10

# TALKING ELECTRONICS

$1.80 ★

$2.40NZ

Issue No 10.

## TEC-1 TALKING ELECTRONICS COMPUTER


## LOGIC PROBE
## ROULED
## COUNTER MODULE - ONE SHOT

# TALKING ELECTRONICS

## *Editorial...*

**Vol. 1 No: 10.**

This is our COMPUTER ISSUE. By bringing out the computer in this issue, we have advanced faster than I have ever intended. But it has been the requests from readers, schools and industry that has caused us to do so.
At first we considered one of the mini computers already on the market, would provide a suitable basis for instruction but on further investigation, this was not to be the case. We required something in the low-price bracket, easy to construct and most important of all, it had to be a Z80 based circuit.
Thus we had to design and develop a whole system ourselves. And after seeing the final design, I think you will agree it has been totally worthwhile.
Designed by John Hardy, TEC-1 is our answer to all those requests.
It is a simple, single-board computer which enables you to learn programming in Machine Code as well as play a number of simple computer games.
Construction is quite easy and if you have produced 8 or more projects from our previous issues, you will be eligible. We have been very careful to include only easy-to-obtain components and of course the CPU (Central Processing Unit) is a Z80 chip. This amazing chip is so cheap that you cannot go past it for performance and price.
The total chip count has been kept very low at 9 and you learn the operation of each and how it controls or is controlled by the rest of the circuit.
But before I use any technical terms, I want to explain the approach we are adopting.

TEC-1 will be divided into 3 stages.

Not 3 EQUAL stages but 3 sections which are intended to draw you into the computer field without causing any frustration.
Even if you don't know the difference between BITE and BYTE, you will be able to build this project, learn how it works, play a few computer games and then create some simple programmes of your own.

It works this way:

Stage 1 is the construction of the board. Just like any other project, it is purely assembly - very delicate assembly - but no computer terms will be involved.
Stage 2 is playing games on the computer. Simple games like Nim, Music, Lunar Landers and producing letter and words. Still no new terms.
Stage 3 is learning about the technical side. Programming in Machine Code, the uses and possibilities for the computer and construction of "add-ons". This issue covers stages 1 and 2.
I will pretend to know nothing so that we can both start together and combat the COMPUTER BARRIER.

*Colin Mitchell.*

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# INDEX



**TECHNICAL**
*Ken Stone*

**ARTWORK**
*Ken Stone*

**ENQUIRIES**
*10 Minute queries will be answered on 584 2386*

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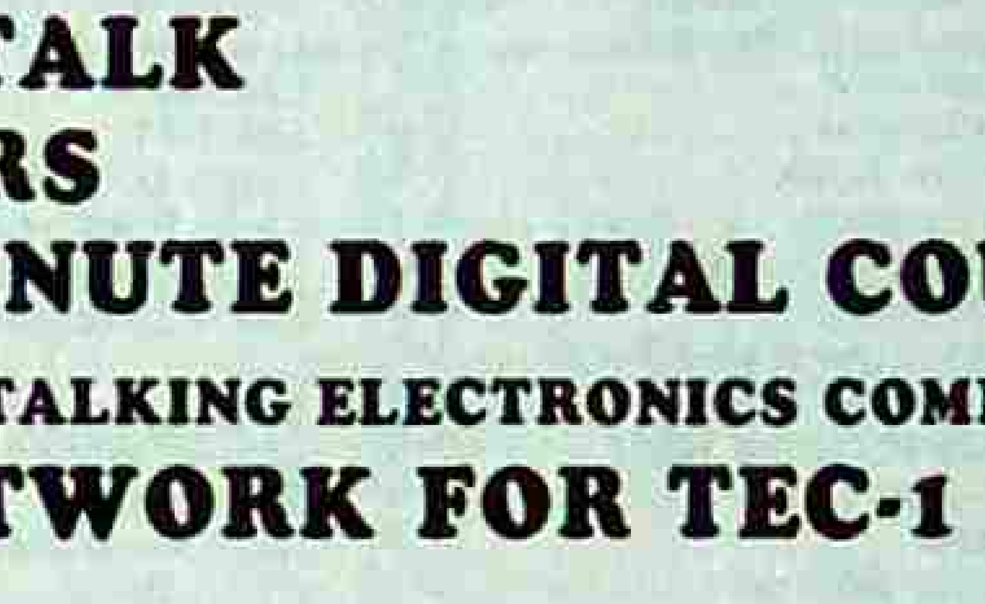
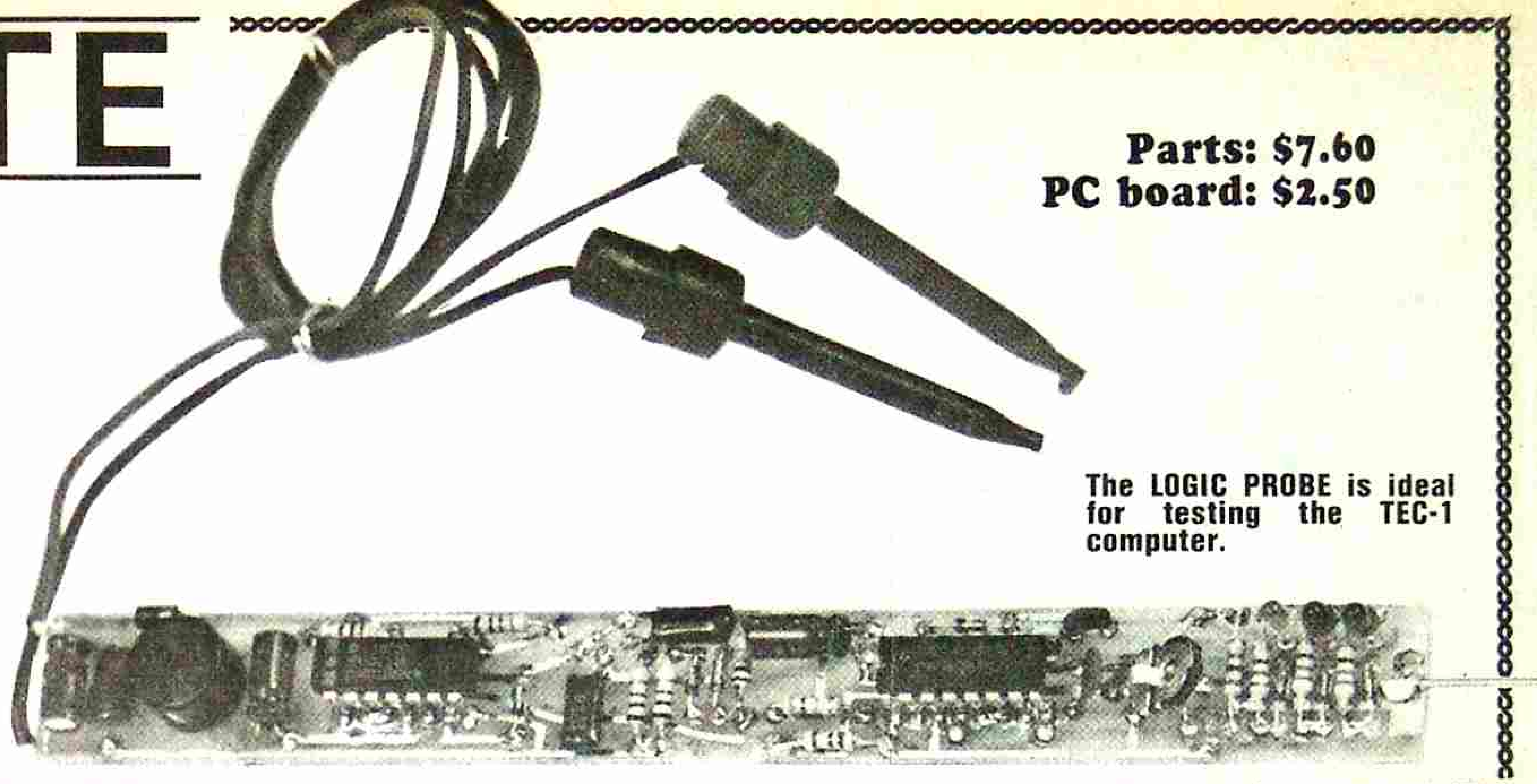
**Talking Electronics (03) 584 2386**



**The TEC-1 ready for programming.**
This will be the only colour issue, so don't think we are getting BIGGER! The colourful TEC-1 was too good to show in black & white.

TE



**Parts: $7.60**
**PC board: $2.50**

**The LOGIC PROBE is ideal for testing the TEC-1 computer.**

# LOGIC PROBE

A LOGIC PROBE is possibly the most important of all pieces of test equipment for the digital designer.

Comparatively speaking, it is equivalent to an electrician's multimeter or an audio technician's CRO.

You may be wondering why we have not described a Logic Probe before. Well, basically, there are two reasons. Firstly we have not had the need for it and secondly the complexity of the circuit has not fitted the scheme of things.

But the time has now come for its application. This is our computer issue and to build a computer without having access to a PROBE is like taking the car on a long journey without a spare tyre.

In fact, with the computer project, the circuit is tested at various stages with the probe to make sure it is functioning correctly.

So, to be without this piece of test equipment is digital suicide.

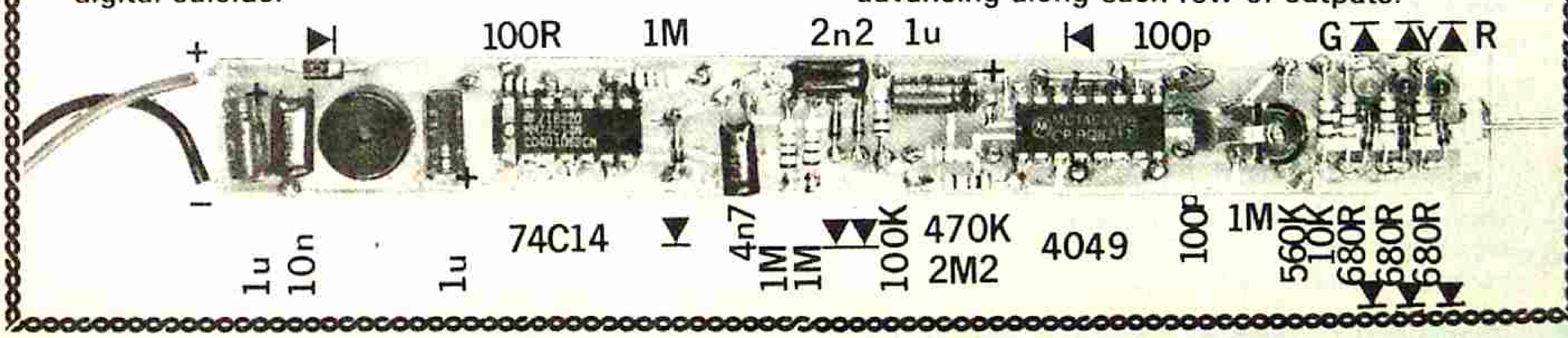
As with all our projects, this probe is the culmination of many hours investigation and diagnosis of the various equivalent products on the market and we have come up with the best design ever.

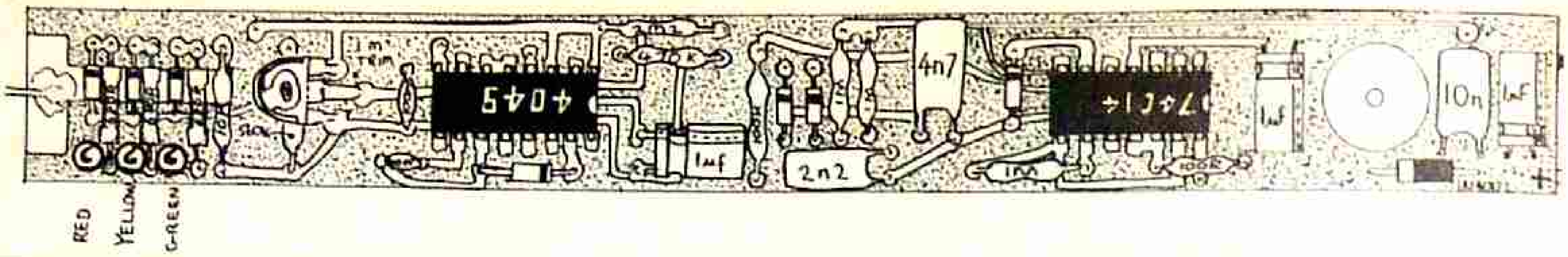
The probe has both visual and audible indication of HIGH, LOW and PULSE and if you have ever used a probe for trouble-shooting, you will know the advantage of an audible signal.

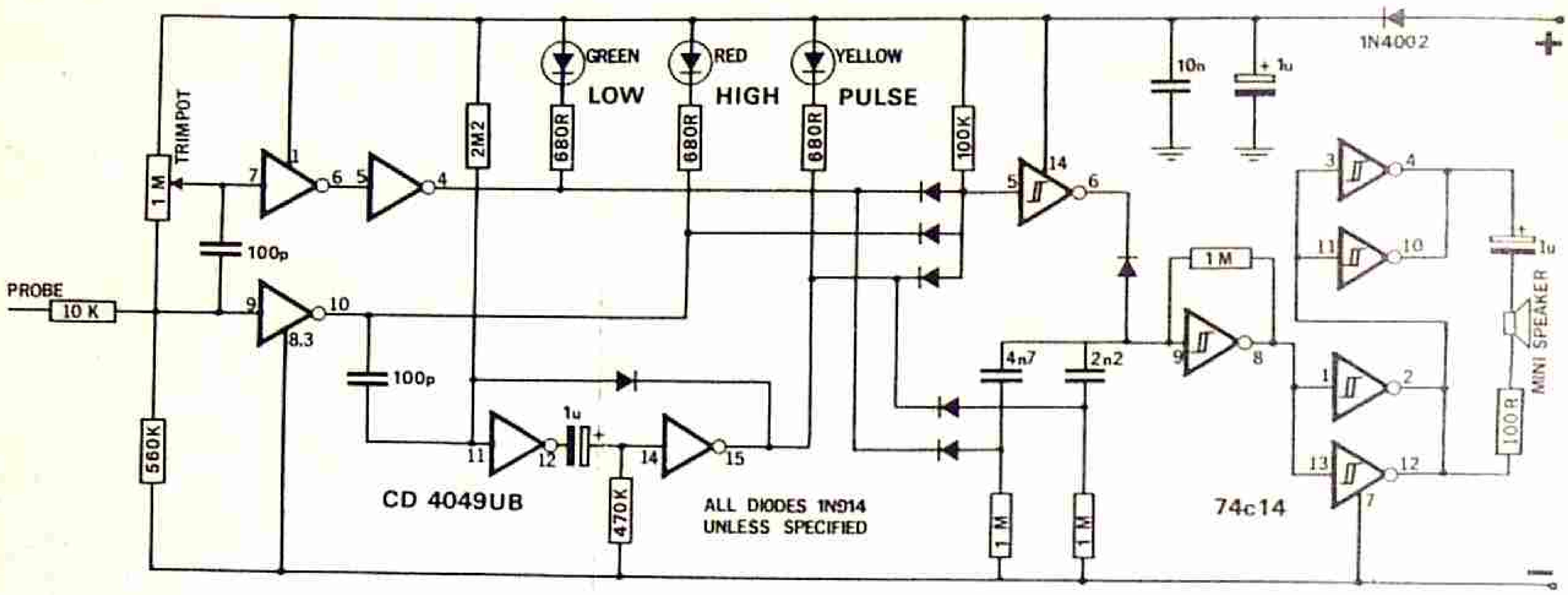
Whenever you are probing around the pins of an IC, it is absolutely essential than you do not take your eyes off the probe, even for an instant.

If you attention is diverted to looking at the indicator LEDs, you can allow the probe to slip off the IC pin and cause a short between two pins. This could easily damage the chip.

But with our design, this cannot happen. The audible tone will keep you up to date with the state of each pin and you can concentrate on advancing along each row of outputs.






## HOW THE CIRCUIT WORKS

The three indicator LEDs are connected to inverters. Each inverter performs a different function and this is how we get the HIGH, LOW PULSE outputs.

The outputs of these three stages must be HIGH when the probe is in the no-signal condition as the LEDs are driven via negative-logic. This simply means the LEDs will illuminate when the output of the driving buffer is low.

The 1M mini trim pot on the input line, sets the voltage level on pin 7 of the top inverter so that the LOW LED is illuminated when the probe detects a LOW.

The section dealing with the LOW signal is the pair of inverters between pins 7 & 6 and 5 & 4. This produces a double inversion so that a LOW on the input will produce a LOW on the output. This LOW illuminates the LED and this is why it is called NEGATIVE LOGIC.

A single inverter between pins 9 & 10 is used to drive the HIGH and once again negative logic causes the LED to be illuminated.

A 100pf capacitor between the inuts of these two circuit blocks acts as a SPEED UP capacitor.

The PULSE-STRETCHER arrangement is a monostable circuit in which pin 11 of the first inverter is normally HIGH, making the output LOW. The 1mfd electrolytic sits in an uncharged condition. The circuit is triggered into operation via the 100pf capacitor on input pin 11. When a LOW is created on pin 10 of the "HIGH" BUFFER, it is passed through the capacitor to pin 11 of the pulse-stretcher circuit. This will cause pin 12 to go HIGH and take pin 14 HIGH with it.

Pin 15 goes LOW and the latching feature is provided by the diode between pins 15 and 11. When pin 15 goes LOW, pin 11 is also pulled LOW and the circuit latches in this state.

The time-delay for the circuit is controlled by the capacitor (and also the 470k resistor). Pin 12 is HIGH and it begins to charge the capacitor at a slow rate due to the 470k resistor in series with the charging voltage.

The voltage on pin 14 gradually decreases until a point is reached when the second inverter will change state. The voltage on pin 14 falls and this will create a HIGH on pin 15. The PULSE LED will be extinguished and the LOW on pin 11 (produced by the diode) will be removed. The first inverter will change state and the charge on the 1mfd electrolytic will be removed fairly rapidly due to the presence of diodes on the input line of the inverter.

The next two blocks on the circuit diagram provide gating for the Schmitt Trigger oscillator.

The actual Schmitt oscillator circuit is made up of the 4n7 capacitor (and/or the 2n2 capacitor), the 1M resistor and the Schmitt Trigger between pins 9 and 8.

But to get this oscillator to produce 3 different frequencies, via a gating arrangement, is not an easy task.

The oscillator requires the earthy end of the capacitors to be connected to ground for the oscillator to keep oscillating. Otherwise it gradually dies away due to the high impedance provided by the gating circuitry.

The three diodes in the centre of the circuit produce a negative logic OR gate and this means it is detecting a LOW on one of the input lines to change the state of the output.

The output of the gate is connected to input pin 5 of a Schmitt Trigger which is acting as an inverter to GATE the Schmitt oscillator.

When pin 5 is HIGH, the output pin 6 is LOW and the oscillator between pins 9 and 8 is prevented from functioning due to the forward-biased diode keeping the voltage below .6v.

When any input of the diode gate goes LOW, the output goes LOW and this causes pin 6 to go HIGH. The oscillator gating diode is now effectively out of circuit and the Schmitt oscillator will produce a frequency which is determined by the value of the capacitors in the earth circuit.

When the LOW LED is illuminated, the 4n7 capacitor will set the frequency. When the PULSE LED is illuminated, the 2n2 will set the frequency. When the HIGH LED is illuminated, the frequency will be set by both capacitors and the 1M resistors in series with them. The isolation diodes on the earthy ends of the capacitors will prevent the HIGH from the imverters from affecting the frequency.

With the 4 remaining Schmitt Triggers, we have paralleled them to provide a push-pull arrangement for the mini speaker. Strictly speaking this is not necessary but it is best to utilize all the gates in a package.

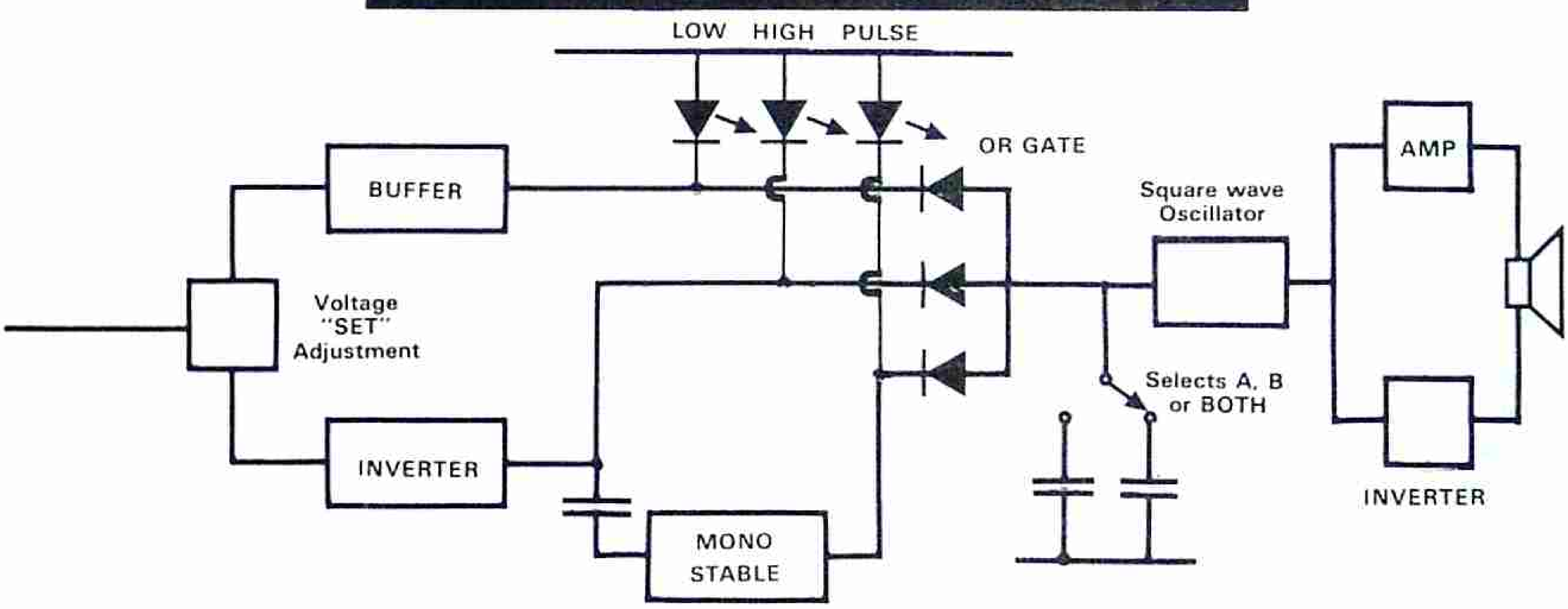
The choice of a 100R resistor and 1mfd electrolytic in line with the speaker prevents overloading of the gates.

A power diode is provided in the positive rail to prevent damaging the probe with reverse voltage if it is connected to the power around the wrong way.

The 1mfd (1u in the schematic) and 10n capacitor across the power rails help remove spikes from the power rails and prevent false triggering.

The 10k input resistor prevents the circuit being tested, from overload or damage.

Finally, one of the inverters of the CD 4049 is unused. Its input line has been tied to earth (pin 3) to prevent the inverter self-oscillating.



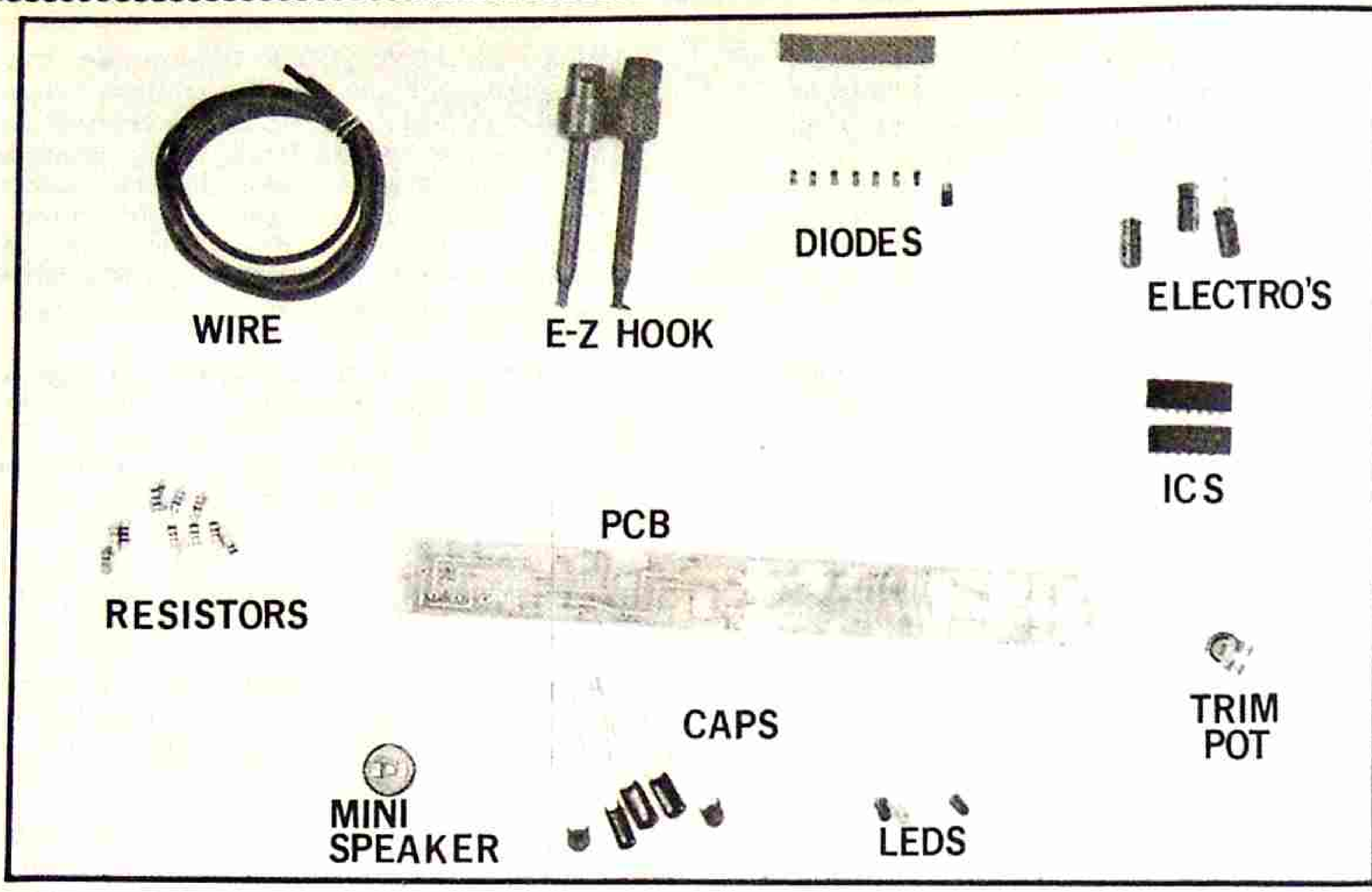

## LOGIC PROBE BLOCK DIAGRAM

The input block is a 'VOLTAGE SET' control to turn the HIGH/LOW indicator LEDs off when no input voltage is present.

The incoming signal is passed through a non-inverting buffer (two inverting buffers in series) and also one inverting buffer. The output of these gives the HIGH/LOW indication.

A pulse-stretcher circuit provides an indication of a pulse as short as 1 micro-second.

The output of the three buffer circuits is fed to an OR gate and this controls a Schmitt Trigger oscillator.
Three different tones are produced by selecting a combination of the two capacitors. The output of the Schmitt Trigger feeds a push-pull arrangement to drive a mini speaker.




We have also overcome the second major obstacle - the cost of the case. Apart from using a pen barrel or cigar case, there has been little else on the market to slip the works into. After a lot of high-level searching, I finally came across one of the most obvious products for use as a case. . . It happened this way:

One day I decided to get rid of my shaggy-dog toothbrush and there, neatly displayed on the chemist's counter, was a row of probe cases! Mind you, only a select band of chemists sell our type of probe case. They are called 'AMCAL' Chemists and this is their own 'house' brand of case. Inside the case you get a FREE tooth-brush! I gave every member of the family a free brush and they think I'm the most generous dad who ever lived. Little do they know the real reason.

The cases are good-quality injection-moulded polystyrene halves which slide-fit together to make a sturdy case. One end contains two holes which have been specially included to take the two power leads and the other end can be drilled with a fine drill to take the probe tip.

By spending tens of thousands of dollars, we could not have come up with a more suitable case. In fact it is exactly the right width for the PC board and by mere coincidence, it has the exact right length.

When the probe project is complete, and the two halves of the case taped together, the case is as sturdy and rigid as any $15 case on the electronics market, and you save $14 on the case alone!

## PARTS LIST

1 - 100R ¼ watt
3 - 680R
1 - 10k
1 - 100k
1 - 470k
1 - 560k
3 - 1M
1 - 2M2

2 - 100pf ceramic
1 - 2n2 greencap
1 - 4n7
1 - 10n

3 - 1mfd 16v electrolytic

1 - 3mm red LED
1 - 3mm green LED
1 - 3mm orange LED

7 - 1N 4148 signal diodes
1 - 1N 4002 power diode

1 - CD 4049UB Hex Inverter IC
1 - 74c14 Hex Schmitt Trigger IC

1 - 1M mini trim pot

1 - 8R mini speaker

short length of tinned copper wire
1 - 30cm red flex for power lead
1 - 30cm black flex for power lead
1 - red E-Z hook
1 - black E-Z hook

1 - CASE (see text)

1 - LOGIC PROBE PC BOARD

Now, on to the more serious side. The PC board is the cover feature for this issue, even though it takes second place to the computer project. If you subscribe to the magazine and ask for the PC boards to be included, you will already have the board at your finger tips. If not, you can send for it, along with the parts for the project. The only item you will have to purchase separately is the case.

The probe PC board is a double-sided board and the majority of the parts are mounted on top of the solder lands. Much to the annoyance of 10 of our readers, we have chosen this arrangement so that the PC wiring remains large and easy to solder to. Jumpers and interconnecting wires are eliminated. To create the same circuit on a single-sided board would create a little congestion near the front-end of the circuit. And anyhow, we wanted to introduce a double-sided board to our readers.

The PC board manufacturers are hoping for a plate-through-hole board soon, but we assured them that this would not happen for many issues yet.

The only advantage with plate-through-holes is for production runs where jumpers and feed-through pins can be eliminated.

For hobby work, time is not chargeable and plate-through-holes are of no advantage.

## BUYING COMPONENTS

Before you start to purchase any of the parts for the probe, remember that all parts must be as small as possible as they have to fit inside the plastic case. To us, all the parts in our prototype are standard as we have been using the smallest and best components for all TE projects, since its inception.

The only new part will be the mini speaker. This is a proper 8ohm voice coil speaker with a metal diaphragm and surrounded by a circular ceramic magnet. It can be used as a miniature speaker for a transistor radio although it does not give the same performance as a normal 57mm speaker. But for our situation, it is ideal. We don't need a loud indication of the logic level and the Schmitt Trigger drives the speaker quite adequately.

The only ODD feature of the layout is the position of pin 1 for each of the chips. They do not correspond with the normal direction of the signal and you will notice the writing on the chips is up-side-down. Take special note of this point and don't go blindly ahead and wire the chips onto the board around the wrong way.

Everything else is straightforward.

Obviously the first item to buy is the case, then you will have an idea of the headroom available for the components.

By now you should have built some of our educational and recreational projects. The Digi-Chaser or Cube Puzzle, for instance, or the Egg Timer, Lotto Selector or Hangman.
If you had difficulty in diagnosing or analysing any of the output stages, you will appreciate the benefit of having a probe. It will inform you of the level of any of the outputs, at a glance.

We have selected CMOS chips for the probe so that it can be used on either TTL circuits (5v operation) or CMOS circuits (5v to 15v ).

The input impedance of the probe is about 300k to 400k and this places very little load on the circuit being tested. Thus an oscillator, for instance, will not change frequency appreciably or a delay circuit alter from its specified delay-time.

But the most basic need for a probe is to detect the logic level of any any point in a circuit. This is provided by the HIGH-LOW readout on the two LEDs or via the tone from the speaker.

Along with the HIGH/LOW capability, a very handy feature is to be able to pick up isolated pulses which are of very short duration. Our probe is capable of detecting pulses which are as short as 1 microsecond and this corresponds to a frequency of 1MHz. These pulses are stretched by a PULSE-STRETCHER circuit and appear on the middle LED for an extended period of time so that it is visible. The signal is also passed to the tone oscillator where it is converted to a short beep to let you know a pulse has been detected.

All these features are yet to be found on a commercially available probe at a cost nearing that of our design.

For anyone contemplating building the TEC-1 computer, this probe project is an absolute must. Build it well in advance of the TEC-1 and have it operating correctly for testing the first stage of the computer.

## CONSTRUCTION

Lay the components, board and case on the work-bench and get all your tools ready for an hour of quality soldering. You will need snips and long-nosed pliers as well as a fine-tipped soldering iron and a length of fine solder, to achieve a neat result.

A printed circuit board holder will be handy and can be made from two clothes pegs screwed to the bench. The only other item I consider

essential is a solder-tray, to accept the dirty solder from the soldering iron,as it must be tapped clean after making each connection.

With all these things around you, an hour will pass very fruitfully as you build ON TOP of the PC board.

The first two components we suggest to be fitted are the two integrated circuits. This is because they are added to the centre of the board. The other components are fitted on either side and access to the solder lands is only available at the commencement of construction.

All the components excepting the mini trim pot will have to be trimmed to fit onto the board as the components should be fairly close to the board to prevent them from bending over and touching other parts.

Because very little heatsinking is available for components with short leads, it is necessary to use long-nosed pliers to act as a heatsink for the LEDs, diodes and resistors, when soldering them to the board.

The electrolytics and capacitors can be held in your fingers when soldering as you will soon know if you are taking too long to tack them in position.

So MUCH has been said about soldering that if you don't know what to do in this case, you should not be attempting assembly.

The only damage to components,I can envisage, will occur when soldering the LEDs. Before soldering them to the board, cut the cathode lead short and try the LED for height before soldering. Do likewise with the other two LEDs. Do not bend the leads apart as this will damage the LED. Tack each one in position so that you can adjust it for height and position.

Basically you can start at one end of the board and add each component as you come to it. The mini trim pot will have to be bent over slightly so that it fits into the case. All the other components will be short enough to enter the case, provided they are kept close to the board.

The electrolytics can be bent over and laid neatly across other components and this will allow their leads to be kept a little longer.

The power leads for the probe should be as long as practical as the probe derives its power from the project under test. With long leads, the probe can be used to trace the circuit on the top-side of the PC board as well as under it.

The last two items to be soldered are the alligator clips, as the power leads have to be fitted through two holes at the end of the case.

But before the works can be put away, a small adjustment is needed via the 1M mini trim pot. With the probe connected to a 9v to 12v supply, connect the tip to earth (negative of the battery) and adjust the pot until the LOW LED is just illuminated.

This completes the probe and it is now ready for encasement.

## USING THE PROBE

The power for the probe is obtained from the project you are testing. This way the voltage is automatically adjusted to match the project. It also saves putting a battery in the probe case.

Connect the positive lead to any positive rail on the test-project and the black lead to earth.

The probe tip should be long and THIN so that it will get into the tightest of places. You can put an insulating sleeve on it so that only the end is bare. This will prevent shorts when testing a very compact circuit.

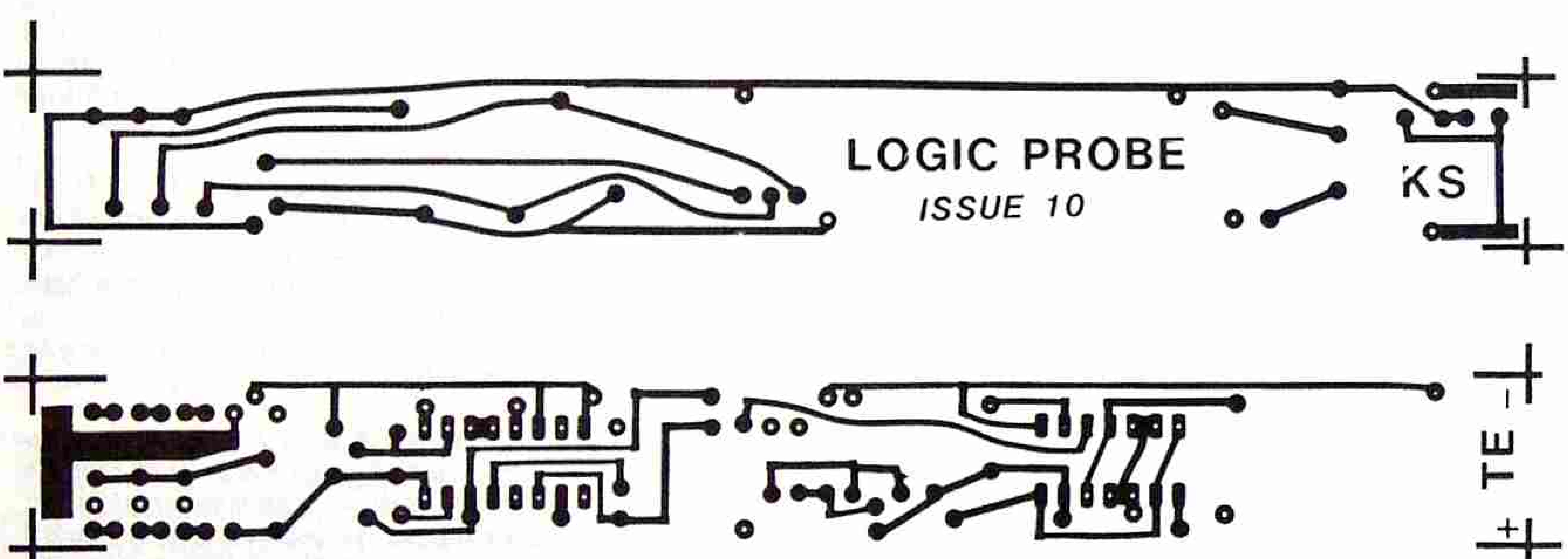
Use the probe project a few times in a KNOWN situation so that you become accustomed to the sound of the high and low signal.

The power leads should be taped together for their full length to prevent them getting tangled.

When using the probe to check a project, you will need a circuit diagram. Before touching the probe on any point at all, ask yourself: "Will it be HIGH, LOW or give a PULSE?" The probe will then confirm your decision.

Muster up all the projects you have constructed from Talking Electronics and analyse them with the probe. You will be quite surprised at the various frequencies within within such projects as the LOTTO SELECTOR and MUSIC COLOUR.

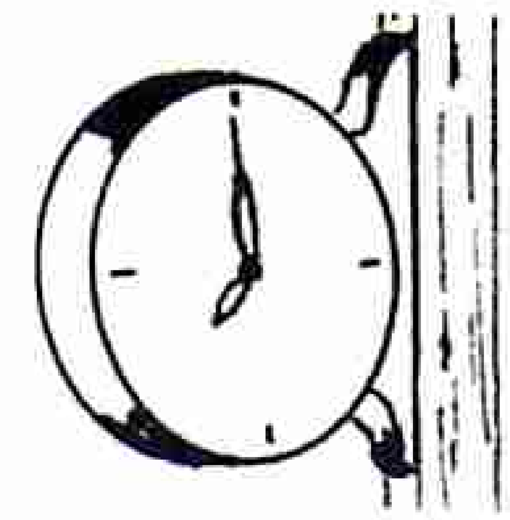
Let us know how you like the probe.




**The LOGIC PROBE is built on a double-sided PC board. These are difficult to make in a home-brew situation as the alignment of the two sides must be accurate and the etching must take place at the same time.**
**You can get around this by making the the lower pattern on a single-sided board and creating the other side with wire jumpers.**

# MODEL RAILWAY CLOCK

P. Rowland,
Feilston Bay, 7015.



Along with scale scenery, scale cars and scale people, model railways have scale TIME.

You don't see it very often due to its high cost but every model railway enthusiast dreams of the day when he will be able to afford to add it to his layout.

Model time may seem like a joke - like decimal time - but every gauge such as 'O' - 'HO' and 'N' has its own time scale.

Some of these are the same but basically there are three different times for model trains.

When you think of it, this is only logical as some layouts are exact replicas of fameous train routes or well-known stations. This means the time taken for a train to travel between stations can be as realistic as possible.

By altering the time, you enter a miniaturized world and a speeded-up world at the same time.

Time-tables and time intervals become more realistic and you can enjoy this realism to its fullest.

At no additional expense, the TE clock from issue 9 can be converted to a model railway clock.

Operating times vary from layout to layout but a clock that operates at four times normal speed, that is at a rate of one fast minute every normal 15 seconds, is the usual practice.

The alterations take place in the gating diode arrangement and this is quite an easy modification. Only three gating diodes have to be re-positioned while the other four diodes remain in the same positions.

Other MODEL TIMES such as 10 seconds to the minute, or 20 seconds to the minute are also possible with the TE clock.

## THE 4040 COUNTER

The basis of the timing for the TE clock is the 4040 counter IC. It counts the number of pulses from the AC mains and produces a single pulse every minute. This means it is a divider in which 50 x 60 pulses are counted for every output pulse.

This means it is a divide-by-3000 counter and for our MODEL TIME project, we must reduce this division so that the output changes at a faster rate.

But before we give you the necessary divisions, we will look into how the divider operates.

Working out a division for a counter can be quite confusing as we have pin numbers, individual output divisions and output values as related to our division. And all these are different. So you will have to understand why before being able to create a new divide-by situation.

A 4040 counter is a binary counter in which each output is a power of 2. This means the first output is a divide-by-2, the second a divide-by-4, then a divide-by-8 and so on.

The highest output for this counter is a divide-by-4096.

Now, here is the secret of how to interpret these values:

The 4096 output goes HIGH after 2048 counts and stays HIGH for a further 2048 counts, making a total of 4096. Every time the output goes LOW, it is detected by another chip or sensing circuit. This means the highest output can be classified as a divide-by-4096 when the counter is operating in its full cycle.

However, when we are detecting the first change in the condition of the output, it must be considered as a divide-by-2048.

Similarly each of the other outputs have a value half of that stated on the pin-out diagrams.

This means we must use the value of 2048 for the highest value, 1024 for the second highest value etc. etc.

