. Pin 1 is identified by either a keyway or notch in the end of the IC or a dimple near the pin. Don't take any notice of any other holes, they are just push-pin holes created when the IC is pushed out of its manufacturing cavity.

Pin numbering is always ANTICLOCKWISE







16 PIN IC

Boards are available from:
TALKING ELECTRONICS Magazine
(See Advert)

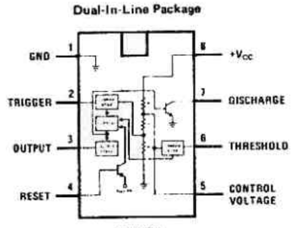
EXPERIMENTER BOARD

THE 555 TIMER

One of the handiest IC's to be invented is the 555 timer. It is contained in a tiny 8 pin package and consists of a complex array of transistors which only need a few external components to produce an accurate time delay.

555 BLOCK DIAGRAM

In this diagram you can see a free-running flip-flop which is triggered via pins 2 and 6 to drive the output pin 3. The 555 timer can provide time delays ranging from several minutes for one cycle of operation to many



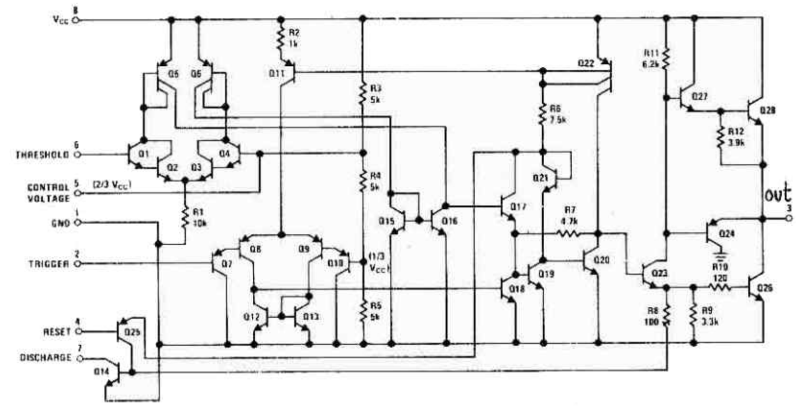
thousands of cycles per second. Any circuit which cycles more than a few times per second is called an oscillator. Below this frequency we cay it is "cycling". The frequency of oscillation is measured in cycles per second (cps) — now called Hertz (Hz) in honour of the scientist H.R. Hertz 1857-94 who experimented with electromagnetic waves which he called hertzian or radio waves — thus the name Hertz.

Only two external resistors and one capacitor are needed to provide timing for the 555 timer. The output can drive a load such as a LED which will flash each time the timer is cycled.

FULL 555 SCHEMATIC

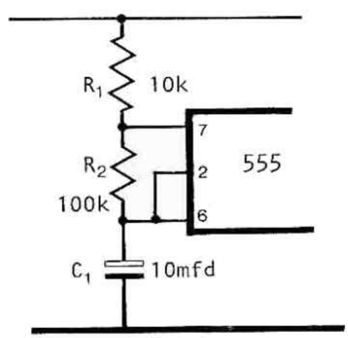
The full schematic diagram is reproduced here mainly to show its complexity. Obviously it would not be worthwhile making this circuit from individual components as the whole chip costs less than 40 cents! It incorporates 28 transistors and a set of resistors housed inside the 8 pin package. The schematic can be simplified somewhat to a block diagram making the operation of the circuit slightly easier to understand.

schematic diagram



HOW DOES THE 555 TIMER WORK?

The 555 timer operates by sensing voltage levels on pin 2 and 6.



TIMING COMPRISES R_1 R_2 & C_1

When the IC is connected to the supply, the capacitor C_1 begins to charge. When its voltage rises to 2/3 of the supply voltage, pin 6 detects this level and turns the IC off. The pin is then effectively disconnected from the circuit and does not have any further function until the IC is turned back on again. At the same instant pin 7 becomes connected to the negative rail via circuitry inside the IC so that the capacitor begins to discharge via R_2. As this occurs, the voltage on pin 2 is reducing to a point where it becomes 1/3 of the supply voltage. Pin 2 detects this and turns the IC on again. It removes the short on pin 7 so that the capacitor C_1 can charge up again. During this charging period pin 2 has no effect on the charge-time as it is virtually disconnected.

In summary: the IC triggers between two voltage limits to turn the LED on and off.

PROJECT ONE

flashing LED

One of the simplest and most effective circuits using the 555 timer is a low frequency oscillator driving a LED. In this first project the components have been chosen to give a frequency of about 2 cycles per second (2Hz). This means the LED will blink twice per second.

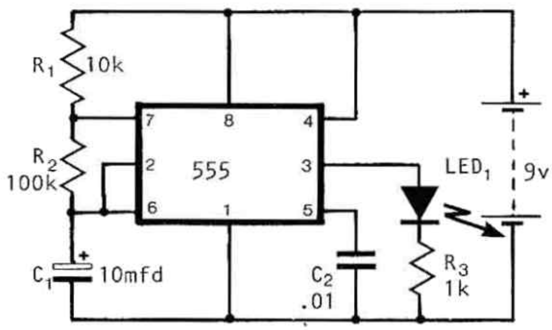
The whole circuit uses just 7 components. These are soldered onto the top of the experimenter board as shown in the layout diagram. You will need 7 jumper wires to connect the IC pins to the parts via the copper tracks. Use a 9v battery to power the LED and connect the battery snap to the positive and negative tracks as shown.

Before connecting the battery, check over these 5 points:

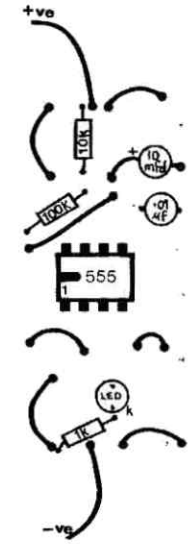
1. Does the dot on the end of the IC align with pin 1 on the board?
2. Does the long lead of the LED connect to pin 3?
3. Does the positive of the 10mfd electrolytic connect to pins 6 and 2?
4. Are the 7 jumper wires in position?
5. Are all the 8 pins of the IC connected?

Connect the battery. With a little bit of luck the LED will flash at 2Hz! If it doesn't, don't despair. Read the project through again. Look for these 6 possible faults:

1. Battery connected around the wrong way.
2. Solder bridging the copper tracks near the IC.
3. Parts touching.
4. LED inserted the wrong way around.
5. A missing jumper wire or part.
6. Weak battery.



Circuit 1 FLASHING LED



FLASHING LED LAYOUT

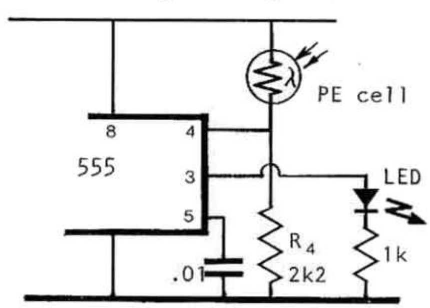
PROJECT TWO

LIGHT ACTIVATED FLASHING LED

With the addition of only two components we can create three different effects on the flashing LED in the first circuit. A Light Dependent Resistor (LDR), more commonly known as a photocell can be combined with a resistor and connected into the circuit so that the LED flashes only when the room is illuminated or conversely, only when the room is in darkness. Another effect is achieved by wiring the LDR between pins 6 and 7. This will alter the flash frequency according to the amount of light falling on the LDR.

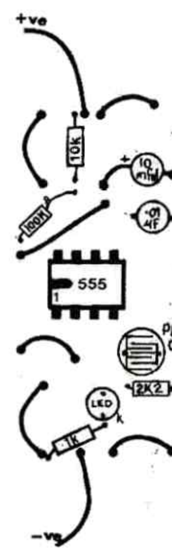
FLASHING LED WITH PHOTOCELL

Circuit 2 shows the photocell connected to pin 4. A 2.2k resistor is used to bias pin 4 at ground potential. When no light falls on the photocell pin 4 is effectively grounded. As the light intensity is increased the resistance of the photocell is reduced thus increasing the voltage on pin



Circuit 2 HIGH ILLUMINATION WILL TURN LED OFF

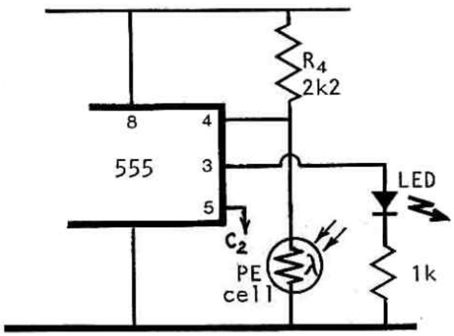
4. A voltage level of about .8v is reached which is detected by pin 4 to turn on the oscillator. The sensitivity of the photocell can be adjusted by varying R4. By experimenting and finding a suitable value for R4, the LED may be made to turn on at the first sign of light.



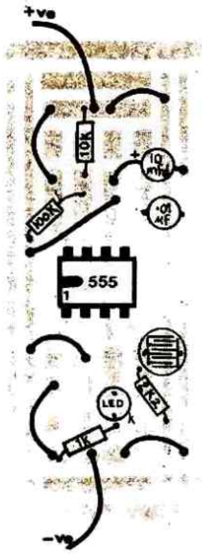
PROJECT THREE

If you want to reverse the effect — namely to extinguish the LED when the light is reduced, circuit 3 will create this effect.

It merely reverses the photocell and biasing resistor. As the light falling on the LDR increases, its resistance decreases and bring the voltage at pin 4 down to a point where the 555 timer will turn off.



