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TALKING ELECTRONICS®

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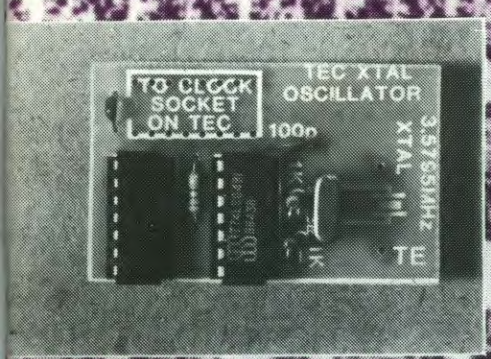
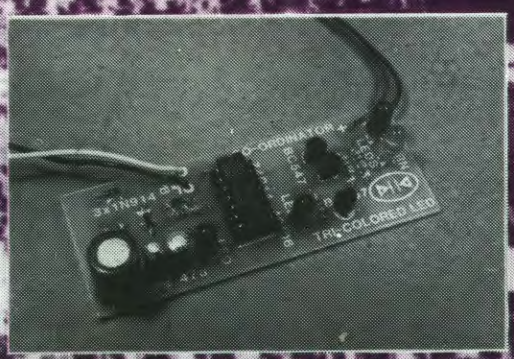
Issue No 14

CONTINUITY TESTER

★ INPUT/OUTPUT BOARD FOR THE TEC
★ MICROCOMP-1 PART II



CRYSTAL OSCILLATOR



CO-ORDINATOR

GUITAR PRACTICE AMP

TTL TRAINER

The experiments for **STARTING IN TTL** are carried out on the **TRAINER DECK.** This comes in kit-form and is available from Talking Electronics.

As the name suggests, **Starting in TTL** starts at the beginning of digital electronics and explains all the basic gates in an easy-to-understand way.

The Trainer has been designed both for class use or for individual experimenting at home, for say a correspondence course, or to assist in designing a new project.

The Trainer can be purchased in two sizes: the large size for teacher demonstrations, and the small size for individual use.

Each experiment is very easy to follow and you are required to answer a set of questions on each circuit.

The course is quite comprehensive and we feel it forms an essential part to grasping the elements of digital designs.

Talking Electronics is basically an educational centre committed to producing text books and projects at an economical price. Everything is backed up completely and is thoroughly researched. At the completion of the course you will say "I have really learnt something!"

Each circuit is constructed with jumper leads and these are sturdy enough to be fitted and removed many times from the terminal pins. The board has been laid out with some of the components on the underside to keep the top uncluttered. In addition, some of the building blocks have been pre-wired under the board to save time when carrying out the experiments.

In experiments 20, 21 and 22 you will be required to build two blocks and use the two pre-wired blocks under the board to create a 4-stage circuit.

After completing the course you will be confident in answering questions on: Sequential Logic, Combinational Logic, Gates, Flip Flops, Bistable, Astable and Monostable Multivibrators, R-S and J-K Flip-Flops in Toggle, Set and Reset modes; The Binary Counter, Shift Register, Decimal Divider and lots of other features relating to these circuits.

The course is self-contained and the Deck is a stand-alone unit with its own battery supply.

The scope for additional experiments is unlimited and one Deck can be combined with another to create larger Counters and Shift Registers.

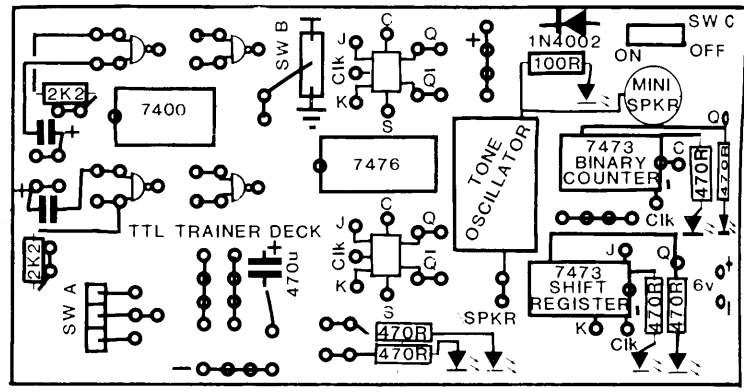
The aim of this course is to get you started and join those thousands of students who have enjoyed the CMOS side of digital electronics. You can start with TTL now, and move onto CMOS later.

TE's policy is to provide educational material at the least cost. Tell your friends and teachers to write for a price list of kits and books, if they don't already know of our existence. We have produced over 20 magazines and books and more than 70 educational kits. These are mainly CMOS based and projects start at the 1-chip level and advance to a simple single-board computer.

By constructing these projects you will be learning about 'building blocks'; the basis to digital electronics, and in this way electronics will become **UNDERSTANDABLE.**

Whether you are doing a home study course, apprentice-ship course or teaching yourself, we urge you to buy the TTL Trainer kit. The course contains lots of questions, of which nearly all the answers can be found in the text, and even though it may appear to be simple, it will increase your understanding considerably.

Constructing the Trainer will also improve your soldering and you can use it to assist with future projects and designs - it will always come in handy.



THE PC OVERLAY FOR THE TTL TRAINER DECK

The cost of the Deck, including PC board, parts, batteries, jiffy box, rubber feet and screws etc. is $27.50 plus $2.50 pack and post.

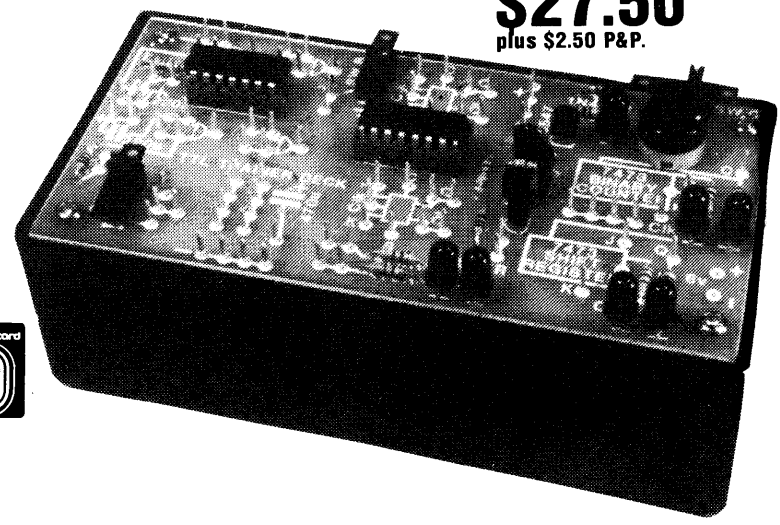
There are lots of small items such as matrix pins, matrix pin connectors, heat-shrink tubing etc that make the kit the best way to go. Otherwise it'll take you weeks to gather everything together and you may give up!

INSTRUCTORS VERSION: The TTL Trainer also comes in a Teacher's version (Instructor's) version. It uses a PC board that is 68% larger and mounts on a UB-1 jiffy box.

It is ideally suited for those who do not want to work on compact layouts and for teachers and instructors to demonstrate in front of the class. The price of the instructor's version is: $35.50 plus $2.50 post.

PC boards can be purchased separately: Student's size: $3.95 plus $1.00 post. Instructor's size: $8.00 plus $1.40 pack and post.

$27.50
plus $2.50 P&P.



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TALKING ELECTRONICS

Vol. 1 No: 14.

Editorial...

A week may be a long time in politics, but so it is too in electronics.

Today's super seller may be tomorrows forgotten wonder.

Take the rise and fall of the Personal Computer.

From a tentative start, the PC rose rapidly to become one of the most popular sales lines ever. The market seemed insatiable. As fast as a new model was released, it was snapped up.

But then the crunch came. The bubble burst and saturation occured. The boom of last week turned into the fizz of this week.

How or why the abrupt end occured, nobody seems to know. Everyone got caught. The biggest losers were the importers. With thousands of boxed computers lying in their warehouses, many have just let them sit; waiting and hoping for a change in the market.

Even though we can buy a model with twice the features, cheaper than last year, nobody wants them.

Maybe it was the realisation that the personal computer is really little more than a glorified games machine, that started a nation-wide re-think. Or was it the improvement in graphics on the arcade machines, that made their graphics look so purile?

In any case, the secondary effect of the slump has been to create an absolute glut of chips on the open market.

All those used in one or more of the popular computers are now available by the million!

To clear this back-log, chip production has slowed to a mere trickle and prices have fallen to a level below the actual cost of manufacture.

A 64k DRAM can now be bought in small quantities for 4¢ less than production cost!

Sadly, the slump is exactly as we predicted.

Computers failed to interface to the real world and although they appeared exciting within themselves, they could not be readily connected to external appliances and gadgets.

Had someone produced a universal interface consisting of say a robot arm, a telephone interface and an alarm system, the capability of the PC would have been extended enormously and its popularity would still be with us.

Until someone comes up with a useful adaptor like this, I cannot see things improving.

We at TE are just as keen as you to see a turn around, as the TEC computer and Microcomp are ideally suited to interfacing to a robot arm.

The only thing holding things up is the non-availability of gearboxes and motors etc.

Let's hope someone has the foresight to produce a range of mechanical units at an economical price so that our ideas for automatics and robotics can come to fruition.

As soon as something comes along, we will be the first to let you know.

Colin Mitchell.

PUBLISHER

TALKING ELECTRONICS is designed by Colin Mitchell of CPW INDUSTRIES, at 35 Rosewarne Ave., Cheltenham, Victoria. 3192. Australia. Articles suitable for publication should be sent to this address. You will receive full assistance with final presentation. All material is copyright however up to 30 photocopies is allowed for schools and clubs.

★Maximum recommended retail price only.

INDEX

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TECHNICAL *Ken Stone*
ARTWORK *Paul Loiacono*
ENQUIRIES *10 minute queries will be answered on* **584 2386** *8am - 6pm.*
ADVERTISING **(03) 584 2386**

For all those who have asked to see a shot of me, I have reluctantly included this recent pose. See, I'm just a normal balding, existentialist.

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COVER PHOTO: The cover photo shows a Z-80 sitting on a micro-photograph of the internal workings.

Cumulative Index A-Z

TE publications are turning into a mini reference library. To help you locate all the information, we present a comprehensive list like this every few issues.

CODE: eg: 1-10 indicates issue 1 Page 10. Stge-1 35 indicates ELECTRONICS Stage-1, Page 35. See note on next page for review and price for this text book.

Included in this list is a reference book **ELECTRONICS Stage-1.** This book is now out of print and has been serialised in this issue and issue 13.

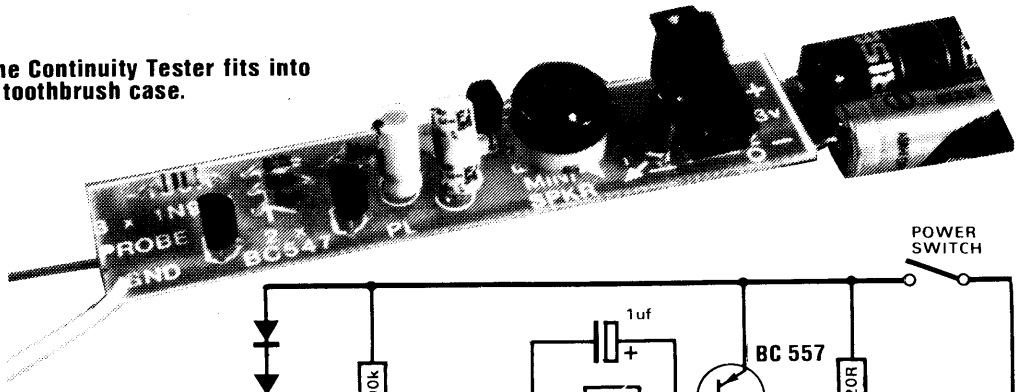
Cont. P.6:

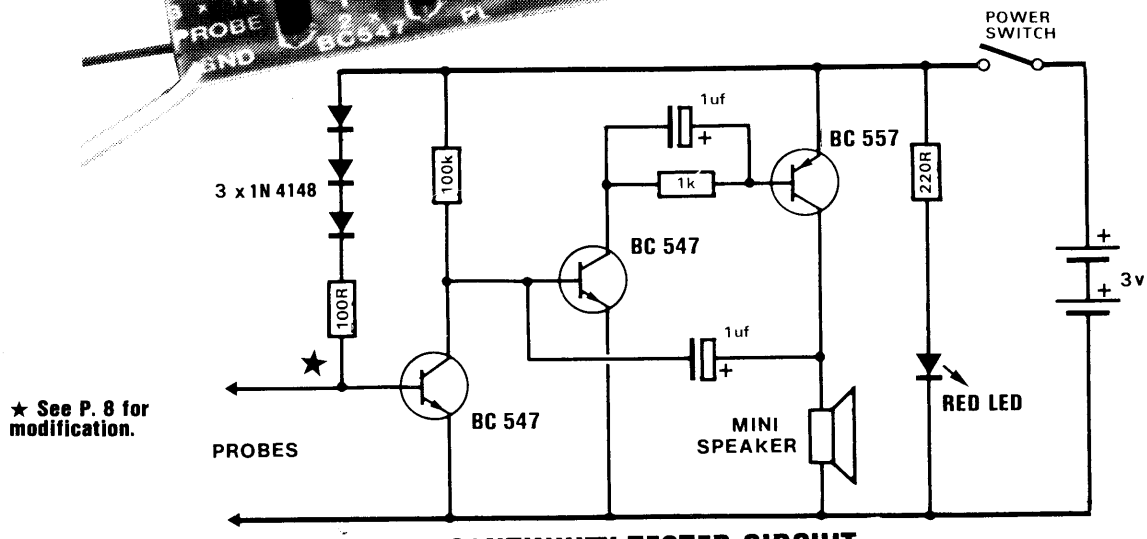
CONTINUITY TESTER

Kit of parts: $5.60
PC Board: $2.10
Complete: $7.70

THE THIRD IN OUR 'TEST PROBE' TRIO. . .

The Continuity Tester fits into a toothbrush case.





★ See P. 8 for modification.

CONTINUITY TESTER CIRCUIT

The continuity tester is the third and final piece of test equipment in the 'test probe' trio.

On the face of it, a continuity tester seems pretty unimportant and you may be tempted to use a multimeter for the job.

But 'horses for courses' is what I always say. The right tool for the application. A multimeter might be alright for some applications but if you are troubled with a nasty fault in a digital project, the continuity tester is faster, better and easier to use than anything else.

It is specially designed for the job and has three very interesting features.

Firstly it gives an audible indication so that you can keep your eyes on the job. This is important when making a continuity check between adjacent pins of a 40 pin IC or on a closely packed bus network such as the data or address bus.

You cannot afford to take your eyes off the board as either the probe will slip off the track or you will miss one of the lines!

Secondly, its response-time is very brief so that you can make contact in a sweeping or stroking motion so that a number of lines can be swept in the one operation.

And thirdly, the continuity tester responds only to a definite short circuit or one in which the resistance is 150 ohms or less.

It will not respond at all to values above 180 ohms and most important it will not respond to the voltage drop across a diode.

This is where the multimeter falls down.

When you are measuring between some of the lines in a digital circuit, the impedance will be quite low or a protection diode will be in the circuit.

PARTS LIST

1 - 100R ¼watt
1 - 120R (for mod.)
1 - 220R
1 - 1k
1 - 100k

2 - 1uF electro

3 - 1N 4148 diode
2 - BC 547 transistors
1 - BC 557 transistor
1 - 5mm red LED
1 - Mini speaker

1 - DPDT slide switch (or SPDT)
2 - AAA cells

1 - paper clip
10cm tinned copper wire
50cm Hook-up flex

1 - CONTINUITY TESTER PC BOARD

The resultant reading on a multimeter will be low (nearly full-scale deflection) but it will be difficult for you to determine if the meter is picking up the voltage drop across a diode or detecting a very low resistance. Apart from this, the time taken for the needle to swing across to its final reading, makes the multimeter approach very slow.

The continuity tester eliminates these problems.

We have found it invaluable for diagnosing the TEC's that have come in for repair. Most of the problems have been shorts between lands or open connections in one of the buses.

This is how we use the tester:

Once we have established that the fault lies in the trackwork (all the chips have been replaced and the system remains dead) we test each pin of the Z-80 against every other pin of the chip. This is actually 40x40 tests and by using the continuity tester it is simplified to only a few operations.

Firstly place the wander lead on pin 1. With the tester turned ON, start at the top of the other side of the chip and quickly wipe the probe down the 20 pins. Repeat for pins 20 to 1. The only time you will hear a beep is when the two probes touch. If a short beep is heard at any stage during the test you should go back and determine if the two lines are joined or if a fault exists.

Continue this procedure with pins 2, 3, 4 etc and very soon you will have covered all 40 pins.

By doing this you will have also covered the bus lines on the EPROM and RAM, however they can be individually checked if you like.

The next part of the diagnosis is to check the continuity of each line in the data and address bus. For this you will need a circuit diagram and pin-out data. Start at data line D0 and check D0 on the EPROM and also the RAM. If a tone is heard, the line is continuous.

It is essential to carry out all these checks as you don't know the exact location of the fault and most faults will be found with a systematic approach.

HOW THE CIRCIT WORKS

As we have mentioned above, the circuit detects resistance values of 150 ohms or less between the probes and allows an oscillator to turn ON and produce a tone in the mini speaker.

A LED is also included on the board to indicate when the unit is switched ON as the electronics consume about 2-4mA and thus the battery would eventually go flat if the tester were left on for long periods.

Actually the circuit doesn't detect resistance at all. It detects threshold voltage across the base-emitter junction of a gating transistor.

When the tester is in the "rest" state, the first transistor is turned ON and this inhibits the oscillator.

It gets its turn-on voltage via the 100R resistor. The 3v supply is passed through 3 diodes which drop a total of 1.9v, leaving 1.1v for the base bias.

When the transistor is turned ON, the base-emitter voltage (the junction voltage) is .7v and thus .4v is dropped across the 100R resistor. This means we have only .4v leeway for the batteries and when they drop to below 2.6v, the tester will fail to work. That's why we have to conserve battery voltage as much as possible by putting an indicator LED on the project to prevent it being left on.

0.4v across the 100R resistor delivers 4mA into the base of the gating transistor and this keeps the oscillator circuit in the OFF state.

When a resistance of 150 ohms or less is placed between base and emitter, the voltage on the base falls sufficiently to turn the transistor OFF.

This allows the 2-transistor feedback oscillator to come into operation and produce a tone in the speaker.

A diode placed between the base and emitter of the first gating transistor will have no effect on the circuit as it will allow .6v to .7v to be present across the probes and thus the first transistor will not change state. The voltage must drop to .5v or less for the circuit to change and this requires a resistance of about 200 ohms.

The two transistor feedback oscillator is set into motion by the 100k base bias resistor.

This turns on the first transistor and thus its collector voltage falls. The collector is connected to the base of the second transistor in the oscillator and this is also turned on.

The result of this action is to raise the voltage of the collector and as you can see, the mini speaker is connected to this lead. Thus a voltage appears across the speaker.

Also connected to the collector is a 1uF electrolytic and it is presently in the discharged state.

As the voltage on the collector rises, it pulls the electrolytic up with it and since it is uncharged, the other lead is pulled up too.

This causes the base of the first transistor to be turned on hard and very soon we have a situation where both transistors are SATURATED.

The next point to understand is the voltage across the electrolytic under discussion. Its negative will be at .65v and its positive will be at about 2.4v. The electro has effectively been stretched between base and rail and its important to understand that the base voltage cannot rise above .65v.

The circuit sits in this condition while the electrolytic gradually charges a little more and this causes the base of the first transistor to turn off slightly.

This is passed to the second transistor which also begins to turn off.

In a short period of time the voltage on the collector falls slightly and this drop is transferred directly the first transistor via the electrolytic. Very soon we have a situation where the first transistor is turning the second off and the second is turning the first off. Both are now completely OFF and the 100k resistor takes over to start the process again.

Each time the circuit "cycles" the speaker produces a 'click' and since these clicks are produced in rapid succession, the result is a pleasant tone.

CONSTRUCTING THE TESTER

All the components are mounted on a small PC board that is designed to fit into a toothbrush case. There are a number of suitable cases and even the small size will fit the board. At first we thought the soft type of case would not be suitable but after Paul tried it, we found it was the best. The soft plastic is more durable and will not fracture if dropped or bumped. The rigid styrene cases tended to crack very easily and one of ours was crushed under foot when it fell on the floor!

The case is the first item to purchase and it will give you a guide as to the maximum height allowable for the components. If some of the parts are too high, they can be bent over and it is important to know about this before you start.

Next you need to determine the type of switch you will be using. The board will take two sizes: a mini single pole double throw or a mini double pole double throw.

Depending on which one you intend to use, the appropriate holes must be drilled in the PC board.

Once this is done, the components can be mounted.

Start assembly at one end of the board and fit each part as you come to it. The mini speaker can be inserted either way around as it is not polarity sensitive but the LED, transistors, diodes and electrolytics must be fitted as shown. If you are not sure about the placement, don't guess, refer to data or get someone to assist you.

The probe is made from a paper clip that has been straightened at one end and bent into a hook at the other so that a strong solder connection can be made.

The two batteries are soldered to the board via short lengths of tinned copper wire. This will keep them firmly together and keep the whole assembly rigid.

The wander lead has either an alligator clip or E-Z clip attached and this allows it to be connected to one rail of the project under test so that the probe can be used to go over the rest of the board in the hunt for the fault.

When everything has been soldered in place, slide the switch ON and the LED will illuminate. Touch the two probes together and the oscillator will emit a tone.

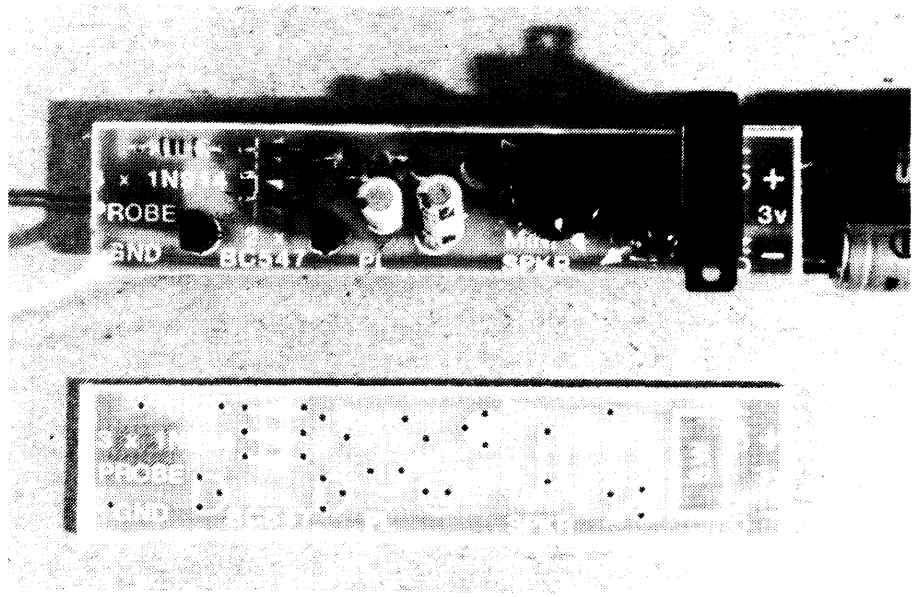
TESTING THE UNIT

You will require a diode, 180R resistor and a 220R resistor.

Place the probes across the diode, firstly one way then the other. The tone should not be heard.

Place the probes across the 180R resistor. The tone should be emitted. Place the probes across the 220R resistor. The tone should not be emitted.

You may find the tester will operate on a resistor which is one value higher or lower than this. The actual value will depend on the battery voltage and the base-emitter junction voltage of the



A close-up of the Continuity Tester and PC board before the modification to the front end. See details of this modification on page 8.
The tester can be housed in a tooth-brush case and the soft-type cases are the best as they don't crack. It can then be added to our two other pieces of test equipment to make a very valuable trio for testing digital projects, especially processor designed projects, as these will be the products of the future.

gating transistor. But don't worry too much about the actual turn-on and turn-off values as most bus lines in computers have resistors of about 470R in their lines and the tester will not detect resistance values above 330R.

IF IT DOESN'T WORK

If the Tester does not emit a tone when the two leads are touched together, follow these steps:

Remove the gating transistor (near the input probe) and turn the unit ON. This should allow the tone circuit to operate. If not, check the value of the 1k and 100k resistors and also their positions. Next check the 1uF electrolytics. Check also the BC 547 and BC 557 transistors. They cannot be swapped over. Finally check the speaker with a multimeter set to ohms to make sure it has continuity.

You can determine if the oscillator is jammed in the ON mode or OFF mode by taking a current reading across the switch. If the current is more than 20mA, it is jammed in the ON mode and this means the BC 547, in the oscillator, is conducting.

The transistor could be shorted between collector and emitter or the 1uF feedback electrolytic is open circuit.

Create a short between the base and emitter of the BC 547 to start the circuit into oscillation or replace the 1uF with 100n.

Remember, the mini speaker is a special 80R type and this value must be maintained for the circuit to work properly.

If the circuit is jammed in the OFF mode, either of the transistors in the oscillator may be open circuit or incorrectly fitted. Try new transistors.

If the circuit remains in the OFF state, remove the 1uF feedback electrolytic between the speaker and 100k and the circuit should turn ON.

If it does, the fault will lie in the electro being either a short circuit or very leaky.

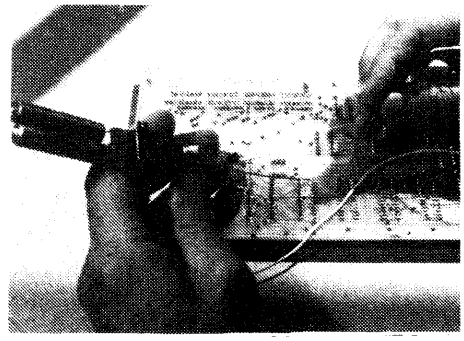
Once the tone circuit operates, the only other stage to be checked is the gating transistor.

If it fails to turn the tone off, the fault will lie in the base bias.

Check the voltage of the batteries. They should give at least .1v drop across the 100R resistor. If there is no voltage drop, check the voltage-dropping diodes. They should drop .65v each. Also check the supply voltage. It should be higher than 2.6v.

If the gating transistor still fails to turn the tone off, replace it. You may have damaged the base-emitter junction.

This should be sufficient to get the Tester working. If not ask another hobbyist to help you.



Using the continuity tester on the BUS lines of the TEC.

HOW TO USE THE TESTER

The project you are going to test must be switched OFF and no part of it should have any voltages present.

This is because the input of the Tester connects directly to the base of a transistor and any voltage over .7v will destroy the junction.

Switch the Tester ON and the indicator LED will illuminate. Touch the two probes together and the tone will be emitted. This is the tone you will be listening for during the tests.

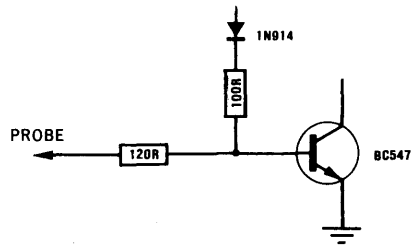
It is important to have a set plan of attack as lots of tests will be required for even the simplest of circuits and a logical approach will prevent you going over the same area twice or missing a test.

MODIFICATION

After using the Continuity Tester for over 3 months, with total success, we decided to present it in TE.

Then Paul came up with a simple but clever modification that would allow the probe to detect down to 47 ohms and also provide a safety feature for the first transistor.

It is simply the addition of a 120 ohm resistor between the base of the first transistor and the probe. Firstly this will act as a limiting resistor to prevent damaging the base of the transistor, should the probe be placed across power rails of a project when the voltage is present.



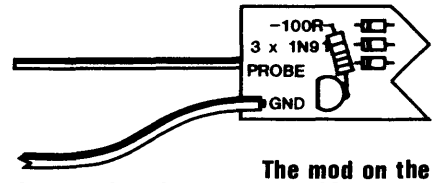
The 120R is added in series with the probe to protect the first transistor.

Secondly it reduces the input range so that the probe detects values from zero ohms to about 47 ohms.

Whereas we have been careful to turn off the supply to any project under investigation, the idea of directly connecting the base to the probe is not wise. It means any voltage above about .7v will have the capability of damaging the input transistor.

This mod overcomes the problem and makes it more robust in use.