The following is a table for the division values for each of the outputs:

We have also included a MODEL CLOCK based on 10 seconds to the minute, 15 seconds to the minute and 20 seconds to the minute.

| PIN: | COUNTS AS: | TE CLOCK: | 10 Secs: /500: | 15 Secs: /750: | 20Secs: /1000: |
|---|---|---|---|---|---|
| 1 | 2048 | ■ | | | |
| 2 | 32 | ■ | ■ | ■ | ■ |
| 3 | 16 | ■ | ■ | | |
| 4 | 64 | | ■ | ■ | ■ |
| 5 | 8 | ■ | | ■ | ■ |
| 6 | 4 | | ■ | ■ | |
| 7 | 2 | | | ■ | |
| 8 | Earth | | | | |
| 9 | 1 | | | | |
| 10 | Clock | | | | |
| 11 | Reset | | | | |
| 12 | 256 | ■ | ■ | | ■ |
| 13 | 128 | ■ | ■ | ■ | ■ |
| 14 | 512 | ■ | | ■ | ■ |
| 15 | 1024 | | | | |
| 16 | Vdd | | | | |

*A comparison of the TE clock with MODEL TIME clocks. The squares in the table indicate the outputs used for each arrangement. Before changing your clock, see how few diodes need to be altered.*

You will notice that only 6 diodes are required for the 10 seconds and 20 seconds timing intervals and the 7th diode is removed from the board.

There are times when a "freeze" is required, for coffee breaks, telephone calls or that unexpected problem on the layout. To achieve this, take a lead from pin 10 of the 4040 (the clock input line) to an ON/OFF switch with the other lead of the switch to earth. The switch will then freeze the clock until you need to resume timing.

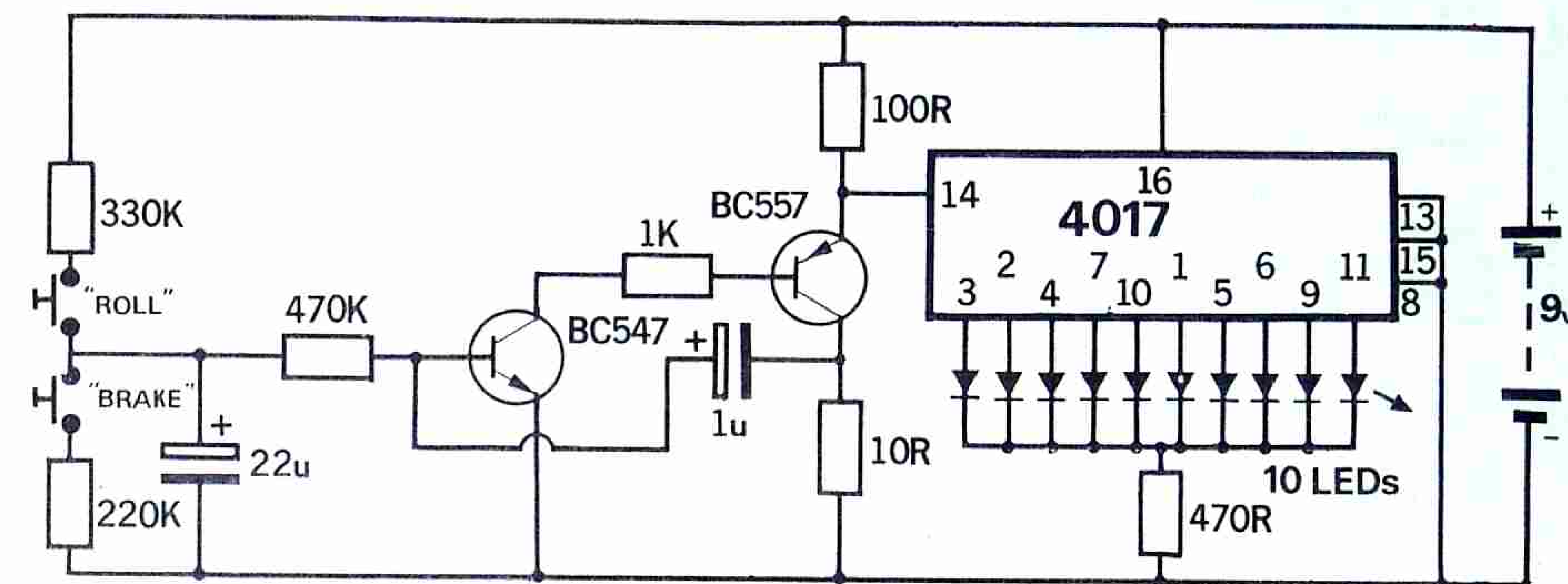
Model clocks have always been an expensive item for a layout, the parts alone have cost around $60, and until now I have been reluctant to build one. But when I realized the TE clock could be modified at little or no extra cost, I put together the arrangement just described. In fact we have two clocks in our club layout due to the size of the layout taking up two full rooms.

It's a great assistance when co-ordinating a number of operators.
I hope you find the time to add it to your layout.

# ROULED

**Parts:$4.60**
**PC board: $3.25**

-by Peter Bollinger
Nth Brighton, 5048.




**COMPLETE ROULED CIRCUIT**

This project is two ideas in one. Basically it is an electronic version of the famous game ROULETTE and we use a circle of 10 leds to simulate the ball on a roulette wheel.

The LEDs are switched on one at a time to give the effect of rotation and we have two press buttons to simulate the speeding-up or slowing-down of the ball. This gives a feeling of reality to the game and adds to the interest.

Although you cannot rig the game, a player will feel he has a degree of control over the outcome when he is in charge of the speed-up and slow-down buttons.

The LEDs gradually start up to a maximum spin rate and will come to rest after a period of time by the natural slow-down rate of the circuit. By pressing the BRAKE control, the slow down will be faster.

As the LEDs gradually lose momentum, you can visualise the ball dropping onto the wheel and bouncing from number to number as the disc gradually loses speed. Finally the ball joggles and bumps no more, to land on YOUR numbered square. As you scoop up the winnings, you wonder why you never thought of making this game before.

ROULED is constructed on a single PC board which acts as a display as well as mounting base for the components.

The rotating effect of the spot of light is most effective at night and you can hang the project in your window, facing the street, to produce an interesting effect for the passers by.

## HOW THE CIRCUIT WORKS

The circuit is made up of two sections. The transistor oscillator stage and the Decade Counter IC.

The 2 transistor feedback oscillator is a voltage controlled oscillator and can be turned on by raising the voltage on the base of transitor Q1 to about .6v. Above .65v it will become over-saturated and the oscillator will "freeze", below .5v the transistor will not be turned on. Between these narrow extremes the frequency of the oscillator will vary to provide the speed-up and slow-down feature.

To turn the oscillator ON, the 22mfd electrolytic is charged via the 330k resistor. The voltage on this reservoir capacitor is fed to the base of Q1 via a 470k separating resistor and the oscillator gradually starts up. The value of the 330k and 470k resistors have been chosen so that the oscillator does not 'jam' in the high frequency mode when the base of Q1 is nearing the high voltage level. They permit the oscillator to run up to a maximum frequency and remain at that frequency.

The oscillator has an extremely small mark-space ratioand gives a pulse to the decade counter via the emitter of Q2.

This most unusual oscillator has a very low value resistor in the collector circuit (called the LOAD resistor) and emitter circuit of the second transistor.

These values must be maintained to provide the short mark-space ratio in which the 10mfd electrolytic is charged up very quickly.

The operation of the feedback oscillator is as follows:

The BC 547 transistor is turned on via the voltage from the 470k resistor and this causes the collector-emitter voltage to be reduced to a few volts. The BC 557 becomes turned on with the action and two things occur.

The emitter voltage falls to about 3v and the collector voltage rises to about .6v. When the emitter voltage falls, this is sufficient to give a LOW to the decade counter and it advances ONE COUNT.

The rise in voltage on the 10R resistor passes via the 10mfd electrolytic to the base of the first transistor. The effect is to turn the circuit ON even harder and this produces the pulse mentioned above.

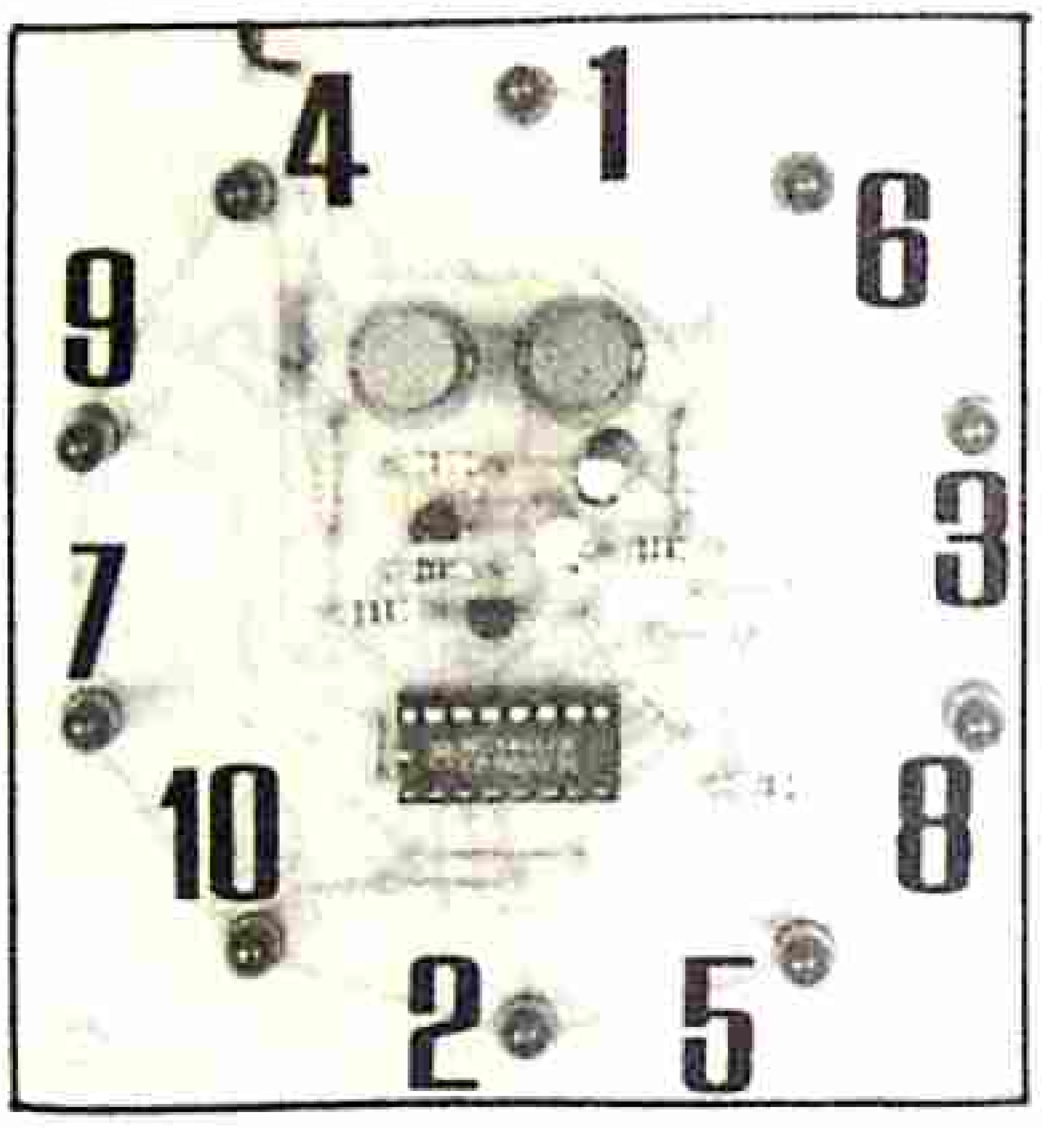
The 10mfd electrolytic is equivalent to a miniature rechargeable battery, which is charged up via the 470k resistor, when the voltage is increasing on the base of the first transistor.

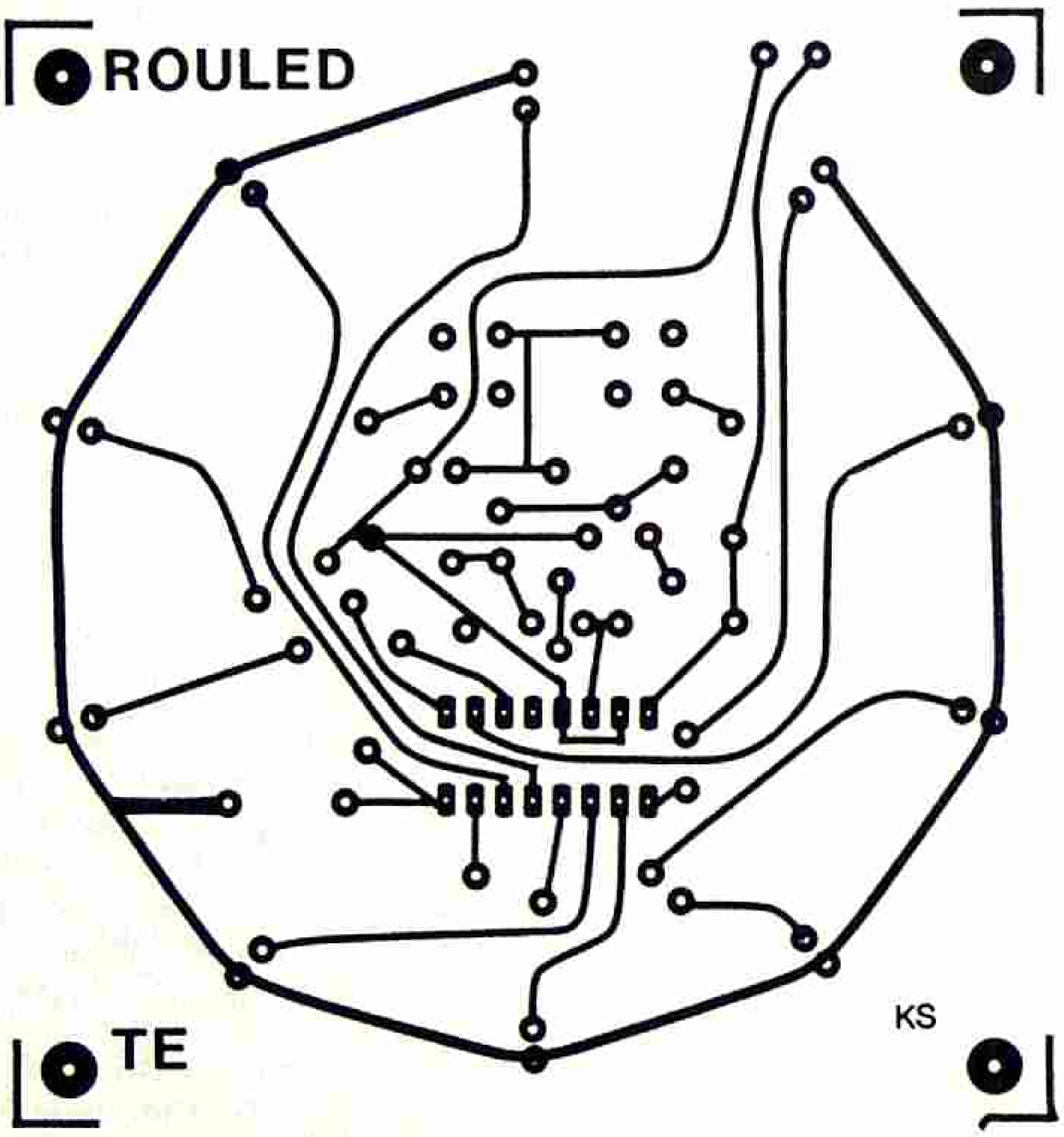
It is now 'jacked' up by about .5v and is required to deliver its energy to the first transistor. In a fraction of a second it becomes exhausted and can no longer keep the first transistor turned hard ON. The result is the transistor turns off slightly and this action is passed to the second stage and causes the two transistor circuit to become turned OFF.

The voltage on the base of Q1 increases once again via the 470k resistor and the voltage on the 22mfd storage electrolytic and the 10mfd charges up to repeat the cycle.

The output of the oscillator is the emitter of Q2 and the Decade Counter detects the pulses to illuminate one of the LEDs in the output.

With pins 13 and 15 at ground potential, the counter will cycle through its 10 outputs without freezing or resetting. Only one 470R resistor is required as a current limiting resistor for the 10 LEDs as only one of them will be on at a time.




**PARTS LIST**

1 - 10R
1 - 100R
1 - 470R
1 - 1K
1 - 220k
1 - 330k
1 - 470k

1 - 1mfd 16v electrolytic
1 - 22mfd 16v electrolytic

10 - 3mm or 5mm red LEDs

1 - BC 547 transistor
1 - BC 557 transistor
1 - CD 4017 Decade Counter IC

2 - push switches PC mount
1 - 16 pin IC socket
1 - battery snap

**ROULED PC BOARD**

## CONSTRUCTION

All the components are mounted on a printed circuit board which also acts as the back plane for the display.

The LEDs are arranged in a circle to give a rotating light effect when they are operating.

The complete electronic circuit is built in the centre of the board and this adds to the fascination of the project. You can see the amount of circuitry required to produce the running light effect.

The arrangement of parts on the board does not follow their position on the circuit diagram and you will need to go by the overlay to make sure they are soldered in the correct places.

Start with the IC socket and place the identification mark on the socket over the dot on the board to identify pin 1 on the chip.

Add the resistors and electrolytics as per the overlay. You will now have some short lengths of wire from the resistors which you can turn into 6 bridges.

The two push buttons are fitted with their flats towards the top of the board however they will work if fitted in any position as we are using the diagonally opposite contacts of the switch.

Fit the BC 547 and BC 557 transistors and finally solder the ring of 10 LEDs around the edge of the board making sure the cathode leads always face the outer edge of the board.

Fit the IC into the socket, add the battery snap and the project is ready for operation.

## IF THE CIRCUIT DOESN'T WORK

Since the circuit is divided into two sections, each can be tested separately.

The transistor stage can be given a readout in the form of a LED connected in series with the 100R resistor and this will show if the oscillator is functioning.

This is where you start. Remove one end of the 100R resistor and connect a light emitting diode with the cathode facing towards the negative terminal of the battery. Don't go by the long and short lead of the LED as some are cut in a non-conventional way. Look inside the LED and locate the larger of the two lands. This will be the cathode.

Connect the battery and the LED will flash when the ROLL button is pressed. The flash rate will increase as the voltage on the base of Q1 increases. If the LED does not come on, the problem will lie in the transistor oscillator circuit.

To check the operation of this circuit, it will be necessary to convert it to a non-feedback situation. In other words, remove the 1mfd electrolytic to leave a 2-transistor DC coupled amplifier. Press the ROLL button and the LED will gradually come on. By pressing the BRAKE button, the LED will gradually go out. If this does not happen, check that Q1 is an NPN transistor and Q2 a PNP transitor. Check the PC board for dry joints and make sure you have the 100R, 10R and 1k resistors in their correct places.

A 4k7 resistor placed between the collector and emitter terminals of Q1 will turn the LED ON. If this does not happen, Q2 may be faulty.

Connect a jumper lead between the base of Q1 and the join of the 470k resistor and 22mfd electrolytic, and the positive rail. This will turn on the LED. If this does not occur, transistor Q1 may be faulty.

The second part of the circuit is the CD 4017 Decade Counter.

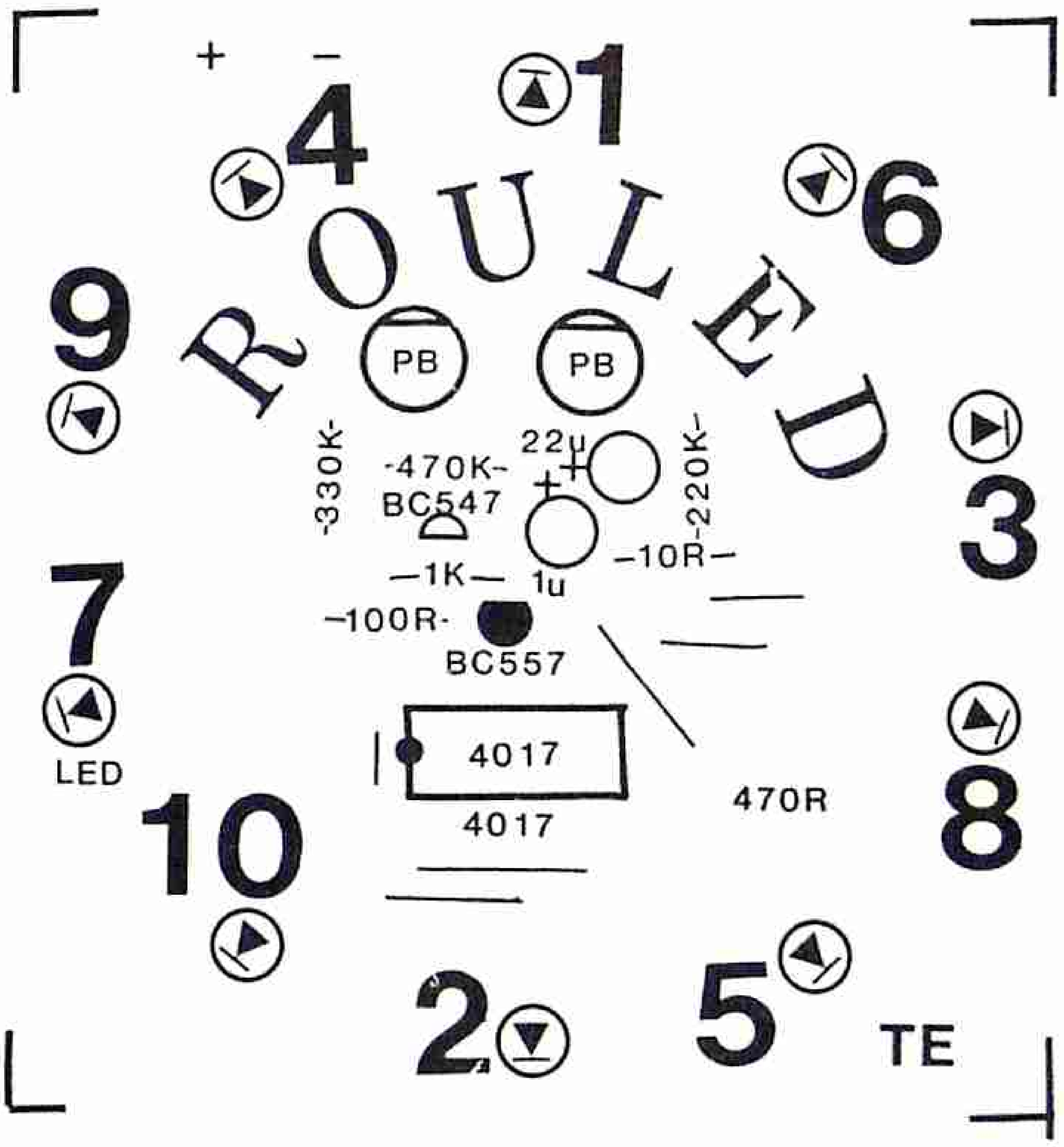
To be able to test this section, the oscillator stage must be operating. You can leave the test LED in series with the 100R resistor as an indication that pulses are being passed to the counter chip. Every time the test LED flashes, the outputs of the counter should advance.

If the first output is illuminated and it does not advance to the next output, the problem will either be the 4017 chip or the voltage levels on pins 13 and 15. Both of these pins should be LOW for the counter to advance.

If NO LEDs are illuminated, the power to the chip may be missing from pin 16 or the 470R resistor may be open or have a dry joint.

When all these areas are checked, the circuit should operate perfectly. The only other point to note is the voltage level on the base of Q1. If the voltage rises too high of falls too low, the oscillator will cease to function. The 330k supply resistor may have to be increased if the circuit 'locks-up' or 'freezes'.

I hope you have as much fun with your model as we had with ours. The only thing we do ask: Don't start placing bets on it!

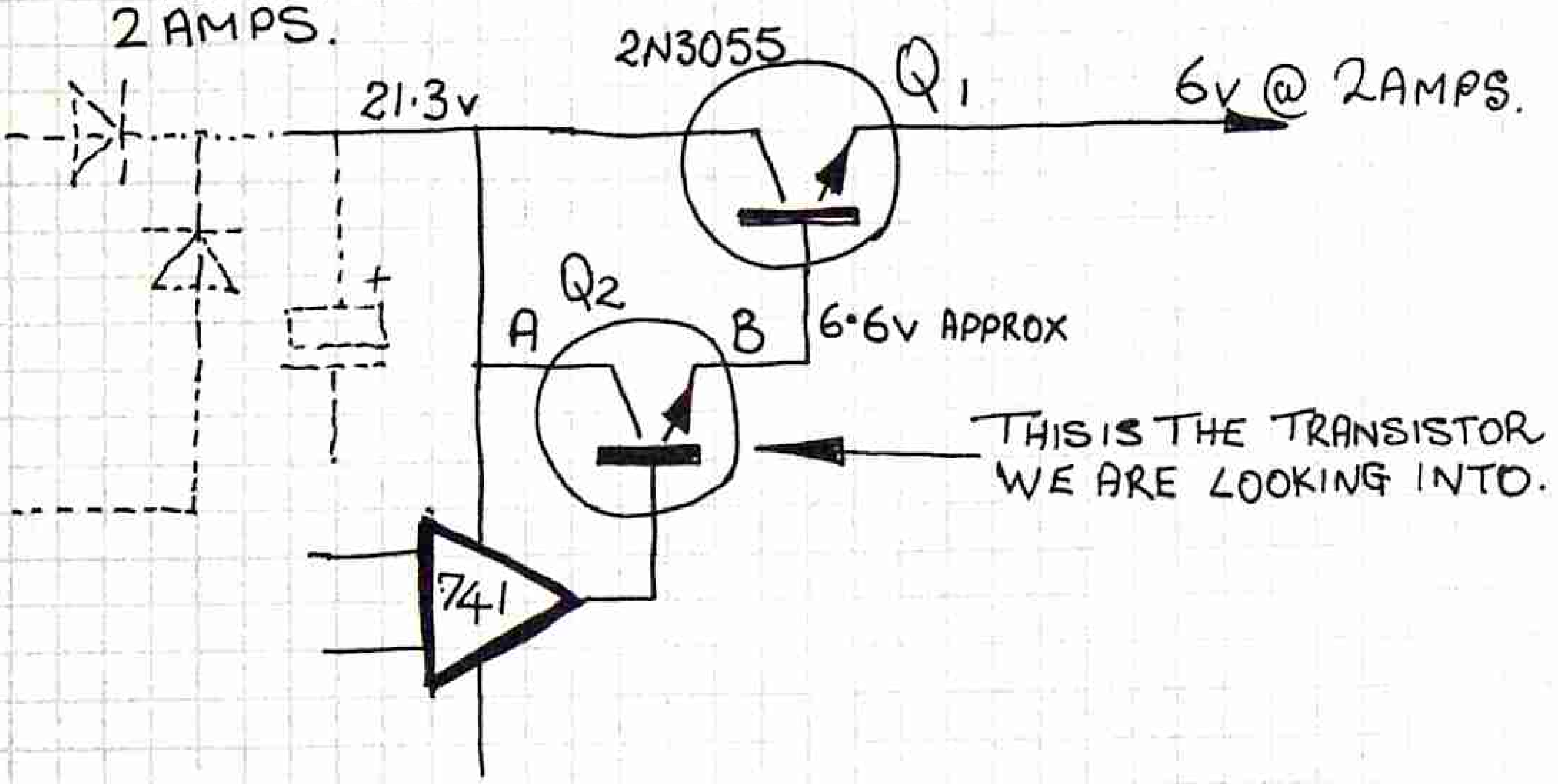


# THE DRIVER TRANSISTOR

— by G.T. Dicker

THE PREVIOUS PAGE CONTAINED A SLIGHT MISTAKE IN THE POWER SUPPLY CIRCUIT DIAGRAM.
THE BC547 CURRENT AMPLIFYING TRANSISTOR WILL WORK BUT ITS ABILITY TO DISSIPATE THE POWER WILL BE INADEQUATE.
HERE'S WHY:

TAKING THE CASE WHERE THE GREATEST POWER IS BEING DISSIPATED (LOST) IN THE SERIES PASS TRANSISTOR $Q_1$ (2N3055), THE CURRENT AMPLIFYING TRANSISTOR $Q_2$ ALSO HAS THE GREATEST LOSS — THIS APPLIES WHEN THE OUTPUT IS 6 VOLTS AND THE CURRENT 2 AMPS.



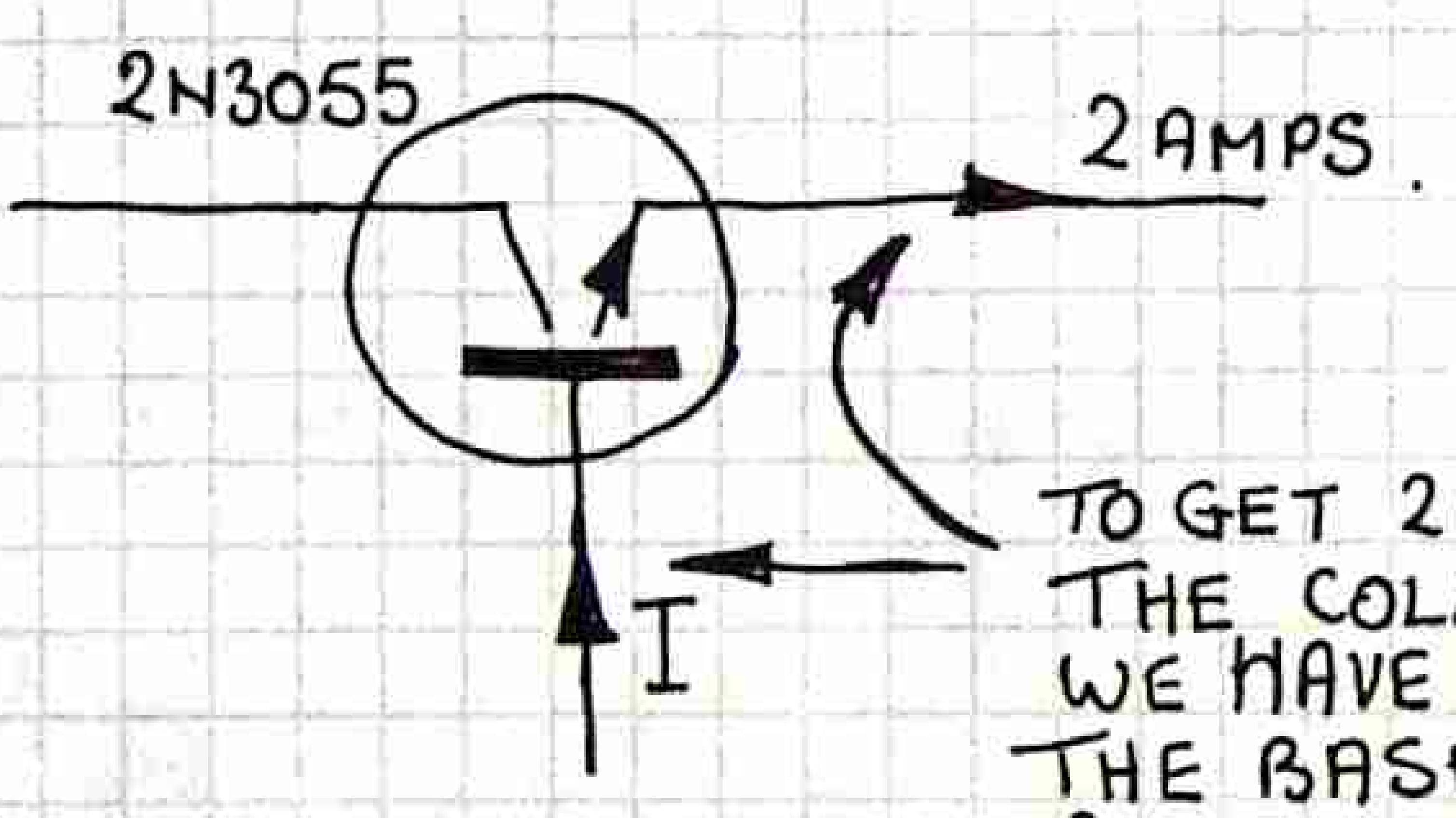

USING A 15v-0-15v TRANSFORMER & 2 DIODES, THE VOLTAGE-OUT FROM THE DIODES WILL BE:

$$= \cdot 71 \times 30$$
$$= 21{\cdot}3 \text{ VOLTS.}$$

THE VOLTAGE BETWEEN POINTS A & B WILL BE:

$$= 21{\cdot}3 - 6{\cdot}6$$
$$= 14{\cdot}7 \text{ VOLTS.}$$

THE DRIVING CURRENT FOR $Q_1$ WILL BE:




TO GET 2AMPS TO FLOW THROUGH THE COLLECTOR-EMITTER CIRCUIT WE HAVE TO PROVIDE CURRENT INTO THE BASE CIRCUIT. THE AMOUNT OF BASE CURRENT WILL DEPEND ON THE "GAIN" OF THE TRANSISTOR.

FOR A 2N3055 ITS GAIN IS ABOUT 10-100 THIS MEANS WE NEED ONLY ABOUT 1/10 OR 1/100 OF 2 AMPS INTO THE BASE TO GET 2 AMPS TO FLOW IN THE COLLECTOR CIRCUIT.

∴ BASE CURRENT:

$$= \frac{2\text{ AMPS}}{\text{GAIN OF THE TRANSISTOR}}$$

$H_{FE}$ IS THE GAIN & WE WILL CHOOSE A VALUE OF 20.

$$= \frac{2}{20}\text{ AMPS}$$

$$= \frac{1}{10}\text{ AMP} = 100\text{ mA}.$$

THIS CURRENT MUST BE SUPPLIED BY $Q_2$.

THE POWER DISSIPATED BY $Q_2$:

[POWER = VOLTS x AMPS]

$$= 14{\cdot}7 \times {\cdot}1 \text{ WATTS}$$

$$= 1{\cdot}47 \text{ WATTS.}$$

CLEARLY THIS IS GREATER THAN THE ABILITY OF A BC547 AS IT CAN ONLY DISSIPATE 500mW. — WITH A HEATSINK IT CAN BE UP-RATED TO ABOUT 1 WATT BUT TO BE ON THE SAFE SIDE IT IS ADVISABLE TO USE A TRANSISTOR SUCH AS BC139 OR TIP 32 AS THESE HAVE A METAL FLANGE WHICH CAN BE BOLTED TO A HEATSINK.

THE MINIMUM POWER DISSIPATED BY $Q_2$ WILL OCCUR WHEN THE OUTPUT IS 15V. FOR THIS CASE THE LOSSES IN $Q_2$ WILL BE:

$$= 21{\cdot}3\text{v} - 15{\cdot}6\text{v}$$
$$= 5{\cdot}7\text{v.}$$

POWER DISSIPATED BY $Q_2$ WILL BE:

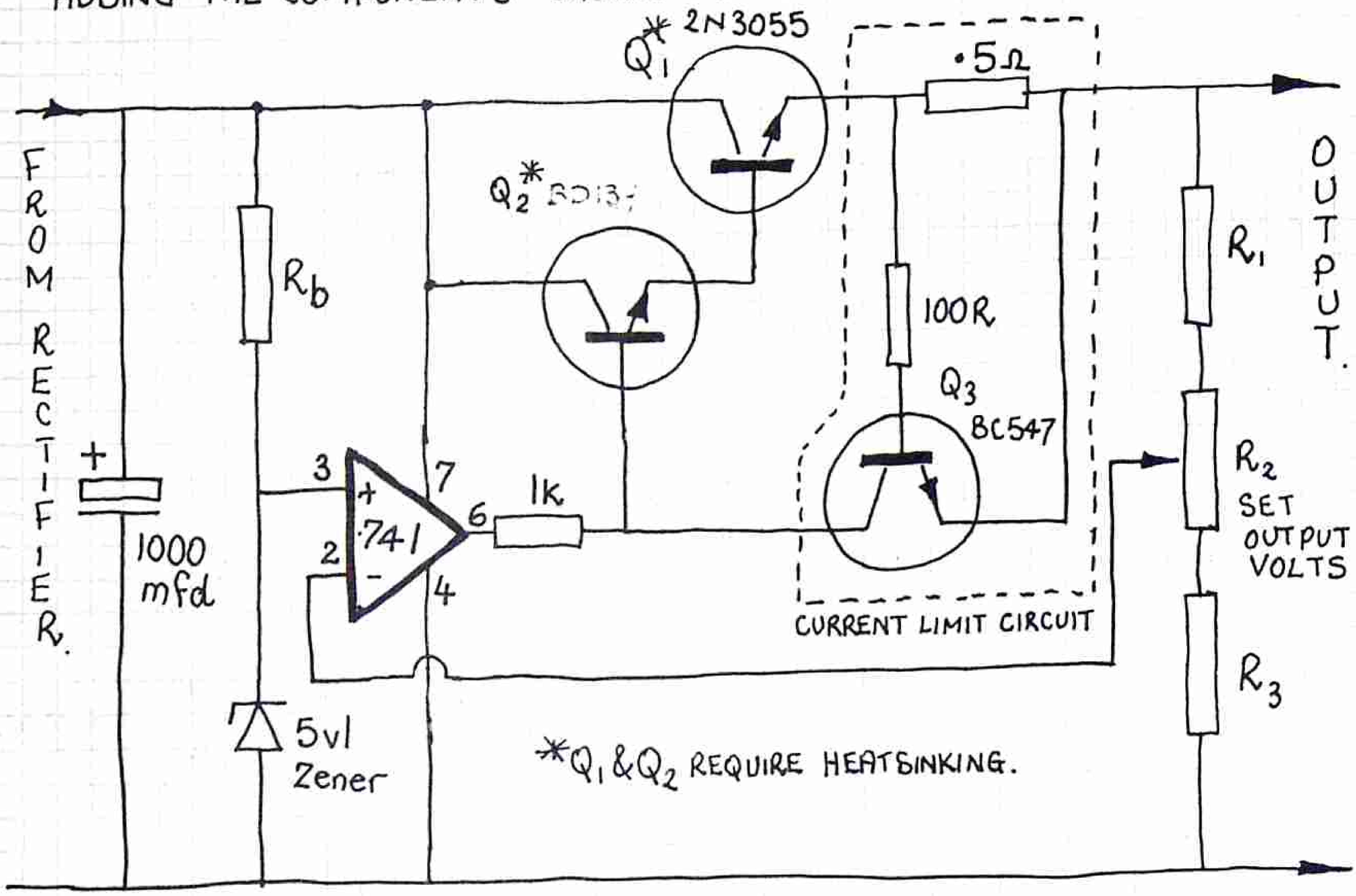
$$= 5{\cdot}7 \times {\cdot}1$$
$$= {\cdot}57 \text{ WATTS.}$$

THIS SHOWS THAT AS THE OUTPUT VOLTAGE IS REDUCED FROM 15V TO 6V, THE POWER LOST IN $Q_1$ & $Q_2$ INCREASES.

THIS SEEMS LOGICAL. THE TRANSFORMER & RECTIFIER ARE SUPPLYING A CONSTANT AMOUNT OF ENERGY. IF THIS POWER IS NOT BEING USED BY THE LOAD, IT MUST BE LOST IN THE REGULATING NETWORK.

# CURRENT LIMITING

THE NEXT STAGE IN POWER SUPPLY DESIGN IS TO LIMIT THE OUTPUT CURRENT DURING SHORT-CIRCUIT CONDITIONS. THIS IS ACHIEVED BY ADDING THE COMPONENTS SHOWN IN THE DOTTED BLOCK:




POWER SUPPLY WITH CURRENT LIMITING.

THE MAXIMUM OUTPUT CURRENT IS DETERMINED BY THE ·5Ω. A 1Ω RESISTOR WILL GIVE A 500mA SUPPLY, ·5Ω GIVES A 1 AMP SUPPLY & ·25Ω GIVES A 2 AMP SUPPLY (APPROX.)

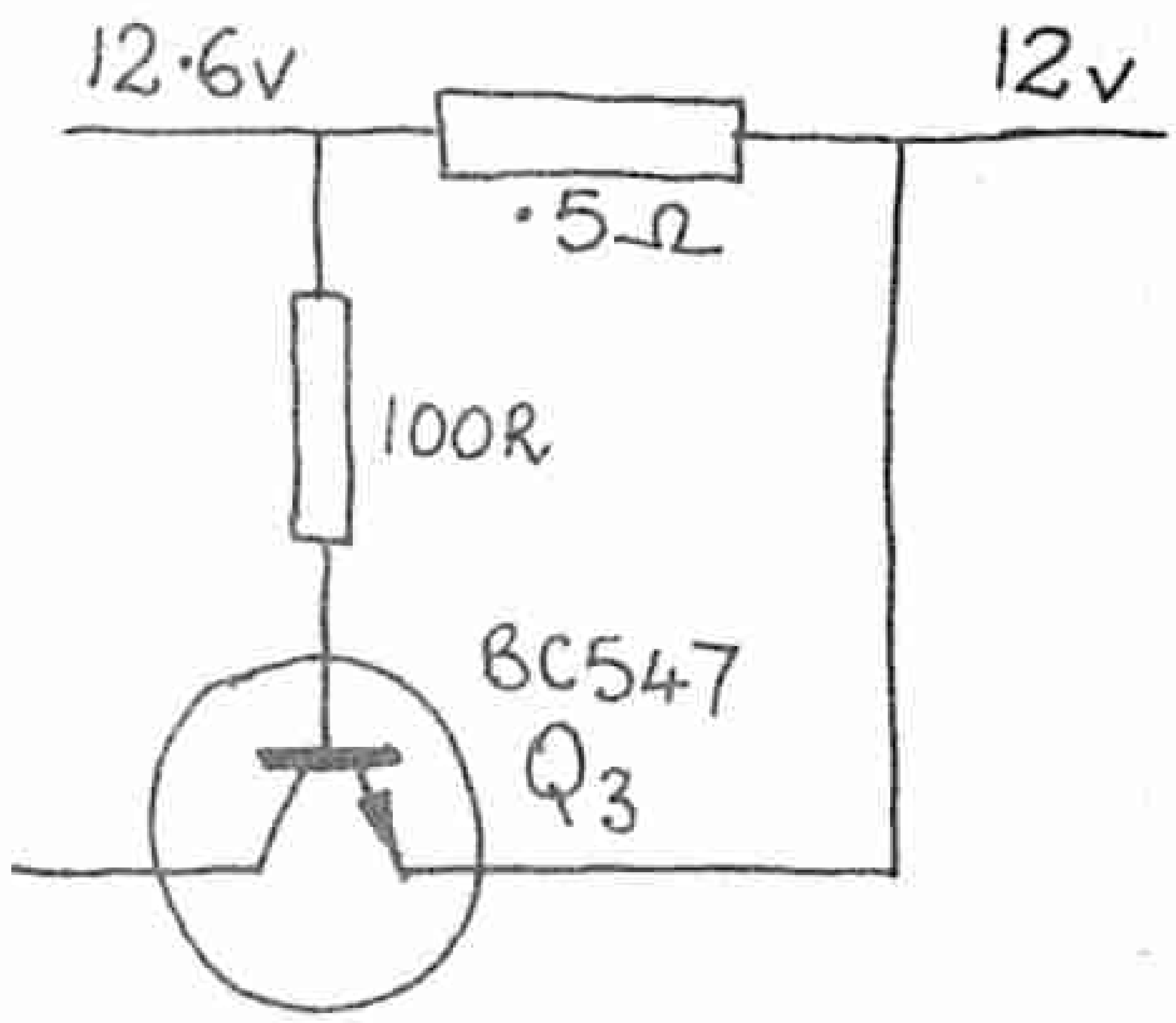
DURING NORMAL OPERATION (UP TO ABOUT 1AMP WITH THE ·5Ω RESISTOR) THE CURRENT LIMITING CIRCUIT DOES NOT COME INTO OPERATION AT ALL. ITS ONLY EFFECT IS THE ·5v DROP ACROSS THE ·5Ω RESISTOR. BUT THIS ·5v DROP IS TAKEN INTO ACCOUNT BY THE SENSING CIRCUIT BECAUSE THE OUTPUT VOLTAGE IS DETECTED AFTER ALL THE DROPS IN VOLTAGE HAVE TAKEN PLACE IN THE REGULATING COMPONENTS.