Circuit 3 HIGH ILLUMINATION WILL TURN LED ON



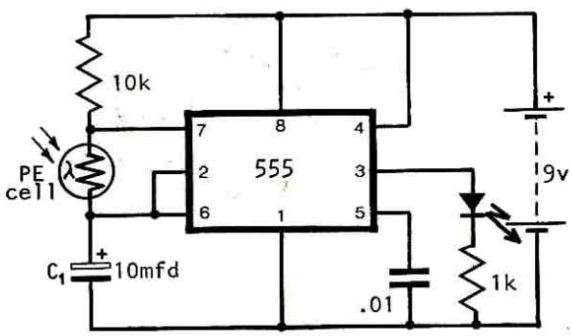
WHAT IS A PHOTOCELL?

A Photocell is a thin sheet of semiconductor material such as selenium, germanium or silicon which is sensitive to light. It has

a parallel grid of 2 conducting wires etched over its face to increase the effective area of conduction. These two wires connect to 2 leads. The whole assembly is mounted behind a clear glass window so that light falling on the cell will change its resistance. Under very bright light its resistance will be in the order of only a few hundred ohms. This increase to over 1 meg in total darkness. This large change in resistance can be used to trigger the IC at specific illuminations or modulate the timing circuit to alter the rate of flashing.

PROJECT FOUR

To vary the frequency of flash we need only to replace R_2 with the photocell. As the light intensity on the photocell changes the charge time for C_1 will vary so that the LED will flash from one cycle every few minutes to a rate so high that it will be beyond your speed of counting. It will appear as if the LED is constantly glowing.



Circuit 4 LIGHT FALLING ON LDR WILL ALTER FLASH RATE

PARTS LIST

For circuits 1 - 5

Resistors:

1 - 1k
1 - 2k2
1 - 10k
1 - 100k

Capacitors:

1 - .01mfd ceramic
1 - .1mfd ceramic
1 - 10mfd electro

IC's:

1 - 555 IC (or NE 555)
(or SE 555)
(or LM 555)
1 - CD 4017 IC

1 - PE cell ORP 12
2 - Red LED's
1 - Push-on Switch
1 - 9v battery
1 - Battery clip

1 - 3-IC EXPERIMENTER BOARD

PROJECT FIVE

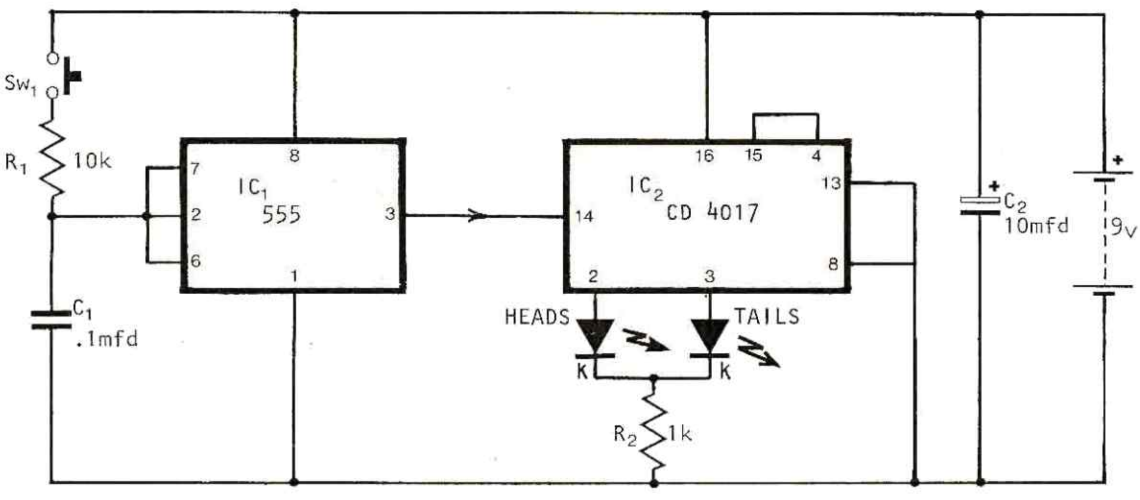
Heads or Tails?

A very simple circuit using a 555 timer and a counting IC.

Have you seen the electronic descision makers on the market? A number of models have been released. Most retail for around $15 to $30 and come in a variety of styles displaying either "HEADS/TAILS" or "YES" and "NO" or "DO IT NOW/DO IT TOMORROW". Effectively they are all the same — consisting of 2 red LEDS on a colourful background displaying the appropriate messages. They make a wonderful gift for a procrastinator or as a party game. A push button starts the LEDs flashing and they gradually slow down to a stable state of either yes or no.

The circuit for the HEADS or TAILS project uses IC's and 2 LEDs. The first IC is a 555 timer. The time-constant components comprising the 10k resistor R_1 and .1mfd capacitor C_1 have been chosen to enable the timer to oscillate at a frequency of 1500 Hz. The output at pin 3 feeds directly into the second IC, a CD 4017 decade counter. It is capable of counting up to ten then setting automatically to begin again. The IC can be programmed or to put it another way, can be adjusted to count up to 2,3,4,5,6,7,8 or 9 simply by connecting the next output to the reset pin. For instance: If you wish to count to 7, connect output 8 to the reset pin and the IC will count to 7 then reset again.

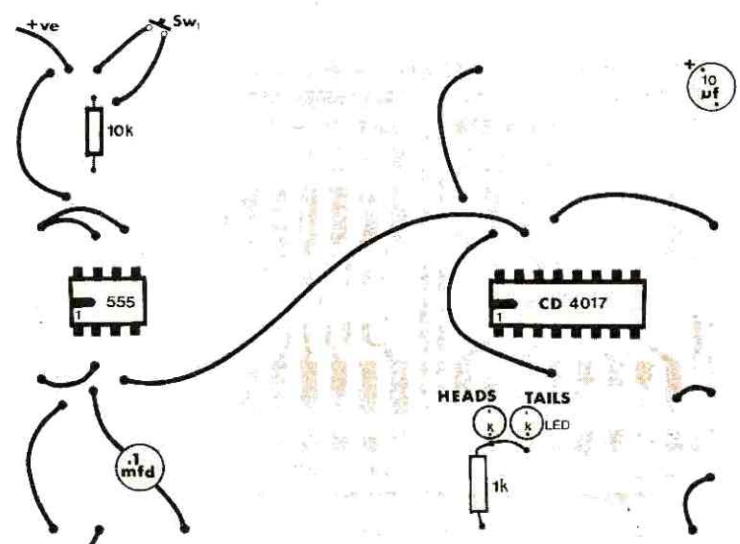
In this project we use only the first two outputs: pin 3 is the first output and pin 2 is the second output. The outputs do not correspond to the IC pin numbers but happen to fall in this order: 3-2-4-10-1-5-6-9-11. If we connect the third output (pin 4) to the reset pin 15, the IC will clock from 3 to 2 then reset back to 3 again. In other words it will oscillate between 3 and 2 at 750Hz at each output. Actually we are using a very complex IC for this simple project however, we will be utilizing more of the IC in the next project so don't worry about the cost at this stage.



Circuit 5. HEADS or TAILS.

Basically, this project performs the same task. Except that it doesn't have the sophistication of allowing the LEDs to slow down before locking into one stable state.

However, this breadboard project could be fitted into a small box and with a little imagination a colourful front panel could be designed to brighten it up and save yourself a lot of money over the bought model. Two very simple panels are included here to give you ideas to work from.



HEADS or TAILS LAYOUT

10-MINUTE DIGITAL COURSE

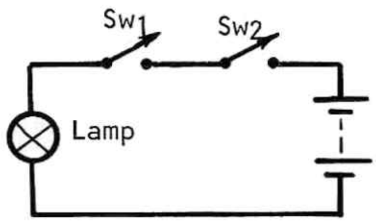
SIMPLIFIED FOR BEGINNERS

There are 5 basic logic elements: AND, OR, NOT, NAND, NOR.
This is how they operate:

SYMBOLS

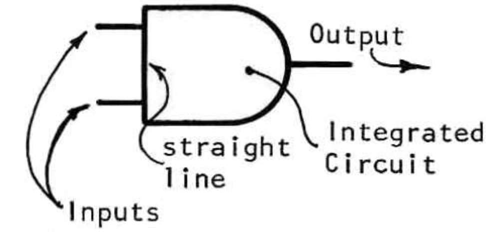
1

AND



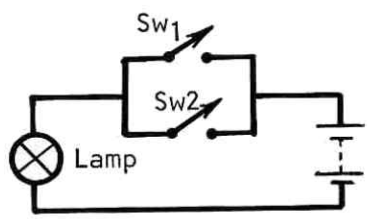
Close both Sw_1 and Sw_2 to light lamp.

An AND element is called an AND GATE.



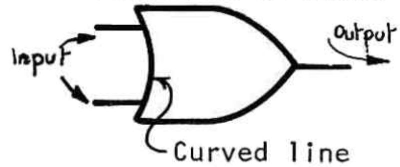
2

OR



Close Sw1 OR Sw2 to light Lamp.

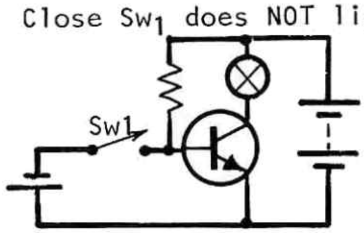
An OR element is called an OR GATE.



3

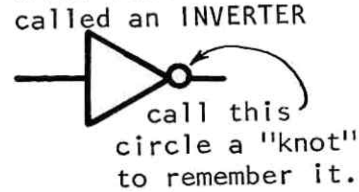
NOT

Close Sw_1 does NOT light lamp



ie: close Sw_1 to turn lamp off.