The modification is carried out as follows:



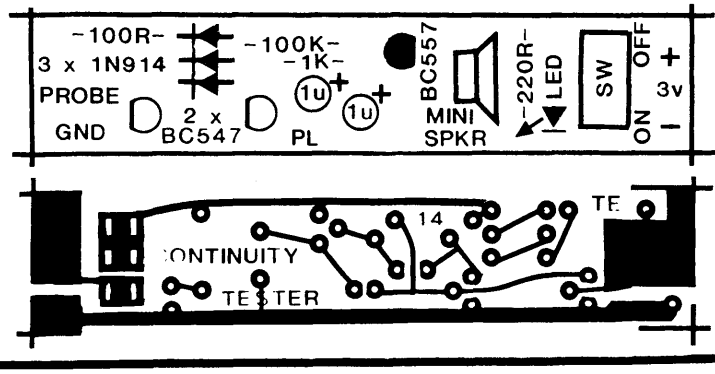
The mod on the front-end of the tester. The 120R is on the underside of the board.

Desolder the probe end of the 100R resistor and take it directly to the base of the transistor. Refer to the diagram for this. Cut the track between the base of the same transistor and the probe. Solder a 120R resistor between the base and the probe, either on the underside of the board or on top, so that it looks as neat as possible.

You may need to use a higher or lower value, according to the characteristics of your probe and experimenting will determine this.

This will make the probe relatively indestructible and I hope you find as much use for it as we have.

Quite honestly, it has found cracks and dry joints that the eye missed and has fixed at least 10 TEC's in the past 2 months. I'm sure you will like it.



TEC-1A & 1B

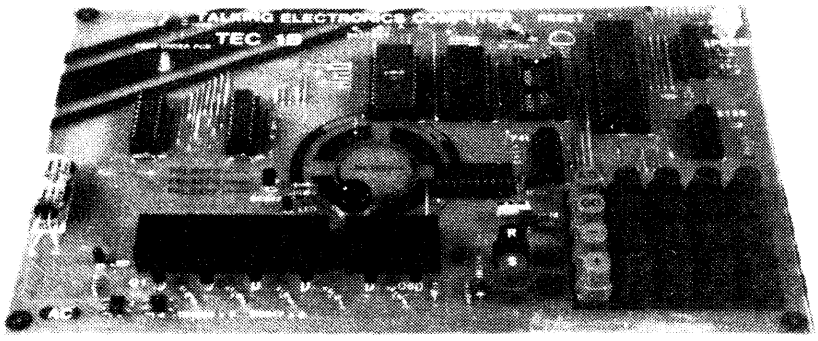
Kit of parts: $90.60
PC Board: $24.30
Complete: $114.90

TALKING ELECTRONICS COMPUTER

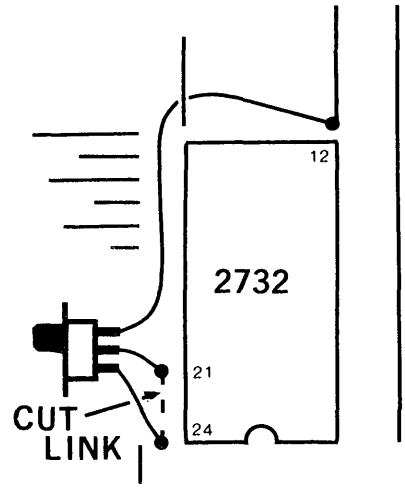
TEC 1A's can be converted to TEC 1B's by ading a push button, a 47k resistor and a diode. When you update to MON 2, the SHIFT function allows INSERT and DELETE and a number of other commands.

PART V

Features in this article:
- ★ **Crystal Oscillator**
- ★ **Input/Output Module**



TEC 1B with SHIFT KEY FITTED.



This is the fifth article on the TEC and quite frankly we have only just scratched the surface up to now.

The more ideas you try, the more you realise the potential of programming.

We have received a number of programmes for the 7-segment displays as well as the 8x8. These have been included in this article and also a few more hints on programming in general.

But before we get onto the programmes, there are a number of loose ends we have to tidy up, to bring the documentation up to date.

So far there have been 4 different models of the TEC and although the changes have been slight, they have not been put down on paper.

As far as the software is concerned, all models are compatible as the only modifications have been in the hardware.

The output latches have been changed from 8212's to 74LS273's, the 2200uF filter electrolytic changed to 1000uF and the 7805 mounted under the board so that its leads cannot be bent or broken.

The rest of the design remains substantially the same with the only addition being a shift button near the keyboard.

This button allows the keys to have a second function and we have already described these in issue 13.

Kits are now supplied with both the 1B ROM and also MON 2 ROM. It is possible to fit both programs into a single 2732 and to select either one program or the other requires a slide switch to take pin 21 HIGH or LOW. With this you can get the best of both monitors.

The computer can be switched between one MONitor and the other by pressing the reset button and while it is pressed, the slide switch is changed. When the reset button is released, the other MON will come into operation.

The following is a reprint of an information sheet supplied with the latest kits:

THE 2732 MONITOR

Both MON 1B and MON 2 are in the same chip and is called MON 1B/2. The MON 1B program has been placed in the upper half of memory so that when it is placed in the TEC, the MON 1B section will run and the computer will display 0800. You can now access all the games, tunes and running letter routines as covered in issues 10, 11, 12 and 13.

The MON 2 routine is more advanced and does not contain any of the games. Instead it has a SHIFT routine that enables you to insert bytes into a program by shifting all the higher bytes, and the byte at the present address, up one location. And a delete function, as well as a number of other routines that have been covered in issue 13.

When you want to accesss the MON 2 program, a switch must be fitted to the board so that pin 21 can be taken to ground. This will enable the lower half of the 2732 to be brought into the system and thus run the MON 2 listing.

The diagram above shows how to fit the mini slide switch to the two halves of the link that has been cut as shown.

You can switch from one monitor to the other at any time by pressing reset and altering the switch.

If you are writing a program using the MON 1B, it is best to start at 0900, so that when (if) you want to use the INSERT or DELETE functions, you can change to MON 2, use the function and then change back to MON 1B.

Gradually you will realise it is best to use MON 2 for most of your programs.

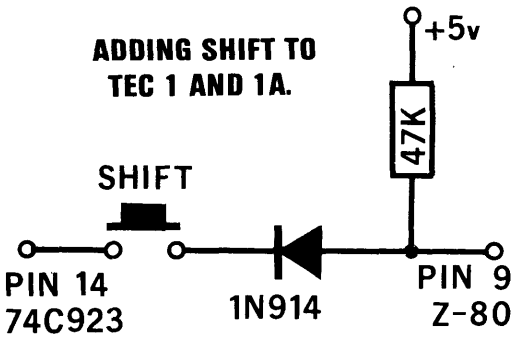
There are two major differences between MON 1B and MON 2. MON 1B uses a simple routine that places the value of a key directly into the accumulator, without firstly saving the value of the accumulator. Thus its original value is destroyed. MON 2 loads the key value into location **08E0** and thus your program must include an instruction that looks at this location for the value of the key.

Unless you load directly into the A register.

Simple programs designed for MON 1B will not run on MON 2 if they include a key press; unless they are altered accordingly.

The second difference is the start address for programming. MON 1B starts at 0800, while MON 2 starts at 0900. Programs written at 0800 cannot be successfully modified via the insert and delete functions as they will run into part of the scratchpad area for the MON 2 system.

The following diagram shows how to add the diode and resistor for the shift function. The diagram in issue 13 was not clear and this is an improvement:



TEC 1A/1B CONSTRUCTION HINTS:

The output latches for the latest TEC's are 74LS273's and the dotted link below each chip is fitted.

The 7805 regulator bolts directly under the PC board and a little thermal compound can be applied to assist heat transfer.

The small link from pin 4 of the 74LS138 IN/OUT decoder must be added. It can be cut later if expansion is required.

About 58 empty holes will be on the board after construction. Some provide for expansion while others are unused.

After the keys have been added and everything is operating satisfactorily, the letters and numbers can be applied to the tops.

Firstly clean the buttons with methylated spirits and apply the rub-down letters. Cover them with clear nail varnish to protect them. If you want to add another layer, wait for the first to dry, otherwise the letters will smudge!

NOTES ON THE 8x8 DISPLAY

The 8x8 has been modified to include sinking and sourcing transistors as described on P 27 of issue 12 and all kits now include 16 transistors and the necessary current limiting resistors.

This results in the LEDs being driven harder and increases the brightness of the display noticeably.

This is important when multiplexing as each LED will be turned on for only about one-eighth of the time and if sufficient current is supplied during this instant, the LED will appear to be on for the total period of time with an acceptable brightness.

We had an interesting fault in an 8x8 last week. It is interesting because the knowledge we gained applies to other projects where LEDs are driven in parallel.

A constructor built the 8x8 and was not happy with the output of about 3 of the LEDs.

He went to his local electronics shop and bought a few replacements.

After fitting them, he was quite surprised that they did not work at all! So he rang us. At this particular point in time we were not familiar with the fault and did not know how to advise him. So we suggested he call around with the project.

Some time later that day he arrived and we noticed the first difference was the colour of the LEDs he had used. They were less opaque than the rest and the crystal inside the LED could be readily seen. This did not disturb us as the light output of the LEDs was our prime concern.

When we tested it, sure enough; the 3 LEDs did not light up.

On measuring across the new LEDs with a multimeter set to low ohms, the voltage drop across the crystal was slightly higher than the rest. (When we are taking a measurement like this, the swing of the needle is being taken as a voltage drop. We are using the 3v suppy in the multi-meter to provide the LED with voltage and the needle tells us the characteristic voltage drop across the crystal.)

We then got three LEDs from our stock and measured the characteristic voltage drop. It was exactly the same as the majority in the display and when we fitted them, the whole screen lit up perfectly.

The reason why the LEDs failed to illuminate was due to the higher voltage needed to turn them on. Even if this is 100mV or so, the result will be the LED will not turn on at all. (See the experiment in Stage-1, P 9)

It is important that LEDs are matched according to this characteristic voltage, for situations where they are placed in parallel. The 8x8 is one example as the LEDs are effectively in parallel when the whole screen is being illuminated in a non-multiplexed situation.

DISPLAYING LETTERS AND NUMBERS

The 7-segment display is quite a unique unit. It will display all the numbers from 0 to 9 as well as many of the letters of the alphabet.

There are only about seven letters that cannot be readily displayed and for these we will have to make a compromise.

The letter M is displayed as a small 'n', with a bar over the top. This corresponds to a feature in mathematics where a dot is placed over the first and last digits in a number to indicate the number repeats. (This is called a recurring number or recurring fraction).

The letter W is displayed as a small 'u' with a bar over the top, for the same reason. The letter 'U' is displayed as a capital letter while V is a small 'u'.

The letter 'X' is displayed as part of a cross and Z is shown as two angles in opposite corners of the display, and looks quite readable.

The only letters which require interpretation are 'K' and 'Q'.

Ten other characters have also been included such as a question mark and 'equals' as well as a reverse bracket to assist in displaying mathematical problems.

A = 6F		? =	4D
B = E6		= =	84
C = C3		– =	04
D = EC		! =	38
E = C7		. =	10
F = 47		" =	0A
G = E3	⌐ ¬	; =	30
H = 6E	⊢ ⊣	— =	20
I = 28	⌊ ⌋	= =	85
J = E8		) =	0F
K = 67			
L = C2			
M = 65			
N = 6B			
O = EB			
P = 4F			
Q = 3F		1 =	28
R = 44		2 =	CD
S = A7		3 =	AD
T = 46		4 =	2E
U = EA		5 =	A7
V = E0		6 =	E7
W = E1		7 =	29
X = 26		8 =	EF
Y = AE		9 =	AF
Z = C9		0 =	EB

TESTING A BLANK 2716 FOR FF's

After erasing an EPROM, such as a 2716, it is wise to make sure it is entirely blank before reprogramming it. The program that follows does just that. It does not inform you of the location or locations that do not contain FF, but rather the screen goes blank and stays blank if a location has not been fully erased.

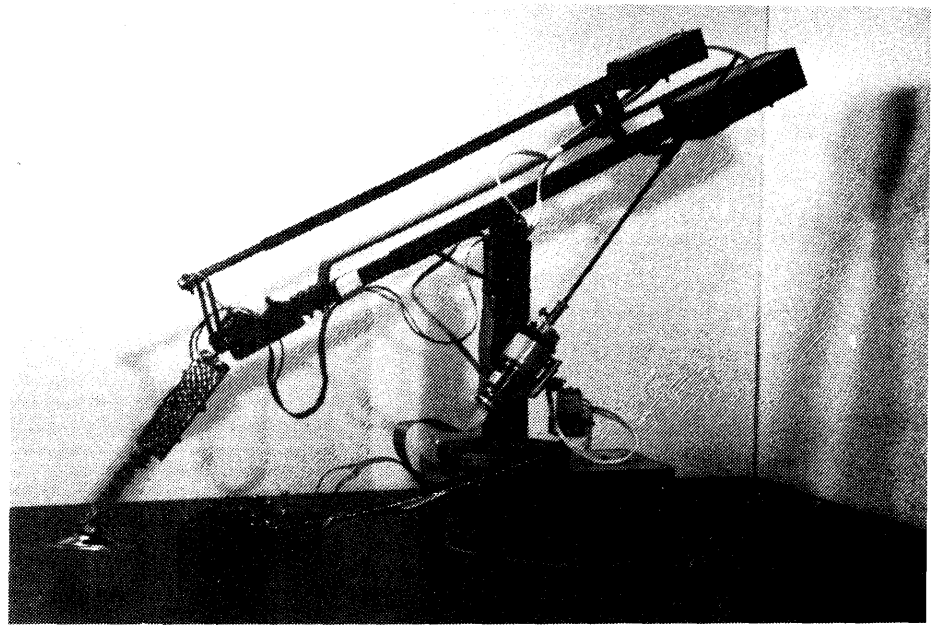
If all locations contain FF, the TEC resets via the MONitor program to the start-up address (either 0800 or 0900). This program can be placed anywhere in RAM and will work with either MON 1 or MON 2.

- by James Doran. 3218

```
11 00 08
21 00 10
7E
FE FF
20 07
23
1B
7A
B3
20 F5
C7
76
```

As promised, a larger photo of the robot arm. If you have built anything like this, why not take a photo and send it in.

Your ideas, combined with others, will help us to present an article.



MON 2 HEX LISTING:

For those with the TEC 1B and an EPROM BURNER, here is the hex listing for the MON 2.

With this you can make your own MON 2, and save the cost of conversion.

Insert the data **0800** on the TEC, and continue through to **0D64.**

Go through the program at least once, checking each of the values to make sure a mistake has not been made. A single mistake can mean the difference between perfection and failure.

MON 2 HEX LISTING FOR TEC 1B:

```
0000 C3 00 02 FF
0004 FF FF FF FF
0008 2A C0 08 E9
000C FF FF FF FF
0010 2A C2 08 E9
0014 FF FF FF FF
0018 2A C4 08 E9
001C FF FF FF FF
0020 2A C6 08 E9
0024 FF FF FF FF
0028 2A C8 08 E9
002C FF FF FF FF
0030 2A CA 08 E9
0034 FF FF FF FF
0038 2A CC 08 E9
003C FF FF FF FF
0040 FF FF FF FF
0044 FF FF FF FF
0048 FF FF FF FF
004C FF FF FF FF
0050 FF FF FF FF
0054 FF FF FF FF
0058 FF FF FF FF
005C FF FF FF FF
0060 FF FF FF FF
0064 FF FF F5 DB
0068 00 32 E0 08
006C F1 ED 45 FF
0070 FF FF FF FF
0074 FF FF FF FF
0078 FF FF FF FF
007C FF FF FF FF
0080 EB 28 CD AD
0084 2E A7 E7 29
0088 EF 2F 6F E6
008C C3 EC C7 47
0090 E3 66 28 E8
0094 4E C2 2D 6B
0098 EB 4F 2F 4B
009C A7 46 EA E0
00A0 AC A4 AE C9
00A4 10 08 18 04
00A8 2C 00 FF FF
00AC FF FF FF FF
00B0 00 09 00 00
00B4 FF FF FF FF
00B8 FF FF FF FF
00BC FF FF FF FF
00C0 1B 18 1E 1D
00C4 12 17 0E 29
00C8 0B 22 29 17
00CC 12 0C 24 29
00D0 29 29 29 29
00D4 FE 1C 1D 18
00D8 17 0E FF FF
00DC FF FF FF FF
00E0 CD 89 02 03
00E4 18 04 CD 89
00E8 02 0B CD 90
00EC 04 CD 70 02
00F0 21 DF 08 CB
00F4 C6 CB 8E C3
00F8 78 03 FF FF
00FC FF FF FF FF
0100 FD 10 10 FD
0104 11 EF 12 E1
0108 13 D5 14 C9
010C 15 BE 16 B3
0110 18 A9 19 9F
0114 1A 96 1C 8E
0118 1E 86 20 7F
011C 22 77 24 71
0120 26 6A 28 64
0124 2A 5F 2D 59
0128 2F 54 32 50
012C 35 4B 38 47
0130 3C 43 3F 3F
0134 43 3C 47 38
0138 4B 35 50 32
013C 54 2F 59 2D
0140 5F 2A 64 28
0144 6A 26 71 24
0148 77 22 7F 20
014C 86 1E 8E 1C
0150 96 1A 94 19
0154 A9 18 B3 16
0158 BE 15 C9 14
015C D5 13 E1 12
0160 EF 11 FD 10
0164 FF FF FF FF
0168 FF FF FF FF
016C FF FF FF FF
0170 C5 D5 E5 F5
0174 A7 20 03 5F
0178 18 02 1E 80
017C 21 00 01 87
0180 85 6F 4E 23
0184 46 7B D3 01
0188 10 FE 46 AF
018C D3 01 10 FE
0190 0D 20 F1 F1
0194 E1 D1 C1 C9
0198 FF FF FF FF
019C FF FF FF FF
01A0 F5 E5 2A D6
01A4 08 7E FE FF
01A8 20 03 E1 F1
01AC C9 FE FE 28
01B0 F1 23 CD 70
01B4 01 18 EE FF
01B8 FF FF FF FF
01BC FF FF FF FF
01C0 21 DF 08 CB
01C4 46 20 07 CB
01C8 C6 CB 8E C3
01CC 78 03 CB 86
01D0 CB CE C3 78
01D4 03 FF FF FF
01D8 C5 06 80 CD
01DC A0 02 10 FB
01E0 C1 C9 FF FF
01E4 ED 4B D2 08
01E8 CD 90 04 CD
01EC 70 02 C3 78
01F0 03 FF ED 4B
01F4 D4 08 CD 90
01F8 04 CD 70 02
01FC C3 78 03 FF
0200 ED 73 E8 08
0204 31 00 09 F5
0208 C5 D5 E5 DD
020C E5 FD E5 08
0210 D9 F5 C5 D5
0214 E5 ED 57 F5
0218 AF 32 CC 08
021C 32 CD 08 3E
0220 FF 32 E0 08
0224 C3 40 02 FF
0228 FF FF FF FF
022C FF FF FF FF
0230 FF FF FF FF
0234 FF FF FF FF
0238 FF FF FF FF
023C FF FF FF FF
0240 31 C0 08 AF
0244 D3 01 D3 02
0248 21 B0 00 11
024C D8 08 01 05
0250 00 ED B0 CD
0254 70 02 3E 08
0258 CD 70 01 3E
025C 0F CD 70 01
0260 3E 01 32 DF
0264 08 CD A0 02
0268 CD 60 03 18
026C F8 FF FF FF
0270 F5 E5 C5 CD
0274 89 02 E6 F0
0278 0F 0F 0F 0F
027C 32 DC 08 0A
0280 E6 0F 32 DD
0284 08 C1 E1 F1
0288 C9 21 D8 08
028C 7E 07 07 07
0290 07 23 86 47
0294 23 7E 07 07
0298 07 07 23 86
029C 4F 0A C9 FF
02A0 F5 E5 D5 C5
02A4 11 D8 08 AF
02A8 D3 01 CD 50
02AC 03 CB 4E 28
02B0 02 CB E7 D3
02B4 02 3E 20 D3
02B8 01 06 20 10
02BC FE AF D3 01
02C0 CD 50 03 CB
02C4 4E 28 02 CB
02C8 E7 D3 02 3E
02CC 10 D3 01 06
02D0 20 10 FE AF
02D4 D3 01 CD 50
02D8 03 CB 4E 28
02DC 02 CB E7 D3
02E0 02 3E 08 D3
02E4 01 06 20 10
02E8 FE AF D3 01
02EC CD 50 03 CB
02F0 4E 28 02 CB
02F4 E7 D3 02 3E
02F8 04 D3 01 06
02FC 20 10 FE AF
0300 D3 01 00 C3
0304 18 03 FF FF
0308 FF FF FF FF
030C CD 89 02 C5
0310 E1 31 C0 08
0314 E9 FF FF FF
0318 CD 50 03 CB
031C 46 28 02 CB
0320 E7 D3 02 3E
0324 02 D3 01 06
0328 20 10 FE AF
032C D3 01 CD 50
0330 03 CB 46 28
0334 02 CB E7 D3
0338 02 3E 01 D3
033C 01 06 20 10
0340 FE AF D3 01
0344 C1 D1 E1 F1
0348 C9 FF FF FF
034C FF FF FF FF
0350 21 80 00 1A
0354 85 6F 7E 13
0358 21 DF 08 C9
035C FF FF FF FF
0360 F5 E5 21 E0
0364 08 3E FF BE
0368 28 0E 7E E6
036C 1F CB 6E 20
0370 02 C6 14 C3
0374 A8 03 FF FF
0378 E1 F1 C9 FF
037C FF E1 F1 C9
0380 FF FF FF FF
0384 CD 89 02 C5
0388 DD E1 DD 23
038C DD E5 E1 7C
0390 FE 40 28 08
0394 DD 7E 00 DD
0398 77 FF 18 EE
039C 3E 00 32 FF
03A0 3F CD 70 02
03A4 C3 78 03 FF
03A8 C6 01 CD 70
03AC 01 C3 21 04
03B0 CD 89 02 0B
03B4 DD 21 FE 3F
03B8 DD 7E 00 DD
03BC 77 01 DD 2B
03C0 DD E5 E1 79
03C4 BD 20 F1 78
03C8 BC 20 ED DD
03CC 36 01 00 CD
03D0 70 02 C3 78
03D4 03 FF FF FF
03D8 E5 F5 DD E5
03DC C5 AF 32 DF
03E0 08 06 06 21
03E4 D8 08 3E 29
03E8 77 23 10 FC
03EC 2A D0 08 7E
03F0 FE FF 20 06
03F4 C1 DD E1 F1
03F8 E1 C9 FE FE
03FC 28 EE DD 21
0400 D8 08 06 05
0404 DD 7E 01 DD
0408 77 00 DD 23
040C 10 F6 7E 32
0410 DD 08 23 06
0414 40 CD A0 02
0418 10 FB 18 D3
041C FF FF FF FF
0420 FF D6 01 36
0424 FF CB 67 C2
0428 C0 04 CB 6F
042C C2 C0 04 21
0430 DF 08 CB 46
0434 CA 55 04 57
0438 CD 89 02 21
043C DF 08 CB 5E
0440 20 03 AF CB
0444 DE 07 07 07
0448 07 E6 F0 82
044C 02 CD 70 02
0450 C3 7D 03 FF
0454 FF 57 21 DF
0458 08 CB 9E CB
045C 66 20 08 01
0460 00 00 CD 90
0464 04 CB E6 CD
0468 89 02 78 07
046C 07 07 07 E6
0470 F0 5F 79 07
0474 07 07 07 E6
0478 0F 83 47 79
047C 07 07 07 07
0480 E6 F0 82 4F
0484 CD 90 04 CD
0488 70 02 C3 7D
048C 03 FF FF FF
0490 F5 E5 21 D8
0494 08 78 E6 F0
0498 07 07 07 07
049C 77 23 78 E6
04A0 0F 77 23 79
04A4 E6 F0 07 07
04A8 07 07 77 23
04AC 79 E6 0F 77
04B0 E1 F1 C9 FF
04B4 FF FF FF FF
04B8 FF FF FF FF
04BC FF FF FF FF
04C0 21 DF 08 CB
04C4 9E CB A6 FE
04C8 10 CA E0 00
04CC FE 11 CA E6
04D0 00 FE 12 CA
04D4 0C 03 FE 13
04D8 CA C0 01 FE
04DC 14 CA 50 05
04E0 FE 15 CA FF
04E4 FF FE 16 CA
04E8 FF FF FE 17
04EC CA F2 01 FE
04F0 18 CA 70 05
04F4 FE 19 CA FF
04F8 FF FE 1A CA
04FC FF FF FE 1B
0500 CA FF FF FE
0504 1C CA 60 06
0508 FE 1D CA FF
050C FF FE 1E CA
0510 FF FF FE 1F
0514 CA FF FF FE
0518 20 CA FF FF
051C FE 21 CA FF
0520 FF FE 22 CA
0524 FF FF FE 23
0528 CA FF FF FE
052C 24 CA B0 03
0530 FE 25 CA 84
0534 03 FE 26 CA
0538 FF FF FE 27
053C CA E4 01 C3
0540 78 03 FF FF
0544 FF FF FF FF
0548 FF FF FF FF
054C FF FF FF FF
0550 CD 89 02 60
0554 69 3A E1 08
0558 23 BE 20 FC
055C 44 4D CD 90
0560 04 C3 53 02
0564 FF FF FF FF
```

HOW THE CIRCUIT WORKS (and a general discussion.)

The circuit diagram is TALKING ELECTRONICS COMPUTER 1B (TEC 1B). It is a 9-chip, single-board computer capable of executing Machine Code commands and displaying the result on either the inbuilt display (a set of 7-segment displays) or on other displays via the expansion socket.

The expansion socket is configured identical to the RAM socket and is accessed via line Y2 of the ROM/RAM decoder 74LS138, at the top right-hand corner of the diagram.

The computer starts-up via a MONitor program contained in the 2732 and two monitor programs are in this chip.

When the ROM select switch is HIGH, MON-1 program is accessed and the computer displays **0800**. When the switch is LOW, the computer displays **0000** and the MON 2 program operates.

This has been done so that the TEC 1B is compatible with the original TEC 1 and it can be upgraded by adding a monitor switch and a programmed 2732 EPROM.

The original TEC 1 had a 2716 EPROM but these chips are no longer manufactured and thus a 2732 is now used. When a 2732 is placed in a 2716 socket the upper half of the chip is accessed and thus MON 1 program has been placed in the upper half.

The MON 1 select switch takes address line A11 LOW for the low half and HIGH for the upper half.

The other major change between TEC 1 and TEC 1B is the output latches. They were originally 8212's but now 74LS273's have been used. These are a modern chip and are more readily available.

STARTING UP

When the power is applied to the computer, the reset line on the Z-80 is taken low for an instant via the 100n capacitor and this resets the internal workings of the Z-80.

Its first operation is to look for the first byte of data at address zero, in the monitor. Depending on this being a one-byte, two-byte or three-byte instruction, the Z-80 will execute it or request one or two more bytes.

The flow of information from the Z-80 to the other chips is via two buses. They are the **ADDRESS BUS** and **DATA BUS.** In addition, there is a set of control lines (sometimes referred to as the control bus) that activate (generally) one chip at a time.

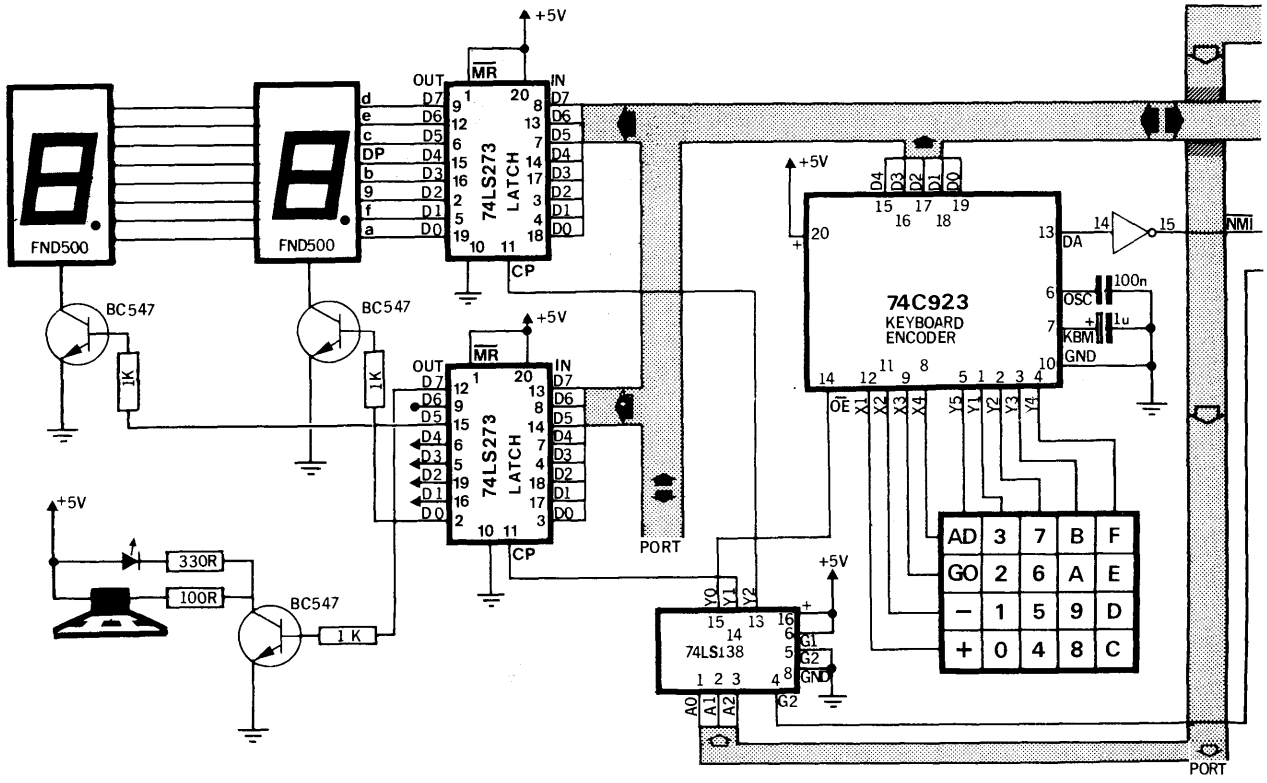
All signals within the computer are at a level equal to rail voltage (called HIGH) or ground (called LOW). For this reason they are called digital circuits.