WHEN THE CURRENT RISES OVER 1 AMP, TO SAY 1·2 AMP, THE VOLTAGE ACROSS THE ·5Ω RESISTOR INCREASES TO ·6V AND IS PASSED TO Q3 WHERE IT APPEARS BETWEEN THE BASE & EMITTER LEADS. THIS VOLTAGE WILL BEGIN TO TURN THE TRANSISTOR ON SO THAT THE VOLTAGE AT THE COLLECTOR WILL BE DRAWN DOWN SLIGHTLY. THIS IS DUE TO Q3 BECOMING EQUIVALENT TO A LOW-VALUE RESISTOR, & THE EMITTER VOLTAGE (WHICH IS EQUAL TO THE OUTPUT VOLTAGE OF THE POWER SUPPLY) WILL BE LOWER THAN THE VOLTAGE ON BASE OF Q2

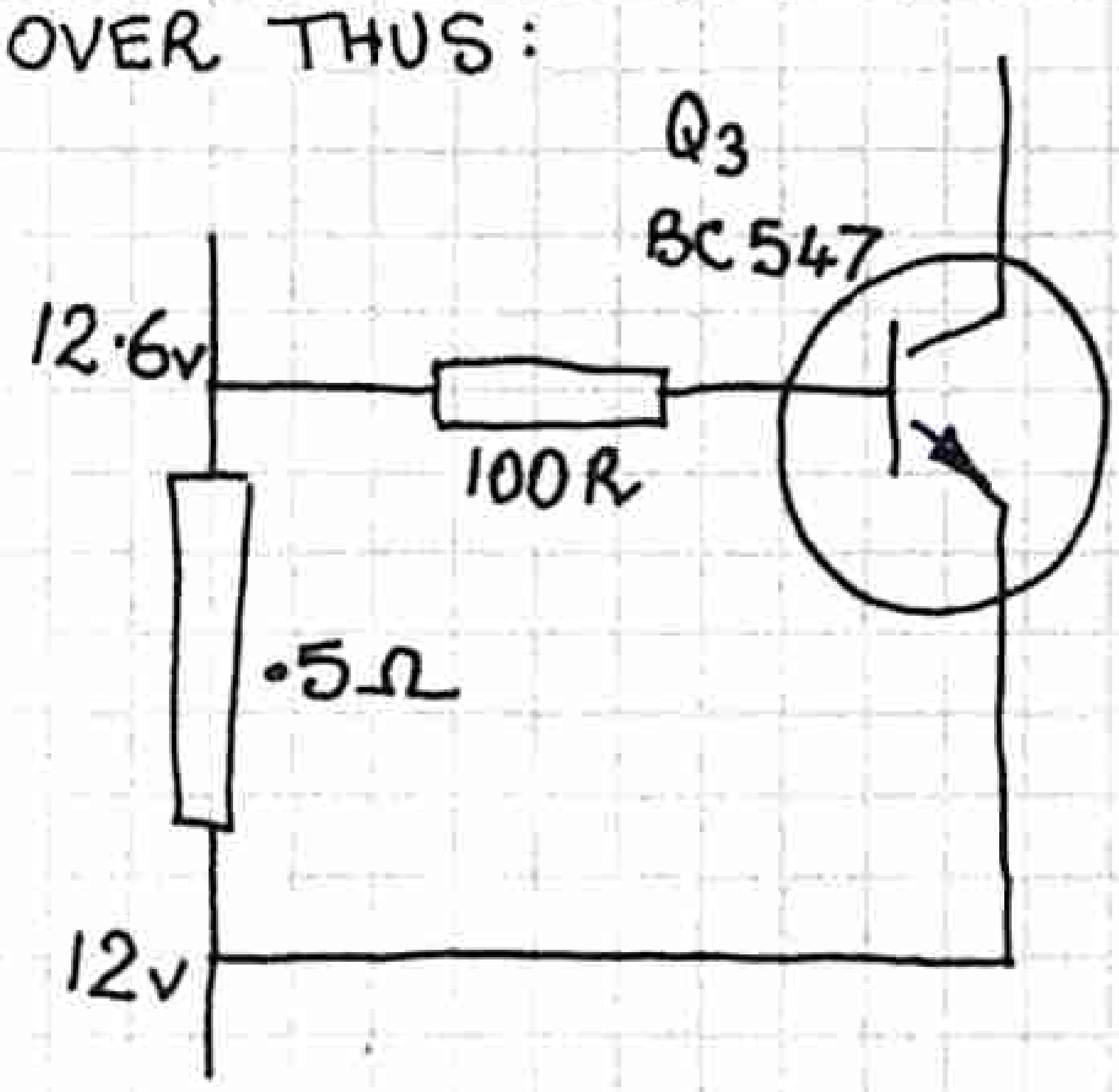
THE 100R RESISTOR IN THE BASE LINE ALLOWS THE CURRENT-LIMIT TRANSISTOR TO OPERATE IN ITS FULL SATURATION MODE WITHOUT BEING OVER-STRESSED WITH AN EXCESS BASE-EMITTER VOLTAGE WHICH MAY OCCUR WHEN HIGH CURRENTS FLOW THROUGH THE •5Ω RESISTOR.

## HOW THE CURRENT-LIMIT TRANSISTOR WORKS

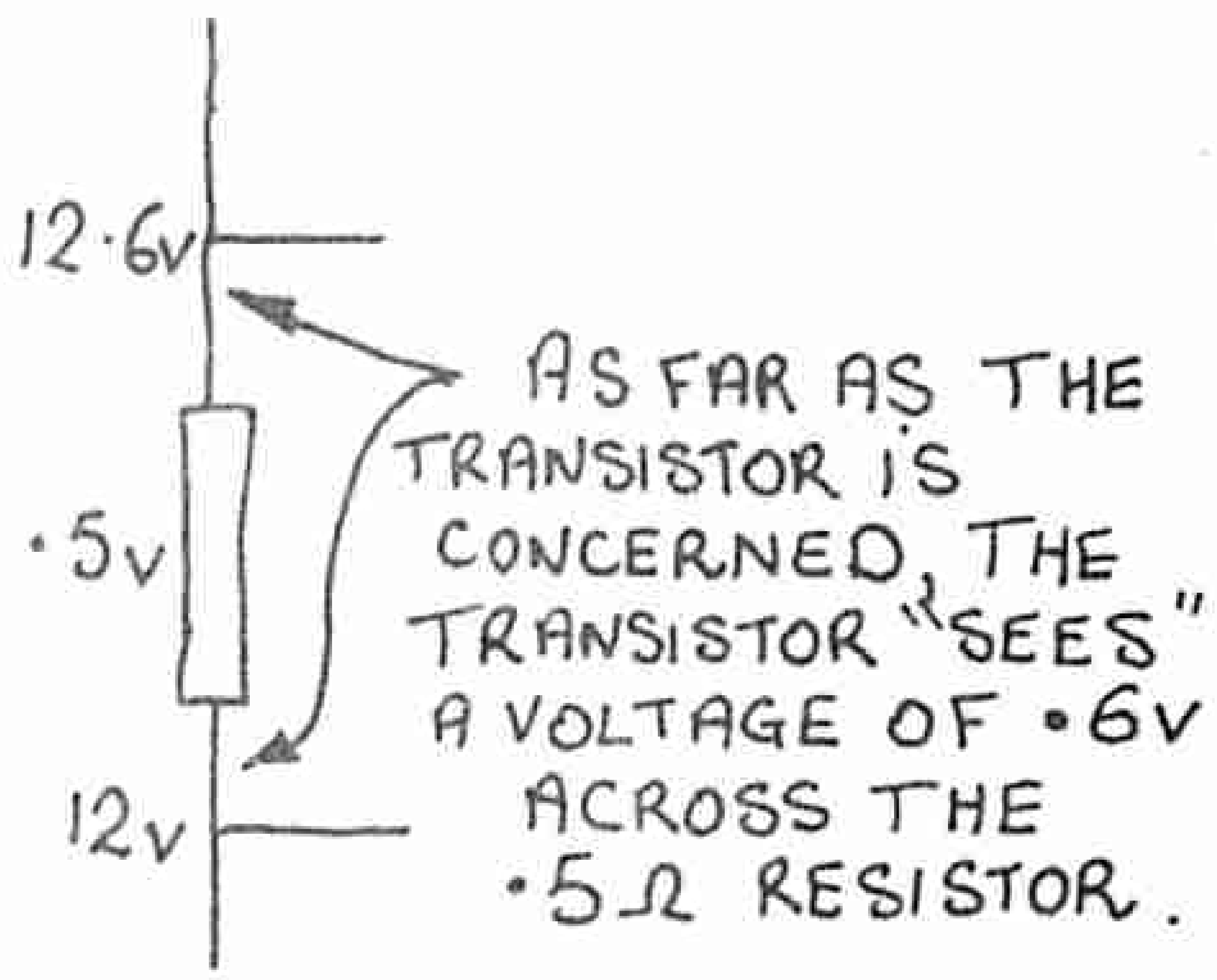
THIS TRANSISTOR CAN BE CONSIDERED AS A COMPLETELY SEPARATE CIRCUIT. TO MAKE IT EASY TO FOLLOW THE OPERATION OF THE CIRCUIT WE WILL TURN IT AROUND & OVER THUS:

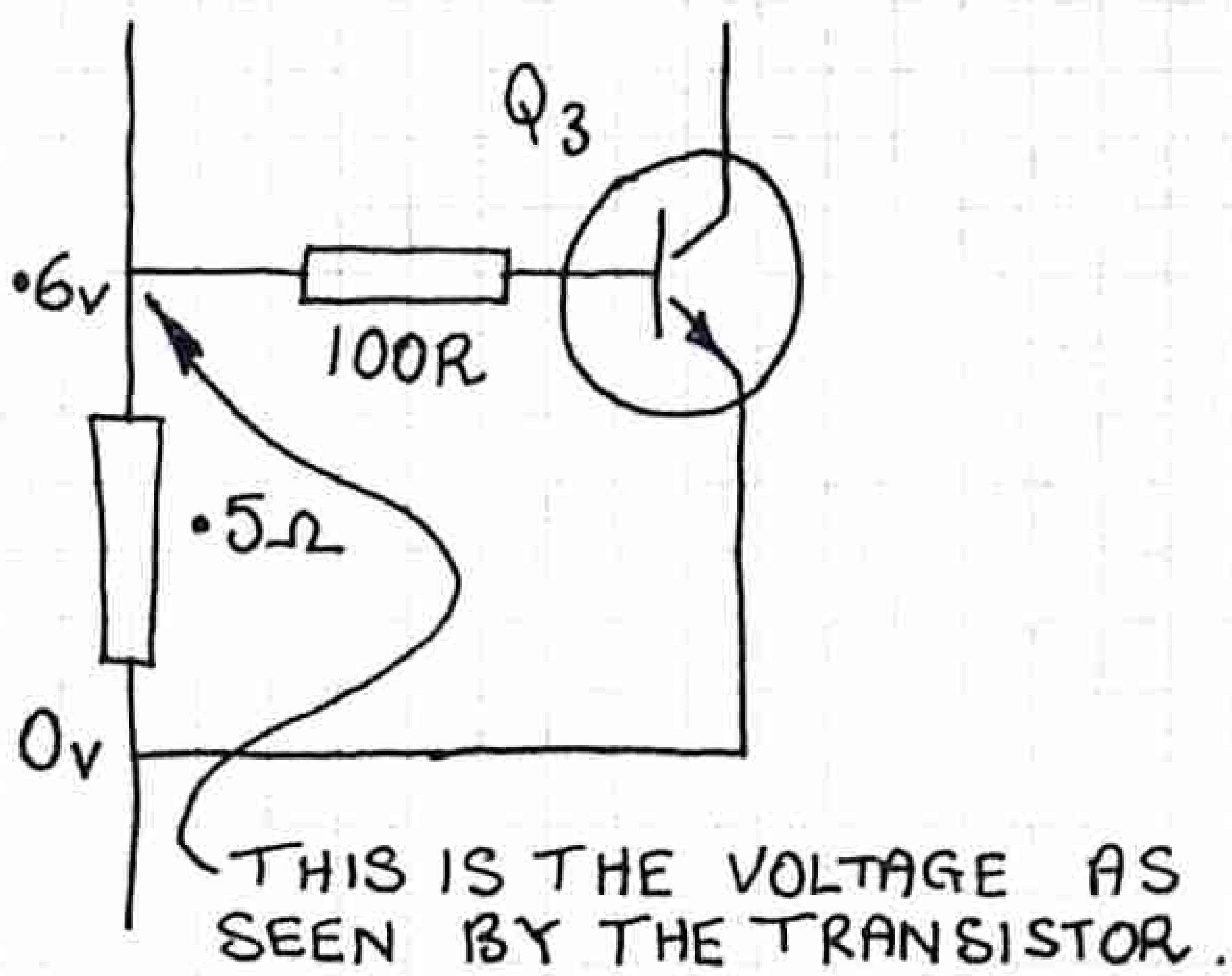



THE CURRENT-LIMIT CIRCUIT EXTACTED FROM THE PREVIOUS DIAGRAM.




THE SAME CIRCUIT TURNED AROUND TO MAKE IT EASIER TO SEE HOW THE TRANSISTOR IS OPERATING.




THE TRANSISTOR "SEES" •6v ON ITS BASE (WITH RESPECT TO THE EMITTER LEAD) AND THIS IS ALL THAT MATTERS TO THE TRANSISTOR. YOU WILL NOW BE ABLE TO SEE WHY THE TRANSISTOR TURNS ON. THE 100R RESISTOR IS ONLY A BUFFER RESISTOR TO PREVENT EXCESS CURRENT FLOWING THROUGH THE BASE CIRCUIT WHEN THE POWER SUPPLY IS IN SHORT-CIRCUIT CONDITIONS.
THE 100Ω RESISTOR CAN BE INCREASED TO 1K WITHOUT AFFECTING THE OPERATION OF THE CIRCUIT — THAT'S WHAT WE MEAN BY A BUFFER RESISTOR.

## THE OPERATION OF THE OP-AMP

WHEN THE OUTPUT CURRENT INCREASES, THE OUTPUT VOLTAGE WILL DROP SLIGHTLY (DUE TO THE DROP ACROSS THE ·5Ω RESISTOR) AND THE OP-AMP WILL BE TURNED ON HARDER. DURING AN OVERLOAD CONDITION THE OP-AMP WILL BE DRIVING THE BASE OF $Q_2$ FULLY & TO PREVENT THE OP-AMP BEING DAMAGED WHEN THE OUTPUT IS SHORT-CIRCUITED, WE HAVE ADDED A 1K RESISTOR (TO OUTPUT PIN Nº6)

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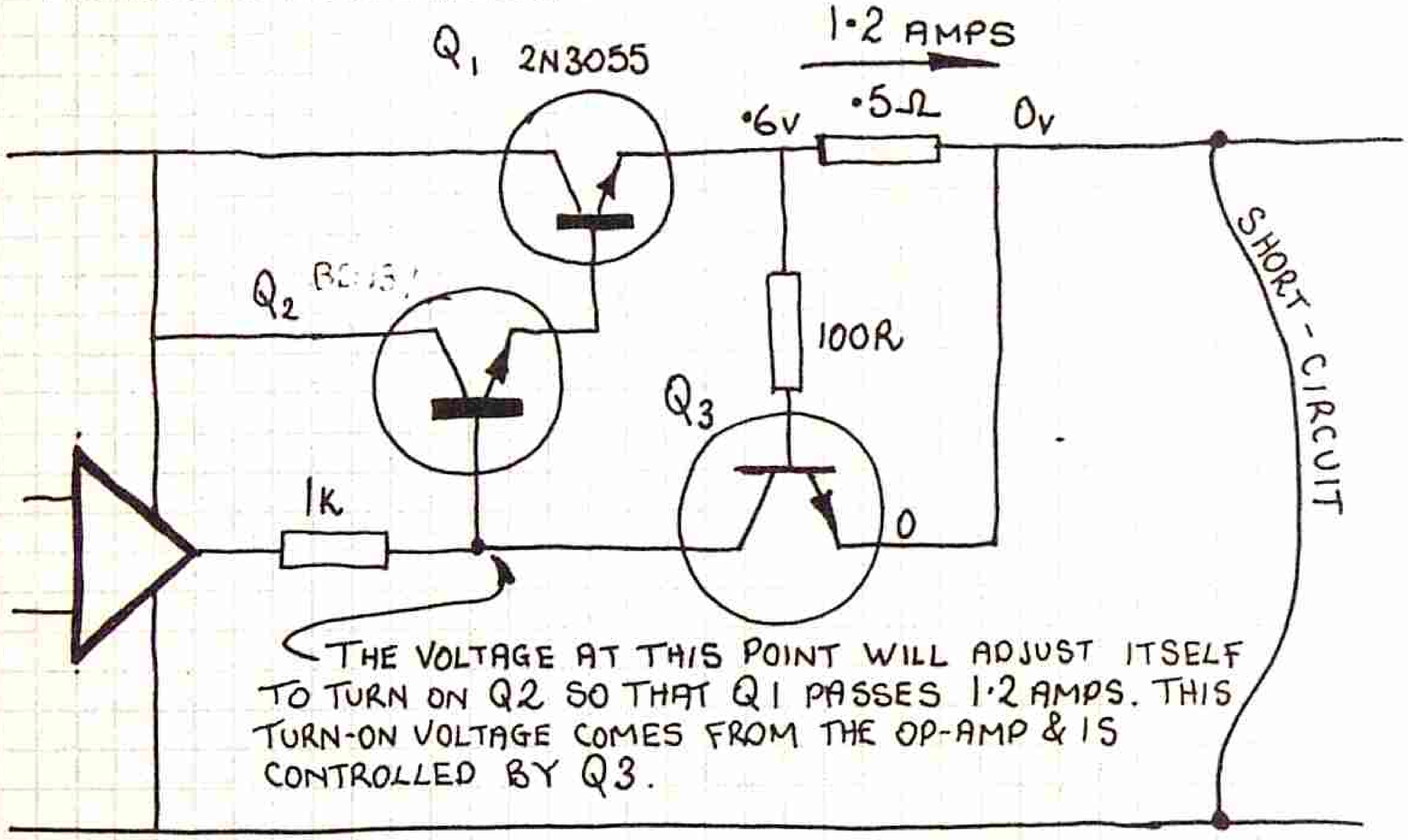
THE CURRENT-LIMITING CIRCUIT WILL BE ESPECIALLY APPRECIATED WHEN A SHORT-CIRCUIT OCCURS AS IT WILL LIMIT THE CURRENT TO ABOUT 1·2 AMPS. WITHOUT THIS CIRCUIT THE CURRENT WOULD BE CONSIDERABLY GREATER AND MAY BE EVEN 3 – 4 AMPS DEPENDING ON THE ABILITY OF THE TRANSFORMER TO SUPPLY THE CURRENT.

## THE OPERATION OF THE CURRENT LIMITER

WHEN THE OUTPUT IS SHORT-CIRCUITED A CURRENT OF ABOUT 1·2 AMPS WILL BE FLOWING IN THE ·5Ω RESISTOR TO KEEP THE CURRENT-LIMITER TRANSISTOR IN OPERATION.




THE POWER SUPPLY IN SHORT-CIRCUIT CONDITIONS.

THIS MEANS THE SERIES-PASS TRANSISTOR Q1 WILL BE DISSIPATING A VERY HIGH WATTAGE (WHICH WILL BE EVEN HIGHER THAN ITS NORMAL OPERATING DISSIPATION). FOR THIS REASON AN IMPROVED SHUT-DOWN IS REQUIRED TO LIMIT THE LOSSES IN THE REGULATOR WHEN THE OUTPUT IS SHORT-CIRCUITED.

# ELECTRONIC TRIP

FINALLY WE COME TO THE MOST IMPORTANT FEATURE OF ALL...., AN ELECTRONIC TRIP WHICH TURNS THE POWER SUPPLY OFF WHEN EXCESS CURRENT IS DRAWN OR A SHORT-CIRCUIT OCCURS. THE ADVANTAGES OF A SHUT-DOWN SUPPLY ARE:

1. REDUCES THE HEAT BUILD-UP IN THE POWER TRANSISTOR.
2. REDUCES THE OVERLOADING ON THE TRANSFORMER.
3. REDUCES THE RISK OF BURN OUT AND/OR FIRE IN THE POWER SUPPLY

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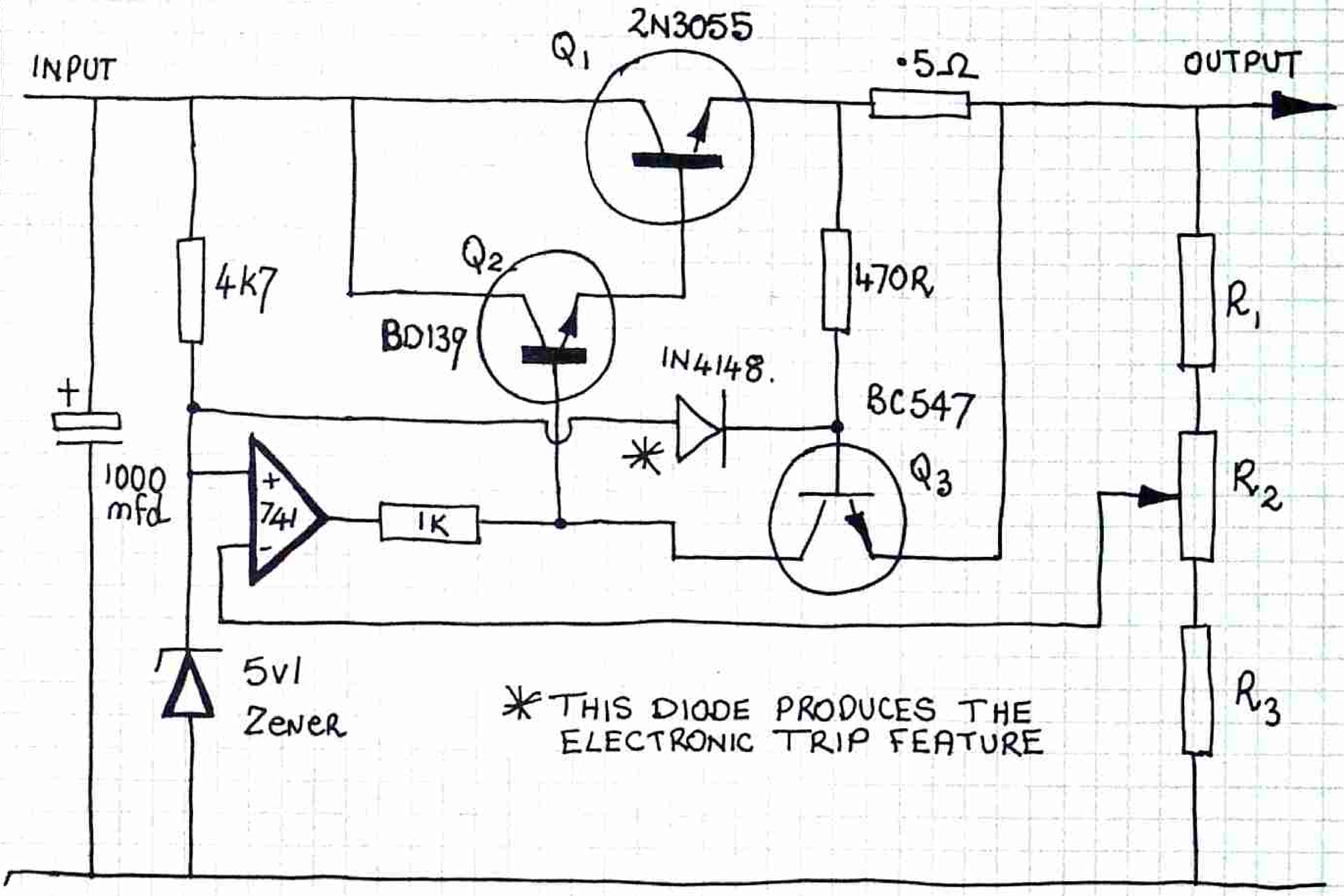
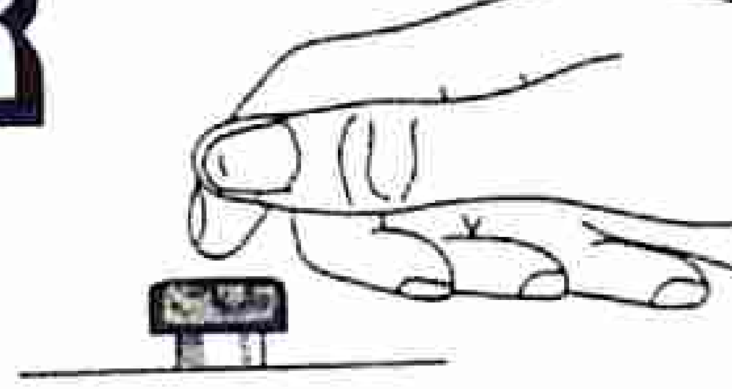
TO ACHIEVE THIS SHUT-DOWN CONDITION ONLY 1 COMPONENT IS NEEDED. A DIODE IS PLACED BETWEEN THE REFERENCE ZENER & THE BASE OF THE CURRENT LIMITING TRANSISTOR

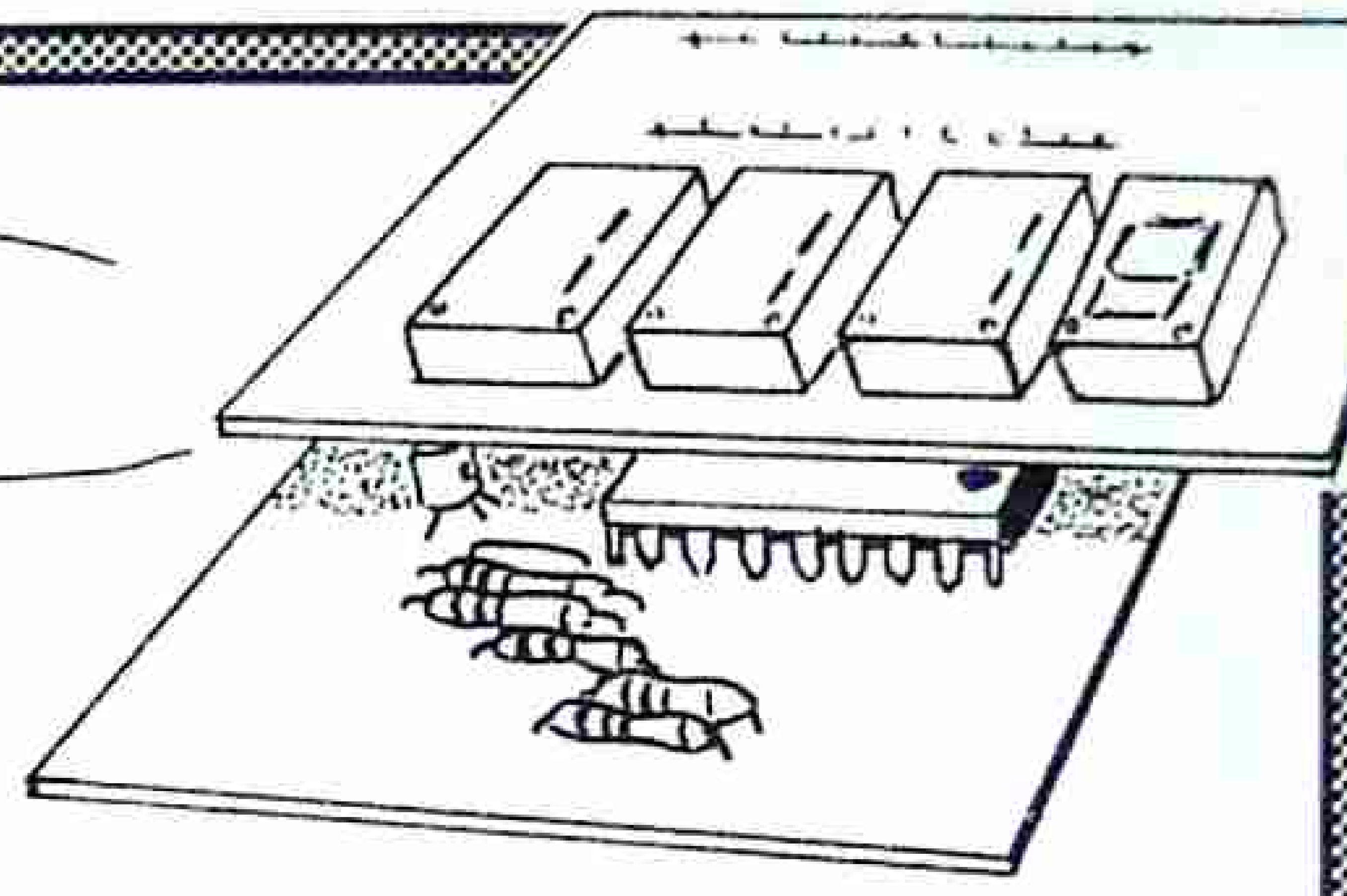



1AMP POWER SUPPLY WITH ELECTRONIC TRIP

THE ELECTRONIC TRIP WILL ONLY COME INTO OPERATION WHEN THE VOLTAGE ON THE BASE OF Q3 IS BELOW THE ZENER REFERENCE VOLTAGE. WHEN THIS OCCURS THE TURN-ON VOLTAGE FOR THE LIMITING TRANSISTOR DOES NOT COME FROM FROM THE VOLTAGE DROP ACROSS THE •5Ω RESISTOR BUT FROM THE "BLEED CURRENT" KEEPING THE ZENER IN BREAKDOWN. IN SHUT-DOWN THE OUTPUT CURRENT FALLS TO A FEW mA & WILL START-UP WHEN THE SHORT IS REMOVED

# COUNTER MODULE

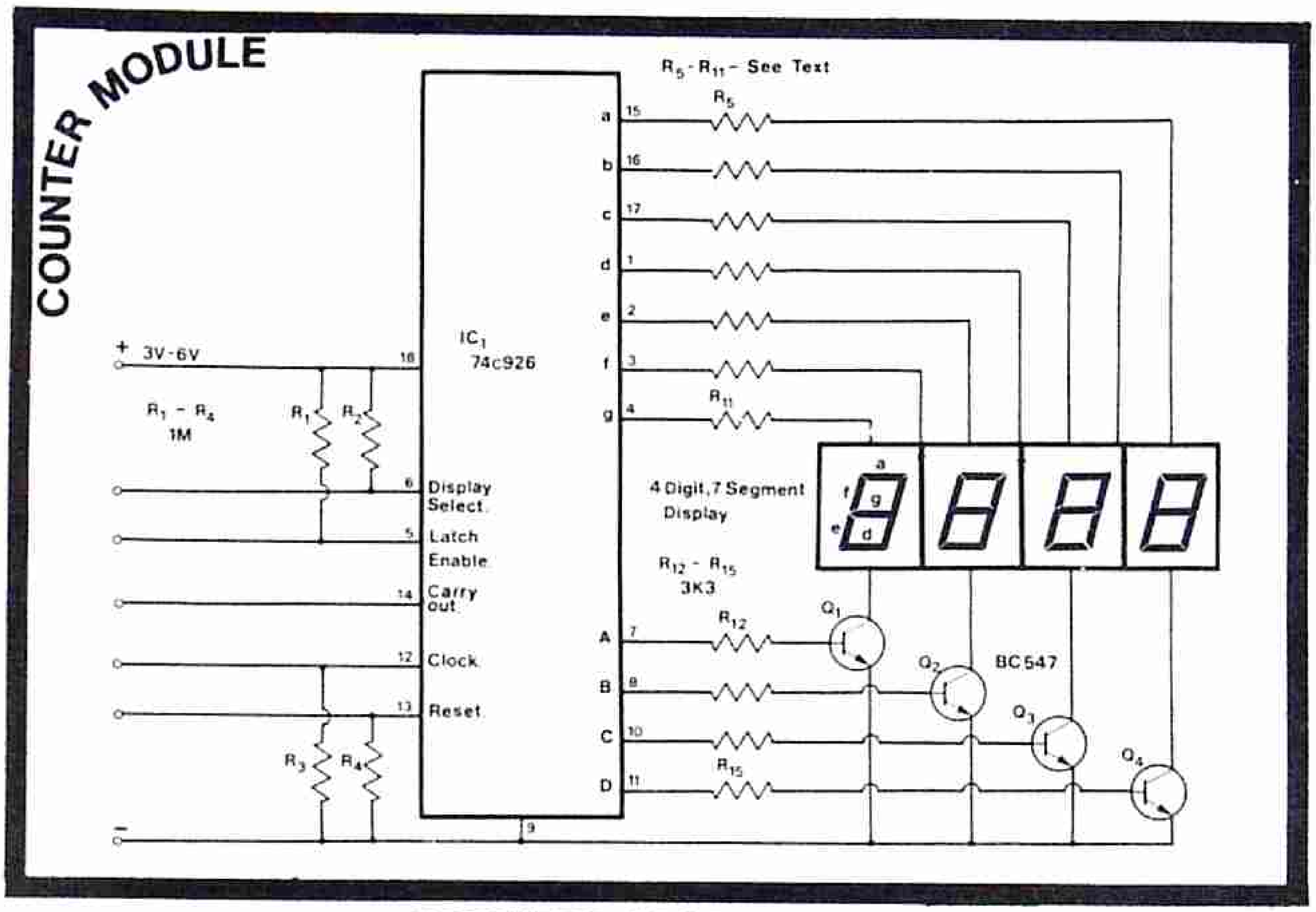




Our COUNTER MODULE project from issue 2 has been a constant seller and aroused a considerable amount of interest from various groups . . . mainly those working in special fields such as counting and measuring.

**Part III**

## ADDING A UNIT COUNT




**COUNTER MODULE CIRCUIT**

One of our readers bought 10 Counter Module kits, saying it was one of the cheapest he had seen. As it turned out, he managed a fabric dyeing business in which the fabric needed to be cut into 500-metre lengths as it came out of the drying cabinets. Up to now they had used mechanical counters which were pulsed from one of the output shafts of the winding machine. The only problem with a mechanical counter is its eventual failure.

Each counter cost them over $90 and their life was between 1 and 3 years.

Our counter, with a HALL EFFECT sensor or reed switch, will last over 10 years and it costs less than $30!

The customer converted the whole plant in less than a week and saved the probable frustration of finding another worn out counter.

Another reader writes musical scores for movies. He adapted the counter to count the movie frames and thus sync his music to the film.

There has also been instances of uses in other fields of counting such as white-line counting on country roads, coil winding and parts counting. No doubt there have been other applications which haven't been related back to us. And possibly there will be new applications to come.

In our initial design, we used an AND display for the readout. This was mainly chosen for its neat appearance, ease of insertion and simplicity of design. It was also pointed out to us that if we used this type of display in the project, it would be imported in larger quantities and the price would come down.

With devaluation and rising costs, not only did the price rise astronomically, but the lead time for ordering quantities, become longer and longer.

The display finished up rising over 50% and with only a couple of distributors handling the product. As this state of affairs is against our policy, we decided to alter the readout to accept a set of standard 7-segment displays.

We have chosen TEXAS INSTRUMENTS TIL 313 displays as they are one of the cheapest and best available.

The ADD-ON feature of the UNIT COUNTER has been designed around two different circuits. Both are Schmitt Triggers with one being an IC arrangement and the other composed of discrete transistors and

resistors. They both produce equally reliable results and for those who like transistor arrangements, the 2-transistor version is very effective. In our prototype, we used an experimenter board and mounted the components on the top of the board. This is by far the quickest and easiest method of assembly as you can prepare the whole circuit without having to turn the board over.

We found the transistor Schmitt Trigger to be completely free of bounce and is possibly the cheaper and better of the two designs.

## MULTIPLEXING

A full definition of Multiplexing can be difficult to understand. In simple terms it is the transmission of a number of pieces of information at the same time.

This usually requires some form of coding and you will see how this is achieved in our project, after you read the following:

Looking at the 4 displays, you will notice they are each capable of illuminating 7 segments. Each display can create the numbers 0 - 9 and all the segments are illuminated when the figure 8 is showing.

On the four displays, this will make a total of 28 segments.

To wire up a display of this nature you would naturally consider the simplest approach. This would involve connecting a lead to the cathodes of each LED in the 28 segments to create a common cathode terminal. You now require 28 leads for the anodes of each LED, making a total of 29 leads. This will allow access to each LED and enable any number or combination of segments to be illuminated.

That's the simple appproach.

But the clever electronics design engineers have reduced the number of input lines to 11. To understand how this has been achieved, you will have to change your thinking on how displays are illuminated.

In this project the displays are not supplied with a constant DC voltage but a set of pulses which creates a scanning effect, just like the screen of a television set.

This idea has been chosen for a number of reasons. It reduces the number of input lines, it pulses the light emitting diodes in their higher-efficiency region and consumes the least amount of power for the maximum brightness.

This system is called MULTIPLEXING.

In this design, all the 'a' segments are connected together, all the 'b' segments are joined and similarly with c, d, e, f, g. This creates a total of 7 input lines.

You may be tempted to think that this would cause all the 'a' segments to illuminate at the same time, but this is not the case. Instead of all the other ends (all the cathodes) being connected together, we only join the 7 segments of one digit together and this is taken to a driver transistor. In our display, this will create 4 separate lines.

The result is, when the first display is showing a figure 8, we can chose which other display shows a figure 8 by selecting the appropriate transistor.

The next portion of our discussion requires you to consider the television screen concept.

The 4 digit readout for the 74c926 is not a static display such as the sign outside a Milk Bar. It is a LIVING sign. You know that the picture on a TV screen is created by a single flying dot, leaving a very long trail. This phenomenon is partly due to the persistence-of-vision of your eyes and partly due to the after-glow of the phosphorus on the screen.

Our display takes persistence-of-vision into account. When our eyes see a light source, it retains the image for about 1/5th of a second after the light is switched off. A camera flash is a perfect example. The flash lasts only about 1/100th of a second but the blinding effect in your eyes lasts about 10 to 30 seconds or more.
This means any flickering light above 5 flashes per second will tend to merge together as a constant light source and the off periods will not be detected.

By increasing the flash rates even higher, the sub-conscious mind will not be stimulated or annoyed so that at about 50 flashes per second, the displays will appear to be constantly illuminated. Our display operates at an even higher frequency and at this speed the efficiency of the light emitting diode and its response-time are at a maximum.

The scanning of the display is created by turning the four drive transistors on and off in sequence.

To illuminate numbers such as 1, 2, 3, 4 on the display, the information fed to the 11 input lines would be as follows:

Lines 'a' and 'b' will go HIGH and the drive to the first transistor will be HIGH. This will create a '1' on the first display, the other three displays will not be illuminated.

To create a '2' on the second display, all lines will go LOW or change to the following:
Lines a, b, d, e, g will go HIGH and the drive to the second transistor will go HIGH. This will create the '2'.

To create a '3' on the third display, lines a, b, c, d, g will go HIGH and also the drive to the third transistor. The other three displays are turned off when this is being displayed.

To create a '4' on the fourth display, lines b, c, f, g and the drive to the fourth transistor will go HIGH.

This completes ONE scan. The most amazing point to realize is the display is being scanned over 1,000 times per second with this same sequence to give the effect of the number 1234 on the display.

## HOW THE CIRCUIT WORKS

One of the most difficult tasks in electronics is matching a mechanical switch to a digital circuit. Most switches produce a large amount of noise and this is picked up by the circuit to result in false readings. One push of the switch may generate 10 or even 50 counts and the only way of reducing this effect is to introduce a DEBOUNCE circuit between the switch and the counting circuit.

This debounce arrangement is designed to remove all the extra 'bounces' or 'noise' from the switch and deliver a single pulse.

Most debounce circuits suffer from one major drawback. The time-delay of the debounce cannot accommodate both slow pressing of the button and rapid pressing. The 'debounce delay' should be set to a longer duration than the operation of the switch. Ideally the push button should be pushed and released within this timing cycle, but this is not always possible. Some times the button will be pressed 5 times in a second. Other times it may be held down for two or three seconds. It is very difficult to provide for a wide range such as this.

The only solution is to produce a universal circuit which has a very high degree of debounce but is not time-conscious.

To achieve this, two Schmitt Trigger gates can be combined together to obtain the high degree of debounce required. The first Schmitt gate reduces the number of pulses to a very low number and sends the output to a time-delay circuit which combines the string of pulses into a single output pulse. Each time the push button is pressed, the counter module will advance ONE count.

This is how the circuit functions:

When the push button is pressed, the input of the first inverter will go LOW and its output will go HIGH. After a very short period of time, as determined by the time delay produced by the 1M and 220pf capacitor, the input of the second inverter will go HIGH and the output will go LOW. This action will advance the counter ONE count.

When the button is released, the input of the first inverter will rise as determined by the time-delay produced by the 330k resistor and 220pf capacitor. The output will go LOW and the 220pf capacitor in the second time-delay arrangement will discharge via the 1M resistor. The output of the second Schmitt Trigger will go HIGH and the whole delay circuit will be ready for the next pulse.