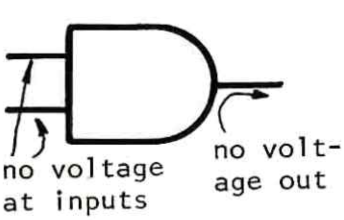
A NOT function is called an INVERTER

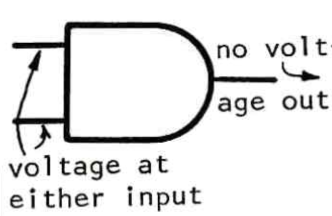


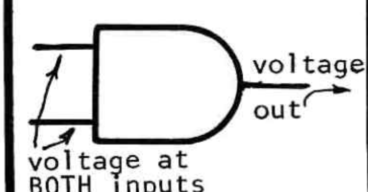
How AND, OR and NOT GATES work:

4

AND Gate:







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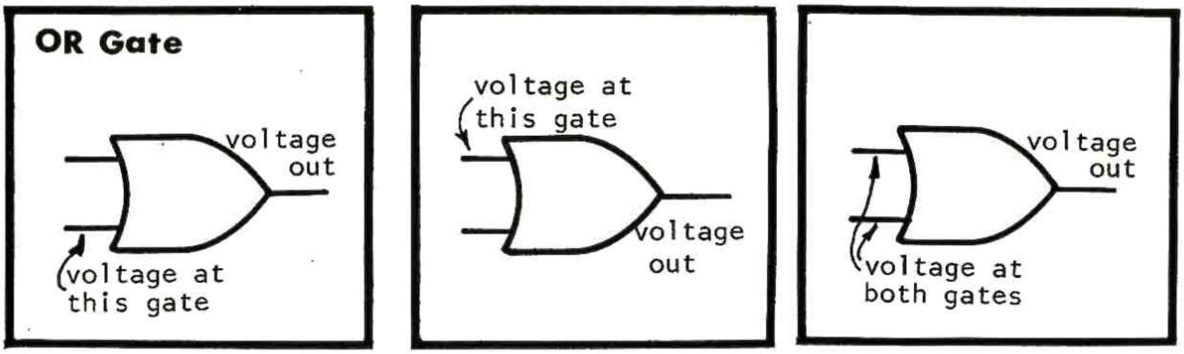

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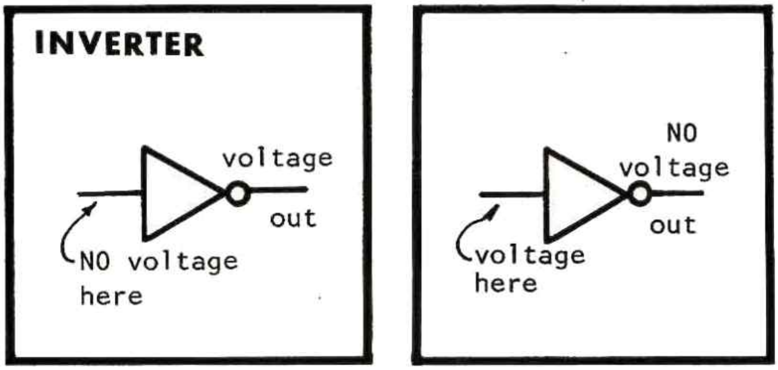


CALL THIS AN INVERTER

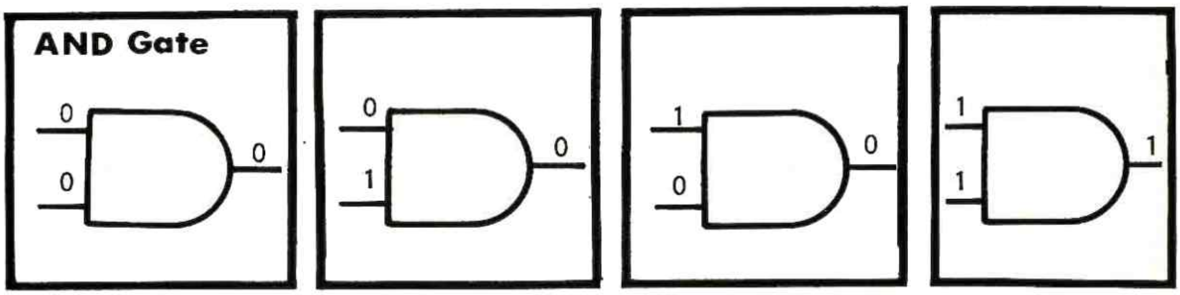
The 2 LOGIC NUMBERS:

0 = no voltage
1 = voltage

7

The Function of the 3 gates can be expressed in logic numbers

8



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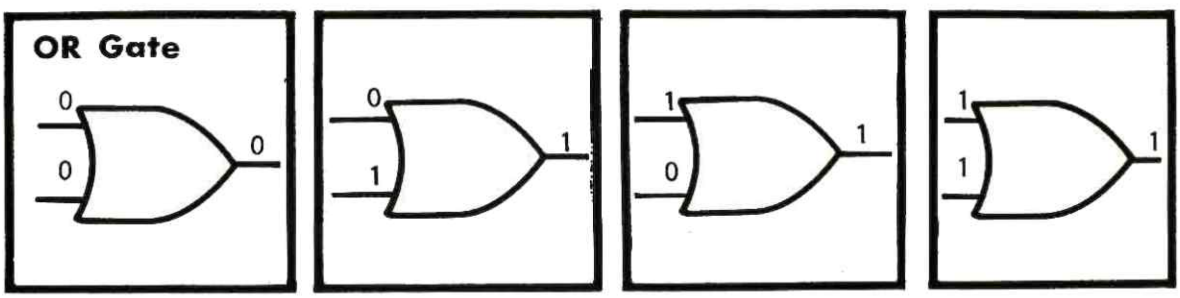

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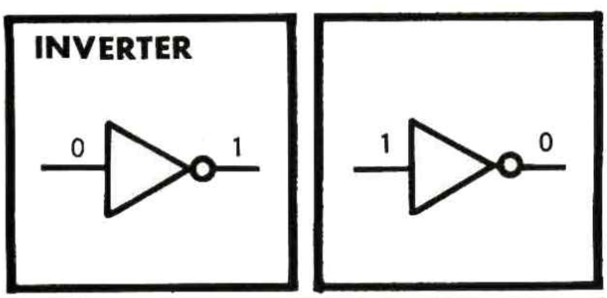


11

The numbers 0 and 1 are called logic values. Each gate can have 2 possible values. TRUE for logic level 1 and FALSE for logic level 0. Thus we can make a TRUTH TABLE for each of the gates.

AND Gate

INPUTS		OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

INPUTS	OUTPUT
*any combination	0
1 1	1

* means any combination except 1 1

OR

INPUTS		OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

INPUTS	OUTPUT
0 0	0
any other combination	1

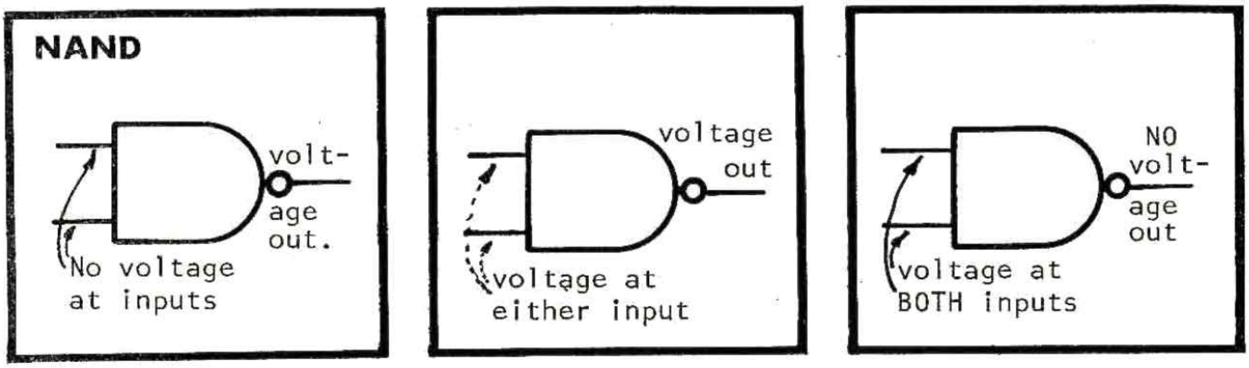
NOT

INPUT	OUTPUT
1	0
0	1

cannot be simplified except to say it's an inverter

Two further gates are:
NAND– the complement of a normal AND gate
NOR – the complement of a normal OR gate

12



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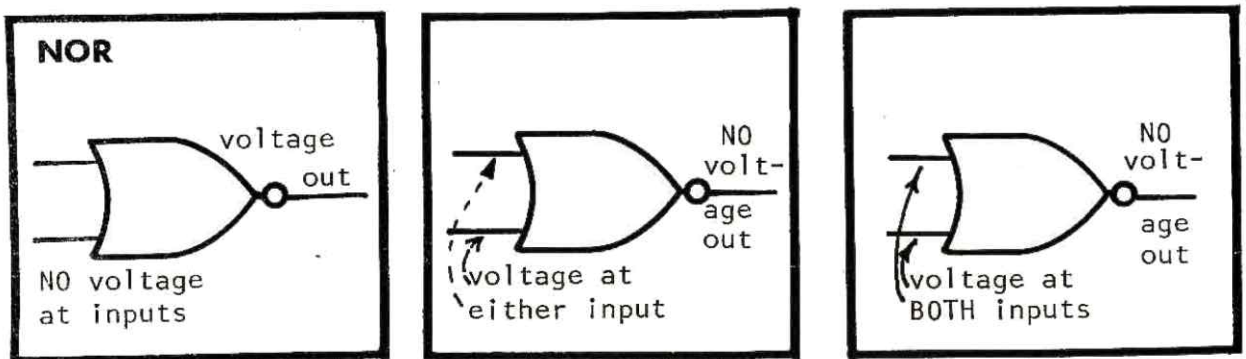