The shaded paths of the diagram represent buses and the address bus contains 11 lines while the data bus contains 8 lines. The data bus is always 8 bits wide for a Z-80 processor and this gives it the name '8-bit system'.

The address bus is a **ONE-WAY** bus in which the Z-80 activates the lines and turns them on and off using binary notation to generate an address value.

When all lines are LOW, address zero is represented. When line A0 is HIGH, address 1 is represented. The Z-80 has 16 address lines and address 1 is:
0000 0000 0000 0001. When line A1 is HIGH, address 2 is:0000 0000 0000 0010

The address lines connect to a number of chips but only one will respond due to a 'turn-on' line called a command line being required to be activated.



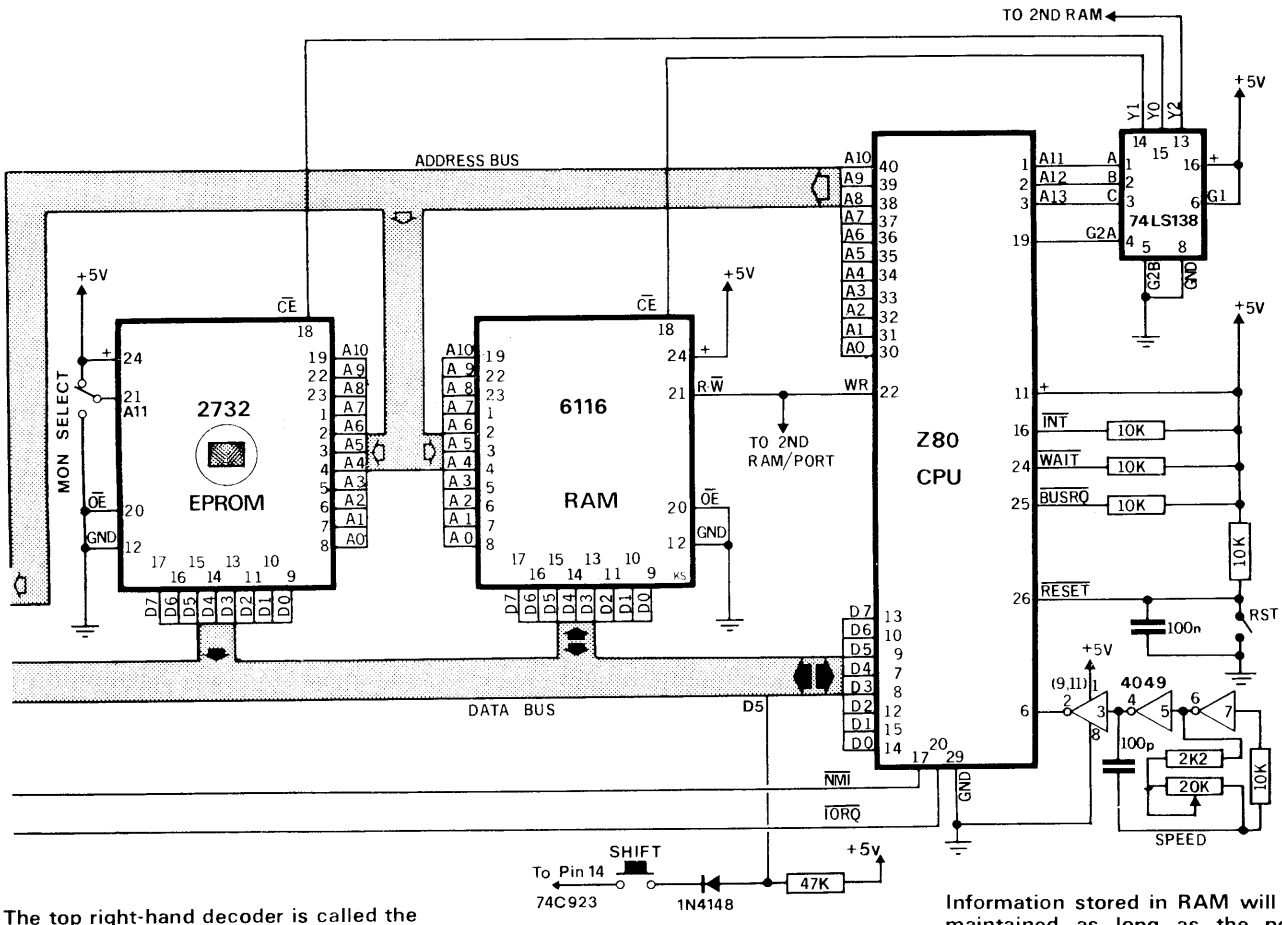
TEC 1B COMPUTER CIRCUIT

These command lines are called chip select, chip enable or output enable and this allows only one chip to be activated at a time.

The chip select lines are the outputs of a decoder chip and this chip is 'turned on' by the Z-80 and only one of its outputs goes low at a time.

It is a 3-line to 8-line decoder and this means it has 3 input lines and depending on the HIGH-LOW values on these lines, one of the outputs will go low.

This is a form of expander so that a single line from the Z-80 (e.g. from pin 19 or 20) can control 8 devices.



The top right-hand decoder is called the ROM/RAM decoder and the lower left-hand, the IN/OUT decoder.

The data from the monitor flows to the Central Processing Unit (the Z-80) along the data bus as 8 parallel bits of information AT THE SAME TIME.

This is called a BYTE of information and can have 256 different possibilities. The Z-80 knows if the byte is data or instruction by the fact that it starts at address zero looking for an instruction byte. From there the program must follow correctly and this is the responsibility of the programmer.

The data enters the Z-80 via a holding register (an instruction register) that is not available to the programmer and to keep the discussion simple, we consider the byte flows directly into the A register (called the accumulator). This is the only register capable of accepting information from the data bus. All other registers must be fed from the accumulator.

Data can also flow out of the Z-80 along the data bus and this bus is BI-DIRECTIONAL. The arrows on the bus show the direction of flow of information.

The keyboard is scanned by the 74C923 and this is called hardware scanning as the chip has inbuilt scanning circuits for a matrix of 20 keys.

When a key is pressed, a signal is generated at the Data Available pin and the Z-80 is notified via the Non-Maskable Interrupt line.

The Z-80 immediately ceases all processing and jumps to address 66 in the MONitor. Here it executes a short program and activates the input/output decoder to turn on the keyboard encoder. The encoder puts a 5-bit number on the data bus and this is stored for later use or operated upon, as required.

When the shift button is pressed, and kept pressed while one of the keys is pressed, an extra bit is added to create a 6-bit number and thus an additional set of 20 commands can be created.

The output latches are also controlled by the in/out decoder and the control line on each latch is called CP (clock pulse).

When these lines are taken LOW, then HIGH again, the data appearing on the input lines is latched into the chip and will appear on the output lines and will remain there.

This allows devices such as 7-segment displays, relays or globes etc. to be activated.

The 6116 RAM is RANDOM ACCESS MEMORY and as the name suggests, bytes of information can be placed anywhere in its matrix of cells. These bytes are generally data however programs can be stored and run in RAM and these are usually developmental programs.

Information stored in RAM will only be maintained as long as the power is applied as the flip flops storing the data will not hold their state when power is removed.

'ADD-ONs'

This computer is only a baby in the computer world however it does have the facility for expansion and already a number of 'add-ons' have been produced.

Possibly the most important add-on is the NON-Volatile RAM. This consists of a battery backed-up 6116, into which programs can be placed.

Other devices can be connected to the system via the expansion port and this includes an IN/OUT module, an OUTPUT module, a display module and a controller module (to come).

The clock oscillator is adjustable via a speed control pot and allows programs to be run at different speeds for assessment. If a real-time situation is required, a crystal oscillator can be fitted and this will allow time to be programmed accurately.

The main intention of this computer is to provide the starting point for an understanding into computer operations. For this reason, machine code programming has been employed. This means you will be able to create your own systems for such applications as controllers and timers for industry and home and be able to produce the project from the ground up, without requiring any external operating system.

PROGRAMS FOR THE TEC DISPLAYS and a sound Program:

Here are three programs for the TEC and TEC displays. The effects that can be produced on a set of 7-segment displays is quite amazing. I thought we had run out of ideas and yet they still keep coming.

The first program is a Space Invaders sound effect using button 4 as the firing button. The other two programs use the displays.

SPACE INVADERS 'SHOOTING'

Phillip Barns, 2118

Computer sounds and effects are always impressive, especially when we have control over them.

This program does just that.

It is a Space Invaders sound effect and you can control it via button 4.

The point to note with this program is the way the delay is increased by inserting a varying value into a delay loop. In the latter half of the program the OFF time is gradually increased by placing another varying value into a delay loop.

The resulting ON-OFF values outputted to the speaker produce the changing tone.

The program only accepts the press of button '4' (determined by **CP 04**) and by pressing this button repeatedly, a firing sound will be produced.

```
LD A,12        800   3E 12
LD I,A         802   ED 47
LD H,FF        804   26 FF
LD B,01        806   06 01
INC B          808   04
LD A,80        809   3E 80
OUT (01),A     80B   D3 01
CALL 0828      80D   CD 28 08
XOR A          810   AF
OUT (01),A     811   D3 02
CALL 0828      813   CD 28 08
LD A,I         816   ED 57
CP 04          818   FE 04
JP Z 0800      81A   CA 00 08
DEC H          81D   25
JP NZ 0808     81E   C2 08 08
CP 04          821   FE 04
JR NZ 0821     823   20 FC
JP 0800        825   C3 00 08

LD C,B         828   48
DEC C          829   0D
JR NZ 0829     82A   20 FD
RETURN         82C   C9
```

THE BOX G.L. Dunt 3219.

This program is an extension of the techniques we have been discussing in issue 12, P 18, covering the control of two or more pixels at the same time.

It produces an interesting piece of animation in which a box with lid is displayed and moved across the screen in a 'chase scene'.

Again we won't say much about the effect, except to say that you can get quite involved with it and find it very easy to improve upon.

The program consists of 25 'frames' and each frame requires 4 bytes of the table to produce the necessary effects. Each time you increase the table (by 4 bytes) you must also increase the counter register by one (for each frame).

By using 4 bytes we gain the ability to control two pixels at the same time. If only one display is required, the two pairs of bytes will be identical.

```
LD IX 0840      0800   DD 21 40 08
LD D,10         0804   16 19
LD C,40         0806   0E 40
LD A(IX + 00)   0808   DD 7E 00
OUT (01),A      080B   D3 01
LD A(IX + 01)   080D   DD 7E 01
OUT (02),A      0810   D3 02
DJNZ            0812   10 FE
XOR A           0814   AF
OUT (02),A      0815   D3 02
LD A(IX + 02)   0817   DD 7E 02
OUT (01),A      081A   D3 01
LD A(IX + 03)   081C   DD 7E 03
OUT (02),A      081F   D3 02
DJNZ            0821   10 FE
DEC C           0823   0D
JR NZ 0808      0824   20 E2
INC IX          0826   DD 23
INC IX          0828   DD 23
INC IX          082A   DD 23
INC IX          082C   DD 23
DEC D           082E   15
JR NZ 0806      082F   20 D5
JP 0800         0831   C3 00 08
```

at 0840:

```
01  01  01  20
E4  E4  80  E4
01  01  10  20
E4  E4  C4  E4

01  01  01  10
E8  E1  80  E4
01  01  20  10
E8  E1  E0  E4

01  01  02  08
E4  01  80  E4
01  02  20  08
E4  E0  E0  E4

01  01  04  04
E2  04  80  E0
01  02  20  08
E2  E0  E0  04

01  01  08  02
E4  80  80  E0
01  02  20  08
E4  E0  E0  04

01  01  10  01
E4  80  04  E0
01  04  20  04
E4  A4  E0  04

01  01  20  01
E2  80  E1  E0
01  08  20  02
E2  64  E1  04
```

Halilovic's Piano:

This program has been designed by BOB Halilovic and gives a piano effect when one of the 20 keys is pressed. The notes have a pre-determined length, and this distinguishes it from the organ programs we have previously presented.

```
Data            0800   00
Data            0801   09
LD A,1F         0802   3E 1F
LD (0901),A     0804   32 01 09
CALL 01B0       0807   CD B0 01
HALT            080A   76
CP 10           080B   FE 10
JR NC           080D   30 07
ADD A,05        080F   C6 05
LD (0900),A     0811   32 00 09
JR 0807         08014  18 F1
SUB A,0F        0816   D6 0F
JR 0811         0818   18 F7
```

G. Sheehan & D. Svendsen. 3175

BOOMERANG

Boomerang is a program for the TEC displays. The effect you get is so clever that we are not going to spoil it by telling you what happens.

The only point we will mention is the composition of the byte table.

Each pass of the program uses two bytes from the table and the end of the program is detected by looking for address **0844.** Register L will be 44 at the end of the table.
By using the table two bytes at a time, we can specify the display we wish to access and the segment to be lit.

Also, using a byte table like this requires less program and fewer registers. It is one of the tricks of compact programming.

The delay at 0900 produces the speed of execution.

Try altering and modifying the program and you will learn a lot about what each instruction does. You can also lengthen it by adding more frames. It'll be like creating your own cartoon.

```
LD HL,0820      0800   21 20 08
LD A(HL)        0803   7E
OUT (01),A      0804   D3 01
INC HL          0806   23
LD A,(HL)       0807   7E
OUT (02),A      0808   D3 02
INC HL          080A   23
CALL 0900       080B   CD 00 09
LD A,L          080E   7D
CP 44           080F   FE 44
JP NZ 0803      0811   C2 03 08
JP 0800         0814   C3 00 08
```

at 0820:

```
01  20  20
09  C0  6F
02  10  10
03  A0  EA
04  08  08
06  24  A7
08  04  04
0C  44  A7
10  02  02
09  C0  28
20  01  01
03  A0  C7
```

Delay at 0900:

```
900   11 FF 0A
903   1B
904   7B
905   B2
906   C2 03 09
909   C9
```

PROGRAMS FOR THE 8x8 DISPLAY:

The 8x8 has remained a popular 'add-on' and we still get requests for more programs for it. Here are some recent submissions:

If you have written a program equal to these, send it in for inclusion in the next issue:

FAN OUT Mk III

Dean Svendsen 3175.

FAN OUT Mk III produces symmetry on the displays and can be seen by the same byte being outputted to both ports 3 and 4. The end of the table is detected by looking at the value of L and starting again when it equals the address of the end of the table.

```
LD HL 0815          21 15 08
LD A(HL)            7E
OUT (03),A          D3 03
OUT (04),A          D3 04
INC HL              23
CALL 0900           CD 00 09
LD A,L              7D
CP 20               FE 20
JP NZ 0803          C2 03 08
JP 0800             C3 00 08
```

at 0815:

```
18      81
3C      C3
7E      E7
FF      FF
E7      7E
C3      3C
```

```
900     11 FF 0A
903     1B
904     7B
905     B2
906     C2 03 09
909     C9
```

BOUNCING BALL AND ROLLING BALL.

G.L. Dunt, 3219.

This program is an extension and improvement over the Bouncing Ball program in issue 12, P. 26.

If you look at P.26, you will notice the program is fairly long.

This is because it is necessary to specify the start address of the ball, each time it changes direction.

Much of the program is a repetition of similar or nearly similar codes and to reduce its length we need to look at any part(s) that repeat.

At first they may not be obvious but one can be found that starts at the base of a column, up the column, across to the next and down to the base again. The sequence ends with the LED jumping to the start of the next column.

If we repeat this 4 times, the whole of the board will be covered. This will reproduce the effect as described on P. 26 of issue 12. Using the same technique, we can travel across the display and back again, to produce a weaving effect as the LED advances up the display. To complete the travel we need to move the LED from the top right hand corner to the lower left hand corner, ready for the start of the next sequence.

By using efficient programming as covered in this program, we can produce twice the effect with about half the program.

Most of the reduction is done by defining the co-ordinates of the ball only once. This is done at the beginning of the program and from there the ball position is kept in the C and D registers. They act as the x and y values in co-ordinate geometry.

To move the LED across or up and down the screen, the C and D registers are rotated left or right. Each register contains only one bit and when this moves out the end of the register, it either "sits in the carry box" or passes it and enters the other end of the register. In either case the carry flag is affected and we look for this to let us know the end of the display has been reached.

As you can see, the LED is either "off the end of the board" or at the other side of the display, when the carry is detected and we must shift it back one location, ready for the next run. This way the LED appears to be darting back and forth from one side to the other, and we are not aware of the 'corrections' that take place.

```
LD C,01         0800    0E 01
LD D,01         0802    16 01
LD A,C          0804    79
OUT (03),A      0805    D3 03
LD A,D          0807    7A
OUT (04),A      0808    D3 04
CALL 0900       080A    CD 00 09
RLC D           080D    CB 02
JR NC 0807      080F    30 F6
RR D            0811    CB 1A
RLC C           0813    CB 01
LD A,C          0815    79
OUT (03),A      0816    D3 03
LD A,D          0818    7A
OUT (04),A      0819    D3 04
CALL 0900       081B    CD 00 09
RR D            081E    CB 1A
JR NC,0818      0820    30 F6
RL D            0822    CB 12
RLC C           0824    CB 01
JR NC,0804      0826    30 DC
RRC C           0828    CB 09
LD A,D          082A    7A
OUT (04),A      082B    D3 04
LD A,C          082D    79
OUT (03),A      082E    D3 03
CALL 0900       0830    CD 00 09
RRC C           0833    CB 09
JR NC,082D      0835    30 F6
RL C            0837    CB 11
RLC D           0839    CB 02
LD A,D          083B    7A
OUT (04),A      083C    D3 04
LD A,C          083E    79
OUT (03),A      083F    D3 03
CALL 0900       0841    CD 00 09
RLC C           0844    CB 01
JR NC,083E      0846    30 F6
RRC C           0848    CB 09
RLC D           084A    CB 02
JR NC,082A      084C    30 DC
RRC D           084E    CB 0A
RRC D           0850    CB 0A
LD A,D          0852    7A
OUT (04),A      0853    D3 04
CALL 0900       0855    CD 00 09
RR D            0858    CB 1A
JR NC,0852      085A    30 F6
RRC C           085C    CB 09
LD A,C          085E    79
OUT (03),A      085F    D3 03
CALL 0900       0861    CD 00 09
RRC C           0864    CB 09
JR NC,085E      0866    30 F6
JP 0800         0868    C3 00 08
```

At 0900:

```
LD HL,06FF          21 FF 06
DEC HL              2B
LD A,L              7D
OR H                B4
JP NZ 0903          C2 03 09
Return              C9
```

RAIN DROPS:

Jim Robertson,

This program produces a very effective pattern, similar to falling rain. The random number generator is the interesting part as it is very difficult to produce random numbers in a program that loops.

```
CALL Random Nos.            CD 00 0A
AND 07                      E6 07
LD H,0B         0805        26 0B
LD L,A          0807        6F
RLC (HL)        0808        CB 0E
LD DE,0006      080A        11 06 00
CALL SCAN       080D        CD 00 09
DEC DE          0810        1B
LD A,D          0811        7A
OR E            0812        B3
JRNZ            0813        20 F8
JR START        0815        18 E9
```

at 0900:

SCAN

```
LD HL 0B00      0900        21 00 0B
LD B,01         0903        06 01
LD A(HL)        0905        7E
OUT (03),A      0906        D3 03
LD A,B          0908        78
OUT (04),A      0909        D3 04
LD B,20         090B        06 20
DJNZ            090D        10 FE
INC HL          090F        23
LD B,A          0910        47
XOR A           0911        AF
OUT (04),A      0912        D3 04
RLC B           0914        CB 00
JR NC           0916        30 ED
RETURN          0918        C9
```

at 0A00:

RANDOM NUMBERS:

```
LD A,R          0A00        ED 5F
LD B,A          0A02        47
LD A,R          0A3         ED 5F
RLA             0A05        17
LD R,A          0A06        ED 4F
DJNZ            0A08        10 FB
RETURN          0A0A        C9
```

PHONE DIALLER

TURNING THE TEC INTO A PHONE DIALLER

The following three or four pages examine the development of an idea. It is a Telephone Dialler capable of storing up to 30 or 40 names and phone numbers with a dialling facility and auto re-dial.

It is only a program of ideas as the output appears on a speaker in the form of tones.

Since this is a fiarly ambitious concept, it has been divided into 3 sections. Each section describes a program that is complete in itself and increases in complexity with complete design in section 3.

The first program is fairly simple. It shows how to get figures from the keyboard and display them on the screen. The second contains two function buttons, **C** and **E**. The 'C' key clears the screen and 'E' indicates the end of a phone number.
The third program is much more complex. It has more features and is keeping track of more things.

Each program has been created from scratch as it is almost impossible to 'add onto' an existing program.

Type each of these programs into the TEC and study them. This way you will learn how they operate.

PHONE DIALLER PROGRAM 1.

This program is limited to displaying 6 digits on the TEC screen as no scrolling feature is present. As the keys are pressed, the numbers fill the screen from left to right. When the screen is full, the capability of the program is reached.

The screen buffer is located at **0900** and the scan rate is determined by the value of B (at **082E** and **082F**). We can increase or reduce the scan rate by altering the value of B and by adjusting the TEC clock speed.

No other features are available in this program. The TEC must be reset and 'GO' pushed to clear the screen so that a new number can be keyed in.

This simple program shows how to get numbers from the keyboard and onto the screen.

The only instruction that will be unfamiliar is **JRNC.** It effectively divides the keyboard in two, allowing keys 0-9 to be accepted and A-F to be disregarded.

JRNC means Jump Relative if the Carry flag is NOT SET. When the previous instruction is a 'COMPARE', it is best to substitute the word 'BORROW' for carry, and the instruction will be much easier to understand. This is because the compare instruction subtracts the data byte from the accumulator and if a borrow is required, the carry flag is SET.

PHONE DIALLER - Part 1

```
LD D, 08        0800   16 08     The first 8 memory locations are cleared so that the program
XOR A           0802   AF        will come on with a blank screen. We need only 6 locations.
LD HL,0900      0803   21 00 09  The 7th location is explained in the text.
LD (HL),A       0806   77        Register A is zeroed and this value is inserted into 0900 - 0907
INC HL          0807   23        via the HL register being the pointer register.
DEC D           0808   15
JR NZ           0809   20 FB
LD A,I          080B   ED 57     The Index register contains the value of the key.
CP 0A           080D   FE 0A     Compare the accumulator with 0A.
JR NC           080F   30 12     Jump relative if the key is A or higher.
LD DE 0880      0811   11 80 08  Load DE with the start of the DISPLAY TABLE.
ADD A,E         0814   83        Add 80 to the key value.
LD E,A          0815   5F        Load the result back into E. DE will point to a table-byte.
LD HL,0900      0816   21 00 09  Load HL with the start of memory.
LD A,(HL)       0819   7E        Look for the first blank memory location by loading the value
CP 00           081A   FE 00     pointed to by HL into the accumulator and comparing with
JR Z            081C   28 03     zero until a blank location is found.
INC HL          081E   23
JR              081F   18 F8
LD A(DE)        0821   1A        When found, load A with the byte pointed to by DE.
LD (HL),A       0822   77        Load the table value into the blank memory location.
LD A,FF         0823   3E FF     Change the value of the index register by loading it with FF so
LD I,A          0825   ED 47     that we can detect the same or another button.
LD C,20         0827   0E 20     start the scan at the left hand end of the display.
LD HL,0900      0829   21 00 09  Load HL with start of memory.
LD D,06         082C   16 06     Load D with 06 for 6 loops of the program.
LD B,00         082E   06 00     Load B with delay value for turning ON each digit.
LD A(HL)        0830   7E        Load the data at the first memory location into A.
OUT (02),A      0831   D3 02     Output to the segment port.
LD A,C          0833   79        Load C into A.
OUT (01),A      0834   D3 01     Output to the cathode port.
RRC C           0836   CB 09     Rotate register C right, to access the 2nd display.
DJNZ            0838   10 FE     Create a short delay to display the digit.
XOR A           083A   AF        Zero A
OUT (01),A      083B   D3 01     Output to the cathode port to turn display OFF.
INC HL          083D   23        Increment to the next location.
DEC D           083E   15        Decrement the loop register.
JR NZ           083F   20 ED     Jump to start of loop if D not zero.
JR              0841   C3 0B 08  Jump to start of program if D zero and look for new key.
```

In our program, **CP 0A** causes the Z-80 to substact **0A** from the accumulator (it will hold the value of the key). When any key below **A** is pressed, the subtraction operation creates a borrow and this sets the carry flag. If we push key **6**, the operation will be 6 - A and the answer will require a borrow. Thus the carry flag will be SET. If we go to the program, we can see the Z-80 will continue down the program and NOT JUMP as the instruction says: JUMP RELATIVE NO BORROW.

To fully understand these instructions you have to comprehend the double negative. For instance: I am NOT, NOT going to jump means I AM going to jump.

Type the program at **0800** and the display conversion table at **0880.**

Push RESET, GO and the displays will blank. Press any combination of keys and notice that only number keys respond.

Modify the value of B in the scan section to increase the scan rate.

Some ideas for experimenting include: scanning from the opposite direction, scanning only 5 displays, allowing letters to appear on the screen, and changing the output to a CODE, so that you can turn it into a CODE-BREAKING game.

at 0880:

EB
28
CD
AD
2E
A7
E7
29
EF
AF

PHONE DIALLER - Part 2

The second part of the Phone Dialler program uses a different approach. As we have said, each must start afresh as it is more difficult to adapt an existing program.

This program accepts a string of digits of any length and will remember them for recall after key **E** (for END) has been pressed.

The **C** button clears the display and can be pressed at any time. When the desired number has been entered, button E is pressed. The display is blanked and the numbers emerge from the right hand end of the display and shift across to the left. Three empty spaces are created before the numbers start again.

This program introduces the concept of control keys and also the need for sub-routines for any sequence that is required more than once.

Programs increase in length as more and more housekeeping is called for. Housekeeping is looking for button presses or detecting the end of a sequence etc.

The prime requirement of the program is to keep the displays illuminated. This means we must be calling SCAN for most of the time and as you will see, the SCAN routine is a favourite place to put house-keeping.

If you want a key to be immediately responsive, it must be checked during the SCAN loop. To be more precise, it must be checked during the inner-most loop as this is the loop which is being run for most of the time.

Key the program into the TEC and run it. Try changing some of the locations and see the result. This is the best way to following what is happening, especially at specific locations.

HOW THE PROGRAM WORKS

The program generates 2 memory areas. One is made up of 6 locations, from **0900** to **0905** and is called the **DISPLAY BUFFER.** The other is from **0907** onwards and is called **MEMORY AREA.**

The SCAN ROUTINE (at 0877) looks at the Display Buffer locations and outputs their value onto the displays.

The remainder of memory, starting at 0907 holds any number of digital as required and is open-ended.

One location, **0906**, is left blank and its purpose will be explained later.

As each number is keyed in, it is stored in memory, from 0907 onwards, and the HL register pair keeps track of the next available location.

The number is also outputted onto the display but firstly a SHIFT ROUTINE is called. The function of this routine is to take the value corresponding to the left-hand digit and drop it out of the buffer zone. The second location is then transferred to the first, the third to the second etc until all the digits have been shifted one place to the left. This leaves an empty hole at the right-hand end of the display.

The way in which this empty space is generated is quite clever. The **'00'** in **0906** is shifted into the 6th buffer location.