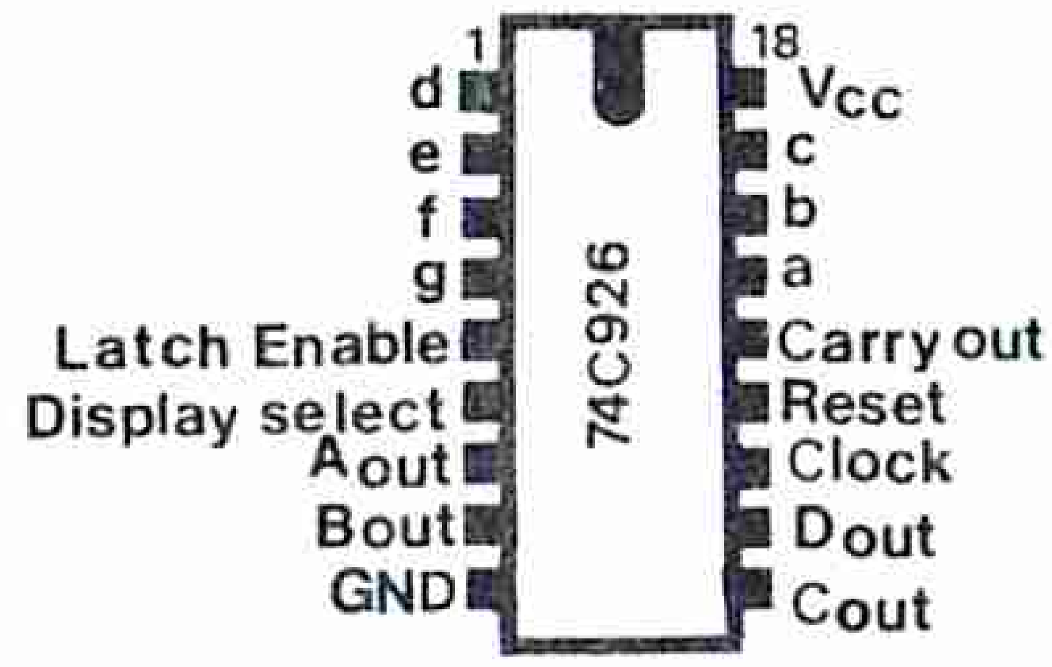
The counter advances on the negative edge of the waveform being presented at pin 12.

This is how it is achieved.

In its rest condition, the two transistor Schmitt Trigger circuit is sitting with Q1 turned ON and Q2 turned OFF. This condition is achieved via the 1M resistor in the base of Q1 turning this transistor On so that the voltage between its collector and emitter leads is too low to turn on Q2.

You will notice the turn-on voltage for Q2 is obtained via the voltage which is allowed to develop across the collector-emitter terminals of Q1. If this voltage is below .5v, Q2 will not be turned on.

In our prototype, we measured the collector-emitter voltage for a saturated BC 547 to be about .2v. This is sufficient to prevent its pair from being turned on.



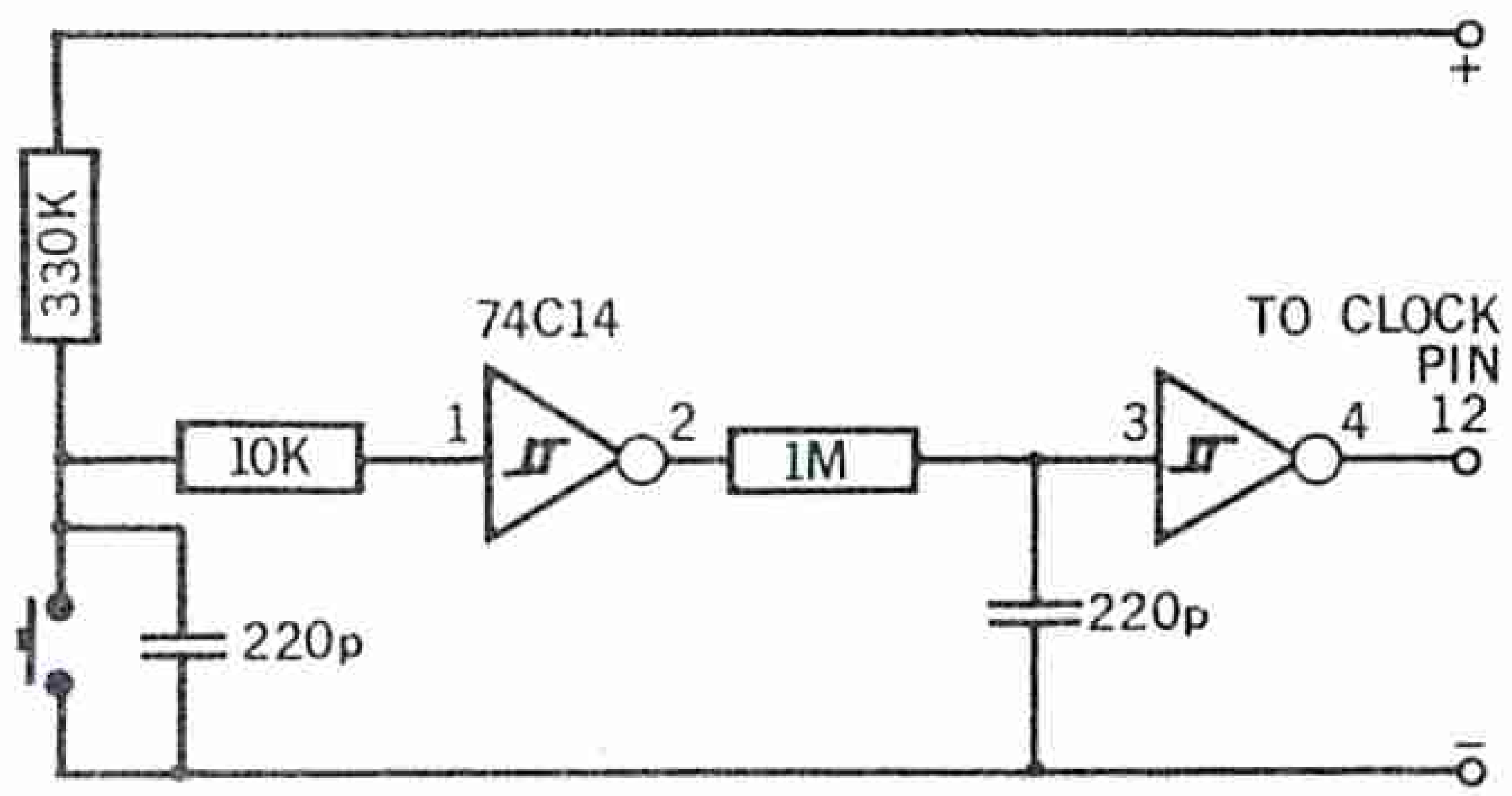

supply is 10v, we can assume the voltage across the 1k resistor to be about 1v.

When the button is released, the voltage on the base of Q1 gradually rises as the 100n capacitor charges. A point is reached where Q1 begins to turn ON and this robs Q2 of its base-emitter voltage. Q2 begins to turn OFF and the voltage across the 1k resistor, R5, is lowered. This effect is transferred to the emitter of Q1 and it sees this as a 'TURN-ON'. A very rapid switching action is produced which has nothing to do with the charging of the 100n capacitor. It is this rapid change which clocks the counter one count. If it were to be a slow change, as dictated by the charging of a capacitor, the counter would advance anything up to 50 counts.

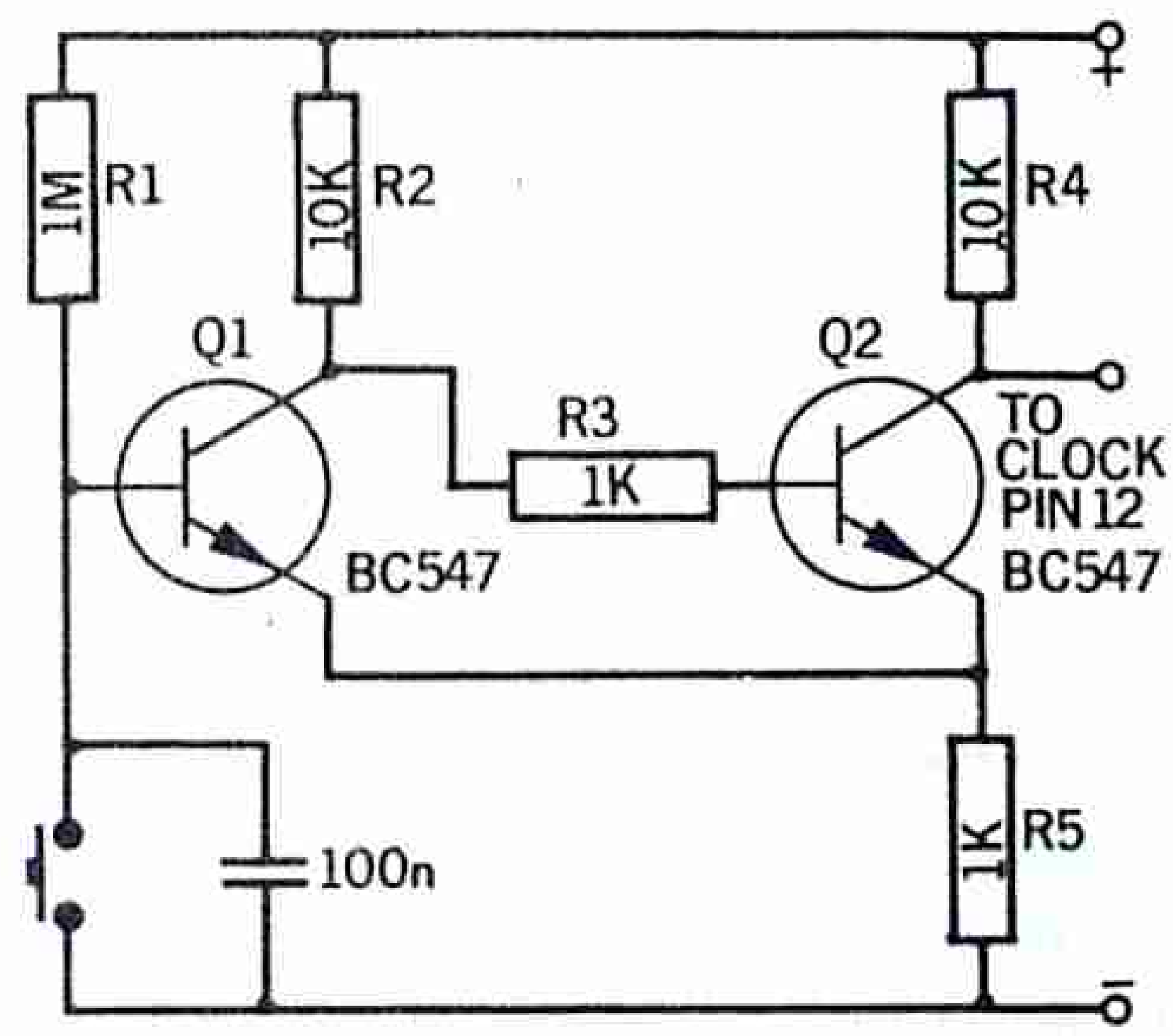
## ASSEMBLY

We have designed a new sub board for this project. The 4 displays are mounted on the board so that the decimal points are near the edge of the board.

You will also need to fit 2 links as shown in the diagram, to complete the circuit.




**A debounce circuit using 2 gates of a Schmitt Trigger 74c14 IC. (or CD 40106 or 40014 IC).**




**A Schmitt Trigger circuit created from two BC 547 transistors. This circuit is built on TE's 24 x 25 Matrix Board or Experimenter Board 3-IC's.**

## HOW THE TRANSISTOR SCHMITT TRIGGER WORKS

Basically a Schmitt Trigger is a circuit which requires a wide voltage range on the input for it to change from one state to the other.

Normally a transistor requires only a few millivolts for it to change from say cut-off to saturation. But this voltage range is increased to 2 volts or more in a Schmitt circuit.

When the button is pressed, the voltage on the base of Q1 falls to below .6v and Q1 turns OFF. The voltage on its collector rises and this is passed to the base of Q2 via the 1k separating resistor. Q2 becomes saturated (fully turned ON) due to the low value of the base resistance (10k + 1k) with the result that the voltage between the collector and emitter of Q2 drops to less than .2v. Almost the whole rail voltage is dropped across R4 and R5, which are in series, if the

Fit the components to the mother board, using an IC socket for the 74c926 to prevent any possible damage due to soldering. The value of the current limit resistors can be selected from the enclosed table. The 1M pull-up and pull-down resistors are necessary for the chip to operate correctly.

The display board is connected to the mother board via 11 extension wires and these connect from the top 24 pin

socket to the lower 24 pin socket. The 11 pins which are used to drive the display are easy to identify as they have copper tracks connecting them to the rest of the circuit.

Before combining the two PC boards, all the components should be mounted and soldered in place. To connect the two boards together, solder 11 lengths of fairly stiff copper wire to the display board. Each of these wires should be of slightly different length to make fitting the two boards easier.

Carefully push the wires into the holes on the mother board and adjust the two boards so that they are parallel to each other. If you want the display board sloping downwards, now is the time to adjust it. Solder the wires and snip any excess off.

The ONE-SHOT or DEBOUNCE circuitry can be constructed on an Experimenter Board 3-IC's. Either circuit can be selected and only 3 connections are needed between the Schmitt Trigger circuit and the counter module.

These are:
1. The positive rail,
2. The negative rail, and
3. The clock line to pin 12.

A push button connected between the positive rail and reset pin 13 will zero the counter ready for the start of a counting operation.

This UNIT COUNT project is not limited to push-button operation. You can use a reed switch and attach a magnet to a rotating shaft or pulley to count revolutions. You can count the number of times a door is opened via the use of reed switch and magnet or you can count the passing of objects as they break a light beam. You can even count the turns on a coil as it is being wound via a HALL EFFECT device or microswitch.

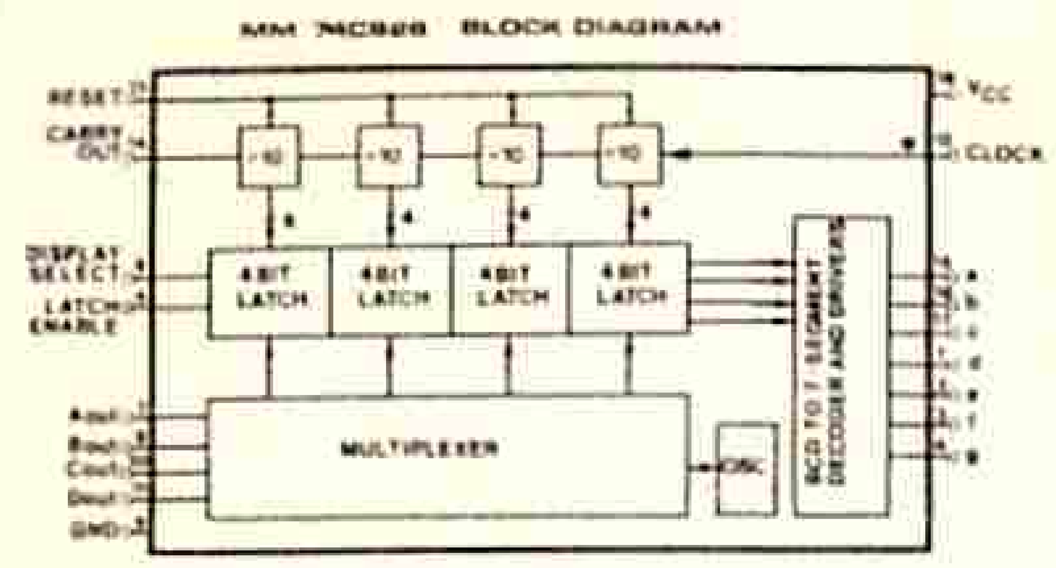
There is no limit to the number of counting operations for this counter and since the circuit is fully debounced, the repetition rate can be as low as once per day or as high as 3MHz.

There are other features on the 74c926 such as count-and-freeze so that high counting speeds can be frozen on the display for evaluation. The chip, in the meantime, is counting the next set of input pulses. These and other ideas will be covered in a later article.

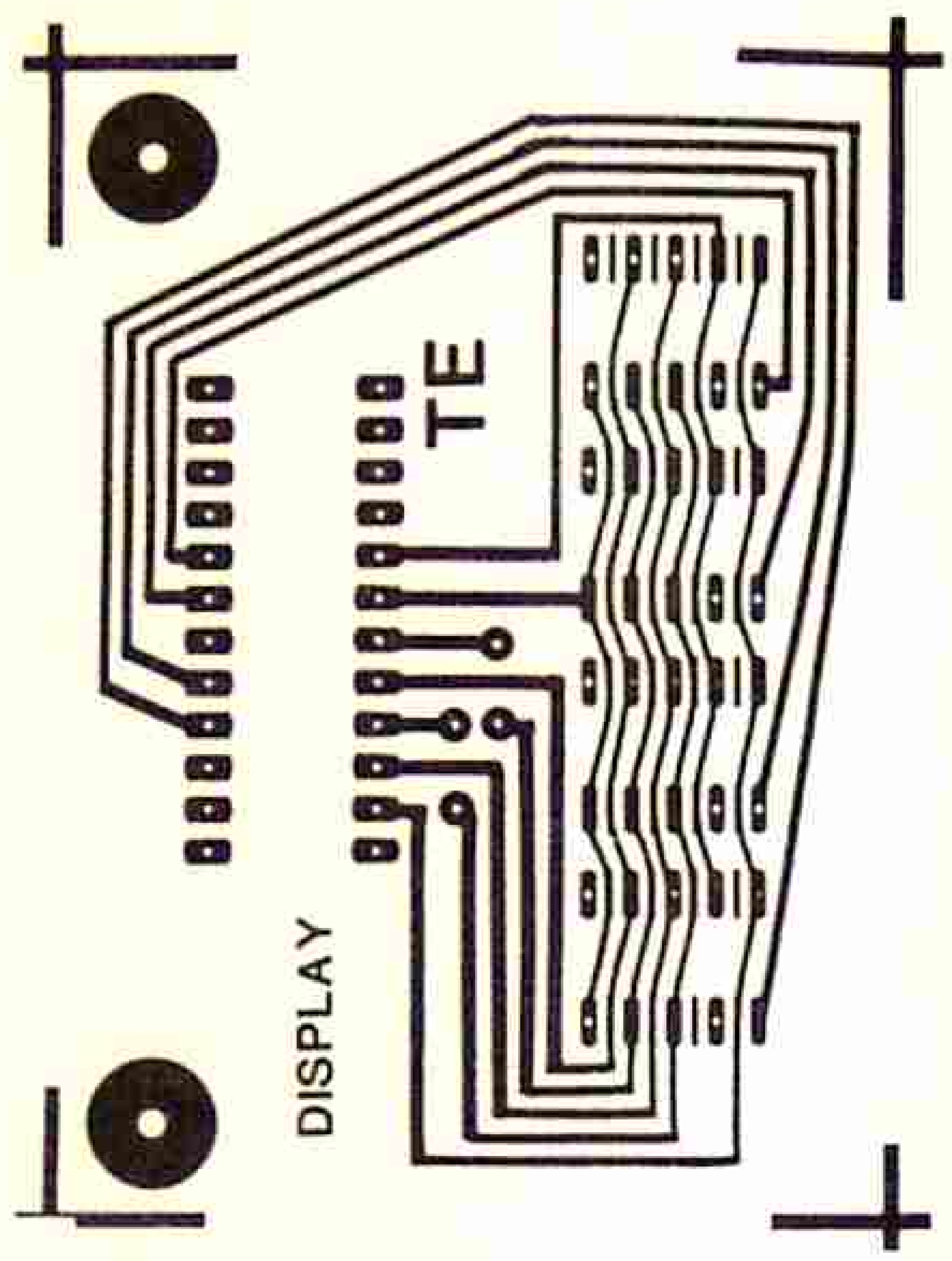
For a simple beginning, try this project. It will prove to be a very reliable, low cost counter.

**Select the value of R5 to R11 from this list:**

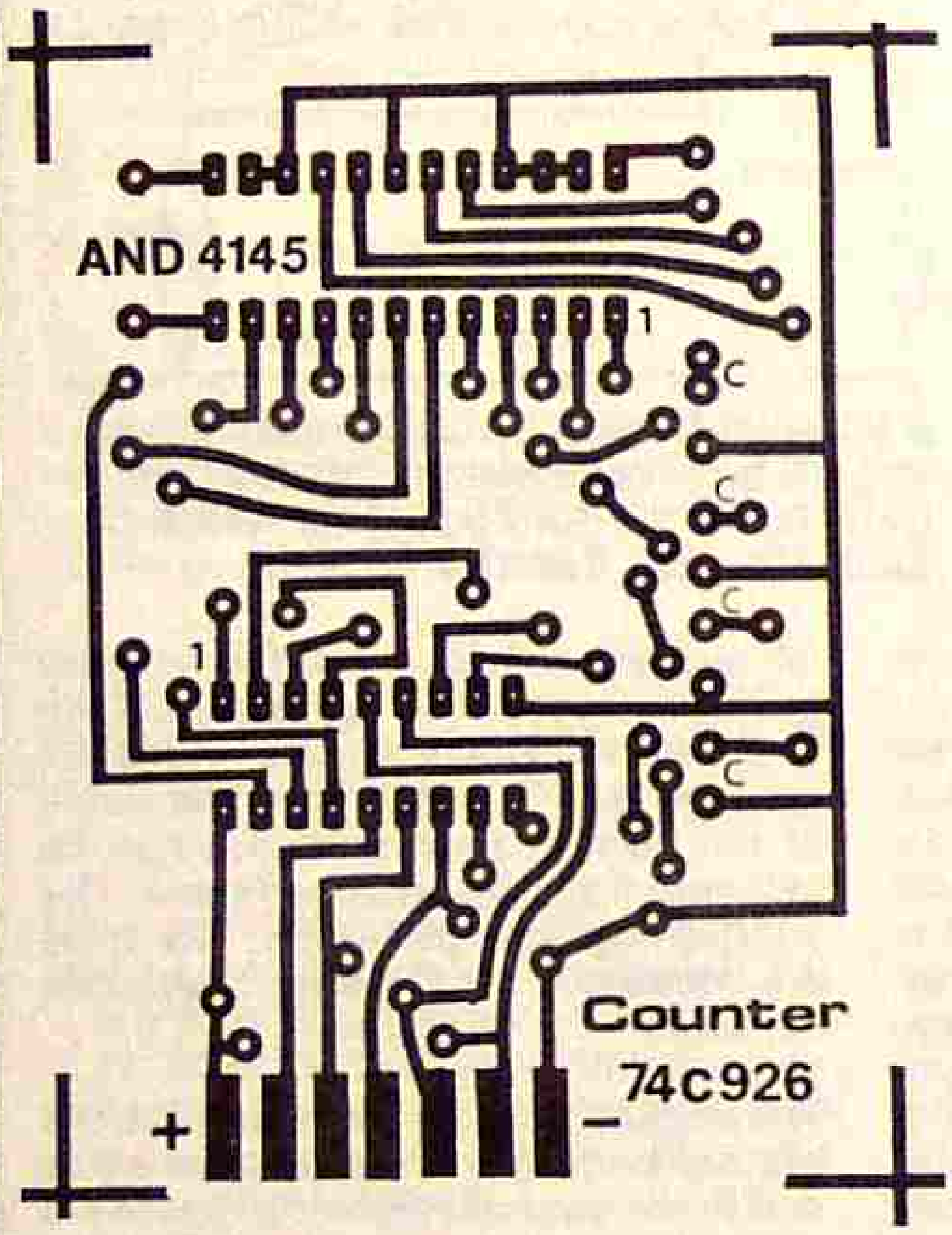
| | |
|---|---|
| 4.5v | 7 - 220R |
| 5v | 7 - 270R |
| 6v | 7 - 330R |

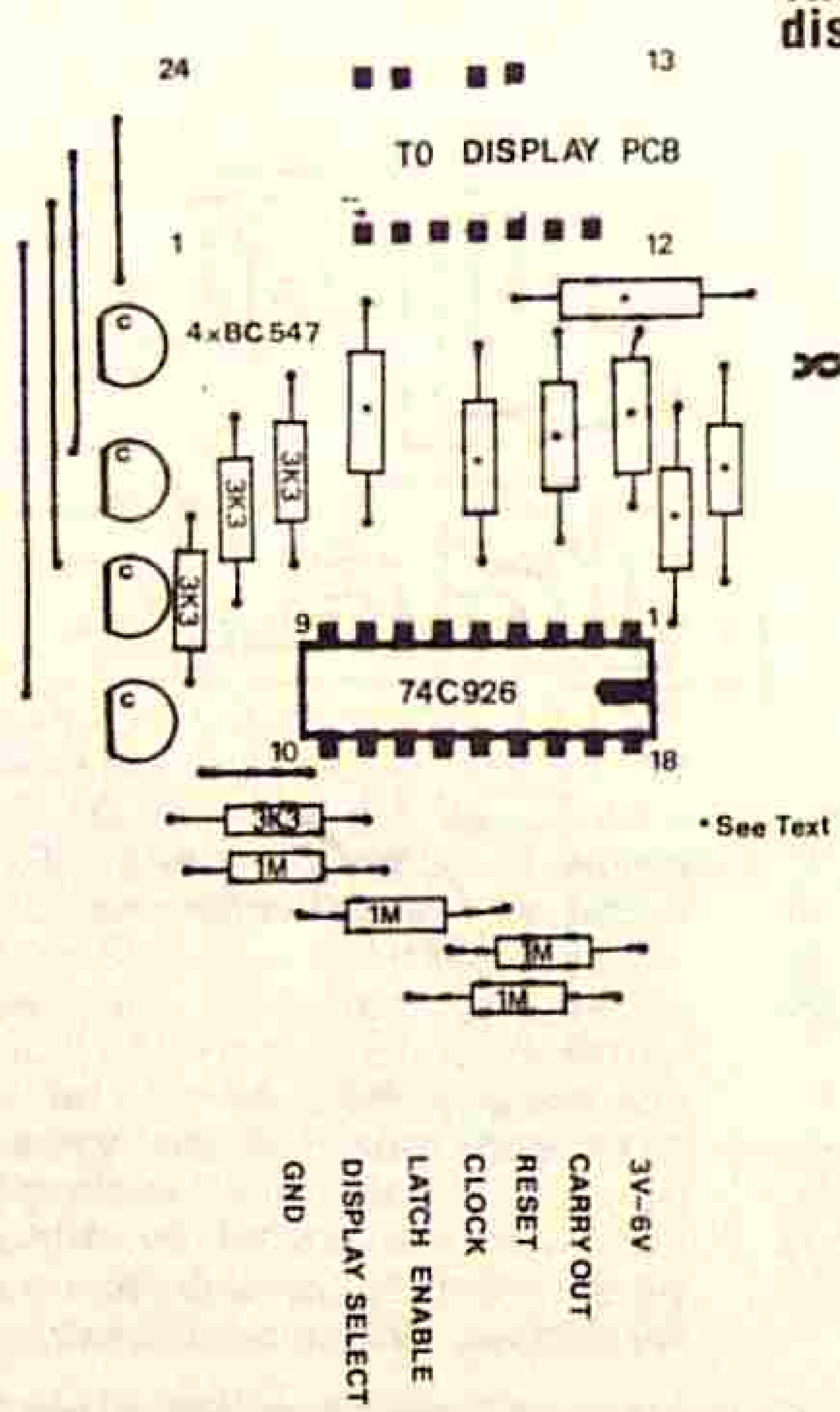



**The internal structure of the 74c926 IC. It would take nearly 11 individual chips to produce the same functions.**




**The display board for the TIL 313 displays.**




7 - 220R Use ONLY ONE value SEE TEXT
7 - 270R
7 - 330R

4 - 3k3
4 - 1M

4 - BC 547 transistors
1 - 74c926 IC

1 - 18 pin IC socket
4 - TIL 313 displays
1 - "DISPLAY" PC

1 - "COUNTER" PC

# SHOP TALK

## We review our recently-released text-book: ELECTRONICS Stage-1.

We mentioned some time ago that it is our intention to introduce an electronics course into Technical, High and Private Schools.

In the past few issues of SHOP TALK we covered some of the contents of various courses which were sent in by readers.

From these and our own knowledge of how to present basic information, we put together a text book covering the first stage of electronic understanding. We have called the book ELECTRONICS - STAGE 1.

It is very difficult to gauge the content of a book by an outline of the topics as it is the facts contained in the text which give it a good or poor rating. But if the content of Talking Electronics Magazine is any indication of a different approach to presenting electronics, the text book will be worth a perusal.

This is a list of the topics covered in the book:

**THE LED**
**THE RESISTOR**
**THE DIODE**
**THE MULTIMETER**
**THE TRANSISTOR PART 1**
**CONTINUITY TESTER**
**THE CAPACITOR**
**SOLDERING**
**DRAWING CIRCUIT DIAGRAMS**
**AUDIBLE LOGIC PROBE**
**THE DRY CELL**
**THE TRANSISTOR PART II**
**POCKET RADIO using a ZN 414 chip**
**THE TRANSISTOR PART III**
**THE 555**
**CD 4017 DECADE COUNTER**
**DOOR CHIME**
**LM 380 AMPLIFIER**
**LOGIC CIRCUITS**
**THE SCHMITT TRIGGER**
**THE CLOCK**
**UP/DOWN COUNTER**
**LOTTO SELECTOR**

The introduction of each of the basic components does not follow the conventional approach. They are covered in a sequence which very nearly follows that in actual daily life.

A component is explained just before it is required in a particular circuit. After all, when you learn about cars and engines in real life, you don't study screws and bolts! In the same way we have re-designed the introduction of components and you will appreciate the approach once you read the introduction in the book.

Any text book should aim at introducing the new developments in electronics and phase out some of the older devices and ideas.

Components such as 20% tolerance resistors, triode valves, black & white TV theory are 10 years out-of-date and LCD displays, large-scale integrated circuits and digital circuits are IN.

Electronics is progressing and expanding at such a rapid pace that we could almost allocate an entire text book to each type of modern component.

But since this is not feasible, each component has to be squeezed into 4 or 6 pages to create a compact text at a reasonable price.

I think this has been achieved in the book and if you are still at school or tertiart college, look for the book at your local newsagent.

In the space left I wish to relate a couple of stories from the past few weeks, which I think you will find quite interesting.

The connection between presenting an electronics text book and servicing electronic appliances may not be immediately evident, but the association can be very close.

One of the advantages of electronics is its universality. Electronics speaks all languages and a circuit designed in one part of the world can usually be understood by a technician in another country.

That is, providing a few of the basic concepts are adhered to. Simple things such as layout and representation of symbols are almost universal, however there are two areas where circuit diagrams leave a lot to be desired. These are the basis of this story.

A circuit diagram should provide instantaneous representation of the workings of the equipment and it is not beyong reason to extend this concept to complex pieces of equipment including colour television circuits.

And last week's jobs reinforced my feelings.

It all started with a call to a Japanese colour set of very recent construction.

In fact, it was barely 18 months old and the symptoms were NO SOUND and a VERY DARK PICTURE. As with many of these modern sets, 90% of the space inside the cabinet is air and the whole circuit is constructed on a flimsy mother board which is held into the bottom of the case with a couple of screws.

Once these are removed, it is an art to extend the flying leads sufficiently to crank the board up and around the protruding picture tube so that the underside of the board can be seen.

These sets have been cleverly designed as a throw-away product as absolutely no thought has gone into the servicing of the circuit. There is a complete lack of support for the board when it is in the up-right position, making the removal of components a 3-handed affair. The board has to be physically held in the up-right position while straining against the masses of connecting wires, to prevent it slipping into its resting position.

Since the chassis is 'HOT', (live - no mains transformer) you cannot ask a member of the family to help and it is beyond me to know how the manufacturers expect repairs to be effected.

This is only the first part of the frustration, as you will see.

I know, from my limited knowledge of TV faults, that Japanese sets are extremely reliable and most of the problems with new sets have been a dry joint or two.

The ideas I have presented in the text book relating to the importance of layout of a circuit diagram have been formed after many years of studying manufacturers circuits, layouts and block diagrams. The difficulty in reading these diagrams came to a head last week.

I maintain a circuit diagram should be easily read. If not instantly, then after a 10 to 15 minute study, the mode of operation should be seen.

So I twisted the chassis while the set was running. At first the twist was very slight and this increased until I finally had the board and frame looping the loop. I came to the conclusion that it was not a 'delicate' dry-joint. Next I tapped a few components, especially around the tuner and EHT transformer where a dry joint can produce this type of fault.

The EHT transformer, apart from being a very high voltage generator, is also a LOW voltage generator, in some sets. They can be designed to produce voltage rails for raster correction, vertical output, sound or even IF supply.

And it is the IF supply possibility that I was concerned with as the fault mentioned above suggests one of the low voltage rails could be absent.

All this prodding and twisting had no effect so I decided to take the major step of looking into the circuit diagram.

This is where the frustration started.

The whole set has been designed around a few large-scale integrated circuits. Although this makes the circuit diagram relatively small, the identification of the chips and their exact *modus operandi* is completely lacking.

Even though a technician knows basically how a TV set works and where to find the various sections, this is not sufficient when attempting to locate a particular fault.

For a set to be serviceable, the circuit must identify as many features as possible. The type of features which must be shown are first-and-foremost voltage levels. But even more important than this is the identification of voltage generators.

As you may be aware, TV sets have a number of different voltage rails and these are generated in all sorts of obscure and wonderful places.

The horizontal output transistor may have a 24v generated on the emitter lead, or one of the tappings of the EHT transformer can be designed to produce anything from 12v to 1200v.

Some thyristor horizontal sections have a 30v @ 1.2amp generator. This is quite a high power stage in technical terms. And the obscurities go on. A 12v regulator on the sound board, a 12v + 24v near the IF strip or a regulator, behind the EHT transformer, which cannot be removed.

It boils down to a constant search; looking for the beginning of a particular voltage generator. Some rails derive their voltage only after another rail has been produced and it can even go around in a circle with the initializing voltage coming from a "kick-start" circuit.

So I sat on the floor with the TV lamp beside me, pouring over this new-arrival to "circuit-diagram-land". I glanced at my watch and thought, "I'll give this 15 minutes and see how we go."

Well, you couldn't have created a more indecipherable circuit if you gave it to a satoteur!

After a full 30 minutes of painstaking examination I had to conclude that I could not even decide upon a starting point! The layout was totally devoid of any arrows, making it impossible to tell which direction the signal was flowing and prevented any understanding of which way the voltage was feeding the various parts of the circuit.

In a situation such as this it is far better to halt the proceedings right then and there AND PACK UP.

With the cost of labour and the feeling of frustration, it is not worth pursuing a fruitless venture.

This is obviously a fault requiring workshop attention and the expense of lugging the set down 3 flights of stairs, is not worth the effort. And invariably the crunch will come two weeks later when the set faults again! It is better to bow out and retain your sanity.

Now for the brighter part of the story.

Three days later I was called to an almost-new import from Germany.

The customer had brought out his fully remote control Nordemende and it had gone on the blink just 2 weeks after being unpacked.

Again, this was the first time I had seen one of these models and as it happens, it is possibly the only one of its type in Australia.

But what a difference. From the moment the back of the set was removed, you could see the engineering. The chassis unscrewed and laid flat for easy servicing, each module was identified with a letter and everything plugged into a main mother board.

However the main difference was in the circuit diagram. The Nordemende circuit is beautifully laid out, with colour-coding for each module. As an ancillary to the main diagram, a block diagram is also supplied showing the position of each of the low voltage generators. Even though they are placed in absurdly stupid places, (such as on the sound PC board) they are clearly identified on the diagram.

Each block shows the main interconnecting lines with an arrow to indicate the direction of the voltage or signal. These features are essential. It reduces time enormously if you can see which way the voltage is flowing, without having to interpret the circuit.

Nordemende have made their sets completely serviceable and although it may take an hour or so to locate the fault, it is a pleasure to work on the set.

The Japanese could take a leaf out of any of the European technical manuals. Although they have copied the basic format they have not extended this to the degree required for easy diagnosis.

So, what's the connection between the text book and TV repairs?

Clear Schematics.

One of the main aims of the text book is to show how to produce circuits which are presented in a standard format. Whether it be a simple 555 timer or a complex digital layout, the presentation must be easy-to-follow.

Even though the text book is only stage 1, it suggests that layout is extremely important when preparing and presenting a project. Circuit diagrams are like a photograph, they must be instantly recognised.

And if the Japanese firm in question had abided by this simple requirement, the set would possibly have been repaired by the writer.

## CORRECTIONS Issue 9:

**The READ/WRITE paragraph above the 2102 diagram on P.70 of the DIGI CHASER is incorrect. The R/W explanation is around the wrong way.**

**That is: information OUT of the chip when pin 3 is HIGH and into the chip when pin 3 is LOW. Consider the R/W pin as "Belonging" to an external circuit. In other words the circuit 'reads' the memory (takes in information) or 'writes' (supplies information to the memory).**

**ELECTRONICS Stage - 1.**

P 68:
On the door chime layout, add a jumper link from the join of the 2u2 electrolytic and the 22k resistor to pin 14 of the 4017.

# LETTERS...

## Good News! TE will still be in the newsagents.

Our LETTERS segment for this issue will be kept to 2 pages because of the length of the computer project.

Most of the letters this month have been from readers wondering about the delayed appearance of issue 10. Others were a little upset with the possibility of the magazine becoming a subscription-only venture.

I will answer these two, first.

Sorry about the delay with this issue. We have been busy with an electronics text book for the past 3 months and by now it will be available in the shops. The book was a greater undertaking than first expected as each page had to be generated from scratch. Each topic, idea and circuit had to be developed and everything had to fit together as compactly as possible. It's a great feeling of satisfaction to see it complete at the layout stage and then have it printed, bound, stapled and trimmed in the same week. You can see it reviewed elsewhere in this issue.

The second group of concerned readers were wondering about the removal of TE from the newsagent's stand. About 2 weeks after the printing of issue 9, we received a 'returns' statement from the distributor which indicated that the sales were fairly good. Even with the down-turn in the economy, TE had not suffered at all. Mind you, sales were not picking up, but they had not fallen, and this will enable us to keep to the previous distribution arrangements.

Magazines will appear without the PC board attached however the PROJECT-BOOK series will have the PC board attached as this is the arrangment we made at the beginning of the series.

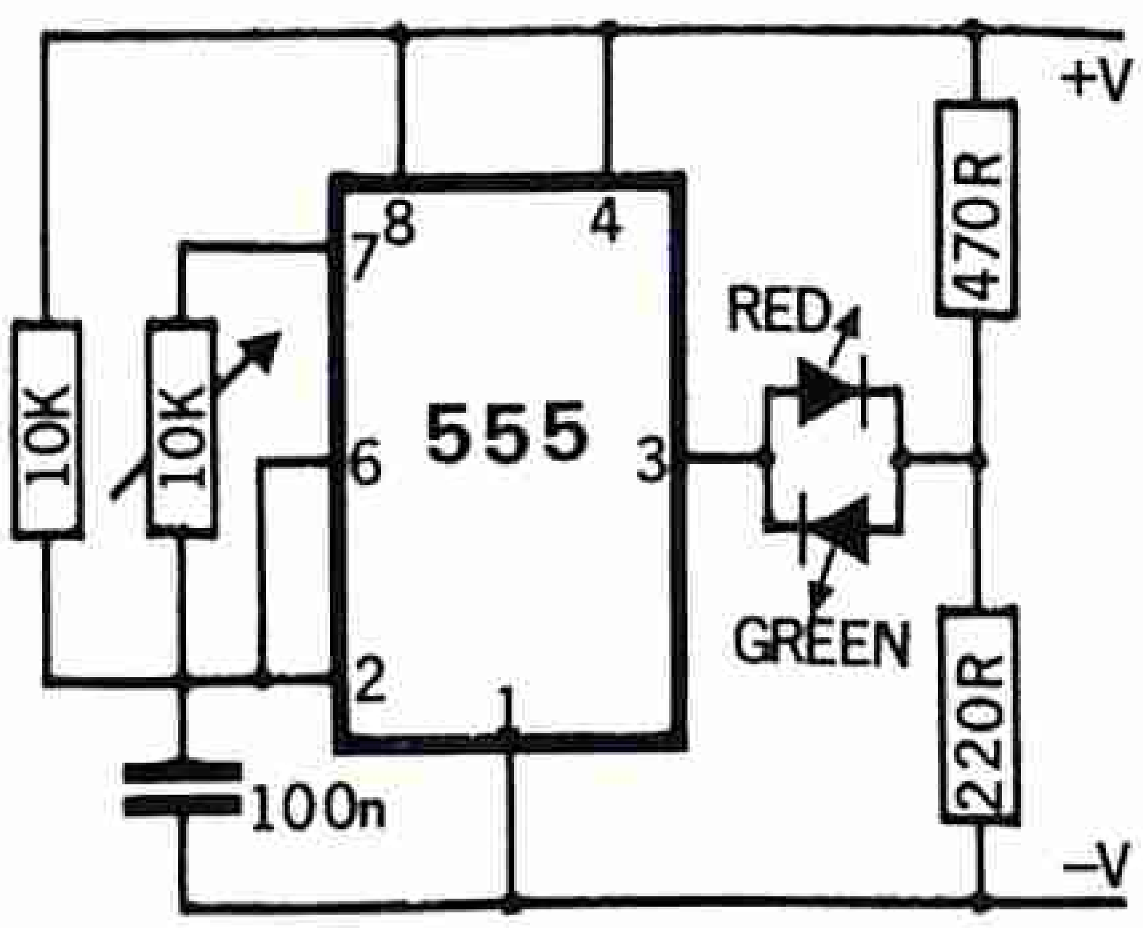
If you do not see any of our magazines in your local newsagent, try your electronics shop. If this fails, try US.

A number of electronics shops stock the magazine and a selection of kits. TE is a very good seller and in the right environment it out-sells all other magazines. In ELLISTRONICS, for instance, we sell more issues than any other electronics magazine!

