TALKING ELECTRONICS®

THE LEARNING MAGAZINE

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Issue No 4.

6 LOW COST PROJECTS

- ★ Shoot Game
- ★ Star-Wars® Noises
- ★ Experimenter Deck
- ★ F.M. Wireless Mic
- ★ 4-Amp Power Supply
- ★ Metronome

TALKING ELECTRONICS

Editorial... Vol.1 No.4

I am getting the exact response I had hoped for. Every day or so I get a jiffy bag in the post containing an assembled project. Generally they only require addition of text and detailed drawing which we have the capability of providing with super speed. Others need some circuit re-designing. The most encouraging part lies in the obvious thought behind them. They have all been a slight advancement of a project we have just presented in the magazine. This is not a simple copying approach but a logical progression. The very approach I am so earnestly attempting to introduce.

If you have an idea, even in partially finished form, let us know. We even supply 3-IC's Experimenter Boards to build them on. But don't let a moment go by. Get something done and you may even see your name in print. It's worth a lot more than money and you will be an encouragement to both yourself and other readers. This is your magazine as well as ours.

To my knowledge, we are the first magazine to produce digital electronics from ground level. Designing around chips is the only progressive approach. After all, where is the next generation to get their knowledge from if they don't have access to the basics now? Even so, we have only about 10 years for discrete chip designing. After that, all equipment will contain custom-designed chips or programmable chips...what an incredible future.

Colin Mitchell.

Technical
- Craig Jones

Artwork
- Steven Babidge

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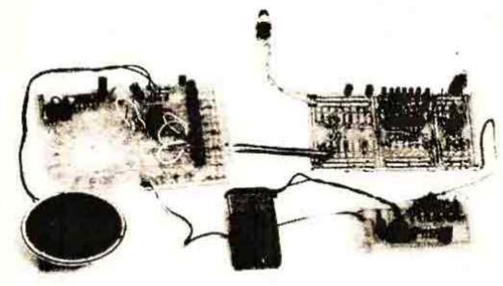
Our Cover Photo:
Electronics is for everyone. André Switzer is an enthusiast, and has made a couple of our projects.
Susan Frost just prefers the finished project. Both attened Sandringham Technical School. Photograph by Kevin Poulter.

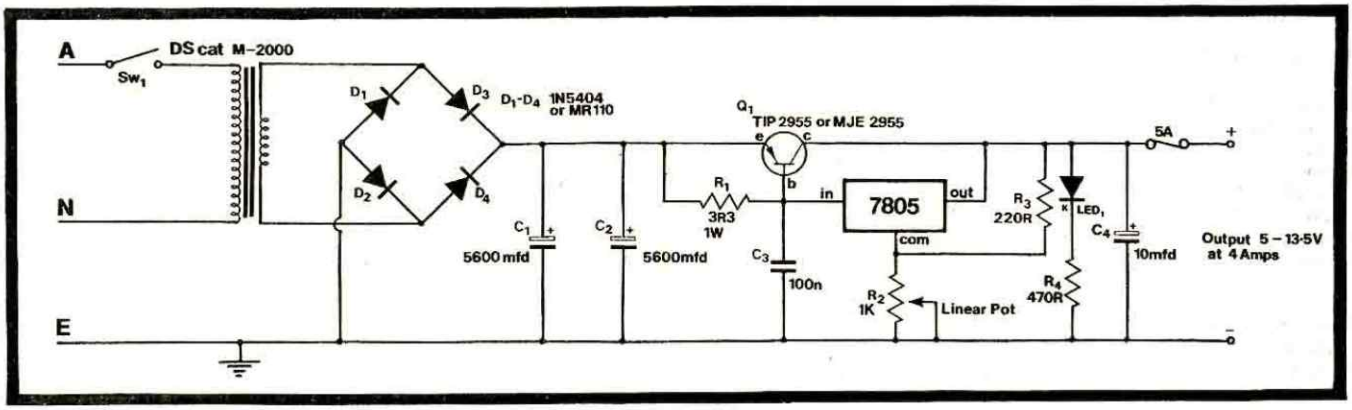


SHOOT GAME P.20

4 Amp Power Supply

David Tindall

3108



We have been asked many times for a 3 or 4 amp power supply for heavy-duty applications such as model railways, computers and 2-way radio base stations. This circuit, supplied by David Tindall, should fulfil these requirements. It is an extension of our 1 amp power supply in the last issue but by increasing the current to 4 amps we are unable to use most of the original components. Not only does the power transformer need to be up-rated, but the power diodes and electrolytics need to be changed. At the end of the article we have made suggestions on the practicality of doubling up the transformer and diodes to give up to 4 amps output. This will depend on the relative cost of a 1 amp transformer compared with a 6 amp version. Similarly a 6 amp bridge will work out cheaper than individual diodes.
The current handling and limiting was originally handled by a 7805. Since this regulator is limited to 1.5 amp, the current handling has had to be transferred to a TIP 2955 transistor. We have still been able to use the 7805, this time it provides the control voltage for the power transistor. Since the shut-down capabilities of the 7805 are not available to us with this circuit configuration, we must include a fuse in the output line.

HOW THE CIRCUIT WORKS

The bridge rectifier and 5600mfd electrolytics smooth the AC to less than .1v ripple and it appears at the emitter of the TIP 2955 transistor at about 22v DC. This voltage would be quite suitable for model trains and any equipment containing an inbuilt regulator, however it does contain an annoying 100Hz hum which would make it quite unsuitable for power amplifiers. In addition it is present at 22v and little, if any, equipment is designed for this voltage. The remainder of the circuit will reduce the voltage to a specified level and improve the regulation considerably.
The 3R3 resistor serves a dual purpose:

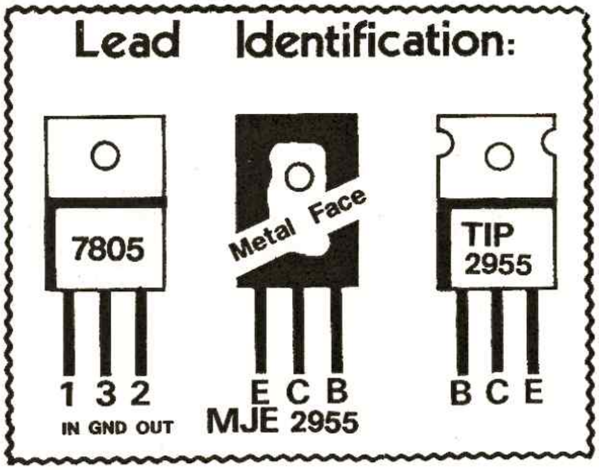
1. It keeps the TIP 2955 turned off, and
2. It will supply current and voltage to operate the 7805 regulator as required.

Suppose we set the adjustable pot to zero ohms. This will mean the common lead of the 7805 is grounded and it will deliver 5v to the output.
How does it maintain this voltage up to 4 amps- as this is greater than the normal handling capacity of the 7805?

To follow the regulation process we will need to take the effects in slow motion.

Firstly we will describe the operation of the TIP 2955 without the 7805 in circuit.
When the power is turned on, the 22v appears at the emitter of the TIP 2955. The transistor will be turned off since there will be no voltage drop in the 3R3 resistor and the base will be at the same potential as the emitter. Under this condition there will be no voltage at the collector output.
If we now add the 7805 regulator, it senses a voltage at its "in" terminal and attemps to provide a voltage which is 5v higher than its "common" terminal, at the "out" terminal. Since the "common" is connected to ground, in this discussion, it will attempt to supply 5v to charge the 10mfd electrolytic. Since the transistor is not providing any voltage itself to the output, the 7805 attempts to do this. In doing so, it puts a load on the "in" terminal, thus creating a voltage drop in the 3R3 resistor to turn the TIP 2955 on very slightly. The collector voltage rises to 5v and remains at this level.

If we put a load on the power supply, the voltage falls very slightly due to the fact that the transistor is only partly turned on. The 7805 senses this drop and puts a slightly higher load on the "in" terminal to turn the TIP on harder. The 7805 thinks it has provided the 5v but, in fact, the TIP has provided it. This effect will continue indefinitely. The only limitation is the capability of the transformer, bridge rectifier diodes and the current rating of the TIP 2955. The 7805 will not shut down as the current rises and we will need to provide a 5 amp fuse in the output to prevent the transistor being destroyed. At full current the 7805 is only drawing current sufficient to turn the transistor on fully. This is about 200mA to produce .6v drop in the 3R3 resistor and only a small heat-sink will be required for the regulator.
The transistor heatsinking will be another matter. You will need a large heat sink as described in the PHYSICS OF ELECTRONICS article. These are readily available from electronic suppliers along with the mounting hardware. It is advisable NOT to use a mica washer if it is at all possible to isolate the heat sink. If you intend to use the metal cabinet for mounting the transistor, it will have to be insulated as the chassis will be at earth potential.
We have not provided constructional diagrams as the supply is an up-rated version of the 1 amp model and as such will be constructed by advanced readers. The only design requirement is to allow for heat dissipation from all the power components: transformer, 4 diodes, transistor and regulator. Even the diodes will require heatsinking if you intend to operate the supply at 4 amps for prolonged periods as they will be dissipating a little over 1 watt each. Small flag heat fins can be soldered directly to the leads where they emerge from the body of the diode.
The power transistor is the "plastic pack" version of the TO-3 package. It still has an adequate metal heat dissipating surface which must be in physical contact with an external heat sink. A dry contact is very inefficient and if a mica washer is used it is imperative to use a thermal conducting grease. The TIP 2955 is electrically equivalent to the MJE 2955. The two outline diagrams show the lead identification.



The bridge rectifier diodes should be rated at about 5 amp to 6 amp for safety. The voltage rating need be only about 100v. The IN 5404 diode is only a 3amp device (@ 400v) and may be used for short periods of time up to 4 amps. Their advantage is low cost (about 30¢-40¢) and can be doubled up to make a 6amp bridge. Alternatively MR110 (100v 10amp) diodes can be used. These cost about $1 each and are stud mounting types. They require to be mounted on a piece of circuit board to enable easy terminations to be made. As a complete alternative, you can use a bridge rectifier such as KPBC602 (200v 6amp) which costs only about $2.50. I consider using a bridge to be the more professional choice.

The value of the smoothing electrolytics will depend on the degree of ripple acceptable at the output. Using 2 x 5,600mfd electrolytics may be a little over-designed however it does correspond to the design requirement of 2000mfd/output amp. You can try electrolytics as low as 2500mfd if the device you are powering has some form of internal smoothing.
No-one has ever mentioned this before, but it is possible to parallel-up 2, 3 or 4 2155 transformers to create a 4 amp power supply. It may be a little cumbersome and produce a lot of intra-wiring, but it is quite a feasable solution as it saves money and utilizes space inside the case to the best advantage. The transformers must be the same type as their voltage and power factor must be exactly the same. This means you will be able to use the 2155 from the first project and add 2 or 3 more in parallel with it. Before they are permanently wired together, the correct phasing must be obtained. To find the polarity (phasing) of the second transformer, its primary is connected to the 240v supply and one of its secondary leads connected to either secondary lead of the first transformer. At this stage you can completely disregard the bridge section as it is not involved. Switch on the power to both transformers and measure the voltage between the two free leads. (Use 0 - 100v AC range on your multimeter). If the reading is about 30v, reverse the secondary of the second transformer and re-test. It should now read zero. To check if any internal current is flowing, connect a 10 ohm ¼ watt resistor in place of the multimeter. Switch the power on for 1 minute. Turn the power off and feel the resistor for any temperature rise. If the resistor is getting warm, an internal current is flowing due to the transformers being not evenly matched. This will reduce the maximum current capabilities. If the secondaries were connected around-the-wrong-way, a very large current would flow between the two units similar to shorting the output leads together, so don't attempt to connect the outputs before checking for correct phasing. When all the transformers are connected together, allow them to run with NO LOAD to determine if any internal loop currents are flowing. Feel the temperature of the cores periodically during the first hour. They should run as cool as a single non-loaded unit. The diodes can be similarly paralleled-up to provide higher current rating, however a complete 6 amp bridge works out cheaper than 8 individual diodes.

PARTS LIST

Since there is a wide variety of components which can be used in this project, it is not feasable to produce a parts list. We consider this to be an extension to the 1 amp supply. You will be able to assemble a power supply to the exact amperage you require so the cost and number of additional components will vary according to the final delivery current.

CONSTRUCTION

Most of the layout will be wired according to the components you purchase and this does not lend itself to designing a printed circuit board.
We suggest mounting as many components as possible to the chassis and provide a tag-strip for the diodes. This will of course depend on the type of diode you use.

TO COME

Our next improvement will be adding an automatic current limiting sensor to take the place of the fuse and prevent the transistor being overloaded, even for short periods of time. Experiment with an auto-latching, current trip yourself. The best design will be featured in our next issue.
May I give you a hint?
Including a diode in the base line of the trip circuit will ensure the power supply remains turned off after tripping. This will stop "hiccuping" or pulsing.

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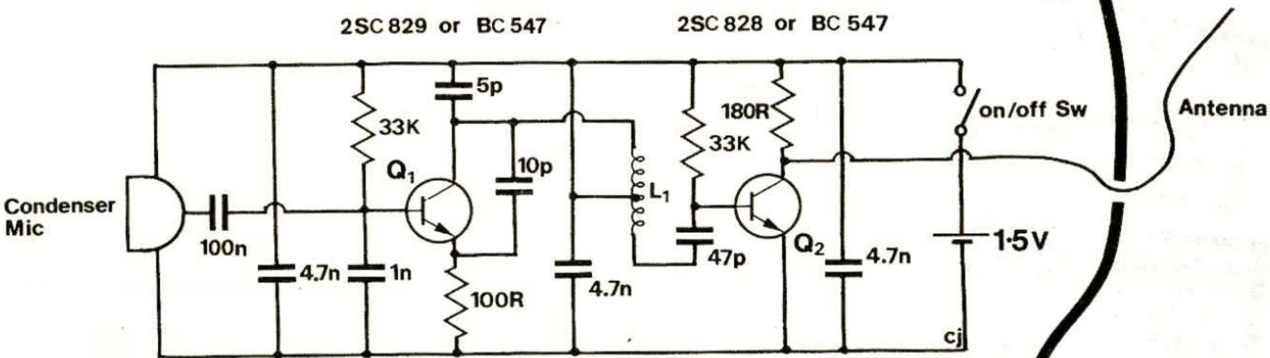
Presents

ACTUAL SIZE

FM Wireless Microphone



Thank you very much for your purchasing of HOMER WIRELESS MICROPHONE. This is specially for school and an experiment. We are very sure you will be satisfied on our HOMER's items.

These are the opening lines from the Wireless Microphone instruction sheet. The Chinese think it wonderful producing instructions in English. Admittedly they also produce for a number of other foreign countries and their job would be quite complex just keeping up with the various translations. But little do they realize how amusing their translations sound. To get correct idiomatic English, most translations must go through two stages. The first translator converts word-for-word from one language to the other then a technical translator is needed to make it read correctly. Generally the Japanese and Tiwanese manufacturing firms rely on only one translation. Such is the case with the FM Wireless Microphone instructions. Some of the wording is so amusing we decided to leave them in the kits for you to read. Mind you, the instructions are correct, just oddly worded. Sometimes we finish up with completely unfathomable sentences such as: you better use the pinset to solder the diode transistor. It is because of weak heater.

We were given a sample kit from a supplier for evaluation. This kit is suberbly presented and the finished case is so small it's no wonder it's been a good seller. But from an instructional standpoint we couldn't tell you in all sincerity to go out and buy the kit as the two layout diagrams do not give enough detail. Neither is there any technical details on the operation of the circuit.

As far as the size of the completed unit is concerned, don't go by the drawings and layouts throughout the article as they are 200%-300% larger than normal to show the fine detail. The transmitter is much smaller than this. It only measures 2½ x 4½ cm and is barely 2 cm deep. It can be quite easily hidden in a shirt pocket, hollow book, pencil case, block of foam styrene or cigarette packet, and will transmit the length of a house via its own antenna. It took us about ½ hour to assemble the components using the original instructions. But since they were not very clear, we have completely redrawn the layout on the PC board to make it much easier to identify the parts. You will be able to fit it together in 25 minutes!

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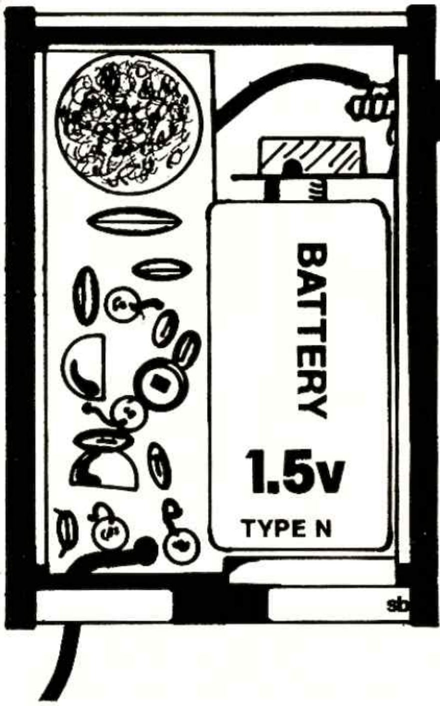
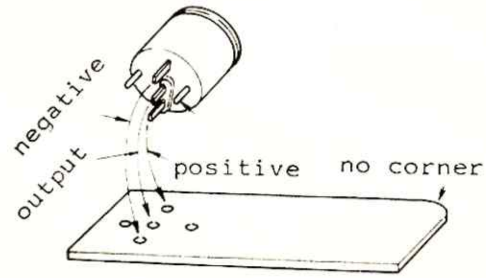




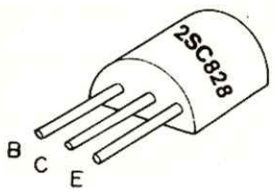
PARTS LIST

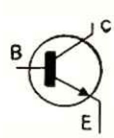
1 -	Condenser Microphone	
1 -	Resistor	100R ¼watt
1 -	"	180R "
2 -	"	33k "
1 -	Capacitor	5pf
1 -	"	10pf
1 -	"	47pf
1 -	"	1n (.001)
3 -	"	4n7 (.0047)
1 -	"	100n (.1mfd)
Q1 -	Transistor	2SC 829,BC 547
Q2 -	"	2SC828, BC547

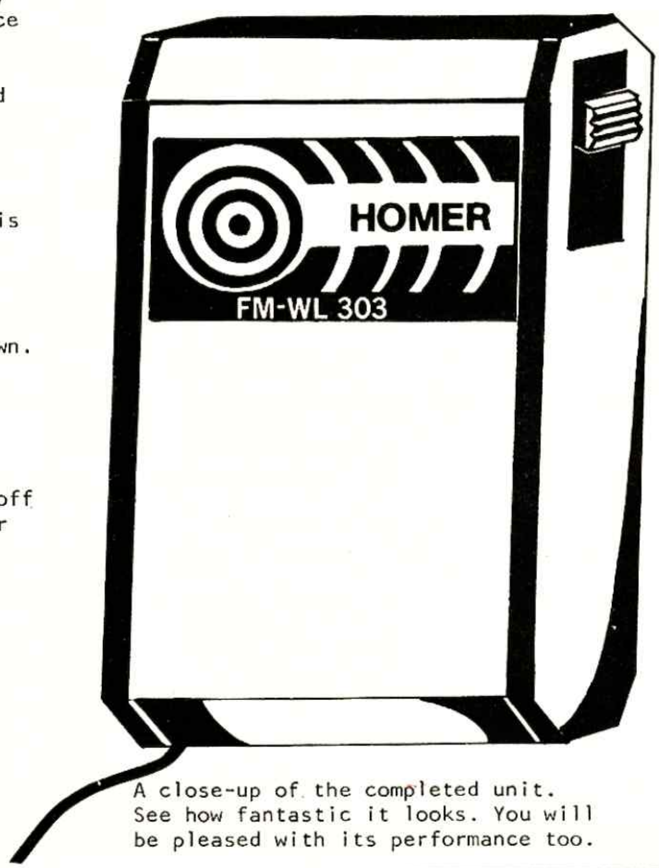
coil & slug
PC board
Case with leads and switch
Hook-up flex for antenna
1.5v cell type N or UM-5

ASSEMBLING THE PARTS

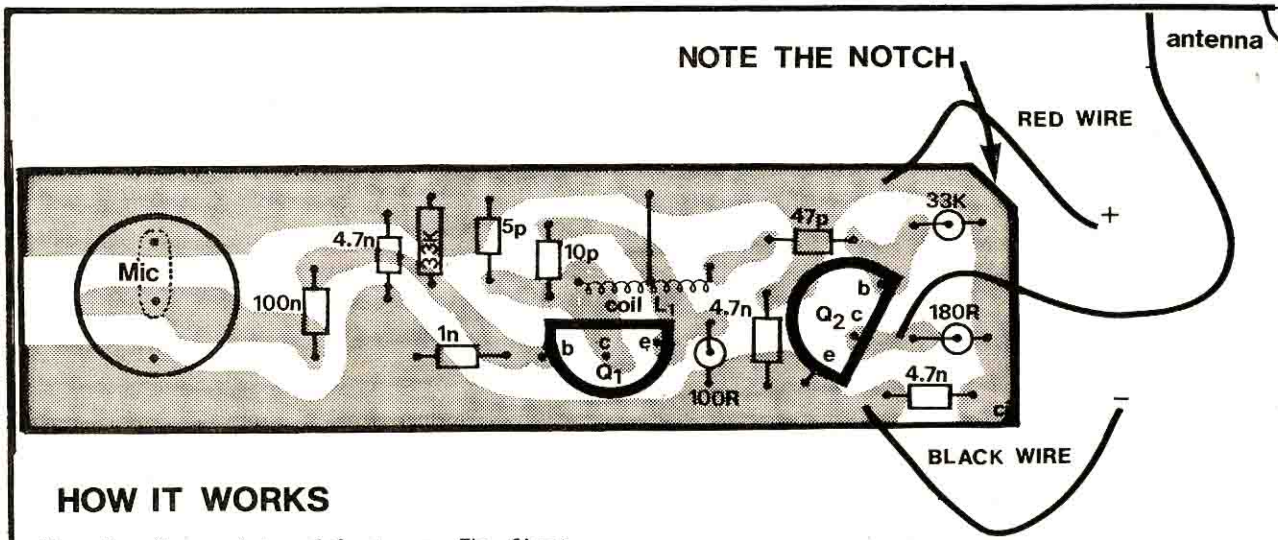
Before starting to build the project we suggest you clean the printed circuit board with a scouring pad to brighten up the nickel-plated coating to make it easier to solder. Rub lightly with a dry pad to remove the tarnishing. Commence assembly by fitting the condenser microphone. One of its pins connects directly to the case. Look for this pin and turn the microphone around so that this pin solders to the negative land. Use the enlarged layout diagram to identify the correct lead. Continue along the PC board with the other components. The coil has already been fitted to the board. Since the insulation on this coil resists soldering, it cannot be burnt off at all. You will need to remove the coil and scrape the leads with a knife and pre-tin the leads before re-fitting. Make sure the tap does not fall off. The transistors are fitted as shown. If you use BC 547's the lead configuration will be different but it will work just as well. The only other trap is connecting the antenna. It must be soldered to the collector of Q_2. Connect the positive lead to the switch and the negative lead to the battery. Make sure the on-off switch turns off properly. Now you are ready for testing.







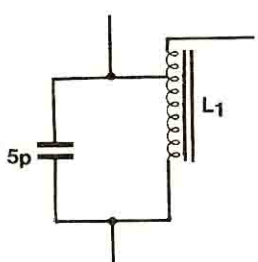
A close-up of the completed unit. See how fantastic it looks. You will be pleased with its performance too.



HOW IT WORKS

The circuit consists of 2 stages. The first transistor is designed to oscillate at about 90MHz while the second transistor is purely an RF amplifier. The two transistors amplify the microscopic output of the condenser microphone to produce a few milliwatts of FM transmission.

This is how the circuit works:
The first transistor is biased on via the 33k resistor. When power is applied the transistor allows current to flow through the collector-emitter circuit. In the collector is a 5pf capacitor and coil L_1. These are connected in parallel. Whenever a coil and capacitor are in parallel, they form a tuned circuit which will oscillate at a frequency set by the value of the components.



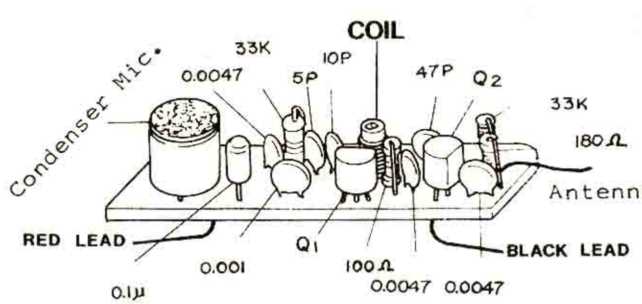
A PARALLEL TUNED CIRCUIT

Theoretically this circuit will oscillate indefinitely with the electrical energy passing back and forth from the capacitor to the coil without the need for any newly applied energy and will cause an oscillating voltage to appear at the collector of the transistor. In practice this oscillatory voltage will decay to zero fairly quickly. To prevent this from happening, a small sample is fed to the emitter of the transistor via the 10pf capacitor to modify the emitter voltage. Thus the transistor sees its base-to-emitter voltage altering in harmony with the resonant frequency of the tuned circuit and turns the collector on and off at the same frequency.

The actual frequency of oscillation is dependent upon the total capacitance of the circuit and the effect of EVERY component on the first half of the PC board. Once this basic frequency of 90MHZ is set via the slug in coil L_1, the condenser microphone picks up sound waves to produce microscopic voltages which are fed to the base via the 100n capacitor. This alters the gain of the transistor and changes its internal capacitance. This junction capacitance modifies the oscillator with a frequency equal to the sound entering the microphone, thus FREQUENCY MODULATING the circuit. Coil L_1 is tapped one-third from the top to place very little load on the oscillator circuit. and its voltage is fed via a 47pf to a common-emitter amplifier Q_2. A short length of hook-up flex is connected to the output of transistor Q_2 and will radiate to any FM receiver within 50 metres.

SETTING UP

Tune your FM radio to the low end of the band and listen to the background noise. Place the wireless microphone 3 metres from the radio and tune the slug very slowly out of the coil. It should not be turned more than one thread out of the coil for 90MHZ. Use a non-ferrous screwdriver to prevent false tuning. The background noise will disappear when the transmitter is on frequency. Adjust the radio for maximum sensitivity as the frequency-band will be quite narrow.
You will now be able to walk into any room of the house and transmit back to the radio.



Basic Electricity

PART II

We now come to combining the facts learnt in BASIC ELECTRICITY part I with TELEVISION SERVICING parts I and II and extend them to repairing electronic equipment. You must remember we are at the very initial stages of application and you will need to have a lot of additional knowledge before attempting a repair, but as far as these 8 examples are concerned, they are fully covered here.
The questions and problems in this article are taken from actual colour TV faults and as such are worth remembering. The approach, however, could equally apply to any high-current power supply in a computer, amplifier or piece of industrial control equipment; so don't think you will never come across this type of fault.

So far we have learnt that resistors can be connected in parallel and series. This is common practice for technicians, for a number of reasons.

1. To obtain an exact value or a different value to that in his kit of resistors.
2. To achieve a higher wattage.
3. To reduce the voltage across a particular resistor in a high-voltage circuit, by connecting 2 or more resistors in series.
4. To obtain a combination of the above.