The program then loads the present key value in the buffer zone, position six, and reverts to a scan situation in which it is looking for an 'end of number' via button E.

When this is detected, memory is incremented one location and E is inserted.

The displays are cleared and the program picks up the first digit at 0907and places it in the 6th position of the buffer area.

The shift routine is called then the next memory value is placed in the 6th buffer location.

Before each new value is loaded into the buffer area, it is compared with **0E** to detect the 'end of message.'

When E is detected, three blank locations are produced and the message starts again.

The CLEAR function is included in the SCAN routine. This has been done so that CLEAR can be detected instantly, as the display scan must be running at all times to keep the displays illuminated.

DIALLER Part 2 listing:

Main Program:

LD D,20	0800	16 20
CALL CLEAR	0802	CD 5B 08
LD HL, 0907	0805	21 07 09
LD A,I	0808	ED 57
CP 0A	080A	FE 0A
JR NC,0820	080C	30 12
INC HL	080E	23
LD DE,08A5	080F	11 A5 08
ADD A,E	0812	83
LD E,A	0813	5F
CALL SHIFT	0814	CD 65 08
LD A,(DE)	0817	1A
LD (HL),A	0818	77
LD (0905),A	0819	32 05 09
LD A,FF	081C	3E FF
LD I,A	081E	ED 47
CP 0E	0820	FE 0E
LR Z,002A	0822	28 05
CALL SCAN	0824	CD 77 08
JR 0808	0827	18 DF
INC HL	0829	23
LD (HL),A	082A	77
LD D,06	082B	16 06
CALL CLEAR	082D	CD 5B 08
LD HL,0907	0830	21 07 09
LD A,(HL)	0833	7E
LD D,20	0834	16 20
INC HL	0836	23
CP 0E	0837	FE 0E
JR Z,0849	0839	28 0E
LD (0905),A	083B	32 05 09
CALL SCAN	083E	CD 77 08
DEC D	0841	15
JR NZ,083E	0842	20 FA
CALL SHIFT	0844	CD 65 08
JR 0833	0847	18 EA
LD E,02	0849	1E 02
LD D,20	084B	16 20
CALL SCAN	084D	CD 77 08
DEC D	0850	15
JR NZ,084D	0851	20 FA
CALL SHIFT	0853	CD 65 08
DEC E	0856	1D
JR NZ,084B	0857	20 F2
JR 0830	0859	18 D5

Clear:

XOR A	085B	AF
LD HL,0900	085C	21 00 09
LD (HL),A	085F	77
INC HL	0860	23
DEC D	0861	15
JR NZ, 085F	0862	20 FB
RETURN	0864	C9

Shift:

LD B,07	0865	06 07
LD IX,08FF	0867	DD 21 FF 08
LD A,(IX + 01)	086B	DD 7E 01
LD (IX + 00),A	086E	DD 77 00
INC IX	0871	DD 23
DEC B	0873	05
JR NZ,086B	0874	20 F5
RETURN	0876	C9

Scan:

PUSH HL	0877	E5
PUSH DE	0878	D5
LD C,20	0879	0E 20
LD HL,0900	087B	21 00 09
LD D,06	087E	16 06
LD B,80	0880	06 80
LD A,(HL)	0882	7E
OUT (02),A	0883	D3 02
LD A,C	0885	79
OUT (01),A	0886	D3 01
RRC C	0888	CB 09
DJNZ 088A	088A	10 FE
XOR A	088C	AF
OUT (01),A	088D	D3 01
INC HL	088F	23
LD A,I	0890	ED 57
CP 0C	0892	FE 0C
JR Z,089C	0894	28 06
DEC D	0896	15
JR NZ,0880	0897	20 E7
POP DE	0899	D1
POP HL	089A	E1
RETURN	089B	C9
POP DE	089C	D1
POP HL	089D	E1
LD A,FF	089E	3E FF
LD I,A	08A0	ED 47
JP 0800	08A2	C3 00 08

at 08A5:

0 = EB
1 = 28
2 = CD
3 = AD
4 = 2E
5 = A7
6 = E7
7 = 29
8 = EF
9 = AF
0 =

PHONE DIALLER - Part 3

The third and final part of the Phone Dialler program is the longest and most impressive. It looks complicated because it is looking after a lot of things.

The program accesses memory and when using the 2k onboard RAM, it is capable of holding up to 36 names and numbers, each fitting into a block of memory 20H bytes long. The program allows up to 27 characters for the name and number and this should be sufficient for any situation.

The program uses a lot of sub-routines and they perform most of the work.

As the processor goes through the MAIN program, it CALLS the sub-routines and they do all the displaying, shifting, display converting etc.

Any operation that is required more than once is put into the form of a sub-routine. This reduces the length of the program and allows the sub-routines to be called as many times as required.

USING THE PROGRAM

Basically the program is self explanatory as the instructions for its use are displayed on the screen after the GO button is pressed.

The first instruction is to select an INDEX NUMBER from 00 to 36 (decimal) into which the telephone number is placed.

Push button E and the screen will blank so that the index number can be inserted.

The index number will remain on the screen for about one second and then the second set of instructions will appear. After reading the instructions, push E. This will cause the screen to blank so that you can type the name corresponding to the phone number.

After the end of the name, insert a space by typing F and the program will convert to displaying a digit for each key pressed.

At the end of the phone number type E and the program will scroll the contents of memory.

To dial the phone number push D. The program will pause for 5 seconds then dial the number.

At the completion of dialling, the screen will scroll the name and number again.

You can redial the same number at any time by pressing D.

To re-load the memory BLOCK, push C. This will re-start the program and allow a new name and number to be inserted.

Once a name and number has been inserted into memory at a particular index value, it can be dialled very quickly. You can push either button C or RESET. If the Reset button is pushed, the GO button must be pushed for the first set of instructions to appear.

Push E and insert the index number; then push D. The computer will dial the number. A constant beeping will indicate the location is not filled and you should try another index.

At the end of dialling, the name and number will scroll and you can confirm it to be correct.

A SUMMARY OF THE PROGRAM

The program creates a display buffer area at **0A80** to **0A85** and the values placed at these 6 locations are directly transferred to the TEC display via the SCAN routine.

The CLEAR routine zeros each of these locations and also the next location. This is one of the clever tricks of the program, and it is cleared for the following reason:

The SHIFT routine starts at a location that is one lower than **0A80**, (namely **0A7F**) and places the data at **0A80** into

PHONE DIALLER PROGRAM:

CALL CLEAR	0800	CD 20 09	The first 7 lines of the program displays "Enter Index. . . . . etc and looks for the value **10** at the end of the table to repeat the sequence. The program also looks for an input value above 9 to jump out of the loop.
LD HL,0A0C	0803	21 0C 0A	
CALL SCROLL	0806	CD C0 09	
CP 10	0809	FE 10	
JR Z,0803	080B	28 F6	
CP 0A	080D	FE 0A	
JR C,0800	080F	38 EF	
CALL CLEAR	0811	CD 20 09	The screen is cleared and the index register is loaded with FF so that we can detect when a button has been pushed.
LD A,FF	0814	3E FF	
LD I,A	0816	ED 47	
LD HL,0000	0818	21 00 00	Memory is set to zero by loading HL with **00 00.**
LD A,01	081B	3E 01	Location **09FE** stores the value 01 so that key value is called once. The requirement of the next 12 lines is to get a double decimal number into location **09FC.**
LD (09FE),A	081D	32 FE 09	
CALL KEY VALUE		CD 30 09	
LD A,C	0823	79	C will contain the key value and this is loaded into memory location **09FC** (first figure).
LD (09FC),A	0824	32 FC 09	
LD A,01	0827	3E 01	Repeat the sequence and call KEY VALUE once more.
LD (09FE),A	0829	32 FE 09	
CALL KEY VALUE	082C	CD 30 09	
LD A,(09FC)	082F	3A FC 09	Load the first figure into A and rotate the accumulator 4 places to the left to shift the number into the upper half of the register.
RLA	0832	17	
RLA	0833	17	
RLA	0834	17	
RLA	0835	17	
ADD A,C	0836	81	Add the second figure to the accumulator and store the result into **09FC** as a two figure decimal number.
LD (09FC),A	0837	32 FC 09	
LD D,20	083A	16 20	Create a delay with register D and call SCAN for 20H loops. (32 loops).
CALL SCAN	083C	CD 80 09	
DEC D	083F	15	
JR NZ,083C	0840	20 FA	
CALL CLEAR	0842	CD 20 09	Clear the display and load the pointer register with the start address of the second table. Display "Enter name . . . . .etc" Look for the end of the table (**10**) and loop, unless a key 0-9 has been pressed.
LD HL,0A2C	0845	21 2C 0A	
CALL SCROLL	0848	CD C0 09	
LD A,(HL)	084D	7E	
CP 10	084C	FE 10	
JR Z,0845	084E	28 F5	
CP 0A	0850	FE 0A	
JR C,0842	0852	38 EE	
CALL CLEAR	0854	CD 20 09	Call CLEAR to clear the display.
CALL MEM ADDR	0857	CD 60 09	Read MEMORY ADDRESS notes.
LD D,1C	085A	16 1C	Register D counts up to 28 characters (max allowed).
LD E,00	085C	1E 00	Register E counts to 2. Two key presses for a char.
LD A,FF	095E	3E FF	Fill the I register via the accumulator so that we can detect when a key is pressed.
LD I,A	0860	ED 47	
CALL SCAN 2	0862	CD D0 0A	Scan the display looking for a key press 0-F.
LD A,I	0865	ED 57	
CP 10	0867	FE 10	
JR NC,0862	0869	30 F7	
INC E	086B	1C	Increment the E register.
LD A,E	086C	7B	Load E into A.
CP 02	086D	FE 02	Compare the accumulator with 02 and jump if the two
JR Z,087C	086F	28 0B	are the same. If not, go to the next instruction.
LD A,I	0871	ED 57	Look to see if a space is required as this will indicate
CP 0F	0873	FE 0F	the end of names and the beginning of numbers.
JR Z,0895	0875	28 1E	Jump relative if F has been pressed.
LD (09FA),A	0877	32 FA 09	Store the value of A at **09FA** and loop for second press
JR 085E	087A	18 E2	of button.
CALL SHIFT	087C	CD E1 09	Call SHIFT to get display ready for next number.
LD A,(09FA)	087F	3A FA 09	Load the first number into the accumulator and shift it
RLA	0882	17	4 places to the left to occupy the upper half of the
RLA	0883	17	register.
RLA	0884	17	
RLA	0885	17	
LD B,A	0886	47	Save the result in B.
LD A,I	0887	ED 57	Put second number into the accumulator.
ADD A,B	0889	80	Combine the two to create a 2-digit number.
LD (HL),A	088A	77	Load this value into the location looked at by HL.
LD (0A85),A	088B	32 85 0A	Also load it into the first display location.
INC HL	088E	23	Increment HL.
DEC D	088F	15	Decrement D and
JR NZ,085C	0890	20 CA	Jump if **1C** locations not filled.
JP 0800	0892	C3 00 08	Jump to start if overflow occurs.
XOR A	0895	AF	Zero A and load it
LD (HL),A	0896	77	into the location looked at by HL to create a space.
CALL SHIFT	0897	CD E1 09	Shift the display digits one place to the left.
LD A,D	089A	7A	Load the remaining locations into A and store at **09FE**
LD (09FE),A	089B	32 FE 09	for use by the CALL KEY routine.
CALL KEY VALUE	089E	CD 30 09	Call KEY VALUE. This will put Nos onto the display.
LD B,03	08A1	06 03	Create 3 blank locations after te numbers have been
INC HL	08A3	23	inserted, to produce a space between the end of the
XOR A	08A4	AF	message and the start so that it can be scrolled across
LD (HL),A	08A5	77	the display.
DEC B	08A6	05	
JR NZ,08A3	08A7	20 FA	
INC HL	08A9	23	
LD A,10	08AA	3E 10	Increment HL and load last location with **10** so that
LD (HL),A	08AC	77	program will loop name and telephone number.
NOP	08AD	00	

this lower location. As can be seen from the program, this lower location is not displayed on the TEC and thus the data shifts off the screen. The data for the second location is shifted to the location for the first display and this repeats for the 6 locations. The result is the data in the blank location at **0A86** is shifted into the last display location and thus an empty space is produced on the display.

It is important for **0A86** to be empty for this to work.

The MEMORY ADDRESS routine creates areas that are 20H bytes long and starts at **0B00.**

The program stores the Index number at location **09FC** and as each memory area is created, it decrements the Index number and the program exits when the count register is zero.

The HL register will contain the start of this address. It is not used for any other purpose and thus it will not be destroyed during the running of the program and will hold the current value for re-dial, if required.

The SCROLL routine picks up the first byte from the table and places it at **0A85** and then calls SCAN for 20H loops (32 passes of the display).

The SHIFT routine is then called and all the bytes (including the blank locations) are transferred one position to the left.

The scroll program then loops and repeats the sequence until the end of the table is reached. It detects this by looking for 10H (we could have chosen any value) and the message re-starts.

When the 'Dial key' '**D**' is pressed, a BEEP routine and PAUSE routine are called. These produce a suitable ON-OFF tone to the speaker and the program converts the values in memory to a string of beeps.

The program ignores the name at the beginning of memory and looks for the first location containing zero.

The end of the phone number is detected by also looking for a location containing zero.

The program then jumps back to calling the start of memory and scrolls the message across the screen.

SUGGESTIONS

The program can be keyed into the TEC and fills about 3 pages, from **0800** to **0AEE.**

After this is done, it is wise to save a copy of the program in non-volatile RAM so that it is not lost.

To save the program, type the following dump routine at **0F80:**

```
11 00 10
21 00 08
01 90 07
ED B0
C7
```

```
CALL CLEAR      08AE  CD 20 09   Clear the screen.
CALL MEM ADDR   08B1  CD 60 09   Get start of BLOCK via 09FC (36 blocks available).
CALL SCROLL     08B4  CD C0 09   Scroll name and number across screen.
CP 10           08B7  FE 10      Look for end of message. If another key is pressed,
JR Z,08B1       08B9  28 F6      jump out of loop.
LD B,20         08BB  06 20      Create a pause before dialling by loading B with 20
CALL PAUSE      08BD  CD 72 09   and calling pause 32 times. This creates approx 2
DJNZ 08BD       08C0  10 FB      second delay.
CALL CLEAR      08C2  CD 20 09   Clear the screen of any junk etc.
CALL MEM ADDR   08C5  CD 60 09   Get start of block (00-36).
LD A,(HL)       08C8  7E         Look for space between name and phone number by
INC HL          08C9  23         comparing the contents of each location with 00 and
CP 00           08CA  FE 00      incrementing until 00 is found.
JR NZ,08C8      08CC  20 FA      The next 6 lines create the dialling pulses by loading
LD IX,0A00      08CE  DD 21 00 0A IX with the start of the number table and calling BEEP
INC IX          08D2  DD 23      routine. (The beep calls a pause). The program then
CALL BEEP       08D4  CD 00 09   compares the byte in the table with the byte in the
LD A,(IX + 00)  08D7  DD 7E 00   block and loops until a comparison is found. Note: we
CP (HL)         08DA  BE         go into the routine 'blind' and beep before a CP!!
JR NZ,08D2      08DB  20 F5      Create a short pause at the end of each digit so that
LD B,10         08DD  06 10      the phone system detects the end of a digit.
CALL PAUSE      08DF  CD 72 09   Increment to next digit, look to see if end of phone
DJNZ 08DF       08E2  10 FB      number has been reached and return to above routine
INC HL          08E4  23         for next set of pulses.
LD A,(HL)       08E5  7E
CP 00           08E6  FE 00
JR Z,08EC       08E8  28 02
JR 08CE         08EA  18 E2
LD A,I          08EC  ED 57      If no buttons have been pressed during dialling, I will
CP 0D           08EE  FE 0D      still contain 0D (from above) and program will scroll
JR Z,08AE       08F0  28 BC      name and number. If any other key has been pressed,
JR 08EC         08F2  18 F8      program will loop with blank screen until D pressed.
```

This is the end of the MAIN PROGRAM. The sub-routines below are called by the main program.

```
BEEP
PUSH AF         0900  F5         Registers A, B and C are used in this sub-routine and
PUSH BC         0901  C5         thus they must be pused onto the stack and saved.
LD B,20         0902  06 20      Reg B holds the number of cycles for the beep routine
LD A,80         0904  3E 80      Register A turns on the speaker bit.
LD C,20         0906  0E 20      Reg C holds the turn-on cycles for the spkr.
OUT (01),A      0908  D3 01      The spkr is turned on via OUT (01),A
DEC C           090A  0D         and a delay created via register C for
JR NZ,090A      090B  20 FD      32 loops.
LD C,20         090D  0E 20      The same OFF delay period is created via register C
XOR A           090F  AF         for an even 'mark-space' ratio for the speaker.
OUT (01),A      0910  D3 01
DEC C           0912  0D
JR NZ,0912      0913  20 FD
DEC B           0915  05         The count register (register B) is decremented and the
JR NZ,0904      0916  20 EC      program loops until B is zero.
CALL PAUSE      0918  CD 72 09   The program calls pause to produce silence.
POP BC          091B  C1         Registers A, B and C are popped off the stack and will
POP AF          091C  F1         contain the original values and before the routine.
RETURN          091D  C9         Return to the main program.

CLEAR
LD D,07         0920  16 07      This routine clears the 6 display locations 0A80 to
XOR A           0922  AF         0A85 and also 0A86 by zeroing A and
LD HL,0A80      0923  21 80 0A   loading HL with start address of buffer zone
LD (HL),A       0926  77         and loading zero into the location pointed to by HL.
INC HL          0927  23         INC HL
DEC D           0928  15         DEC D
JR NZ,0926      0929  20 FB      and jump for 7 loops.
RETURN          092B  C9         Return to main program.

KEY VALUE
LD DE,0A00      0930  11 00 0A   Load DE to point to beginning of number table.
LD A,I          0933  ED 57      Load key value into accumulator.
CP 0A           0935  FE 0A      Compare with 0A and jump if the key value is A-F or
JR NC,0952      0937  30 19      not pressed or go to next instruction if 0-9.
INC HL          0939  23         INC HL (used when creating phone number)
LD C,A          093A  4F         Save A in C.
ADD A,E         093B  83         ADD the start of table to A (table may start at 0A03!).
LD E,A          093C  5F         Make DE ready to point at value in table.
CALL SHIFT      093D  CD E1 09   SHIFT display contents one place to left.
LD A,(DE)       0940  1A         Load byte from number table into accumulator.
LD (HL),A       0941  77         Load number byte into loaction in BLOCK.
LD (0A85),A     0942  32 85 0A   and also into right hand display.
LD A,FF         0945  3E FF      Load A with FF and then into I to detect when another
LD I,A          0947  ED 47      key has been pressed.
LD A,(09FE)     0949  3A FE 09   09FE caontains 01 via beginning of of main program
DEC A           094C  3D         and KEY VALUE is called once. Or 09FE contains 1C
LD (09FE),A     094D  32 FE 09   to keep track on the number of locations being filled in
RET Z           0950  C8         the BLOCK.
XOR A           0951  AF         Zero A.
CP 0E           0952  FE 0E      Compare accumulator with E and RETURN if E key is
RET Z           0954  C8         pushed. Otherwise call SCAN and display the
CALL SCAN       0955  CD 80 09   contents of the 6 memory locations. Jump to stat of
JR 0930         0958  18 D6      KEY VALUE sub-routine and loop until 0-9 pressed.
```

Decrement to **0F80** and push GO. Make sure the non-volatile RAM switch is on RAM (read/write) so that the data will be accepted. Check that the program has been dumped by addressing **1000** and compare the data with the listing.

If you have inserted names and numbers into index locations and want to save them, address **0F80** and push GO. Make sure the RAM card is in read/write mode and everything will be saved.

Switch to ROM mode and everything will be preserved.

You can now turn the TEC off.

To transfer the program back to **0800**, address **1780** and change 2 of the bytes to the following:

```
11 00 08   <- these two bytes
21 00 10   <- are changed
01 90 07
ED B0
C7
```

Decrement to **1780** and push GO. The RAM card should be in ROM MODE for this operation.

Push GO again and the program will run.

All names and numbers will be available.

AUTO REDIAL

An automatic re-dial facility can also be included so that the number automatically re-dials after say 5 or 10 minutes; if the number was originally engaged. This is very handy for those occassions when you particularly want to contact a person and their number is busy. By the time you get around to calling again, they have gone!

A simple addition to the program can be fitted in at **08BE** and this will create a delay by counting the number of times the name and phone number scroll past the display. This is only a suggestion and we have not actually produced the program for re-dial.

Register E is the 'count register' and the remainder of the program remains the same. The only bytes you will have to change are jump relative values as well as the jump value at **09B4**. You may also need a subroutine and a flag to pick up redial mode.

Here is a suggested AUTO RE-DIAL program for insertion at **08B4:**

```
LD E,40
DEC E
JR Z
CALL CLEAR
CALL MEMORY ADDR
CALL SCROLL
CP 10
JR Z
CALL CLEAR

JR
```

MEMORY ADDRESS

```
LD HL,0B00      0960   21 00 0B
LD A,(09FC)     0963   3A FC 09
LD D,20         0966   16 20
CP 00           0968   FE 00
RET Z           096A   C8
INC HL          096B   23
DEC D           096C   15
JR NZ,096B      096D   20 FC
DEC A           096F   3D
JR 0966         0970   18 F4
```

Memory Address sub-routine locates the beginning of the name and phone number block. Each block is 20H bytes long (32 bytes) and memory starts at **0B00.** The BLOCK No is stored at **09FC** and the program increments 20H loops for each block by decrementing register D to zero, then decrementing register A by ONE. This is repeated until A is zero. The sub-routine then exits. HL pair is constantly incremented during this program and will point to the start of the block we want.

PAUSE

```
XOR A           0972   AF
OUT (01),A      0973   D3 01
LD DE,02FF      0975   11 FF 02
DEC DE          0978   1B
LD A,E          0979   7B
OR D            097A   B2
JR NZ,0978      097B   20 FB
RETURN          097D   C9
```

Pause produces a silence from the speaker by outputting zero to port 01. Register DE is decremented and 'wastes computer time' for about 1/10th second. This sub-routine then returns to where it has been called.

SCAN 1

```
PUSH HL         0980   E5
PUSH DE         0981   D5
LD C,20         0982   0E 20
LD HL,0A80      0984   21 80 0A
LD D,06         0987   16 06
LD B,20         0989   06 20
LD A,(HL)       098B   7E
OUT (02),A      098C   D3 02
LD A,C          098E   79
OUT (01),A      098F   D3 01
RRC C           0991   CB 09
DJNZ 0993       0993   10 FE
XOR A           0995   AF
OUT (01),A      0996   D3 01
INC HL          0998   23
LD A,I          0999   ED 57
CP 0C           099B   FE 0C
JR Z,09A9       099D   28 0A
CP 0D           099F   FE 0D
JR Z,09B2       09A1   28 0F
DEC D           09A3   15
JR NZ,0989      09A4   20 E3
POP DE          09A6   D1
POP HL          09A7   E1
RETURN          09A8   C9
POP DE          09A9   D1
POP HL          09AA   E1
LD A,FF         09AB   3E FF
LD I,A          09AD   ED 47
JP 0800         09AF   C3 00 08
POP DE          09B2   D1
POP HL          09B3   E1
JP 08BB         09B4   C3 BB 08
```

The SCAN routine uses H, L and D registers and thus they must be pushed onto the stack and saved.
Load HL with start of display buffer.
The routine displays 6 locations.
The left-hand display is accessed via line '20'.
Load B with a short delay value.
Load the byte at the first location into A.
Output to port 02.
Load C into A, and
output to port 01. This will turn on left-hand display.
Rotate register C to the right for the next display.
Short delay via register B.
Zero A, and
output to port 01.
Look at next memory location.
Load the keyboard value into A.
Look to see if CLEAR has been pressed.
Jump if it has.
DEC D ready for outputting to the next display.
Jump relative if D is not zero.
Pop DE and HL register pairs off the stack.

and RETURN to the main program.
If CLEAR has been pressed, pop DE and HL and load the I register with **FF** so that the program will detect when another key has been pressed.

Jump to **0800.**
POP DE and HL and jump to **08BB** if D (DIALS) has been pressed.

SCAN 2

```
PUSH HL         0AD0   E5
PUSH DE         0AD1   D5
LD C,20         0AD2   0E 20
LD HL,0A80      0AD4   21 80 0A
LD D,06         0AD7   16 06
LD B,20         0AD9   06 20
LD A,(HL)       0ADB   7E
OUT (02),A      0ADC   D3 02
LD A,C          0ADE   79
OUT (01),A      0ADF   D3 01
RRC C           0AE1   CB 09
DJNZ 0AE3       0AE3   10 FE
XOR A           0AE5   AF
OUT (01),A      0AE6   D3 01
INC HL          0AE8   23
DEC D           0AE9   15
JR NZ,0AD9      0AEA   20 ED
POP DE          0AEC   D1
POP HL          0AED   E1
RETURN          0AEE   C9
```

SCAN 2 is identical to SCAN 1 in the scanning section. The only difference is the 'checking' instructions, to see if a particular key is pressed. SCAN 1 above checks to see if a function key is pressed, whereas SCAN 2 performs the scan without any checks.

By careful programming both routines could be incorporated into one. This would require a 'check bit' and if 'set', the sub-routine would check the function keys.

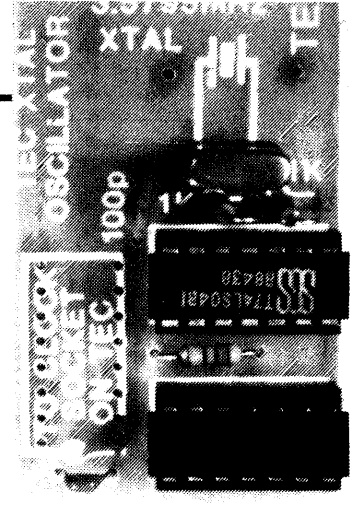
Cont. P.51:

Please note we now have a reader in New Zealand interested in suppling back issues of the magazine, and maybe boards and kits. Please write to him at the following address:

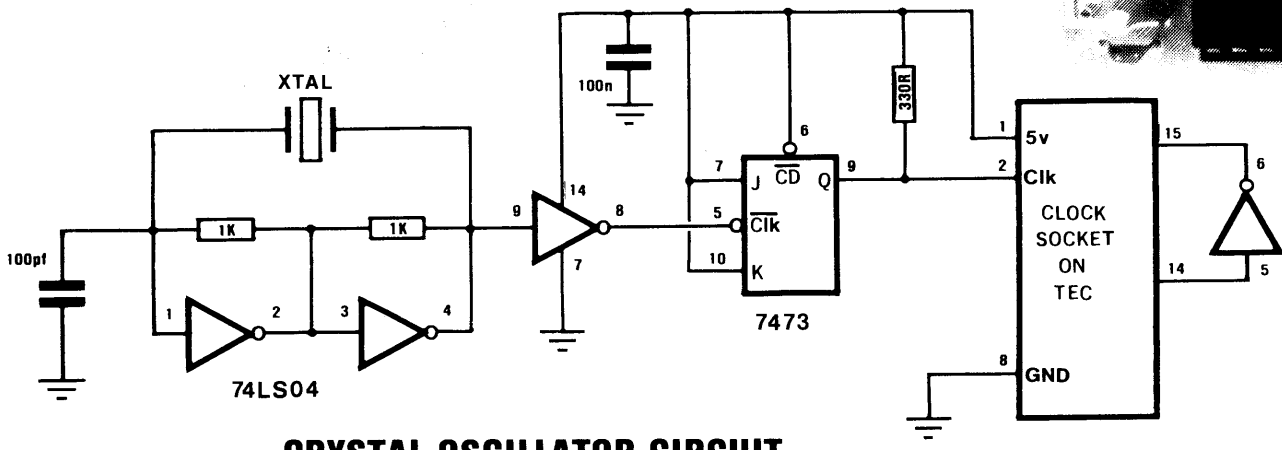
Trevor Cooper,
33 York St.,
Timaru,
New Zealand.
Phone: 83787

CRYSTAL OSCILLATOR

Kit of parts: $9.85
PC Board: $2.10
Complete: $11.95



CONVERTS THE TEC TO REAL-TIME CAPABILITY



CRYSTAL OSCILLATOR CIRCUIT

This project is a crystal oscillator for the TEC. It turns the TEC into a fixed-frequency computer in which each of the Machine Codes takes up a precise period of time.

This means programs such as controller programs or timing programs will run for a precise time span and will not vary from one day to the next due to speed control adjustments.

As you know, the TEC was originally designed with an adjustable clock and its frequency could be altered by turning the speed control.

This served a valuable purpose as the games of skill (contained in the MONitor ROM) could be adjusted according to the skill of the player.