Enough of my ramblings. Here are some of the letters:

### TRI-COLOUR LED PUZZLE

*I have enclosed a tri-colour LED puzzle which I have used to trick some of my friends. The knob is concealed on the back of a box and only the LED is visible.*




CIRCUIT FOR TRI-COLOURED LED

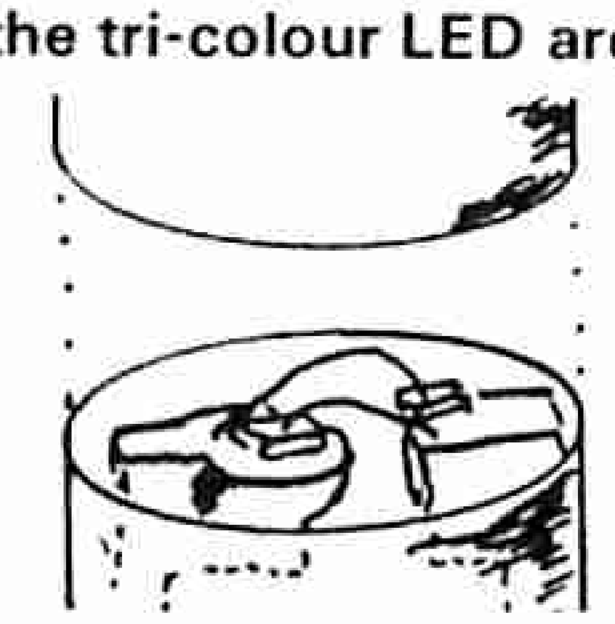
*By waving your had over the LED, and turning the knob secretly at the same time, the LED changes colour. Young friends think it's magic.*

*David Gardner,*
*Boolaroo, 2284.*

A very interesting circuit showing how the variation of the mark-space ratio will create the three different colours on the tri-colour LED. Here is some of the background theory:

### HOW A TRI-COLOUR LED WORKS:

Inside the tri-colour LED are 2 chips.



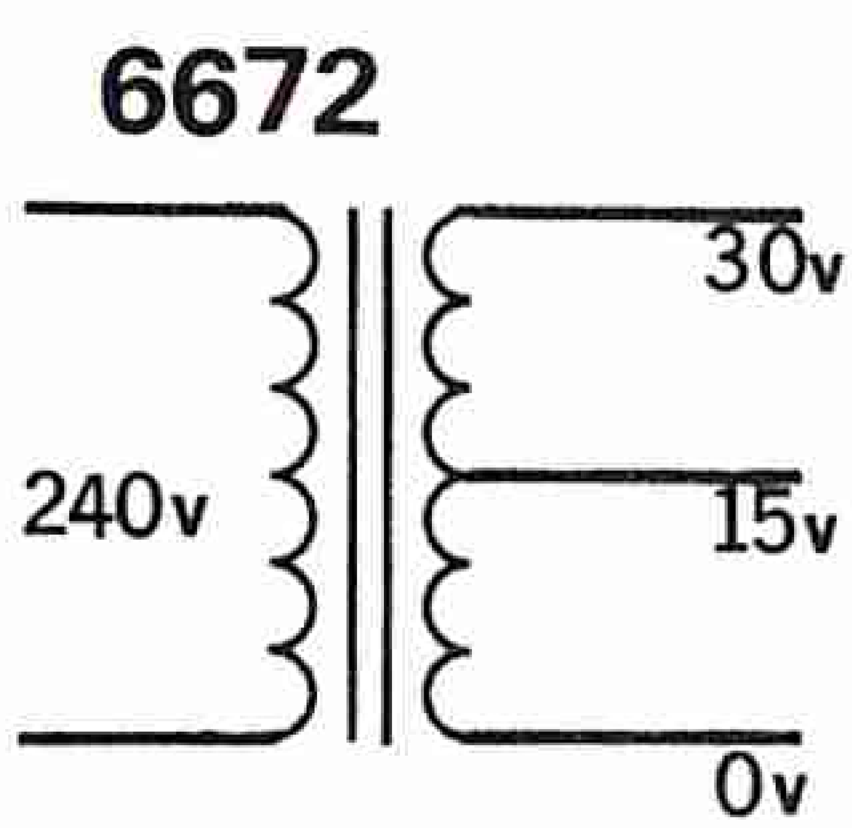
INTERNAL LAYOUT

One is RED, the other is GREEN. When the LED is connected to a DC supply, the RED chip will illuminate. If the supply voltage is reversed, the GREEN chip will illuminate. If the supply is AC, or in other words, if the voltage changes back and forth very quickly, BOTH chips will light up and the two colours will be mixed together in the lens at the top of the LED and the result will be YELLOW.

The circuit sent in by David produces a voltage which is constantly changing direction so that both chips will be illuminated. In addition, the mark-space ratio can be adjusted so that the relative brightness of the two chips can be altered and balanced to obtain a good yellow. This is not necessarily a 50:50 ratio as one chip can have a higher emission than the other. We found this to be the case with the sample LED we obtained from a Tandy store. It had a light output of about 2mcd. Compare this with 200mcd to 500mcd for super-bright LEDs!

### VA RATING

*While building the power supply from issue 4, I encountered a problem*




*with the VA rating of a 6672 transformer.*

*When using this multi-tapped transformer, the volt-amp rating is 30. Its output voltage is 30v and its maximum current capability is 1 amp. What is the VA rating when the 15v winding is being used? You can see that this is effectively using only half the output winding.*

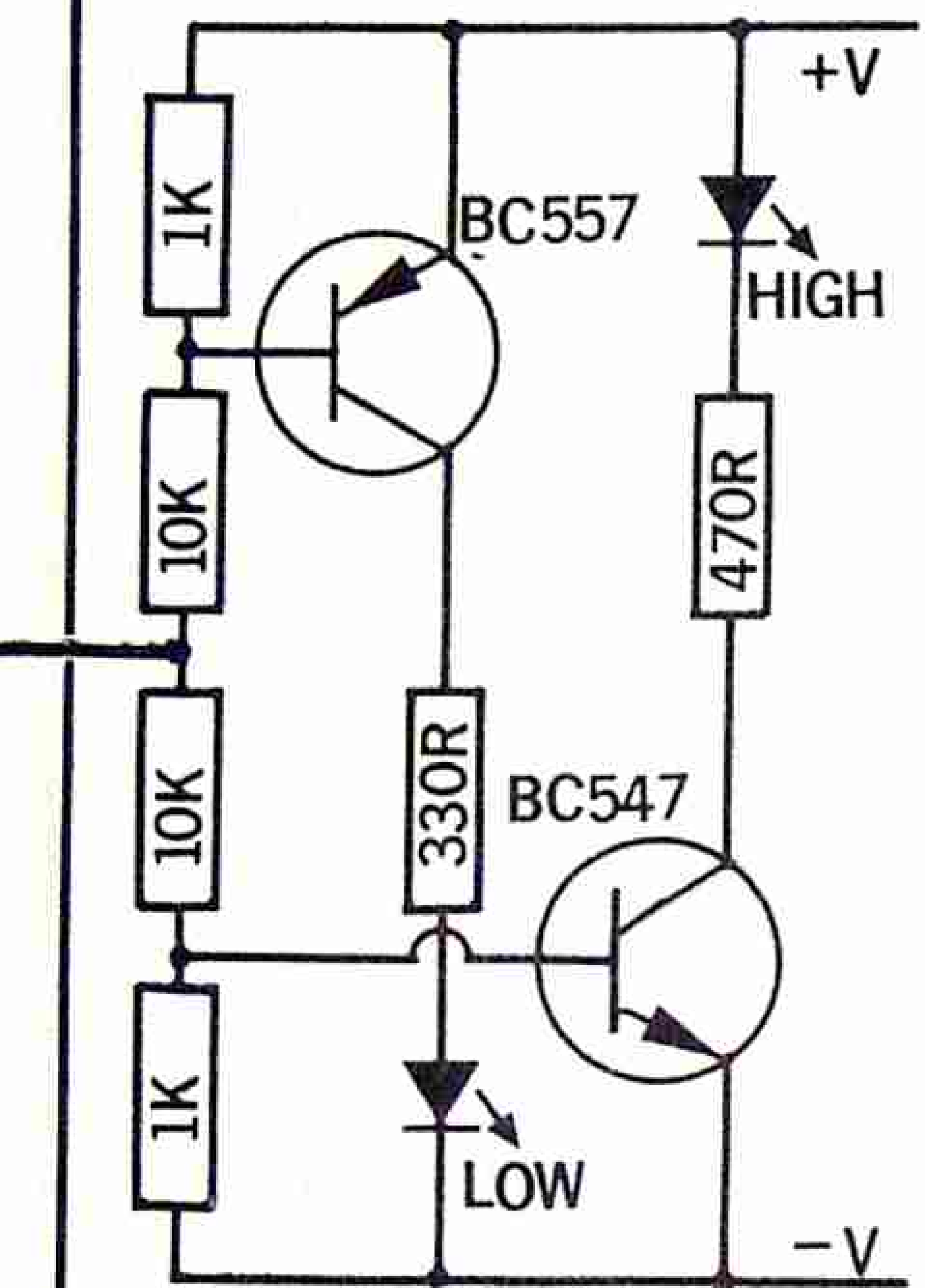
*A Doukakis,*
*Forresters Beach, 2260.*

As with any piece of electrical or electronic equipment, whenever ONE of the ratings is reached, the component cannot be operated or loaded any further. When using the 15v winding, the limitation comes when the current flow is 1 amp. This means the VA rating for the transformer is only 15VA. This is one of the disadvantages of using a multi-tapped transformer. Actually a slightly higher current can be drawn but not as high as 2 amps and so the full 30VA can only be obtained when the full output winding is used.

*On constructing the Simple Logic Probe circuit in issue 4 P. 60, I found that one of the LEDs was illuminated at all times when the power was applied. I was wondering if you could design a circuit in which neither LED was alight when the project was not testing a circuit.*

*Rod Bent,*
*Albury, 2640.*

The project as described in issue 4 has some limitations and one of the LEDs will always be lit when the circuit is connected to a battery. This is a waste of power and the circuit has been re-designed so that both




**HIGH-LOW PROBE CIRCUIT**

LEDs are extinguished. The improved circuit is shown above.

**We get a number of letters from readers who are unable to visit newsagents, for one reason or another. The following letter comes from one such reader. It highlights the need for improvisation in these situations.**

*I am a middle-aged TV serviceman who has found himself the guest of Her Majesty for a considerable period of time. Whilst here, I have been given the opportunity to keep everybody's TV's cassette recorders and radios in workable order. As you can imagine, without being able to visit the local electronics shop, I have to entirely make-do with what I have on hand. Practically everything has to be salvaged from discarded pieces of equipment and the only tester is a 30k multimeter.*

*Circuit diagrams are virtually non-existent and I have to rely on my knowledge of circuit operation from the past few years. This makes repairs very slow and to top it off, the sets have usually been fiddled-with. Leads have been disconnected, IF's detuned, silver paper placed across fuses and components bent in all directions.*

*With plenty of time on my hands, I don't knock back any job on first appearances. A busy serviceman would invariably say NO! but when you know the low earnings of your fellow friends, and what a TV set means, you always weaken and take on the job.*

*Some repairs are straight-forward as they haven't been compounded by Mr Fixit's and the usual fault-finding procedures will get the set going. Most of the component values can be created with parallel or series combinations and these parts can be taken from an old set. If the fault is more difficult, I use another TV or amplifier of the same or similar manufacture and use the working section from one unit to feed a signal into the non-operating set.*

*For tools and equipment, we cut up plastic knives and forks to create alignment tools, any any other discarded pieces of metal-work we can scrounge.*

*There is no such thing as CAN'T.*

*The more insurmountable a problem seems to be, the greater the challenge. And when you finally see it completed, the feeling of satisfaction is great.*

*I have achieved success on projects which I would normally have shelved. Unfortunately I can't build any of the digital projects from Talking Electronics as the IC's are not available in old equipment! But I still enjoy reading the articles, for the time when I will be able to get to an electronics store.*

*Once again, thanks for the magazine.*

*Colin Roberts,*
*Adelaide, 5001.*

## COLLECTOR OF EVERYTHING

*I felt I must write to you regarding the article "My Thoughts" on P. 66 of issue 9. I have been collecting and hoarding empty cases from watches, cigars, motor extras, cassettes, and tools for the past three years and I am always finding them handy for housing projects and for storing components. It's possibly because they don't cost me anything, that I appreciate them all the more.*

*It seems to be a characteristic of hobbyists, to collect anything that may have the slightest usefulness in the future. Thanks for the article. I'm glad I'm not the only hoarder.*

*I J Flemming,*
*Rutherglen, 3685.*

*I have been buying Talking Electronics ever since the first issue and have found it to be very informative.*

*I have been an electronics hobbyist for quite a number of years and have successfully built many projects. They usually work first time as I have found the secret to success.*

*It is to check, double check, then check-again, each stage of construction.*

*But the main reason for writing is to relate a recent incident. I was unfortunately involved in a motor cycle accident a number of years ago and as a result of this, I attended a rehabilitation centre for nine months.*

*I was greatly involved with electronics at the centre and I built a number of projects for both myself and the centre. I also helped some of the others who were also convalescing. There were people who had trouble constructing even the most simple of projects and I was pleased to be able to help them and also show them where they went wrong.*

*The best method of learning, I have found, is to make a mistake! It is then a matter of going through a circuit and check each component until the fault is found. Our electronics supervisor once told me that the most valuable aids in servicing any piece of equipment are your nose, ears and eyes! And I have found this to be very true. This is very similar to the view-point in TE. I like the way you explain how to locate and rectify a problem in simple language. It's very easy to achieve something once you have been shown, but the first time out, it's a mystery.*

*N F Bush,*
*Canterbury, 2193.*

This is exactly the way I approach everything, too.
It's only from your own mistakes that an improvement can be made.

If every project works so well, like you say, I hope you will be constructing the computer project. We need lots of feed-back on programming, applications and add-ons. If anyone has any suggestions, send them in immediately.

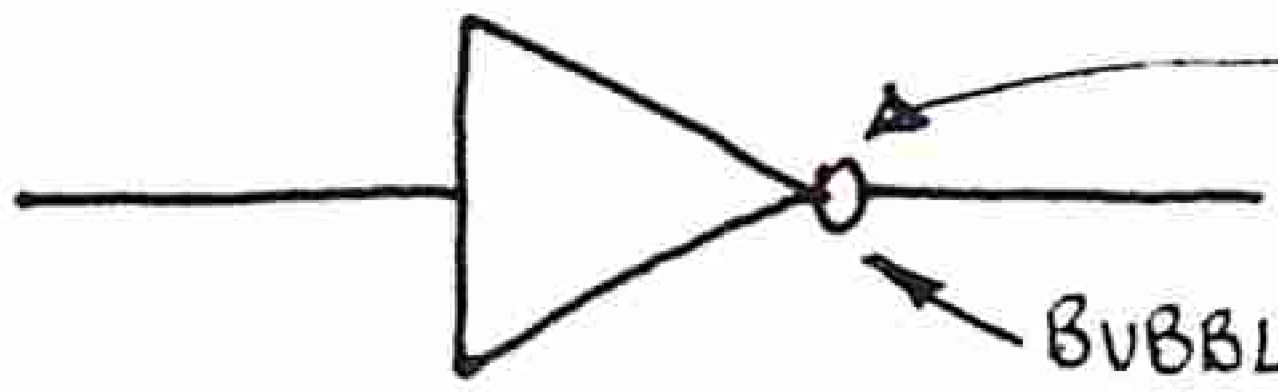
\- Colin.

# "BUBBLES"

SMALL CIRCLES OR BUBBLES ARE QUITE OFTEN FOUND ON GATES & BUILDING BLOCKS AND CAN CAUSE A LOT OF TIMING PROBLEMS IF NOT UNDERSTOOD.

THIS IS HOW TO INTERPRET THEM:

THE EASIEST BUBBLE TO UNDERSTAND APPEARS AT THE OUTPUT OF A BUFFER:



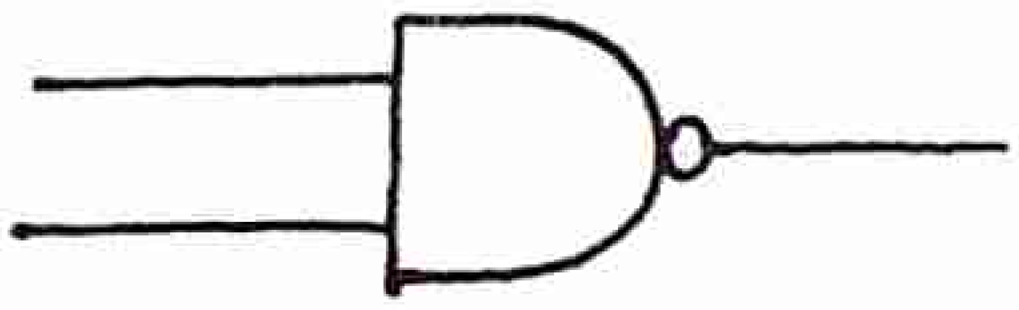
BUBBLE, CIRCLE OR "NOT" (KNOT).

THE BUBBLE INDICATES INVERSION OF THE SIGNAL THIS MEANS:

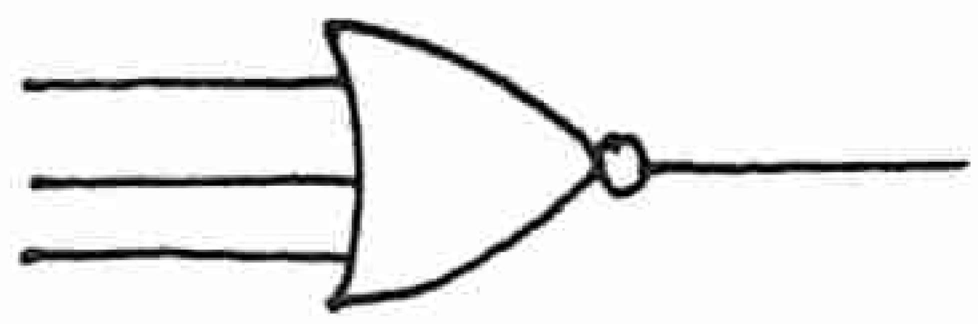
WHEN THE INPUT IS LOW THE OUTPUT IS HIGH

& WHEN THE INPUT IS HIGH THE OUTPUT IS LOW

THE SAME APPLIES TO THESE GATES:



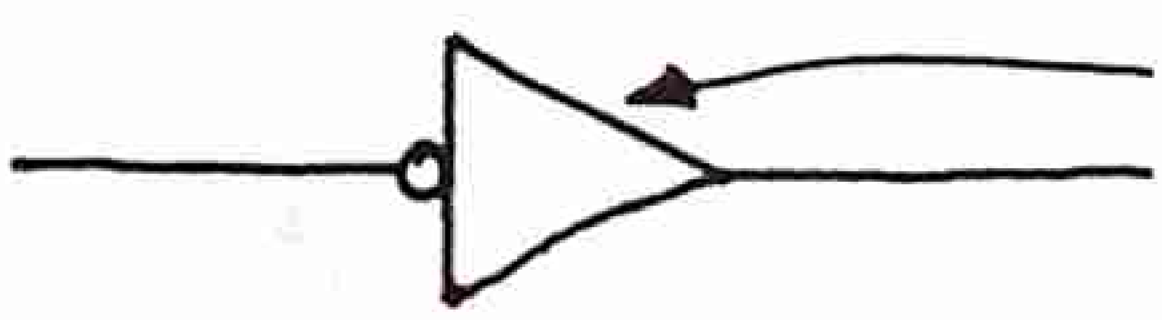
NAND GATE



NOR GATE

THE BUBBLE INDICATES THE COMPLEMENT OR NEGATIVE OUTPUT. THIS IS INDICATED BY THE N AT THE FRONT OF THE AND GATE & OR GATE. TO DETERMINE THE EFFECT OF THE BUBBLE FOR SAY THE AND GATE IT IS NECESSARY TO LOOK UP THE TRUTH TABLE FOR AN **AND GATE** AND INVERT THE OUTPUT FOR ALL THE INPUT POSSIBILITIES. THE SAME APPLIES TO THE NOR GATE.

BUT SUPPOSE A BUBBLE IS PLACED AT THE **FRONT** OF A GATE THUS:



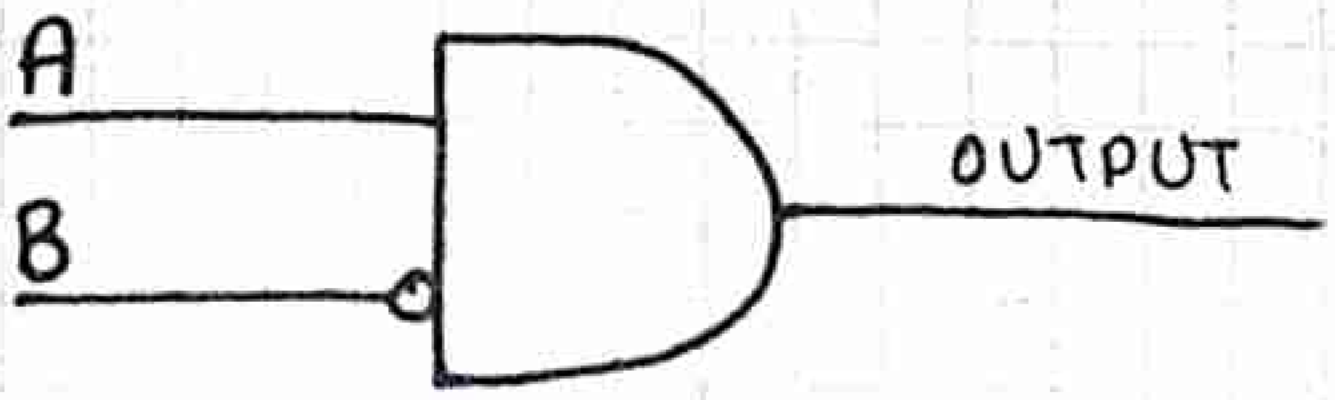
**THIS IS STILL AN INVERTER OR NOT GATE.**

THIS MEANS THE BUFFER WILL BE HIGH AT THE OUTPUT ETC AS SHOWN ABOVE. BUT.......

MORE IMPORTANTLY THE BUFFER IS DESIGNED TO CHANGE STATE WHEN THE INPUT GOES LOW. . . . .

WE SAY THAT THE BUFFER IS "**ACTIVE**" WHEN A LOGIC LOW IS APPLIED TO THE INPUT.

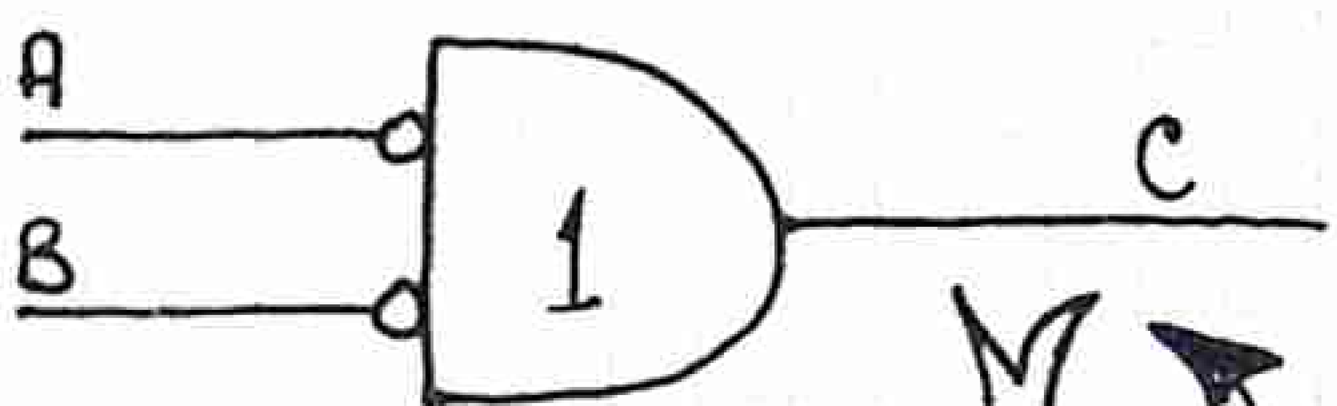
.....THIS MAY NOT HAVE MUCH SIGNIFICANCE AT THIS STAGE BUT YOU WILL SEE IT HAS A LOT TO DO WITH **TIMING OF THE INPUT SIGNAL** AS EXPLAINED IN THE NEXT FRAMES.......




AND GATE WITH ONE NEGATED INPUT

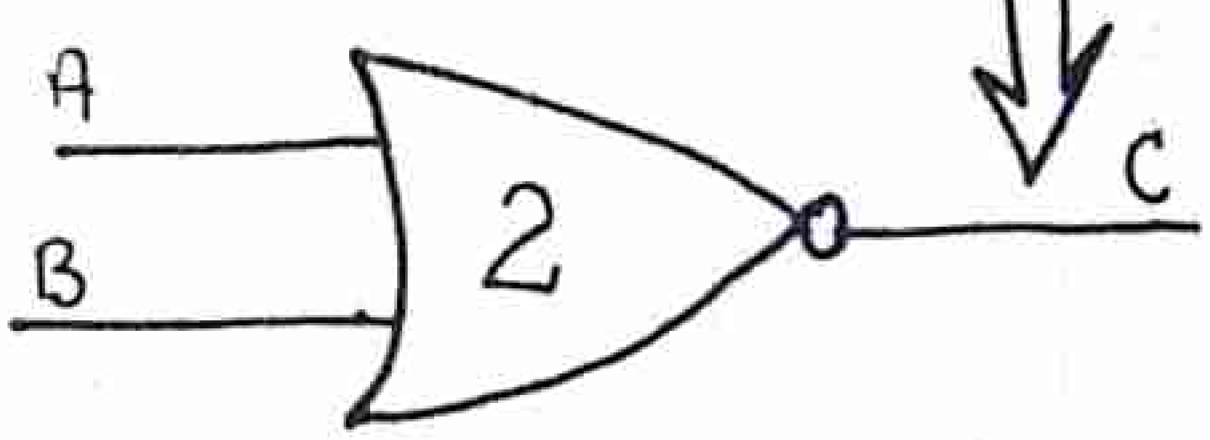
THE GATE WILL BE ACTIVE (THAT IS: PRODUCE A HIGH ON THE OUTPUT) WHEN INPUT A IS LOGIC HIGH (THE SAME AS SAYING "HIGH") AND INPUT B IS LOGIC LOW.

---




AND GATE WITH 2 NEGATED INPUTS. OPERATES THE SAME AS A NOR GATE

THE OUTPUT C WILL BE HIGH WHEN INPUT A IS LOW AND B IS LOW. THIS RESULT IS NOT THE SAME AS A NAND GATE OR AN AND GATE, SO THE EFFECT OF THE BUBBLES AT THE FRONT HAS PRODUCED A DIFFERENT TYPE OF GATE.
TO SHOW THIS WE WILL HAVE TO REFER TO TRUTH TABLES.
THE PREMISE FOR THE TRUTH TABLE (INITIAL FACT) LIES IN THE NEED FOR BOTH INPUTS TO GO LOW TO CREATE THE HIGH OUTPUT.




NOR GATE

TRUTH TABLE FOR

| A | B | C |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

THIS IS THE IMPORTANT CONDITION. (row 0 0 1)
IF THIS IS NOT MET THE OUTPUT GOES LOW.

TRUTH TABLE FOR NOR GATE

| A | B | C |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

THESE TABLES ARE THE SAME !!

WHEN BOTH INPUTS TO A GATE HAVE BUBBLES AS SHOWN IN GATE 1 WE CALL THE GATE A NEGATED AND GATE AND THE TRUTH TABLE FOR THIS GATE IS SHOWN ABOVE.

THIS IS THE SAME SET OF OUTPUTS AS FOR A NOR GATE AND SO THE TWO ARE SIMILAR IN OPERATION.

BUBBLES CAN HAVE UNUSUAL CONSEQUENCES & CARE MUST BE TAKEN TO DETERMINE THE FINAL EFFECT. FOR INSTANCE AN **AND GATE** CAN BE SUBSTITUTED FOR AN **OR GATE** PROVIDED ALL THE INPUT LOGIC LEVELS ARE REVERSED.

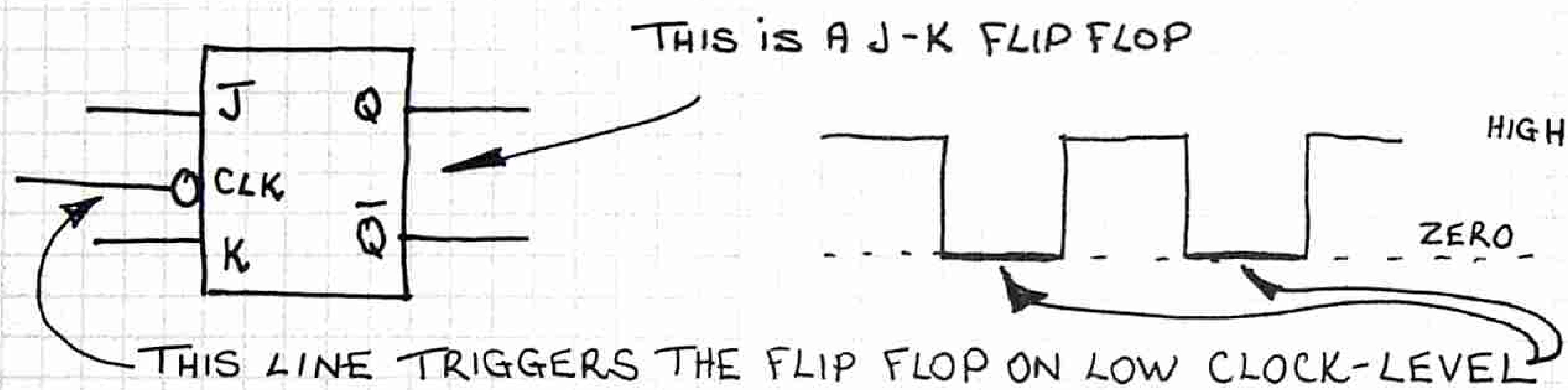
SIMILARLY AN **OR GATE** CAN BE SUBSTITUTED FOR AN **AND GATE** PROVIDED ALL THE LOGIC (INPUT) LEVELS ARE REVERSED.

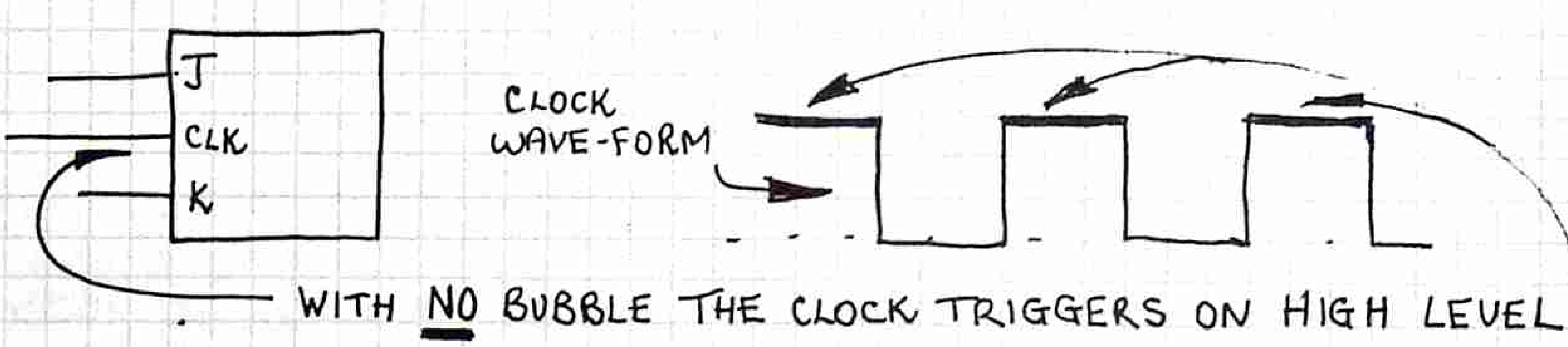
HERE ARE TWO MORE:

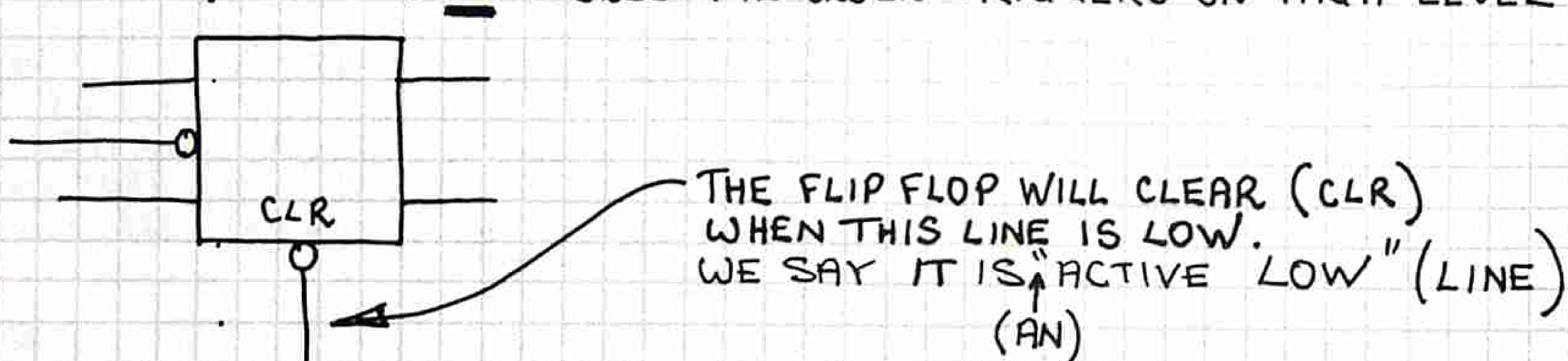
A NEGATED NOR GATE ACTS AS AN AND GATE.

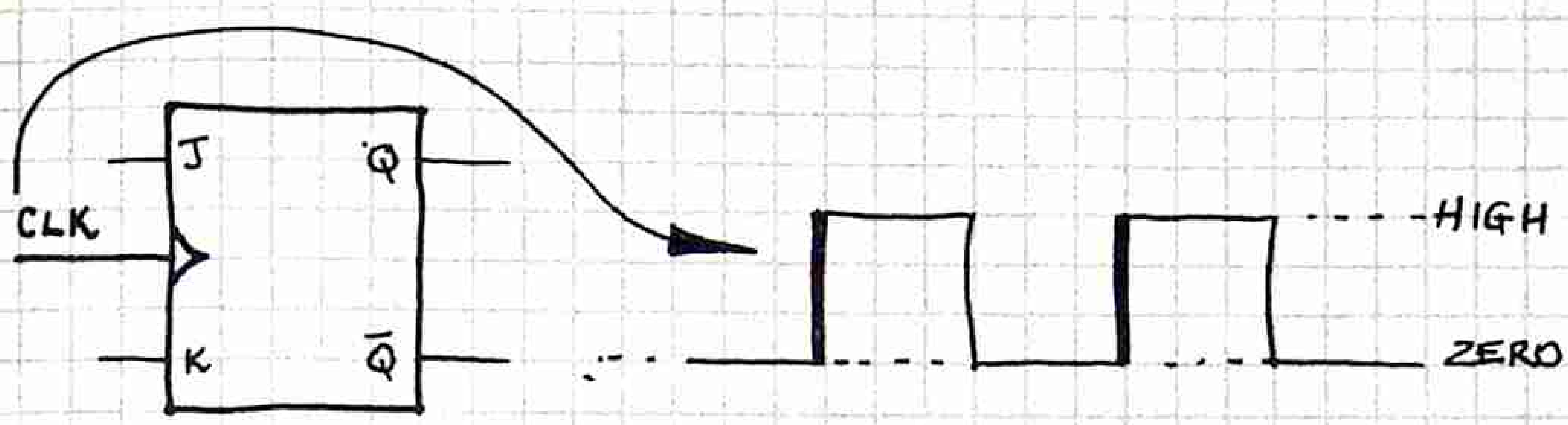
A NEGATED NAND GATE ACTS AS AN OR GATE.

BUBBLES ALSO APPEAR ON FLIP-FLOP DIAGRAMS:

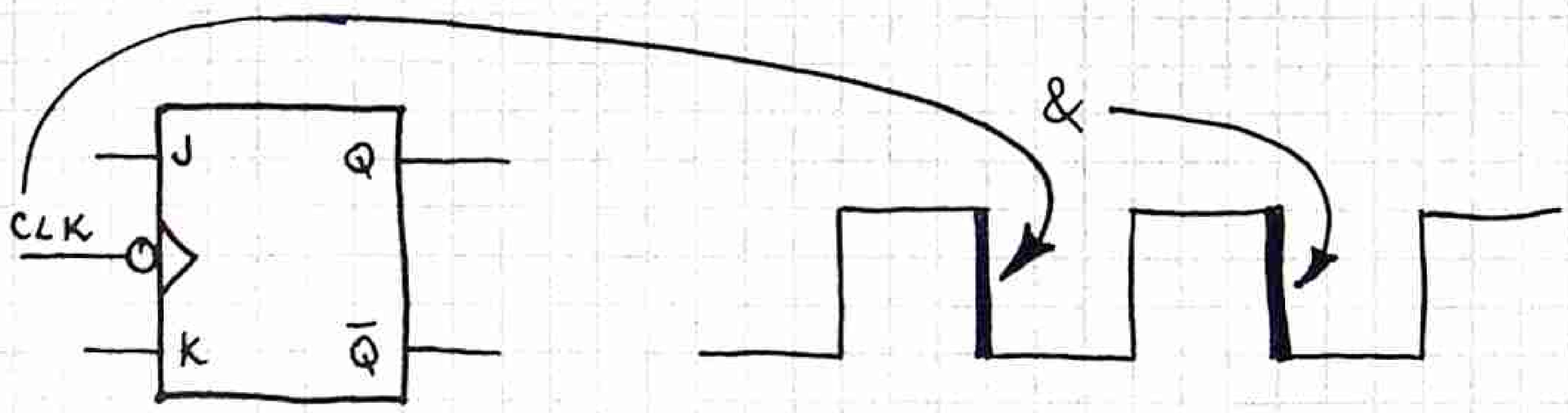





A SMALL TRIANGLE AT THE CLOCK INPUT INDICATES POSITIVE-EDGE TRIGGERING.

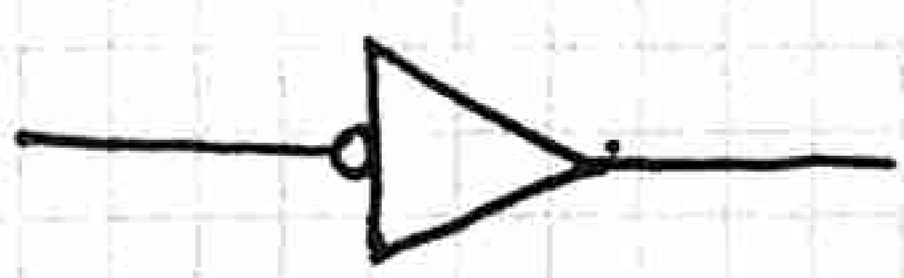



A BUBBLE & A TRIANGLE INDICATES NEGATIVE-EDGE TRIGGERING.

THESE BUBBLES ONLY COME INTO IMPORTANCE WHEN A COMPLEX CIRCUIT IS BEING CONSTRUCTED & THE TIMING OF EACH BLOCK NEEDS TO BE CO-ORDINATED. YOU CAN SEE THAT A FLIP-FLOP WITHOUT A BUBBLE WILL BE ½ cycle OUT-OF-PHASE COMPARED WITH ONE HAVING A BUBBLE ... AND THUS IT MAY BE TOO LATE TO CATCH A CLOCK PULSE.
SO POSITIVE OR NEGATIVE EDGE-TRIGGERING MUST BE TAKEN INTO ACCOUNT.

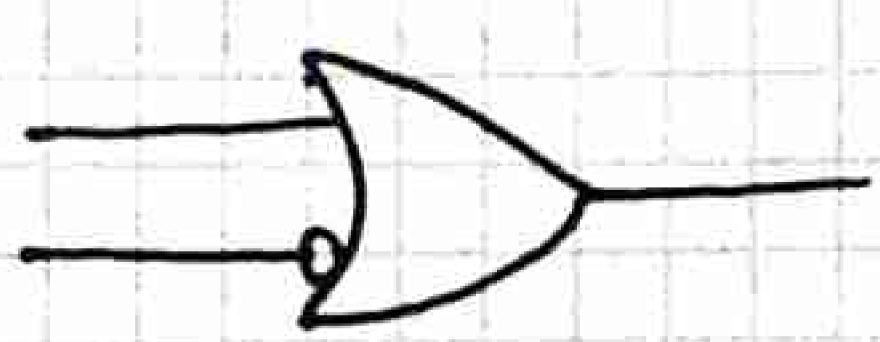
## QUIZ:

1. THE BUBBLE ON THE AMPLIFIER INDICATES:



(a) ACTIVE-LOW INPUT
(b) A "NOT" GATE
(c) AN INVERTER

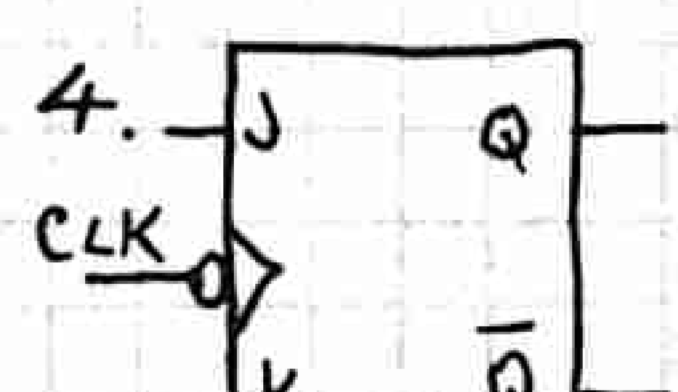
2. THE DIAGRAM REPRESENTS:



(a) A NOR GATE
(b) AN OR GATE WITH 1 NEGATED INPUT
(c) A NOR GATE WITH 1 NEGATED INPUT.

3. 

(a) THE BUBBLES CANCEL EACH OTHER OUT & THE DIAGRAM IS CORRECT.
(b) THE AND GATE SHOULD BE A NAND
(c) THE AND SHOULD BE A NOR
(d) THE AND SHOULD BE AN OR GATE.

4. 