This usually applies to in-home-servicing where a full range of components is not available.

To be able to work on the following **12** questions you will need to know 2 pointers.

A: RESISTOR WATTAGE VALUES.
B: OHM'S LAW.

The first point is simple. Resistors come in ¼watt, ½watt, 1watt, 5watt, and 10watt.

These are always obtainable and are the only ratings you need stock in your workshop.

At the small cost of ¼ and ½ watt resistors, I would suggest any hobbyist or intending serviceman carry between 5 and 10 of each type from 1ohm to 3M3. Maybe some of the more uncommon values such as 1R8 or 180k need not be stocked.
Three each of the 1 watt values from 10ohm to 3M3 would be ideal for repair work. For the high wattage values, I have listed the most useful types:

WIREWOUNDS:

5 WATT:	10 WATT:
3 - 3R3	2 - 3R3
3 - 8R2	2 - 8R2
3 - 33R	2 - 120R
2 - 120R	2 - 330R
2 - 220R	2 - 390R
1 - 330R	2 - 470R
1 - 470R	2 - 1k
1 - 1k	2 - 4k7
1 - 2k2	3 - 10k
1 - 3k3	
1 - 4k7	

This covers all the special-value resistors I have ever needed to fabricate on-the-spot.
Sometimes you will need 2 or 3 resistors of a particular value to make up the wattage or resistance... this is the purpose of this article.

When you see a burnt out resistor, you should ask yourself two questions. Was it the result of an over-load or was the wattage of the resistor insufficient for the job? This type of question will be answered in TV SERVICING. In this article we will only be concerned with making up the resistor with those from the selection above.

OHM's LAW

Ohm's Law states the relationship between volts, ohms and current according to the following law:

$$I = \frac{V}{R}.$$

Where I is the current flowing
V is in volts
R is the resistence in ohms

When a current flows through a component, heat is given off. Resistors are designed to dissipate this heat but it also develops in other components including transistors, transformers, capacitors and coils. This heat is measured in watts and sometimes we are required to calculate this wattage when designing or replacing a component, especially a resistor.

Wattage is obtained from the following formula:

$$P = V \times I$$

where **P** is the wattage in watts
V is the voltage in volts
I is the current in amps

PROBLEMS USING OHM's LAW

Five common TV faults require the replacing of high-wattage resistors. When they burn out, you will need to make up an equivalent resistance using resistors from the above list. This is how it is done:

1 Thorn-Atlas hybrid portable sets have string-line filaments and use a 180 ohm 20watt surge suppressor cum voltage dropper resistor. It quite often fails after years of service. You requirement is to make up a duplicate from the list of wire-wounds. Firstly select 2 x 10watt resistors to handle the wattage. From the previous article on BASIC ELECTRICITY, we found that 2 resistors in parallel resulted in a combined resistance of half the value of either resistor. Working backwards, we will need 2 resistors of twice 180 ohm or about 360 ohm each. Since we do not have 360 ohm wire-wound resistors, you can select 2 x 330 ohm or 2 x 390 ohm. Remember, if you select the 2 x 390 ohm the heat dissipated will be slightly greater than if you use 2 x 330 ohm. This technical point will be discussed later.

2 ITC sets use a string of 15 ohm 10 watt resistors to supply the 150 volt rail from 220 volt power supply. In this example, the first resistor has burnt out due to a short in the tripler, which has taken the horizontal output transistor. These components have been replaced and it is now required to fit a new dropper resistor. Since the exact value is not stocked, choose 2 x 8R2 ohm @ 5 watt and connect them in series. Each resistor will dissipate 5 watts, making a total of 10 watts since the combined resistance is very close to the the 15 ohms required. (Actually the resistors will get marginally hotter as they have a resistance of 16.4 ohms.

3 Blaupunkt and Siemens sets use a 3.3ohm 5watt resistor to supply the vertical output stage. Fortunately this value is included in the list. If the vertical output stage draws 1 amp, calculate the wattage dissipated by the resistor and the voltage across it.
Firstly write down the letters I, E, R, and **P.**
Fill in any known information:

I = 1 amp
R = 3.3 ohm

From the formula, calculate V, the voltage drop:

$$I = \frac{V}{R}$$

$$1.0 = \frac{V}{3.3}$$

$$V = 3.3\text{volts}$$

The wattage dissipated = 3.3 x 1.0
= 3.3watts

If the current increases by 25% to 1.25 amps, calculate the wattage dissipated by the resistor.

$$1.25 = \frac{V}{3.3}$$

$$V = 1.25 \times 3.3 = 4.125\text{volts}$$

wattage = V x I
= 4.125 x 1.25
= 5.2 watts

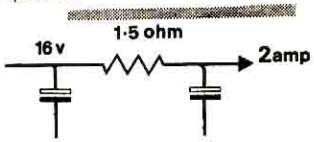
We see that when the current increases by 25%, the wattage required to be dissipated by the resistor has increased by over 60%. This is why it is very important that a fault is not allowed to go unchecked. Not only will the dropper resistor be affected but the output transistors will also overheat.

4 Pye sets use a 120 ohm 10 watt resistor in the power supply as a start-up resistor and to supply some of the load to the set. Suppose you were missing a 120 ohm 10 watt resistor. How would you create this value?
(use the same reasoning as in question No1.)

5 Sanyo sets invariably burn out an 8.2 ohm 3 watt resistor in the vertical when one of the vertical transistors punctures. Or it can sometimes fail for no apparent reason.
What value would you replace it with?

Transistors draw so little current that we rarely need to design circuits for wattage dissipation in resistors. The only circuits left/needing allowances/are power supplies and amplifiers. Here are two simple examples involving power dissipation.

6



A simple RC filter in a power supply is shown above. If we use a 1.5 ohm resistor, what wattage will it dissipate?
Write down the letters I, E, R and **P.**
Fill in the known values:

I = 2 amp
R = 1.5 ohm

Putting these into the formula we get:

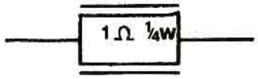
$$2 = \frac{V}{1.5}$$

$$V = 3\text{volts}$$

Power = V x I
= 3 x 1.5
= 4.5 watts

Use a 5watt resistor

7



The symbol for a fusable resistor is shown. What is the maximum current it will handle?

Write down the known values:

R = 1ohm
P = ¼watt

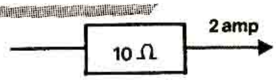
$$P = V \times I$$
$$\tfrac{1}{4} = V \times I$$

and
$$I = \frac{V}{R}$$
$$I = \frac{V}{1}$$

substituting:

$$\tfrac{1}{4} = V \times V$$
$$V^2 = \tfrac{1}{4}$$
$$V = \tfrac{1}{2}\text{volt}$$
and $I = \tfrac{1}{2}$amp

8

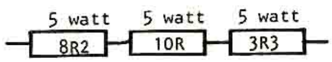


If the current through the 10 ohm resistor above increases by 50%, from 2 amp to 3 amp. What will happen to the wattage dissipated by the resistor?

9

If one resistor burns out, what would happen to its mate?

10



1. Which resistor will burn out first?
2. What will happen to the other two resistors?

11 From the list of wirewounds, make up these resistors:

100 ohm 20 watt
2k2 10 watt
25 ohm 15 watt

12

List 3 ways to tell if a wirewound is working:

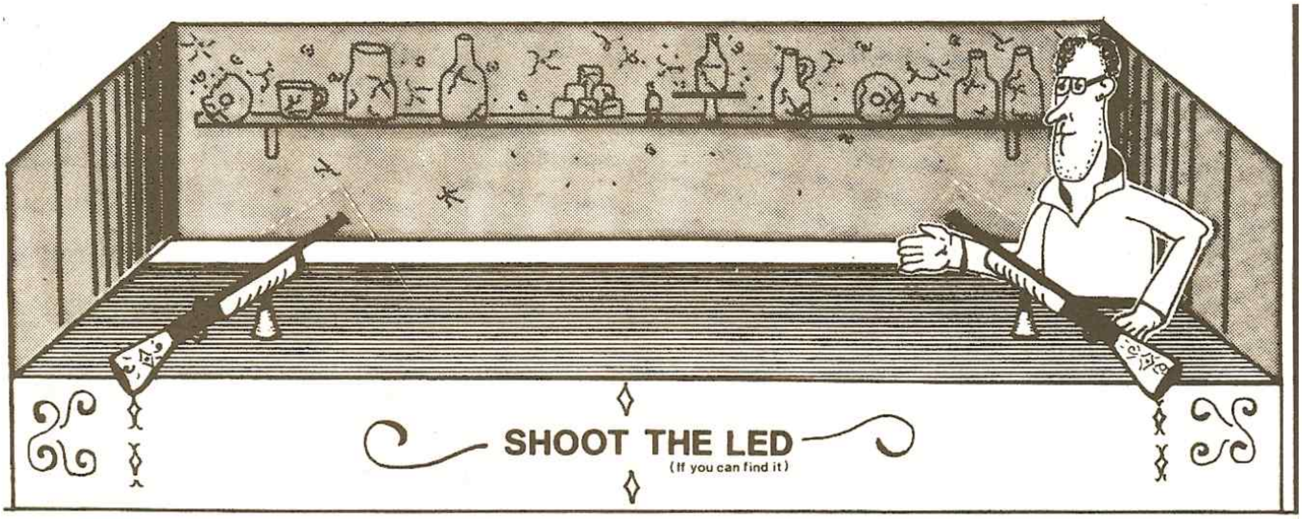
1. _
2. _
3. _

ANSWERS:

4. Use 2 x 220R 5 watt resistors in parallel.
5. Use 8.2 ohm 5 watt
8. The wattage increases from 40W to 90W.
9. Its mate will burn out almost immediately as it tries to handle twice the wattage.
10. The 10 ohm will burn out first. The other two will not be affected as they are in series.
11. Use 4 x 470 ohm 5 watt in parallel
Use 2 x 4k7 ohm 5 watt in parallel
Use 3 x 8.2 ohm 5 watt in series
12. Feel it.
Measure it with an ohmeter.
Measure the voltage on each end.

Shoot Game

R.BROWN TIMARU – N.Z



This game was originally sent in by R. Brown of Timaru NZ. Little did he realize how closely allied his ideas were with ours on such a game. This final design combines his basic concept with three of our modular projects. We are still going to give him full credit for initiating this project and will be using his circuits and descriptions where ever possible.

This game combines three of our projects:

RUNNING LIGHT
SQUARE-WAVE OSCILLATOR
BINARY COUNTER

to produce a skillful shoot game.

There are two ways of looking at the cost of this game. If you have already assembled the three modules, the only extra components will amount to a dollar or two. If you have not constructed any of the sections of the game, I suggest you do so right away.

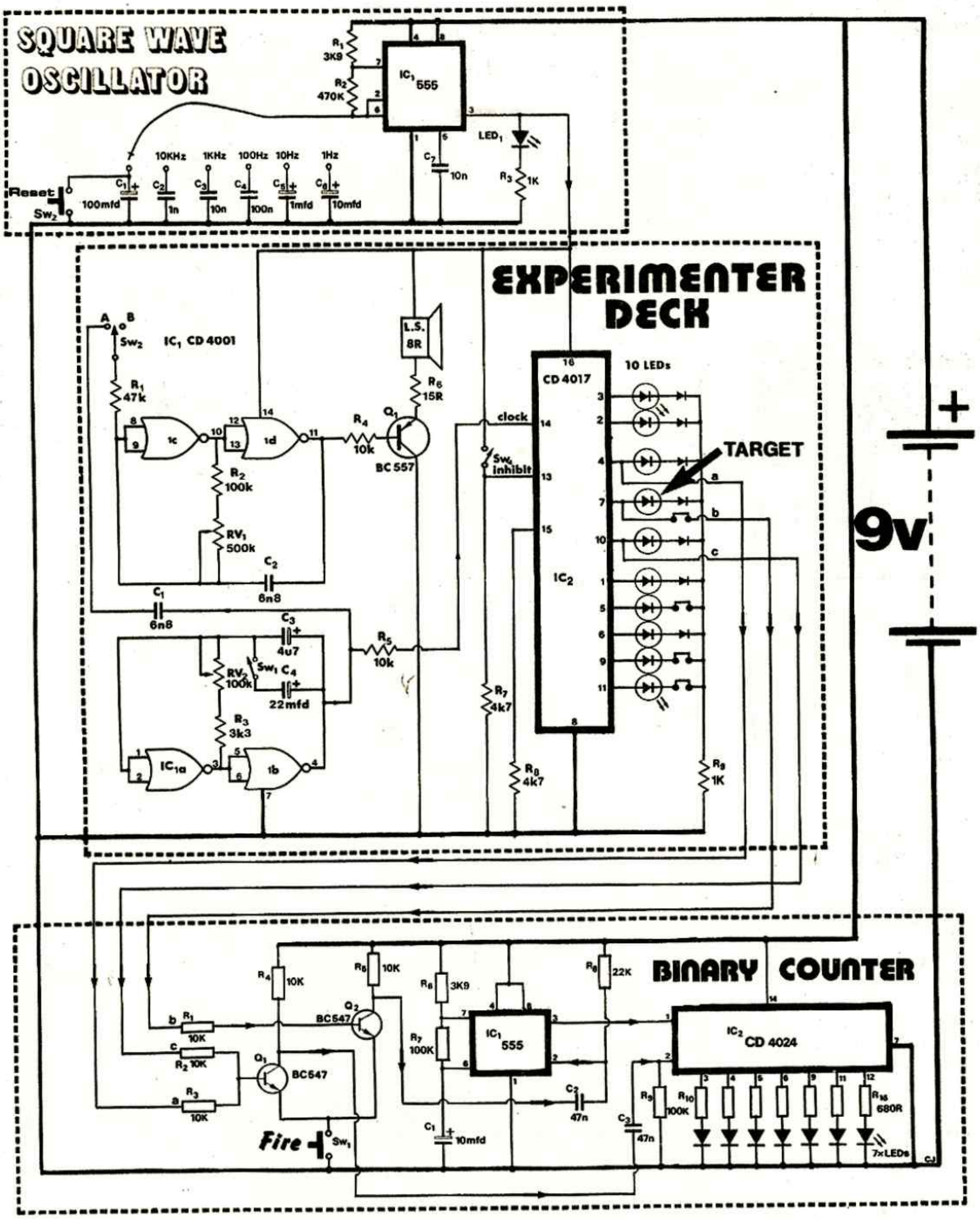
Building this game will prepare you for our forthcoming PHONE ALERT project which uses numerous feedback and timing circuits to produce an alarm after a prescribed number of telephone rings. But before this project is released, you will need to understand the basics of timing circuits resetting a counting IC and simple gating to the clock-line inputs.

The most important aspect of this type of circuit is the understanding of each individual module in case you need to troubleshoot a fault.

Since the description and operation of each of the three "building blocks" has been described under their own project titles, we will only need to describe the modifications when connected to the other two units.

PLAYING THE GAME

This game can be played by one or two players. It is a game of extreme skill and concentration as the slightest mistake will erase your score. The object of the game is to get the highest score in the one minute alloted. The points scored are registered on a seven LED readout binary display. Hopefully you will be able to read binary by now and count up you winnings. If not, the answers to each of the readouts is given in the columns beside the Binary Counter project in the last issue. The highest number scored can be recorded and will be the target value to be broken next attempt. As you become more adept at firing on "target," the speed of the travelling light can be increased. This may well give a higher potential score but also increases your chance of misjudgement. Start your game on the lowest speed and get accustomed to hitting the button when the green LED is illuminated. You will need to be extremely accurate as the LEDs change sharply and the gating transistors will respond instantly to a mistake. The scoring counter has been purposely delayed in response to give the impression that it is thinking about the hit and also to give you time to look away from the target area to the score card. This delay is most effective and adds to the intrigue of the game. After the one minute has elapsed and you wish to start the game afresh, press the reset button then the fire button to reset the counter and then press the reset button again when you wish to begin timing.

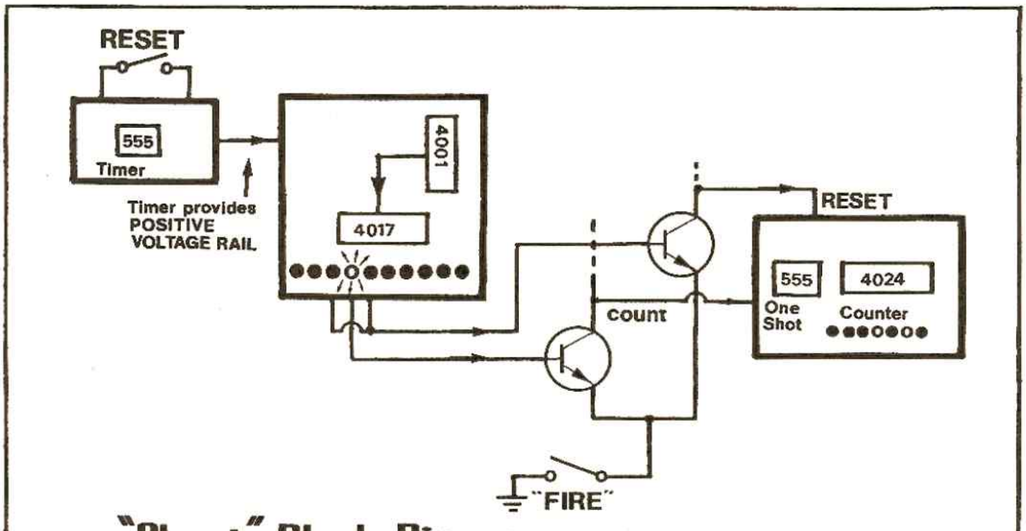


COMPLETE SHOOT CIRCUIT

This is the complete SHOOT CIRCUIT DIAGRAM. Don't be put off by its complexity. It is really very simple. You will already be 95% through with its construction if you have built our three separate projects: SQUARE WAVE OSCILLATOR, EXPERIMENTER DECK, and BINARY COUNTER. We have tried to keep the three modules separate by using different style resistors and have framed each module with heavy dotted lines. Study this diagram in conjunction with the BLOCK DIAGRAM to make it easier to understand. The object of the game is to hit the target LED No 4 when it illuminated by pressing the de-bounced "FIRE" button. LEDs either side of the TARGET LED are gated to destroy your score should you miss. The score-card counts to 127, which should be adequate for the one minute allowed. If you ever get 128, let us know.

BLOCK DIAGRAM

The SHOOT GAME circuit can be simplified into 3 blocks and 2 transistor gates. The arrows on the feed lines show the direction of the pulses.
The CD 4001 is used as a free-running oscillator at about 2Hz to 3Hz and feeds a CD 4017 decade counter. The output appears on a string of 10 LEDs to produce a running light effect. LEDs 3, 4 and 5 are gated via 2 transistors to the input of the binary counter.
The gate circuit is turned on momentarily by the "fire" button and will transfer either a count-of-one pulse or a reset pulse. The count signal is detected from LED 4 and sent to a one-shot 555 IC which feeds a CD 4024 binary counter. The readout from the counter appears on 7 LEDs and is capable of recording a count of 127. The whole game is being timed by another circuit consisting of a 555 which originates from the square wave oscillator project. The positive supply voltage to the Experimenter Deck is being provided via the timer circuit. On expiration of 1 minute the output of the 555 goes low, cutting off the display and oscillator.



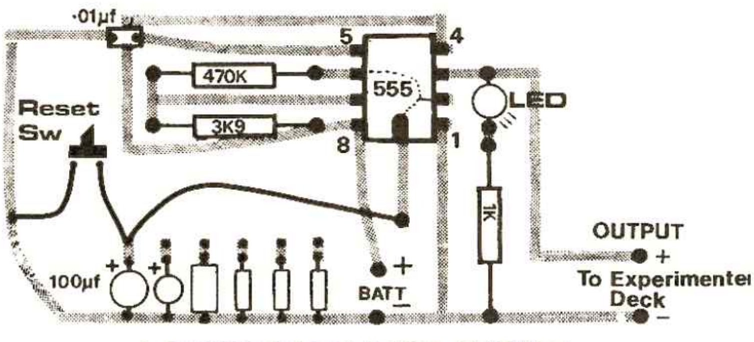
"Shoot" Block Diagram

MODIFYING THE SQUARE WAVE OSCILLATOR

The Square Wave Oscillator project uses a 555 timer IC. This IC is capable of timing minute intervals as well as frequencies up to 100kHz. By adjusting the timing resistor and capacitor we can obtain a delay of 1 minute. Replace the 10mfd capacitor with 100mfd and the 68k with 470k. This will give a delay of 1 minute. You may wish to check this time and use a value either side of the 470k if the delay is not quite accurate. The time interval may vary up to 1½ minutes as the tolerance on the electrolytic is typically -20% +100%. You will not require the other 5 capacitors or the LED with its dropper resistor. These can be removed or left on the board as they have no effect on the operation of the circuit. Since the timer provides the positive rail voltage to the running light target, via the output pin of the 555, this pin (marked +) goes to the +ve on the EXPERIMENTER DECK.

FAULT FINDING

If the LED does not extinghuish after 1 minute, Check that a voltage is present on pins 4&8 and that pin 1 is connected to ground. Test pin 3 for a HIGH. Using either the 10mfd or 100mfd in circuit, detect a rising voltage on pins 2&6, which is actually the voltage on the capacitor. Your multimeter may load the circuit too much to see the IC change states so don't expect the IC to operate with the meter connected.

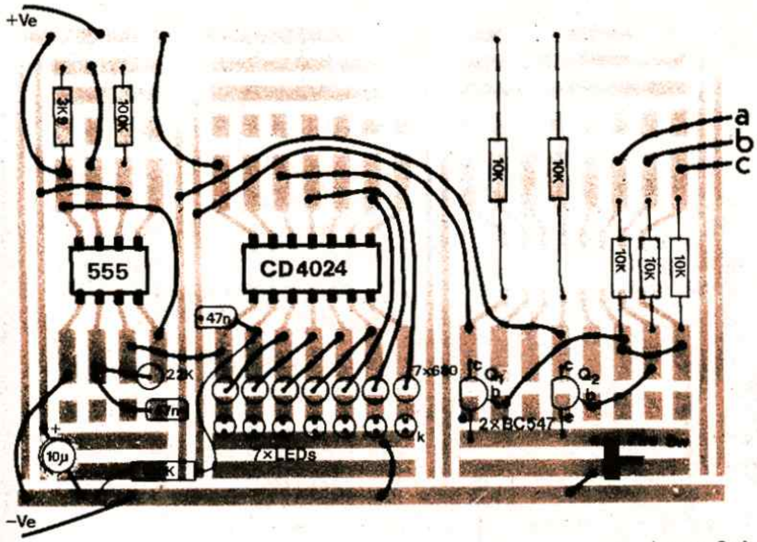


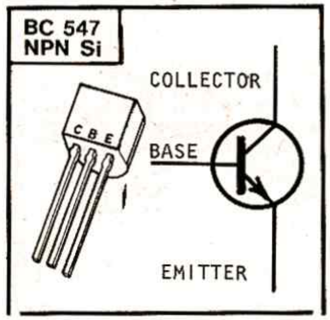
1 MINUTE TIMER LAYOUT

MODIFYING THE BINARY COUNTER

No modifications need be made to the binary counter excepting the new layout to allow the 2 gating transistors to be added to the board as shown:

We have re-constructed the COUNTER project on the Experimenter Board using 7 smaller 3mm red LEDs to create a tighter, neater, display. It has also enabled us to use the third section of the board for the gating transistors. They are fitted neatly on top of the board along side the display and should be tested as a unit before connecting into the SHOOT GAME.





FAULT FINDING

The binary counter comprises 2 circuit blocks. These can be tested separately. The 555 circuit is very similar to the timer circuit except that when pin 2 detects a LOW, the IC will begin to time one cycle. Since pin 2 is not connected to the other pins, the IC will not begin another cycle unless it is triggered externally. This makes it a "one-shot" circuit.The time delay for it to pulse the binary counter is determined by the 10mfd electrolytic. Use the previous test procedure to check its operation and place the test LED on pin 3 to detect a HIGH-LOW change. Testing the CD 4024 binary counter IC is very similar to testing the CD 4017 decade counter. Check the presence of a voltage on pin 14 and see that 2 & 7 are decked. Check each output for a HIGH. You may find more than one output has a HIGH as the binary readouts will be hard to check individually as to whether they should be HIGH or LOW.

THE GATING CIRCUIT

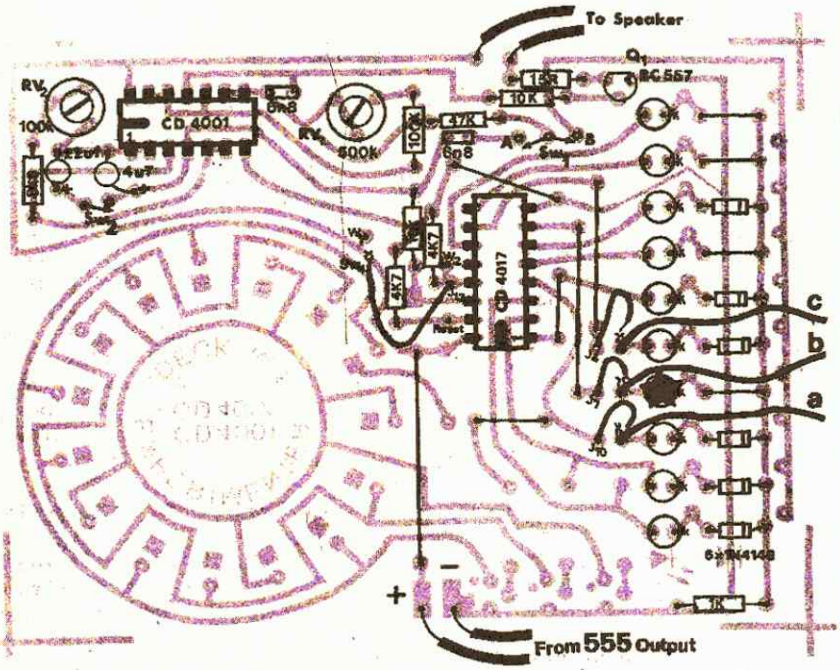
The only new circuit in this project is the 2 gating transistors connected between LEDs 3, 4 and 5 and the counting module.
One of the requirements of the gating section is to detect a voltage or pulse on the LEDs either side of the target LED and pass this pulse to the reset pin of the CD 4024 binary counting IC. Since the reset pin is active HIGH it is necessary to keep it LOW during the counting operation. The 100k resistor keeps the reset pin LOW. It needs to be a fairly high resistance to allow a spike voltage from the capacitor to feed into the reset pin without any attenuation. A low value earthing resistor may attenuate (reduce) the spike to below the resetting voltage.
The other requirement of this circuit is to detect a pulse on the target LED number 4 and send this pulse to the one-shot circuit using the 555. This provides debouncing and delayed counting so that you can only score a unit count for each pass. To trip the 555 the count pin (pin 2) must be brought LOW momentarily since it is active LOW. Thus the 22k resistor is needed to keep the pin HIGH, ready for each count pulse.