It also proved that the Z-80 could be run at very low speeds and even adjusted while operating and still execute the programs correctly.

The only disadvantage of a variable speed control is its inability to create accurate REAL-TIME programs.

This is highlighted by the clock program (as presented in issue 12). Everyone expects a clock to keep accurate time as even 'two dollar' watches are accurate to two seconds a month. The clock program could only approach this accuracy as it had to be manually adjusted via the speed control.

To remedy this situation Paul has produced a crystal oscillator module that plugs into the 4049 socket.

It contains an inverter chip (74LS04) and a divider chip so that a 4MHz crystal or colour-burst (3.5795MHz) can be used (because they are cheap) and a divider chip (7473) to divide the frequency by two so that the TEC will run at about the maximum speed permissible for a Z-80 CPU.

The 7473 is wired in TOGGLE mode to provide a divide-by-two output.

Some of the earlier model TEC's used a Z-80 CPU (later models used a Z-80A as these were cheaper than the Z-80!!) and the maximum operating speed for a Z-80 is about 2.5MHz.

Almost any crystal can be used in this circuit providing it is in the range 1MHz to 5MHz for a Z-80 or up to 8MHz for a Z-80A. If a crystal other than 4MHz or colour-burst is used, it will be necessary for you to carry out your own conversion for timing etc, if a real-time situation is required.

An inverter is also necessary to invert the Data Available line from the keyboard encoder to the NMI line of the Z-80 so that the NMI line goes low when data is available from the keyboard encoder. This is provided via one of the unused inverters of the 74LS04.

The oscillator circuit is a simple twin inverter using feedback resistors.

A 100pf capacitor at the front end provides guaranteed start-up and the crystal provides a capacitive feedback that is a maximum at the fundamental frequency of the crystal.

This is why the oscillator circuit operates at the frequency as specified on the crystal.

A 100n capacitor on the oscillator module reduces noise on the power rails and a 330R pull-up resistor in the clock line guarantees a full amplitude waveform for the Z-80.

To convert the TEC to crystal control, remove the 4049 and plug in the crystal oscillator board. The speed control pot will have no effect and the speed of execution of the monitor will be about double.

This will too fast for many of the games and you may have to convert back to the adjustable speed by replacing the 4049 by pressing the reset button and keeping it pressed while changing over the clocks.

PARTS

1 - 330R
2 - 1k

1 - 100pf ceramic
1 - 100n monoblock

1 - 3.5795MHz crystal

1 - 74LS04 IC

1 - 7473 IC

2 - 14 pin IC sockets
1 - 16 pin dip header

1 CRYSTAL OSCILLATOR PC BOARD

All future programs will have to be written especially for the new speed and this will mean delay values etc will have to be lengthened accordingly.

ASSEMBLY

Assembly is very simple and we suggest, as always, that the two chips be fitted via IC sockets. The two 1k resistors stand upright and the 330R lays flat against the PC board. The leads of the crystal must be left long enough to allow the crystal to lay over after it has been soldered and a wire strap placed over the body to prevent it being damaged, as the leads are very thin.

The 100pf and 100n are fitted against the PC board and soldered in the positions shown. Don't get them swapped over or the oscillator won't work!

The module is connected to the TEC via a 16 pin dip header soldered under the board.

If the cermet pot on the TEC is a stand-up version, it will be necessary to include a wire-wrap socket between the dip header and the board to create additional clearance for the pot. This is not supplied in the kit as you can fold the cermet pot over slightly to allow the clock board to fit.

When you have the new board in place, the first program you can try is the Clock in issue 12, P.23. The best idea is to type it into the non-volatile RAM at **1000** and down-load it to **0900** via a block-transfer program:

```
11  00  10
21  00  09
01  A0  00
ED  B0
C7
```

To convert the program to operate with 4MHz crystal, two of the inbuilt delay values must be altered and a 'fine tune' delay added to the end of the program. This will create a clock that is accurate to within a second a day.

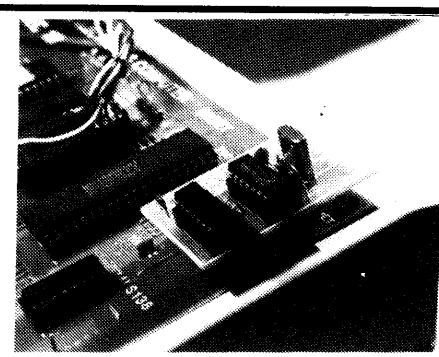
Type the complete program as per issue 12 then change the following locations and also add the extra 7 bytes:

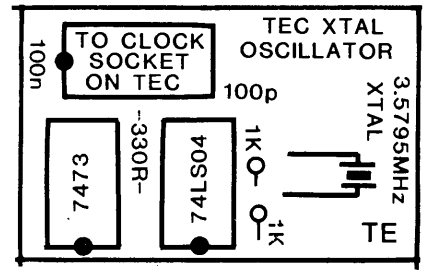
For a 4MHz crystal:

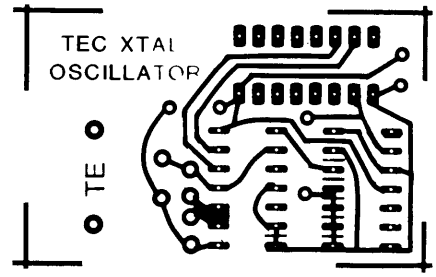
```
94C   06 FA
962   1E 41
970   C3 93 09
993   06 55
995   10 FE
997   C3 00 09
```

For a 3.5795MHz crystal:

```
94C   06 FC
962   1E 39
970   C3 93 09
993   06 37
995   10 FE
997   C3 00 09
```

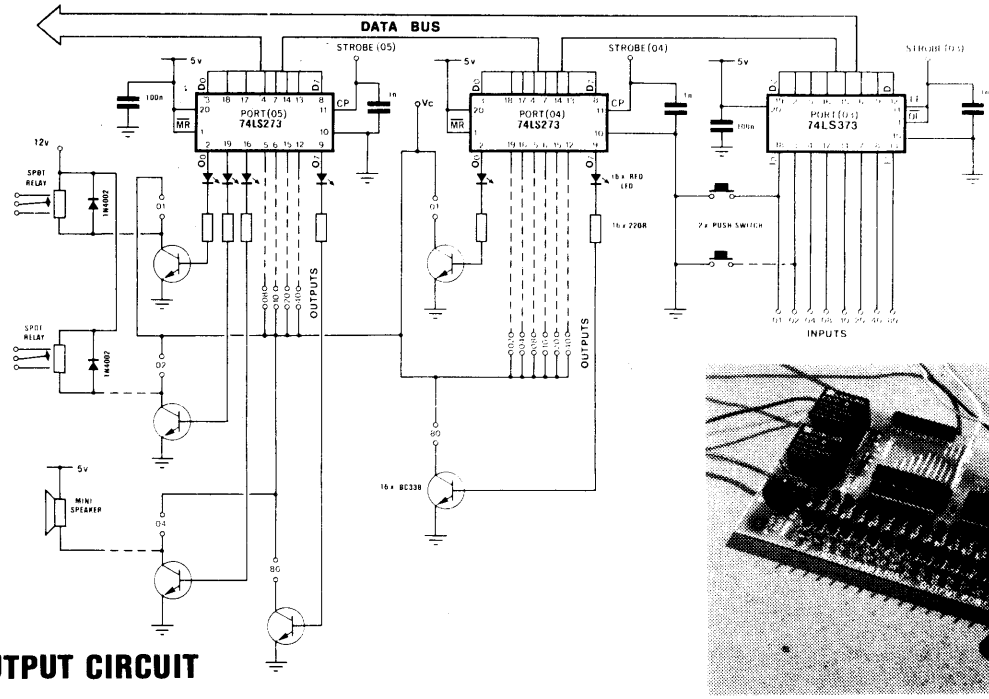






INPUT/OUTPUT MODULE

Kit of parts: $33.80
PC Board: $5.00
Complete: $38.80



INPUT/OUTPUT CIRCUIT

This project allows the TEC to talk to the outside world and also accept information from the outside. It is the first interface we have described that brings the possibility of robotics to the TEC.

The INPUT/OUTPUT MODULE has one input port and two output ports. This means it will input 8 bits (8 lines) and output 16 bits (16 lines).

To allow the module to be functional as soon as it is constructed we have included two input switches and three output devices so that a simple program can be written and seen in operation. The output devices are two relays and a mini speaker. These will allow you to test the board and see how it operates, before adding any other devices.

We have included some test programs in the article and they will show the indicator LEDs in operation.

These LEDs indicate when a particular output is high and will be invaluable when trouble-shooting a fault in either a program or in hardware.

The 5 flying leads on the module are clearly marked and you will see the input port is controlled via strobe line 03 and output ports via strobe lines 04 and 05.

Each of the 8 input and 16 output lines is further identified by a hex value on the PC overlay and this will assist you when writing a program.

The most interesting use for the board will undoubtedly be for robotics and when designing in this field, a whole new world of mechanical and electromechanical terms will be encountered.

Before embarking on a design, it is important to have some idea of what you are going to create. It may be an arm, a wheeled vehicle or a mechanical controller such as a door opener, a lift, crane or remote controlled boat or plane.

No matter what the project, begin by collecting articles and notes describing similar or related devices and study how other designers have puts things together. Combine the features you like and make sketches and diagrams of how you indend yours to look.

The most important point is not to be too ambitious on your first attempt. Aim for a simple design, using maybe a single motor and gearbox with say one or two flashing lights and a speaker.

You will have sufficient interfacing problems with these to keep your inventive skills at work for a while.

The other point to remember is to select materials that you can readily obtain and don't choose thick material as this will be very difficult to work with.

PARTS

16 - 220R ¼watt

3 - 1n greencap
2 - 100n

2 - 1N 4002 diodes
16 - 3mm red LEDs
16 - BC 338 transistors

2 - 74LS273 IC
1 - 74LS373 IC

3 - 20 pin IC sockets
2 - PC mount push buttons
1 - Mini Speaker 80R
2 - SPDT relays

50cm tinned copper wire
5 - PC matrix pins
5 - Matrix connectors
10cm - Heatshrink tubing
15 - 20cm lengths of hook-up flex

20cm - 10 core ribbon cable
1 - 12 key telephone pad

1 - INPUT/OUTPUT MODULE PC

3mm clear plastic sheet is the best choice as it can be cut, bent, folded and even heated into shape. It also looks appealing and being clear, you can see through it and this makes the project look more complex!

Equally suitable is PC board as it has a copper surface that can be soldered to and thus small brackets can be added for shafts etc.

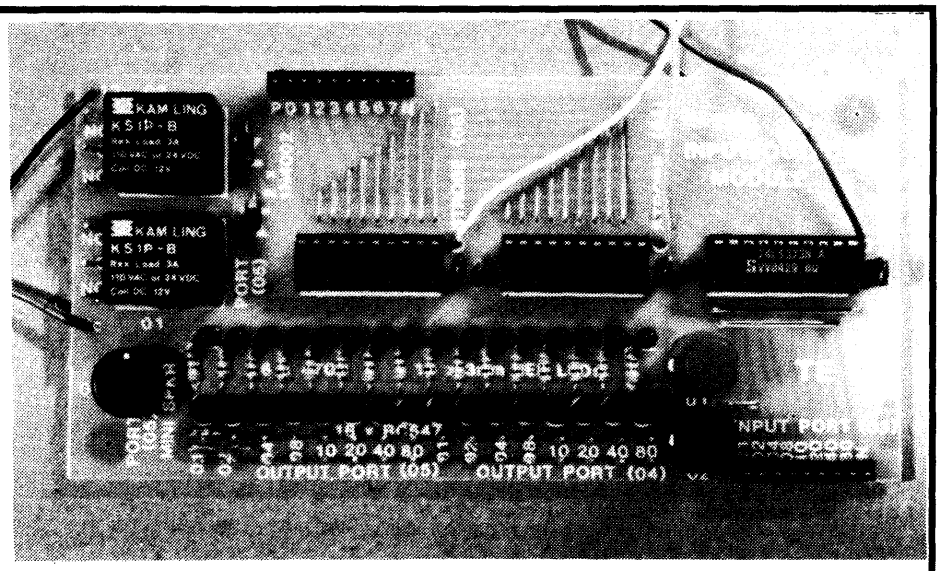
The only material I would avoid is sheet metal. Even though it has good strength, the same can be provided via plastic with the use of a few strengthening pieces, without the difficulty of cutting folding and drilling. For tinplate to have any strength it must be reasonably thick and you will require heavy duty tools etc to shape it.

Another handy medium is wood, however this should be restricted to base panels and platforms, where a number of items need to be screwed into position. You should only use soft wood, as it will be lighter and easier to drill and screw into. Don't use nails for fixing or joining as they tend to work lose.

Lastly, don't be frightened to use parts you already have on hand, especially from the kitchen and laundry where you will find plastic bottles, lids and boxes ideally suited for turning into pulleys and wheels. Use all your imagination and initiative - you will need it as you are basically breaking new ground!

In robotics, lots of new terms need to be understood to make the project function properly. But the best way is the hard way. By trial and error. Terms like gear ratios, torque, drive speeds, strength of beams, can involve an enormous amount of mathematics. That's why it's best to look through articles and see how it has been done by others.

At the time of writing, only a very limited range of motors and gearboxes are available at the low end of the market and the best of these we found at Dick Smith Electronics.



The gearboxes are in kit form and require a small amount of assembly to fit the gears onto the shafts to produce a gearbox known as a compound gearbox.

A gearbox reduces the rotational speed of a motor and at the same time increases the torque.

Torque is the twisting or turning force of a shaft and after 3 or 4 gear reductions, a shaft will have a considerable turning force.

This will be sufficient to turn wheels or move a robot arm or lift a weight. Sometimes it is necessary to convert rotation into straight-line motion and this can be done with a rack and pinion, winch and string, crank and arm or wheel and track.

Apart from the problems you will encounter adapting the mechanics into the available space, there will be problems interfacing the motor to the electronics.

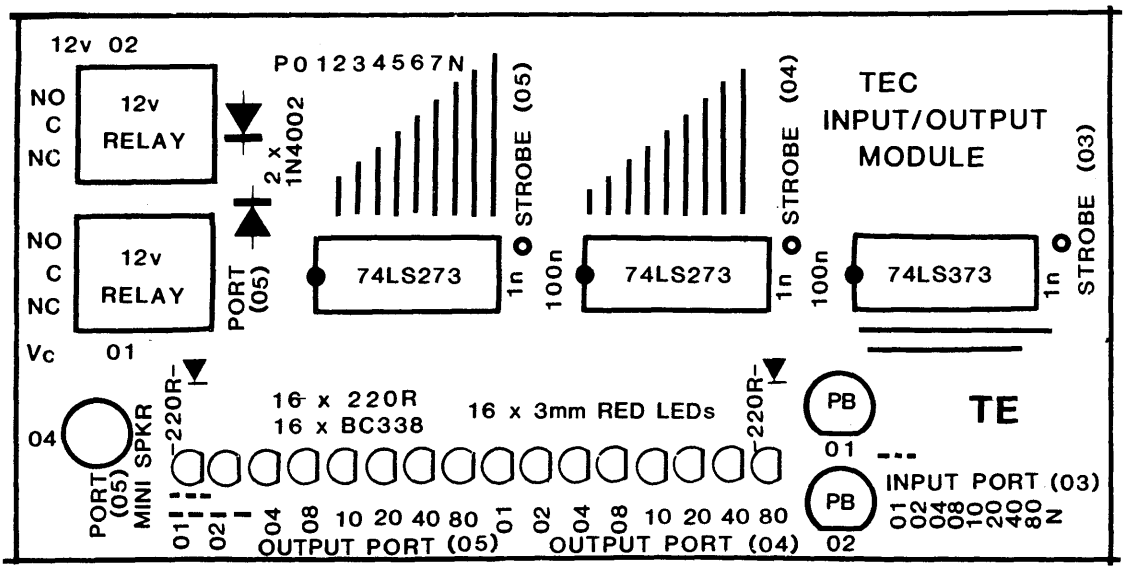
One of the major problems will be noise. Motors are inherently high noise producers and they must be kept far away from the electronics, both physically and electrically.

This may require a separate power supply so that noise and glitches from the motor do not get into the computer bus lines.

It will also be necessary to have high current available for the motor(s) as they draw a high current under load and if they stall, you must have sufficient current available to allow them to restart as soon as the load reduces.

A stalled motor can create a virtual short circuit and if connected to the computer 5v supply, the computer may drop out.

This has been avoided on the INPUT/OUTPUT MODULE by providing a separate supply line for the collectors of the output transistors and also the relays.



This will allow you to select your own supply voltage, with the necessary current capability.

When you are driving a motor, there will be three functions (or commands) needed. These are: ON/OFF (one command) FORWARD and REVERSE.

To achieve this, a number of lines (bits) will be required from the output port. Depending on the circuit used to drive the motor, either 2 or 3 bits will be required.

If you require the motor to operate in the forward direction as well as reverse, it will be necessary to use a relay. For a simple ON/OFF and FORWARD direction, a transistor can be used and only one bit (1 line) will be required. You can also get speed control from this line by including it in the program.

Basically speed control consists of outputting a high for a short duration and a low for a long duration and repeating the sequence about 100 times per second. To increase the speed, the duration of the high is increased and the low decreased. The only feature that remains constant is the repetition rate. It is essential to keep the pulses above 100Hz so that the motor rotates smoothly.

ASSEMBLY

By now you will be familiar with our assembly technique. Neatness is the overall aim. No matter how you build, the final result must be as neat as possible. This means the jumper links must be straight and sitting firm against the board, the LEDs must be close to the board and likewise the transitors, resistors and diodes. I thought it would be unnecessary to mention these points but we are still getting projects for repair in which the parts are mounted high above the board, the jumper links are twisted and kinked and the soldering is rough.

On the topic of soldering, It is important to use enough solder to cover the land and the hole. Again, we are seeing the smallest amount of solder on some joints, just enough to tack the lead to the land!

This is a very dangerous situation as you can create a problem that will be very difficult to locate. Sometimes the holes in the PC board cut through the track and the circuit relies on the solder to bridge the gap.

If you don't solder all around the lead, the copper track may contain a gap and obviously the project will fail to operate. Inspect the board before starting and check your workmanship after construction and you should have no problems in this area.

Begin assembly with the jumpers. Make sure they are straight and touching the board.

Next fit the resistors, followed by the LEDs transistors and two spike-suppressing diodes. The overlay shows how these components are placed.

The 5 spike-suppressing capacitors are next and must be fitted close to the board. The IC's are mounted in sockets and the dot on the overlay indicates pin 1. You will find one end of the IC socket has a 'cut-away' portion to match with pin 1.

Fit the relays, mini speaker and switches. Then inspect the board to make sure all leads have been soldered properly.

After adding all the parts to the board, the 5 jumper lines are added and a female matrix connector soldered to each lead. These are covered with heatshrink to prevent shorting between leads when connecting to the TEC board.

MATRIX PINS

You will notice the module in the photographs has a set of matrix pins on the output ports and also the relays. These pins are not included in the kit however you can buy some and fit them as shown in the photo if you wish.

The 5 pins included in the kit are for adding to the TEC PC board to take the 5 flying leads from the input/output board.

Paul has included a 9 pin input plug and a 10 pin plug for connecting to the TEC. These are not included in the kit but can be easily made from 18 pin and 20 pin IC sockets. They are small and delicate but will last a number of insertions and removals.

TESTING

The first program in the list is the test program. It has a short routine to flash the output LEDs so that every second LED is lit and then the others are flashed. The program repeats this a number of times then changes to detect an input from the input port. The result is indicated on the corresponding output LED.

If this sequence is not observed, the program should be double-checked. Make sure it contains the correct commands. Then check the flying leads. They must be connected to the correct outputs on the decoder chip. Refer to the line diagram for the position of each lead.

TEST PROGRAM

LD B,10	0900	06 10
LD A,AA	0902	3E AA
OUT (04),A	0904	D3 04
OUT (05),A	0906	D3 05
CALL DELAY	0908	CD 50 09
LD A,55	090B	3E 55
OUT (04),A	090D	D3 04
OUT (05),A	090F	D3 05
CALL DELAY	0911	CD 50 09
DJNZ	0914	10 EC
LD A,00	0916	3E 00
OUT (04),A	0918	D3 04
OUT (05),A	091A	D3 05
IN A,(03)	091C	DB 03
CPL	091E	2F
OUT (04),A	091F	D3 04
JR	0921	18 F9
LD DE,0000	0950	11 00 00
DEC DE	0953	1B
LD A,D	0954	7A
OR E	0955	B3
JRNZ	0956	20 FB
RET	0958	C9

The second program is a 12-note organ using a solf-touch key pad for the input and the mini speaker on the IN/OUT module as the output.

The ide of an organ may have limited possibilities in itself, but the knowledge of how to produce a tone will be very beneficial.

In robotics, for instance, a mouse can be equipped with a speaker to produce a tone when it touches an obstacle etc. The note sounds for as long as the robot touches the object.

The importance of the program is to show how a tone is produced and how the pitch can be altered by adjusting the delay value.

Follow through the program and see how this is done:

ORGAN PROGRAM

XOR A	0900	AF
OUT (01),A	0901	D3 01
OUT (02),A	0903	D3 02
OUT (04),A	0905	D3 04
OUT (05),A	0907	D3 05
LD HL,09FF	0909	21 FF 09
IN A,(03)	090C	DB 03
CP FF	090E	FE FF
JR Z,090C	0910	28 FA
LD BC,03FF	0912	01 FF 03
DEC BC	0915	0B
LD A,B	0916	78
OR C	0917	B1
JR NZ,0915	0918	20 FB
IN A,(03)	091A	DB 03
INC HL	091C	23
INC HL	091D	23
CP (HL)	091E	BE
JR NZ,091C	091F	20 FB
INC HL	0921	23
LD B,(HL)	0922	46
DJNZ 0923	0923	10 FE
LD A,04	0925	3E 04
OUT (05),A	0927	D3 05
LD B,(HL)	0929	46
DJNZ 092A	092A	10 FE
XOR A	092C	AF
OUT (05),A	092D	D3 05
IN A,(03)	092F	DB 03
CP FF	0931	FE FF
JR NZ,0922	0933	20 ED
JR 0909	0935	18 D2

at 0A00:		
00	64	3C
FA	BD	CF
84	5C	34
DE	F3	AF
7C	54	2C
BE	D7	FF
74	4C	
F9	B7	
6C	44	
DD	EB	

KEY PAD CONTROLS OUTPUT LINES

The third program controls the 16 output lines via a 12-key phone pad.

To turn on one of the left-hand outputs (port 05), press the asterisk key then a number button from 1-8. The right-hand port (port 04), is accessed by pressing the 'hatch' key then a number from 1-8.

When a second number key is pressed, the corresponding output-line changes state. Thus a high output will go low and vice versa. To access the other latch, one of the control keys (asterisk or hatch) must be pressed.

The program is fully described beside each instruction and this will assist you to design your own programs.

An important point to remember is DEBOUNCE. The soft-touch keys require a time to settle down before a value can be read. This means a short delay must be included in the program (see address **0913** and **0914**).

The reason is the contacts in the pad are made from a carbon compound and they create a considerable amount of bounce when a key is pressed.

Since the computer is a high-speed piece of equipment, it will pick up an incorrect value if the three contacts in the switch are not closed when it is being read.

To overcome this a short delay is introduced between the time when a key is pressed and when it is read.

The program can be modified to suit your own requirements. For example: a random output can be turned ON, or more than one output can be turned ON at the same time. A delay could be introduced to turn OFF and output after a set period of time or you could create a visual effect on a set of LEDs.

It's up to you. Study the program and try making some modifications.

For a very simple test program, try this:

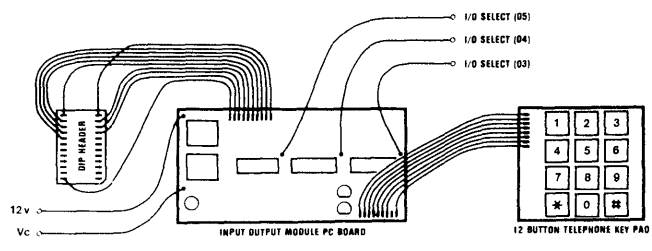
```
3E FF
D3 04
C7
```

Eight LEDs will illuminate to show the program and board is working.

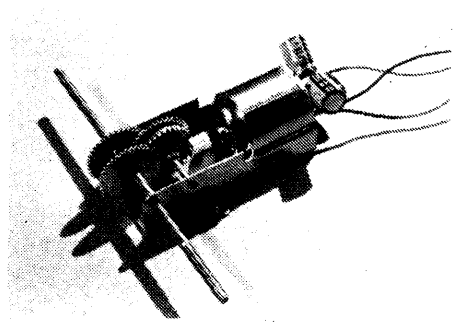
XOR A	**0900**	**AF**	Data for port 05 is stored at 0A05 and 0A04 for port 04. These two locations are initially cleared in the first 6 lines of the program. Later, you will see why we have chosen registers B and C for this operation.
LD B,0B	**0901**	**06 0B**	
LD C,04	**0903**	**0E 04**	
LD (BC),A	**0905**	**02**	
INC C	**0906**	**0C**	
LD (BC),A	**0907**	**02**	
LD HL,09FF	**0908**	**21 00 0A**	HL is the pointer for the byte table.
LD D,00	**090B**	**16 00**	D is the count register for the key.
IN A,(03)	**090D**	**DB 03**	The program inputs via port 03, looking for a key press. Any value other than FF will exit from the loop.
CP FF	**090F**	**FE FF**	
JR Z,090D	**0911**	**28 FA**	A short delay is created via the D register to give the pressure sensitive keypad switches a short period of time to settle to a value that can be read correctly.
DEC D	**0913**	**15**	
JR NZ,0913	**0914**	**20 FD**	
IN A,(03)	**0916**	**DB 03**	Input this key value via port 03 to the accumulator.
INC D	**0918**	**14**	The next 4 lines generate a value for D that will be the same as the key. This is done via a loop and incrementing D until the key value compares with the byte in the table will make D equal the key value.
INC HL	**0919**	**23**	
CP (HL)	**091A**	**BE**	
JR NZ,0918	**091B**	**20 FB**	
CP EB	**091D**	**FE EB**	The next 8 lines look for the STAR key or HATCH key and if either is pressed, C is loaded with either 05 or 04. This will allow the program to output to the correct port via the instruction **OUT (C),A** Also locations 0A05 and 0A04 use the C register for storage. In this way the C register serves a dual role and some of the powerful instructions such as OUT (C),A can be employed.
JR NZ,0925	**091F**	**20 04**	
LD C,05	**0921**	**0E 05**	
JR 0945	**0923**	**18 20**	
CP AF	**0925**	**FE AF**	
JR NZ,092D	**0927**	**20 04**	
LD C,04	**0929**	**0E 04**	
JR 0945	**092B**	**18 18**	
LD A,(BC)	**092D**	**0A**	Load A with the byte at location 0A05 or 0A04.
LD E,D	**092E**	**5A**	Store the key value for later use.
RRCA	**092F**	**0F**	The next 3 lines rotate the accumulator so that the wanted bit is rotated to the end of the register and thus only one TEST will be required.
DEC D	**0930**	**15**	
JR NZ,092F	**0931**	**20 FC**	
BIT 7,A	**0933**	**CB 7F**	Look at the highest bit and jump if it is zero. Otherwise execute next instruction.
JR Z,093B	**0935**	**28 04**	
RES 7,A	**0937**	**CB BF**	At this line the bit will be '1' and thus the program resets it to '0' and a jump is performed.
JR 093D	**0939**	**18 02**	
SET 7,A	**093B**	**CB FF**	The highest bit is SET via this instruction.
LD D,E	**093D**	**53**	Load D with the key value in readyness for rotating the accumulator back to it previous position. RLCA is a single byte instruction that rotates the accum and sets the carry flag. The bits don't enter the CARRY.
RLCA	**093E**	**07**	
DEC D	**093F**	**15**	
JR NZ,093E	**0940**	**20 FC**	
LD (BC),A	**0942**	**02**	Store the resulting byte in memory.
OUT (C),A	**0943**	**ED 79**	Output the byte to either port 05 or 04.
IN A,(03)	**0945**	**DB 03**	Look at the input port and loop the next 3 instructions until the key has been released. This is a debounce routine, essential to produce a clean key action.
CP FF	**0947**	**FE FF**	
JR NZ,0945	**0949**	**20 FA**	
JP 0908	**094B**	**C3 08 09**	Jump to the start of the main part of the program.