THE BUBBLE & TRIANGLE INDICATE:

(a) NEGATIVE-EDGE TRIGGERING.
(b) ACTIVE LOW CLOCK
(c) POSITIVE-EDGE TRIGGERED CLOCK

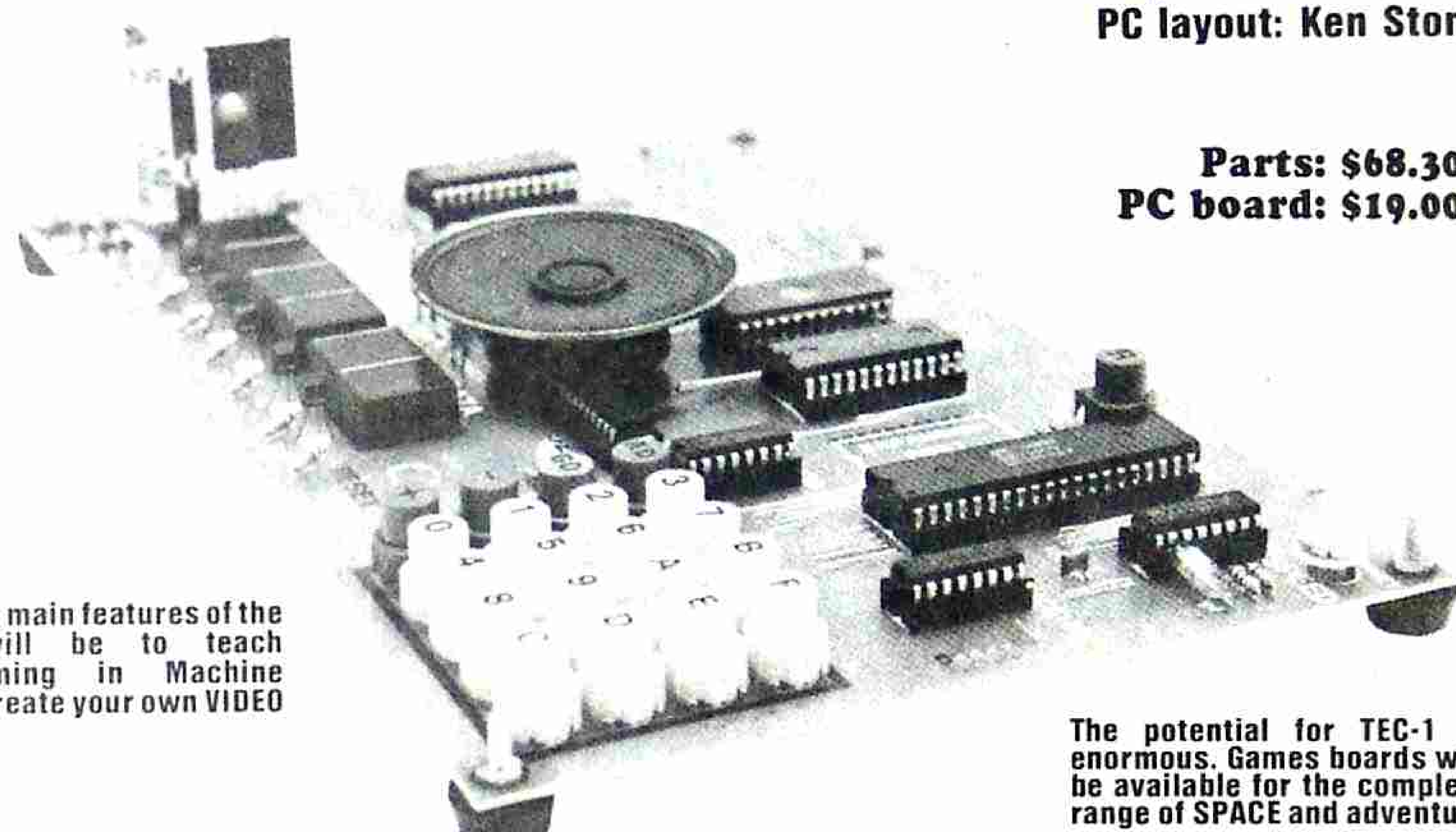
ANSWERS:
1. (a) but (c) IS ALSO CORRECT. 2. (b)
3 (d) 4. (a).

# TEC-1

# TALKING ELECTRONICS COMPUTER

—by John Hardy
PC layout: Ken Stone.

**Parts: $68.30**
**PC board: $19.00**



One of the main features of the TEC-1 will be to teach programming in Machine Code to create your own VIDEO GAMES.

The potential for TEC-1 is enormous. Games boards will be available for the complete range of SPACE and adventure programs.

If you think TALKING ELECTRONICS Magazine is a good place to start learning about electronics, you will find our TEC-1 computer absolutely fantastic.

We have spent many hours looking into the type of computers on the market and also computer kits.

Nothing has come up to the capabilities of the unit we are about to describe. And more important, you will learn the facts and operations of programming from ground level. We will assume you know nothing and thus place special attention to covering the meaning of every term and feature as it comes up.

The only requests we make are the following:

You must have already constructed at least 6 projects from Talking Electronics or equivalent magazines and it would be nice for you to have built the DIGI CHASER and say a couple of equally difficult projects such as the LOTTO SELECTOR and CLOCK.

This means you will be accustomed to soldering fine connections and know how to prevent making bridges between lands.

Fortunately the computer board has a solder resist mask and this means only the individual solder lands are exposed and they are already pre-tinned for easy soldering.

However some of the lands are close to one-another and a small low-wattage soldering iron is required for the project.

We have built 4 final designs and they all work perfectly. On one board we accidently created a solder bridge and this needed a little trouble-shooting, but we finally found it. So, for this reason, each kit includes a length of de-solder wick to mop up the surplus solder.

If you don't have a small soldering iron, fine solder and desolder wick, they will have to be obtained before constructing the kit.

## BUYING THE KIT

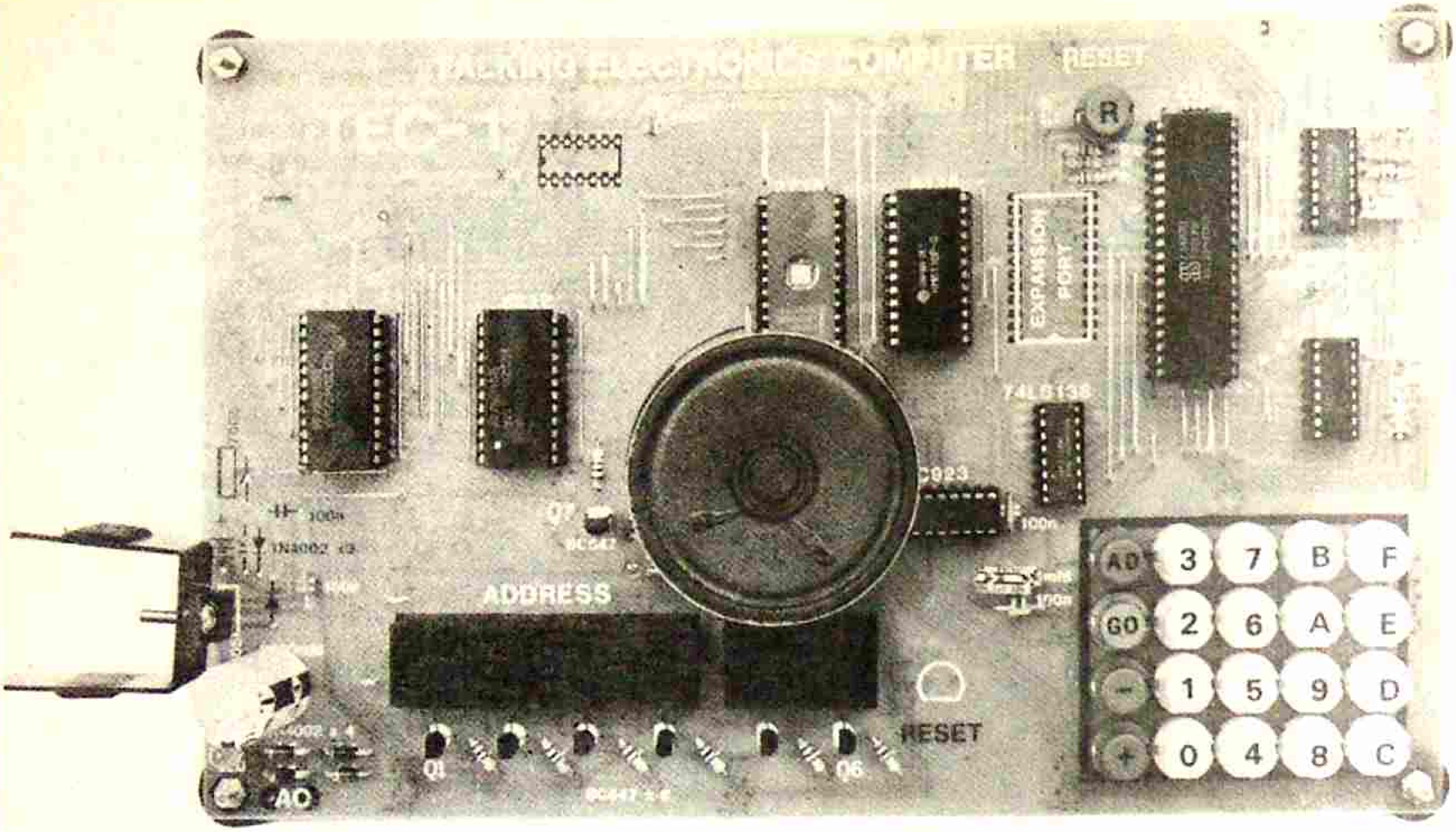
One thing you may not be aware of, is the need for one special chip.

Every computer requires a specially programmed chip so that it will start up and execute the correct operations. This chip can be likened to the BOSS in a work establishment. The chip we are referring to is the 2716 EPROM. You can buy it quite cheaply at any electronics store but unfortunately it is BLANK. And obviously it won't do a thing if you put it into a computer. To be of any use you will have to program it or write a program for it yourself.

Obviously this is way out of the question and so you have to buy one which is pre-programmed, from us.

For this service you have to pay a programmer's fee. A lot of time has

cont. P 60....




## TEC-1 IS A SINGLE-BOARD COMPUTER

# AN OVERVIEW:

The TEC-1 is a single-board computer with readouts in the form of 7-segment displays. The complete unit is shown in the photograph. It contains its own on-board regulated power supply which needs only an AC input for the computer to be fully operational.

The key pad is constructed from individual switches inscribed with hexadecimal numbers 0 to F and 4 switches labelled AD for address, GO, + for incrementing the address and − for decrementing the address.

The computer will play a number of games as well as present the alphabet and all this is contained in the 2716 EPROM which is directly above the speaker. The TEC-1 can also be connected to 8 output devices and they can be turned on and off in any combination as determined by the program you write. This program is stored in the 6116 RAM and any information in this chip is lost when the computer is turned off.

The reset button above the empty expansion port socket will reset the computer to the first address location (0800) and by pushing the GO button TWICE, any program you have entered into the computer, will run.

The computer contains 2k of RAM and this is programmed in machine code. Machine Code is very memory efficient and has a fast execution rate, making it possible to create high-speed programmes for video games and multi-function controlling.

Extra memory can be added via the expansion port and this is added to a daughter board directly above the main board via a dip header plugging into the expansion port socket. This will increase the capabilities of the computer to 12k plus 2k of memory-mapped in/out ports.

The speaker has two functions. It gives an audible beep every time a key is is pressed and becomes the output when music or tones are being played.

All the names of the chips are written on the overlay of the board and in simple terms they provide the following functions:

8212 - drives each digit for the display via buffer transistors.
8212 - drives the segments A - G and the decimal points for the display.
2716 - EPROM (Erasable Programmable Read-Only Memory). This has been programmed by John Hardy and contains the brains of the TEC-1.
6116 - The RAM (Random Access Memory) into which you put your own program. The Z80 also uses it during the operation of some of the programs.
Z80 - The heart of the computer.
4049 - The oscillator or CLOCK for the TEC-1.
74LS138 - selects between ROM (2716) and RAM (6116).
74LS138 - Selects between keyboard and display.
The photograph has been illuminated from the rear to show the tracks on the underside of the board. Normally these tracks are hardly visible as they are hidden under the solder mask.
Notice how neat everything is presented. You can credit the superb layout to Ken Stone who recognises the importance of making a project look appealing. Note especially the few resistors and capacitors required for a fully digital project.

The 20k cermet pot has been specially chosen as it has a cover which is connected to the wiper contact so that the pot can be turned with your fingers. This controls the speed of the operation of the computer and you will be using this control quite a lot.

The output pitch of the notes will vary according to the setting of the speed control as will the difficulty of the

games and the scrolling of the screen when the letter sequence is addressed.

All chips are mounted in sockets for a number of reasons:
1. It looks professional.
2. It makes construction easy.
3. It makes testing and replacement easy, and
4. You can test other chips in the sockets.

The 100n capacitors are miniature solid dielectric types, about the size of a match-head, and they are specially suited to removing any spikes generated by the chips or from the power supply.

The TEC-1 will operate from a 6v battery such as a 509 lantern battery or from the mains via a transformer. The 7805 regulator keeps the operating voltage at 5v which is absolutely necessary for the chips we are using.

The battery back-up arrangement means you can have a battery sitting beside the computer in case the power fails or if you wish to change the computer from one room to another. When the battery back-up is operating the complete TEC-1 is operating as it is not posssible to power-down the Z80 without it affecting the contents of the RAM.

There are two empty IC sockets as well as a number of rows of holes on the board. These are for later expansion and not used at this stage.

The RESET key can be positioned near the display is desired. It is connected via 2 jumper leads to this lower position.

Finally you will be pleased to know the TEC-1 doesn't need any TV monitors, additional keyboards or bulky power supplies. It is self-contained on the single PC board.

## THE EXPANSION PORT

The expansion port socket can be used in two different ways.

1. It can be used to increase the on-board memory of the computer to 4k RAM by inserting a 6116 RAM with IC socket, directly into the vacant space.

2. Alternatively, the expansion port can be used to increase the memory on steps of 2k by adding a daughter board above the main computer board. This will take a row of 5, 6116 chips and a bank of latches. Each 6116 will provide 2k of RAM and this is one of the add-ons which will be described in the next issue.

Each of the chips on the daughter board is selected by a line from the 74LS138 (near the clock oscillator). It is known as an address decoder and the first decoded output selects the EPROM. The second output selects the on-board 6116, the third selects the expansion port socket. If a duaghter board is used, the first chip on the board is selected and so on until 7 lines are used. 5 individual wires must be taken to the daughter board to provide this selection feature. They are taken from the 5 unused holes near the 74LS138.

To give an indication of the amount of memory you may require, here is a simple guide:

Each 6116 will accept 2048 bytes of information. A normal program contains between 1 and 4 bytes of data per instruction and this means one 6116 will accept about 600 instructions! To hand-assemble a program of this length wuld take months. We have only 3/4 filled the 2716 and you will be amazed at the capabilities of its contents.

So you can see, 2k will be quite adequate for most purposes.

The main use for the expansion is when the microcomputer is colecting and storing its own data for later retrieval. In this mode the computer can use up an enormous amount of memory, very quickly.

Take an example of a music sequencer. 2k of memory will last about 10 to 20 seconds. Or an echo unit. This will last less than 1 second!

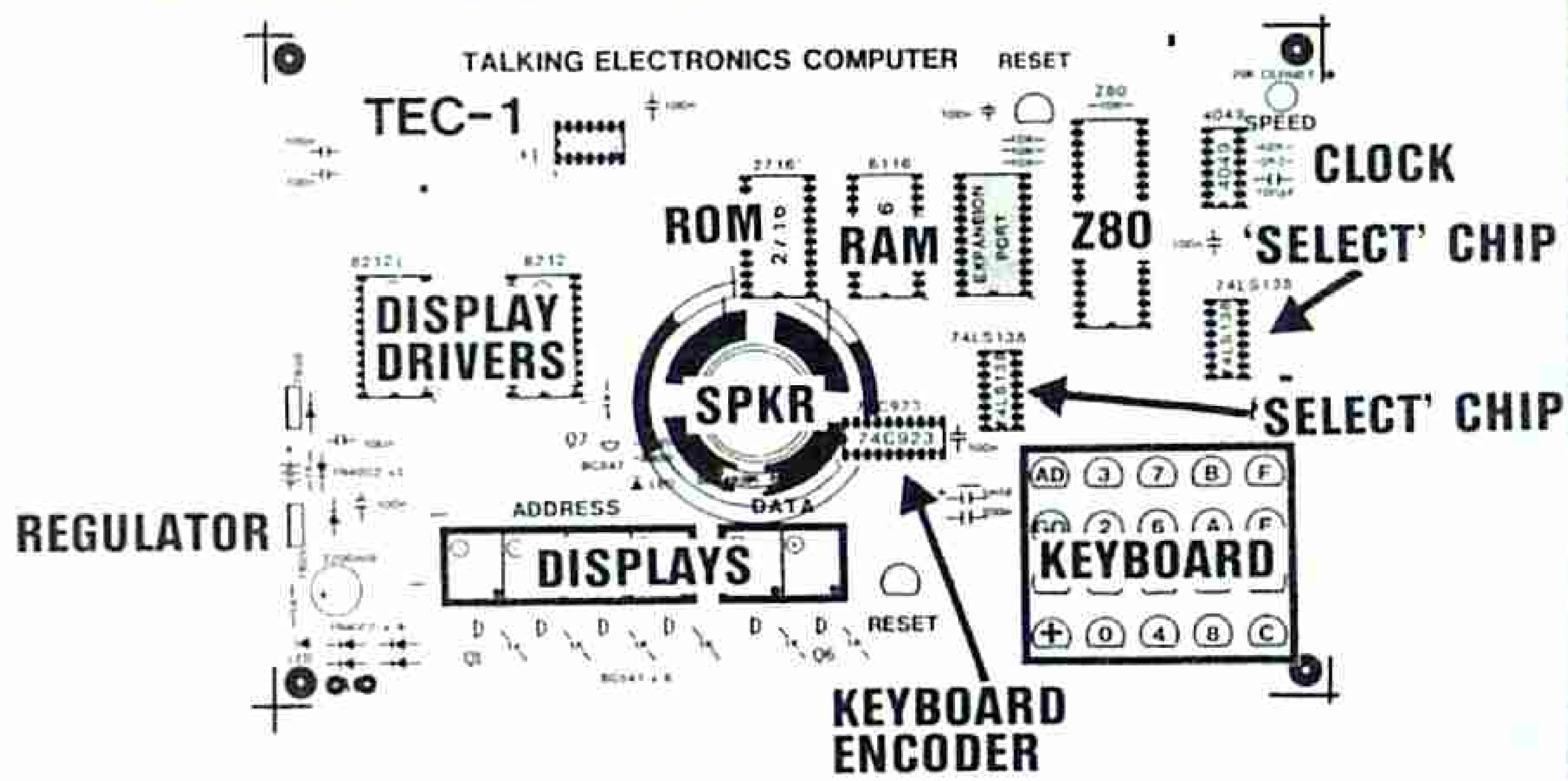
## BATTERY BACK-UP

To use battery back-up, diode A must be installed. Connect the battery via a switch so that you can move from one location to another. Switch the battery OFF when the computer is using the mains power.

## MARKING THE KEY-TOPS

The key tops can be lettered using LETTRASET. 16pt letters and numbers are used for 0 - F and 12pt letters for the AD and GO keys.
A coat of nail varnish will stop the lettering from wearing away.

## THE FUNCTION OF EACH CHIP




*TEC-1 is a complete microcomputer on a single PC board.*

*The function of each chip will become clearer after reading the text.*

*The most important concept is to understand how each chip is controlled by the Z80.*

*The above diagram shows where the ROM, RAM, Z80 etc are postioned on the board along with the other chips and devices.*

been spent to get a set of instructions into the 2716 EPROM and each is individually filled from a master and verified, before it is added to a kit. This takes time and royalties are due to the designer, like the sale of a book or record. This accounts for its high cost.

We have called the EPROM a 2716 but actually it is a 2716-MON-1 EPROM, indicating it contains a program.

This is the only expensive chip. All the others have been chosen for their low price and availability. This is the way we approached the design of the computer. We looked at the price of each component and arranged the design around the low priced items.

The only components special to the TEC-1 are the EPROM and the printed circuit board. All the other components can be purchased at major electronics shops. The only advantage with buying a kit is the saving in time and frustration.

It would be very rare indeed for you to be able to buy all the components at one electronics shop. And so you will have to spend time and money in the hope of saving money.

In addition, there are a couple of pitfalls for the inexperienced. For instance, 4049 chips made by Fairchild should be avoided. They do not work in our situation. Also the push buttons should be the type suggested as one of the links inside the switch is used to create the wiring for the matrix.

The price structure for each kit is broken up as follows:

1. The Printed Circuit Board.
2. The 2716 MON-1 EPROM.
3. The kit of components.

The only other parts you will need to purchase are a 2155 transformer and power lead or a 9v DC plug pack rated at 500mA. You can, of course, use a lantern battery. This will be sufficient to operate the computer for about 5 to 8 hours, but will prove to be a very expensive way of running the TEC-1.

## WHAT THE COMPUTER WILL DO

When you are going to spend a lot of money on a project and a considerable number of hours in its assembly, it's nice to know what the project will do.

Here is a summary of the first stage of the capabilities of the computer. Apart from the obvious experience gained in assembling a computer, the TEC-1 will make you aware of the chip-types required to create a complete system.

You execute some simple programs which use pre-programmed information from the EPROM and display it on the screen. If we take the letter program for instance, you create a single static letter,then add another letter and enable them to run across the display. Finally you create your own words and sentences which can be made to pass across the display at a rate determined by the setting of the SPEED control.

But most important you learn some of the instructions necessary to write your own programmes.

You also learn to increment and decrement the memory address to look at the contents of each location and possibly alter it if required.

You carry out the same procedure with a set of tones and these can be combined to produce a tune. You can also access two tunes in the ROM and this will give you an indication of what can be achieved. Your own tune can be added to the end of the RUNNING WORD DISPLAY and create a wide variety of possibilities.

There are also three games in the EPROM and these can be played in-between the educational programming.

The first game is NIM. Everyone knows this game as 23 matches. The address location for this game is 03E0 and the computer starts with 23 on the display. The object of the game is to try and leave the computer with last match. You can take 1, 2 or 3 matches during your turn. Believe me, it isn't easy.

The second game is LUNA LANDER. Its address is 0490. The numbers on the screen represent velocity and height. You are required to land on the surface of the moon at zero velocity without running out of fuel. The full details of this game are on the last page of this article.

The third game is INVADERS. A number is set up on the left hand end of the display and invaders approach from the right. See the article on how to exterminate them on P 74.
Difficulty is set by the speed control and your score apprears at the end of your turn.

This is only the beginning. In the next issue we will expand the TEC-1 and interface it with the outside world.

## PRICES:

Here are the prices for the TEC-1.

Depending on how much you already have in stock and how you intend to construct the project, so the price will vary. Don't spoil the ship for a ha'penneth o' tar. Use only the best components.

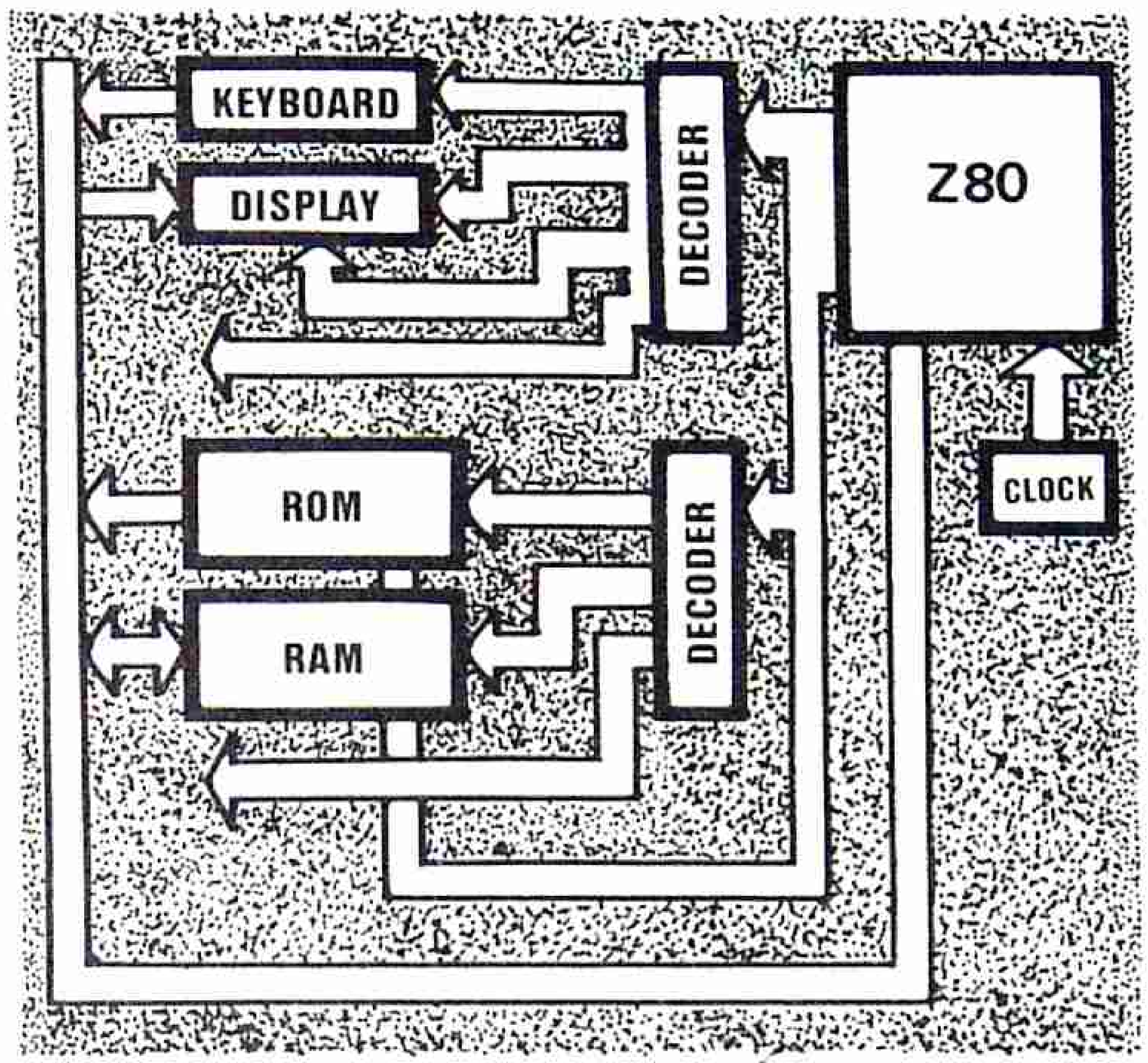
Complete kits are available at our larger outlets and the PC board will be available with pre-programmed EPROM from some of the other outlets. As a back-up service, the complete kit will also be available through the magazine as listed on the kit pages. Remember, the board is double screened and solder masked to give a classy finish to the project. If you have never made your own PC boards before, don't start with this board. The work involved in making a board of this complexity is enormous and the result will be nothing like the cover photo.

The only two outlays you have to accept are the PC board and the pre-programmed EPROM. All the rest can be obtained from your local supplier.

**PC Board $19.00** (post $2.50)
**2716 - MON - 1** Programmed EPROM **$12.00**(Post $1.50)
**Kit of Parts** (including EPROM)**$68.30** (Post $2.50
**All Parts & PC Board $87.30** (Post $4.50)
You will also need a 6v lantern battery (from your local hardware shop) or a 2155 transformer ($5.90) and a power lead or a 9v AC or DC Plug Pack rated at 500mA ($14.50)

**Complete TEC-1 with transformer $93.20** (Post $5.50)
**Complete TEC-1 with Plug Pack $101.80** (Post 5.50)

-ADD-AND-BIT-CALL-DEC-EX-IN-INC-JP-LD-NEG-NOP-OR-OUT- POP-PUSH-RES-RET-RL-RST-SBC-SET-SLA-SRL-SUB-XOR-




## TEC-1 BLOCK DIAGRAM

This simplified BLOCK DIAGRAM shows how each of the chips are inter-connected.

The Z80 Central Processing Unit is the overseer of the whole system and it selects which device it wishes to access via one of the 74LS138 decoder chips. Each will select one-of-eight output lines. These decoder chips are not fully utilized in this project and this leaves room for further expansion.

If we take the key-board as an example, we see it passes its information to the Z80 via the DATA BUS.

This bus consists of 8 lines and carries binary information. This will allow any number from zero to 255 to be sent.

The ADDRESS BUS is a 16 line path which is only a one-way street. Information only emerges from the Z80 on this bus. The Data bus is a two-way street of 8 lines. Information can be passed into the Z80 on this path as well as emerge from it.

Each block in the diagram represents a chip and the only two chips missing are the display drivers.

### OUR BORDER

**Z80 computer terms have been added to the top and bottom of the pages, for this project. Some of the more common instructions are contained in this string.**

**Here are the meanings of these terms:**

**ADD** Add the contents of a CPU register to the accumulator.

**AND** This is a logical AND operation in which two binary numbers are compared. If the first digit in each number is a 1, the answer is a 1. If only one number is 1, the answer is 0. If both numbers are 0, the answer is zero.

**BIT** This is an instruction to test the status of a bit in a register.

**CALL** This is a call instruction which will be executed if a particular condition is satisfied. If the condition is not satisfied, then the call instruction is ignored and the program execution continues.

**DEC** This is an instruction to decrement the value of a CPU register by one.

**EX** This is an exchange command. The contents of any register can be exchanged with any others.

**IN** Input to a CPU register from an input port.

**INC** The increments the value of a CPU register by one.

**JP** This is a jump instruction.

**LD** This is a load instruction.

**NEG** This instruction negates the contents of the accumulator. The result is the same as subtracting the contents from zero.

**NOP** This is the NO OPERATION instruction.

**OR** This is a logic instruction which compares two numbers. If either of the first digits is a 1, the answer is a 1. The same applies to the second and third digits. etc.

**OUT** An output instruction from a specified CPU register.

**POP** This is an instruction to POP from the stack into a register pair.

**PUSH** This is an instruction to PUSH an index register onto the stack.

**RES** This is an instruction to clear the status of a single bit in a CPU register to the logic zero state.

**RET** This is a conditional return instruction.

**RL** This rotates the contents of a CPU register to the left through the carry bit.

**RST** A restart subroutine directive

**SBC** A double subtraction instruction

**SET** Sets the status of a single bit in a CPU register to the logic ONE state.

**SLA** This instruction shifts the contents of a memory location to the left

**SRL** This shifts the contents of a CPU register to the right

**SUB** This instruction subtracts the contents of a CPU register from the accumulator

**XOR** This is a logic instruction which compares each bit of two numbers and gives an answer of 1 if either bit is one. But if both are 1, the answer is zero.

## LOOKING INTO THE TEC-1

There are two chips in our computer which provide the major amount of processing.

To make it easy to understand, we will call them the BOSS and WORKER. The boss is the 2716 which is the specially programmed Read Only Memory (ROM) and contains all the information to get the computer started and keep it operating.

The worker is the Z80. It is the arms and legs to which all instructions are sent and it provides the ability (muscles) to carry out the requests of the ROM.

The Z80 can also be thought of as an octopus, extending out its tentacles to all parts of the computer to keep everything in very strict control.

These two chips are the most important items in the computer and it will almost run without any other devices. But you would not be able to push any buttons or see the results of the operations. So we need more chips.

The first of these are the display chips. Because each has only 8 outputs, we need two. The display is multiplexed (see issue 2. P.5.) and this type of design uses the least amount of wiring and the least number of input leads. For a 6 digit display with decimal points, we require 8 inputs for the segment drive and 6 inputs for the digit drive. One 8212 is used for each of these with the digits being driven via driver transistors.

This leaves two spare outputs and one of these is used to drive the speaker via a buffer transistor (Q7).

The Z80 (the microprocessor) is constantly feeding information into the display via the pair of 8212's. When you understand the operation of multiplexing a display you know it is constantly being scanned to create the figures.

To prove this feature, turn the speed control down to minimum and shake the board. You will be able to detect the strobing of the display.

The keyboard is also an interesting feature. It is also being constantly scanned by the 74c923 (the chip near the speaker), waiting for one of the keys to be pressed.

The scanning commences at the first row, which is the bottom row and it reads from each of the columns to see if any of the buttons have been pressed. Next it progresses to the second bottom row and again checks the columns. If a button is detected, it sends a debounced signal to the Z80 and interrupts it. The Z80 drops whatever it is doing and accepts a 5 bit binary number from the 74c923, which corresponds to the key being pressed. An example of a 5-bit binary number is 10011 and the following table gives the value for each key on the pad.

| KEY | Binary No. |
|---|---|
| 0 | 00000 |
| 1 | 00001 |
| 2 | 00010 |
| 3 | 00011 |
| 4 | 00100 |
| 5 | 00101 |
| 6 | 00110 |
| 7 | 00111 |
| 8 | 01000 |
| 9 | 01001 |
| A | 01010 |
| B | 01011 |
| C | 01100 |
| D | 01101 |
| E | 01110 |
| F | 01111 |
| + | 10000 |
| - | 10001 |
| GO | 10010 |
| AD | 10011 |

The 2716 ROM tells the Z80 how to interpret the 5-bit binary instruction and what to do with it.

This means we could change the position of all the keys, re-program, the 2716 and the system will be operational again. In other words it is a SOFTWARE programmed set of instructions.

The 74LS138 below the EXPANSION PORT selects between the keyboard and display. Take this example: Button 5 is pressed. The Z80 has all its attention directed to scanning the display via the pair of 8212's. The 74LS138 is allowing the 8212's to function and at the same time prevents an output from the 74c923 to be passed to the Z80.

When button 5 is pressed, the 74c923 sends and interupt signal to the Z80. The Z80 stops scanning the display, requests the 74LS138 to shut down the display and open up the information from the 74c923 from the keyboard. Once the keyboard is read, the Z80 reverts to scanning the display.

This happens so fast that you cannot see the display flicker. The blanking you may see on your model is the result of the time taken to beep the speaker. The longer the beep, the longer the displays are blanked.

The RAM is like a black board. It holds temporary information which is being constantly modified by the microprocessor. When the power is switched off the contents of the 6116 is lost.

The 2716 has a set of instructions which allows the user to access the RAM. Without these instructions you would never be able to get into its memory.

The 74LS138 near the speed control selects between the ROM and the RAM and also any extra memory added to the expansion port.

The 4049 is simply an oscillator or clock which produces clock pulses for the Z80.

Because the Z80 is a dynamic device, its registers need to be constantly cycled to retain their contents. There is a minimum clock rate for this and if the rate is reduced, the computer will crash.

## SUMMARY OF EACH CHIP

8212 - Display driver. One chip supplies 8 lines to the segments and the other drives the digits via a driver transistor.

2716 - ROM. The central library of the computer. It tells the computer how to operate.

74c923 - Keyboard control device which interfaces the keyboard with the Z80 chip.

6116 - RAM. Temporary storage for data and instructions. Storage for your own programmes.

74LS138 - Selects the display or keyboard as required by the Z80 chip.

Z80 - The core of the computer. Contains all the necessary logic for executing programmes and manipulating numeric data.

4049 - Wired as an oscillator and fed to the Z80 to determine the operating speed of the system.

74LS138 - Selects between the ROM and RAM as instructed by the Z80.

-ADD-AND-BIT-CALL-DEC-EX-IN-INC-JP-LD-NEG-NOP-OR-OUT-POP-PUSH-RES-RET-RL-RST-SBC-SET-SLA-SRL-SUB-XOR-

# THE Z80 CPU

The heart of the TEC-1 is a Z80 CPU. This is the largest chip on the board, having 40 pins, and is the central item around which all the other chips operate. The 40 pins are all used to advantage as they are needed to send and receive data as well as send out address locations. On top of this, 8 pins are required for controlling the functions of the Z80.

If we consider the Z80 to be a worker, the BOSS will have to be the 2716 EPROM.

When the computer is first turned on, the Z80 has just enough intelligence to output an address to the EPROM to locate the CPU's first instruction. The EPROM returns this instruction via the DATA BUS and the two start communicating. The EPROM tells the Z80 what to do, how to do it and where it must be put. In less than a second, the start-up procedure has been completed and the whole system comse alive with the START ADDRESS appearing on the display.

For the moment, the Z80 is the chip we wish to investigate.

Most of its pins are ADDRESS and DATA lines. Eight of these are grouped together to become the DATA BUS and 16 are grouped together to become the ADDRESS BUS.

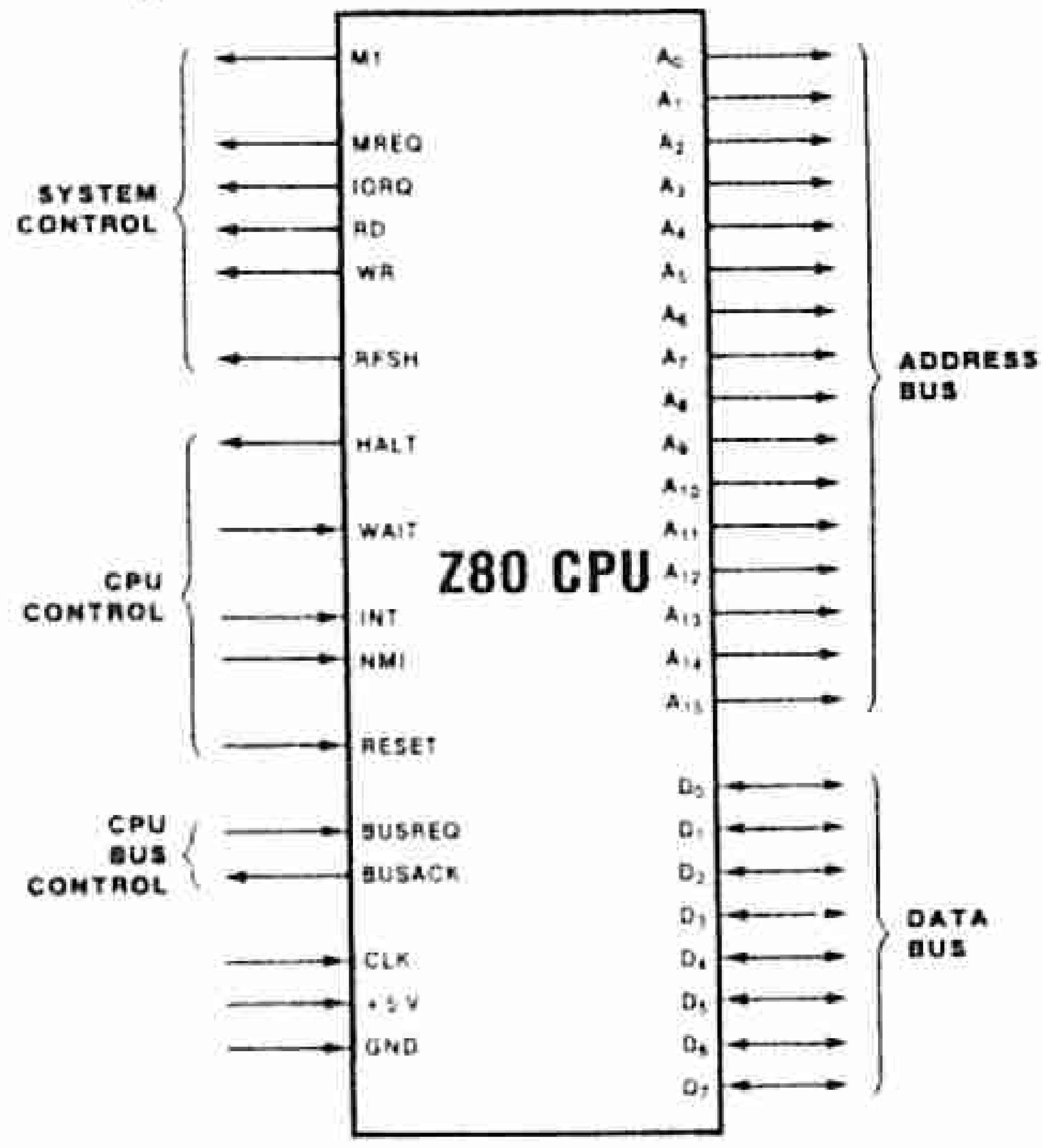
The Z80 uses the ADDRESS BUS to locate the data it wants. This may be in the ROM (the 2716) or in the RAM (6116). It uses the ROM/RAM select chip 74LS138 in this process. Or the information may be from the keyboard. In this case it uses the display/keyboard select chip, another 74LS138.

The Z80 can only do one thing at a time and it is only because the system is operating at between 250kHz and 2MHz (as determined by the speed control) that you think everything is happening at once.

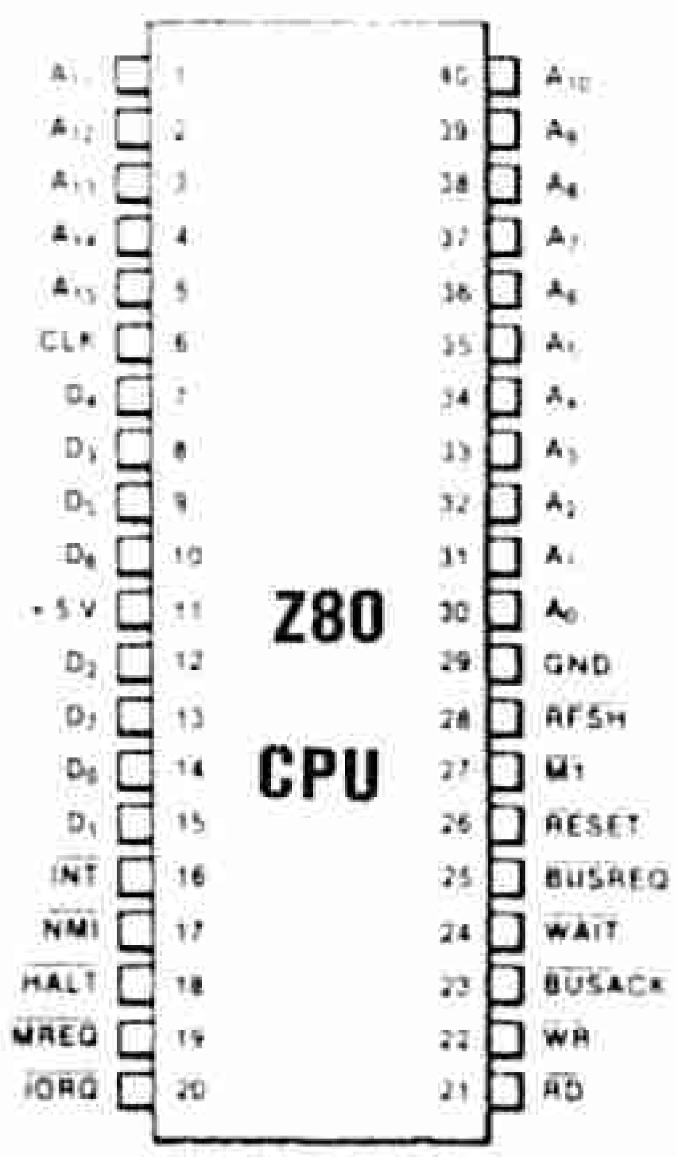
## THE Z80 SERIES

The Z80 series (without an 'A' after the 80) was the first to be developed and has a maximum operating speed of 2.5MHz. The Z80A series operates at 4MHz.