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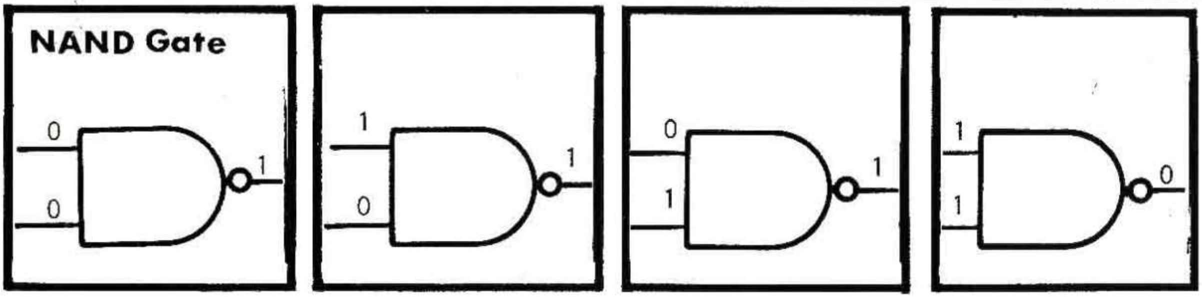

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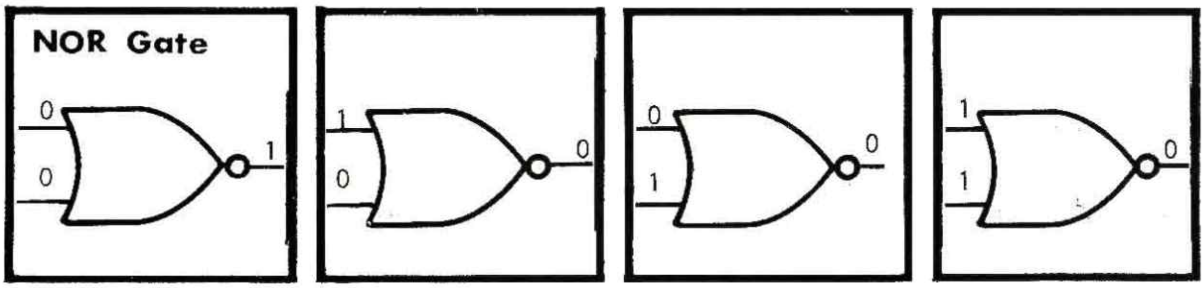


16

NAND Gate

INPUTS		OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

➡

INPUTS		OUTPUT
1	1	0
any other combination		1

NOR Gate

INPUTS		OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

➡

INPUTS		OUTPUT
0	0	1
any other combination		0

SUMMARY

For an AND gate:
A voltage at one input will have no effect but a voltage at both inputs will change the state of the output.

For an OR gate:
A voltage at one input will change the output and the other input will have no effect.

For an INVERTER
The output is of opposite logic level to the input.

For A NAND gate:
A voltage on one input will have no effect but a voltage at both inputs will change the state of the output.

For a NOR gate:
A voltage at either input will change the output.

TEST

Answer these questions:

1. Name the 4 commonly used types of gates:
2. What is the common name for a NOT gate?
3. What are the two TRUTH values?
4. Look at the four TRUTH tables to answer these:
   - A: With one gate of an AND GATE at logic 1 will the other gate alter the output?
   - B: With one gate of an OR GATE at logic 1 will the other gate alter the output?
   - C: With one gate or a NAND GATE at logic level 1 will the other gate alter the output?
   - D: With one gate of a NOR GATE at logic level 1 will the other gate alter the output?

TEST YOURSELF... No1

How good are you at identifying resistors? This quick test will give you a rating.

The most common component in electronics is the resistor. You see it so often you may take it for granted that you know a lot about resistors. But do you? Actually you could spend a whole lifetime studying resistor characteristics and insulating materials and still only know a fraction. This simple test should bring out your knowledge of resistors.

Can you name any other component which is made to exacting standards yet sells for just 2 cents? No, possibly not. Automation has made this possible as quarter and half watt resistors have reduced in price dramatically in the past decade and yet their quality has risen dramatically.

This test is graded into two sections: Beginners should attempt questions 1 to 10 while more advanced hobbyists can work right through. The answers appear at the end of the test.

1. Write down all the resistors between 10ohms and 270ohms: (use the E12 series or common series) (16 marks)

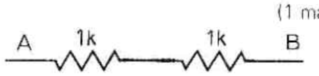
2. Draw the symbol for:
   (a) A fixed resistor (1 mark)
   (b) A potentiometer (1 mark)

3. What is the difference in appearance between a 47ohm resistor and a 4k7 resistor? (1 mark)

4. Write down the value of these resistors:
   (a) red–red–orange: (4 marks)
   (b) yellow–purple-brown: (4 marks)
   (c) blue–grey–orange: (4 marks)
   (d) red–purple–green: (4 marks)
   (e) green–blue–red: (4 marks)

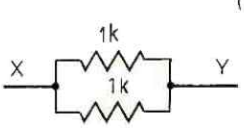
5. What are the colours of these resistors?
   (a) 2.2M (4 marks)
   (b) 470ohm (4 marks)
   (c) 56k (4 marks)
   (d) 220ohm (4 marks)
   (e) 3k3 (4 marks)

6. What is the value between A&B? (1 mark)



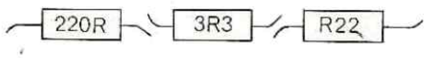
7. If two resistors have the same colours but are of different size; what does this tell us? (1 mark)

8. What is the value between X&Y? (1 mark)



9. What is the value of these resistors?
   (a) Silver–green–orange–orange. (4 marks)
   (b) Gold–brown–purple–red: (4 marks)

10. Explain the value of these resistors: (3 marks)



Total 73 Marks

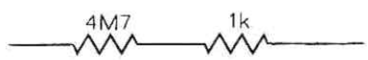
SECTION 2: More Advanced

11. With 2 resistors in series, why should the value of each be nearly the same: (4 marks)

12. Choose ½ watt resistors to make each of these values:
    (a) 1k 1 watt: (2 marks)
    (b) 3k3 2watt (2 marks)
    (c) 4M7 1 watt: (2 marks)

13. Give 2 situations where question 12 may arise in practice:
    (i)
    (ii) (2 marks)

14. Explain why this is unnecessary (Hint: tolerance) (1 mark)



15. A 2k2 ½ watt resistor is getting too hot. What should you do? (1 mark)

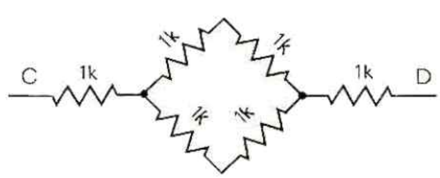
16. Four resistors, all consisting entirely of red bands, are paralleled. What is the combined resistance? (4 marks)

17. How can you detect, without instruments, if a wire-wound resistor is not functioning? (1 mark)

18. What is the value of these?
    (a) yellow–purple–gold–silver: (4 marks)
    (b) red–red–gold–gold: (4 marks)
    (c) yellow–purple–silver–gold: (4 marks)

19. What are the colours of these resistors?
    (a) R27 10% (4 marks)
    (b) 1R5 10% (4 marks)
    (c) 3R3 5% (4 marks)
    (d) 1R0 5% (4 marks)

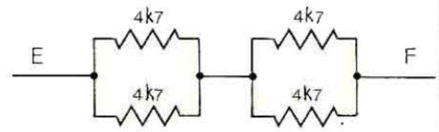
20. What is the value across the terminals C&D? (5 marks)



21. From a sample of 50 different resistors, which colour appears most often? (2 marks)

22. A black bag contains 10 1k resistors and 10 3k3 resistors. How many resistors must you choose to be guaranteed a resistance of:
    (a) 1k (5 marks)
    (b) 10k (5 marks)
    (c) 4k3 exactly (5 marks)

23. What is the resistance between E&F? (5 marks)



Total 74 Marks

Answers:

1. 12ohms, 15ohms, 18ohms, 22ohms, 27ohms, 33ohms, 39ohms, 47ohms, 56ohms, 68ohms, 82ohms, 100ohms, 120ohms, 150ohms, 180ohms, 220ohms. 2. (a) (b) 3. The third colour band: black, red. 4. (a) 22k (b) 470ohms (c) 68k (d) 2M7 (e) 5k6 5. (a) red–red–green (b) yellow–purple–brown (c) green–blue–orange (d) red–red–brown (e) orange–orange–red 6. 2k 7. Their wattage is different 8. 500ohms 9. They were read around the wrong way! (a) 3M3 10% (b) 270ohms 5% 10. 22ohms; 3point3 ohms; point 22 ohms 11. So the heat dissipated by each will be nearly the same. So that the voltage across each will be nearly the same. 12. (a) Two 2k2 resistors in parallel or two 470ohm resistors in series (b) Four 12k resistors in parallel or four 820ohm resistors in series (c) A 2M2 and 2M7 resistor in series or two 10M resistors in parallel. 13. When no 1 watt resistor is available, when a high voltage is present two resistors are put in series. 14. The tolerance of the 4M7 resistor will swamp the small effect of the 1k resistor. 15. Check the circuit for leaky or shorted transistors. If the voltage across the resistor is correct it may need a higher wattage. 16. 550ohms 17. Touch it with a wet finger, it should be hot. 18. (a) 4R7 10% (b) 2R2 5% (c) R47 5% 19. red–purple–silver–silver (b) brown–green–gold–silver (c) orange–orange–gold–gold (d) brown–black–gold–gold 20. 3k 21. red 22. This is a trick question. (a) you must choose 3 resistors which can be paralleled up to give 1k1 or 1k. (b) 12 resistors, at worst you may be choosing nine 1k resistors then you need three at 3k3. (c) 11 resistors. 23. 4k7.

score:

For each section:

Over 65 marks	– Excellent
Over 50	– Very Good
Over 40	– Good
Below 40	– Not a Pass

THE TRANSISTOR PAGE

A SERIES OF PROJECTS USING PARTS FROM YOUR JUNK-BOX.