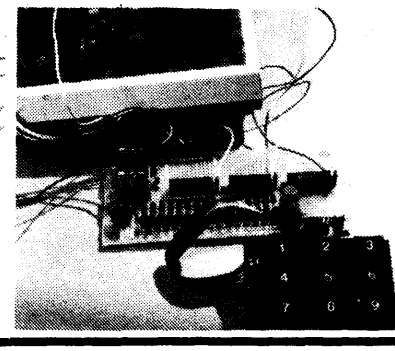
At 0A00:

```
FA
DE
BE
F9
DD
BD
F3
D7
B7
CF
EB
AF
```



Wiring diagram showing the connection of the phone pad to the input/output module, and the module to the DIP header plug. Note: line '80' is not used when connecting the phone pad.

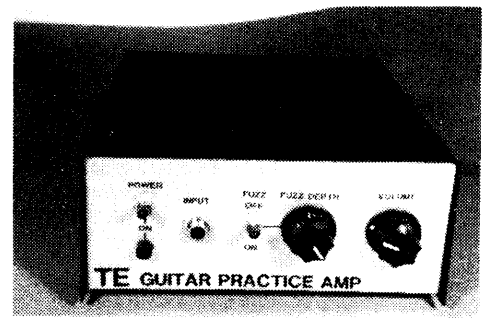




Photo, left: Motor and gearbox with two 100/16v electrolytics placed back-to-back to create a non-polar capacitor to reduce spikes from the motor. (i.e: the positive lead of each electro connects to a motor lead and the join of the negative leads is left 'floating').

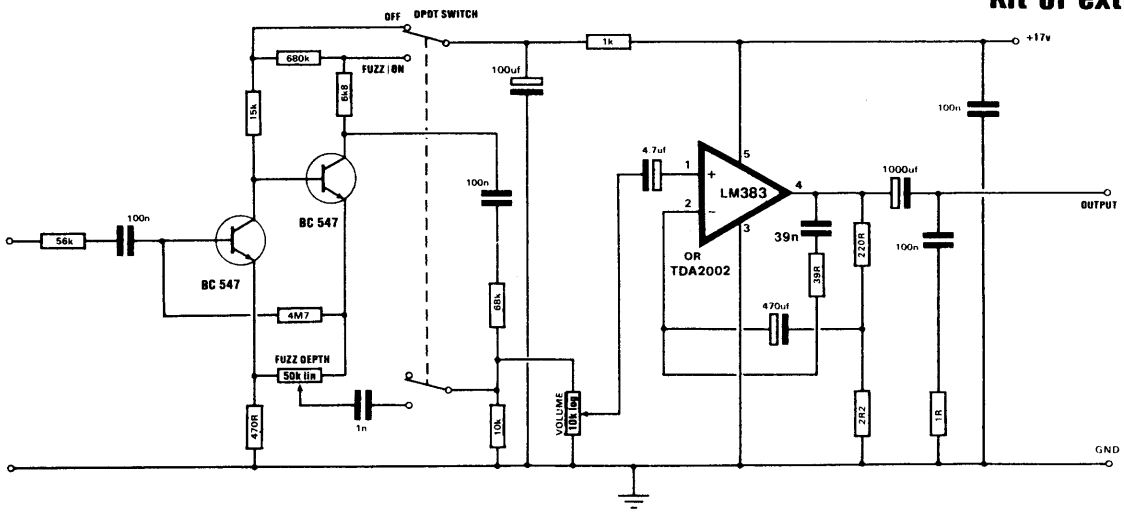
Photo, right: The key pad connected to the input/output module via ribbon cable and to the TEC via hook-up flex.

GUITAR PRACTICE AMPLIFIER

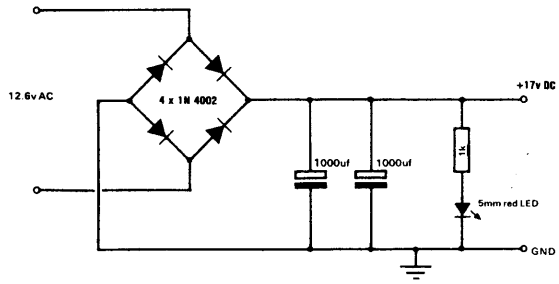


AN 8-WATT AMPLIFIER WITH PRE-AMP AND FUZZ

Kit of parts: $12.30
PC Board: $3.40
Complete: $15.70
Kit of extras: $26.40



GUITAR PRACTICE AMPLIFIER CIRCUIT



POWER SUPPLY (INBUILT)

Following the success of the 8-watt amplifier in issue 9, Paul has designed a project around the 8-watt chip and the result will have an even wider appeal.

It's an amplifier with a built-in pre-amp section, a fuzz section and a power supply which makes the unit completely self-contained.

As an amplifier it can be used as a mini amp for halls or outdoor events while the fuzz effect makes it suitable for guitar practice etc.

The circuit is quite simple as the use of a single chip eliminates the need for the usual array of components. It also makes the project extremely reliable as most of the work associated with biasing and matching of output devices has already been done.

It just takes a few external components to get the chip operating and a few more to create the pre-amplifier/fuzz section. The power supply is merely a set of diodes and a filter electrolytic, this being found adequate to eliminate any hum.

PARTS LIST

1 - 1R ¼watt
1 - 2R2
1 - 39R
1 - 220R
1 - 470R
2 - 1k
1 - 6k8
1 - 10k
1 - 15k
1 - 56k
1 - 68k
1 - 680k
1 - 4M7

1 - 10k mini trim pot
1 - 50k mini trim pot

1 - 1n greencap
1 - 39n
4 - 100n

1 - 4u7 25v PC mount electro
1 - 100uF 25v PC mount
1 - 470uF 25v PC mount
3 - 1000uF 25v PC mount

2 - BC 547 transistors
4 - 1N 4002 diodes
1 - 5mm red LED
1 - LM 383 (TDA 2002) IC

1 - DPDT slide switch
1 - Mini U heatsink
1 - 6BA nut and bolt

1 - GUITAR AMP PC BOARD

In the past, we have been hesitant to include a transformer in any of the projects as it requires working on components that will carry the 240v supply.

We have now overcome much of the previous apprehension by laying out the wiring in such a way that the live terminations can be completely covered with heatshrink, thus totally eliminating possible contact with the mains voltage.

This means the assembly must be carried out strictly according to instructions and the wiring checked by an authorised supervisor before connecting the project to the mains.

Even though the mains section involves only about 4 or 5 connections, the possibility of a faulty or misplaced lead is always there, and thus someone else must check you work before plugging it into the outlet.

Once again, the LM 383 amplifier chip has been used as it is virtually impossible to damage with overload.

In our circuit, we are supplying a safe operating voltage and include an electrolytic in the output, thus offering no cause for complaint. The chip is designed to deliver its full output wattage into 1.6 ohms and even if the output leads are shorted together, the internal temperature limiting circuit will prevent the chip from getting too hot.

The advantage of delivering into a low impedance such as this means the amplifier can be connected to up to five 8ohm speakers in parallel and each speaker will be supplied with about 2 watts.

It works like this: If you connect one 8ohm speaker to the output, the wattage from the chip will be about 2 to 3 watts. If another 8ohm speaker is added to the output, the power delivered by the chip will be about 5 watts. This is 2.5 watts per speaker.

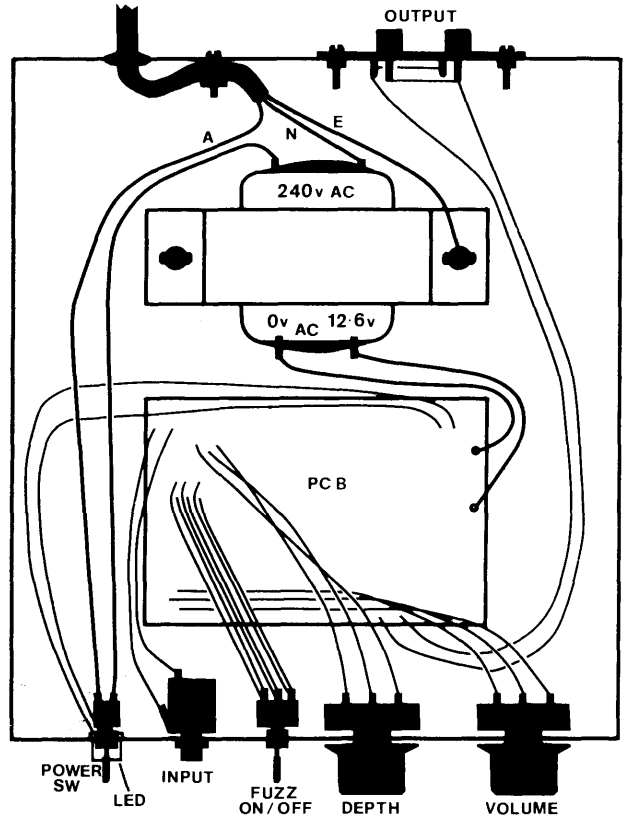
When 3 speakers are connected, the output power rises to 6 watts so that when 4 speakers are connected the power becomes about 8 watts. The data on the chip indicates the output power is about 10 watts when the load is 1.6 ohms but these figures are absolute maximum and would only occur on peak signals.

The main point to realise is the fact that the power delivered to each speaker does not alter appreciably as the number of speakers is increased.

This is handy if you wish to use the amplifier in a hall, or large room, where you may need full power.

The terms: POWER, MUSIC POWER, DECIBELS, and RMS OUTPUT are all very difficult to grasp and far too much discussion has been centred around trying to explain what they mean.

We are not intending to make an amplifier that will damage your eardrums or fill a concert hall and so the loudness of the amplifier is of no real concern.



The reason why all these terms are hard to grasp is because the energy required to increase the loudness of a sound is not linear but a logarithmic scale and as such we can make the amazing comment that to double the loudness from the speakers would require an amplifier of about 50 watts. See how irrevelant figures are!

The only way to determine the suitability of an amplifier is to build it and use it.

Providing you don't expect too much from 8 watts, you will find this project to be adequate for all types of situations.

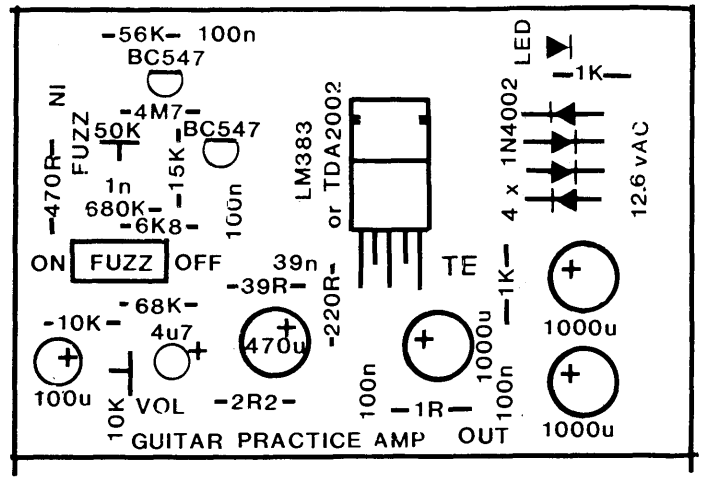
In fact we think it is loud enough to call it a Guitar Practice Amplifier. And you can be sure neighbours from two or three doors down will hear you practicing.

Most of the effectiveness of an amplifier is in the speakers and there is one enormous misunderstanding concerning them.

Most people think large speakers require more power to drive them and as such you must use speakers capable of handling say 2 watts, for this project. But this is not so.

The wattage rating on a speaker refers to its maximum power handling capability and you could quite comfortably use four 15 watt speakers for this project.

The reason why large speakers are to be preferred in any amplifier system is due to the large amount of cone area they offer.



As the cone of the speaker moves in and out, it shifts an equally large amount of air. It is this air which forms the sound waves that are picked up by the ear.

Obviously there are certain limits to this analogy but large speakers will certainly produce more room-filling sound than small ones.

To this extent it is not a bad choice to use a speaker capable of handling 15 watts, for a 2-watt amplifier.

HOW THE CIRCUIT WORKS

This project is based on a single amplifier chip LM 383 and as the schematic diagram shows, it can be thought of as an amplifier block with an inverting and a non-inverting input.

Provided the circuit board is correctly designed, the chip is highly reliable and produces a very clean output when supplied by smoothed DC in the range 12v to 18v. (Note: the SGS type MUST NOT be supplied with more than 18v as it has automatic switch-off at 18v!!).

A portion of the signal is taken from the output and fed into the inverting input to provide negative feedback. This reduces the output power slightly but more important it reduces the distortion.

Although we may want a considerable amount of distortion when in the fuzz mode, we require the amplifier section to be relatively distortion free so that it can be used as a PA amplifier etc.

The pre-amplifier/fuzz section is a clever design. It consists of two transistors and by using a switch, the bias on the two can be altered so that they change from amplifying mode to distortion mode.

This distortion mode is called fuzz and as they try to amplify, the high value of collector resistor causes the supply voltage to fall and thus the signal becomes distorted.

In addition, an AC feedback path is created via the 100n, 68k, 10k, 1n and 50k pot and this further upsets the DC bias so that the characteristic fuzz can be adjusted in depth.

When the fuzz switch is turned off, the first transistor provides a small amount of amplification to increase the input wavefom about 2 times.

The power supply is a simple rectified and smoothed supply, suitable for the LM 383 chip, with an indicator LED on the supply line to show when the unit is on.

CONSTRUCTION

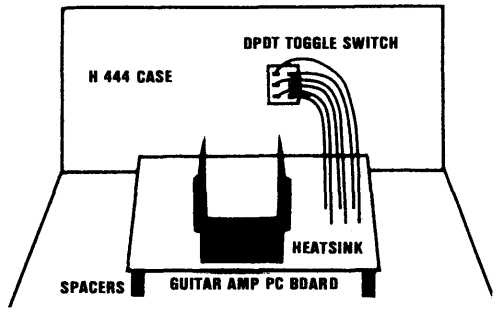
It is essential that this project be built on a PC board as the characteristics of the LM 383 are such that it requires a heavy earth plane to be present.

Without a tight earth plane and the hum reducing kink in the PC track, there is a tendency for the amplifier to generate its own background hum.

Only after designing 3 different PC layouts did we reduce the background hum to near zero. That's why we suggest construction on our PC board pattern.

This still allows you to make your own board from the artwork on the back page, but don't forget, our boards come with an overlay and once you have worked on boards with an overlay, you will never go back to a plain board again.

All the parts fit on the board and the controls are attached via plated leads. The twisting or plating of the leads serves to keep them neat and reduce interference between various parts of the circuit.



FUZZ SWITCH WIRING

Only the input lead needs to be screened to reduce hum pick-up and providing the others are not too long or placed near the power transformer, no induced hum can be detected.

The parts list at the beginning of the article includes all those items required for the PC board. The 'extra' parts list below will complete the project as shown in the photos.

Start by assembling the components on the PC board. Solder the resistors in place first and then the 4 power diodes. The diodes are placed alternately one way then the other with the bar or line on the overlay representing the band on the end of the diode.

GUITAR AMP EXTRAS

Kit: $26.40

1 - 10k lin pot
1 - 50k lin pot
2 - knobs to suit
1 - 6.4mm mono socket
1 - 2way RCA socket
1 - SPDT toggle switch
1 - DPDT toggle switch
10cm heatshrink tubing 2.6mm diam
20 lengths of hook-up wire 15cm long
2 lengths of heavy duty hook-up wire
20cm shielded microphone cable
1 - 2155 transformer
1 - mains cord and plug
1 - H 444 case
1 - rubber grommet
2 - 4BA nuts and bolts
3 - 6BA nuts and bolts
4 - 1/8" whitworth nuts & 25mm bolts
4 - 9mm spacers
1 - earth tag
1 - cable clamp

The 1 ohm and 2.2 ohm resistors will be new to many readers and they can be identified as follows: 1R =brown, black, gold, gold. 2R2 = red, red, gold, gold.

Next mount the amplifier chip and fit it onto the mini U heatsink with a 6BA nut and bolt. Push the 5 leads through the holes in the board and screw it into position. Make sure the leads are slightly bent as the heat from the chip will gradually expand and contract the leads and we do not want them to push on the solder lands. Bend the leads slightly and solder them in place.

Next fit the greencaps, making sure each one is identified correctly and solder them in place.

Finally the electrolytics are added to the board, making sure the negative lead as identified on the body of the electro goes down the negative hole. You will notice the positive is identified on the board and make sure this doesn't cause confusion.

This completes the PC assembly and is normally where we finish a project. But this one requires a number of external controls and so we have made an 'extras' kit containing the pots, switches, transformer, case, plugs and sockets so that you can complete the project.

The first thing to do is mount the controls on the front panel in the same relative places as in the photograph.

The switches are mounted using two nuts one on the front and one on the back of the panel, so that the switch does not protrude too far.

The same applies to the pots so that the knobs fit nearly flush with the panel. Use the line diagram on the previous page to assist you with wiring between the controls and the PC board. Each of the connecting wires should be about 15cm long to allow the board to be turned over for soldering. If the connecting wires are too short, you will experience great difficulty in repairing the board, should a fault occur.

Plat the three wires from each pot to keep them together and use different colours for each line so that they can be easily recognised at the other end.

When all the leads have been added, fit the board to the base of the case with 4 long bolts and use spacers to keep the board above the base.

Mount the transformer so that it is near the back of the case to prevent hum pick-up and use the 0v and 12.6v tags for the project.

The output sockets are a pair of RCA sockets and are mounted on the rear of the case with 2 6BA buts and bolts. The idea of this is to allow two 8 ohm speakers to be connected to the amplifier and up to four 8 ohm speakers can be connected to realize the full 8 watts output.

The last item to add is the power lead. Use a grommet in the rear of the case and also fit a cable clamp inside to prevent the cord twisting around inside the case and straining on the lugs of the transformer.

Take the active lead directly to the switch on the front of the case and another lead from the switch to the AC input on the transformer.

The neutral lead is taken directly to the other AC tag on the transformer and the earth lead is connected to one of the legs of the transformer to make contact with the case.

It is wise to use heatshrink tubing over each of the mains voltage connections to prevent accidental touching of an exposed joint.

Check over the completed project and make sure it looks like our version. When you are satisifed all has been done, its ready for testing.

TESTING

Plug an electric guitar or microphone into the input socket and connect speakers to the output.

Switch the unit on and try the amplifier with the fuzz section off. You should hear a clean response, even with the volume control turned fully up. The background hum and noise should be barely audible when an input jack is inserted and will drop considerably when removed.

Switch on the fuzz and adjust the depth control. You will be most impressed with the effect. It's now up to you to put it to good use.

FAULT FINDING

If the unit fails to operate, turn it off immediately and remove the PC board from the mounting screws. Check to see that no short-circuits exist and that all components are placed around the correct way. Also check the underside of the board for solder bridges or connections that may have been missed.

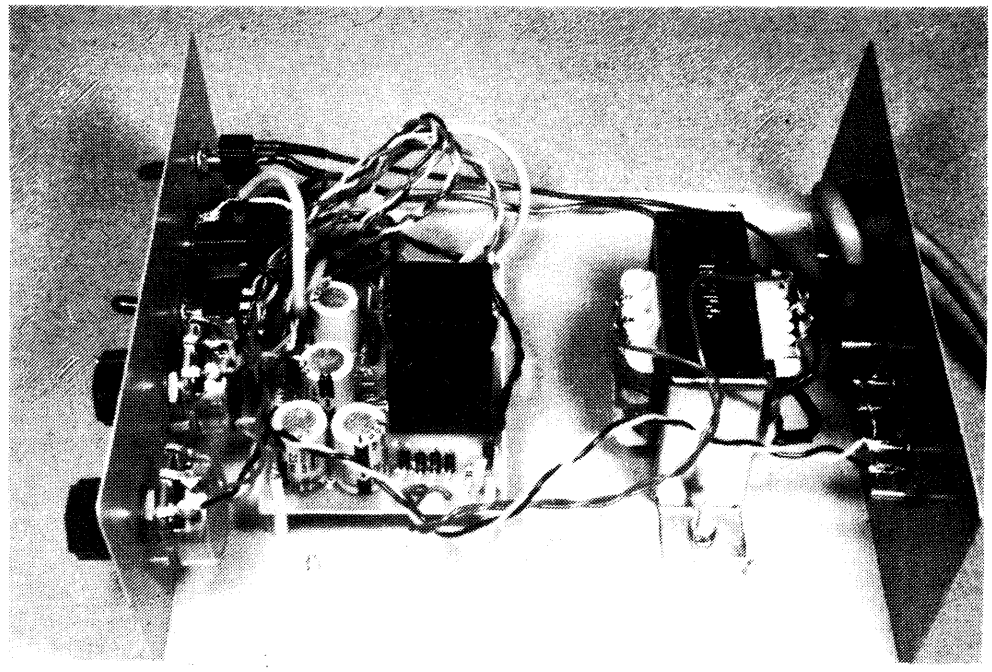
There is very little chance of a fault developing in the electronics of this project as the amplifier chip is fully protected against overload.

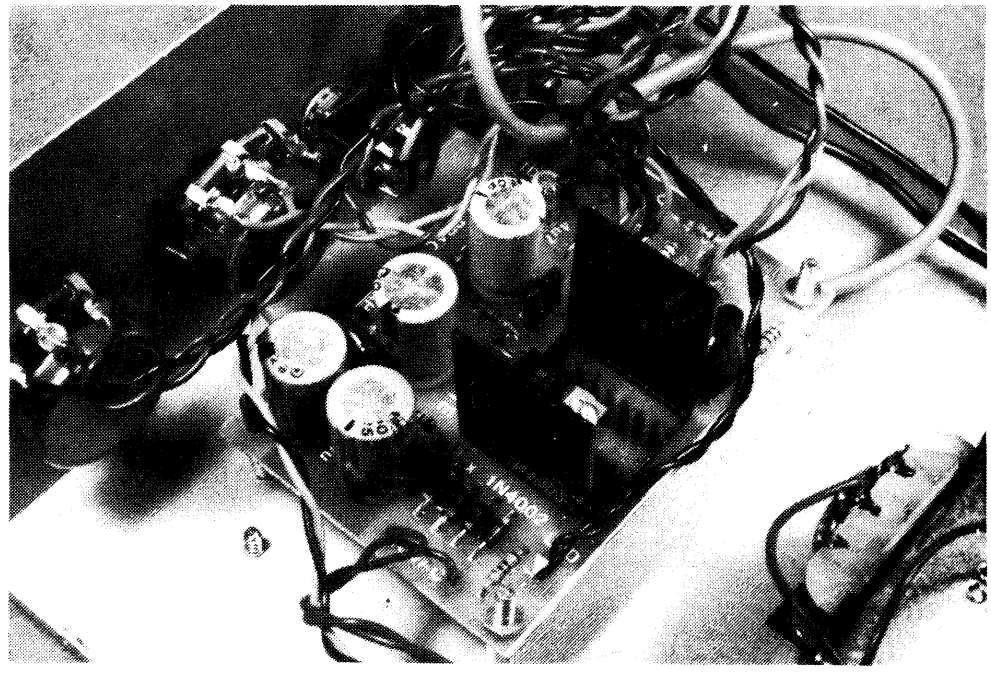
The most likely place to look is on the fuzz switch and input socket. If you are not sure how to wire these, use a multimeter set to low ohms and trace through the circuit before soldering.

The only other cause of a short circuit will be due to fine strands from one piece of hook-up wire touching another.

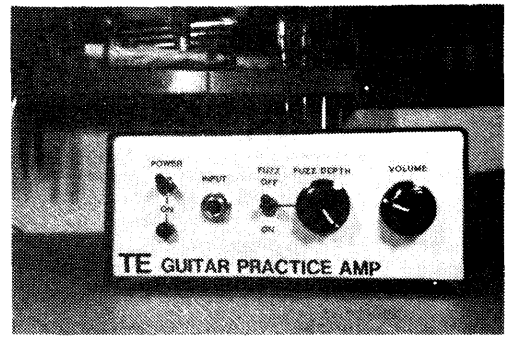
I hope you don't encounter any problems with the project and have the same success as we did.

It's a handy amplifier for those who want to practice without disturbing the rest of the household and can be used for amplifying other devices such as speech chips for the TEC computer!!





The two photos above show the wiring of the PC board to the controls, transformer and output plugs. Use these in conjunction with the layout diagram on P. 28 and also the fuzz switch diagram on P. 29 to produce a neat layout. Plat the leads to keep them together and choose multi coloured wires to make wiring easier.

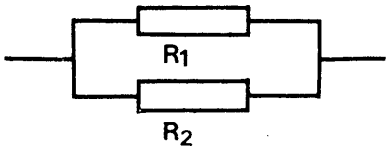


The completed Guitar Practice Amplifier.

RESISTORS IN SERIES AND PARALLEL

RESISTORS IN PARALLEL

Two resistors can be connected in parallel thus:



For two resistors in parallel, the resistance of the combination is:

$$\frac{1}{R_{TOTAL}} = \frac{1}{R1} + \frac{1}{R2}$$

(find a common denominator)

$$\frac{1}{R_{TOTAL}} = \frac{R2 + R1}{R1\ R2}$$

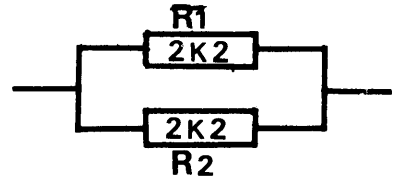
(invert both sides to get:)

$$R_{TOTAL} = \frac{R1\ R2}{R2 + R1}$$

The formula states, in effect, that the total resistance in a two resistor parallel circuit is found by the multiplication of the two values, divided by the sum of the two values.

The main reasons for connecting two resistors in parallel is to increase the wattage handling ability or 'make-up a value' as required in the opening problem. You can connect the two 2k2 resistors in parallel to produce a 1k resistor.

In our problems we will deal with the simple case of TWO EQUAL resistors (or nearly equal) so that the answer is to halve the value of R1.



R_{TOTAL} = **1k1** (Half the value of R1).

Calculate the value of these parallel combinations:

1. 390R in parallel with 390R
2. 4k7 in parallel with 4k7
3. 1M in parallel with 1M
4. 10k in parallel with 10k
5. 47k in parallel with 47k
6. 220k in parallel with 220k
7. 10R in parallel with 10R

LOW-OHM RESISTORS

.1 OHMS TO 10 OHMS.

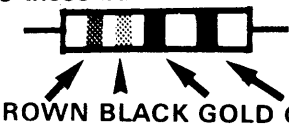
All the resistors we have dealt with so far have a resistance value greater than 10 ohms. To identify resistors less than 10 ohms we have two interesting colours for the third band. These are GOLD or SILVER. When used in the third band, they do not represent tolerance but are a divisor.

GOLD indicates the value of the resistor is to be divided by 10.

SILVER indicates the resistor is to be divided by 100.

This enables us to identify resistors such as 1 ohm, .22 ohm 3.3 ohms etc. We already know about standard form and these values should be written as: 1R, R22, and 3R3.

For example a 1R resistor will have these bands:



BROWN BLACK GOLD GOLD

The first band gives us the figure 1, the second band gives us the figure 0. This gives us a value of 10. The third band indicates that the value is to be divided by 10. The answer is thus 10/10 or 1 ohm. The fourth band indicates the tolerance is 5%.

Thus we have the interesting situation where a band can represent two different things.

SUMMARY:

For resistors less than 10 ohms:

GOLD = DIVIDE BY 10.
SILVER = DIVIDE BY 100.

An easy way to remember this: Gold has less letters and thus 1/10.
Silver has more letters and thus you divide the value by more.

Use the table to find the value of these:

(a) Yellow - Purple - Gold - Silver
(b) Red - Red - Gold - Gold
(c) Green - Blue - Silver - Gold
(d) R27 10%
(e) 1R5 5%
(f) 3R3 10%
(g) .47 ohm 5%

ANSWERS:

(a) 4R7 10% (b) 2R2 5% (c) R56 5% (d) Red - Purple - Silver - Silver (e) Brown - Green - Gold - Gold (f) Orange - Orange - Gold - Silver (g) Yellow - Purple - Silver - Gold.

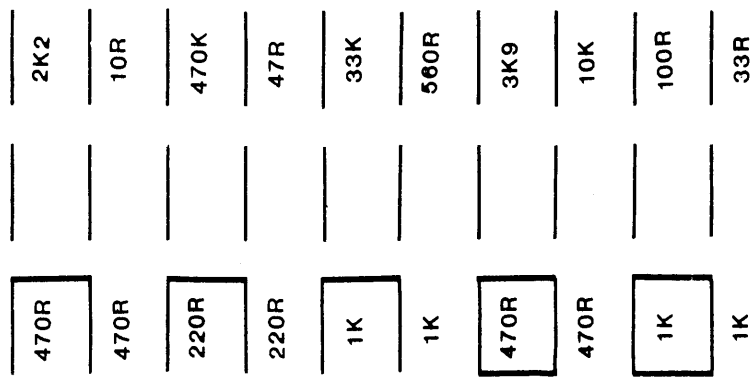
Expt: 2 THE RESISTOR

AIM: To identify the values of a set of resistors by reading the colours of the bands.