There is a whole family of Z80 chips and you must be careful to read the letters which follow the Z80 name, to identify the actual function of the chip.




Z80 LOGIC FUNCTIONS




Z80 PIN OUTS

The Z80 microprocessor is the central element of a microprocessor (computer) and is called CPU. This stands for Central Processing Unit.

Five other chips provide support for the CPU in complex computer systems. We have not used any of these in our simple system but it is handy to know of their existence.

They are: The PIO (Parallel Input/Output). This can be wired to interface peripheral devices such as printers and extra keyboards etc.

The CTC (Counter/Timer Circuit). This chip features 4 programmable 8-bit counter/timers each of which has an 8-bit prescaler. Each channel will operate in either counter or timer mode.

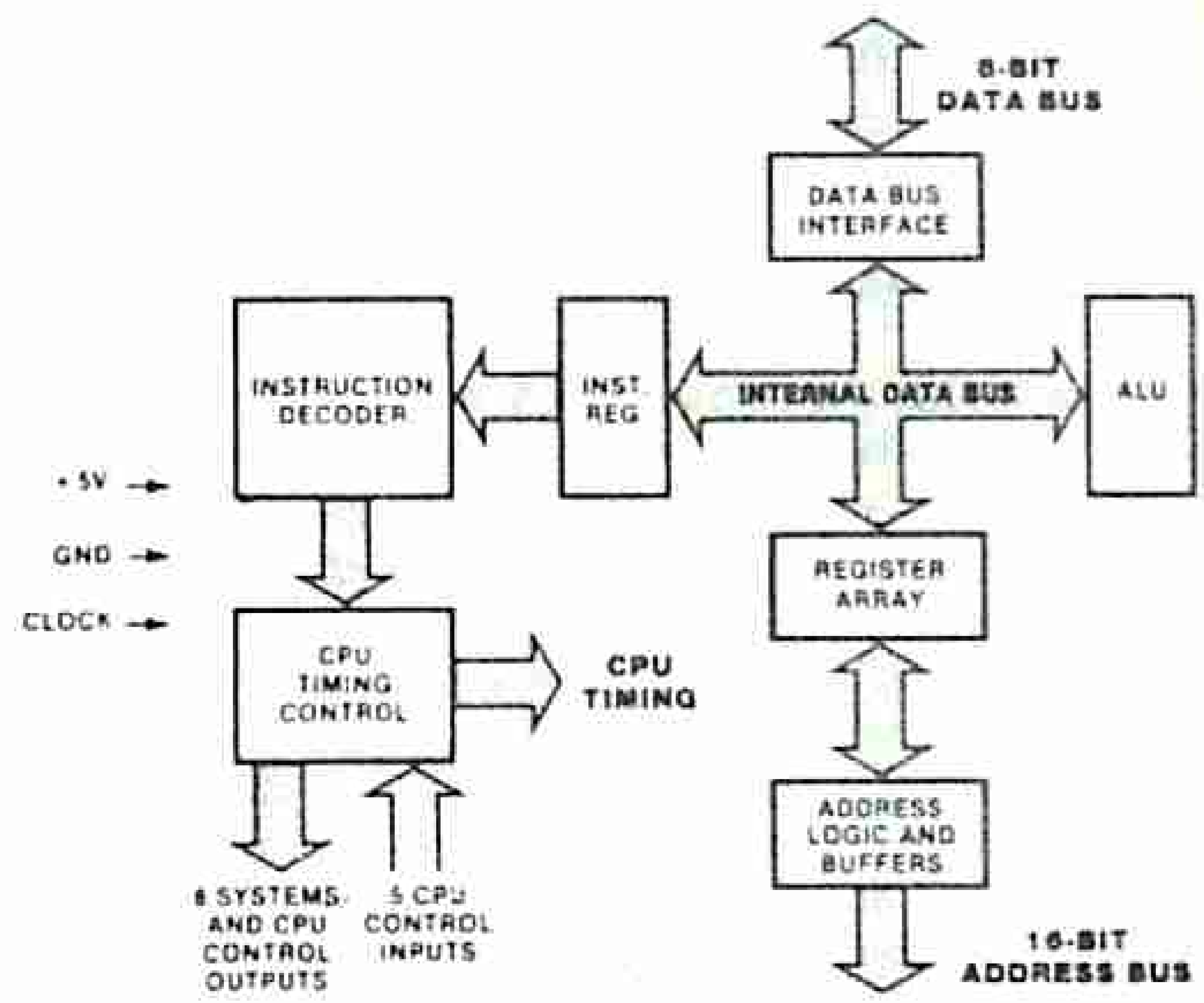
The DMA (Direct Memory Access). This controller provides dual port data operations.

The SIO (Serial Input/Output). This controller offers two channels. It is capable of operating in a variety of programmable modes for both synchronous and asynchronous communication.

The DART (Dual Asynchronous Receiver/Transmitter). This chip provides low-cost asynchronous serial communication. It has two channels and a full modem control interface.

The Z80 series of chips have completely different operations from each other and the letters on the chip are VERY important.

It's difficult to realize, but the Z80 is classified as a "dumb worker". It may be dumb but it is very quick. It is capable of carrying out instructions at the rate of about 10,000 to 200,000




Z80 CPU BLOCK DIAGRAM

operations per second, depending on the type of instruction. Each of these takes a particular number of cycles to execute and these features are contained inside the Z80 architecture and cannot be altered.

Each operation for the Z80 has a machine code instruction such as 1E, 06, 0E, 85, E6 dd, 06, E9, 8, 81, ED 47, 00 etc and these will be discussed in a later article. For the moment, we want the computer to seem a reality.

There are lots and lots of sections inside the Z80 chip and most of them are very difficult to explain in simple terms.

One area which can be explained via a simple comparison is the bank of registers. These perform most of the operations in the Z80.

They are given the names B, C, D, E, H and L, with an accumulator register A. These registers can be likened to a car space in a parking lot. Each register represents one car space. The car represents one WORD of information and this work consists of 8 bits or one BYTE. A bit is a signal on a single line which can be either HIGH or LOW and 8 lines enter the Z80 in the form of a DATA BUS.

This data bus is the same as the road into a parking lot and the car is one word. The 8 bits are 8 seats and each car can have up to 8 people. Depending on where they sit and the number of people, the size of the byte is determined. We can say that byte and word are the same for our system as the Z80 is an 8-bit microprocessor. If it were a 16-bit microprocessor, a word would be 16 bits.

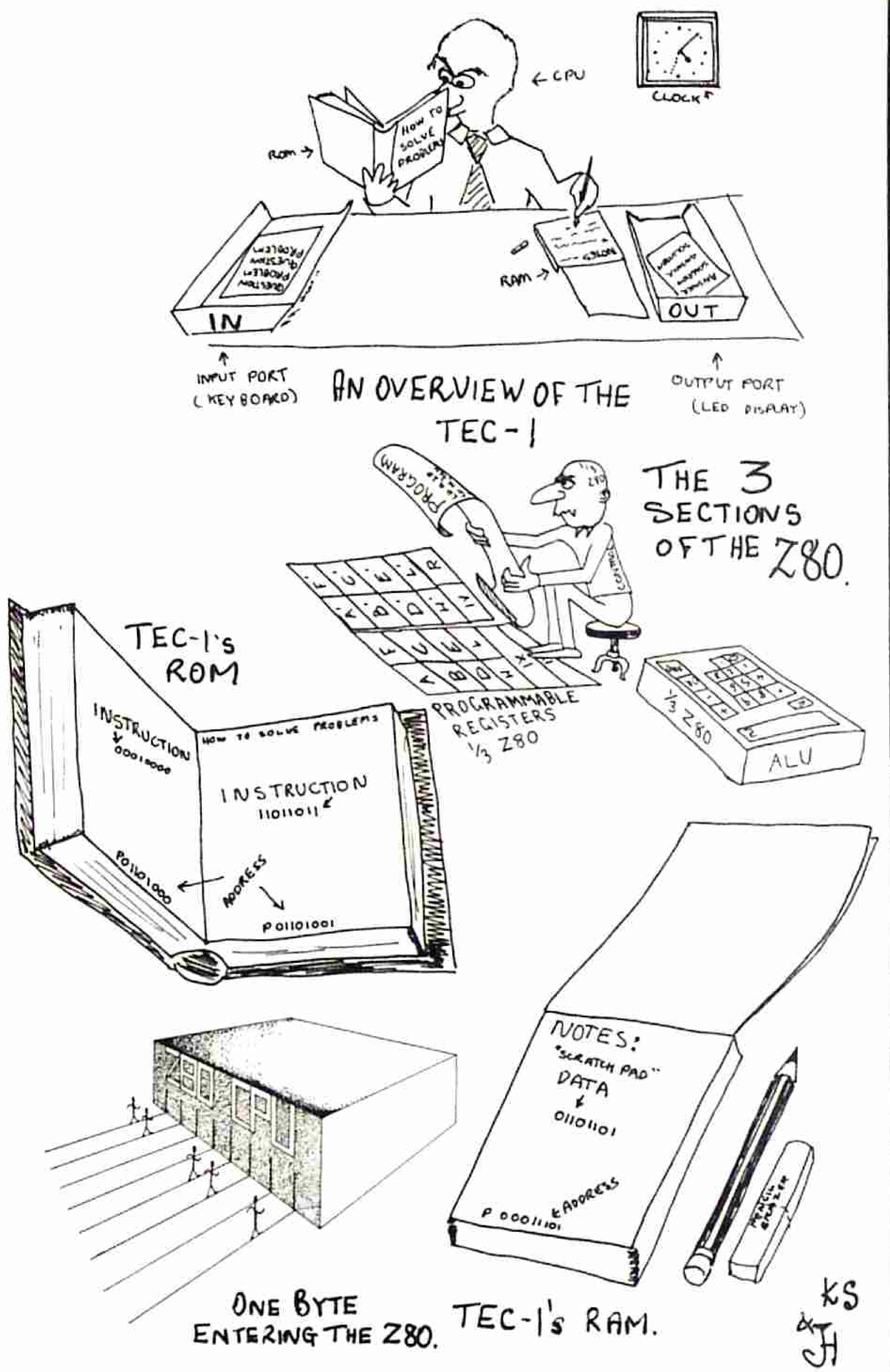
Normally the car parks in space A (register A) and this is also called the accumulator register as the answer for any addition instruction, for instance, will appear in register A.

The car can represent a number from 00 to 255 and the register will accept any of these numbers. This is all the register will hold. . .just one number from zero to 255.

There is one important fact that we have omitted to mention. Before the byte can be put into register A we must send an instruction to the Z80 so that it will know where the number is to be put.

This instruction happens to be 3E for register A. If you wanted to load register B, the operation code would be 06 and to load register C it would be 0E. These codes are called "MACHINE CODES" or MACHINE CODE LANGUAGE and they are interpreted by the Z80 to perform one of over 245 different shuffling or arithmetic operations.

If you want to add a number to the number above, it will have to be firstly loaded into register B, then the two registers can be added. This will take a number of operations with the result always appearing in register A.




You can transfer the contents of register A to the RAM (6116) via a further instruction so that the result is not lost when the next number is sent to register A. Otherwise the previous contents of register A are written over.

The Z80 contains an equivalent bank of emergency registers which can be accessed via a special instruction. These are called A'(A-prime) B', C', D', E', F', H', and L'. It also contains a number of 16-bit registers (like a space for car and trailer) and numerous building blocks which are needed to keep the Z80 operating. These can be likened to the workers needed to keep a parking lot neat and with a smooth flow of traffic.

# CONSTRUCTING THE TEC-1

Constructing the TEC-1 is no more complex than building any of the cover-projects in Talking Electronics . . it only takes longer.

The most important aspect of this project is NEATNESS. We have gone to a lot of trouble to create a printed circuit board that looks really neat, with a layout that is very pleasing. Don't upset the aesthetics of the board with poor-quality layout or incorrect components. If you intend to buy the components individually at your local electronics store, look at the photos in this article for the type of components we have used, and purchase the same styles.

Don't use anything old or dirty and make sure the tinned copper wire for the jumpers is CLEAN, thick and absolutely straight. We will tell you how to do this in the notes.

The TEC-1 is not designed to be fitted into a case. It is too beautiful to hide. Like all our projects, it is designed to be viewed. This keeps you alert to the construction, contents and arrangement of the chips and components. You must constantly remind yourself of the name of each chip and its function. It's an indoctrination process which can only be of benefit in the long term.

Before commencing construction we suggest you get everything organised on the workbench.

We can't stress strongly enough, the need for a good soldering iron.

We have a range of soldering irons in our assembly area including: a 10watt, 12v pencil iron, a 15watt 240v Micron, a 60watt Constant Temperature Scope iron and a Weller Soldering Station. We also have a plummer's soldering iron and two instant-heat solderings as well as a miniature instant-heat iron. Which one would you choose?

If you chose an instant-heat iron, we don't want to know you. They will lift the lands off the board and create more problems than you can imagine. Also construction time will be considerably longer as you have to wait for them to heat up for every connection. Our choice is the 10watt 12v type. It it light-weight, and enables you to produce a speedy connection. This is important when constructing a large project like this.

Other important tools and aids are: fine solder, sharp side cutters, and a pair of long-nosed pliers. You will also need a soldering-iron stand and a solder tray to accept the dead solder left on the iron after making each joint.

Get everything ready on a clean part of the workbench and have all the components available for insertion.

The first part of construction is the most laborious. It is the fitting of the 55 links. You must take great care when fitting these links as they must be absolutely straight, with their ends bent to a sharp 90°. The whole link must touch the board.

Start at one end of the board. Cut a length of copper wire about 10cm long, which will be sufficient for about 5 links. With a pair of pliers at each end of the length of wire, pull the two pliers apart until the bends and kinks are removed and the wire is perfectly straight. Now you can use the wire. Bend one end with the pliers and insert it into one hole in the board. Solder this end and snip the excess wire from the joint.

Feed the other end down an appropriate hole and pull it through with the pliers until the link becomes straight. Keep this part pressed against the board while soldering it. Cut the surplus from the connnection and inspect the first addition to the board. Continue with each link as you come to it and take your time. It will take the best part of an hour and no link should be loose enough to touch any other, even if it is pushed slightly.

The next components to add to the board are the resistors. There are 15 of these and they should also touch the board. Check the value of each resistor before inserting it. They are hard to remove if you make a mistake.

Next are the IC sockets. The reason for inserting them at this stage will be quite obvious. As each socket is inserted, it becomes the highest component on the board and this means the board can be turned over and the socket will rest on the workbench while the pins are being soldered.

You almost cannot make a mistake with these sockets as the number of pins corresponds to the holes in the board. The only point to remember is the identification notch at one end of the socket. These should cover the dot so that when the chips are inserted, the notch on the chip aligns with the dot on the board.

Next add the 6 FND 500 displays. Once again the board can be turned over and rested on the display to keep it pressed against the display while the pins are being soldered.

The next order of insertion is not critical and would consist of inserting the power diodes, 2 LEDs, 7 100n

cont. P. 68

## PARTS LIST

1 - 100R
1 - 330R
8 - 1k
1 - 2k2
5 - 10k

1 - 20k cermet

1 - 100pf
7 - 100n 100v
1 - 1mf 16v
1 - 2200mfd 25v

4 - 1N 4002 diodes

7 - BC 547 transistors

1 - 5mm red LED
1 - 5mm green LED
6 - FND 500 or 560 displays
1 - 7805 regulator

2 - 8212
1 - 2716 TEC-1 Monitor
1 - 6116
1 - 74c923
2 - 74LS138
1 - Z80 CPU
1 - 4049 NOT Fairchild)

3 - 16 pin IC sockets
1 - 20 pin IC socket
4 - 24 pin IC sockets
1 - 40 pin IC socket

21 - PC mount push switches

1 - 8R speaker
1 - heat fin for 7805
4 - rubber feet
5 - nuts and bolts
60cm tinned copper wire
3m fine solder
10cm desolder wick

**Substitutes:**
**2200mfd electrolytic can be replaced by 1000mfd in the TEC-1.**
**Rubber feet can be stick on feet.**

-ADD-AND-BIT-CALL-DEC-EX-IN-INC-JP-LD-NEG-NOP-OR-OUT- POP-PUSH-RES-RET-RL-RST-SBC-SET-SLA-SRL-SUB-XOR-

# HOW THE CIRCUIT WORKS

The TEC-1 circuit looks very simple and, in fact, it is very simple.

This is because many of the chips in a computer circuit are connected to a parallel wiring system called a BUS. There are 2 main buses in a computer and they are called ADDRESS and DATA.

Normally the ADDRESS bus is 16 lines wide but our computer is only a baby design. We have used 11 lines in the address bus with line 12, 13 and 14 going to a decoder chip to select between display, keyboard, memory and expansion.

The data bus is like a highway with data passing to and from the Z80 and the other chips. The data line will carry a binary number between 00000000 and 11111111, which is 0 - 255.

The 8212's are latches which drive the displays. One controls the segments a to g and the decimal points while the other drives the digits via a set of buffer transistors.

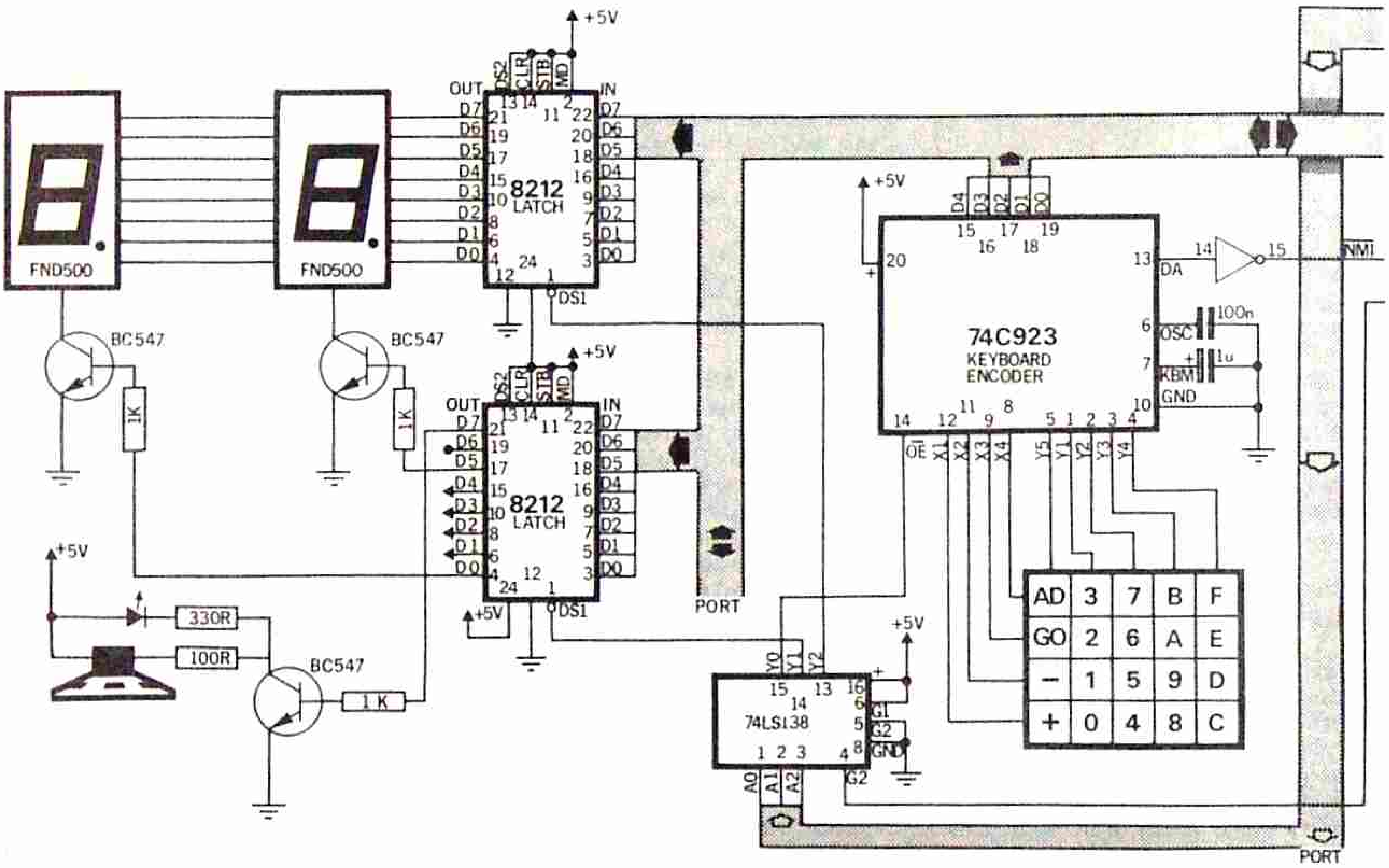
Data and program are stored in the memory whch comprises the 2716 EPROM and 6116 RAM.

The Z80 addresses a particular location in the memory by sending a binary number down the address bus. It determines the condition of SENDING or RECEIVING by the state of the R/W line (pin 22). When this line is LOW, the Z80 is sending data to the RAM and when HIGH, it is receiving data from the memory.

Data is sent or received via the data bus and only one data transfer can occur at a time.

When the reset button is pressed, the computer sets the condition for initial data entry. These include entering (or loading) the address pointer to 0800, setting the dots on the data displays, setting the stack to the highest point in the 6116 RAM and calling a routine to produce the two-tone 'ready' beep.

The Z80 then goes into a scan routine to display 0800. This information is

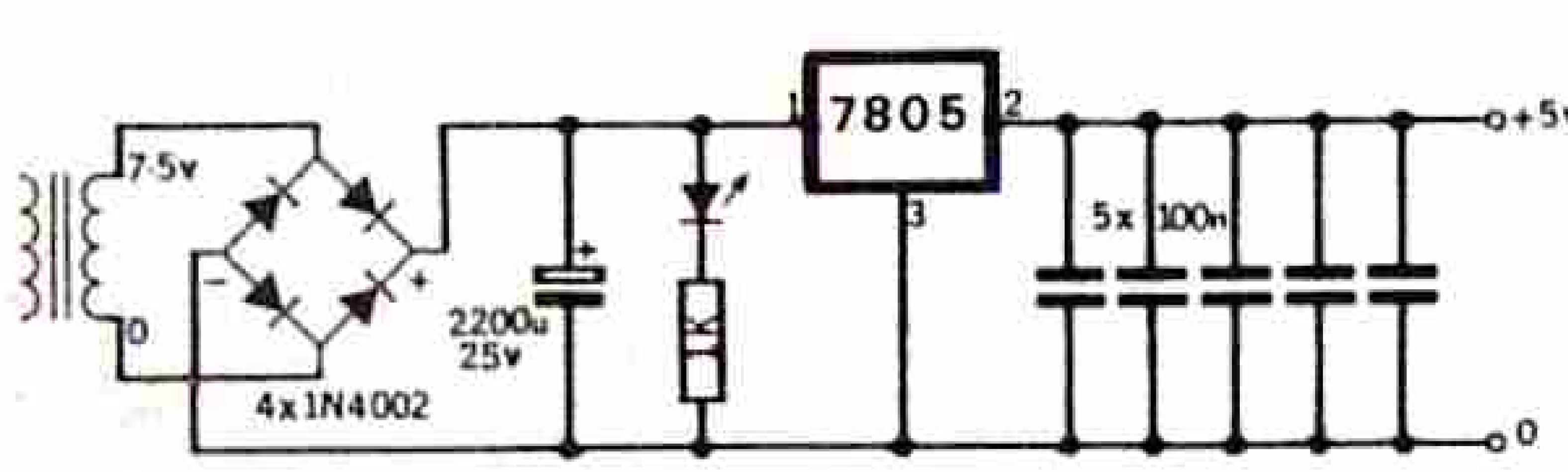



## POWER SUPPLY

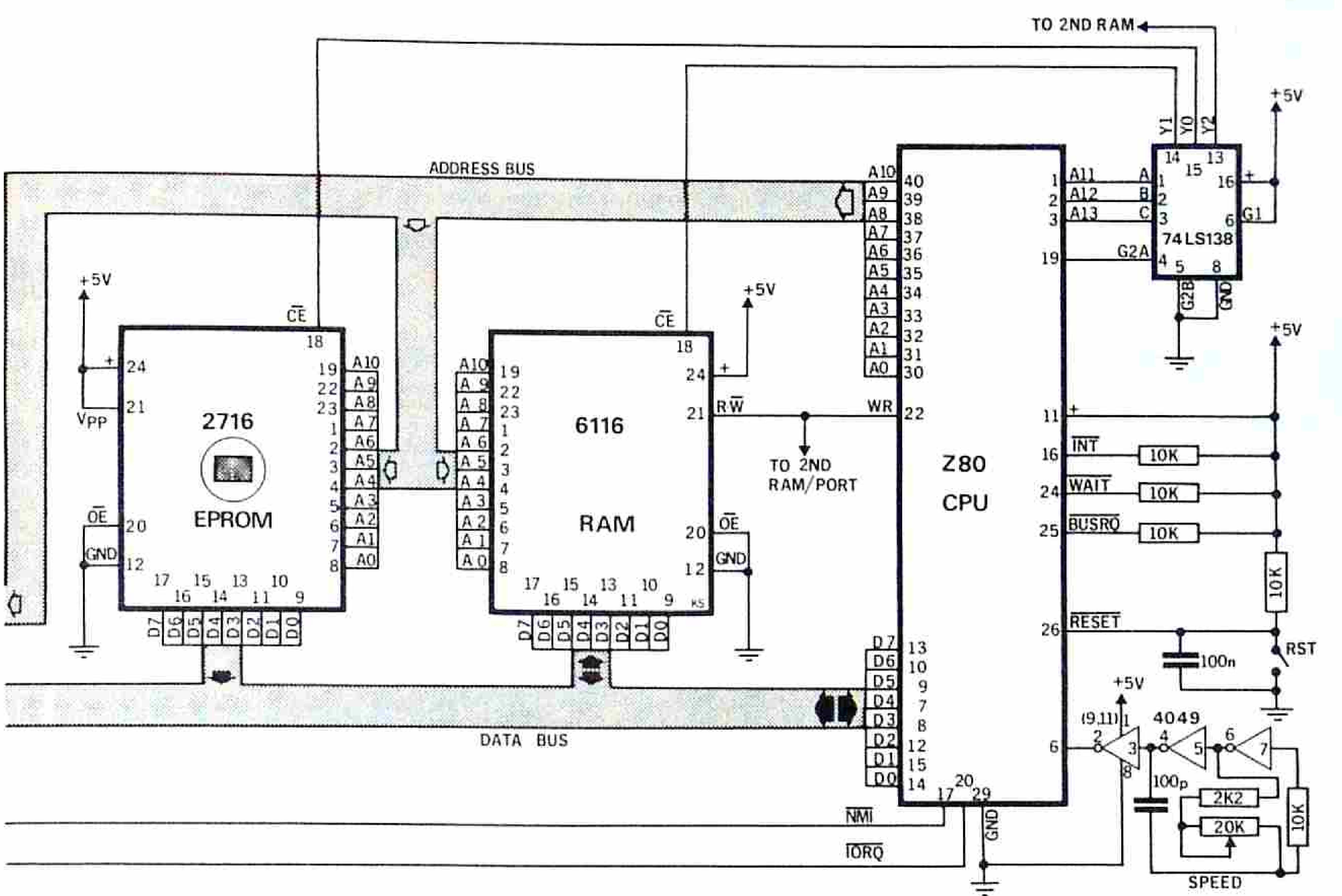
The 7805 regulator is included on the PC board. When using a 2155 transformer to power the TEC-1, use the 7.5v tapping. This will produce about 9.5v DC into the regulator which is ideal to gain full voltage and current from the power supply without overheating the regulator.

The TEC-1 will accommodate a DC Plug Pack. Use a 9v type capable of delivering 500mA.

The five 100n capacitors on the output line are spike suppression capacitors. They are placed near each of the chips to prevent noise from one chip upsetting the funtion of the computer. We suggest low-impedance mono-block types for this application.




POWER SUPPLY




taken from the highest bytes in the RAM, which have been deposited in the set-up routine.

The Z80 will continue to scan the displays until it is interrupted by the 74c923, via the inverter of the 4049 chip. This is a Non Maskable Interrupt line. The Z80 immediately branches to a routine at 0066H which inputsthe binary code of the key being pressed and stores it in a register in the Z80.

It firstly checks if the key is a function key or a numeric key 0 - F. It does this by checking bit '4' of the 5-bit binary number. Bit 4 is the 1 in: 10000. The first bit is called bit 'zero'.

If the display is in the address mode, the function key will simply put it into the data mode. This is indicated by the dots moving to the data displays.

If the computer is in the data mode, a function key will perform the function intended. A + will increment the address pointer , a − will decrease the address pointer AD will set is to the address mode and GO will execute the program starting at the address shown in the display.

If a numeric key is pressed, the data displays are cleared and the digit is shiftedin from the right. A second key will produce a 2-digit number.

When the + key is pressed when the displays are in the data mode, the address will increment.

While this seems a simple operation, an enormous amount of data is flowing from the Z80/ROM/RAM combination. The address pointer, which is temporarily stored in RAM, is loaded into the Z80 HL register (two 8-bit registers connected to become a 16 bit register). This register increments by instruction 23 (inc HL) and HL is then stored back into the same location in RAM.

The display is then changed to reflect its new address and contents of RAM (in data displays). The Z80 then reverts to its scan routine waiting for another key to be pressed. All this happens in a few milliseconds!

The 74LS138's are simple DEVICE SELECTING chips. The have 3 binary input lines and this enables them to select any one of 8 devices. These can be ROM, RAM, keyboard, display, speaker, or external chips, even additional memory or video displays.

The speaker is simply an amplified version of a 'BIT'. A BIT is a HIGH or LOW state and constant rapid changing from HIGH to LOW will produce a tone.

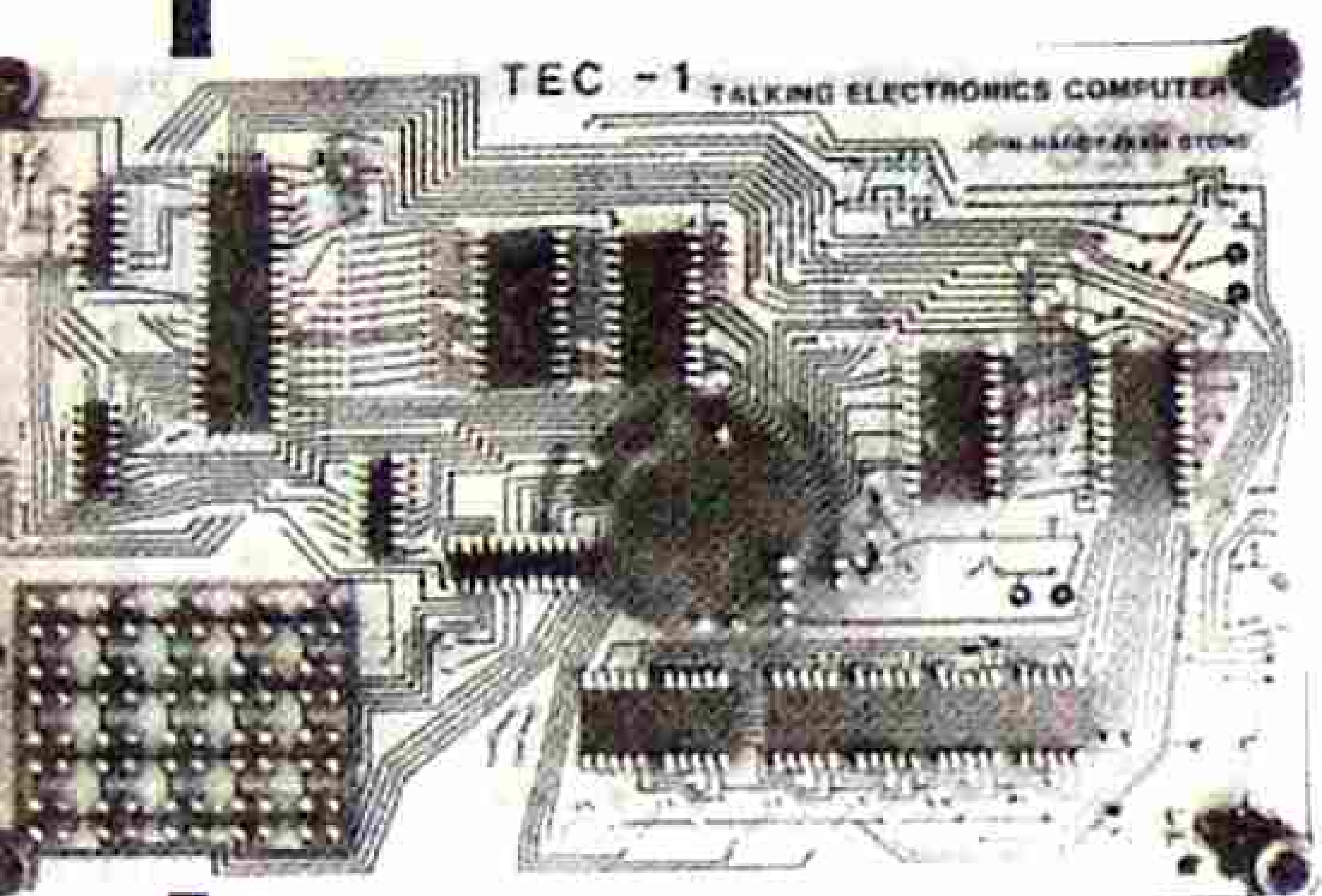
The quality of the sound can be altered by the ratio of the HIGH to the LOW. White noise is a result of random bit production. Correct programming enables the production of music and sound effects.

The power supply is a simple 7805 voltage regulator arrangement. Provided the input voltage is only about 3v above the output voltage, the regulator will not need a large heat-fin. The 2200mfd electrolytic can be replaced with a 1000mfd electrolytic as the computer consumes only about 500mA.

The speed of the TEC-1 is controlled by the 4049 clock oscillator. This is only a simple 2-inverter oscillator which can be adjusted via a speed control to vary the speed of the information passing the displays. A crystal controlled clock can be added at a later stage.

capacitors, 7 transistors, 1- 100pf capacitor, 20k cermet pot and 1 - 1mfd electrolytic.
Attach the flag heat-sink to the 7805 and insert the regulator into the holes nearest the 2200mfd electrolytic.

The other 7805 powers the expansion board and will be covered at a later stage. Insert the 2200mfd electrolytic and solder the leads.




**The underside of the TEC-1 showing the layout of the copper tracks.**

The keyboard switches are individually inserted and soldered as shown on the overlay. The flat on the switch runs across the bottom of the switch so that the jumper link inside the switch completes the wiring of the matrix.

Attach the speaker to the board via a piece of double-sided sticky tape and connect the voice coil to the circuit via short lengths of tinned copper wire.

Four rubber feet are attached to the board with nuts and bolts to prevent the underside of the board from scuffing the workbench.

The final, and most important items to add, are the IC's. These are pushed into the sockets so that pin 1 on each chip is facing towards the display. The 74c923 faces towards the left and you double check each chip before AND after it is inserted. If the rows of pins are too wide, they can be pressed closer by pressing the edge of the chip on the PC board and then the pins will be easier to insert into the socket.

Connect an AC supply to the board and the TEC-1 is ready for operation.

You can use either a 2155 transformer or a 9v plug pack capable of delivering 500mA. In either case the incoming voltage should not be more than 8v to 9v to prevent the regulator getting too hot.

Switch on the power and note the display lights up with 0800. This is the first available address and indicates the computer is ready for action.

If you are well-versed in Machine Code language, you can begin immediately with preparing your own programmes. You will find the TEC-1 is very versatile in its applications and will allow a wide variety of expansions to be accommodated.

Treat the computer as a basis for experimenting and learning. Later we will provide add-ons for a crystal oscillator, output displays for games, and control devices for up to 8 different items at the same time.

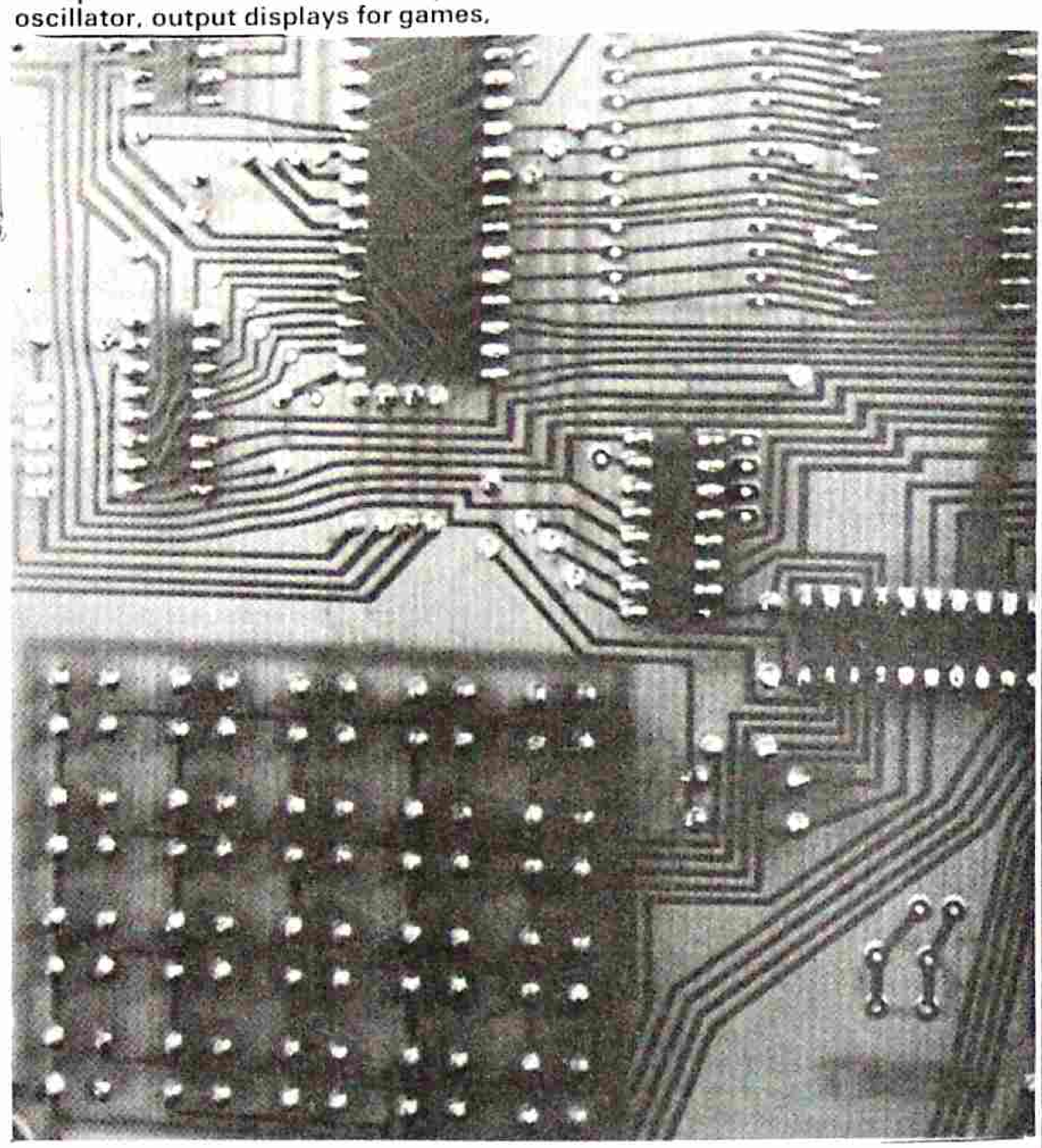
We will also welcome any programmes you write for the computer and it doesn't matter what subject they are witten about.

The tape interface to be added in the next article will allow you to save programmes and re-use them later.

If you are new to programming, you will appreciate the introduction presented on P. 71. It starts at the beginning and shows you how to key a short program and activate a readout in the form of a visual display as well as a musical score.

Three games on P. 74 will intrigue everyone. The level of skill can be adjusted by turning the speed control. This increases the rate of operation of the whole computer.

The are also other programmes in the EPROM and these will be discussed in the next article.



**An enlargement of the Key-board section showing the soldering.**

If you are having trouble getting the TEC-1 to operate, see the article on P. 70. It will solve most of the simple construction faults.

We all wish you the best with your new acquisition.

Don't under-estimate the capabilities of the TEC-1. It is a very powerful machine.

# IF THE TEC-1 DOESN'T WORK:

If you are faced with the situation where the TEC-1 fails to operate properly, or if it doesn't work at all. . . don't worry. This will be a blessing in disguise.

You learn a lot more about electronics and computers by fixing the TEC-1, than just building and running it.

As requested in the introduction to this project, you should already have a certain amount of background in building projects. This is when all these skills will come together.

The first point to remember with the TEC-1 is this: The TEC-1 SHOULD operate perfectly the first time it is turned on. This is because it is built with NEW components which are first-quality items and the PC board has been thoroughly checked. If you are unfortunate enogh to produce a dud, you must firstly realise that there is a 99% possibility that the fault is in the construction.

You should go over the entire project again, checking every component, connection and the value of each part. The best way to do this is to ask someone ELSE to do the checking. This is because you cannot check your own work. Most of the projects that come to us for repair are simple faults, overlooked by the constructor. Faults like 1k instead of 1M, 22k instead of 3k3 etc. This type of fault can very easily creep in. This is because humans think positively. Most constructors are CERTAIN all the values are correct! How could they make a simple mistake like THAT?

After passing the TEC-1 over to a government checker (anyone impartial) you can begin the TEST procedure. This will need test equipment.

This is where the LOGIC PROBE will come in handy. That's why we presented it in this issue. You will find it invaluable, as most of the lines on a computer are PULSE lines and these are constantly changing accoding to the clock rate or as requested by the Z80.

The first test is a RESISTANCE TEST.

To carry this out successfully, you should remove all the chips. This is to prevent any false readings.

We will be looking for solder bridges between one or more of the pins. These can be very difficult to see as they are sometimes as fine as a human hair or even merely a microscopic splash of solder.