NO — WE HAVEN'T FORGOTTEN THE TRANSISTOR!

Here are 5 novel circuits you can build with any small-signal silicon transistors. You may use any odd transistors you have in the junk-box or take advantage of the special offer of 20 transistors for $2.40 Any transistors salvaged from computer boards or having an odd type number can be identified as either PNP or NPN by testing it with the SIMPLE TRANSISTOR TESTER described in this article. It does not give any other characteristics however,as these circuits are so simple that you can use any of them as a tester in themselves. The TICKING BOMB, for instance, is ideal as it uses both an NPN and a PNP transistor so that either one can be substituted with an unknown type. As a precaution against reverse voltage you should include a 1k resistor in series with one lead of the battery. This will limit the reverse current to 10ma while the electrolytic reduces the impedance of the supply to enable the circuit to operate.

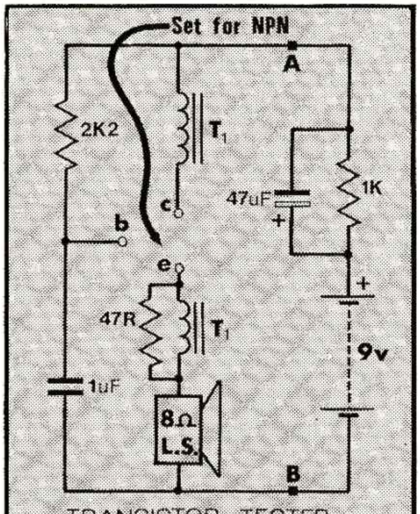
The transistor offer contains 20 NEW and fully guaranteed transistors. They are not rejects or seconds. This offer has been made available by this magazine at almost cost-price to encourage new experimenters into the field of MAKING rather than looking and thinking. Some electronics shops are also participating in this offer so ask the manager of your local shop first, before sending for the offer.

The whole 5 circuits can be constructed on one piece of veroboard strip, 81 holes long by 15 holes wide. The cost of this is less than $2. The board can be cut into lengths for each project to make a neat and thoroughly presentable finish. The 81 copper strips run across the board and have been cut in the middle by the manufacturer, making over 160 useful contact pads.

A SIMPLE TRANSISTOR TESTER

Do you have a number of transistors which have their numbers rubbed off or odd transistors of an un-identified type?

This circuit will test them and find out if they are PNP or NPN. It is short-circuit proof so putting a transistor round the wrong way will not damage it. The diagram is set for NPN types. The terminals marked C B and E can be alligator clips on short lengths of hook-up wire. The transformer T_1 is a speaker transformer salvaged from a transistor radio. It can have any impedance such as 400:8 ohm and must be inserted so that the primary winding gives a feed-back to the secondary winding. When this occurs, you will hear a whistle in the speaker. Now you are ready to try all your odd types. Those that do not oscillate should be put aside and re-tested when the battery with its current limiter is reversed at terminals A and B.



TRANSISTOR TESTER

EQUIVALENTS FOR THIS PROJECT:

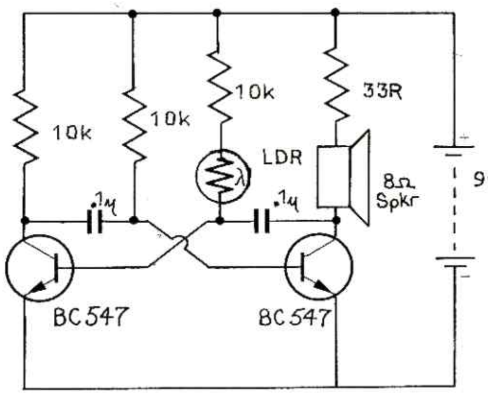
PNP TYPES		
BC 157	BC 158	BC 159
BC 177	BC 327	BC 557
BC 558		

NPN TYPES		
BC 107	BC 108	BC 207
BC 208	BC 337	BC 547
BC 548	BC 635	

...the transistor page

LIGHT ALARM

This project has a number of uses. Essentially it is a light alarm which is triggered into oscillation by the Light-Dependent-Resistor. Under dark conditions the LDR has very high resistance and thus the first transistor has no bias on its base. This prevents the multi-vibrator from functioning and in this condition draws only about 1ma. As the light intensity increases, the resistance of the photocell decreases and the multi-vibrator starts up. Its frequency gradually rises to a high pitched whistle as set by the limiting resistor in series with it. Now, the possibilities for an alarm of this nature are endless. It will give an audible indication of the intensity of a light source or compare two illuminations. As an alarm it is useful as a theft device. It can be put into a cupboard or drawer to protect it from prying fingers. It can be used as an alert for the medicine chest or money drawer. In any case its advantage lies in the fact that it doesn't have to be wired to any switches and can be moved around with ease.



LIGHT ALARM

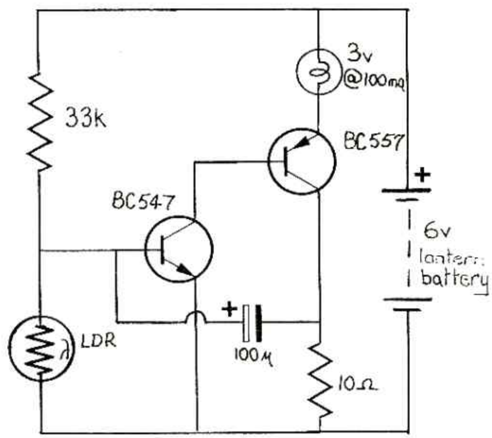
A piece of veroboard 12 holes long will accommodate all the parts making it a very compact project which can be disguised as a packet of pills by using a suitable empty container.

Parts

2	transistors	BC 547
3	resistors	10k
1	resistor	33 ohm
2	capacitors	.1mfd
1	LDR	type ORP12
1	2¼" speaker	8 ohm
1	9volt battery	
1	battery clip	
1	piece of veroboard	

BLINKER

Have you seen the blinking lights at the road-side to warn motorists of roadworks or an excavation? These lights turn off during the day and begin to operate only at dusk. They contain 1 or 2 lantern batteries, a Light-Dependent-Resistor and a 2-transistor flasher. The main requirement for a circuit to operate this type of warning device (apart from creating the flashes) is for its daytime current to be as low as possible to conserve battery. Since the flash of the globe is extremely short, the average current drawn from the battery will be quite small. This circuit achieves both of these requirements.



"BLINKER"

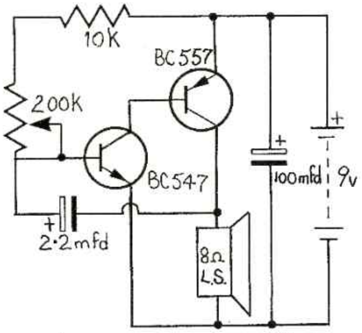
The stand-by current is only 100microamp and the average operating current is less than 25 milli-amps. The only two critical components in the circuit are the 10 ohm resistor and globe. The resistor must be 10 ohms. A 5 ohm or 15 ohm resistor will not work. The lamp must be a low current type. A miniature model railway globe of about 3v - 4v is ideal. It must be rated at .05 to .1 amp to operate successfully. Ordinary torch globes of 2.5v @ 300ma will not work at all. Use a light dependent resistor type ORP12 or similar which has a dark resistance of 10M and a light resistance of 300 ohms.

Parts

1	transistor	BC 547
1	transistor	BC 557
1	resistor	33k
1	resistor	10 ohm
1	LDR	type ORP12
1	electro	100mfd 16v
1	globe 3v 100ma	
1	6v lantern battery	
1	piece of veroboard	

TICKING BOMB

When you build this circuit you will see what we mean. The effect from the speaker is very similar to a loud ticking clock. The 100mfd electrolytic is very important. It reduces the internal impedance of the battery (especially if it is low) and changes the tone from a soft tick to a very loud sharp click. It also reduces the current from 25ma to about 2ma. The circuit operation is very simple. On connecting the battery the 10k resistor, 200k pot, 2.2mfd capacitor and 8 ohm speaker are the only parts drawing current. As the capacitor begins to charge the base voltage on the NPN transistor rises to about .6v This turns the transistor on and in turn switches the second transistor to a conducting state. This results in a click from the speaker. At the same time the negative lead of the electrolytic is brought nearer the positive rail and thus the charge on the electrolytic is reduced. This turns off the first and second transistors to begin the cycle over again.



"TICKING BOMB"

The rate of charge of the electrolytic is dependent upon the value of the resistors in series with it. Thus the rate of ticking can be altered by the trim pot. Almost any NPN and PNP transistors can be used in this circuit. In fact this circuit is an ideal simple test for transistors. It will determine if they are NPN or PNP. All the parts are mounted on a small piece of veroboard 15 holes by 15 holes.

Parts

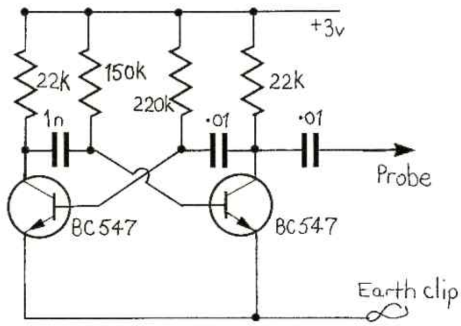
1	transistor	BC 547
1	transistor	BC 557
1	resistor	10k
1	electro	2.2mfd 16v
1	mini-trim pot	200k
1	electro	100mfd 16v
1	2¼" speaker	8 ohm
1	9v battery	
1	battery clip	
1	piece of veroboard	

SIGNAL INJECTOR

This circuits produces a very handy signal injector. It is a free-running multivibrator with an output of square wave form at a fundamental frequency of about 2kHz and thus is rich in harmonics and can provide a continuous note when injected into any receiver, up to about 20MHz.