APPARATUS:
DIGITAL ELECTRONICS BOARD B
COLOUR CODE TABLE

METHOD: Use the COLOUR CODE table to identify the top two rows of resistors on board B. Write your answers on the layout on this page.

Determine the value of the set of series and parallel combinations and check your answers with your instructor.



DIGITAL ELECTRONICS BOARD B

RESISTORS

1% and 2% resistors are currently available on the market at quite a low cost and they are gradually appearing in hobby projects.

These resistors are usually used in precision applications where accuracy is important and for reference situations such as a voltage divider ladder for A - D conversion.

The two most noticeable differences about these resistors is the presence of 5 bands instead of 4 and the absence of the gold or silver bands.

At first you will find these resistors hard to read or completely unreadable so a few pointers will be handy.

Since the tolerance is 1% or 2%, we can use colours for the last band which we have already learnt about. We know brown has the value 1 and red the value 2.

We can use these to represent 1% and 2% and this is easy to remember.

It may be a little confusing to have two meanings for the one colour but don't forget they will be on the resistor in different positions.

Apart from the tolerance bands, there will be four colours representing the resistance. The first 3 bands produce 3 figures for the resistance such as: 13k3, 10k5, 1k54.

The fourth band supplies the number of zeros, just like the 3rd band in the 5% or 10% range.

But because of the extra band, a 10k resistor in the 1% range will have a red band as the multiplier colour whereas the 10% range will have an orange band. And likewise through the range, the multiplier will be a different colour in the two ranges. That's why you will have to take care when reading 1% values.

Follow through these examples then attempt the set of questions which follow:

Ex:

red black green orange brown
2 0 5 000 1%
205k 1%

Ex:

yellow yellow red red red
4 4 2 00 2%
44k2

Ex:

brown green yellow brown brown
1 5 4 0 1%
1k54 1%

Ex:

brown black green red brown
1 0 5 00 1%
10k5 1%

QUESTIONS

1 .What is the value of these:

(a) brown red purple brown red.
(b) red brown green orange brown
(c) orange grey orange orange red
(d) brown brown black black brown
(e) green brown brown brown brown

2. Write the colours for these resistors:

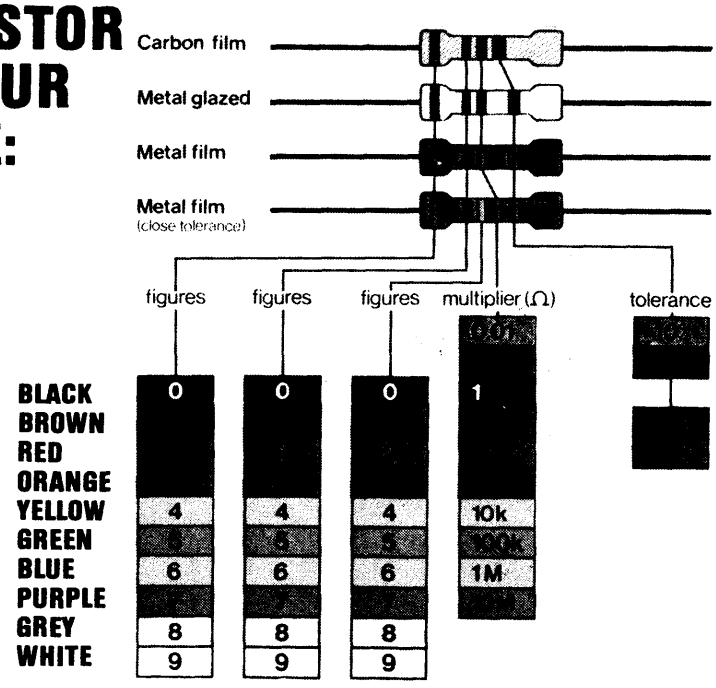
(a) 3k16 1%
(b) 18k7 2%
(c) 105k 1%
(d) 147k 1%
(e) 59k0 2%
(f) 100k 1%
(g) 162k 1%
(h) 40k2 1%
(i) 2k37 2%
(j) 12k7 2%

ANSWERS

1(a) 1k27 2%
(b) 215k 1%
(c) 383k 2%
(d) 110R 1%
(e) 5k11 1%

2(a) orange - brown - blue - brown - brown
(b) brown - grey - purple - red - red
(c) brown - black - green - orange - brown
(d) brown - yellow - purple - orange - brown
(e) green - white - black - red - red
(f) brown - black - black - orange - brown
(g) brown - blue - red - orange - brown
(h) yellow - black - red - red - brown
(i) red - orange - purple - brown - red
(j) brown - red - purple - red - red

RESISTOR COLOUR CODE:



3 THE DIODE

A look at the SMALL SIGNAL DIODE and POWER DIODE.

We will study two types of diodes in this section. These are:

1. SMALL SIGNAL DIODES,
2. POWER DIODES.

They both have the same basic construction but they have different values for the following features:

1. Size of the PN junction - and the physical size of the diode.
2. The current handling ability.
3. The reverse voltage characteristic.
4. The operating frequency.

Firstly we will consider the SMALL SIGNAL DIODE.

The symbol for a diode is:

Small signal diodes such as 1N 4148 are the most common type of signal diode. They are capable of passing about 10 to 20 milliamps and have an ability to withstand a reverse voltage of about 90 volts. Their main task is to pass a signal in one direction and block any signal in the opposite direction. Depending on the type of circuit and the other components, we can create a number of other functions such as charging a capacitor, producing an AND or OR gate, or simply use it to provide a voltage drop of .6v. But their main use it to pass information in one direction and block it in the opposite direction.

HOW DIODES WORK

The heart of a diode is the PN junction. To obtain a useful junction it must be created from a single crystal of semiconductor so that the transformation from P-type to N-type occurs in a continuous lattice structure.

Junctions can be made from a base structure of germanium or silicon, the latter being the most widely used due to its higher operating temperature and lower leakage levels. Germanium is still used for some applications due to its lower junction voltage however most of the diodes in present use are silicon.

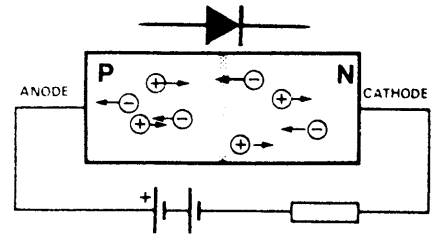
To explain the operation of a PN junction we will use a simplified model. The first diagram shows this. On the left side of the junction is a P-type material and the right side an N-type material. Where they join is a neutral section and this forms the secret of how a diode conducts in only one direction.

Silicon is an element with a crystalline structure. As a pure substance it has a very high resistance and would be useless for the manufacture of diodes. But by adding a small trace of another element to the structure when it is in the molten state, we can achieve a most remarkable effect.

Although the silicon atom has only 4 electrons in the outer orbit, it has the ability and desire to have 8 electrons in this shell. And it achieves this by sharing its 4 electrons with two other atoms. This produces a tightly bound structure through which the electrons cannot flow to carry electrical current.
This makes it a very poor conductor. In other words, it is a very good insulator.

But for the manufacture of a diode we need a partial conductor. To achieve this we mix a small amount of impurity into the silicon when it is in the molten state. This process is called "DOPING". If we add phosphorus, we find this atom has one more proton in is centre and one more electron in its outer orbit. When present in the doped structure, we find the extra electron wanders freely through the lattice looking for unfilled orbits. A number of these are constantly moving about but do not escape from the structure.

Electrons are negatively charged and for this reason we call this type of material N-type.



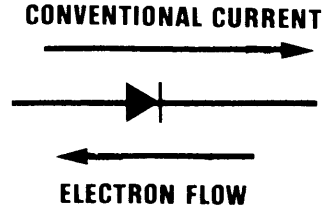
FORWARD-BIASED JUNCTION

If we dope silicon with Boron, we obtain a structure which has a number of excess holes and electrons find it very easy to move into these spaces. Although holes do not move, the fact that electrons are moving

CONVENTIONAL CURRENT FLOW:

The direction of current flow through a diode introduces two different schools of thought. This comes about when showing the direction of current flow on a circuit diagram.

The arrows help analyse the circuit



and are a definite aid. The arrow on the symbol seems to be showing the direction of current flow but there are two different interpretations to this, depending which school of thought you prescribe to. The diode was one of the earliest semiconductor developments and it was thought that electricity came out of the positive pole of a battery and entered the negative pole. Thus the diode was drawn with an arrow to show which way the current flowed.

More recently, it has been demonstrated that electricity is a passage of electrons and these flow from the negative terminal to the positive terminal. Thus the diode symbol is around the wrong way for our electronic thinking.

For simple DC circuits using globes, relays, heating elements etc. we can use conventional current flow and this direction is the same as shown on the diode symbol.

But for electronic circuits using transistors, intergrated circuits, signal diodes etc. we will use ELECTRON FLOW direction and this is in the opposite direction to the arrow on the diode symbol. It's unfortunate, but we have to live with changes and improvements. This is just one of the complexities of electronics.

around and filling the holes creates the impression that the holes are moving in the opposite direction.

To produce a diode, a piece of N-type material is joined to a piece of P-type material. This produces the important feature: the PN junction.

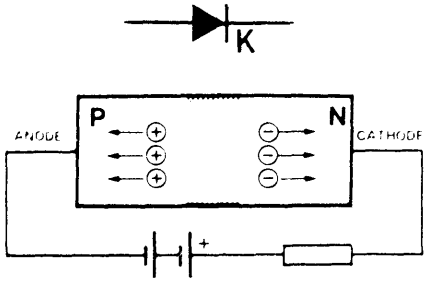
At the junction a neutral zone is formed where these materials have to share electrons. The atoms at the junction are stable and form a barrier which will resists current flow.

When a voltage is placed across a diode, the number of atoms that share electrons will increase or decrease depending on the polarity of the voltage. This either increases or decreases the width of the barrier and thus the resistance of the diode is altered.

A diode connected in the forward direction will conduct. This is due to the electrons emerging from the negative terminal of the battery entering the N-type material where an excess of electrons already exists.

For every electron pushed into the N-type material, one must emerge. And this occurs at the junction. An electron crosses the junction because we have given it additonal energy to do so. It crosses the junction and fills an empty hole. At the same time "bound electrons" are drawn from the P-region and flow to the positive terminal of the battery.

If a diode is connected in the reverse direction, current will not flow.



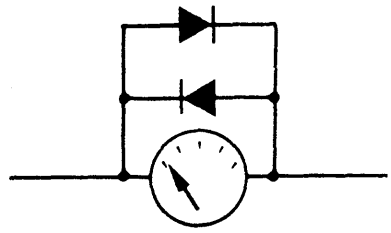
(The BATTERY has been reversed.)

REVERSE-BIASED JUNCTION

This is due to the electrons in the N-type material being attracted to the positive terminal of the battery and the electrons from the negative terminal attracting the holes in the P-type material. But unfortunately an electron cannot emerge from the N-type material without another electron firstly entering the structure. And since this is not happening, the diode refuses to conduct. The final result is a very wide junction zone which has the same insulating property as undoped pure silicon.

DIODE APPLICATIONS

When you measure a diode with the ohms range of a multimeter you find it is low in one direction and high in the other. Thus you think the diode has a low resistance in one direction and a high resistance in the reverse direction. This can lead you to a false understanding of the characteristics of a diode, especially when confronted with circuits such as these:



MULTIMETER PROTECTION

One of the interesting uses for a diode is to protect the meter movement in your multimeter. Two diodes are placed across the meter terminals as shown in the diagram. One in the forward direction and one in the reverse direction.

Under normal operation, a 50 microamp movement will have a voltage drop of about 20 millivolts across its terminals, when full current is flowing.

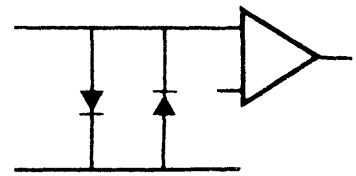
If an overload occurs and the current increases to 100 microamps, the needle will hit hard on the right-hand stop, but the current will not be sufficient to burn out the coil. Even at 200 microamps the coil attached to the needle is not going to burn out. So we don't have to protect the movement until excess currents are flowing. Something in the order of 10 times normal current.

The interesting fact with any diode, whether it be silicon or germanium, is its resistance. For a germanium diode, it has an almost infinite resistance in both the forward and reverse direction, when the applied voltage is below 200 millivolts. The same is true for a silicon diode up to 600 millivolts across the junction.

This means the diodes in the meter protection circuit are effectively a complete OPEN CIRCUIT to the passage of electricity until the voltage across them is 200 millivolts. One diode protects for an overload in the forward direction and the other diode protects in the reverse direction. One of these diodes will come into operation when the current is about 10 times normal as this will produce 10 times normal voltage across the movement. For this circuit we will need to use germanium diodes, where the conduction starts at 200 millivolts.

Large over-loads are by-passed through the diodes (or diode) and the movement never sees any more than 10 times rated current.

The same characteristic is used in the op-amp protection circuit. If we use silicon diodes, the first diode will clip any positive peaks above 600 millivolts and the second diode will clip negative peaks which are above 600 millivolts. These diodes protect the input of the op-amp from damage as



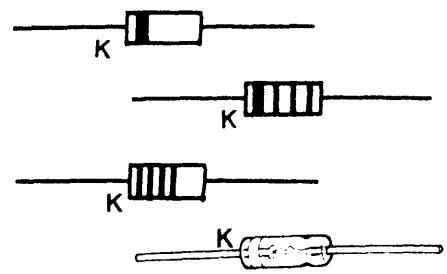
POWER AMP INPUT PROTECTION

they only require input voltages of about 10 to 50 millivolts to operate.

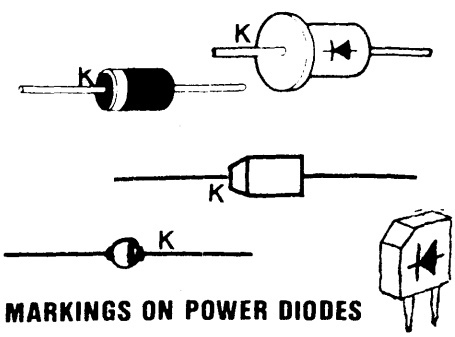
IDENTIFYING A DIODE

A number of methods are available for identifying the cathode of a diode. We are only interested in the cathode lead (the other is obviously the anode)

Most often the cathode is marked with a band or has a number of bands which are closer to the cathode end.



SMALL SIGNAL DIODES

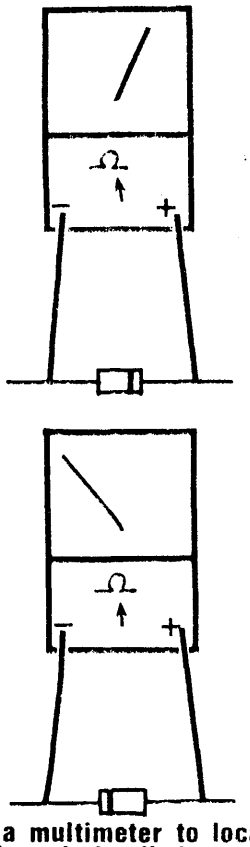


MARKINGS ON POWER DIODES

Larger diodes such as power diodes have a chamfer on one end, making it slightly pointed. Others have a corner removed if it is a block-type diode or they may have the diode symbol stamped on the case.

In all these cases the cathode is obvious. But suppose the markings have been rubbed off? How can you find the cathode end?

Simply by measuring it with a multimeter set to OHMS RANGE.



Using a multimeter to locate the cathode end of a diode.

The multimeter is indicating that the diode is conducting in one direction and not conducting in the reverse direction. It is not measuring resistance. The fact that the needle moves aross the scale to about '20' on the ohms range is showing that the voltage drop across the diode is a percentage of the voltage supplied to the meter movement fom the battery inside the multimeter.

Switching the multimeter to HIGH OHMS range will show the diode conducts in the forward direction but more important, it has a very slight leakage in the reverse direction.

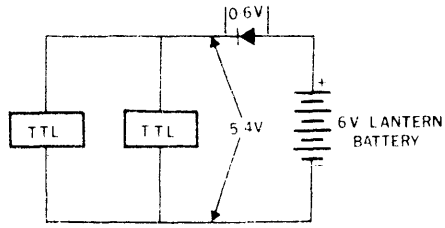
VOLTAGE DROP

When a diode is placed in a circuit, a voltage of about .6v is dropped across the junction. This is a characteristic of a silicon diode and the voltage remains constant no matter how much current is flowing, within limits.

For a germanuim diode the voltage drop is .2v as shown in the multimeter protection circuit.

Most of the diodes used in digital electronic circuits are silicon and the .6v applies.

Because this voltage does not alter, it is called a characteristic or phenomenon. We can use this feature in a number of ways. The most valuable use is to reduce 6 volts from a lantern battery to about 5.5v when TTL chips are placed in a circuit. TTL devices must not have any more than 5.5v across them and this simple arrangement can be used:



OPERATING TTL CHIPS FROM 6v.

You can measure the voltage drop across the diode with a multimeter by making this circuit. A load resistor of almost any value can take the place of the TTL chips because the current flowing does not alter the .6v drop across the diode.

The following set of diagrams will give you an understanding of how a diode operates.

When the battery is connected as shown in figure 1, current will flow through the circuit when a load is connected to the output terminals.

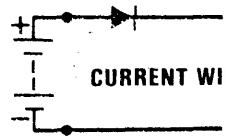


Fig. 1. Current flows when a load is connected to the output

When the battery is reversed as shown in figure 2, NO current flows in the circuit because the diode is reverse biased.

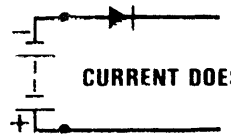


Fig. 2. NO current flows when a load is connected.

If the battery is replaced with an alternating voltage we have a voltage which is changing direction similar to the battery changing polarity. The diode allows the waveform to pass in one direction and blocks it in the other direction in a similar way to blocking the voltage in diagram 2.

This situation is shown in fig. 3. The diode permits the positive portions of the AC waveform to pass through the circuit and clips the negative parts of the cycle.

This is the basis of RECTIFICATION.

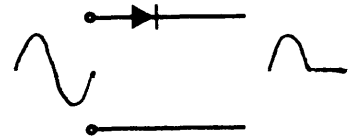


Fig. 3. The diode passes the positive parts of the waveform.

When a diode is placed as shown in figure 4, the positive output voltage is clipped by the diode and only .6v appears at the output. The negative portion of the signal is not affected by the diode.

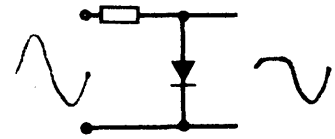


Fig. 4. The positive portions of the waveform are clipped.

When the diode is placed as shown in figure 5, the positive output will rise to full input voltge but the negative portions will be clipped.

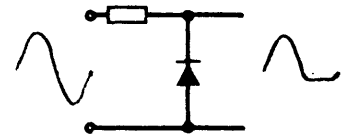


Fig. 5. The negative portions of the waveform are clipped.

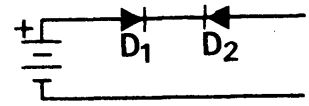


Fig 6. NO current flows due to the reverse biased diode D2.

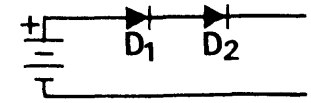


Fig. 7. Current flows and 1.2v is dropped across the two diodes.

These circuits show that the operation of a diode is a little more complex than merely performing a one-way passage for electricity.

At this stage of the course, it is sufficient for you to understand these 3 points:

1. A diode conducts in only one direction.
2. The voltage drop across a diode is .6v
3. The junction voltage (.6v) remains constant for all values of current.

RECTIFICATION

One of the most important uses for a power diode is to convert ALTERNATING CURRENT into DIRECT CURRENT.

Actually it is alternating VOLTAGE which is converted into direct VOLTAGE but the way we say it is: The diode converts AC to DC.

For the moment you can neglect the .6v drop across the diode junction as it is very small when cosidering 12v, 22v or 200v circuits.

The AC voltage we are referring to is the 240v mains. This is a waveform which is in the shape of a sine wave at 50 cycles per second.

For powering electronic circuits, a wave of this shape is completely useless. Electronics requires a steady, reliable, constant DC voltage in the range 5v to 20v, not an AC voltage.

To achieve DC we must RECTIFY the mains with the aid of a diode or set of diodes and a filter network. We will look at the part the diodes play in this chapter.

Firstly we must convert the 240v to a lower voltage. This is achieved via a transformer and we now have a miniature reproduction of the mains waveform, but at about 20v.

To keep the record straight, this 20v is actually 20v RMS or in other words "effective" voltage and the peak will be nearly 30v.

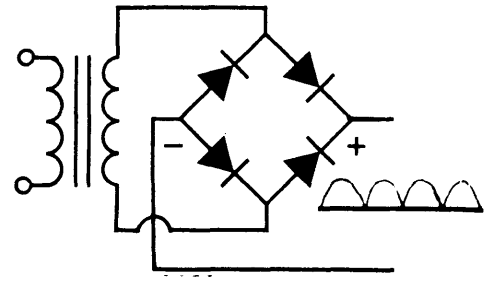
The output (or secondary) of the transformer can be connected to a single diode to produce pulsating DC as shown in the diagram.

SINGLE DIODE RECTIFIER

The positive half cycles are passed by the diode but the negative halves are blocked. An electrolytic can be added to the output to improve the DC level and create a positive voltage and this will be discussed in a later chapter.

You can see the negative half-cycles are lost in this arrangement and although you are not billed for this portion of the cycle (under these conditions) it would be nice to gain both halves of the waveform and increase the output power of the circuit.

This can be achieved by connecting 4 diodes in the form of a bridge as shown in the following diagram. The



BRIDGE RECTIFIER

negative half cycles are now added between the positive half cycles to achieve a vastly improved output waveform. How this waveform is converted to smooth DC will be covered in book 2. It is sufficient at this stage to see what the diodes are doing to the AC waveform.

Expt: 3. THE DIODE

AIM: To observe and measure some of the characteristics of a signal diode and a power diode.

APPARATUS:

DIGITAL ELECTRONICS BOARD 'C'
6v BATTERY
MULTIMETER

METHOD:

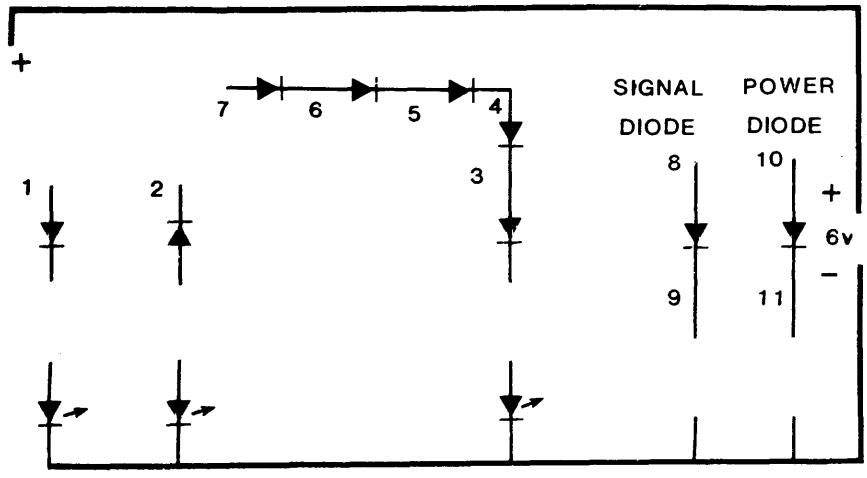
Attach the wander lead to terminal 1 and observe the illumination of the Light Emitting Diode. Change the lead to terminal 2 and note the non-illumination of the LED. What is the difference between these two circuits?

Connect the wander lead to terminal 3 and observe the brightness of the LED. Compare this with terminal 4. Which position creates the higher brightness? Can you give a reason why? Connect the wander lead to terminals 5, 6 & 7 and note the effect on the brightness of the LED.

From this can you conclude that you can see the effect of .6v reductions in the brightness of the LED?

Connect the wander lead to terminal 8 and use the multimeter set to a low voltage range to measure the voltage drop across the small signal diode. What value dc you obtain _____

Connect the wander lead to terminal 10 and measure the voltage across the power diode, between terminals 10 & 11. Is the voltage drop the same as for the small signal diode?



CONCLUSION:

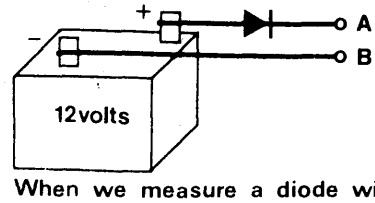
1. The diode will only conduct in one direction as shown _____

_____ _____

2. A voltage drop of _____ can be detected via the brightness of a LED. This voltage drop is a natural phenomenon of a diode.
3. The voltage drop across the small signal diode was measured as _____ and a power diode as _____ This tends to show that all silicon diodes have the same voltage drop.

DIODE TEST

What is the voltage between terminals A&B?



When we measure a diode with a multimeter which has been set to 'ohms' range, we find its forward resistance reads "about 20 ohms" and when connected around the opposite way, has a reverse resistance of 'about 300k'. What is the needle really telling us?

Explain how a shunt diode protects the micro-ammeter movement.

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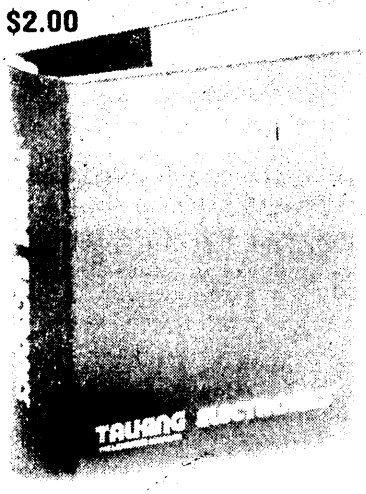

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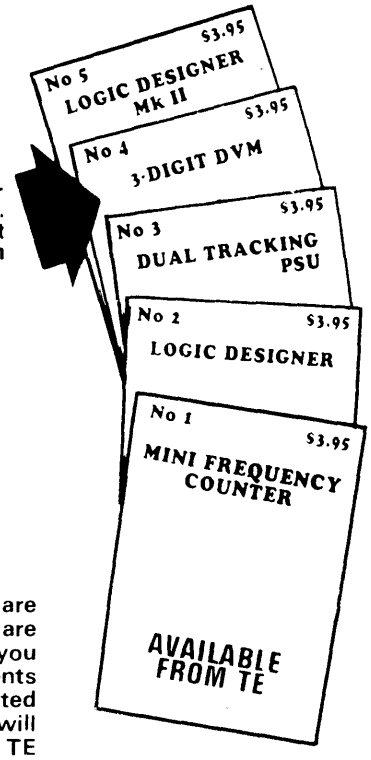

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4 THE MULTIMETER

Using the MULTIMETER to measure VOLTAGE, CURRENT and RESISTANCE.

One of the most important pieces of equipment for any electronics experimenter or serviceman is a MULTIMETER.

It is a very simple piece of equipment which must be mastered just like the art of soldering or reading the resistor colour code.

After a few years 'in electronics' the fear of damaging or blowing up a multimeter will have passed but until that time, you should be aware of the possibility of damaging the movement (the pointer assembly) or even burning out some of the components inside the multimeter.

For this reason we will study the instrument and discuss its capabilities and limitations in detail. The most important fact to understand is the large range of current and voltage values it is capable of measuring. Typically, a multimeter can measure 0 - 2.5v up to 0 - 1,000v or higher, merely by changing a selector switch. Everything is fine at the high end of the range (1,000v) but as you get to the lower ranges you are effectively getting closer to the movement and less protection is available.

Take the example of DC volts: Most multimeters have a top range of 1,000v. On this scale it would be almost impossible to damage the movement. You would need something like 5,000 volts to produce any arcing effect inside the meter and more than 10,000 volts to swing the needle hard against the end stop.

But take the lower range: On the 10v scale or 2.5v scale, it would be possible to oversupply the movement with voltage from a 20v power supply and cause the needle to hit hard on the end stop. This is because 20v can produce more than 5 times the required full-scale deflection on the 2.5v range and the needle will overshoot the scale in an attempt to register the voltage.

On any range, such as the 10v range, the needle will deflect to give a FULL SCALE DEFLECTION (FSD) when connected to a 10v source.

For the CURRENT scale, the situation is even more critical. On the 50 micro-amp range, the leads connect almost directly across the movement and an over-load current is very easy to achieve. This would be less than a milliamp and a prolonged reading of this value could permanently damage the meter, not only through bending the needle but the small current-limiting resistor (called a SHUNT resistor) inside the meter, could over-heat or even burn out.