It is now required to turn on these two sections with one switch. The problem with positioning the switch lies in the fact that the 555 is active LOW and the CD 4024 is active HIGH. If we were to position the switch in the collector circuit, every time we pushed the "fire" button, it would reset the binary counter.
By placing the switch in the emitter circuit, the voltage on the .047mfd capacitors does not alter unless a voltage is present on one of the bases and the transistor is turned on. Otherwise the transistor is turned off and it will have no output, no matter how many times the button is pressed We have used 5 x 10k resistors as they are standard design values for 9v circuits. You could use values either side of this value without any problem.
The two 10k resistors in the base circuit serves to isolate the base from the output of the CD 4017 decade counter and enable the LEDs to illuminate. If the base were connected directly to the output of the CD 4017, the base-emitter voltage would drop the output voltage to less than 1v and extinguish the relevant LED.

MODIFYING THE RUNNING LIGHT

The running light target uses the circuit from project 4 of the Experimenter Deck series. Since we are now supplying this project with 9v, (less the drop across the 555 IC,) the only resistor which needs to be changed is R_9, the 120 ohm LED dropper resistor. It should be increased to 1K to limit the current through the LEDs.
The green target LED is moved from position 9 to position 4.
Three leads 15cm long are soldered on the underside of the PC board next to LEDs 3, 4 and 5. This is directly below the three molex pins. These leads will connect to the base of the 2 transistors on the Binary Counter module.

should be illuminated but if not, check all the outputs: 3,2,4,7,10,1,5,6,9,11 for a high with either the multimeter or LED. If any output is HIGH but its LED is not illuminated, you may find the LED is connected around the wrong way or the diode is reversed. Once you have established a HIGH on one of the pins which does not clock to the next output, check that there is no voltage on the inhibit pin 13 or the reset pin 15. As a test, these pins can be connected directly to ground.



PARTS LIST

FOR SQUARE WAVE OSCILLATOR:

R2	resistor	470k ¼watt
C1	electrolytic	100mfd 16v
Sw2	"RESET" push button	

FOR EXPERIMENTER DECK:

R9	resistor	1k ¼watt

FOR GATING CIRCUIT:

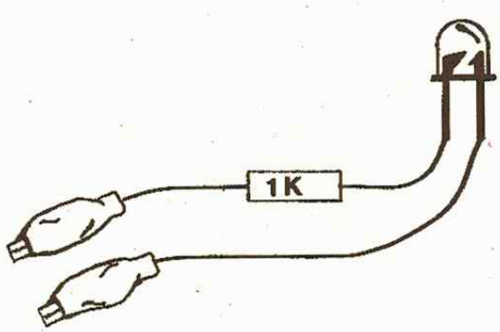
R1	resistor	10k ¼watt
R2	"	10k "
R3	"	10k "
R4	"	10k "
R5	"	10k "
C2	capacitor	47n (.047)
C3	"	47n
Q1	transistor	BC 547
Q2	"	BC 547
Sw1	"FIRE" push button	

FOR BINARY COUNTER:

R9	resistor	100k ¼watt
C1	electrolytic	10mfd 16v
15cm	10 core ribbon cable	

FAULT FINDING

To test the two remaining modules you will need a TEST LED. This is made from a red LED (taken from the Square Wave Oscillator Module) and a 1k resistor. Solder these to short lengths of hook-up flex and add a couple of alligator clips. You will also need a low-cost voltmeter set to the 10v range.
Firstly check the polarity of the test LED by clipping one lead onto the negative rail and touching the positive of the supply. Reverse the leads if the LED does not light.
To test the Deck, check the output pin 4 of the CD 4001 with the flying end of the test LED. The LED should pulse on and off at 2Hz. If not, check wiring to the oscillator including the polarity of the electrolytic and the continuity of the 2 resistors. Check that you have a voltage on pin 14. If none of the 10 LEDs illuminates, check pin 16 of the CD 4017 with a voltmeter to see if voltage is going into the IC and pin 14 for rising and falling voltage. Theoretically one of the LEDs



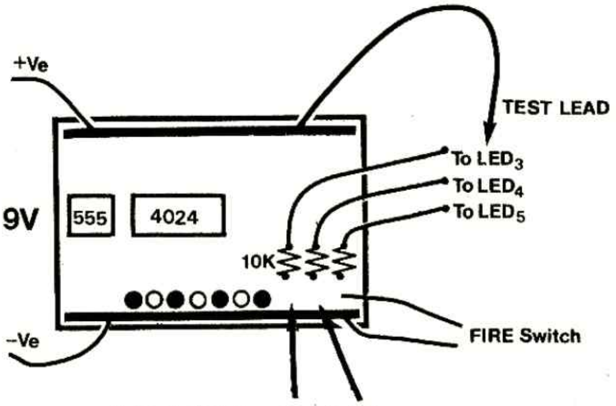
TEST LED

TESTING THE GATING TRANSISTOR STAGE

Assemble the gating section and locate R_1 R_2 R_3 the 3 - 10k resistors connecting LEDs 3, 4 and 5 to the base of the two transistors. Connect the 9v supply and with the test lead shown, touch R_1, the resistor coming from LED 4. It is the centre resistor on the PC board. Nothing should happen. Press the "fire" switch and keep it down while touching this resistor again. The binary counter should clock over one unit. With the switch still pressed, touch one of the other resistors coming from LEDs 3 or 5. The counter should reset. If not, follow these steps:

To produce one-shotting of the 555, connect a lead to earth and touch pin 2. This must work as we have only replaced the switch in project 7 with a jumper. Next touch the collector lead of Q_2 to earth to see if the same effect is being produced via the .047mfd capacitor. To test the transistor Q_2, clip the positive lead of a voltmeter onto the collector. It should measure about 9v. Desolder lead b from R_1 (the centre 10k) and connect this free end of the resistor to the positive rail via a jumper lead. The voltage should not alter. Now, with your third hand, press the "fire" button and notice the voltage drops when the base is connected via the HIGH lead. The output will now one-shot the 555. The same testing procedure apples to the other transistor as both circuits are identical, excepting that the reset pin of the CD 4024 is kept LOW during the count period and any spike through the capacitor will reset the count.

The .047mfd capacitor isolates the transistor from the IC...DC wise. However AC in the form of spikes readily pass through the capacitor and will trigger the reset.



TESTING Q_1&Q_2

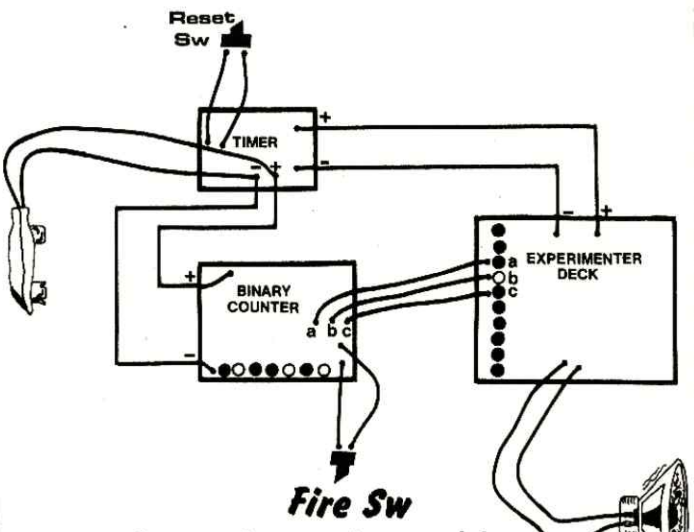
GETTING IT ALL TOGETHER

Naturally I hope you have already built up the three modules from the previous issues and have them working perfectly before embarking on this combined project.

Don't expect to build a project like this in one hit and get it going the first time. That's expecting too much and is not the policy of the magazine. You must build and test each portion separately and have them working properly before combining them together. Then you CAN expect it to work. In case you have experienced a fault in any of the modules, we have explained clearly in the text the check points to test them individually. Once you are satisfied everything is ready, you can interconnect the modules with hook-up flex as shown in the accompanying diagram. Terminate the positive and negative lines with a 9v battery clip. You can use either a 216 battery 6 penlite cells in a holder or a 9v regulated supply. Obviously a 216 battery won't last long but can be used for initial set-up. You will notice we have left the sound section of the Experimenter Deck connected. This will add a little more character to the game. The 100k pot will adjust the difficulty of the game by speeding up the running light. It should be set slow at the beginning to get some practice. You can set it faster as your skill improves. The pitch of the sound is adjusted via the 500k pot RV_1. Unfortunately it does not let you know if you have scored a hit. This, however, would be quite easy to provide.

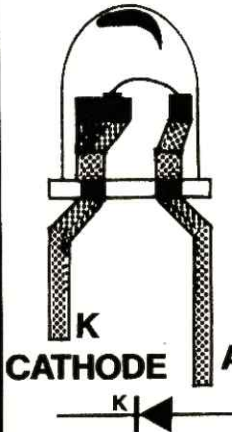
We won't have to explain any more on how to play the game except to say that speed is the essence of high scoring and you are competing against a 1-minute time interval. Actually the 555 timer will cycle after about 1 minute in the low state. This means you will be able to add to your score without it being reset via Sw_2.

We had a lot of fun with this game, I hope you do too.

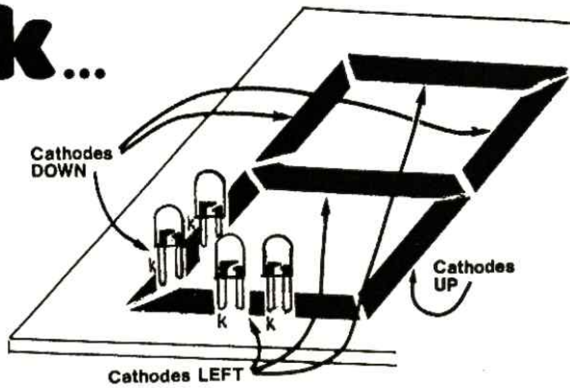


Connecting up the modules

A closer look...

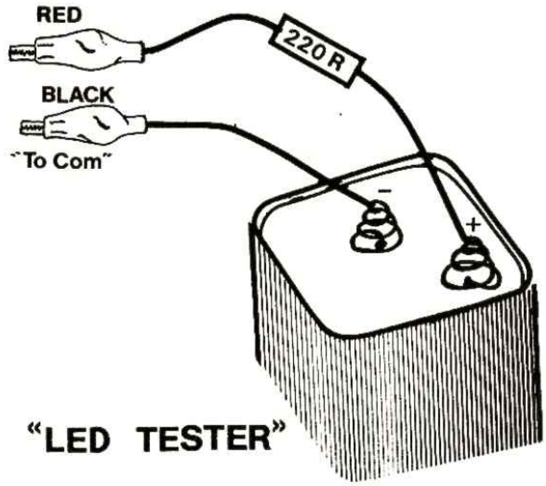


Before beginning, take a little LED and study it. Hold it up to the light and look into the case. Be sure you can recognise the kathode oops...cathode even when the leads are cut the same length. Soldering 60 LEDs into a board is a long process, turning then around takes even longer!



The 7 segments are formed by pairs of LEDs in SERIES.

The 7-segment LED display is wired as a common cathode configuration to suit the 74C926 counter IC. The diagram above shows the cathode lead is the shorter lead and when looking into the light emitting diode, has a large kink inside the diffusing plastic package to keep the lead from being pulled out. Inside the LED this cathode lead is also the thicker and larger of the two.

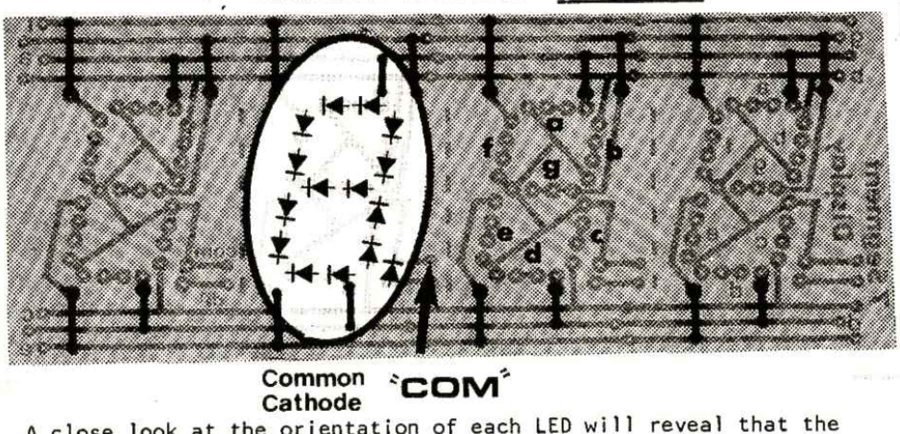


TESTING

Each pair of LEDs should be tested for correct insertion and relative illumination as they are fitted with either a 4.5v or 6v supply.
Place the negative lead on the common line, MARKED ON THE DISPLAY AS: "com" and solder either a 100 ohm for 4.5v or 220 ohm for 6v in the positive lead and check each segment.
If a pair does not light, test each LED individually. The dropper resistor will limit the current to less than 20ma when checking a single LED.

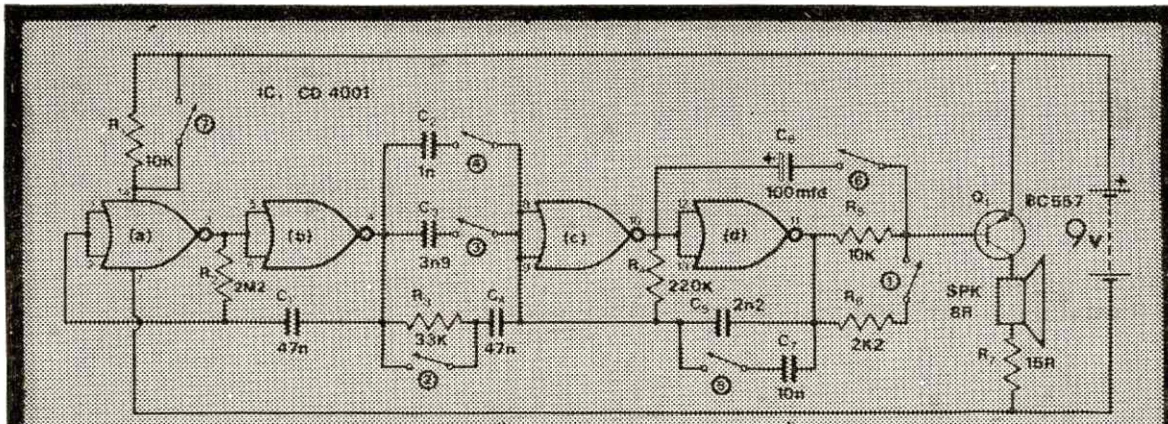
Follow the two drawings carefully as you insert each LED as the only faults we have repaired have been due to incorrect insertion of one or more LEDs.

7-SEGMENT DISPLAY: TOP SIDE



A close look at the orientation of each LED will reveal that the short lead connects to the common line.and this is why some of the LEDs are wired with cathodes up, to the left-hand side,or down.

Star Wars 'Noise-A-Tron'



STAR WARS "NOISE-A-TRON"

Chirp - buzz - squeel - click - pop - pop - pop - beep - whine - click - buzz - ttsshh - ttsshh... just some of the sounds produced by our NOISE-A-TRON.

Have you ever wanted to produce sounds similar to those from "STAR WARS?" Sounds such as a "space gun", "phaser", "explosion" or "shooting down enemy space ships" can now be re-created with this simple project.

Although its looks simple, it can produce a range of quite weird sounds and noises. Many of its tones and noises cannot even be described while others sound like a bird in distress or a high pitched HEE HAW.

Operation

The circuit is designed around ONE IC and uses a PNP buffer transistor to drive the loudspeaker. The high input resistance of the CMOS IC makes it ideal for this type of circuit as a wide range of frequencies can be obtained and in addition the resistance of your fingers can be used to modify the frequency of the oscillator. Since more than one switch can be pressed at a time, the variety of tones and noises which can be obtained is very varied. Adding to this the changing resistance of your fingers, the range becomes almost infinite.

PARTS

R1	resistor	10k	¼ watt
R2	"	680k	"
R3	"	33k	"
R4	"	220k	"
R5	"	10k	"
R6	"	2k2	"
R7	"	15R	"
C1	capacitor	47n	100v
C2	"	1n	"
C3	"	3n9	"
C4	"	47n	"
C5	"	2n2	"
C7	"	10n	"

C6 electrolytic 100mfd 10v

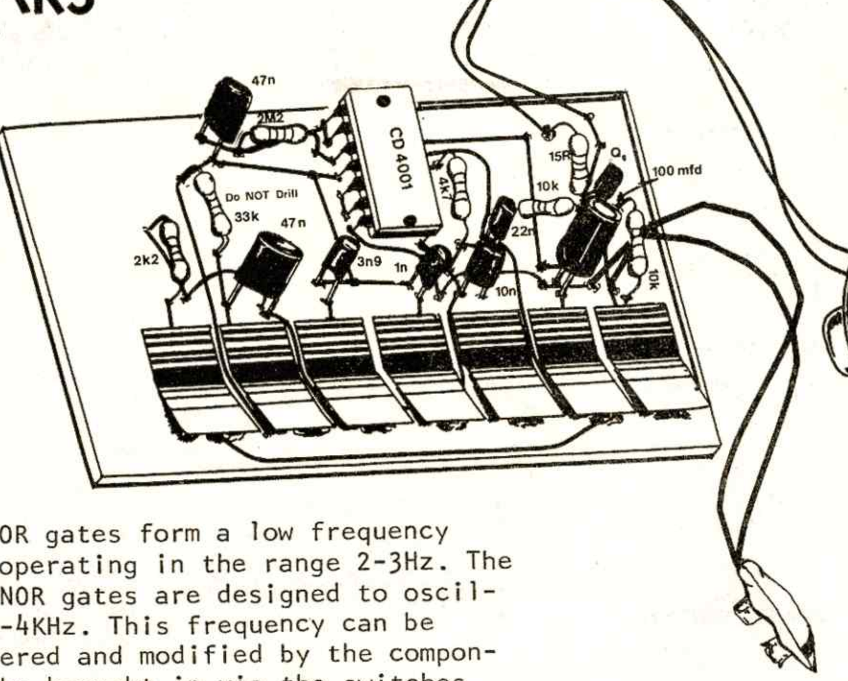
IC1 CD 4001

2¼" speaker 8ohm or 15ohm
9v battery clip
9v battery
Sw_1 - Sw_7 springy brass .01" thick x .8cm wide x 17cm long.

NOISE-A-TRON PC BOARD

STAR WARS LAYOUT

Project cost: $7

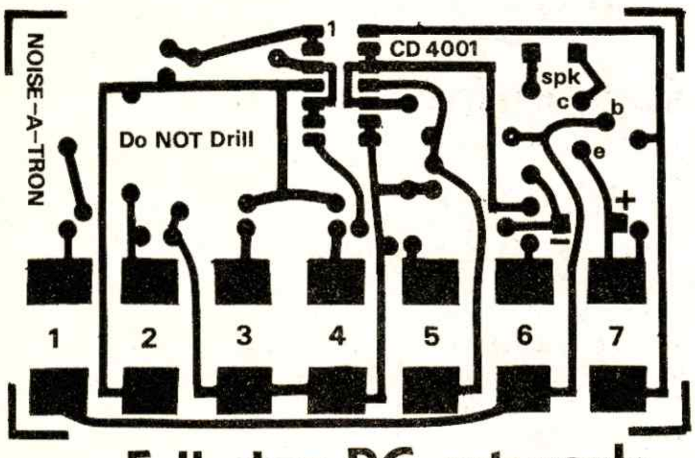


The first two NOR gates form a low frequency multivibrator, operating in the range 2-3Hz. The second pair of NOR gates are designed to oscillate at about 3-4KHz. This frequency can be drastically altered and modified by the components which can be brought in via the switches. I tried to photograph the waveforms on an oscilloscope but would you believe the waveforms were too complicated to reproduce and have any meaning. The complex waveforms are the result of two widely differing frequencies interacting with each other but not in simple additive terms.

Construction

All the components mount on a small Printed Circuit Board. Again we have used the board "up-side-down" with the copper circuit uppermost to mount a row of fabricated switches. This arrangement not only keeps cost down but allows the resistance of your skin to alter the frequency of some of the sounds. The 7 switches are made from .01" thick springy brass. (This thickness is called 10 thou). The brass is cut to 2.2cm lengths and soldered onto the board to make a very rigid press-switch. To make a positive contact, the board should be tinned where it will touch the underside of the brass.

This board will be ideal for you to make at home. You can use the photographic method or a Dalo pen. You could even use stick-on transfers to protect the copper from the Ferric Chloride etchant. Don't forget; the board is NOT drilled!



Full-size PC artwork

EVEREADY® BATTERY SCIENCE

1

Portable Power . . .
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Can you imagine for a moment what your life would be like without electricity? It was just over a hundred years ago that the great Michael Faraday perfected his experiments for which we call him "The Father of Electricity". Other famous scientists who have worked with electricity include Sir Joseph Swan, Allesandro Volta, Thomas Edison and Georges Leclanché.

Within the next twenty years many of the things you use every day will be "Cordless" . . . powered by either disposable carbon-zinc, alkaline, silver or mercury batteries, or, new rechargeable (reusable) nickel-cadmium batteries. Portable TV sets, radios, phonographs, cameras, vacuum cleaners, carving knives and brushes are on the market now. Packaged electricity . . . the batteries you use every day were first offered for sale under the "Eveready" brand in 1890. Since then battery "know how" has grown tremendously as Union Carbide researchers strive continuously to put the most power in the least amount of space for the lowest possible cost in today's NEW WORLD OF PORTABLE POWER.

2

What is Electricity?

Matter is anything that has mass or weight and takes up space. As either a solid, liquid or gas, matter is made up of atoms. Atoms, in turn, are tiny particles with *electrons* orbiting around one or more protons (and neutrons) in the centre of the atom. A hydrogen atom has one electron and one proton.

Balanced atoms have a neutral electrical charge. An electron is the basic negative electrical charge. It cannot be divided. All electrons are identical. Some, however, are more closely tied to their nuclei (protons and neutrons) than others, these are called bound electrons. Some escape their orbit and are free to form an electric current.

Protons and neutrons are found in the nucleus (centre) of an atom. A *proton* has a positive electrical charge. *Neutrons* have no electrical charge.

The experiments in this Handbook are designed to help you discover what electricity does . . . what it's like. We have spoken of electrons and protons as having charges. Like charges repel each other. Unlike charges attract each other. Electrons move from negative to positive. The flow of electrons is called current and is what we commonly call electricity.

Electric current is produced when something causes electrons to move. This something is called an *electromotive force* (emf). This force can be caused by a chemical reaction (as in a battery), heat, light, friction, pressure or magnetism. In a motor, for example, a magnetic attraction is used to perform a work task. *Power* is the rate at which work is done. It is equal to the amount of work accomplished divided by the time needed to do it.

3

Science Safety Rules and Warnings

If you are interested in this book, you are a scientist. **Good Scientists don't get hurt. They work carefully and don't take chances.** If you follow the instructions exactly, you will be in no danger. Start now to learn science safety. We suggest you memorize the following rules:

1. Never work alone. Have one of your parents, a teacher or an adult in the room or within easy call.
2. Work in a fairly large room near a supply of running water.
3. Don't splash any liquids you use (even salt water). If you do, immediately rinse the splashed area with running water. If you splash liquids on your skin or in your eyes, wash out immediately with plenty of water and call your parents or teacher.
4. Clean up carefully. Pour all liquids directly down the drain and rinse the work area and sink thoroughly with plenty of water. Don't leave materials around where younger children can find them.
5. Use some type of eye protection. Professional scientists wear safety glasses or safety goggles.
6. Keep all chemicals away from your eyes, nose and mouth.

7

Current in a Circuit

Materials

Thick pencil lead / A flat piece of wood / Two lengths of coated wire / One No. 950 "Eveready" Battery / Flashlight bulb / Adhesive tape

Steps

1. Tape a long pencil lead to a flat piece of wood.
2. Strip the coating off the ends of two lengths of wire.
3. Wrap one end of a length of wire around the tip of your pencil lead. Tape the other end to the tip of a battery.
4. Twist one end of your other wire length around the grooves of a flashlight bulb. Tape the other end of this wire to the bottom of your battery.
5. Touch the base of the bulb to the pencil lead. Slide the bulb along the pencil lead. Does the light become brighter? The less lead in the circuit the brighter the light.

Explanation

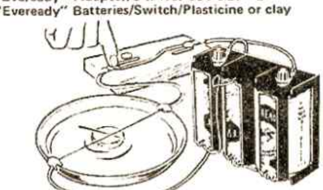
The lower the resistance the brighter the light will become. Movement of electrons through a wire is called current. The battery acts like a pump to keep electricity flowing. The resistance of the wires is like friction. It cuts down the flow of the electrical charge, or electrons.

8

Oersted's Experiment

Materials

Magnet/Needle/Cork/Water/Deep dish/No. 20 or No. 22 gauge insulated connecting wire/714 "Eveready" Adaptor/3 x No. 950 size "D" "Eveready" Batteries/Switch/Plasticine or clay



Steps

1. Stroke a needle 50 times with a magnet, from the centre to one end of a needle. Place it on a floating cork. The needle will turn to a North-South direction. Move your magnet near the needle. What happens?
2. Make a circuit with the adaptor, a switch and a foot or more of wire. Stretch and secure the wire over the top of the dish with two pieces of plasticine or clay in the same direction as the needle (which should settle to a North-South direction). Turn your switch on and off several times. What happens?

Explanation

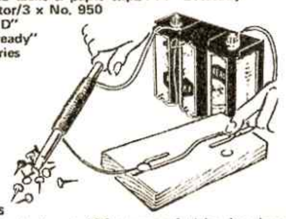
A Danish scientist named Oersted first performed this experiment. His discovery in 1819, that a magnetic needle is deflected at right angles to a conductor carrying an electric current proved there is a close connection between electricity and magnetism. The electric current produced the same effect as the magnet. The study of electromagnetism led to the development of the electric motor.

9

Building an Electro Magnet

Materials

Screwdriver/2 yards of thin insulated wire/Switch/ Thumb tacks & paper clips/714 "Eveready" Adaptor/3 x No. 950 size "D" "Eveready" Batteries



Steps

1. Wind about 100 turns of thin, insulated wire around a screwdriver in the same direction. Leave wire ends free. Remove insulation from ends.
2. Connect the wire ends to your adaptor & switch. Dip the screwdriver into your tacks and paper clips. What happens?
3. Disconnect the wire leads. Dip the screwdriver into the tacks and clips again. What happens now? Unwrap the wire from the screwdriver and again try to pick up metal objects. Can you?

Explanation

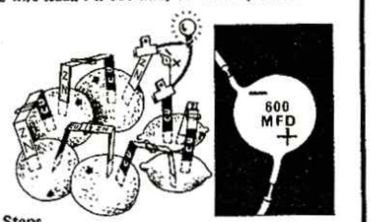
An electro-magnet consists of a metal core with a wire coil around it. The core becomes magnetized. Magnet strength is measured by lifting power (pounds) and is based on the number of wire turns and the current in amperes, the product is called ampere-turns.

Strength (pounds)	5	10	20	50
Ampere-turns	225	300	400	800
Diameter of Metal Core (in.)	½"	½"	¾"	1¼"

4
How to make a battery

Materials

2 grapefruit/2 oranges/2 lemons/1.5 Volt "grain of wheat" light bulb/2 alligator clips/Adhesive tape/6 copper strips/6 zinc strips/Paper clips/2 wire leads/1 x 600 mfd, 10 Volt capacitor.