The signal injector can be fitted into a plastic tube about 10 to 15 cm long so before cutting the veroboard it is best to find a container. A small plastic pill bottle is ideal and the veroboard can be cut to size. The probe can merely be a long thin bolt mounted in the centre of the lid.

To find a fault in an amplifier or superhet radio, simply connect the earth lead to the chassis of the amp and move through each stage starting at the speaker. Obviously an increase in volume should be heard at each preceeding stage. This injector will also go through the IF stages of radios and FM sound sections in TV's. Use 2 mercury button batteries for the supply and fabricate a switch into the screw-on lid. The first use for this injector will be to test the operation of the next project...The MINI AMPLIFIER.



SIGNAL INJECTOR

Parts

2	transistors	BC 547
2	resistors	22k
1	resistor	150k
1	resistor	220k
1	capacitor	1000pf
2	capacitors	10n
1	earth clip	
1	probe tip	
2	button cells	
1	plastic container	
1	piece of veroboard	

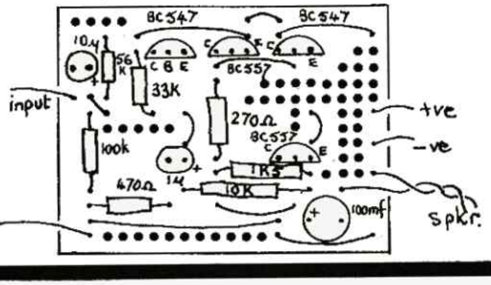
MINI AMPLIFIER

This 4-Transistor COMPLEMENTARY PUSH-PULL amplifier is designed around discrete components to show the basics of audio amplifier design. This type of circuit requires relatively few components, needs no transformers and provides very good results. The four transistors are directly coupled and DC feed-back loops help stabilize working conditions throughout. Transistors 3 and 4 are arranged as a complementary pair operating in push-pull. Each output transistor deals with one half of the audio cycle, one being cut-off when the other is driven into conduction. This is economical on battery current, which is quite low with moderate volume, rising to 25 - 30ma as volume is increased. This gives us a 250 milliwatt amplifier, enough to drive a loudspeaker to the same volume as a transistor radio.

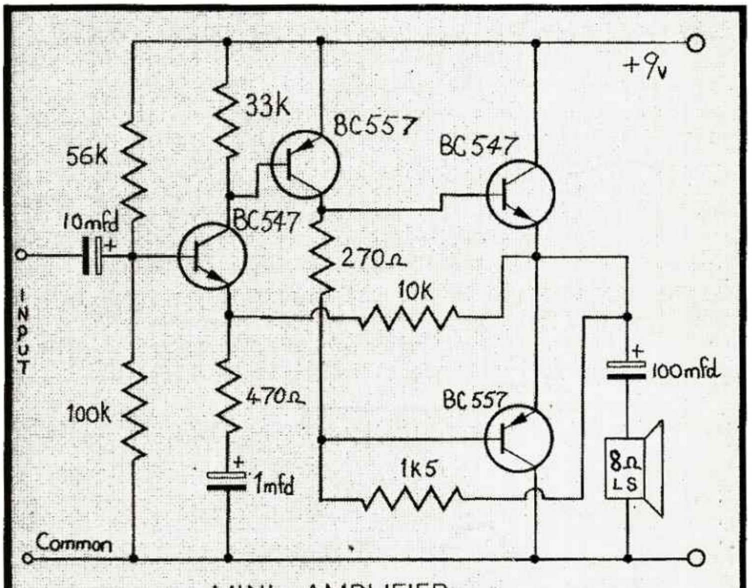
The first two transistos operate as a pre-amp to increase the incomming voltage to drive the output pair. The bias of the whole circuit commences with the voltage divider made up of the 56k and 100k resistors. This provides the base with a bias voltage of 5.5v The emitter voltage will be .6v less than this, and will be 4.9v The second transistor is biased so that it provides a voltage across the 270 ohm load resistor which will give the output transistors a voltage differential of .6v between their base and emitter leads.

Parts

2	transistors	BC 547
2	transistors	BC 557
1	resistor	270 ohm
1	"	470 ohm
1	"	1k5
1	"	10k
1	"	33k
1	"	56k
1	"	100k
1	electro	1mfd 16v
1	"	10mfd 16v
1	"	100mfd 16v
1	2¼" speaker	8 ohm
1	9v battery	
1	battery clip	
1	piece of veroboard	



This is needed to reduce cross-over distortion which occurs whenever two transistors are connected in push-pull. The 100mfd electrolytic prevents DC from appearing across the speaker which would "off set" the cone. The DC would pull the cone in a little and require the speaker to oscillate around this new position.



MINI AMPLIFIER

The amplifier may be driven from a ceramic cartridge in a record player or across the volume controlof a transistor radio. The input must be about 100 - 500 millivolts to drive the amplifier fully. A small piece of veroboard 20 - 25 holes long is needed for the amplifier. Make a layout diagram first which very nearly follows the schematic diagram before attempting any soldering. With care you will find you will not have to cut any of the veroboard tracks and most of the parts will fit neatly onto the board as they all .1" spacing. When you have completed soldering, connect the battery via a milli-ammeter to check that the current is within 30ma and most probably be 5 - 15 ma with no input signal applied. You may like to trace through the amplifier with the signal tracer from the previous project and satisfy yourself where the amplification is performed and where voltage comparisons are maintained. Obviously all the stages cannot provide amplification since a transistor can achieve a gain of at least 20 times and sometimes an in-circuit gain of 100. Thus this amplifier would achieve at least 20 x 20 x 20 or 8,000 times! But this is not so. With the input requirement of about 250 milli-volts the amplifier needs to provide a gain of about 40 to 80 times. Your signal tracer will indicate which transistor is providing this gain. See for yourself.

In all, these combined 5 transistor projects should give you hours of fun.

EXPERIMENTER DECK

BUILD THESE 10 EXPERIMENTS ON ONE PC BOARD:

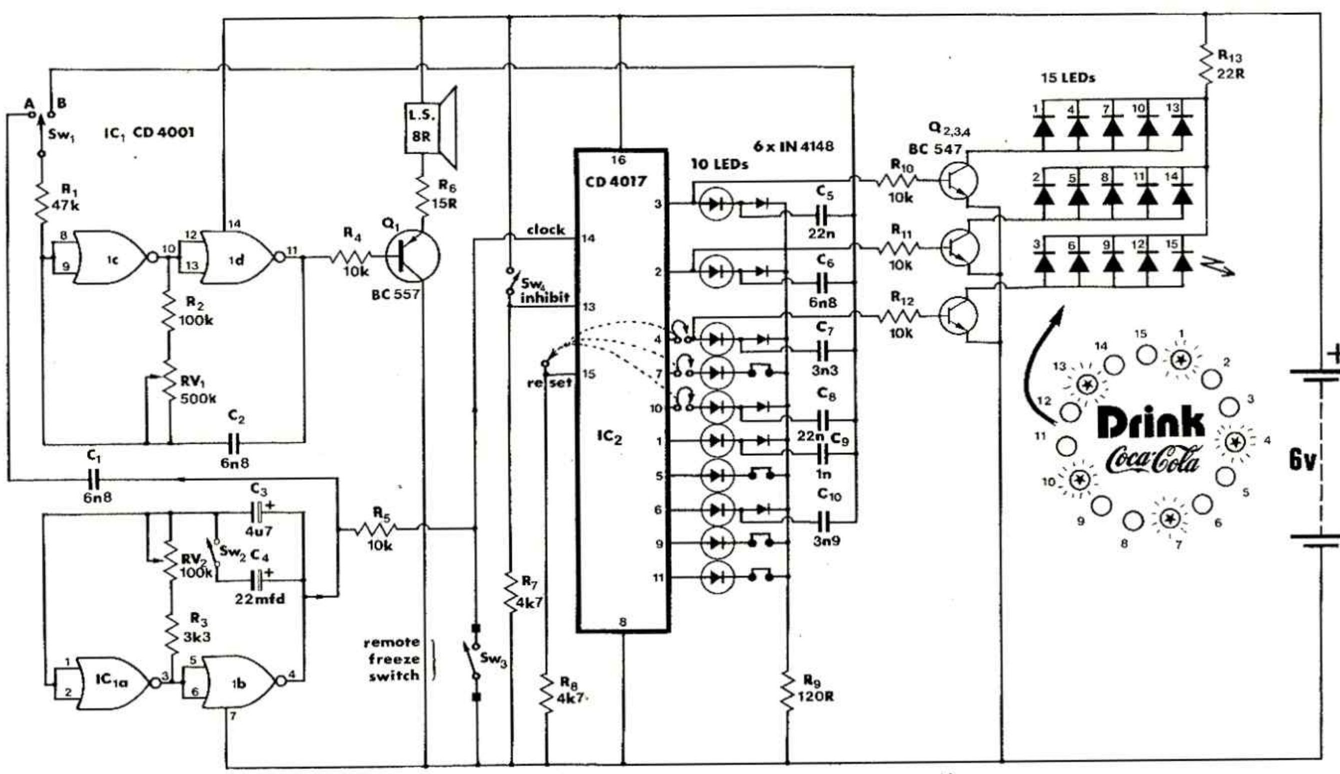
1. HEE HAW SIREN
2. HEADS or TAILS?
3. DECISION MAKER
4. RUNNING LIGHT
5. CRICKET GAME
6. TIMER
7. TEST YOU REFLEX TIME
8. TUNE
9. MAKING MUSIC
10. ADVERTISING SIGN

'THE DECK'.... What does it do?

These 10 projects are presented in a graduated form. The first project "HEE HAW SIREN" uses only 25% of the parts --- each preceeding project uses either additional parts or a different combination of switches or potentiometer settings to give a completely different experiment. This gives the EXPERIMENTER DECK a wide variety of uses and an allowance has been made for additional experimenting such as in project number 8, in which the pre-programmed tune can be re-programmed to any tune or scale you wish.