That's why you must never tap the soldering iron on or near the board, as excess solder will fly off the tip and land on some unknown part of the board. This will cause a bridge which will take hours to locate. You must only tap the iron in a solder tray and this must be done after every joint to prevent dropping solder and creating a problem, like now.

Set the multimeter to LOW OHMS RANGE. Make sure you adjust the ohms control so that the needle travels to the far right hand end of the scale to indicate very LOW resistances.

When all the chips are removed, most of the wiring on the underside of the board consists of individual conductors and this means almost no adjoining pins are connected. This makes it ideal for testing via a resistance measurement.

The first place to check is the RAM/ROM section where each of the pins has a conductor running between them. Turn the board over and measure the resistance between each solder connection. The multimeter needle should not move at all. If all the readings are HIGH. progress to the Z80, and then each of the other chips. If the pointer deflects at any stage, trace through the wiring to see if a resistor or push button is in the path. You will also get some low readings when testing near the display. So don't treat these as faults.

## USE THE LOGIC PROBE AS DESCRIBED IN THE FIRST PROJECT, TO TEST THE TEC-1.

Another very important check you can make is the continuity of all the printed wiring on the underside of the board. Sometimes one of these tracks can become eaten away in the etching process, resulting in a break.

Place one of the probes on one end of a conductor and visually trace it through to the end. Place the other probe at this point and prove that it is conducting. You can also make sure the jumpers are connecting by checking the ends of each run.

If all these checks fail to locate any problem, you will have to carry out tests with the computer operating. This will mean replacing the chips and connecting the power.

Start by placing the probe on pin 6 of the Z80. This is the clock input pin and without any signal here, the whole computer will not operate. The three LEDs on our LOGIC PROBE will illuminate and you will hear a frequency from the mini speaker in the probe. As you adjust the speed control, the sound will change pitch, If the 3 LEDs don't flash, change the 4049. Some chips are very critical in this circuit and others don't work at all. If a chip fails to oscillate, you can reduce the 10k to 2k2 and this will give you a broader range. Some chips may tend to drop out at the low end. You should buy a CD 4049 as soon as possible.

Once you have a clock pulse entering the Z80, you can check some of the other sections of the computer.

The computer can be placed in a WAIT situation by tying pin 24 to earth. This pin is connected to the 10k which is the closest to the reset switch. It has an empty hole to which you can solder a test wire and use a jumper lead to create the wait situation. Press RESET and probe pin 15. If it is LOW, everything is OK. If it is not LOW, you may have a dry joint or short-circuit on pins 1 - 6 of the 74LS138. While the computer is in the WAIT condition, test the operation of the key-board by probing pin 15 of the 4049. This is the output of the 74C923 key-board encoder, after it has passed through an inverter to the non-maskable interrupt of the Z80.

This output line is normally HIGH and goes LOW when a key is pressed. The only other pin of the 74C923 which can be checked in a simple manner is pin 7. It is normally LOW and goes HIGH for the duration a key is pressed.

The 74C138 select chip below the expansion port selects between the key-board and the two 8212 driver chips. When in the wait mode, pins 13, 14 and 15 are HIGH. Under running conditions, pin 15 pulses LOW when a key is pressed.

The two display driver chips, (8212) are difficult to test under static conditions as the display is multiplexed.

When in the wait mode, one of the displays may illuminate and you will be able to detect the HIGH's entering the 8212's.

The advantage of the sockets becomes apparent when you have to remove or change any of the chips.

If the computer still fails to operate correctly, try replacing the set of chips. This will only be feasible if you know someone with a TEC-1. Within your own board you can exchange the two 8212's and 74LS138's. Don't forget, the 2716 must be programmed. A blank one will not get the computer started.

Make sure no pins are bent under the sockets or broken off at the chip. Be sure the chips are around the correct way and most of all, make sure the chips are in the correct positions.

If all this fails, write to us. We have a repair service available. If sending the project by post, pack the board between two thick pieces of foam or stiff card-board. Use a large jiffy bag and mark it fragile. Certify the parcel in case anything is damaged. This way it will get to us in one piece. We will have a look at your project and let you know what it will cost to fix. Usually it doesn't cost much and this will take a load of your mind.

I hope it never gets to this stage, but at least you know the service is available.

# EXPERIMENTS FOR THE TEC-1

The computer should now be fully assembled and ready to go. All you have to do is learn how to operate it.

The following set of experiments will give you the experience necessary to recall some of its routines and produce a simple sequence of your own.

To introduce you to the TEC-1 we have programmed a welcome message into the EPROM. This can be located at 02D1.

To call up this program, press the following sequence of keys:

*RESET, D, 1, + 0, 2, ADdress, 0, 2, 7, 0, GO, GO.*

Adjust the speed control and see what John has written. If that's not a clever way of personalizing a piece of equipment!!

**If you don't know what to do, don't worry. Follow through these experiments and come back to the WELCOME mesage later.**

Now to the learning section:

### Experiment 1.

**AIM:** To examine the increment of the address.

**Apparatus:** TEC-1.

**Procedure:** Turn the TEC-1 on and look at the address display. The address is the first four digits. When the TEC-1 is turned on, the first available address is 0800. This can be incremented by pressing the '+' key and the address will increase to the next available location. Carry out this procedure by pressing the '+' key and watch the display: 01, 02, 03, 04, 05, 06, 07, 08, 09. The next location is 0A and this is where the computer departs from the reading you would expect. The TEC-1 is programmed in Hexadecimal in which 4 binary lines are grouped together to form a hex number. In this way we can write binary numbers from 0000 to 1111 and this means we can go higher than 9 as nine is only 1001 in binary. The next hex number is A, then B, C, D, E, and finally F. The following table shows the binary equivalent for 0 - F.

| Decimal: | Hex: | Binary: |
|---|---|---|
| 0 | 0 | 0000 |
| 1 | 1 | 0001 |
| 2 | 2 | 0010 |
| 3 | 3 | 0011 |
| 4 | 4 | 0100 |
| 5 | 5 | 0101 |
| 6 | 6 | 0110 |
| 7 | 7 | 0111 |
| 8 | 8 | 1000 |
| 9 | 9 | 1001 |
| 10 | A | 1010 |
| 11 | B | 1011 |
| 12 | C | 1100 |
| 13 | D | 1101 |
| 14 | E | 1110 |
| 15 | F | 1111 |

**A comparison between decimal numbers (based on the power 10) hexadecimal numbers (based on the power 16) and binary numbers (based on the power 2). The data for TEC-1 is entered in hex on the key-board. Examples of hex are: 3F, 4C, 5B, FE, C4, DD, The max hex for 2 digits is FF and this corresponds to 255.**

Press the + and watch the display increment,
Press the − key and watch the display decrement.

### Experiment 2
### STUDYING HEX

**Aim:** To study hex notation and count in Hex.

**Equipment:** TEC-1.

**Theory:** Each byte of data for a program must be given an address. The computer automatically advances one address location on pressing the + key. However we must be able to read and write hex values to be able to prepare a program.

**Procedure:** Study the Hex notation in expt 1. and answer the following set of problems:
Use the TEC-1 to verify your answers.
Problem 1: A program starts at 0800. What are the next 21 addresses?

0801 ★ ★ 0804 ★ ★ ★
0808 ★ 080A ★ ★ ★ ★
★ ★ 0811 ★ ★ ★ 0815.
To verify your answer, press RESET then keep pressing + + + + + etc. Don't worry about the values in the data displays.

Problem 2: A program starts at 0A00. Complete the following set of addresses:
0A00 ★ ★ ★ ★ ★ 0A06
★ ★ ★ ★ 0A0B ★ ★ ★
★ ★ ★ 0A12.
To locate address 0A00: Press RESET, press AD (the dots will appear on the address displays indicating the address can be changed).

Press 0, A, 0, 0. Press +. This becomes the first address location. Press + + + + + etc to increment the display.

Problem 3: A program of 50 addresses finishes at 091E. What are the previous 35 addresses?
091E ★ 091C ★ ★ ★ ★
★ ★ etc to 08Fb.

Problem 4: (a) Add 4 address locations to 0209.
(b) Add 8 address locations to 1FFF.
(c) Add 4 address locations to 0BFD.
(d) Decrement the address 7 locations from 0800.

Work out all the above answers on paper before checking with the TEC-1

**ANS: 4(a) 020D, (b) 2007 (c) 0C01 (d) 07F9**

### Experiment 3:

### CREATING A BEEP

**AIM:** To create a tone or beep on the TEC-1.

**Theory:** The 2716 has been pre-programmed with a loop to give a pulse to the speaker. Depending on the speed of the system, the tone of the pulse will be varied.

**Procedure:** We can address the beginning of this routine by pressing the following keys:
*RESET, ADdress, 0, 1, 8, E, GO, GO.*

You will hear two beeps, and by turning the speed control down, they will become separated. The first beep is the one you have programmed. In the next experiment you will will change the frequency of the beep.

**Notes:**
When the TEC-1 is reset, the decimal points appear in the DATA readouts. This indicates the data can be changed by pressing the keys 0 - F.

By pressing the ADdress key, the dots will appear in the ADDRESS readouts. This can now be changes by pressing the keys 0 - F.

**Experiment 4:**

**Creating a Tone or Note.**

**AIM:** To create a tone.

**Theory:** It is possible to produce a tone from the speaker which is the result of a routine in the EPROM.

**Procedure:** To create a single note or tone, press the following:

*RESET, 2 + 8 +* **1** *ADdress, 1, B, 0, GO, GO.*

Only the first note to be heard in the speaker is the product of our programming. The other beep or beeps come from other routines.

The number **1** in the routine above selects the particular note. It can have one of 24 different values and thus we can create different effects as shown in a later experiment.

**AIM:** To create a single note with a period of silence.

The instruction for silence is 00.

Run the following program:

*2 + 8 + 0,3 + 00 + 00 + 00 + 00 + 0,3 + 00 + 00 ADdress 1, B, 0, GO, GO.*

You will notice that pressing 00 is the same as pressing 0. The DATA entry is self-adjusting. Thus 03 is the same as 3 on the data display.
Turn the TEC-1 off between experiments so that the 6116 RAM has its contents destroyed. Otherwise some of the previous programs will come through the speaker.

**To create a scale:**

Program this sequence:

*2 + 8 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + A + B + C + D + E + F + 10 + 11 + 12 + 13 + 14 + 15 + 16 + 17 + 18 + 0 + 0 + 0 + 0 Address 1, B, 0, GO, GO.*

The speaker will produce the scale, then silence.
To hear the sequence again: Press RESET, ADdress, 1, B, 0, GO, GO.

**AIM:** To produce a repeat function.

The note, notes or sequence can be repeated by adding the instruction 1E to the end of the list.

Try this routine:

*2 + 8 + 1 + 2 + 3 + 4 + 5 + 6 + 5 + 4 + 3 + 2 + 1 + 1,E Address 1, B, 0, Go, Go.*

To produce a repeat function with a pause or silence, try this routine:

*2 + 8 + 1 + 2 + 3 + 4 + 5 + 0 + 0 + 0 + 0 + 5 + 4 + 3 + 2 + 1 + 1,E Address 1, B, 0, GO, GO.*

**Experiment 5:**

**To Create A Tune.**

By using the note table on P.73, any tune or melody can be produced. Try this sequence, then write your own tune.
*2 + 8 + 0A + 08 + 06 + 08 + 0A + 0F + 0A + 0D + 0F + 06 + 06 + 0A + 0D + 06 + 0D + 0A + 0D + 12 + 16 + 14 + 12 + 0f + 11 + 12 + 0F + 0D + 0D + 0D + 0A + 12 + 0F + 0D + 0A + 08 + 06 + 08 + 0A + 06 + 06 + 00 + 1,E, Address 1, B, 0, GO, GO.*

Question: How do you recall this sequence?

**SOUNDS AND TUNES**

The TEC-1 has a number of musical routines programmed into the 2716 EPROM.

These are accessible via the keyboard. The first of these is an Irish Jig. This is called by the sequence:

RESET, E, F, GO,

With all tunes the pitch of the notes is dependent upon the speed of the computer. This is determined by the speed control.

You can experiment with adjusting the 20k cermet for each of these tunes, to get different effects.

In order to access some of the other tunes, you will need to follow this key sequence:

*RESET 3 0 + 5 address 1 B 0 GO, GO.*

**Experiment 6:**
**Creating a Running Letter**

**AIM:** To produce a running A.

**Procedure:** Press the following sequence of keys:

*RESET, 2 + 8 + 1 + 0 + 0 + 0 + 1,E Address 2, 7, 0, GO, GO.*

The letter A is being shifted one place to the left by the routine at 0270.

The letter can be made to travel the full length of the display by adding further zeros to the program.

Press this sequence of keys:

*RESET 2 + 8 + 1 + 0 + 0 + 0 + 0 + 0 + 0 + 1,E address 2, 7, 0, GO,GO.*

**To produce a running sentence:**

Press this sequence of keys:

*RESET 2 + 8 + 07 + 0E + 0E + 04 + 0 + 9 + 04 + 05 + 01 + 1A + 0 + 0 + 0 + 0 + 0 + 1,E address 2, 7, 0, GO, GO.*

**Experiment 7:**
**Combining Words With A Tune**

**AIM:** To combine a tune and running words in one sequence.

**Procedure:** The programme we will be writing in this experiment consists of a set of instructions and included in this are two CALL statements (call 1B0 and call 270) followed by a PITCH table and a LETTER table.

The result of your programming will be a short tune followed by three letters running across the screen and this will be repeated.

We will firstly describe the program for experiment 7 in **WORDS.** Refer to the program below to see what we are talking about.

The program starts at 0800 and in the first two bytes (800 will accept a byte of data and 801 will accept a byte of data) we will store the address of the pitch table (which starts at 0900) . Later the computer will store the letter table and this will be repeated over and over again as the program contains a jump or repeat instruction.

First of all we will discuss each instruction at each address so that you will be able to understand the program you will be keying into the TEC-1.

At address 802 the instruction 3E tells the accumulator to load the immediate byte, which is 00.
This takes up address 802 and 803.

At address 804 the instruction 32 tells the computer to load the contents of the accumulator into the address given by the following two bytes. The lowest byte is always

presented first, then the highest-order byte. Thus 00 is loaded first then 08.

The next available address is 807.

The instruction 3E tells the accumulator to load with the immediate byte which is 09.

At address 809 the instruction 32 tells the computer to load the contents of the accumulator into the address given by the following two bytes.

Address 80C. This is a CALL instruction which calls the routine located at 1B0. This is the address of the music programme.

At 80F the instruction is to load the accumulator with the contents of the immediate byte which contains 0A. This 0A is the most significant byte of the address for the letter table. As 800 already contains the byte 00 (the least significant byte of the address for the letter table) we do not have to load it again.

At address 811 the instruction is to load the address 801 with the contents of the accumulator (800 is already loaded correctly).

At address 814, the instruction is to call the letter printing routine located at 270. This routine contains an instruction to look at location 800 and 801 and see where the look-up table is located. In our case it is at 0A00.

The final address 817 is an instruction to JUMP to address 802. This is used as a repeat function.

## THE PROGRAM:

```
800   Push + + to get 802.
802   LD A,00         3E 00
804   LD (800), A     32 00 08
807   LD A, 09        3e 09
809   LD (801), A     32 01 08
80C   CALL 1B0        CD B0 01
80F   LD A, 0A        3E 0A
811   LD (801), A     32 01 08
814   CALL 270        CD 70 02
817   JP 802          C3 02 08
```

**The first column is the address of the memory location in RAM.**

**The centre column is the assembly language in mnemonics.**

**The third column is the Machine Code listing.**

## PITCH TABLE:

0900:

01
00
01
00
02
03
04
05
04
05
1F - means to return to line LD A, 0A.

## LETTER TABLE:

0A00:

01
02
03
00
00
00
00
00
00
1F - means to return to line JP 802.

To run the program: Press: Reset, +, + ,GO, GO.

This is how the sequence should be keyed:

Press RESET to get the first location. Press: *00 + 09 + 3E + 00 + 32 + 00 + 08 + 3E + 09 + 32 + 01 + 08 + CD + B0 + 01 + 3E + 0A + 32 + 01 + 08 + CD + 70 + 02 + C3 + 02 + 08 ADdress 0900 + 01 + 00 + 01 + 00 + 02 + 03 + 04 + 05 + 04 + 05 + 1F ADdress 0A00 + 01 + 02 + 03 + 00 + 00 + 00 + 00 + 00 + 00 + 1F RESET + + GO,*

You now have enough information to be able to produce your own sequence. Try a longer note sequence and a longer sentence. You have the availability of including 255 in each table.

The next issue of TE will show how to write a program to display ONE segment of any particular digit, then two segments, so that you can create your own characters.

This is the beginning to writing programmes for video games and you will be shown how to prepare the internal structure of a simple moving target game.

We will also introduce some expansion and interface projects. So, be prepared.

Use the following table to create your own tunes.

## NOTE TABLE

| | |
|---|---|
| G | 01 |
| G# | 02 |
| A | 03 |
| A# | 04 |
| B | 05 |
| C | 06 |
| C# | 07 |
| D | 08 |
| D# | 09 |
| E | 0A |
| F | 0B |
| F# | 0C |
| G | 0D |
| G# | 0E |
| A | 0F |
| A# | 10 |
| B | 11 |
| C | 12 |
| C# | 13 |
| D | 14 |
| D# | 15 |
| E | 16 |
| F | 17 |
| F# | 18 |
| Repeat | 1E |
| Return | 1F |

Use this table to create your own words:

## LETTER TABLE

| | |
|---|---|
| | 00 |
| A | 01 |
| B | 02 |
| C | 03 |
| D | 04 |
| E | 05 |
| F | 06 |
| G | 07 |
| H | 08 |
| I | 09 |
| J | 0A |
| K | 0B |
| L | 0C |
| M | |
| N | 0D |
| O | 0E |
| P | 0F |
| Q | 10 |
| R | 11 |
| S | 12 |
| T | 13 |
| U | 14 |
| V | 15 |
| W | |
| X | |
| Y | 16 |
| Z | 17 |
| — | 18 |
| . | 19 |
| ! | 1A |
| Repeat | 1E |
| Return | 1F |

-ADD-AND-BIT-CALL-DEC-EX-IN-INC-JP-LD-NEG-NOP-OR-OUT-POP-PUSH-RES-RET-RL-RST-SBC-SET-SLA-SRL-SUB-XOR-

# NIM

Key sequence: AD, 3, E, 0, GO,GO.

**When the game ends, press any key to restart.**


You are playing against the computer in a battle of wits. The computer has an obvious advantage.

There are 23 matches and you take turns in removing 1, 2, or 3 matches. The object of the game is to make the computer take the last match.

At each turn you can only take 1, 2, or 3. The computer lets you go first. The number of matches is displayed on the last two digits of the display. When you press a button, say 3, this will be displayed as **Y 3.** This indicates you took 3 matches. Then it will display **I 3.** This will mean the computer took 3 matches.

It is now waiting for your next move. Be careful, the computer is smart. It is waiting for you to make your first mistake. It will then take immediate advantage of it.

If you are playing a purely random game, you will find yourself holding the last match every time. The computer will let you know too! Read the message it displays!

The computer is a pretty bad loser but be thankful it doesn't self-destruct in disgust!

If you are playing a careful **well-calculated** game, you can **WIN.** So, try your skill and see the winning message.

# LUNA LANDER

**Key sequence: AD, 4, 9, 0, GO, GO.**

**Set speed control to your level of skill (strength of gravity). When the game ends, press any key to restart.**

You are in a luna module, orbiting some 50 kilometres above the luna surface. You have 20 litres of astro fuel left and you have to land your spacecraft without denting either the moon or the craft.

Gravity is constantly pulling you down and you can only slow your descent by blasting with your retro rockets.

Your height is indicated by the first two digits and this starts at 50. Watch yourself descend without blasting your retros and as you fall, you will descend faster and faster - until you HIT!

Press any key to restart (except reset). To blast for a short time, press: +. This may slow you a bit and to slow yourself down more, press + several times. If you over-do this command, you will slow down to zero velocity and even start going UP! Never move upwards as this is a waste of fuel.

Every time you blast, your fuel goes down by ONE LITRE. Once your fuel runs out, you can't fire any more and you start falling towards the luna surface.

So, use your fuel wisely to survive!

# INVADERS

Key sequence: AD, 3, 2, 0, GO, GO.

**Set speed control to your level of skill. When the game ends, press any key to restart.**

The object of **INVADERS** is very simple. You shoot anything that moves! Your position is represented by the number on the left. The invaders appear from the right. They shift across the display and if they touch you - "POW". The game ends and the score is shown on the screen.

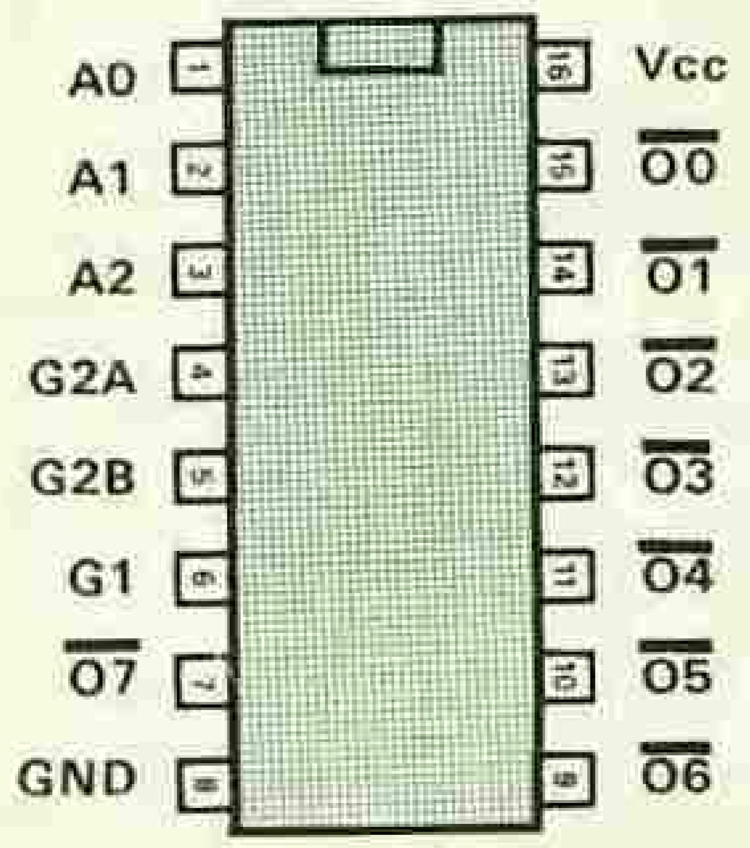
You can't stop the invaders advancing but you can defend yourself by blowing them up. The fire button is button 0 but you can only destroy those invaders which have the same number as your space-gun.

To change your number to match the first invader, press the + button. You can only increase your number and not reduce it. By using the + and fire keys you will be able to keep the invaders at bay. To improve your skill, advance the speed control. You can also destroy those behind the front invader by matching the numbers.
Try your fire power, you'll find it most absorbing.

# DATA

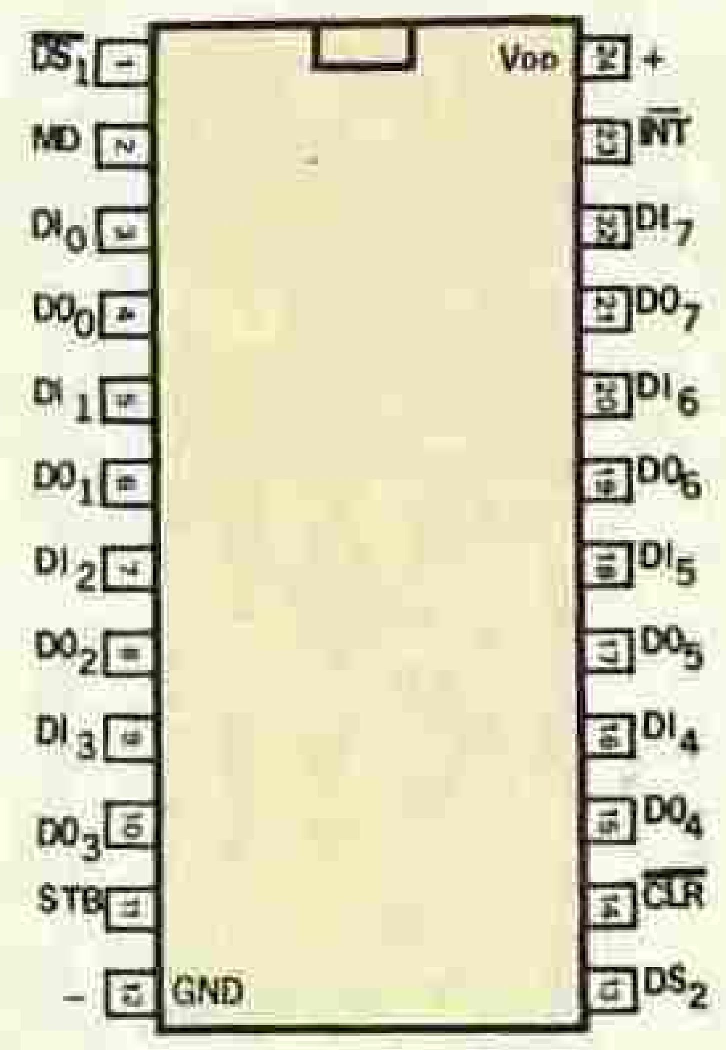


## 74LS138



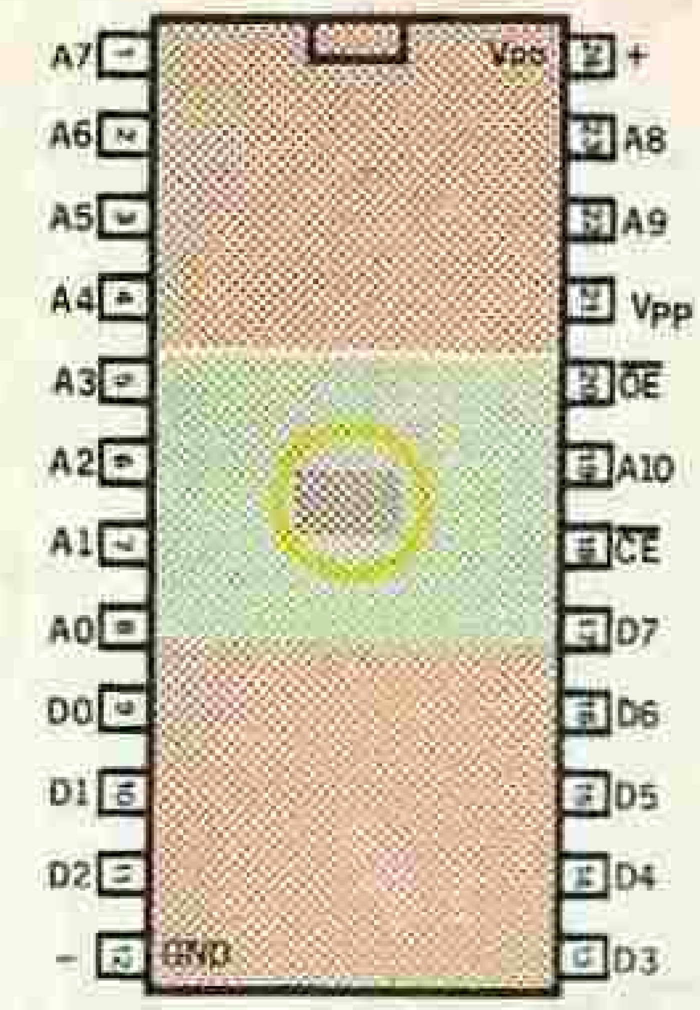

1 - 8 DECODER

## 8212



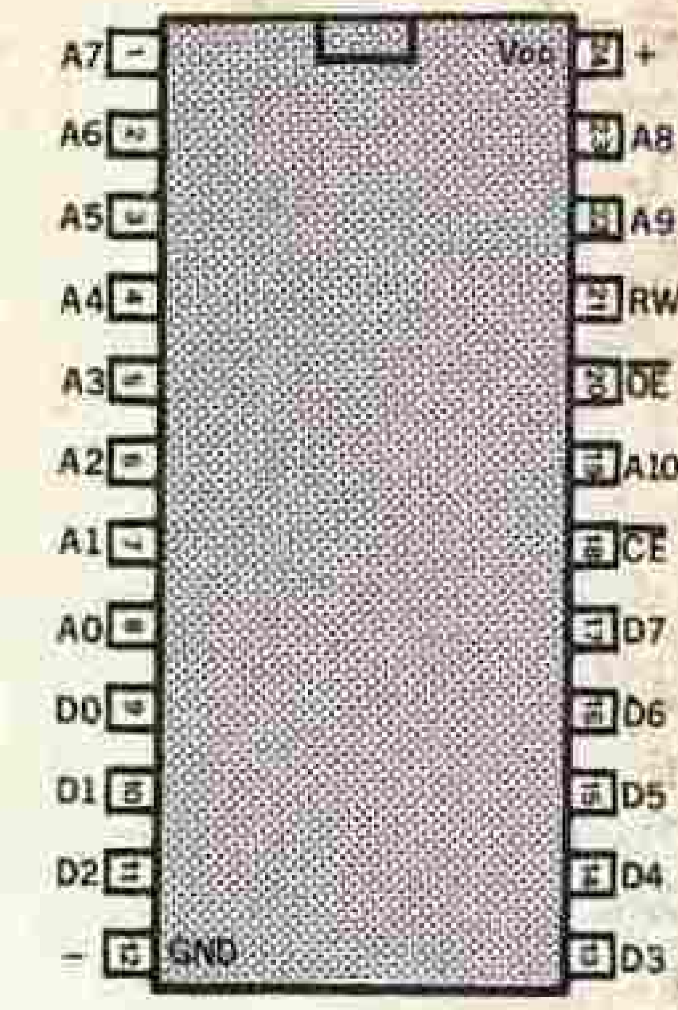

LATCH

## 2716



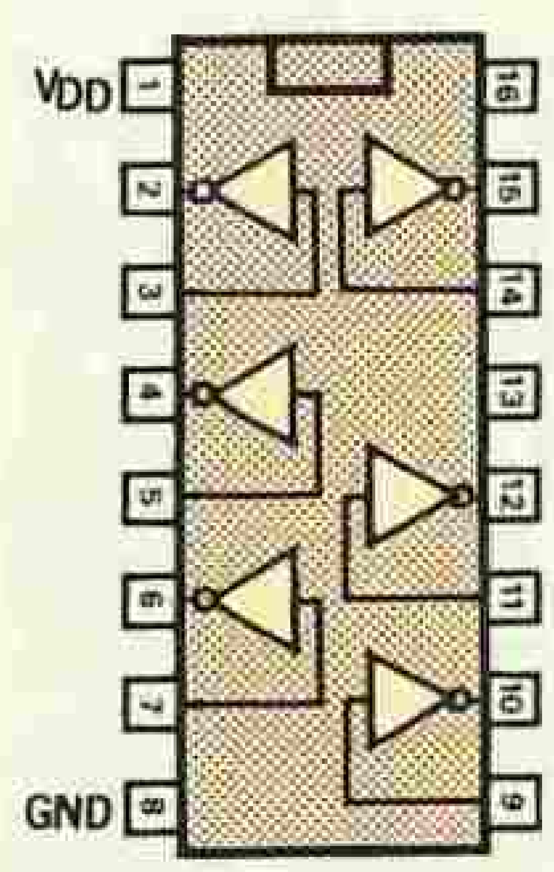

2k x 8 BIT EPROM

## 6116



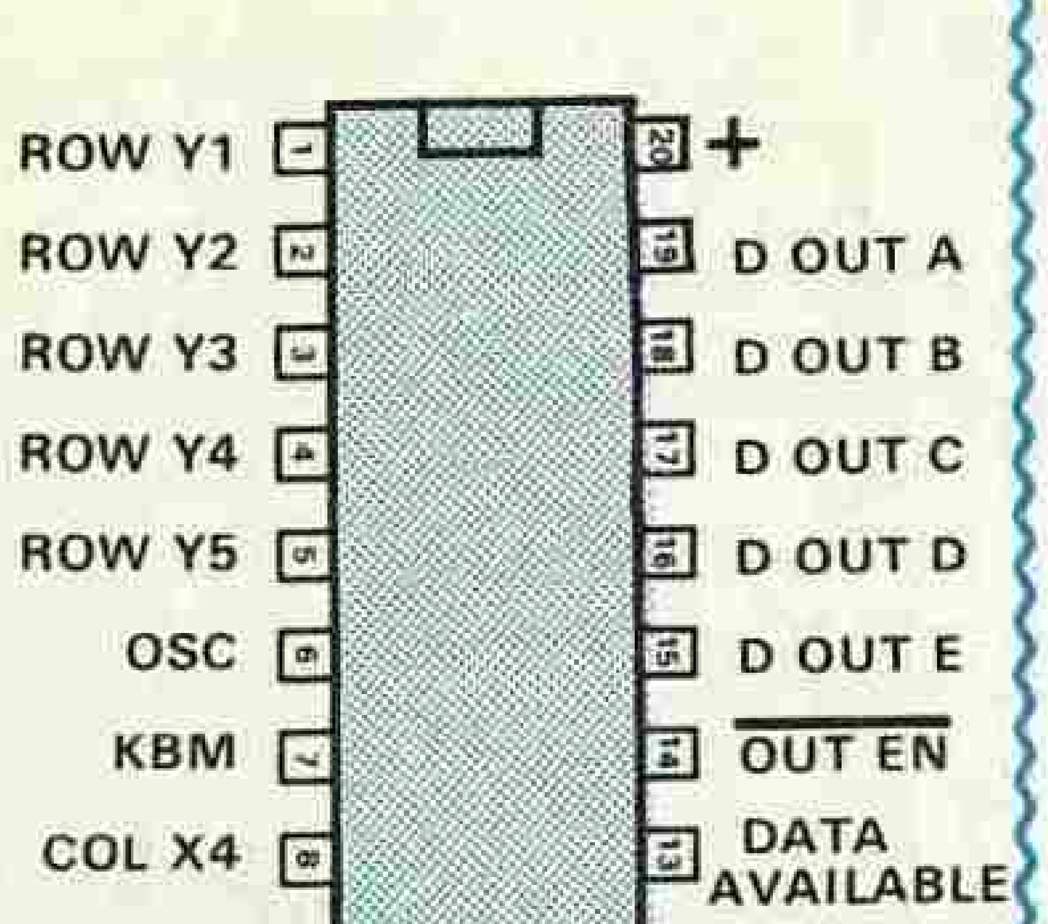

2k x 8 BIT RAM

## 4049




HEX INVERTER

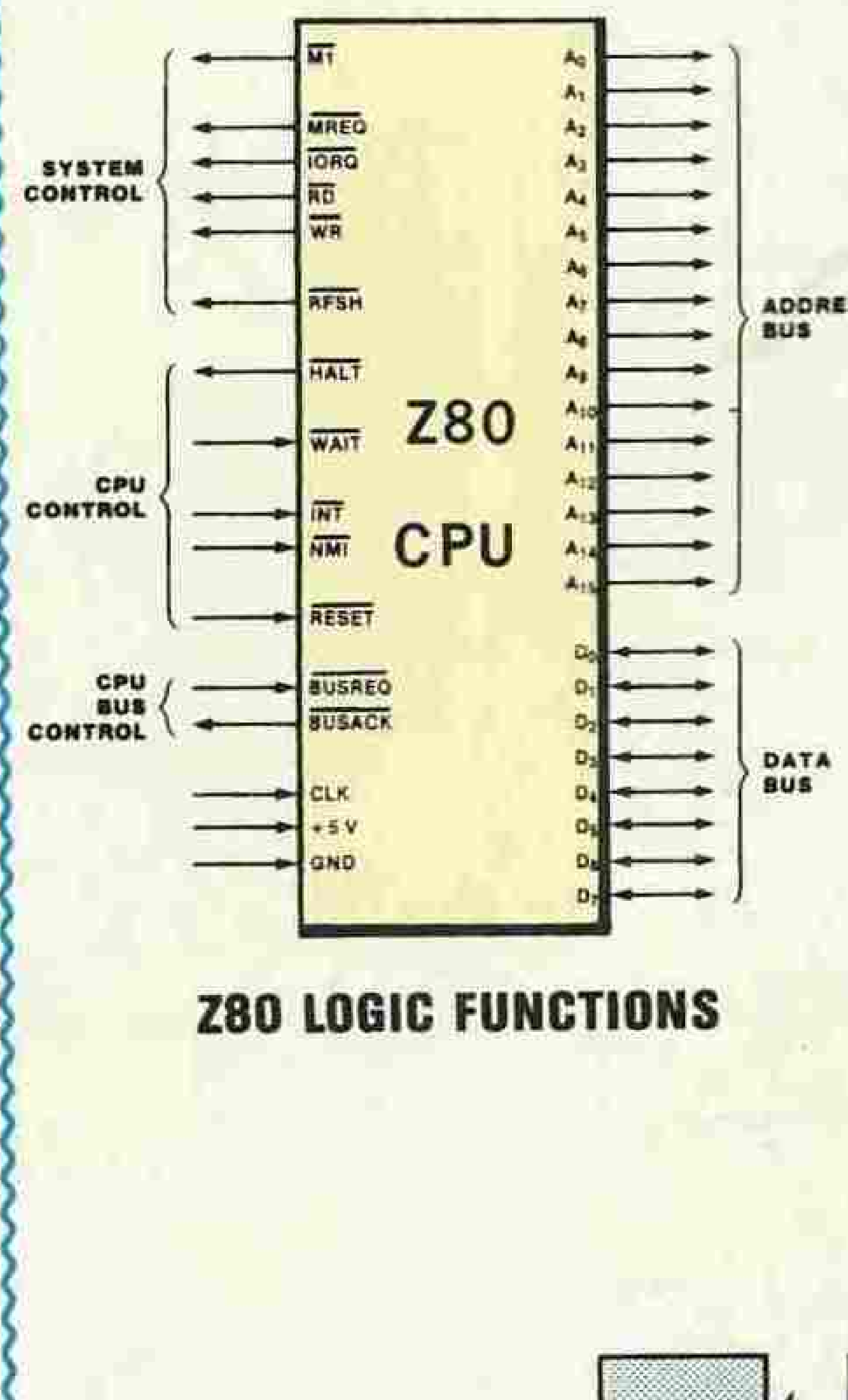
## 74C923




20-KEY ENCODER

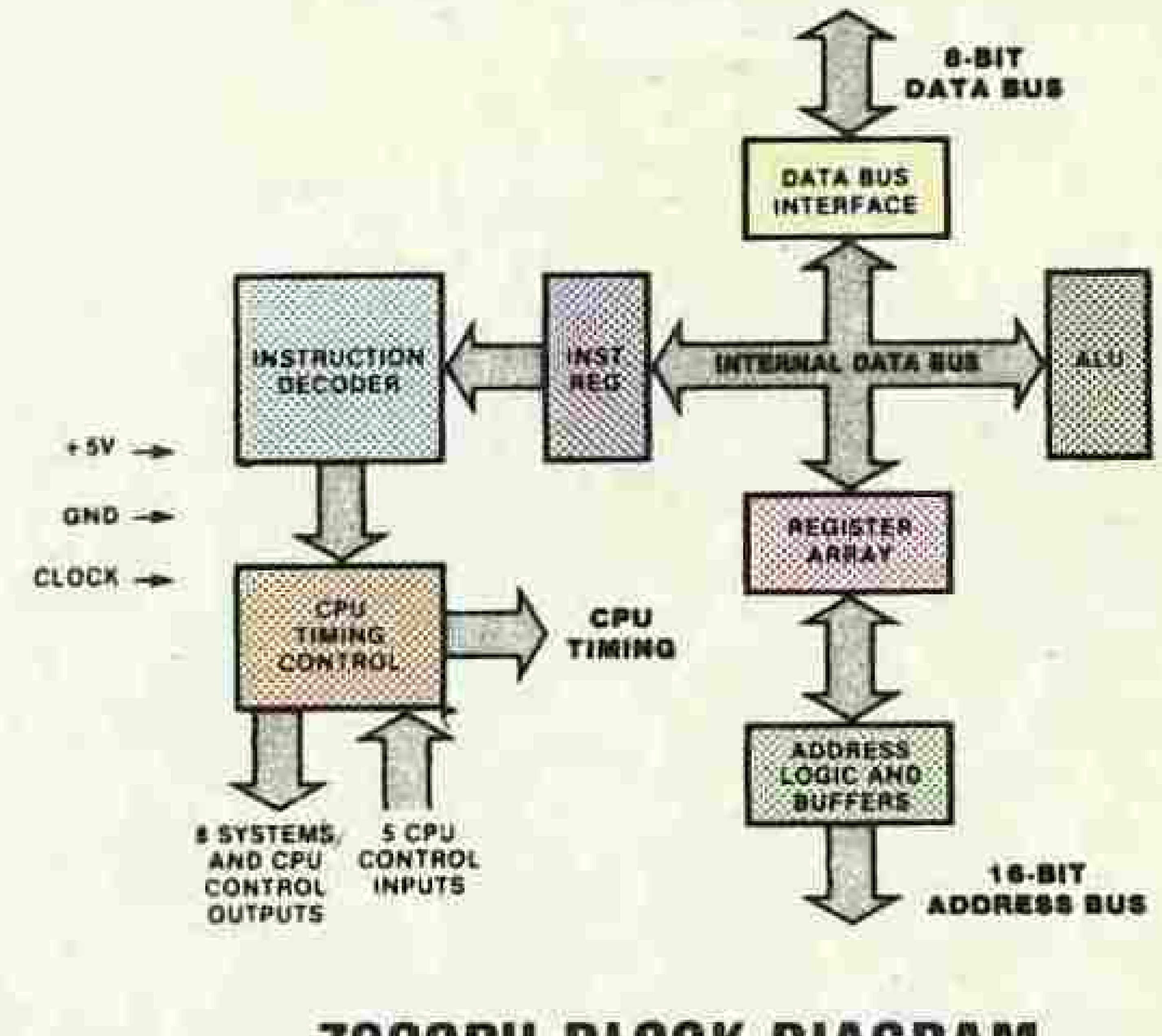
## Z80 CPU

SOURCE: SGS DATA BOOKS.




Z80 LOGIC FUNCTIONS


Z80 PIN OUTS




Z80CPU BLOCK DIAGRAM

DESIGNED and PUBLISHED by COLIN MITCHELL at 35 Rosewarne Ave., CHELTENHAM, VICTORIA, 3192 (03) 584 2386