Steps

1. Insert the copper (positive) and zinc (negative) strips into the fruit. Be careful they don't touch inside the fruit.
2. Connect the copper and zinc strips with paper clips as shown. Leave the last two strips unconnected.
3. Touch the light bulb leads to the unconnected strips. Does it light?
4. Connect the capacitor to the two strips. Be sure the copper strip is connected to the "positive" on the capacitor. Wait two minutes. Touch the light bulb leads to the two strips while the capacitor is still connected. Does the bulb flash?

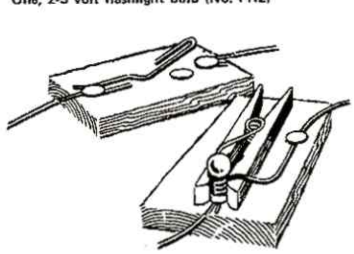
Explanation

You have made a battery which is capable of delivering very small currents. Batteries are miniature chemical plants. The citric acid in the fruit reacts with the metal to produce electricity. The capacitor stores up the electricity your battery produces . . . builds up an electrical charge to flash the light bulb.

5
What is a Circuit?

Materials

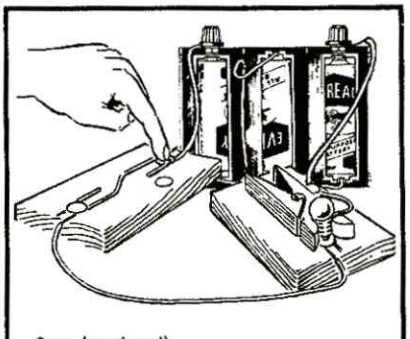
714 "Eveready" Adaptor/3 x No. 950 size "D" "Eveready" Batteries/Small blocks of wood/Thumb tacks/Paper clips/Spring-tension/Clothes pin/Nail/No. 20 or 22 gauge insulated wire/One, 2-3 volt flashlight bulb (No. PR2)



Steps

1. Build a Switch. Wind a bare wire end tightly around a thumb tack. Hook a paper clip around the tack and press it into a wood block. Wind another bare wire end around another thumb tack and press it into the wood. Connect this wire adaptor (−terminal). Place a third thumb tack in the middle of the wood block to hold your paper clip switch in place.
2. Build a Bulb Holder. Nail a clothes pin to a wood block. Wrap the bared end of your unconnected wire around a bulb. Clamp it in the jaws of a clothes pin. Tack the loose wire to the wood. Place another tack with wire under the bulb. Connect this loose wire to your adaptor (+terminal).

6
What is a Circuit? (continued)



Steps (continued)

3. Press paper clip against the thumb tack to turn switch on.
4. When the light shines, cut the wire. Place various objects against the loose wire ends. Conductors let electricity pass through them. Insulators do not. Make a list on conductors and insulators.

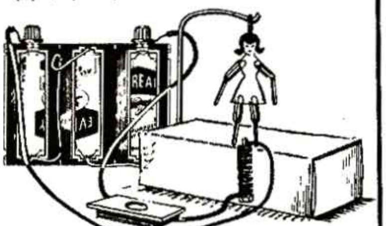
Explanation

A circuit is an arrangement of conductors which allow the passage of an electric current through things, usually wire. Metal objects make the best conductors. Copper, brass and silver, etc. have many free electrons capable of being pushed or moved along by an electro-motive force such as the voltage in a battery. In insulators, electrons are not free to move easily from atom to atom. A flashlight is an example of a portable circuit. When its switch is on the circuit is complete and the bulb lights.

10
Building Dancing Dolls

Materials

Electromagnet/Bell switch/714 "Eveready" Adaptor/3 x No. 950 size "D" "Eveready" Batteries/Wire leads/Cardboard box/Stiff paper/Paper clips/Rubber band/Scissors



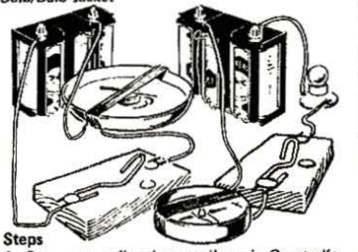
Steps

1. **Build an Electromagnet.** Wind 100 turns of No. 20 or 22 gauge magnet wire around a ¼" x 3" bolt. Leave ends free. Remove insulation from the wire ends. Place in an upright position and secure with clay on a wood block.
2. Connect wire leads in series from your adaptor to the bell switch to the electromagnet.
3. Place a cardboard box over the electromagnet. Be sure magnet is close to the top of the box.
4. Draw and cut out your doll(s) from stiff paper. Use 2 paper clips for each arm and each leg for each doll.
5. Suspend your doll(s) with a rubber band(s) as shown.
6. Press and release bell switch several times. Watch the dolls do their own electromagnetic dance.

11
Building a Galvanometer

Materials

Dish/Wire/Cork/Needle/Switch/Compass/714 "Eveready" Adaptor/3 x No. 950 size "D" "Eveready" Batteries/4½ Volt flashlight Bulb/Bulb socket



Steps

1. Set up your floating needle as in Oersted's experiment. Wrap a wire around the dish, over the needle, and complete your circuit. Remember how far the needle turned.
2. Wrap the wire around the dish several times and complete your circuit. Did the needle turn any farther?
3. Repeat the experiment substituting a compass for the needle. Also connect the bulb in series to reduce the current. Measure the different degrees the compass needle turns as you increase the wire turns. Keep a chart which records the number of wire turns and the degrees the compass needle moves.

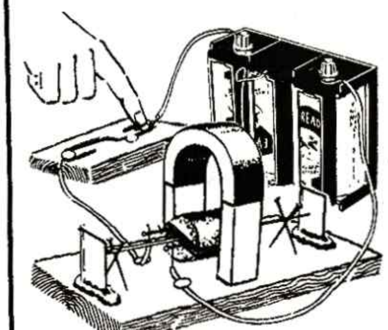
Explanation

The greater the number of wire turns used, the greater is the electro-magnetic attraction. You have made a galvanometer which measures electric current. It is named for its inventor, Luigi Galvani.

12
Building an Electric Motor

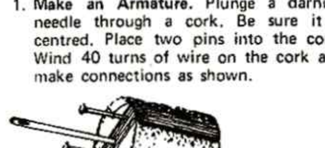
Materials

Horseshoe magnet/¾" cork/Pins/Darning needles/No. 22 magnet wire/Soft wood block/Clay/2 cardboard strips/Metal thumb tacks/714 "Eveready" Adaptor/ 3 x No. 950 size "D" "Eveready" Batteries



Steps

1. **Make an Armature.** Plunge a darning needle through a cork. Be sure it is centred. Place two pins into the cork. Wind 40 turns of wire on the cork and make connections as shown.



SHOP TALK

— CONDUCTED BY THE EDITOR

Most readers will have realized by now that TALKING ELECTRONICS is produced every alternate month. This has a number of distinct advantages as you will see in a minute. The main reason for deciding on a bi-monthly publication was to give you, the reader, sufficient time to purchase components and assemble the project before the next issue appeared. Eight weeks may sound an interminable time to you but believe me, it slips by very quickly when you are racing against time. Our policy is quality before quantity and we would prefer to present six or seven digital projects in each issue rather than dilute them into two issues. Our ideas and presentation is far ahead of anything else available and it only needs you to follow along with us and you will be assured of capturing the magic that is ELECTRONICS. If you only sit back and think for a moment, electronics is the only field which will be advancing and expanding right through the next 20 years. Many people thought electronics would be the fairy-godmother to job creation in the 80's but although it does create new jobs, it inherently pares away at ineffecient sectors to consolidate their operations. In this way we have seen whole sections of businesses become replaced by a central operator and a bank of sophisticated machines or central data storage.

Unfortunately this is progress. I say unfortunately because we all know the consequences of progress. However this advancement will benefit anyone with knowledge of electronics. Electronics will effect everyone in the near future, but few will be able to make it work in their favour. If you have technical know-how you will be able to take advantage of the progress. Whether you specialize in automotive electronics, industrial, consumer or amusement electronics, you can be fairly well assured of serving the next 20 years. Provided, of course, you keep strictly up-to-date with technical advancements. The projects we have presented to date and future project have and will all be carefully considered before inclusion. Our overall aim is one of practicallity. They all dovetail into oneanother and it will take a year or two before the whole interlocking intention will jell.

All of a sudden, like learning to skate, you will wake up one day and say: "I'm finally understanding it!"

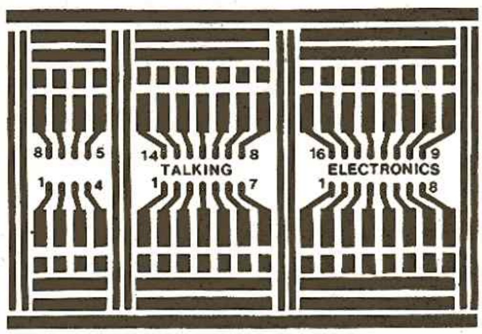
With the most important tool securely locked into your system you will be able to branch out into almost any field. The most important tool is of course: DIGITAL ELECTRONICS.

It cannot be too strongly emphasized: digital electronics will be in very great demand during the next 10 to 20 years. Even at the moment it is seeing a phenominal growth rate and as yet has not entered the automotive or consumer market to any appreciable extent. Within the next 10 years, cars will be almost entirely digitally equipped and controlled. The saving this will realize from simpler wiring looms, cheaper instrumentation, additional fail-safe devices, fuel metering and measuring, will stabilize car costs and create intense competition between makers. Additional equipment such as anti-collision radar, speed and braking controls and sobriety monitoring equipment will become standard features on the next, next, next generation of cars. All these features will need designing, modifying and adapting, fitting, testing and repairing. They will all break down eventually and as is the situation at present, twice as many workers will be employed repairing equipment as manufacturing it.

With even the most basic understanding of electronics, you will be welcomed with open arms. But you can fool your employer for a while. If you can't produce the goods, your term will be short. It's all very well being able to assemble electronics, but getting it to work by diagnosing the fault is another matter. Anyone can make electronic gadgets but fixing them is another matter. It takes understanding. Fault finding is the most important part to understanding. That's why much of our magazine is devoted to getting the project to run. We don't describe a project on the assumption that it will work first time for everyone because we know from experience, it just doesn't happen. Even the most careful assembly and exacting soldering can result in a dud.

Remember you are one of the elite for the 80's. Other professional groups have been catapulted to the fore in the past, now it is our turn to take and accept this prestigious position knowing that a minute number of electronics wizards will be responsible for transforming the life and status of practically the entire population of the world.

So much for extrapolating. Let's come back to earth. Sometimes I get a little carried away but this time I couldn't help expounding. Every time I read or see a program on tomorrows world, I see electronics in the fore front. But before we can take on tomorrows technology we must understand what is available today. Before we can run we must be content to crawl. At the moment we are crawling. Crawling and colsolidating. This brings me back to my first point. A bi-monthly magazine will enable you to consolidate learning processes and direct you to application rather than expectation. It will also give US sufficient time to design and test new projects or add to existing ideas. This is what we have done in this issue. You will notice we have arranged a couple of projects to extend your knowledge one small step. We have combined a number of projects from the previous issues to make a more complex arrangement. If you don't build these little circuits you won't have the enjoyment of turning them on or the reward of trouble-shooting a fault. You cannot learn vicariously, you need to apply yourself. With electronics this is essential. If you find the cost of constructing all the projects prohibitive, I suggest you invest in one of the two construction panels. The cheapest and simplest is the EXPERIMENTER BOARD. It is



designed to accept up to 3 IC's, an 8 pin IC, a 14 pin IC, and a 16 pin IC. You may use sockets to avoid the possibility of damaging an IC and since the components are placed on the copper side of the board, they can be removed very easily without damaging either the part or the board. For the more complex project I suggest the breadboarding system distributed by Ellistronics. It is by far the cheapest and the best available. It has a sensible number of holes and will accept a number of IC's arranged along the centre of the board. The most popular size retails for \$13 and can be used again and again without the holes becoming loose or noisy. Some form of breadboarding is a great advantage if you wish to build a project quickly before launching into buying or making a printed circuit board. You can test the projects' suitability for your particular application without incurring excessive costs.

WB-2N 200 + 640 Holes

\$12.90 INC

NOTE: The 4 top and bottom bus lines are broken in the middle. You will need four jumper wires to complete the board.

All the parts are fully recoverable and it only takes a couple of minutes to dismantle a whole nights effort.

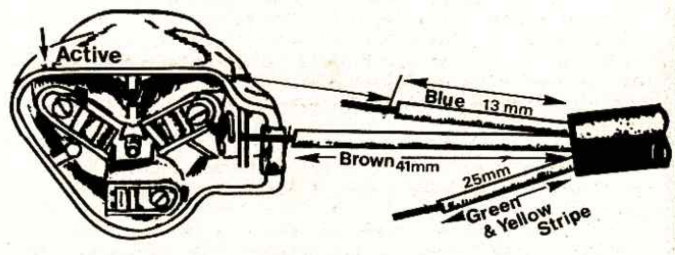
These boards have already proven extremely popular and hardly need any recommendation or advertising. I'm only describing their existance because they have just been released and the first stocks ran out within four weeks. It's an odd quirk of advertising, people know or sense a bargain. Even though something may be heavily advertised, it does not guarantee immediate sales. It must be value-for money. Sometimes it still needs a genuine recommendation from an independent source before its qualities become apparent. This is the case with the breadboards. They are half the cost of any other system.
As new equipment is released on the market we will endevour to evaluate it and prepare a report.
Fortunately I am in the enviable position of being able to knock back unsuitable advertising or unrelated advertising so you can be fairly sure that the products advertised in TE are closely related to the projects.

As our range of projects increases we are being approached by a few electronics shops wishing to stock individual items such as PC boards or special components and kits. It could be that your local electronics shop has seen the advantage of stocking TE kits as they form a valuable learning staircase to compliment the magazine. If your local shop has not seen the magazine it would be in your interest to ask them to contact us. Not only would they benefit with up-to-date kits each month but the potential sales growth and dissemination of information will benefit your locality.
Our next immediate intention will be to set up digital electronics shops throughout Australia supplying a completely (as yet) unseen range of electronic components. Shops already displaying our kits or intending to display them will become prime outlets for these new promotions.
As more and more of the older style electrical and "electronic" shops close down, an opening develops for retailing the next generation of electronic componentry.
We must be ahead of the opposition if we are to survive. In this regard I think we have scored a few extra points.
Since the magazine comes out bi-monthly we have the availability of interleaving its appearance with an entirely new and exciting venture. During the non-issue months we will be releasing a 32 page project booklet containing one or more projects in the line of valuable test equipment or a universal household project. In any case it will be something of proven worth. These project will fit onto a specially designed Printed Circuit Board.
Now, here's the exciting part. The project board will be attached to the booklet at its point of sale. This means when you buy the book at your newsagents or electronics shop, it will have the PC board attached, so you can commence construction almost immediately. By arranging mass production of the boards, we can keep costs very low and offer both the project booklet and board for less than $4.00 We hope to keep it at this level for the whole series. Our first release will be a MINI FREQUENCY COUNTER, using just 4 IC's and three digits in the display. After buying the instructions and PC board, the kit of parts will be available for less than $15. Our prototype showed amazingly good response up to 10MHz although we will guarantee it to about 5 or 6 meg. At this upper frequency, we can measure crystals in colour TV's (4.433619MHZ) or the 3.579545MHz crystal used with 5369 IC to produce a 60Hz timebase. Since this is designed as a piece of test equipment, we will be offering calibration for $3 plus postage. Again this is near our cost price to bring the maximum number of hobbyists into the field. Where else can you buy a frequency meter for under $20?
A FREQUENCY COUNTER has quite a number of uses and in the project book we have described 3 input sensores to extend its usefulness. With sensors to detect sound, light and oscillatory circuits you will be able to reference from known frequencies to calibrate the counter yourself. Then you will be able to check the frequency of any sound source or oscillator within the range 100Hz to 10MHz. This will prove to be a valuable piece of test equipment at a very low price. If you would like to send for your copy of the project and PC board "MINI FREQUENCY COUNTER", the cost is $3.95 incl post and pack. As these project books will be available periodically, you can subscribe to the first five issues for $19.50 and you will receive them the moment they are released. This will avoid disappointment as we are only printing a limited number of each issue and we know there will be a sell-out situation at some stores. A few readers have already experienced this situation with issue number 1 and 2 of the magazine, so don't get caught.

CORRECTIONS ISSUE 3

P6. On the main circuit diagram the transformer should be 2155 not 2115

P6. The wiring to the plug top may be mis-interpreted by some readers. The bare wires from each conductor should be just long enough to fit under the screw terminals. We have corrected the diagram here to show the length of the bare wires:



P 7. Letters E & F on the layout diagram should be interchanged as F goes to pin 2 of the regulator. The PC layout is correct.
P 28. 100k & 3k9 resistors should be interchanged to read R_1 = 3k9 & R_2 = 100k
P 33. Parts List: R1 resistor 3k9
R2 " 100k
Under Circuit Operation: line 4:
Depending on the position of Sw_1 the counter....
Line 8:
a one-shot with triggering from Sw_2......

When Sw2 is pressed, the short on pin 7 is.....
P 41. The mini amplifier has R_3 and R_4 repeated twice. Don't worry about the letters R_3 R_3 R_4 & R_4. The resistor values are all correct and the diagram is correct.
P 56. The Cricket Layout has Sw1 and Sw2 transposed. Refer to the circuit diagram for the correct letters.

LED ZEPPELIN

Two readers have experienced difficulty with the LED Zeppelin illuminating the top LED. We have found this to be entirely due to a weak battery. Small 9v batteries are notorious for dropping their voltage nearly 2v while still providing adequate current to operate apparatus such as a transistor radio. At 7v there will be insufficient voltage to supply 1.7v to the top LED as nearly 6v is dropped across the transistor stair-case, lower diode and upper switching transistor. We need over 2v to light the top LED with its 270R dropper resistor. Thus a new battery will be needed for this project. An alkaline cell will hold its voltage for a longer time before dropping very sharply near the end of its life.
Don't forget the note in last issue regarding the orientation of the 4.7mfd electrolytic. If you don't use a tantalum capacitor in this position, it may be necessary to reverse the polarity of an ordinary electrolytic to start the oscillator.

LETTERS...

Well, what an enthusiastic response! Let's not kid you, we haven't received thousands of letters but we have received letters nearing the hundred region. These have been an insight to your ideas and thoughts on not only the magazine but electronics in general. I feel these provide a valuable contribution to the magazine and enlighten you to the interests of fellow hobbyists. Most of the letters will be presented in their original style but some of the more lengthy ones have been condensed a little to give room for variety.

Regressing to Issue 2, we had a topical letter from Mr T. Baitch. You will recall his suggestion to use rectangular symbols for resistors and very simple square blocks for integrated circuits. We had a number of letters and comments from readers. Some of these appeared in issue 3 and I was hoping for a reply from Mr Baitch on the prominance given to his letter. I was going to say I haven't heard from him as yet but low and behold, his letter has just arrived on my cluttered desk.

Firstly I'll give you the main extract from his latest letter:

Dear Sir,

Simply to let you know I have read issue 2 with great interest and have number 3 just to hand. Congratulations on your efforts.

Thank you for providing space in the magazine to discussing modern symbol standardizing. I am delighted at your now more positive reaction, at least towards the resistor "box" symbol (see pages 34 & 35 of issue No 3) and hope to see it firmly introduced in the near future. The "staggering" of wire connections (centre picture on P 35 of issue No 3) is of course recommended SAA practice, while the skewed solution on the right is anathema (banned) in drafting circles. In the near future I hope you will see your way clear to use the dot for joining wires and to have crossings without a loop and without a dot for non-connecting wires. This will be in line with Australian and world-wide practice. The drawings on pp 28, 33 and 38 use the latest symbols and look really good. I am very pleased with your mention of the new rectangular symbols on P 45 of issue 3. You chalked up an Australian first.

T. Baitch, 2147.

Before we let this matter rest, I would like to get further comments from readers in general. I am particularly impressed with the thoughts of young experimenters as they are starting completely afresh, with unbiased views. How do they react to being taught one system and constructing with another system? I will formulate my final decision before the next edition.

Dear Sir,

I must congratulate you and your staff in publishing TALKING ELECTRONICS which at last caters for beginners of all ages in Australia.

Young beginners in particular, have not been provided for in this country and articles such as TEST YOURSELF and DATA SHEETS has not been presented prior to your publication. Information such as "how it works", how much it will cost and where the parts or kits can be purchased is particularly helpful. I wish you every success and can also mention that the young lads who come around to my home to experiment with electronics also echo my sentiments.

B. Jackson, 5343.

Thanks for your encouraging comments. A little dramatic to say hobbyists have not been catered for, prior to TE. But I know how you feel. A set of two books which provide a valuable basic understanding into electronics is available either at your local newsagent or city books shop specializing in technical books. It can be bought as two separate books and is called <u>ELECTRONICS, IT's EASY.</u> Written by Peter H. Sydenham, Professor and Head of School of Electronic Engineering, SA Institute of Technology, and published by ETI for TAFE. These two books are a prerequisite to reading TALKING ELECTRONICS. Volume 1 (about $3) is ideal for picking up background knowledge and terms. Volume 2 (about $5.95) covers more advanced topics while still following a very simple line. You can read it and absorb it quite easily. Nearly every page contains at least one photo or circuit diagram so it reads fairly quickly. It has a good index and a handy glossary of terms.

Remember Mr Macrill, he suggested removing IC with an Oxy-Acetylene torch. He wrote again last week confirming the honesty of his original letter. He still swears by his success rate at removing IC the plumbers way (oops sorry) and added a further delightful sentence: "..during the de-soldering process the tip of the Oxy was held about 2 feet from the board." Wow, how can I beat that!

Dear Sir,

I like your magazine and its new concept. I have a suggestion for a low-priced PC drill. A cheap hobby motor can easily be adapted to accept a number 60 drill. The different diameter of the two shafts can be taken up with a piece of plastic tubing. If used carefully, it is capable of completing quite a number of boards. Since the drill is very fine, I found it necessary to operate the motor from 9v to obtain a speed of 6-7,000RPM. I use a small 9v power supply similar to the one described in issue 3 to power the motor. I hope this is a handy hint for others making their own boards.

G. Cost. 3156.

Dear Sir,

In reference to your new magazine, I am happy at last to see such a publication for hobbyists with some down-to-earth projects and easy-to-read text. I don't go along with the current spate of computer articles which are gradually adding more and more pages to magazines and less information for the constructor. Crying in the wilderness are many hobbyists who cannot find how to make simple and useful projects. I don't appreciate flashing LEDs or games. From my experience, the seeming need for such devices rapidly diminishes. Yet when one needs to make something useful such as a reasonably small AC to DC power supply, the circuits are non-existent. I have a number of requests for circuits which I have been unable to locate. The most important concerns deaf people. Or should I say hard of hearing people. About 30% of people in Australia have a limited audio range. Nothing can give them ears to enjoy Hi-Fi music but by use of audio range compression, they can at least hear more clearly. Few of the partially deaf really want people to speak any louder. Their problem usually lies in not being able to detect parts of the audio spectrum. Radios of old appeared to have music compressed into the range 200Hz to 4kHz and they could sit close enough to enjoy listening. Nowdays everything is Hi-Fi and the problem has been accentuated. The two circuits I would like to see involve frequency compression and visual signalling for severely deaf people. I hope you will consider presenting these much-needed circuits in the near future.

C.F. Pearce, 3166.

Thank you for your letter. I have selected only one of the topics for discussion at the moment. I note you do not like gimmicky games such as flashing LEDs etc. Yet in the second half of your letter you are requesting signalling devices for deaf people. Do you realize the technology behind the flashing light is closely akin to your request? Your requirements such as lights, vibrating sensors, visual displays and talking machines is exactly what this magazine is all about. I can see the day when a deaf person will be able to carry around a small voice synthesiser containing a set of buttons which when pressed in an almost infinite number of combinations, will produce sounds similar to speech. Think of the avenues he will again be able to utilize, including the most prized of all, the telephone. Don't knock the flashing LED, it's the gateway to our dream inventions.

I am considering a beeper transmitter for not only deaf people but for aged and bed-ridden folk. It would transmit to the house next door and summon the neighbours in case of emergency. Various different calling codes could be added such as "come immediately","require food etc." or ". . . . " This whole unit could be constructed for $40, which is considerably less than $23 per week as charged by the telephone link-up system presently available. It also beats the flashing light warning system installed by some elderly folk.

Here is another letter from an "old-timer". We can learn so much from our previous generation and can appreciate the enormous changes which have taken place in their lifetime.

Dear Sir,

I recently purchased a copy of your magazine, issue No 2. Previous to that I had seen your issue No 1 on sale, which on examination, seemed to be of no interest to me, as it appeared to be aimed at beginners. I am a retired electronics engineer, with many years of experience in radio, radar, TV and industrial electronics.

However, on seeing your issue number 2, I am beginning to change my mind. I will be looking forward to future issues. Naturally I was interested in your article on TV servicing. The finger-touch servicing is almost as old as radio itself and in the early days, I used little else for servicing. However the need for instruments came along and in 1926, I became the proud owner of the latest type of test meter, made by Triplett. I still have that test meter in good order. I think your serviceman who got only two years life out of a 1k ohms per volt instrument is somewhat ham fisted. In 1945 I bought an Avo-minor VOM 1k ohms per volt instrument. By 1948 I was servicing an average of 1000 receivers per year. In 1948 some of the jobs were getting a bit complex for a 1k ohms per volt job, also TV arrived. This was in the UK and some early TV sets had power transformers with 5,000 volt secondaries. These were lethal and the finger servicing was out very definitely.

I then obtained a Taylor meter, which had nearly 90 ranges and a sensitivity of 20k ohms per volt. I still have the instrument in good order and condition. My grandson has the Avo-minor, using it for testing the batteries in his toy cars and other bits of electrical equipment.

Two years ago, due to the fact that the Taylor meter is a bit large to carry around (being in a large wooden case) I purchased a small test meter, 20k sensitivity and found it was made in JAPAN. Although the volume of servicing has fallen of dramatically due to retirement and the reliability of modern electronic equipment, this japanese meter is still functioning perfectly.

In my experience, servicing of electronic equipment needs the following expertise:

80% experience and

20% knowledge of basic fundamentals.

Practical experience is the most important requirement and must include a sharp memory of past problems. You must be absolutely resolute and have grim determination to stay with it until the problem is located.

The 20% electronic knowledge required for servicing may reflect why do-it-yourselfers sometimes succeed in a one-off situation. They would fail miserably if given a number of items for repair. Repairing is a specialized industry. The 20% knowledge factor applies only to this sector.

When constructing and designing even the old "breadboard" valve or transistor circuits I have found considerably more skill is required. When it comes to integrated circuits and PC construction, an even finer degree of competence is needed. This is where your magazine comes in. It has shown me a new range of ideas and has explained each stage of construction so simply.

I commend you on the presentation of your magazine.

J. Ratcliffe, 4215.

Thank you for your lengthy letter and the insight into the years gone by. We can look back and smile at the simple approach to servicing the old valve radios and the first generation of B&W TV sets. But don't laugh, within 10 years IC's will be so specialized that every product will contain its own custom designed circuitry inside a single chip. As I remarked in the Editorial of issue 1, calculators will contain only one or two components. Radios will contain 4 or 5 items and TV's will be built around only a dozen or so parts. Maybe our approach to learning will be obsolete then, but until that time comes...keep studying.