The circuit board builds up to the final project THE ADVERTISING SIGN which uses all the parts including the circle of 15 LEDs to flash in a similar manner to lights running round a neon sign or movie screen at a drive-in. The combination of the duel frequency tone from the speaker, 3 LEDs from the train of LEDs acting in a pump-like manner and the 15 circulating LEDs, is really captivating in a darkened room. It's like a miniature sound-and-light display.

Only the first project: HEE HAW SIREN, is presented in this issue. We advise, however, to purchase the full kit of parts in readiness for the next issue. Keep them in a safe place. The complete circuit may look complex but each individual project is simple.



COMPLETE "10 EXPERIMENT" CIRCUIT

Complete list of parts for the 10 projects:

1 - EXPERIMENTER DECK No1 PC board

1 - CD 4001 IC
1 - CD 4017 IC

R1	Resistor	47k	¼watt	
R2	"	100k	"	
R3	"	3k3	"	
R4	"	10k	"	
R5	"	10k	"	
R6	"	15R	"	
R7	"	4k7	"	
R8	"	4k7	"	
R9	"	120R	"	
R10	"	10k	"	
R11	"	10k	"	
R12	"	10k	"	
R13	"	22R	"	
C1	Capacitor	6n8	100v	(6800pf,.0068)
C2	"	6n8	"	(" ")
C3	Electrolytic	4u7	10 - 35v	(4.7mfd)
C4	"	22mfd	10 - 16v	
C5	Capacitor	22n	100v	(.022mfd)
C6	"	6n8	"	(6800pf,.0068)
C7	"	3n3	"	(3300pf,.0033)
C8	"	22n	"	(.022mfd)
C9	"	1n	"	(1000pf,.001)
C10	"	3n9	"	(3900pf,.0039)

6 - Diodes IN 4148 or IN 914

RV1 - Mini trim pot 500k Cermet type VTP
RV2 - Mini trim pot 100k Cermet type VTP

25 - LEDs or 24 red LEDs & 1 green LED.

Q1 - Transistor BC 557 or any PNP type
Q2 - " BC 547 or any NPN type
Q3 - " " "
Q4 - " " "

1 - Speaker 2¼", either 3Ω,8Ω,15Ω or 33Ω.

30cm of 10 core ribbon cable or 10 pieces of coloured hook-up flex

1 - Length of tinned copper wire or pieces cut from resistors

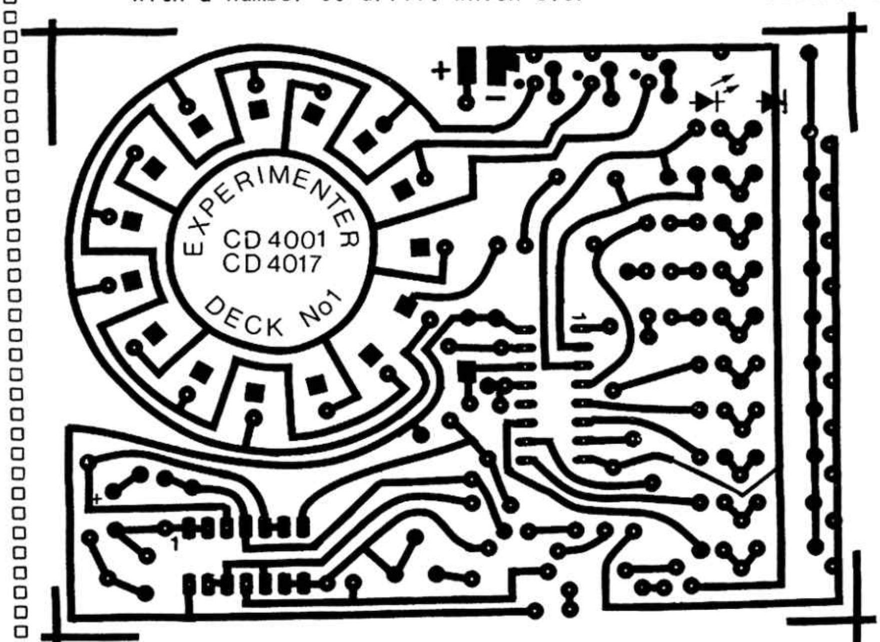
1 - 6v lantern battery

Roll of fine solder (as thin as resistor leads)

Soldering iron - preferably a constant-heat type or a small mains-voltage iron. But NOT an instant heat iron as it will lift the copper circuit off the board.

Side-cutters

This is a full-size artwork for the EXPERIMENTER DECK PC board. You can make your own board if you follow the instructions in the previous project "MAKE YOUR OWN PC BOARDS". Or you can buy it ready drilled or just etched and drill it yourself with a number 60 drill. Which ever way you choose, be sure to initiate yourself now. Time goes so fast. The next issue will be around and you haven't started. Don't forget: When soldering the parts, follow through the experiments in a logical order. This will not only make construction easy but produce 10 different projects, all for about $16.



PC BOARD

Cut out the sign and paste it onto the PC board inside the ring of 15 LEDs for the ADVERTISING SIGN PROJECT.

HEE HAW SIREN

PROJECT ONE

A Hee Haw siren reminds us of police, fire and ambulance. The idea of emitting two different notes is not new. Its effectiveness in alerting our attention is well known. Take, for instance, a simple two-tone door bell or the telephone bell. They are considerably more alerting than a constantly ringing bell because a continuous note tends to blend in with the background noise. However a constantly ringing bell on board ship is the most frightening of all as it signifies FIRE!

This project uses a single IC to give two tones. A transistor amplifies this to drive a speaker. The resulting HEE HAW can be adjusted via two mini trim pots to sound just like a fire truck or re-adjusted to sound like a computer gone wild.

Parts for this project:

1 - EXPERIMENTER DECK PC board

R1	Resistor	47k	
R2	"	100k	
R3	"	3k3	
R4	"	10k	
R6	"	15R	
C1	Capacitor	6n8	100v
C2	"	6n8	"
C3	Electrolytic	4u7	10v
C4	"	22mfd	10v

RV1 Mini trim pot 500k Cermet
RV2 Mini trim pot 100k Cermet

Q1 Transistor BC 557 or similar

IC1 CD 4001

1 2¼" speaker

Hook-up flex

Tinned copper wire

6v lantern battery

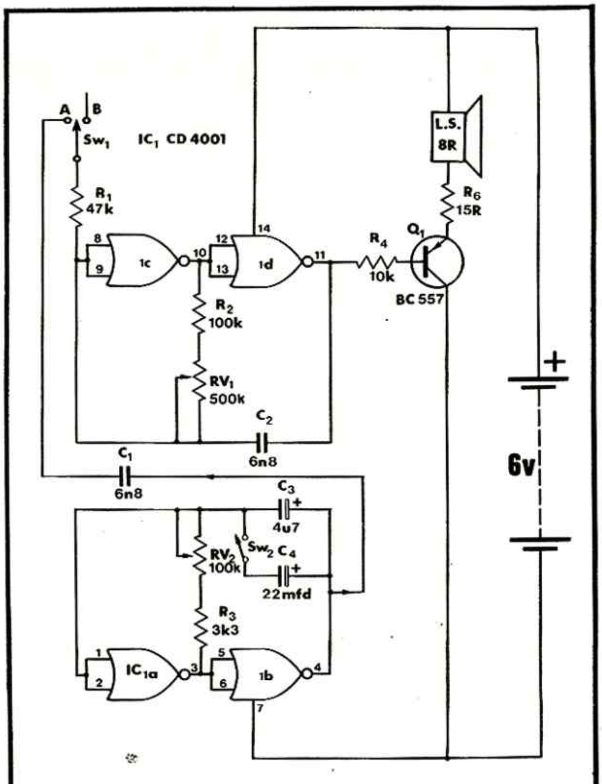
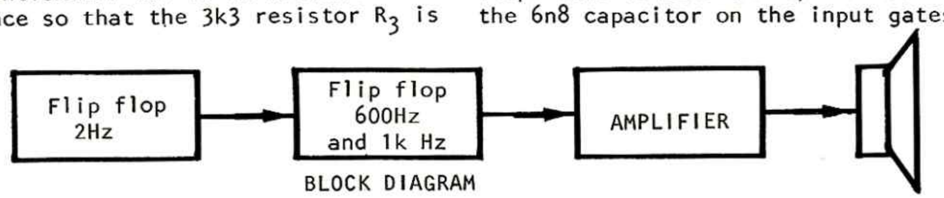


fig.1 HEE HAW SIREN

HOW THE CIRCUIT WORKS:

The circuit consists essentially of two multivibrators. A multivibrator can also be called a FLIP-FLOP. The word flip-flop sounds much better so we'll use it. These two flip-flops are arranged to oscillate at widely differing frequencies. The first oscillator has a frequency of 25Hz when the potentiometer RV2 is at minimum resistance so that the 3k3 resistor R_3 is providing the oscillator frequency. By adjusting RV_2 slightly we obtain the characteristic HEE HAW sound. This frequency is now about 2Hz. Altering the switch Sw_2 will give us a single note which will be sustained for up to 4 secs then change in pitch. The note we hear is actually the frequency of the second flip-flop being modified by the first flip-flop. This is achieved by the effect of the 6n8 capacitor on the input gates 8&9.