We received these two delights last week:

Dear Sir,

Concerning the coupons for the free transistors. I enclose 2 coupons. Could you please send the radios to the address on the envelope.

****

Some of the Pre-Pak pages were missing from the magazine I borrowed. Please send a Pre-Pak cattledog to my address.

Dear Sir,

The newly formed Pakuranga College Electronics Club congratulates you and your electronics magazine. The senior section of our club meets regularly to read, discuss and construct circuits from Talking Electronics. Unfortunately we started late and are already one and a half issues behind but are constantly narrowing this gap. By systematically working through your magazine, members of the club gain confidence and knowledge of electronics. We hope you keep up your high standard and publish more circuits using the same four integrated circuits.

M. Bryham, Howick N.Z.

Dear Sir,

I think your approach to teaching digital electronics to the newcomer is a very sound one. Encouraging the reader to construct and experiment, then answer the tests and quizzes has driven home to me the point that "I think I know, but I know I don't!". Congratulations on a great magazine.

R. McCosker, 4352.

Editor,

I very nearly decided not to subscribe as I regard those who encourage the defacement of books and journals by cutting out coupons as no better than vandals. Any magazine with a shaddow of pride in its editorial content would not encourage such practices.

I.B. Staples, 4880.

A number of readers have made the same comment. Nearly half the orders have been sent in on photocopies for this same reason. I didn't realize a simple non-technical article such as Technical Writing would prevent so many people sending in a coupon. You will notice we have re-designed the order forms in this issue to avoid any further grief.

Dear Sir,

I recently encountered some capacitors marked as follows:

1.0M	500v	(electrolytic)
.01Z	2kV	(ceramic)
33k	2kV	(ceramic)
100nS		(poly)

and a wire wound:

8R2 PW10K

I was wondering if you could advise me of their values. I read your article on capacitors in issue 2 but these capacitors still leave me mystified.

G.J. Mc Leod, 2756.

Not having seen the capacitors in question, I cannot gauge an approximate answer by their size. In their absence I would suggest these to be their values:

1mfd 500v	M is tolerance
.01mfd 2kV	Z is tolerance
33pf 2kV	K is 10% tolerance
.1mfd	n is nano S is tolerance
8.2 ohms	10watts 10% tolerance

Then we got a letter from a reader who has worked for many years in proof-reading. He picked us up on our many mistakes, especially where we split a word at the end of a sentence. He also makes a comment about our resistor symbols.

....The item on how to represnt resistors and how to represent crossing wires reminds this reader of two things. Firstly of a letter to another electronics magazine which asked whether the R which shows where the decimal point is represents 'Redundant', and secondly the custom in the one electronics magazine I could find money for in the year I started work of putting a 'humpback bridge' in the line representing one of the non-joining wires.

An overseas English magazine I saw recently used the box for both electrolytics (with polarity signs alongside) <u>and</u> resistors!

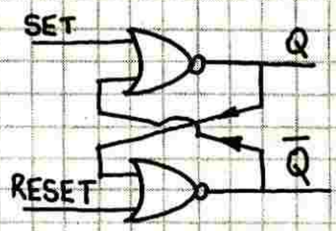
With thanks for the added understanding of the state of the problem you have allowed this 'teenage oldy' (nearly 50) to achieve.

I.D. Crompton, 5033.

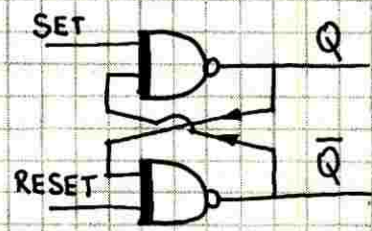
27 FLIP-FLOPS

RS FLIP FLOPS

* THE SIMPLEST FLIP FLOP IS CALLED R-S (RESET - SET)
* IT CAN BE MADE FROM 2 NOR GATES OR 2 NAND GATES
* ONLY ONE INPUT GATE CAN BE SWITCHED AT ANY ONE TIME
* IT WILL HOLD THE STATE EVEN AFTER THE INPUT SIGNAL IS REMOVED
* WITH NOR GATES — THE INPUTS ARE HELD AT 0 AND PULSED HIGH
  " NAND " " " " " HIGH " " LOW
* ONE OUTPUT IS LABELLED Q
* THE OTHER OUTPUT IS LABELLED $\overline{Q}$ (Q-BAR) INDICATING THE COMPLEMENTARY
* THE R-S flip-flop IS A BASIC MEMORY UNIT.



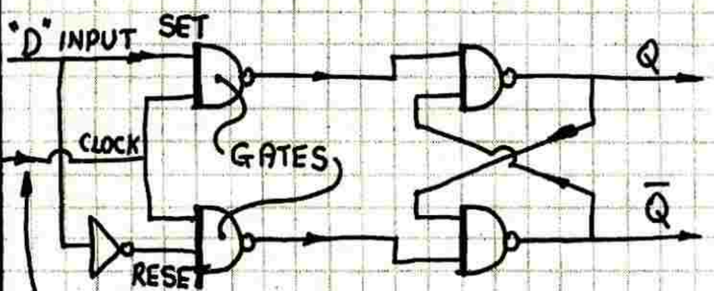
NOR GATE R-S FLIP FLOP



NAND GATE R-S FLIP-FLOP

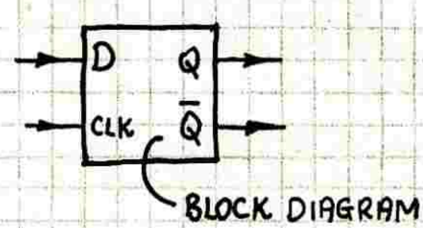
"D" FLIP FLOP

IN A SIMPLE R-S FLIP FLOP, IF BOTH INPUTS ARE LOW AT THE SAME TIME FOR A NAND GATE OR HIGH AT THE SAME TIME FOR A NOR GATE, THE OUTCOME IS UNPREDICTABLE. THIS IS A DISALLOWED STATE. TO AVOID THIS SITUATION A "D" TYPE FLIP FLOP HAS BEEN INVENTED. IT HAS AN INVERTER ADDED TO THE INPUT TO INSURE THE "SET" DATA WILL BE THE COMPLEMENT OF THE "RESET" DATA.



D TYPE FLIP-FLOP

INPUT FROM PULSER.

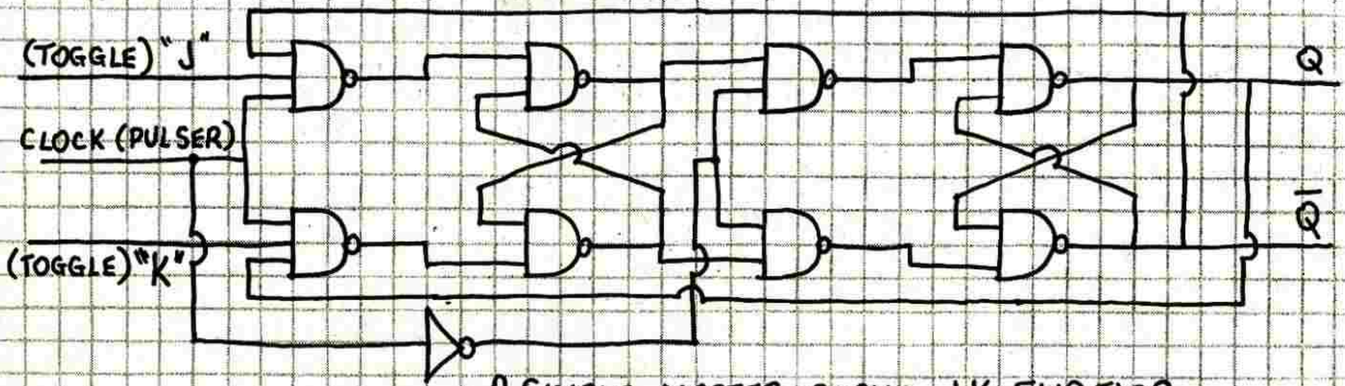


D TYPE FLIPFLOP

THE PULSER IS A COMMON CLOCK IN THE COMPUTER AND ALLOWS THE INFORMATION TO PROCEED TO ALL THE CIRCUITS AT A CONTROLLED RATE. THE D INFORMATION OR "DATA" IS PRESENTED FIRST AND WAITS FOR THE CLOCK TO OPEN THE GATES AND "FLIP" THE FLIP FLOP. WE CAN REPLACE THE ABOVE LEFT-HAND LOGIC DIAGRAM WITH AN EQUIVALENT BLOCK DIAGRAM. IT SAVES DRAWING EACH GATE. THE ARROWS ARE NOT NORMALLY PLACED ON THESE DIAGRAMS. I HAVE INCLUDED THEM TO SHOW THE DIRECTION OF THE SIGNAL. IF THEY ARE OMITTED YOU CAN GENERALLY ASSUME THE SIGNAL TRAVELS FROM LEFT TO RIGHT. AND ANY FEED-BACK SIGNAL TRAVELS FROM RIGHT TO LEFT. NOW YOU HAVE TO IDENTIFY FEED-BACK SIGNALS!

28 "T" AND JK FLIP FLOPS

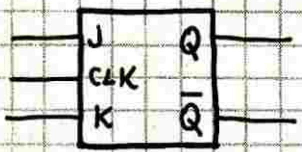
THE MOST UNIVERSAL FLIP FLOP IS THE MASTER-SLAVE JK FLIP FLOP. IT CAN BE USED AS A "T" (TOGGLE) TYPE OR "D" (DATA) (DELAY) TYPE.



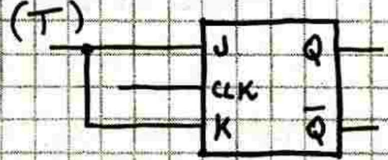
A SIMPLE MASTER-SLAVE JK FLIP FLOP

THE ABOVE DIAGRAM CAN BE SIMPLIFIED TO:

A JK FLIP FLOP CAN BE WIRED AS A "T" OR "D" FLIP FLOP:



JK FLIPFLOP



JK WIRED AS A "T"

JK WIRED AS A "D"

THE "T" REFERS TO TOGGLE AND IN PLACE OF TWO INPUTS IT HAS ONLY ONE. WHEN THE T INPUT IS HELD LOW THE FLIP FLOP IS FROZEN AND WILL NOT CHANGE AFTER THE CLOCK PULSE OR CLOCK PULSES. IF THE T INPUT IS HELD HIGH, THE CLOCK WILL FORCE THE FLIP FLOP TO TOGGLE OR CHANGE STATE — NO MATTER WHAT THE INITIAL CONDITION. IT WILL CHANGE BACK AGAIN ON THE NEXT CLOCK PULSE AND CONTINUE TO TOGGLE WITH T HELD HIGH.

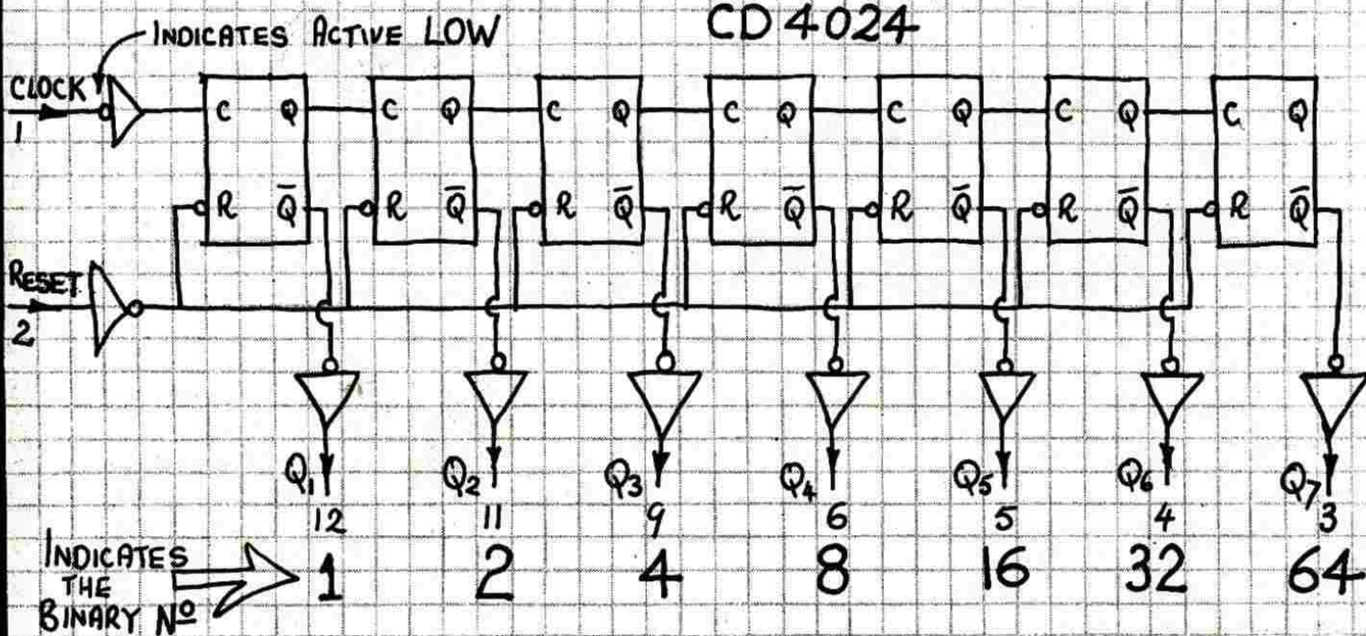
THE "D" REFERS TO DELAY IT CAN ALSO BE CALLED A LATCH. IF THE INPUT IS LOW, WHEN THE CLOCK PULSE ARRIVES, THE OUPUT WILL BECOME LOW AND REMAIN IN THAT STATE. IF THE INPUT IS HIGH THE CLOCK PULSE WILL CAUSE THE OUTPUT TO GO HIGH (OR REMAIN HIGH) THIS IS SIMILAR TO A DELAY CIRCUIT AS THE FLIP FLOP EFFECTIVELY STORES THE HIGH OR LOW LOGIC LEVEL AT D INTO ITS MEMORY UNTIL THE ARRIVAL OF THE NEXT CLOCK PULSE.

BOTH T & D FLIP FLOPS HAVE PREDICTABLE OUTCOMES FROM EVERY OPERATION. THERE ARE NO "INDETERMINATE" SITUATIONS.

FLIP FLOPS ARE CAPABLE OF STORING ONE "BIT" OF INFORMATION AND CAN BE GROUPED TOGETHER TO FORM A COUNTER. THE SIMPLEST FORM OF COUNTER IS A BINARY COUNTER. IT USES THE TWO VERY-RELIABLE STATES OF HIGH & LOW TO CREATE ONE OF THE MOST BASIC ELECTRONIC BUILDING BLOCKS. SINCE A SINGLE FLIP FLOP DOES VERY LITTLE AS REGARDS A COUNTING OPERATION, WE WILL NEED A WHOLE STRING OF SIMILAR-LOOKING FLIP FLOPS TO COUNT TO SAY 64 or 128.

29 BINARY COUNTERS

BINARY COUNTERS ARE THE HEART OF SIMPLE DIGITAL CIRCUITS. THE BASIC DESIGN OF A BINARY COUNTER IS A CHAIN OF DIRECTLY CONNECTED "TOGGLE" FLIP FLOPS. EACH FLIP FLOP IS CAPABLE OF DIVIDING BY 2 SINCE IT TAKES TWO CLOCK PULSES TO BRING THE Q OUTPUT BACK TO ITS ORIGINAL CONDITION. THIS CAUSES A PULSE TO BE SENT TO THE NEXT FLIP FLOP. THE THIRD FLIP-FLOP WILL NOT BE ACTIVATED UNTIL THE 4th CLOCK PULSE. LETS LOOK AT THIS USING AN ACTUAL CMOS I.C. A SIMPLE BINARY COUNTER IS THE CD 4024. IT HAS 7 STAGES CAPABLE OF COUNTING TO 127 BEFORE COMPLETELY RESETTING AND STARTING AGAIN. EACH FLIP FLOP IN THE CHAIN HAS A BUFFERED OUTPUT FOR DRIVING A DISPLAY.



"INDICATES ACTIVE LOW" MEANS THE GATE WILL RESPOND WHEN THE CLOCK CHANGES FROM A HIGH TO A LOW. THIS CAN BE SHOWN IN THE FORM OF A DIAGRAM IN WHICH THE ARROW SHOWS THE DIRECTION OF THE CHANGE.

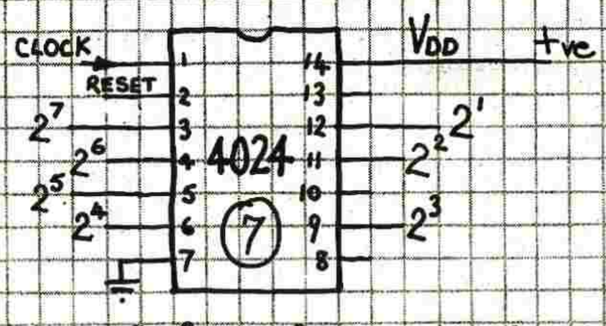
	CLOCK	STATE
a	0	NO CHANGE
b		" "
c	1	" "
d		COUNT +1

EVERY TIME THE CLOCK PERFORMS THE OPERATION d, THE OUTPUT Q_1 WILL EITHER TURN ON OR OFF. WE CAN MAKE A TABLE SHOWING THE FIRST 14 CYCLES OF THE CLOCK.

CLOCK PULSE	Q_1	Q_2	Q_3	Q_4
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1

LOOKING DOWN THE COLUMNS CAN YOU SEE THE ON-OFF PATTERN?

30 BINARY COUNTER/RIPPLE COUNTER/DIVIDER

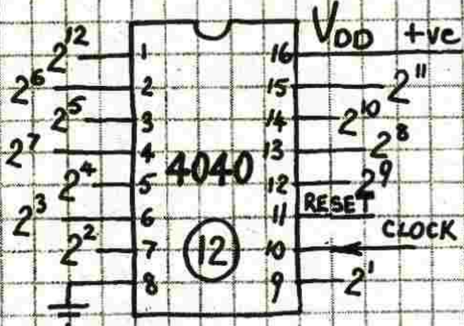


4024 BINARY RIPPLE COUNTER

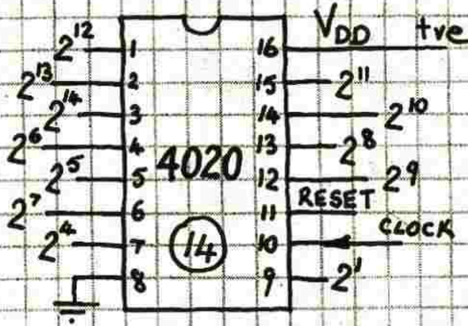
A CD4024 IS A 7-STAGE BINARY RIPPLE COUNTER/DIVIDER. THE TERM "RIPPLE" REFERS TO THE CHANGING OF EACH FLIP FLOP DOWN THE CHAIN AS A NEW CLOCK PULSE ARRIVES. IT HAS 7 BINARY OUTPUTS AND IS CAPABLE OF DIVIDING AN INPUT FREQUENCY BY 128 or 64 or 32 or 16 or 8 or 4 or 2, DEPENDING ON THE OUTPUT USED.

EACH COUNTING STAGE IS A STATIC MASTER-SLAVE FLIP FLOP. THE COUNTER IS ADVANCED ONE COUNT ON THE NEGATIVE-GOING PORTION OF EACH PULSE. ALL INPUTS AND OUTPUTS ARE BUFFERED AND IT IS CAPABLE OF DRIVING A LED DISPLAY.

FOR LARGER DIVISIONS A 12 STAGE & 14 STAGE RIPPLE COUNTER IS AVAILABLE. THE CD4040 IS A 12 STAGE WITH ALL OUTPUTS & A CD4020 IS A 14 STAGE DIVIDER WITH OUTPUTS Q_2 & Q_3 (2^2 & 2^3) MISSING TO ALLOW IT TO FIT INTO A 16 PIN PACKAGE.



4040 BINARY COUNTER

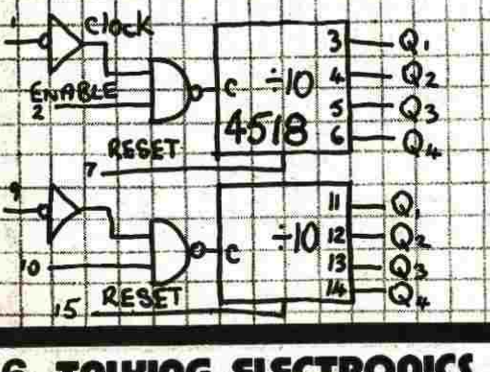


4020 BINARY COUNTER

$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
$2^6 = 64$
$2^7 = 128$
$2^8 = 256$
$2^9 = 512$
$2^{10} = 1024$
$2^{11} = 2048$
$2^{12} = 4096$
$2^{13} = 8192$
$2^{14} = 16,384$

BCD COUNTERS

WITH THE THREE COUNTERS ABOVE WE CAN SET THEM TO COUNT TO 8 or 16 BUT THEY WILL NOT COUNT TO 10 AND THIS IS QUITE OFTEN NEEDED AS MOST OF OUR MONETARY FIGURES ARE IN MULTIPLES OF 10 — SUCH AS $'s & ¢'s FREQUENCY COUNTER READOUTS AND DIGITAL VOLTMETERS.



FOR THIS WE USE A SPECIALLY DESIGNED PACKAGE SUCH AS CD4518 TO COUNT TO 10 WITH BINARY OUTPUTS. TO DO THIS 4 OUTPUTS ARE REQUIRED AND OUT OF THE POSSIBLE 16 COUNTS, WE ARE USING ONLY 10 (THEN THE COUNTER RESETS) THE OTHER 6 ARE WASTED. THIS CODING IS EXPENSIVE ON COMPONENTS BUT VERY CONVENIENT.
SINCE WE NEED ONLY 4 OUTPUTS FOR A COUNT TO 10, WE CAN ACCOMMODATE 2 UNITS IN THE ONE PACKAGE.

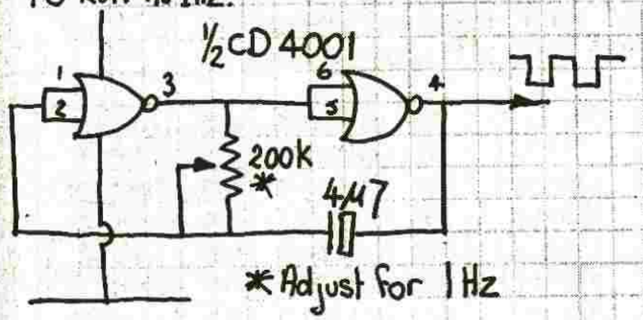
31 A CLOCK

CLOCK BLOCK DIAGRAM

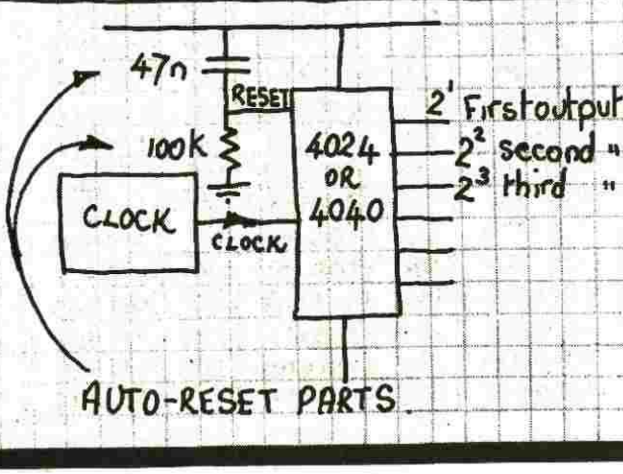
THE OUTPUT IS A SQUARE WAVE, IDEAL FOR DRIVING ALL DIGITAL INTEGRATED CIRCUITS AS THEY LIKE FAST RISE AND FALL TIMES CHARACTERISTIC OF SQUARE WAVE OSCILLATORS

THIS IS THE PORTION OF THE SQUARE WAVE WHICH TRIGGERS A BINARY COUNTER SUCH AS 4024 TO COUNT A PULSE.

A SIMPLE CLOCK TO DRIVE A BINARY COUNTER CAN BE MADE FROM ½ CD 4001. AS WE KNOW FROM BLOCK 22, IT CAN ALSO BE CALLED A MULTIVIBRATOR OR SQUARE-WAVE GENERATOR. THIS CIRCUIT IS ADJUSTED TO RUN At 1Hz.



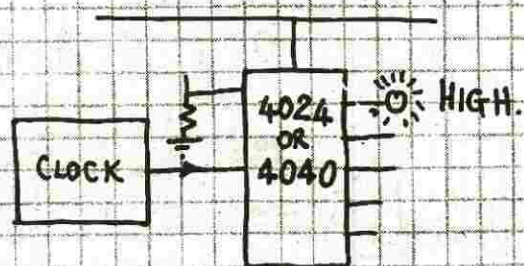
ADDING A CLOCK TO A COUNTER



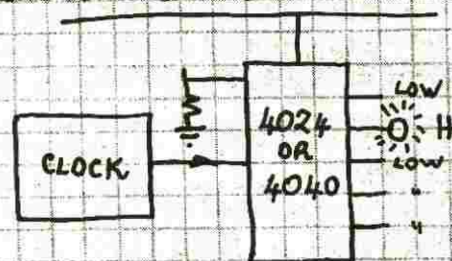
AUTO RESET

TO RESET A COUNTER AUTOMATICALLY WHEN THE SUPPLY IS SWITCHED ON, ADD A ·047mfd AND 100K RESISTOR AS SHOWN. WHEN THE SUPPLY IS TURNED ON, THE CAPACITOR WILL PRODUCE A SPIKE TO THE RESET PIN WHICH WILL GRADUALLY DECAY AND LEAVE THE RESET PIN EFFECTIVELY EARTHED VIA THE 100K RESISTOR.

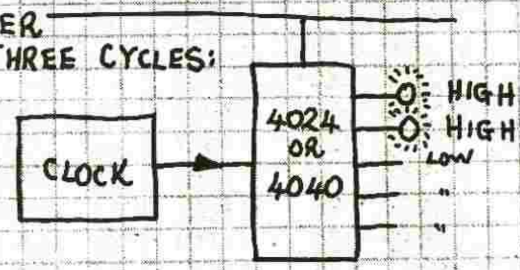
AFTER ONE COMPLETE CYCLE OF THE CLOCK THE FIRST OUTPUT WILL BE HIGH.



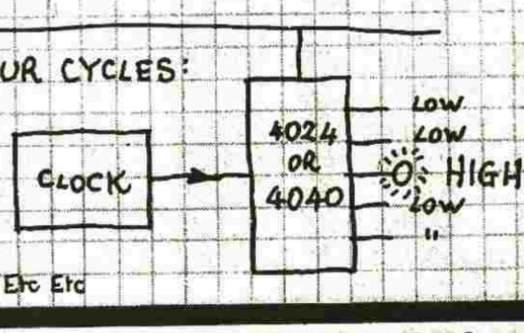
AFTER TWO COMPLETE CYCLES THE SECOND OUTPUT WILL BE HIGH AND ALL OTHERS WILL BE LOW.



AFTER THREE CYCLES:

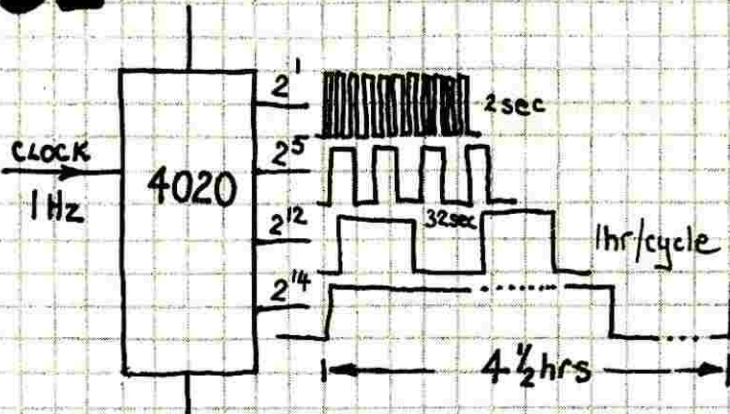


FOUR CYCLES:



Etc Etc Etc

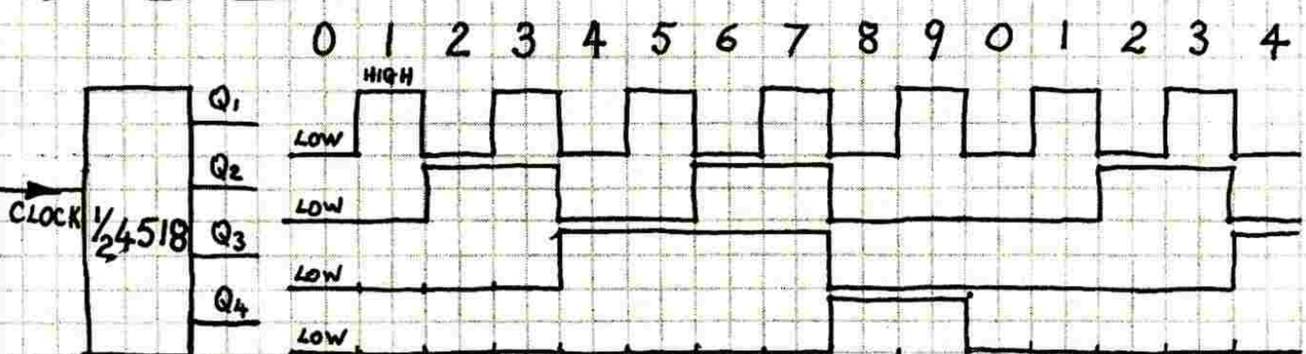
32 BINARY-COUNTER OUTPUTS:



WITH THE CLOCK OSCILLATING AT 1 Hz WE CAN MAKE VERY LONG DURATION TIMERS. USING A 4024 THE TIMER WOULD CYCLE EVERY 128 SECONDS OR 16,384 SECONDS WITH A 4020 IC, WHICH IS JUST OVER 4½ HOURS! THIS LONG TIME DELAY CAN BE UTILIZED PROVIDED THE OUTPUTS ARE DECODED.

THE 4020 OUTPUTS SHOWN HERE ARE NOT TO SCALE. THEY ARE ONLY TO SHOW THE VERSATILITY OF A BINARY COUNTER WITH ITS RANGE OF OUTPUTS, CAPABLE OF FEEDING DIFFERENT CIRCUITS WITH SHORT, SHORTER, OR VERY SHORT TIME INTERVALS.

BCD COUNTER OUTPUTS:



INSIDE THE 4518 ARE 2 BINARY COUNTERS CAPABLE OF COUNTING 10 PULSES THEN RESETTING. EACH BINARY COUNTER CONSISTS OF FOUR EDGE-TRIGGERED "D" FLIP FLOPS WITH APPROPRIATE GATING TO RESET AFTER THE 10TH CLOCK PULSE.

0 → 127 IN BINARY				40	0101000	62	0111110	84	1010100	106	1101010
Decimal	Binary			41	101001	63	111111	85	1010101	107	1101011
0	0000000	20	0010100	42	101010	64	1000000	86	1010110	108	1101100
1	0000001	21	10101	43	101011	65	1000001	87	1010111	109	1101101
2	10	22	10110	44	101100	66	1000010	88	1011000	110	110110
3	11	23	10111	45	101101	67	1000011	89	1011001	111	110111
4	100	24	11000	46	101110	68	1000100	90	1011010	112	1110000
5	101	25	11001	47	101111	69	1000101	91	1011011	113	1110001
6	110	26	11010	48	110000	70	1000110	92	1011100	114	1110010
7	111	27	11011	49	110001	71	1000111	93	1011101	115	1110011
8	1000	28	11100	50	110010	72	1001000	94	1011110	116	1110100
9	1001	29	11101	51	110011	73	1001001	95	1011111	117	1110101
10	1010	30	11110	52	110100	74	1001010	96	1100000	118	1110110
11	1011	31	11111	53	110101	75	1001011	97	1100001	119	1110111
12	1100	32	100000	54	110110	76	1001100	98	1100010	120	1111000
13	1101	33	100001	55	110111	77	1001101	99	1100011	121	1111001
14	1110	34	100010	56	111000	78	1001110	100	1100100	122	1111010
15	1111	35	100011	57	111001	79	1001111	101	1100101	123	1111011
16	10000	36	100100	58	111010	80	1010000	102	1100110	124	1111100
17	10001	37	100101	59	111011	81	1010001	103	1100111	125	1111101
18	10010	38	100110	60	111100	82	1010010	104	1101000	126	1111110
19	10011	39	100111	61	111101	83	1010011	105	1101001	127	1111111

THE PHYSICS OF ELECTRONICS

"Which travels faster? HOT or COLD?" We have all been asked this riddle at one time or another, and nearly always been tricked by the answer: HEAT, because you can catch COLD! With reasoning like this being accepted by the majority of people, it's no wonder nearly everyone leaves the adding of milk to a hot cup of coffee till the last moment -- and wonder why its gone cold.

Physics and electronics are closely allied. They share a multitude of similarities and we have devoted a little space here to touch on one important physical phenomina which will affect all electronic constructors at least one in their life if they build high-power projects. The physical comprehension you will need to understand is HEAT. Or more specifically THERMAL CONDUCTION.

Firstly we must get an overall evaluation of your conception of heat transfer. As heat is one of the most important and expensive forms of energy, we expend a considerable degree of engineering to retain it, dissipate it and create it. In electronics we are mainly concerned with dissipating heat but to ascertain your knowledge on heat transfer, I would like to pose these questions:

1. Does HEAT really travel faster than COLD? If you said YES, you would be wrong. If you said NO, you may be correct because, in fact, it travels at the same rate. Heat is the same as cold. It is merely the reference level which determines whether we call a temperature hot or cold. Usually we use our hand or fingers to obtain a comparison. That which is cold to the touch is called cold or hotter than blood temperature called hot. If you immerse your hand into a tub of cold water filled with ice-blocks for five minutes, then run the cold water tap over your hand, you may well find the tap water warm -- it's all relative.

Here is a question to test your reasoning. You must have seen bottles of soft drink covered with a thin layer of foam which not only acts as a label but insulates the contents. The question is: Take an insulated bottle together with a non-insulated bottle from the fridge and leave them on the table for half an hour. What will be the temperature difference between the two drinks after the time has elapsed? If you said the temperature difference was noticeable you would be quite wrong. It is negligible. Glass is such a poor conductor of heat that it provides the greatest insulating effect on the drink. The foam is too thin to have any appreciable effect. It is purely aesthetic and provides a cheap base for a label. It also protects the bottle from breakage in case it drops onto a hard floor.

Take the same time-delay, but this time our test samples are a can of drink and a normal bottle of soft drink. (Equal volume of contents.) This time the temperature difference is considerable. The aluminium can, being a good conductor of heat, not only dissipates heat into the air very rapidly, but will condense more moisture on its surface in a given time and create a larger temperature gradient through the thin metal wall, thus allowing more heat to be released. The can will be considerably warmer after the half hour.

Here is another question to test your understanding:

We have all been bombarded by massive advertising expounding the virtues of one type of insulation over another and quoting a magic rating figure as if they had added something special to the product. But how important is the material which is used? Apart from the fact that it must be cheap, what part does it play? The problem is this:

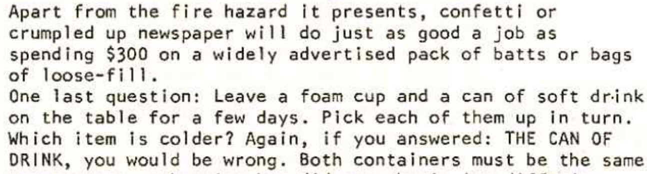
A ceiling is covered with say 10cm of these products:

1. CONFETTI - finely chopped-up pieces of paper
2. SCREWED-UP SHEETS OF NEWSPAPER
3. SAWDUST - dry sawdust laid loosely
4. MINERAL WOOL - mineral rock spun into threads
5. SEAWEED - dry seaweed chopped finely
6. CHOPPED-UP TELEPHONE BOOKS
7. FIBRE-GLASS BATTS
8. SHEETS OF FOAM STYRENE
9. " " " " COVERED WITH ALUMINIUM.
10. COTTON WOOL
11. STEEL WOOL

Which product is far superior to the others as far as insulating is concerned? (Don't consider fire hazard, health or vermin resistance). Leaving out steel wool, the other materials are almost all identical in insulating qualities. The effectiveness of the insulation comes from the air trapped in cells within the material and NOT the material itself. The complete closure of the air cells makes heat transfer more difficult and improves its rating.

Apart from the fire hazard it presents, confetti or crumpled up newspaper will do just as good a job as spending $300 on a widely advertised pack of batts or bags of loose-fill.

One last question: Leave a foam cup and a can of soft drink on the table for a few days. Pick each of them up in turn. Which item is colder? Again, if you answered: THE CAN OF DRINK, you would be wrong. Both containers must be the same temperature, otherwise how did one obtain its differing temperature? We gauge the temperature of an item, not only by our initial feeling but also by how fast the item will remove heat from out hand. Take the case of the foam cup. It initially feels cold but within a fraction of a second, has taken a minute amount of heat from our hand to raise its temperature to that of our hand. It contains so little absorption material that the temperature rises very fast. An equilibrium is created whereby the exchange of heat from hand to cup ceases. The cup now feels warm and we wrongly conclude that it is warm. The can of drink however, will absorb heat from our hand for an hour or so and we interpret this as room temperature. (The only correct deduction to date.) If you answered that question correctly, let me trap you with this one. Take a room completely enclosed with 30cm of insulation on all walls, ceiling and floor. There are no windows and no doors. In the middle of the room place a refridgerator - a normal fridge plugged into a power point. Turn on the fridge and open the fridge door. The question is this: Will the fridge eventually cool the whole room?



What is all this leading us to?

If you answered some of these questions incorrectly, you will need to become more aware of heat transfer and the effect of dissipating surfaces. What is a dissipating surface? A surface by design or luck that conducts and/or radiates heat away from an area of high temperature and passes it to another medium such as air or water.

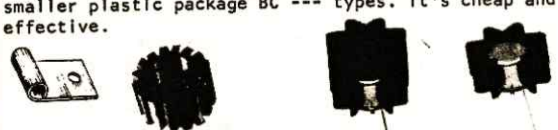
In electronics we call these surfaces HEAT FINS or HEAT SINKS. The importance of these simple objects cannot be over-stressed. No electronic component likes temperature rise especially semiconductors such as transistors and IC's. Ideally they should all be operated at touchable temperatures to keep their projected life infinite. In low power circuits they are ok. No heatsinking is required and the failure rate is nil. If we wish to get into power circuits, we need to have a great deal of understanding on heat flow, temperature gradients, heat dissipation, temperature limits and even a knowledge of horizontal and vertical heat dissipation, fan forced dissipation, refridgerated water cooling, thermal insulation, surface radiation and and and. Yes, it can get extremely complex so lets get back to 2 simple heat dissipators which are more in our line of requirement.

1. A FIN HEAT SINK
2. CHASSIS MOUNTING HEAT-SINK

1. Using a FIN HEAT SINK.

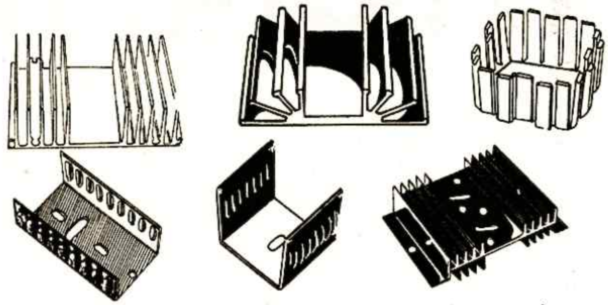
Take this simple case. You have a small power transistor in a plastic package and it is getting a little too hot. You can just hold it for about 3 seconds in your fingers. Will a heat fin clipped over it make much difference?
YES!! It will make a vast difference. The heat which can be dissipated by a simple heat fin is up to 5 times more than that of the transistor case itself and will lower the temperature of the transistor dramatically. Not only will it lengthen the life of the transistor but will improve the performance of the equipment by reducing distortion and thermal noise.
Here's another simple question:
A pair of 2N 3055 transistors will handle 100 watts of music power (whatever that means). That's a vague statement so I'll tighten it up by saying the pair of 2N 3055's are releasing a total of 60 watts into their heatsink. They are mounted via dry mica washers and their body temperature is too hot to touch. They only last a few months in service. What would you do to improve their life?
If possible the area of the heatsink could be increased, but this would involve a considerable amount of work. An equally effective method of reducing the temperature is to apply a liberal layer of thermal conducting compound to both sides of the mica washer and refit a new pair of transistors. The mica washer is acting like the sheets of newspaper in the ceiling we mentioned before. An extremely thin layer of air is present between the mica washer and the transistor and an equally thin layer between the washer and heatsink. The heat particles find it extremely difficult to traverse these two air gaps and so the transistor cannot release the heat as fast as it is generated. The addition of a thin layer of thermal compound will make a considerable difference; those few degrees of temperature reduction will extend the life of the transistor multi-fold.
Ok I wont keep you frustrated any longer about the fridge question. The room will gradually heat up since there is energy coming into the room in the form of electricity and this must raise the room temperature. You could go into a lot of complexity concerning the efficiency of the compressor and heat exchanger but to keep it simple, the first law of thermodynamics says the room will heat up.
I would like to conclude with a transistor thermal problem but I don't think you will have any trouble answering it after reading these notes.
The question is:
We have 2 different 20watt amplifiers. One circuit uses class A output stage (ie one transistor in the output) and the other uses class B output (2 transistors in push-pull). Which output stage will get hotter?

Now lets look at a range of heatsinks for transistors available from Dick Smith Stores:
The smallest heatsink is a FLAG. It was originally designed for TO-1 metal can transistors but can be bent to suit the smaller plastic package BC --- types. It's cheap and very effective.



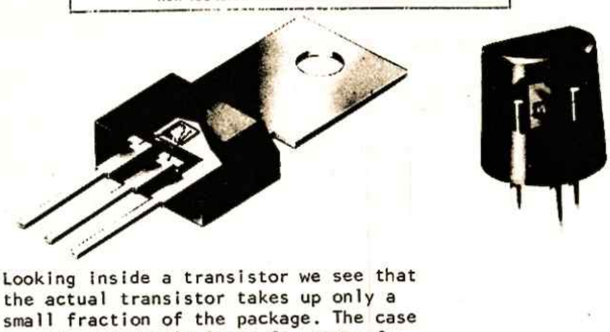
For the next size power transistor, TO-5, TO-39 package, a round heat sink has been designed. In general this heat sink is not very effective as it has insufficient surface area to dissipate the heat generated. Two types of TO-5 heat sinks are shown. One fits snugly over the transistor and needs heat conducting compound to conduct heat to the heat sink. The other type is corrugated and only touches the transistor in spots around the circumference. A high-rise model is available to increase efficiency and is available from large elecronics suppliers. Remember that the heat sink is connected to the collector and will be "live" so don't take it to deck.

On the other hand the TO-3 and TO-66 packages have been adequately catered for. Their cases are well designed and allow for maximum heat transfer to the heat sink. Direct connection via thermal grease is the most efficient but will be a problem with push-pull circuits.



The heatsinks illustrated will dissipate from 10 to 40 watts and have been drilled for one or two transistors or left blank. Three designs are stampings and three are extruded aluminium. The most important feature to look for is the number of heat fins. Numerous fine heat fins will be much more effective than a smaller number of thick fins. In addition, the transistor mounting platform must be absolutely flat with no burrs in the mounting holes. Thermal conducting grease must be used and the screws tightened to exude excess grease.

"NOW YOU KNOW WHY I LOCK MY WORKSHOP!"



Looking inside a transistor we see that the actual transistor takes up only a small fraction of the package. The case is made relatively large fo ease of handling, heat dissipation, lead termination and create a new package style just to make things a little more complex.

This has been only the very simplest introduction to heatsinking. In a future article I hope to get more technical. Let us know if this is warranted.

TV Servicing Part III

by our staff serviceman

If a serviceman were to be granted one wish, it would be quite a simple request. For every serviceman has an eternal wish. It would not be for a shorter working week or more money. Or even to buy a luxurious yacht. In fact it wouldn't be a selfish wish at all. It would be entirely in the interests of his customers...to save them considerable expense and enable their sets to be repaired on-the-spot with a minimum of fuss. The wish would be FOR ONE BRAND OF SET AND ONE CIRCUIT. If he were asked to choose a set and circuit, it would undoubtably be PHILIPS. Now, surely this kind of request isn't beyond a fairy godmother? Without a doubt the Philips set has by far the greatest number of points going for it. Ease of servicing, availability of parts and circuit diagram, quality of picture even after 4 or 5 years and a good range of models. Let me point out that I do not work for Philips nor am I seeking any position with them. It's just that I intend to relate the facts as I see them. If all sets were one brand and one circuit, think of the saving it would provide for the electronics industry and consumer alike. If there were any advantage in providing a range of 40 different brands, I would not advocate this monopoly position. I see no advantage in providing the small Australian market with 40 brands of colour sets (this has now been reduced to about 15 brands) each having up to 12 or more completely different circuits and up to hundreds of different modules, none of which are interchangeable. As these sets become older, the parts are becoming increasingly more difficult to obtain and in many instances, the change-over service on modules is being withdrawn. The television repair industry is in a state of extreme complexity. All the dreams of efficient servicing, specialized repairing and in-home servicing have been eroded away by the sheer weight of circuit variations and up-dated models appearing in the shops at more than one a month.
To try and break into this morass, we will present three helpful pointers on circuit understanding.
These are:

1. Tripler faults
2. The bus-line circuit diagram
3. The SMPS (Switch-Mode-Power-Supply)

Extending from my last article, I had occasion this month to repair a whole spate of tripler faults. This was due to dust build-up and very damp weather conditions. Let me firstly explain that there are DOUBLER AND TRIPLERS in colour TV's (just to make things more complex). For the purpose of this article, I will be discussing triplers as they are the most common of the two. There is no guaranteed method of identifying a doubler from a tripler as some are a completely sealed unit however most 22" (56cm) and 26" (63cm) sets use a tripler to convert the 8.5kV from the EHT transformer to about 22kV to 26kV DC. Doublers have only 2 or 3 leads. Input and Output (& Earth) Triplers have 4 or 5 leads. They cannot be interchanged with one-another and a tripler cannot be converted to a doubler. Fortunately we have a Universal tripler which can be adapted to take the place of nearly all the other types. Not only is it cheaper but has a higher voltage rating. This Universal tripler will be discussed later in this article.

Triplers themselves cannot be tested out of circuit with simple test equipment due to their extremely high impedance and high working voltage. We use the set itself to test them. This can be an expensive test as a shorted tripler will instantly blow the horizontal output transistor in sets such as Nordemende. Other sets have shut-down facilities and you will hear a tink tink tink from the power supply as it hiccups under the excessive load. If the horizontal output transistor has been damaged, we can prevent this re-occuring while testing the tripler, by placing a 1k resistor in line with the tripler. We do this by adding a 1k 1watt between the input terminal of the tripler and the EHT lead. Due to the high voltage and high frequency, you will not be able to hold the lead or the resistor while the set is operating but you will be able to test the tripler within ½sec by following a simple method.

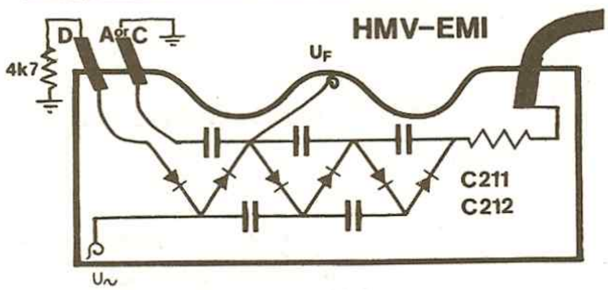
The most valuable instrument for measuring EHT voltages is a Turner T162 screwdriver. It has a red sleeve covering the shaft and is the only type of screwdriver I recommend for TV servicing. With it you will be able to measure EHT voltages from a few thousand volts to over 26kV. An experienced technician is able to gauge the presence of 8.5Kv by touching the top of the EHT transformer. The resulting spray from the EHT bobbin to the screwdriver tells him the stage is operating. Placing the screwdriver near the EHT lead will see a spray about 1cm long and moving closer to the tripler input will obtain a healthy tracer. It must be remembered that the voltage is dissipated into the air, the screwdriver merely acts as a medium to enhance this. The screwdriver must be held away from the shaft to prevent possible puncturing of the screwdriver insulation (which is only 10kv DC, and would only be 6kv AC).
I have been approached by a number of people on the subject of safety with regard to testing the EHT section. May I repeat, these notes are not for beginners. You will need to have some technical knowledge behind you before tackling any type of TV repair, especially the dangerous circuits we are discussing in this article. I consider replacing a fuse more dangerous than working on the EHT section for the simple reason that you are applying considerable pressure when inserting a fuse and you are always tempted to support your hand on the chassis or provide additional purchase with the aid of your other hand. Keep in mind, some power supplies have electrolytics which are fully charged up even after the fuse has "blown" and this can give you a nasty bite as you bridge the circuit with your fingers on the fuse. With the EHT section, the high frequency can give you pre-warning as the high voltage generally begins to hiss before you actually touch the circuit.
Notwithstanding this, I still take particular care and use a screwdriver as my probe and only put one hand inside the set when it is operating. This denies the current a complete path through my body and has been my saviour on a number of occasions.

Almost every 56cm and 63cm colour TV suffers from EHT faults. After all, they are all handling voltages in excess of 22kV. Some have corona protection such as sealing the exposed leads and sealing the corona cap onto the picture tube, while others have nothing at all. Nonetheless, they all break down eventually. Many customers complain of a hissing sound when the set is first switched on, which gradually diminishes after the set has warmed up. To re-create this fault condition when you arrive on the scene, all you need do is huff on the tripler, focus resistor and EHT cap on the tube. The moisture in you breath will accelerate the corona discharge and locate any badly leaking spots. The most dangerous place for leakage is from under the corona cap as the lightening sparks from here will flash 6cm across the back of the tube and pierce the de-gaussing coils and blow the power supply as explained in the last article. This is extremely critical in Blaupunkt, Siemens and Nordemende sets. A liberal squeeze of sealant around and under the rim of the EHT cap will eliminate the flashes completely, provided the surface around the EHT hole has been cleaned before-hand. The leads going to the tripler itself can also be sealed to prevent leakage to earth.

Last week I serviced four sets laid low by the insistence of the owner smoking in a non-ventelated room. The cigarette tar had been drawn to the tripler by electrostatic attraction, convectional air currents generated by the heat from the various components and the electric wind generated by the high voltage discharge around the EHT section and was deposited all over the tripler. Cigarette tar is highly conductive and drops out just where it is most destructive. The focus voltage uses this coating to generate a path towards deck and as the track increases, it converts the originally non-conducting plastic into a carbon track. The final result was a track winding its way some 15cm around the edge of the tripler to chassis! This is not particularly descructive in itself but can cause the death of the horizontal output transistor and the tripler if it is allowed to worsen. Generally the picture quality suffers before this occurs and the customer gleefully reports "lots of sparks and crackling from down there!"

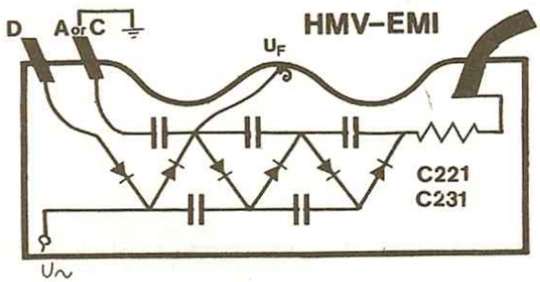
A shorted tripler will drag the power supply down to the stage where it will hiccup, whistle or trip the thermal resistor. If you suspect the tripler, the input lead from the EHT transformer should be removed and the set switched on for ½sec and then switched off. During this time listen for the power supply to come on normally and place the screwdriver on the EHT bobbin. If the EHT comes up, it will be the tripler dragging the supply down. If the rail voltage fails to rise, the horizontal out transistor could be damaged. Remove the base and emitter leads but firstly make a note of the relevent colours of each lead on the chassis. Test the transistor with a multimeter set to high ohms range. It will produce an obvious dead-short between either or both leads and collector if the transistor is punctured. Always replace HOP transistors with the original type or an up-graded version. 2SD350A will generally replace BU108, BU208, 2SC1170, 2SC1172 2SC1325 and 2SC1415. If you wish to re-test the tripler to confirm that it took the horizontal output transistor,you will need to add a 1k resistor to the input lead and switch the set on for ½sec. Place a screwdriver very close to the input of the tripler and note the very low voltage present. The resistor acts as a buffer between transformer and tripler. In nordemende set I have found the tripler quite often takes the transformer also, making it a very expensive repair. To prevent the three items failing again, I add a 1ohm ¼watt resistor permanently in the line. Should the tripler fail again at a later date, it will just take the safety resistor with it. The resistor should be housed in a piece of plastic sleeving to reduce corona attack.

TRIPLER SUBSTITUTIONS



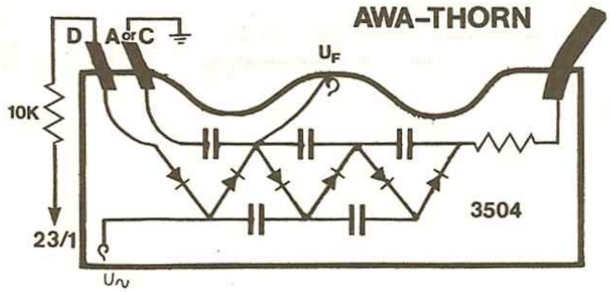
CTV's Model C211 and C212:

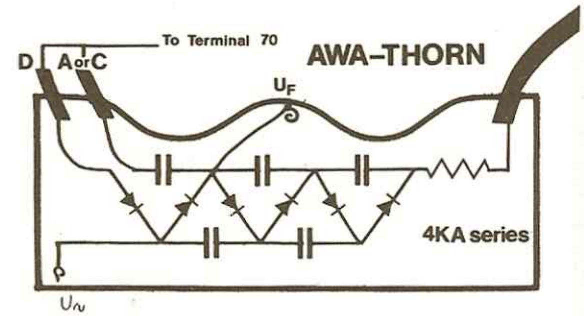
1. Remove link between pins 201 and 301.
2. Connect pin 201 to pin 207 or 307.
3. Insert 100k 1watt resistor between pin 301 and pin 222.
4. Remove diode D 208
5. Connect D on tripler to earth via 4k7 ½w salvaged from TVK 52.
6. Connect C to earth.
7. Connect F to focus pot
8. Connect U∼to PCB2 skt.