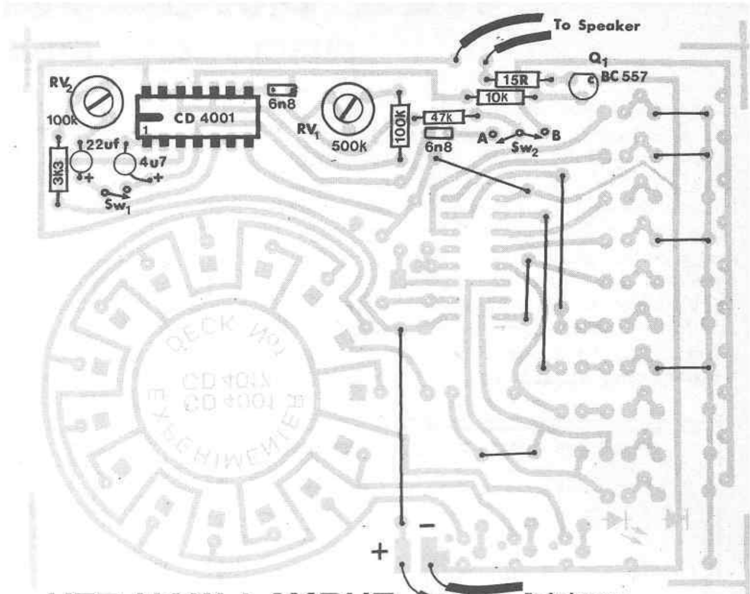


BLOCK DIAGRAM

The 2Hz flip-flop modulates the 2nd flip-flop to give a frequency of 600Hz or 1kHz.

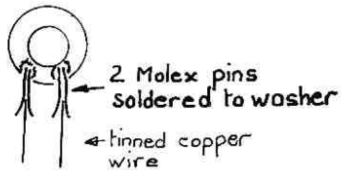
PREPARING THE PRINTED CIRCUIT BOARD:

Before mounting any parts, the PC board requires 10 jumper wires. Refer to the layout diagram for the exact positions of these jumpers. They are made from tinned copper wire or from the leads of resistors. Be sure to locate the correct holes as you will be using them as a guide to positioning the parts in the future. You will notice some of these jumpers are required for the HEE HAW SIREN while others are used in later projects. But it is best to fit them all now.



HEE HAW LAYOUT

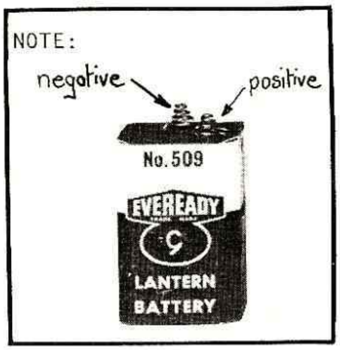
Make two switches as shown here:



They will be needed for the first project. Any type of terminal pin will be suitable and even a full-size switch may be used, connected to 30cm of hook-up wire.

MOUNTING THE PARTS

Fit the two mini trim pots. Cermet trim pots are preferred as you can turn their body with your fingers or use a screwdriver in their slot. Start at the left-hand side of the PC board and fit each component in turn. The CD 4001 IC should be left until last as it is a CMOS IC and requires fast insertion to protect it from static build-up. Once it is soldered in position it is quite robust. Use your fingers to heat-sink the IC so that it does not get too hot. Connect hook-up wire to the places marked for the speaker and battery. No on-off switch is shown in the diagram as the wire can be fitted under



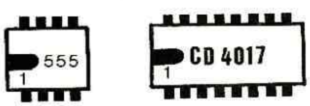
the spring terminals of the battery or 2 alligator clips can be connected to the battery terminals.

After soldering all the parts onto the PC board, check once more with the layout diagram, then connect the battery. By varying the two trim pots you will be able to get a wide variety of notes which will very from a HEE HAW SIREN for a toy fire engine to a type of electronic music emitted when a computer goes wrong.

Projects 2 - 10 will be presented in the next issue. Don't miss your copy!

Quiz: What have you learned?

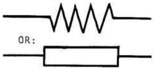
1. How many pins does a CD 4001 have?
2. What type of IC is the CD 4017?
3. What type of gate is inside the CD 4001?
4. Which lead is the cathode? 
5. Identify each pin by referring to the projects and circuit diagrams in this issue:



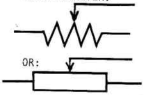
6. In about 50 words describe what new items you have learnt from this issue:

DATA Sheet No.1.

RESISTOR:



POTENTIOMETER:



Ω = ohms
R = ohms
k = 1,000 ohms
M = 1,000,000 ohms

103 = 10k ohms
104 = 100k "
105 = 1M ohms

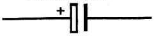
CAPACITOR:

mfd = microfarad
pf = picofarad
n = nanofarad

1000pf = 1n
1n = .001mfd
1000n = 1 mfd
2n2 = .0022 mfd
22n = .022 mfd

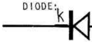
102 = 1,000pf
103 = 10,000pf
= .01 mfd
104 = .1 mfd
105 = 1 mfd

ELECTROLYTIC:



BATTERY:

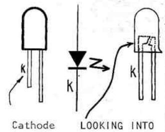
DIODE:



SIGNAL DIODE:

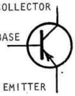
POWER DIODE:

LED:

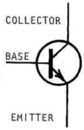


Cathode lead is SHORT

LOOKING INTO LED. Cathode is LARGER.

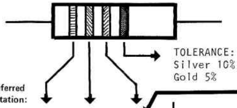


PNP TRANSISTOR



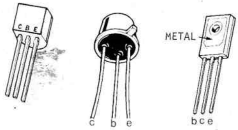
NPN TRANSISTOR

COLOUR CODE FOR RESISTORS



Silver or gold here is a divisor, NOT tolerance.
Silver: DIVIDE by 100
Gold: DIVIDE by 10

Resistance	Preferred Notation			
.22ohm	R22	red	red	silver
.27ohm	R27	red	purple	silver
.33ohm	R33	orange	orange	silver
.39ohm	R39	orange	white	silver
.47ohm	R47	yellow	purple	silver
.56ohm	R56	green	blue	silver
.68ohm	R68	blue	grey	silver
.82ohm	R82	grey	red	silver
1.0ohm	1R0	brown	black	gold
1.2ohm	1R2	brown	red	gold
1.5ohm	1R5	brown	green	gold
1.8ohm	1R8	brown	grey	gold
2.2ohm	2R2	red	red	gold
2.7ohm	2R7	red	purple	gold
3.3ohm	3R3	orange	orange	gold
3.9ohm	3R9	orange	white	gold
4.7ohm	4R7	yellow	purple	gold
5.6ohm	5R6	green	blue	gold
6.8ohm	6R8	blue	grey	gold
8.2ohm	8R2	grey	red	gold
10ohm	10R	brown	black	black
12ohm	12R	brown	red	black
15ohm	15R	brown	green	black
18ohm	18R	brown	grey	black
22ohm	22R	red	red	black
27ohm	27R	red	purple	black
33ohm	33R	orange	orange	black
39ohm	39R	orange	white	black
47ohm	47R	yellow	purple	black
56ohm	56R	green	blue	black
68ohm	68R	blue	grey	black
82ohm	82R	grey	red	black
100ohm	100R	brown	black	brown
120ohm	120R	brown	red	brown
150ohm	150R	brown	green	brown
180ohm	180R	brown	grey	brown
220ohm	220R	red	red	brown
270ohm	270R	red	purple	brown
330ohm	330R	orange	orange	brown
390ohm	390R	orange	white	brown
470ohm	470R	yellow	purple	brown
560ohm	560R	green	blue	brown
680ohm	680R	blue	grey	brown
820ohm	820R	grey	red	brown
1k	1k	brown	black	red
1.2k	1k2	brown	red	red
1.5k	1k5	brown	green	red
1.8k	1k8	brown	grey	red
2.2k	2k2	red	red	red
2.7k	2k7	red	purple	red
3.3k	3k3	orange	orange	red
3.9k	3k9	orange	white	red
4.7k	4k7	yellow	purple	red
5.6k	5k6	green	blue	red
6.8k	6k8	blue	grey	red
8.2k	8k2	grey	red	red
10k	10k	brown	black	orange
12k	12k	brown	red	orange
15k	15k	brown	green	orange
18k	18k	brown	grey	orange
22k	22k	red	red	orange
27k	27k	red	purple	orange
33k	33k	orange	orange	orange
39k	39k	orange	white	orange
47k	47k	yellow	purple	orange
56k	56k	green	blue	orange
68k	68k	blue	grey	orange
82k	82k	grey	red	orange
100k	100k	brown	black	yellow
120k	120k	brown	red	yellow
150k	150k	brown	green	yellow
180k	180k	brown	grey	yellow
220k	200k	red	red	yellow
270k	270k	red	purple	yellow
330k	330k	orange	orange	yellow
390k	390k	orange	white	yellow
470k	470k	yellow	purple	yellow
560k	560k	green	blue	yellow
680k	680k	blue	grey	yellow
820k	820k	grey	red	yellow
1M	1M	brown	black	green
1.2M	1M2	brown	red	green
1.5M	1M5	brown	green	green
1.8M	1M8	brown	grey	green
2.2M	2M2	red	red	green
2.7M	2M7	red	purple	green
3.3M	3M3	orange	orange	green
3.9M	3M9	orange	white	green
4.7M	4M7	yellow	purple	green
5.6M	5M6	green	blue	green

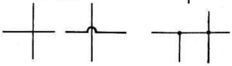


Any transistor CASE may be PNP or NPN.

SWITCH:

PUSH-ON SWITCH:

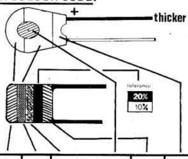
CONDUCTORS:



NOT CONNECTED

CONNECTED

CAPACITOR COLOUR CODE:



BLACK	0	0	x1pF x1uF		10v
BROWN	1	1	x10pF x10uF		
RED	2	2	x100pf	250v	
ORANGE	3	3	x1000pF		
YELLOW	4	4	x0.01mfd	400v	6.3v
GREEN	5	5	x0.1mfd	100v	16v
BLUE	6	6		630v	
VIOLET	7	7			
GREY	8	8	x0.01mfd		25v
WHITE	9	9	x0.1mfd		3v
PINK					35v

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