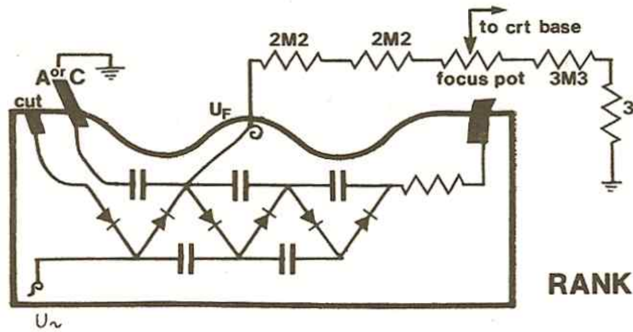


CTV's Model C221 and 231

1. Delete D 207, C228 and R 202
2. Connect C to earth
3. Connect D to pin 221 on PCB2.
4. Connect U_F to focus pot
5. Connect U∼ to socket on PCB2.
6. Change C224 to 100pf 2kV
7. For Model 221, Change R 931 and R 929 from 100k to 220k
8. For Model 231, Change R 903 and R 905 from 100k to 220k.





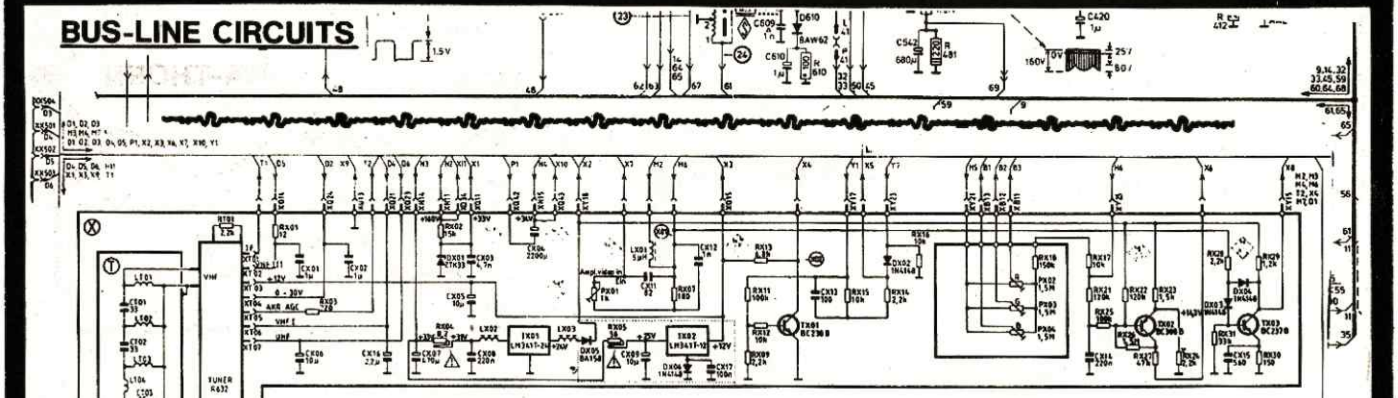


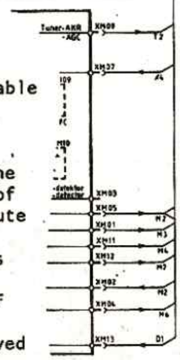
UNIVERSAL TRIPLER

A number of replacement triplers are available to cover the whole range of original units. All triplers are basically coded with similar identification. The most obvious lead is the thick double insulated lead fitted with a corona cap. Also emerging from the tripler are two thinner leads. One is marked D and connects to the first rectifying diode. The remaining lead may have the letter A,C or an Earth symbol. They all mean the same and it connects to a high voltage capacitor inside the tripler. Do not follow any lead colouring or positioning of the leads as they vary from one manufacturer to another. The remaining terminals are wires projecting from the potting compound. One terminal is marked U∼ and the other U_F. The five main tripler substitution circuits are also shown to make replacing a tripler a simple operation. The Rank circuit requires 4 high-voltage resistors to be connected to the focus terminal. Use special high stability resistors for the 2M2 values as normal 1watt types will only last one or two years due to the high frequency present. (you wouldn't want a call-back, would you!)

If you are not sure about a particular lead, connect it via a 10k resistor. If it is incorrect, the resistor will get hot instantly, and you will save the tripler. The resistor can be omitted only after briefly bridging it with a jumper lead. Of course, you can't leave the 4k7 or 10k resistors out of the HMV or AWA circuits.

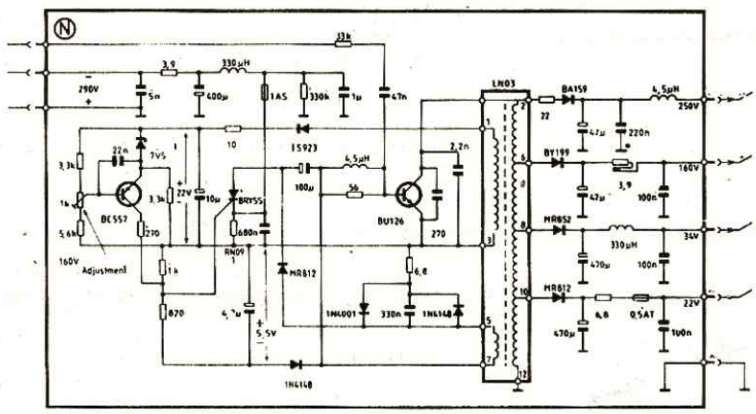
BUS-LINE CIRCUITS





In an attempt to simplify colour TV circuit diagrams, some manufacturers have introduced bus-line wiring diagrams. It is generally shown as a single thick line. This saves numerous parallel lines which would otherwise take up considerable space on the sheet and create undue strain on the eyes as you try to follow one particular line which may travel from one side of the circuit to the other. At first glance the circuit looks very simple and you approach the layout with enthusiasm. It's not until you see a numbered lead disappearing into the bus-line that the reality finally dawns. You are now required to search the full length of the loom to locate it re-emergence. At times it has taken me 5 minutes of absolute frustration, pouring over the circuit diagram in the home, looking for the continuation. This brings a sympathetic feeling from some customers while others peering over the back of the set walk off into the kitchen and you hear muffled sounds like "he doesn't know what to do!" The two diagrams above are examples of bus-line circuitry and show the difficulties involved in the big search. These diagrams represent only one quarter of the full circuit and can get quite involved when you have to remember four or five terminations relating to the one section.

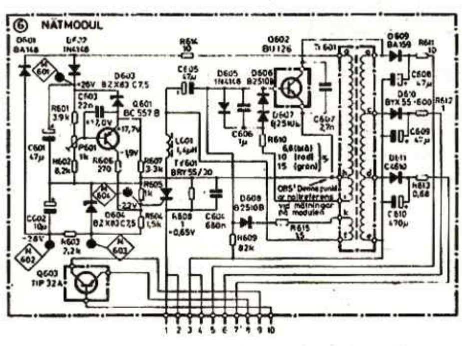
THE SWITCH MODE POWER SUPPLY



These three SMPS are almost identical. They provide extremely good regulation under varying brightness levels and mains fluctuations. Rail voltages are more critical in colour TV's than B&W sets to keep the picture geometry stable for convergence. The power supply will shut down when a short-circuit occurs or excessive current is drawn from the power supply. The only problem: it doesn't have over-voltage protection as described in the text.

The Switch Mode Power Supply is used in Luxor colour sets and the Australian designed HMV colour set. Co-incidentally, both these power supplies are identical, so by describing one, we will cover both sets as well as a number of similar designs in other sets. Since the biggest number of breakdowns occur in Luxor supplies we will concentrate on this model.

Switch Mode Power Supplies have one distinct advantage. Since the output is virtually independent of mains voltage, it will give a fully regulated output when the mains are as low as 180v or as high as 300v. The other advantage lies in the frequency of operation. At 30 to 40kHz the transformer can be made considerably smaller, in the order of less than 1kgm for a 100 watt power supply. This produces a saving in copper and reduces the overall weight of the set slightly. Since this type of power supply uses a transformer, the output can be completely isolated from the mains, making the TV safer than "hot-chassis" models.



HOW THE CIRCUIT WORKS

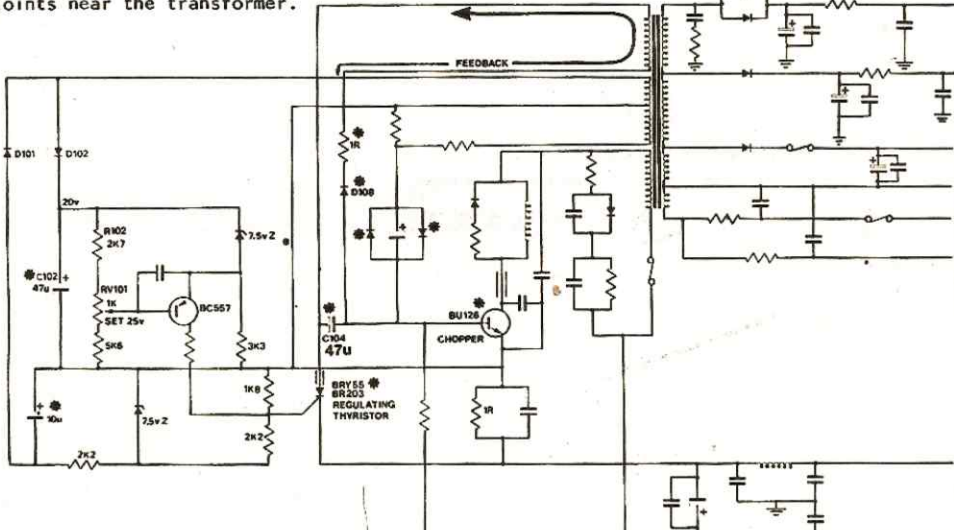
The BU 126 chopper transistor is wired as a free-running oscillator with the feed-back winding connecting directly to the base. Without any of the pre-stage components, it would drive the transformer and supply a voltage to the set of rectifying diodes and smoothing electrolytics. If a load was connected to the output, the frequency of the oscillator would drop appreciably. To maintain the required frequency, and thus keep the output voltage constant, a sampling voltage is taken from the transformer and rectified by diode D102 to produce a voltage of about 20v across the 47mfd electrolytic. This is fed to the sensing stage consisting of the BC557, potential dividers 2k7,1k pot, and 5k7. The voltage reference is obtained from the 7v5 zener diode and 3k3 resistor. When the voltage across the 47mfd reaches 20v, the transistor begins conduction. At the same time, the sampling line charges the 10mfd electrolytic via diode D101, and supplies 7v5 to the voltage divider network 2k2 and 1k8. The collector of the BC 557 is connected to the mid-point and will supply a positive to this point whereas the voltage divider network supplies a negative voltage. This will give us a voltage range for turning the thyristor on.

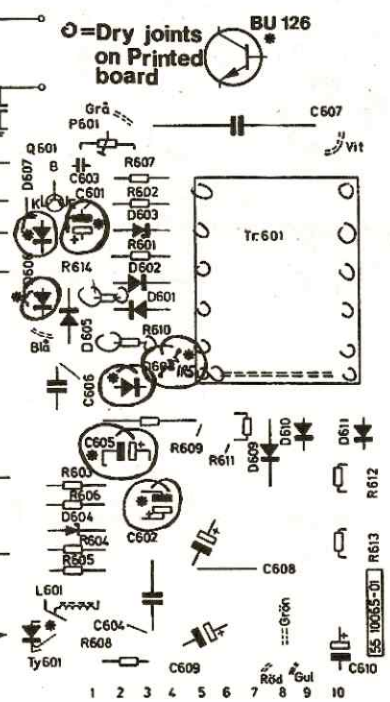
When the BU 126 is conducting, a current flows through the transformer and the 1 ohm resistor in the emitter circuit. A negative voltage thus appears on the cathode of the thyristor. Once this has reached the correct value, it begins to conduct and turns off the BU 126 via the 47mfd in the base circuit. The 47mfd begins to charge and the BU 126 switches on. Accurate voltage regulation is maintained by the BC 557 sensing the voltage across the 47mfd C102. If the voltage tends to fall, the transistor turns off. This makes the thyristor turn on later and effectively allows the BU 126 to drive for a longer period of time.

If the voltage rises, the BC 557 turns on harder and makes the thyristor switch on earlier to reduce the duty cycle of the BU 126.

TYPICAL SWITCH MODE POWER SUPPLY:

An overhaul on these power supplies involves replacing the parts indicated with a ●. Their location on the printed circuit board is also shown via the layout diagram. The most critical line is the FEEDBACK line. Make sure it has no dry joints near the transformer.





So much for how the circuit works. The amazing fact with repairing electronic equipment confirms that you do not have to know how a circuit works to be able to repair it. But it helps.

Switch Mode Power Supplies are very reliable once the bugs have been eliminated. Undoubtedly the most troublesome power supply is the Luxor Unit. But why? Its compactness and operating temperature produce a host of faults. These can be listed as:

1. Heat from the components dry out the electrolytics.
2. Wire wound resistors are located too close to the board. and produce hairline cracks in the copper tracks.
3. The power transformer vibrates at high frequency and causes faulty lead connections.
4. Dry joints to other components form due to insufficient solder when the module was assembled.

When a Luxor or HMV power supply fails, it is wise to completely overhaul it rather than try to locate the faulty part or parts.

Here is a list of the parts needed for a Luxor overhaul. They are also shown circled in the layout diagram.

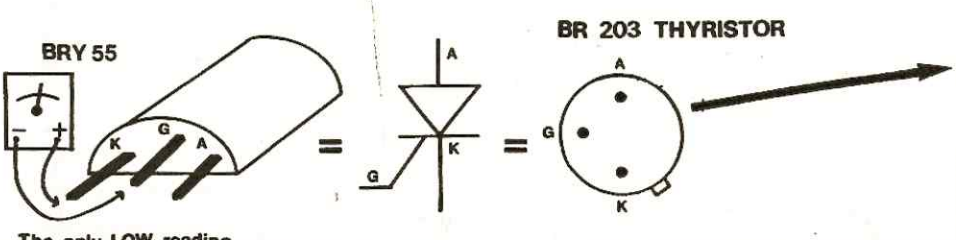
3 - BYX55/600 or MR812 or BY199 600v High Speed diodes
1 - 10mfd 63v
2 - 47mfd 63v
1 - 1.5ohm ½watt

Fit the 7 components and test the other three electrolytics and their feed diodes.

Next test the thyristor and the chopper transistor. These must be removed from circuit and can be tested with a multimeter set to high ohms.

The power supply cannot be tested until the original dry joint is located. The most dangerous fault originates in the feedback line. When this goes open, the 185v output line increases to over 250v. This supplies the horizontal output stage and will produce over 35,000 volts from the tripler. Within a few milliseconds something has to give. It will be either the tripler, the horizontal output transistor, the power supply or all three...at a huge expense!

The most common dry joints are shown on the layout diagram. You may even consider resoldering the whole board, it may be cheaper than replacing expensive semiconductors.



The board is full of dry joints, over-heated solder lands, hairline cracks, dried-out electros and intermittent high-speed diodes.

TEST YOURSELF...

Using a multimeter

Simple multimeters haven't changed in 25 years. See this American Advertisement of 1960:

The 200H is still popular today. It makes use of an ingenious positioning of the movement to enable a full scale to be fitted into a compact case. Even the ranges on the 1960 model are identical to todays.

ARLEC
200H

A very handy pocket sized instrument for the tradesman. This compact but sensitive multimeter features the popular quadrant-scale styling.

Specification (14 measuring ranges)

Sensitivity	20,000 ohms/volt D.C.
D.C. Volts	0-5, 25, 125, 500, 2500
A.C. Volts	0-10, 50, 250, 1000
D.C. Current	0-50 uA, 250 mA
Resistance	0-50K, 0-5 M ohms
Decibel	-20 to +22
Dimensions	116 x 85 x 34mm
Weight	0.29 Kg
Accessories	Test Prods, 1.5v battery, Instructions

Excluding the recent introduction of digital multimeters, FET meters and multi-function meters, a multimeter is fairly simple to operate and read. You can compare them to digital watches vs Swiss movements. The pointer or hands require a certain amount of interpretation and this needs skill and judjement. And it only comes with time. Every hobbyist should know how to use a multimeter. It is the most amazingly useful item on your workbench. Try this test and see how much you know about its use.

(No Pun Intended)

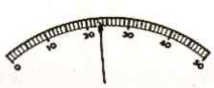
1 Without looking at your multimeter, list its ranges.

2 Which scale of the multimeter reads "Backwards".

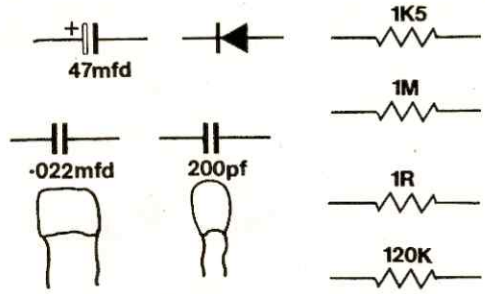
3 Are all the scales linear on the multimeter?

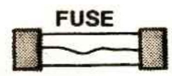
4 Switch your multimeter to 250v range and rotate the instrument sharply but gently in a clockwise direction and then anti-clockwise. Notice the amount of swing on the needle. Switch to a high current range and repeat. From this, explain which is the better range for transporting the multimeter.

5 What voltage is being indicated:

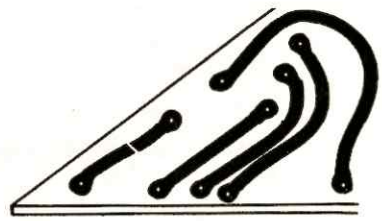


6 How would you test these components: They are out of circuit. Write as many facts as possible about the effectiveness of each test.



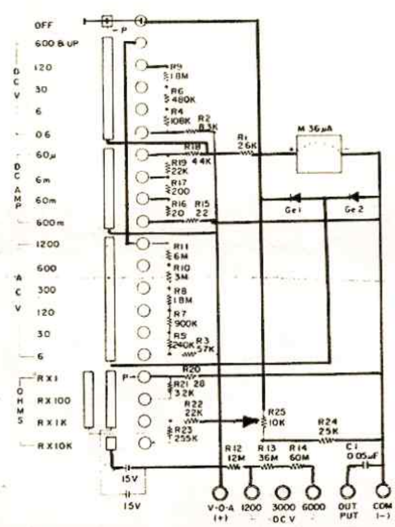


7 This PC circuit contains two faults. Explain how you would locate them.



8 One multimeter reads 0-5M, another reads 0-10M. Is one meter twice as good as the other?

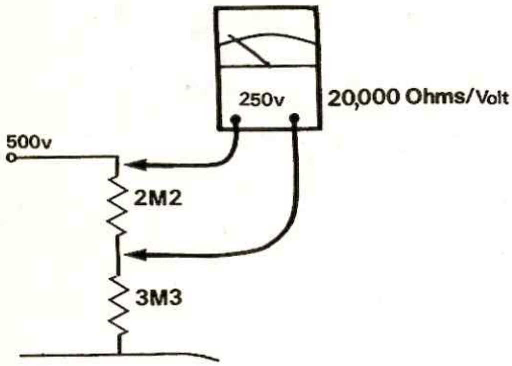
9 The schematic diagram for a multimeter shows a number of non-standard resistors such as 108k & 225k. Can you suggest why this is so?



10 On the ohms scale shown, where do you think the accuracy ceases?

11 The 9v battery is nearly exhausted. How would you discover this?

12 Using a 20k ohms per volt meter, what voltage will it read across the 3M3 resistor? Why is this reading different to the true voltage of 200v?



13 On which range does the movement receive the least amount of protection?

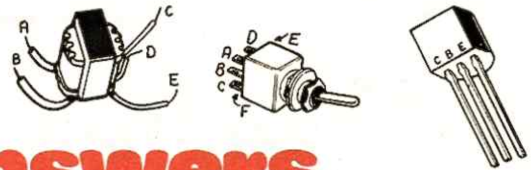
14 What is meant by: "a voltmeter loads the circuit?"

15 On some multimeters, the scale includes a mirror. What is the purpose of this mirror?

16 Which scale uses the battery in the multimeter?

17 Some multimeters use a 15v or 22.5v battery for the high ohms range. Under what conditions can this voltage be dangerous.

18 How would you test these components:



Answers

1. Most multimeters have ranges similar to the type 200H illustrated. It is important to remember all the functions on your multimeter. Otherwise its like driving a car and forgetting you have a fourth gear!

2. Ohms scale.

3. No. Ohms and db is non-linear.

4. You may notice the pointer moves more easily on the 250v range, due to the absence of "shunt resistance". Multimeters should be carried in fully dampened conditions similar to high current range conditions but this could cause a problem if a voltage was measured before re-setting the range on the multimeter!

5. 20.35v

6. The 47mfd electrolytic can be tested for shorts and charge-up time. It cannot be accurately tested for capacity without the aid of an AC source.
The diode can only be tested for forward and reverse "resistance", by setting the multimeter to high ohms range.
The .022mfd can be tested for shorts and charge-up time by setting the multimeter to high ohms range.
The 200pf can only be tested for open circuit.
The fuse should be tested on LOW ohms range.
Set the multimeter to low ohms range when testing low value resistors and high ohms range when testing over 50k. In all cases the multimeter is extremely inaccurate when reading the high values as the graduations are extremely close together.

7. A hairline crack is present on the board. Two of the tracks run very close together. Check the circuit continuity with a multimeter. Scrape the gap clean if in doubt.

8. No. The distance between 5M and 10M is microscopic.

9. The resistors must be selected to give a full scale deflection of say 50v or 250v when combined with other resistors

10. The accuracy ceases after about 300 ohms.

11. The battery must be tested under load. Connect it to a project and measure the voltage after one minute.

11. A voltmeter, even at 20k ohms per volt requires a little energy from the circuit to move the pointer. This will give you a slightly inaccurate reading.

13. The least protection occurs on the 50uA range.

14. 139v

15. The mirror prevents "parallax" errors due to reading the meter from the side. Look straight on top of the needle when reading.

16. The ohms scale.

17. These type of multimeters should be avoided. When measuring base-emitter characteristics of transistors, this 15v can puncture the transistor.

18. These three components must be tested in every combination with the ohms range. This may involve 12 or more readings. From these you will be able to determine the internal wiring of the component.

SCORE

Give yourself a pass or fail according to the number of questions answered correctly. We will leave the marking up to your own honesty. Try to come back to this test in a few months time and re-test yourself.

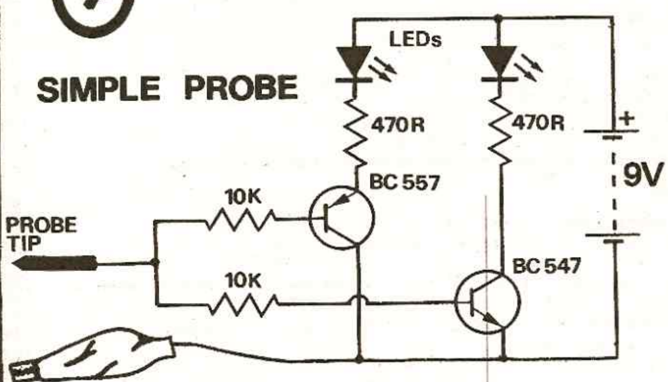
YOUR SCORE_____%

THE TRANSISTOR PAGE

Use Your 2 FREE Transistors in These 3 Simple Projects

④ SIMPLE PROBE

S. Quartly 6057



If one of the projects from TALKING ELECTRONICS doesn't work, that's good. You will learn more from getting it to work than blindly putting together a kit of parts and have it work first time. When a project doesn't work, the thinking cap has to come out. A valuable aid to trouble shooting is a multimeter but if you wish to keep your meter free for testing other parts of the circuit, you will need a simple test probe.
This circuit uses just two transistors and four resistors to light 2 LEDs. It will show a HIGH or LOW according to the voltage present on the probe tip. You can use a red LED and a green LED for the two readouts to distinguish between a HIGH and LOW reading.
The circuit is so simple it requires almost no construction details. The whole probe can be built on a piece of veroboard 7 holes x 17 holes, with the copper strips running lengthwise.
An aligator clip is needed and must be clipped to the negative rail of the project for the probe to work.

The cost of this project would be less than $2.00 and the two free transistors from issues 2 and 3 can be used in its assembly.

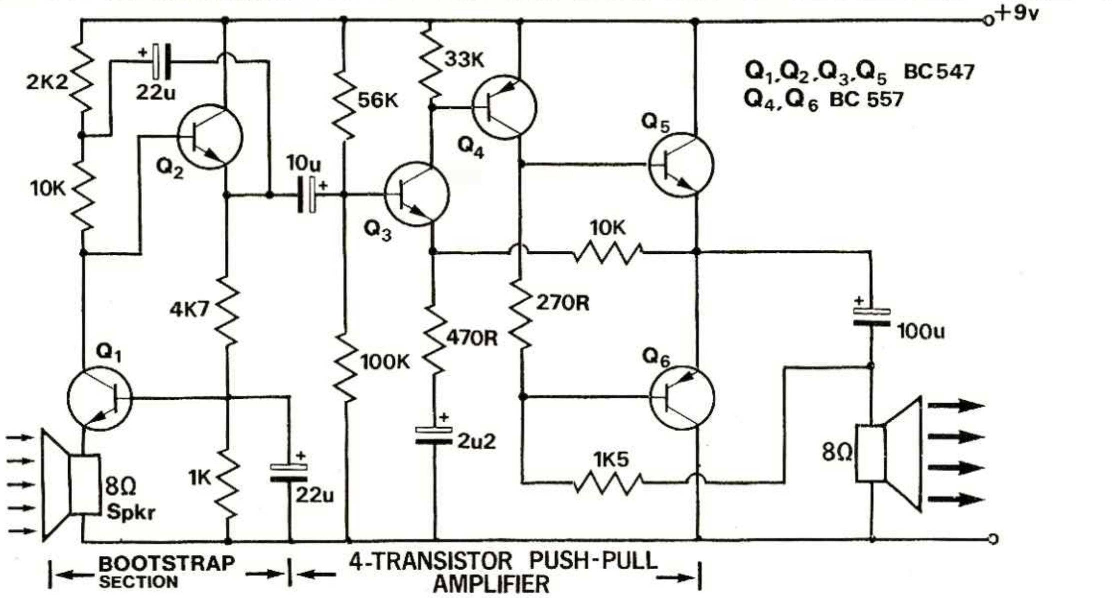
SUPER BUG ⑤

One of the difficulties when designing a listening bug device is the long leads required from the microphone to the amplifier. Obviously you want to be as far as possible from the conversation. This means either the amplifier has to be close to the microphone or the amplifier has to be close to the speaker. In the first instance, the disguising of the amplifier and battery become a problem and in the latter, the microphone cable tends to pick up stray hum. also this type of screened cable is fairly expensive. To overcome these two problems we have designed a grounded base pre-amplifier which will accept very low input impedances. Inputs as low as 3 ohm will be ideal and any loudspeaker having a voice coil up to 47 ohm will work. The remaining part of the amplifier is our well-known FOUR TRANSISTOR PUSH PULL AMP, described in the previous issues.
The signal gain of a grounded base stage is about 100 but if it is fed into a common-emitter stage, the resulting gain falls to 10. To overcome this we can feed the signals to an emitter-follower stage which has a high input impedance and does not load the first stage. The output of the emitter-follower stage is taken from the emitter and is fed into the 4 transistor amplifier.
Since the input and output of the emitter-follower stage is in phase, the signals entering the base will appear amplified at the emitter and are fed back to the input via the top 22mfd electrolytic. Thus only a small signal current will flow through the 10k resistor and to AC signals this resistor will look like about 100k. The effective voltage gain of this arrangement is about 500. This method of increasing the ohmic value of a resistor is known as BOOTSTRAPPING. It is analogous to a man lifting himself by his shoelaces.

So, in effect, the first two transistors operate as a pair. You cannot take one away and get half gain. It would drop to 10. This BOOTSTRAPPING circuit is an important building block and will be used in latter circuits to match a low input impedance to a medium output impedance, while giving a very high voltage gain.
Remember this circuit. By adding one transistor we have improved the effectiveness of a common-emitter circuit and enabled complete matching to a very low input impedance.

We have designed these "add-ons" in stages. If you follow through each of these stages, you will now be very pleased with the sensitivity.

SUPER BUG



METRONOME

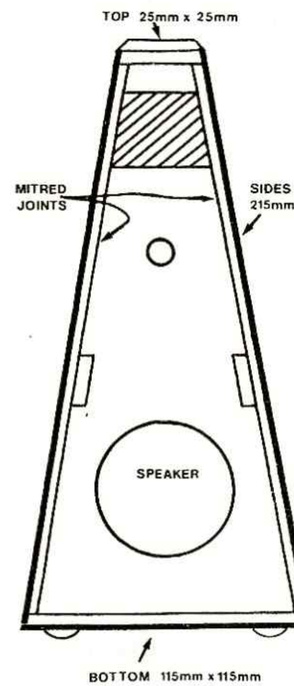
R. Welsby 3782

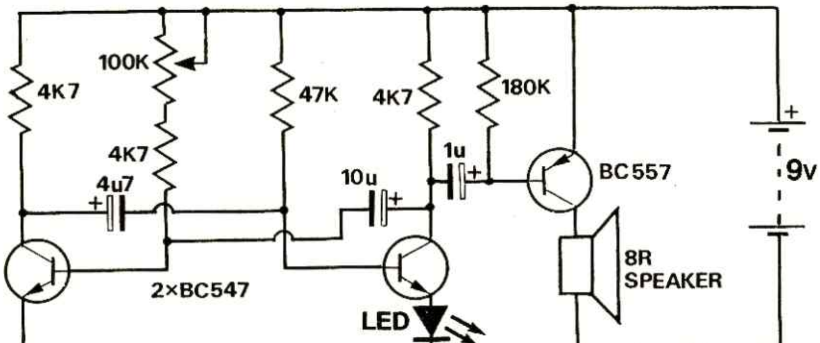
I am currently learning a musical instrument and find the use of a metronome of great benefit. The inclusion of a visual as well as the audible indication of beat is also very handy. The circuit shows a simple multivibrator with driver transistor to fulfil this requirement. The speaker is driven by its own transistor to give give a short, sharp powerful spike to imitate the characteristic tick, tick, tick of the mechanical unit.

The circuit draws very little current and a small 9v battery will last up to 100 hours. The LED in the emitter circuit will illuminate in time with the speaker clicks.

None of the components are critical. You will notice the electrolytics & resistors are not symmetrical values. These are not important as the potentiometer will vary the mark-space ratio to give a suitable range of beats per minute. The sound is very similar to the mechanical unit designed some 150 years ago by Maelzel. Little did he think an electronic version would rival his invention. He could take heart in the fact that his familiar case is being duplicated in the modern version. The wooden pyramid acts as a sounding board to increase the click from the speaker. All the case segments are made from 5mm plywood. The drawing shows all the dimensions required. It only needs careful cutting and gluing together with PVA glue. The joints should be mitred to give the glue an area to provide strength. Small fillets will help strengthen the case. Mitred corners conseal the under layers of the plywood so that the unit can be sandpapered and stained to give a really professional finish.

6



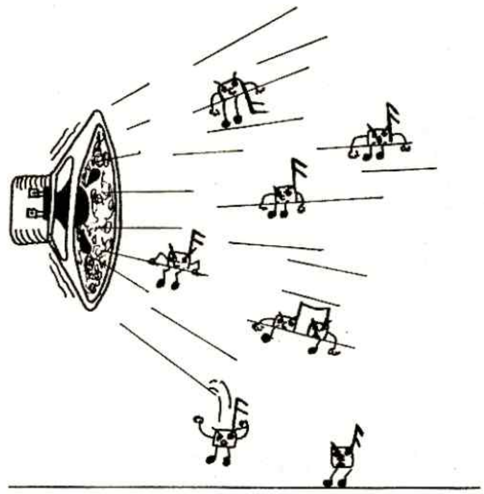


....Continuing our series on the

EXPERIMENTER DECK

TUNE

PROJECT EIGHT



ADDITIONAL PARTS YOU WILL NEED

Capacitors:	3n9	(.0039mfd)	100v
	1n	(.001mfd)	"
	22n	(.022mfd)	"
	3n3	(.0033mfd)	"
	6n8	(.0068mfd)	"
	22n	(.022mfd)	"

The very first electrical (not electronic) pre-programmed tune was the two-tone door-bell. The tune was set and you could make it go ding-dong but were unable to make it go dong-ding unless you re-arranged the parts inside the box. Following this came the warbler and BIG BEN multi-note door bell. Recently we have seen the introduction of the electronic multi-tune door bell capable of anything from Beethoven's 5th to the wedding march. Although these may sound wonderful, they are all programmed inside a large scale integrated chip and it is not possible to see any of the workings, let along be able to alter any of the sequences. This is not suitable as a learning aid. A simpler circuit is needed. One which can be easily altered. The experimenter deck has been designed to offer this facility. The range is limited but at least you can say "I did it".

OPERATION

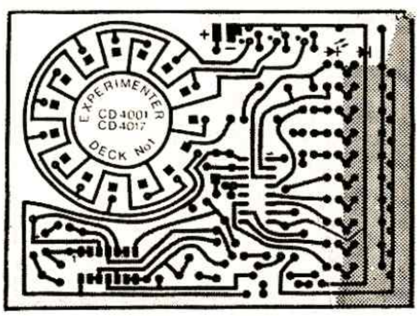
This project has only a single set of notes and the only adjustment is the speed with which they are scanned. The scan rate is adjusted via RV_2, the 100k trim pot. The overall frequency of the notes can be adjusted up or down the scale by trimming with RV_1.
Once you have successfully completed this section, you will want to experiment with adjusting the notes to create your own arrangement. These are only very basic experiments to get an understanding.

HOW THE CIRCUIT WORKS

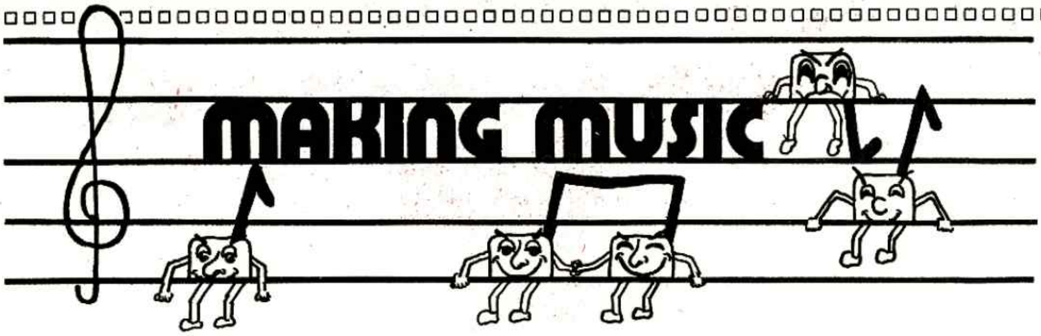
The low frequency multivibrator made up of IC1a and IC1b is adjusted to about 10 cycles per second. This is fed to the counting IC CD 4017 and each of its 10 outputs goes high in sequence. Six of the outputs are gated to diodes and fed back to the input of the tone oscillator, which is the higher frequency oscillator, made up of gates IC1c and IC1d. In the HEE HAW siren project the low frequency oscillator controlled the tone oscillator to produce the HIGH and LOW notes. Here the counting IC selects one of the six capacitors to alter the tone. When the 4017 falls on an output which does not contain a capacitor, the tone reverts to its lower frequency.
The six capacitors are diode-gated from one another to prevent cross-interference. A voltage on pin 3 enables the top 22n capacitor to have an effect on gates c & d. The other five capacitors are prevented from having any effect due to the isolating effect of the LEDs.

CONSTRUCTION

fit the six capacitors as shown in the layout diagram on the next page. That's all the assembly required.



Shaded area covers the soldering for projects 1-8.



PROJECT NINE

MAKING MUSIC

This project is an extension of the PRE-PROGRAMMED TUNE. Provision has been made on the PC board for the addition of 4 more capacitors and 4 more gating diodes.

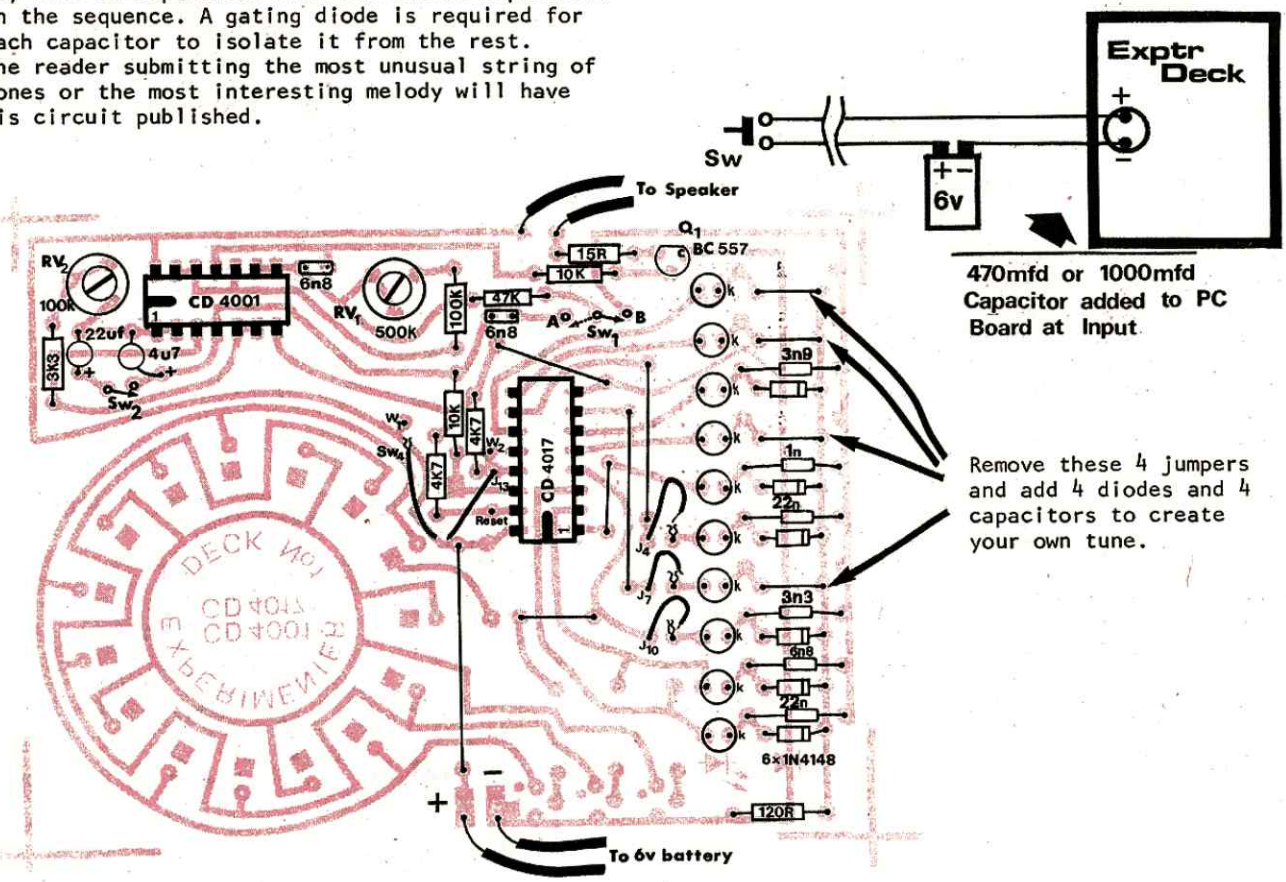
PARTS YOU WILL REQUIRE FOR EXPERIMENTING:

4 diodes - IN 4148
4 capacitors - in the range 1n to 39n

From the previous project, quite a number of vatiations of tones and noises can be created by adjusting the speed control RV_2 and the tone control RV_1. Once you are accustomed to the range and effect of each capacitor has on the tone, you may like to experiment with additional capacitors in the sequence. A gating diode is required for each capacitor to isolate it from the rest. The reader submitting the most unusual string of tones or the most interesting melody will have his circuit published.

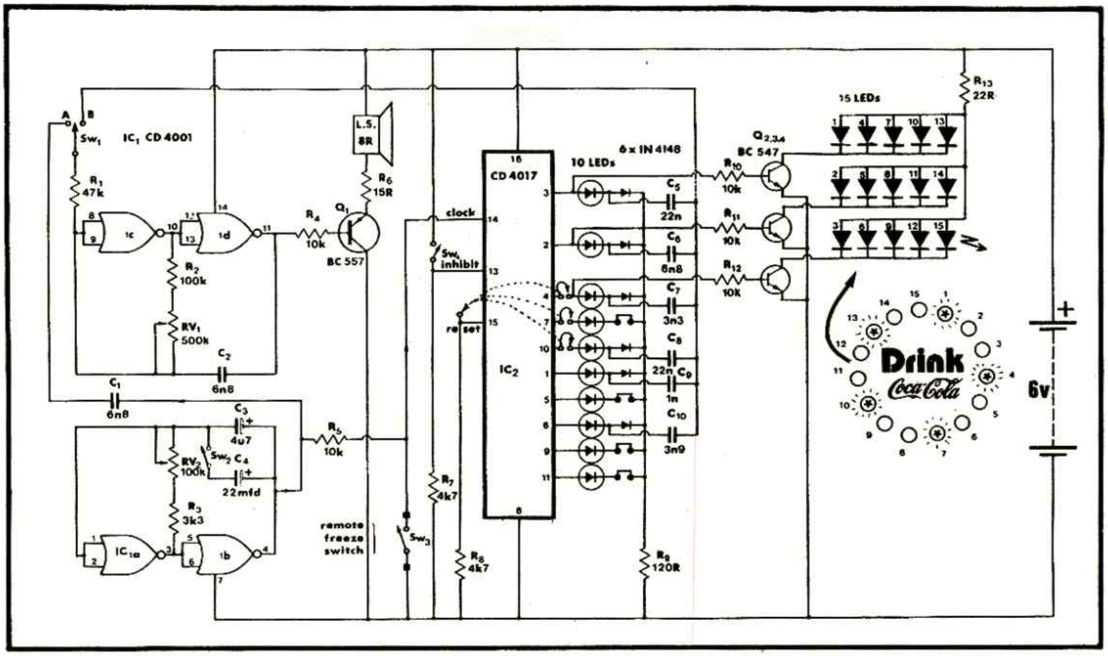
This project shows, in a very simple way, how tunes can be created by selecting a set of capacitors to frequency-modify an oscillator. The HEE HAW siren achieved this to produce 2 notes while this project has the capacity of 10 different tones.

One of the best suggestions for our pre-programmed tune is to use it as a door-bell. The circuit can quite easily be arranged to operate for a short time after the button is pressed by adding a 470 to 1000mfd electrolytic across the input as shown in the diagram. This capacitor will become charged when the button is pushed and gradually deliver its energy over the next few seconds. This will extend the call time, even though the bell-push may be pressed for only a fraction of a second. This arrangement also lengthens the life of the battery as the circuit draws current only while the button is being pressed.



ADVERTISING SIGN

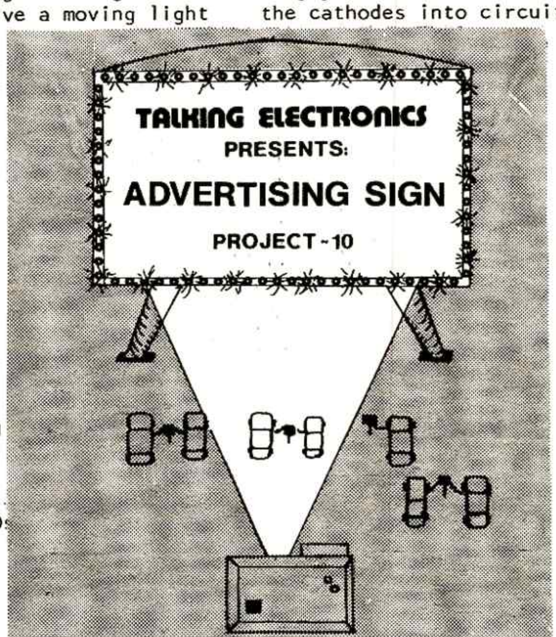
PROJECT TEN



ADVERTISING SIGN

This project is a most exciting and dramatic culmination to the EXPERIMENTER DECK series. I think you will feel the same way too after you build it.

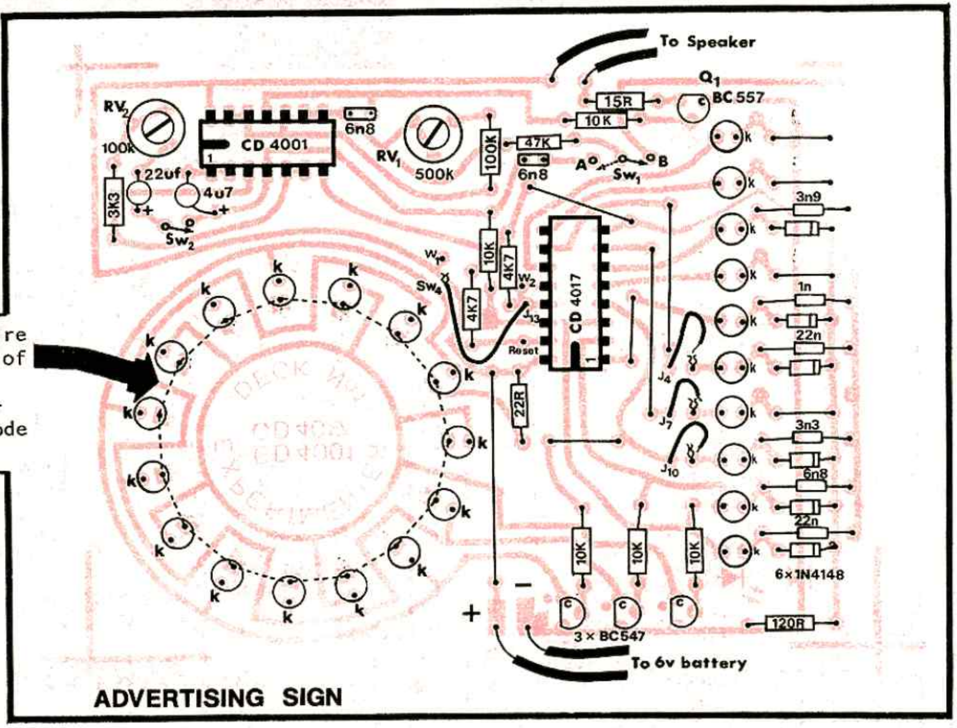
How many times have you seen an advertising sign consisting of hundreds of lights being switched on and off alternately to give a moving light effect? Possibly dozens of times. The city buildings and amusement parks are full of them. Have you ever said "I'd like to make something like that!" Well now you can. This final portion of the experimenter deck uses a set of 15 LEDs arranged in a circle to give the effect of a rotating wheel of light: like a ferris wheel at night. In a darkened room this project looks most effective. The combined effect of the sound changing in harmony with a pumping effect of the three LEDs in the row of LEDs and the circulating circle of 15 LEDs cannot be described. You'll have to make it to see what I mean.



MOUNTING THE PARTS

The 15 LEDs are mounted in a circle with their long leads inwards. The long leads must be soldered to the square solder-lands. You will need to connect all these together with thin tinned-copper wire after the LEDs have been soldered and their leads cut off. This jumper wire will form a ring just above the board and will connect all the cathodes into circuit via the last square solder land. Make sure this wire does not touch any other copper lands on the PC board or it will short out. The collector of each of the three transistors is identified. They are fitted next to each other as shown. Solder the three 10k resistors and 22R resistor in position. Adjust the middle jumper from pin 7 of the CD 4017 to the reset pin 15 of the IC to allow the first three outputs to function. Connect the lantern battery. The effect will be a LED chaser similar to the lights around the screen at the drive-in.

Don't forget the fine wire connecting the anodes of each LED to the common rail. The square solder-lands indicate the cathode connections.



ADVERTISING SIGN

We have already received a number of extensions to this project. One interesting model was built on a home-made PC board. It contained 62 LEDs arranged in a diamond pattern and connected to six outputs of the 4017 to form a receeding diamond of light. This is exactly what we want. With a few more submissions, we will produce a project with the running light feeding a display. Our next series of DECK projects will contain a memory chip which can be programmed and altered to give an infinite variety of sequences.

ADDITIONAL PARTS REQUIRED

3	transistors	BC 547	
3	resistors	10k	¼watt
1	"	22R	"
15	5mm red LEDs		

In the meantime, complete this series of 10 projects and get it operating correctly. If you intend to provide a complex LED display, one point worth remembering: When driving more than one LED from an output, it is necessary to include a buffer transistor. If you hit upon a great idea, let us know, we have some ideas but a few more will give us the variety we are looking for. Lots of luck.

Quiz:

Obviously you attemped the third quiz. Now try these:

Draw the block diagram for:

(1) A HEE-HAW siren

(2) Advertising Sign Project.

Write the binary for these numbers:

(a) 7

(b) 31

(c) 64

(d) 97

How do you identify the CATHODE of a LED?

What voltage is produced when 3 dry cells are connected in series?

What voltage is produced when 4 dry cells are connected in parallel?

The output of a 4518 BCD counter is active HIGH or LOW?

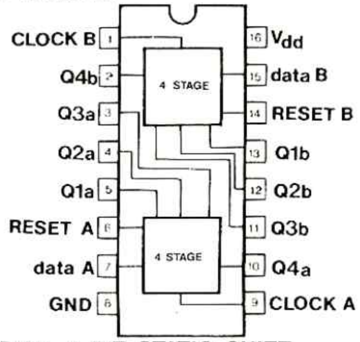
Draw an active low inverter.

Draw an active low buffer.

Describe in about 100 waords how a multivibrator works. That'll keep you busy.

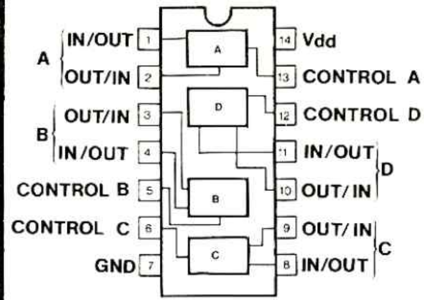
DATA

CD 4015 B



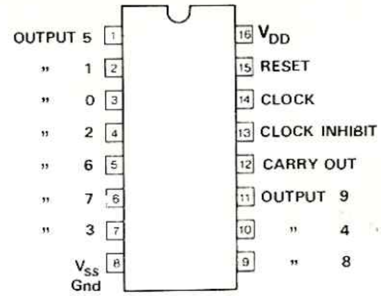
DUAL 4-BIT STATIC SHIFT REGISTER

CD 4016 B



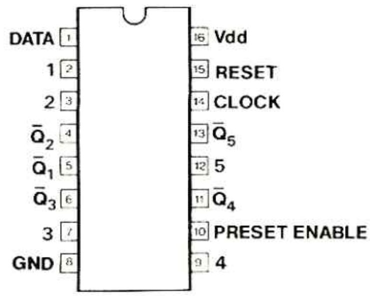
QUAD BILATERAL SWITCH

CD 4017 B



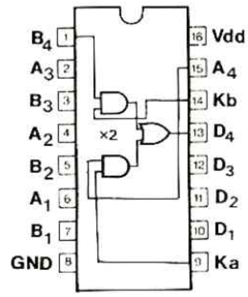
DECADE COUNTER/DIVIDER

CD 4018 B



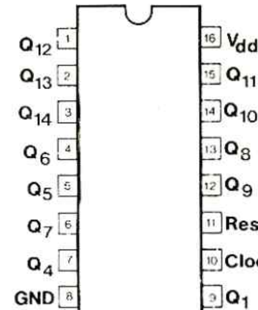
DIVIDE BY 'N' COUNTER (PRESETABLE)

CD 4019 B



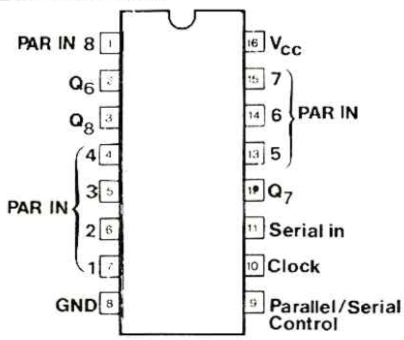
DUAL AND OR SELECT GATE

CD 4020 B



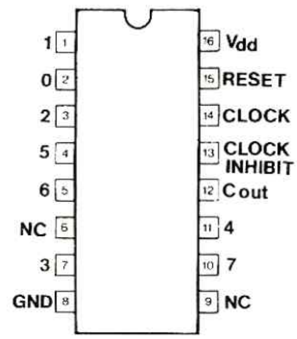
14 STAGE RIPPLE CARRY BINARY COUNTER

CD4021 CN



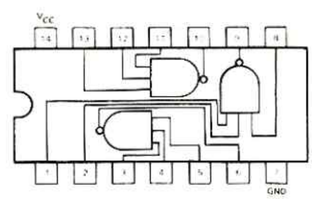
8-BIT STATIC SHIFT REGISTER

CD 4022 B



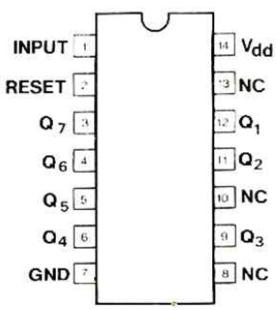
DIVIDE BY 8 COUNTER/DIVIDER

CD 4023 B



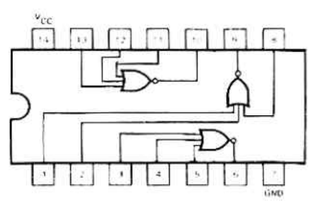
TRIPLE 3-INPUT NAND GATE

CD 4024 B



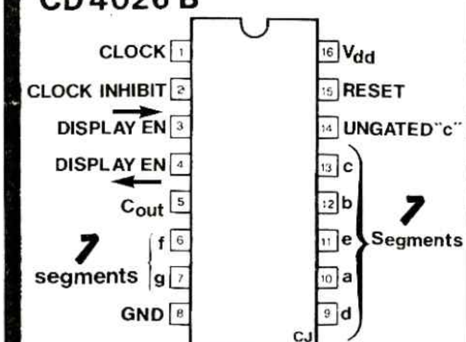
7-BIT BINARY COUNTER

CD 4025 B



TRIPLE 3-INPUT NOR GATE

CD 4026 B



DECADE COUNTER/7 SEGMENT DECODER

CPW

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