But don't worry. The solution is simple. You only need to follow a few basic rules and the multimeter will last for ever.

MICRONTA®

A TANDY ELECTRONICS trade-name

A typical multimeter with 25 ranges. The high voltage ranges have separate banana sockets. All the other ranges are selected with the rotary switch.

Before measuring a current or voltage, switch the multimeter to the highest range. This is very important when testing an unknown voltage. Take a transistor stereo amplifier. Most of these operate on 15v, 30v or 50v. But some imported sets have a rail voltage of 100v or 120v. You have no way of telling which voltage is used (simply speaking) so you should always switch to the 250v range. Then you can probe the power supply electrolytics or dropper resistors for an indication of the voltage level. If the needle only rises half-way up the scale, or to the 35v reading, you can change the scale to the 50v range.

By changing down one range, the divisions between each volt will be greater and it will be easier to read.

The reason for the different ranges is to keep the pointer near the centre of the scale, where the greatest accuracy is achieved. Measuring 35v on the 250v scale will mean it is difficult to see if the voltage is 35v or 33v or 38v. For transistor amplifiers or TV sets, an incorrect rail setting of only a few volts can cause lack of height or width and create hum bars. In amplifiers it will mean that full output power is not being achieved. Sometimes voltage and current values must be accurate, other times it is not so important.

THREE MAIN TESTS

The three main uses for a multimeter are for measuring:

VOLTAGE
RESISTANCE
CURRENT

The approach for each of these is different and you must understand how they are measured BEFORE handling a multimeter.

MEASURING VOLTAGE

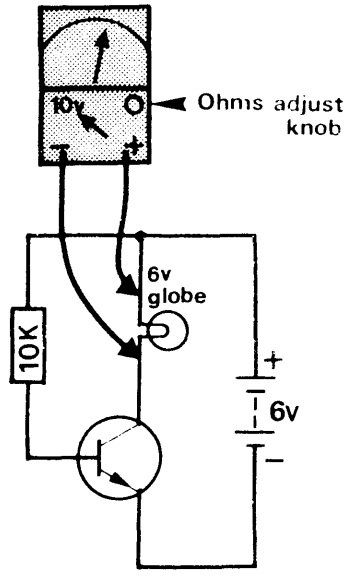
For most voltage measurements, the components of the circuit do not have to be removed. For the other two tests they do. That's why most circuits include a full listing of voltage values. They are the quickest to check.

One of the smartest things to do with the negative leads of a multimeter is to remove the probe and add an alligator clip. This will enable you to clip the lead onto any earth point or one end of a component and leave one of your hands free to change the range switch or write down the meter readings.

It is important to have some idea of high and low voltages in a circuit so that the probe doesn't touch high voltages when set to a low reading.

There are basically two methods of taking a voltage reading. One is to connect the negative probe to earth and read all values as being 'above earth potential' and the other is to measure the voltage across various components by taking the negative lead to one end of the component and the other lead to the higher end. This will give you a reading of the voltage across the component and is very important for some calculations.

Remember, when you are doing this, the multimeter is 'rising above earth' and although you may be reading a voltage of 10 volts, the component may be sitting at 200 volts above earth.



MEASURING VOLTAGE

The multimeter is across the load.

The final point to understand is the placement of the positive and negative leads. If you connect them to the component around-the-wrong-way, the needle will swing down-scale and not up-scale. To prevent this from happening and damaging the movement, you should always tap the probe onto the component very quickly and watch the pointer. If it begins to move down-scale, reverse the leads.

MEASURING RESISTANCE

All multimeters have a very good coverage of resistance values. But one important fact to remember is the inaccuracy of these ranges. It is not important to read resistance values to 1% or 5%. We only need to know if a resistor is functioning and to make sure it is not burnt out or changed its value enormously through an ageing process.

Before making any resistance measurements it is necessary to carry out a simple procedure.

Firstly select the resistance range you will be requiring. It is not necessary to start at the highest range so select the most convenient. If you make a mistake the needle will either swing full scale or barely move. But it will not over-shoot the scale like the current and voltage ranges.

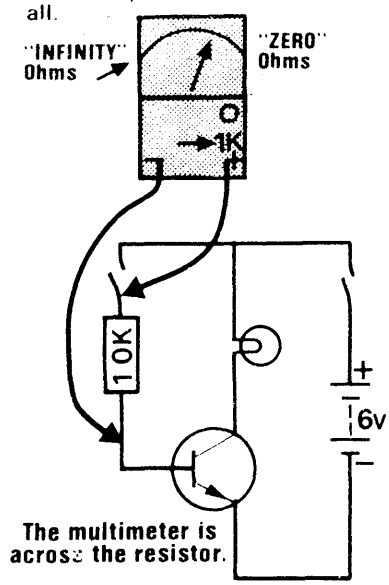
Secondly the multimeter must be set for "ZERO OHMS". This involves touching the two probes together and turning the Ohms Adjust knob on the front of the meter. As a point of interest, this procedure must be carried out each time the meter is used to measure ohms and each time the switch is set to a different ohms range. This is necessary because the battery inside the meter ages and its voltage falls. It should be replaced when it becomes impossible to zero set the low-ohms range.

Suppose the battery is new and the needle ZERO's correctly by moving across to the right hand end of the scale.

The multimeter is now ready for use.

It is very important to remember the ohms scale reads in the opposite direction to all the other ranges.

Zero ohms is represented by a FULL SCALE DEFLECTION and infinity is shown by the needle not moving at all.



MEASURING RESISTANCE

For an accurate ohms reading, the needle should be somewhere about mid-scale. But this is not possible for high value resistors and so these readings become extremely inaccurate and can offer little better than 20% accuracy. Very high value resistors can only be checked to determine that they still have a resistance value.

Before making any resistance measurements on our simple transistor circuit, it is necessary to remove the battery. Any voltages which are present in the circuit when the multimeter is connected, will upset the resistance readings and give a completely wrong value.

Even in this simple circuit we can make at least 8 different resistance measurements. Each pair of the transistor leads can be measured in the forward and reverse direction for short circuits. The resistor can be measured as can the globe. The resistor and globe need only to be measured in one direction as the reverse direction will be the same value. The transistor, however, is different. It is a semiconductor and has a forward and reverse reading.

When making a resistance measurement, it is necessary to remove one end of the component from the circuit to prevent the resistance of the other components from upsetting the reading. By removing one end of the resistor, all the components in our circuit will be separated from one another.

It does not matter which lead of the multimeter is connected to the top of the resistor as we have already pointed out that the resistor will have the same reading in either direction. The resistor will indicate 10k on the multimeter, the globe will indicate a very small resistance and the transistor will range from a low reading in one direction to a high reading in the other.

Most multimeters have a good coverage of resistance values and some have 4 ranges to cover the spread: 10 ohms to 2 meg ohms.

These ranges overlap and you will need to take care when reading the scale as the multiplier for each setting must be taken into account. The easiest ranges to use are the direct reading ranges and the x1k range. For these you don't have to add zeros to the reading.

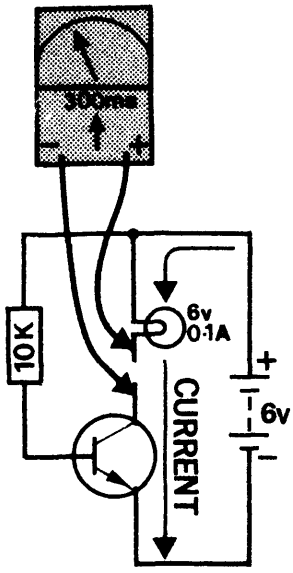
When taking high resistance measurements such as across the junction of the transistor, don't touch both leads with your fingers. This will reduce the reading and create a false impression that the transistor is leaky.

MEASURING CURRENT

When measuring current in a circuit, you must dis-connect one end of the component you are testing. Connect the two probes of the multimeter across this opening so that the current flows throught the meter and the component IN SERIES.

Firstly this will mean the multimeter will be 'above earth' and secondly you will need to arrange for a break to be made. This may mean de-soldering or cutting one of the component leads so that it can be tacked together after the test.

This is often messy and tends to be a slow process. For this reason current measurements are limited to total current flow for a circuit via a fuse or jumper link.



MEASURING CURRENT

The multimeter is in series with the current.

Before connecting the probes, the range switch should be set to the highest range.

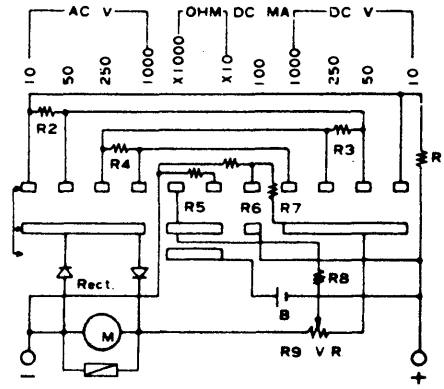
The positive probe (red) is connected to the point having the higher voltage and the negative probe (black or alligator clip) connected to the other side of the break. This will ensure the needle will give an up-scale reading when the power is applied.

Correct interpretation of the scale is important. Check the value on the range switch with the highest number on the meter scale. For instance, 0 - 50v and 0 - 500v will both be read on the same scale. If the scale reads 0 to 50, the high voltage range will have to be mentally multiplied by 10.

Remember the following equivalents:

1,000mA = 1 amp
1mA = .001 Amp
so that 1500mA = 1.5 amp
25mA = .025 amp
150mA = .15 amp

SCHEMATIC DIAGRAM



R1	19 2K	R7	1 4K
R2	80K	R8	4 7K
R3	400K	R9	1 7K
R4	1 5M	Rect.	1 2 Wave C32
R5	55 6	B	1 5V "AA"
R6	7	M	200UA Meter

CIRCUIT FOR A 1,000 OHMS PER VOLT MINI-TESTER.

ABOUT MULTIMETERS

A multimeter is about as important as a soldering iron. And it can be used with just as much skill. But a lot of myths abound about multimeters. Some say a cheap multimeter is sufficient, others specify a FET meter while some servicemen demand a digital meter.

So, what's the truth?

Unfortunately this isn't an easy question to answer. It all depends on the type of circuit you are testing and the accuracy required.

Without completely dismissing the FET or DIGITAL meter, we are going to say that they are not needed for this course.

As a learning exercise we are only covering the standard multimeter with about 11 to 35 ranges, and average sensitivity.

The sensitivity of a multimeter is the most important feature. It is the factor which governs the price and determines the accuracy of the readings.

It works like this:
Take a multimeter with very low sensitivity. The cheapest have a sensitivity of 1,000 ohms per volt. This term will need explaining. It means the multimeter will be equal to a 10k resistor when the range is set to 10v and a 100k resistor when set to 100v. When measuring a 9v battery, this will cause .9mA to flow and this slight load will not be of any concern.

But when the meter is placed in a circuit the loading effect will be noticeable.

Take a situation such as this:

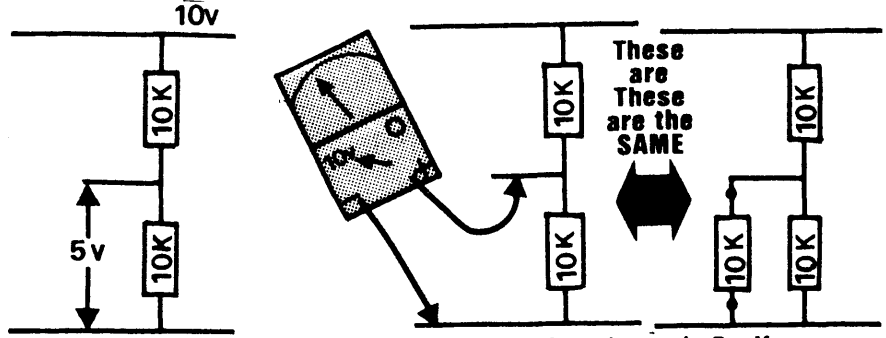
We know the voltage at the mid point of the two resistors in the diagram below is 5v, but if you use a 1k/volt meter, the result will be exactly the same as placing another 10k resistor across the lower resistor. The resulting voltage at the mid point is now 3.3v and the multimeter will give a reading of 3.3v. This is far from the 5v expected. This highlights how a low-sensitivity meter will give highly inaccurate readings.

If the two resistors were 100k and 100k the reading would be less than 1v! For this reason a 1k/v movement is not sensitive enough for our readings. The next quality starts at 2k ohms per volt or 5k ohms per volt but these are also too insensitive for our requirements. They will place too much load on the circuit.

A suitable meter starts at 10k ohms per volt and the best choice is 20k or 30k. When you get to 50k, the movements become ultra delicate and the cost rises enormously.

By using our choice of 30k ohms per volt, the original problem of a meter loading the circuit applies to a 500k resistor in series with a 500k resistor.

Thus you will have to remember the limitations of the meter you are using and not attempt to read the voltage across any component which is being fed from a 500k resistor. In practice this rarely occurs and the sensitivity of 30k ohms per volt is the most readily available and is our recommendation.
The notes in this text book apply to a meter such as this and you should be able to see a selection at your local electronics store at a price to suit.



The voltage at the mid-point of the two 10k resistors is 5v. If we measure this voltage with a 1k ohms per volt meter it will have the same effect as placing another 10k resistor across the lower resistor. The meter will read 3.3v and this is far from the correct value

THE MOVING COIL ASSEMBLY

When a current flows through a wire, a magnetic field is generated which is perpendicular to the wire. This field is concentrated when the wire is wound in the form of a coil and further improved by winding it over a soft iron core.

This arrangement is called an electro-magnet and when it is placed between the poles of a permanent magnet, and a current supplied to the coil, it will twist or turn as the field produced by the coil and the permanent magnet interact. This means they will push against each other if the two lines of force are the same polarity or pull towards each other if opposite polarity. If the current is increased, the coil will rotate further. If we attach a pointer to the coil, we can detect this movement and provide a scale for the pointer so that graduations can be made.

The sensitivity of this movement is governed by the number of turns on the coil. As the turns increase, the thickness of the wire must be reduced to keep the mass of the winding low. The upper and lower bearings and return spring must also be finer for more sensitive movements and thus they should be handled with the care they deserve.

This is the basis for the movement in all multimeters. The three diagrams show how the movement is manufactured and this design has not altered since the earliest introduction of a multimeter.

THE PARTS OF A MOVING COIL INSTRUMENT:

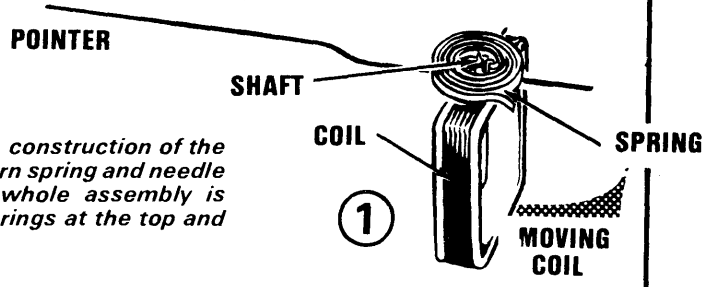


Fig 1. shows the construction of the coil with the return spring and needle in place. The whole assembly is mounted via bearings at the top and bottom.

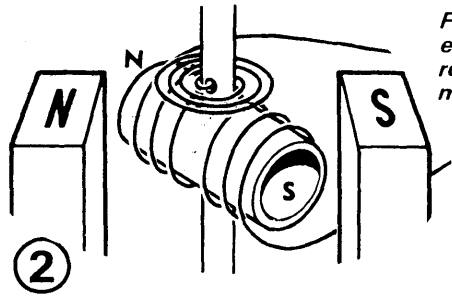


Fig 2 shows how the coil is effectively an electro-magnet which rotates in the field of a permanent magnet.

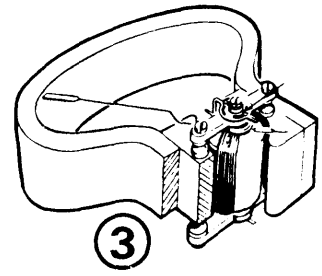


Fig 3. shows the complete movement mounted in a horse-shoe magnet.

THE GOLDEN RULE:

Connect the negative lead to an earth point. TAP the positive probe onto a component lead and WATCH the POINTER.

MULTIMETER TEST:

1. What values are being measured in the following problems:
(a) The meter reads '20' on the 60 volt range.
(b) The pointer reads '20' on the 600 volt range.
(c) The pointer reads '10' on the ohms range.
(d) The pointer reads '10' on the ohms x 10 range.
(e) The pointer reads 30 on the ohms x 1k range.

2. Are all the scales linear on a multimeter?

3. Which scale reads 'backwards'.

4. Is a multimeter polarity sensitive?

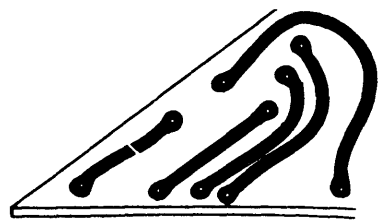
5. Which end of the scale is more accurate for the resistance readings.

6. What range is used to measure a FUSE.

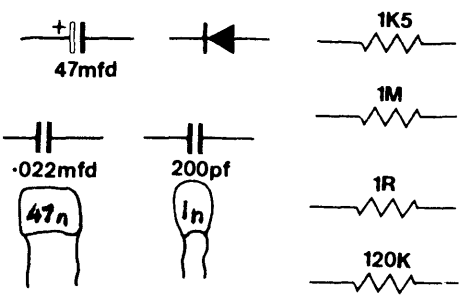
7. What is the function of the mirror on a multimeter?

8. On the schematic diagram of the 20k/v multimeter, why are some 'odd-value' resistors used?

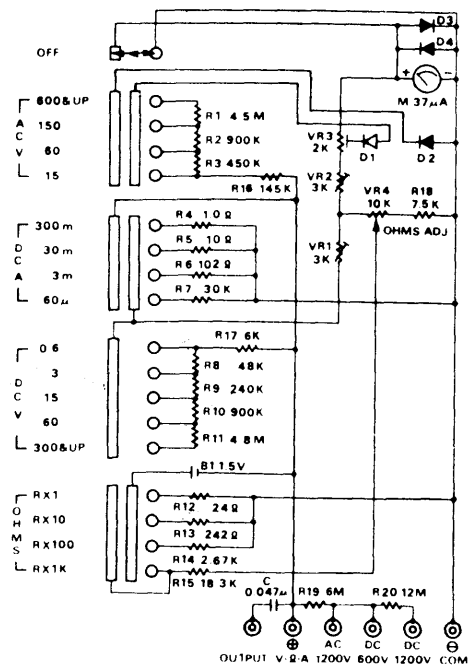
9. This PC contains two faults. Explain how you would locate them.



10. How would you test these components:



20k/v SCHEMATIC



Circuit for 20,000 ohms per volt MULTIMETER.

5 THE TRANSISTOR PART I

THE SMALL-SIGNAL TRANSISTOR

Biasing an NPN transistor in a COMMON EMITTER circuit. And a brief look at a PNP circuit.

This chapter will be dealing with the small signal transistor in its two forms: The PNP version and the NPN version. They both belong to a group called BIPOLAR JUNCTION transistors.

The most widely used type is the NPN variety because it is usually available in a larger voltage and current range than the PNP equivalent.

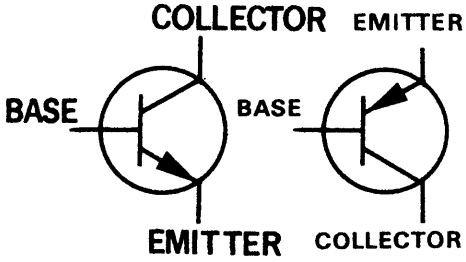


Fig.1. NPN PNP

For all our NPN requirements we will use a BC 547 however there are many equivalent types which will work just as well. Any low-power NPN silicon transistor capable of delivering 100 milliamps can be used. But before we look into the characteristics of any of these transistors we will look at how they operate.

The simplest circuit to show how a transistor works is shown in figure 2. It uses a pot to vary the voltage on the base and a LED to show when the transistor is conducting.

A multimeter connected between the negative rail and base will indicate the voltage on the base.

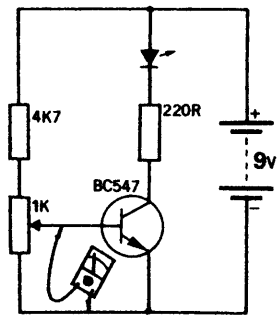


Fig. 2. Measuring the base voltage.

When a battery is connected, the centre arm of the pot is near the negative rail and the voltage on the base is zero. The light emitting diode is not illuminated. The transistor is not conducting and in this condition the transistor is said to be CUT OFF.

As the wiper of the 1k pot is rotated, the voltage on the base increases until a voltage of ,55v is reached. At this level the LED just begins to glow. Increasing the base voltage to .65v will brighten the LED until it is fully illuminated. The transistor is fully conducting and it is said to be SATURATED. If you continue to rotate the pot, the base voltage will not increase above .65v and the 2v on the top of the pot will be pulled down to .65v. This is due to the characteristic of a silicon junction which prevents more than .65v from appearing across it.

This shows that the voltage on the base of a transistor is critical. It only needs to be altered 100 millivolts for the transistor to change from a CUT-OFF condition to a SATURATED condition.

Actually the transistor is a current amplifying device and it is the current flowing in the base circuit which is amplified by the transistor to allow sufficient current to flow in the collector-emitter circuit to turn on the LED.

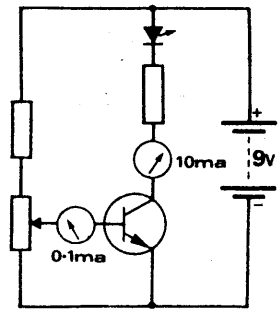


Fig. 3. Determining the gain of a transistor.

Figure 3 shows 2 milli-amp meters, one in the base circuit and one in the collector circuit. The ratio of the two current flows is the gain of the transistor. In our case this is 10/.1 and represents a gain of 100.

The same type of circuit can be set up for a PNP transistor. See fig. 4. This time the BC 557 is connected "HIGH". (HIGH means the transistor is connected to the positive rail and the load between the collector and negative or earth rail.) The pot is connected between emitter and base

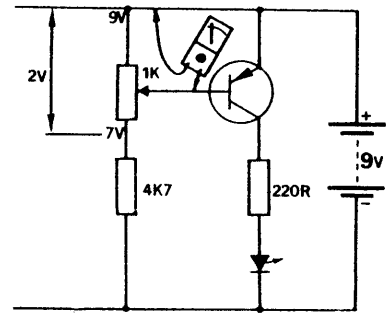
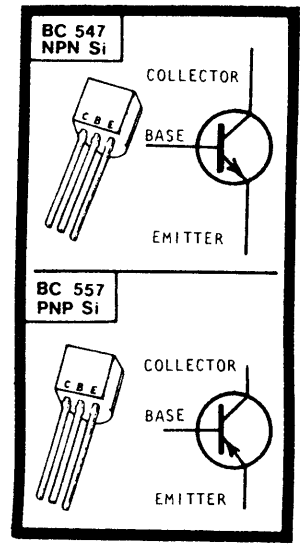


Fig. 4. Measuring the turn-on voltage

and the 4k7 limit resistor between pot and ground. (The 4k7 limits the current in the base circuit so that the transistor is not damaged.)



Identifying the transistor leads.

To start the demonstration, rotate the arm of the pot to the 9v end and connect the battery. The voltage between the base and emitter leads will be zero as the emitter will be at 9v and the base will also be at 9v. The transistor will not be conducting and the light emitting diode will not be illuminated. The transistor will be CUT-OFF.
As the pot is rotated towards the 7v end, the LED begins to come on.
Note the position of the voltmeter. It is connected between emitter and base. This arrangement will enable us to measure the voltage between base and emitter as the transistor only 'sees' a voltage which appears between the wiper and top terminal of the pot.

As the voltage between base and emitter increases to .55v the light emitting diode begins to turn on. At .65v it is fully lit and the transistor is said to be SATURATED. Again the base-emitter voltage will not increase above .65v, just like the NPN transistor.

NOTES:
In either circuit, the pot and 4k7 resistor make up a voltage divider network in which nearly 2 milliamps is flowing. This current is called BLEED CURRENT and although it is wasted current, it is necessary to have a high current flowing in a voltage divider for it to function correctly. We need about .1mA to supply the base with current and the remainder is wasted in the resistors.

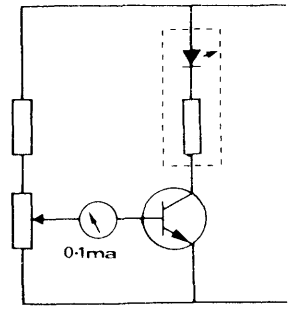


Fig. 5. The LOAD is shown dotted.

The load for the transistor is made up of the light emitting diode and its dropper resistor. These are shown in fig. 5.

WIRING UP A TRANSISTOR

Fig 6 shows how an NPN transistor is wired into a circuit. The emitter lead is connected to the negative rail and tne collector is connected to the positive via a load.

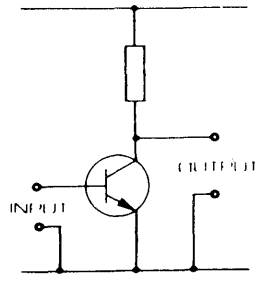


Fig 6. The INPUT, OUTPUT and EMITTER are common to each other.

The input terminals are the base lead and the negative rail and the output is between the collector and the negative.
This shows the negative to be common to both the input and output. The emitter is also connected to this rail. For this reason we call the stage a COMMON EMITTER STAGE and is the most often used stage for NPN transistors because it uses the transistor to its best advantage with high amplification and good input/output impedances.

CURRENT GAIN

The gain of a transistor is the ratio of the output current divided by the input current.

This is represented by the symbol hfe and refers to the AC current gain in the forward direction for a common emitter circuit.
The DC current gain is hFE and for our discussion we will consider these to be nearly equivalent and interchangeable with the term ß.

The gain of a transistor is a highly variable parameter and the specification sheet for a BC 547 gives this to be in the range 110 to 800. What an enormous range. It shows the variables which combine to give a transistor its natural amplification factor. But when a transistor is placed in a circuit, the gain of the stage can drop to as low as 70 - 200, due to the component loss in the circuit. Losses occur in the capacitors coupling the stages due to stage matching and in the biasing and feedback networks.

The best proof for determining if a stage has sufficient gain is to build the circuit and try a number of transistors in situ.

But before building a circuit you will need to know how a common emitter circuit works and how to select the values of resistance required for correct biasing.

BIASING THE TRANSISTOR

Every transistor in a circuit must be biased correctly. It does not sit dormant in a circuit, it must be biased so that it is partially turned on. . . even though the circuit may not be passing a signal.

Correct biasing of a transistor is very important.

If you don't turn it on enough, it will distort the signal and if it is turned on too much it will distort the signal. So the correct bias level must be obtained.

We will discuss three methods of achieving this. Fortunately two methods are 'auto-bias' and the transistor sets its own correct bias for a wide range of conditions and so circuit designs are not as complex as you think.

Before looking into biasing a transistor, we need to learn three terms:

1. CUT-OFF
2. PARTIAL CONDUCTION
3.SATURATION

From the first circuit in this chapter, we can demonstrate the meaning of these three conditions.

CUT OFF

When the rotating arm of the pot is at the negative rail, the LED is not illuminated and the transistor is said to be **CUT OFF.**

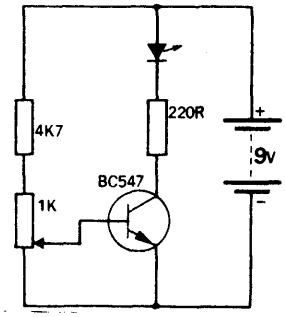


Fig. 7. A transistor in CUT-OFF.

PARTIAL CONDUCTION

When the wiper is rotated until the LED is partially illuminated, the transistor is said to be partially conducting. The voltage on the base will be about .55v to .6v.

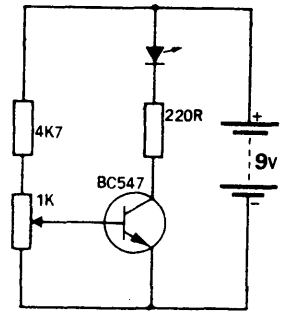


Fig.8. A partially conducting transistor.

SATURATION

When the wiper is taken towards the 4k7 resistor, the voltage on the base increases to about .65v and the LED becomes fully illuminated. The transistor is fully conducting and is said to be **SATURATED.**

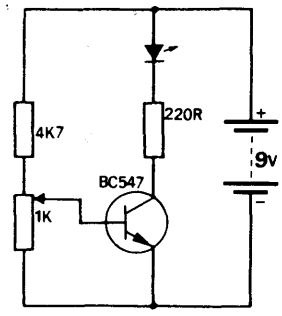
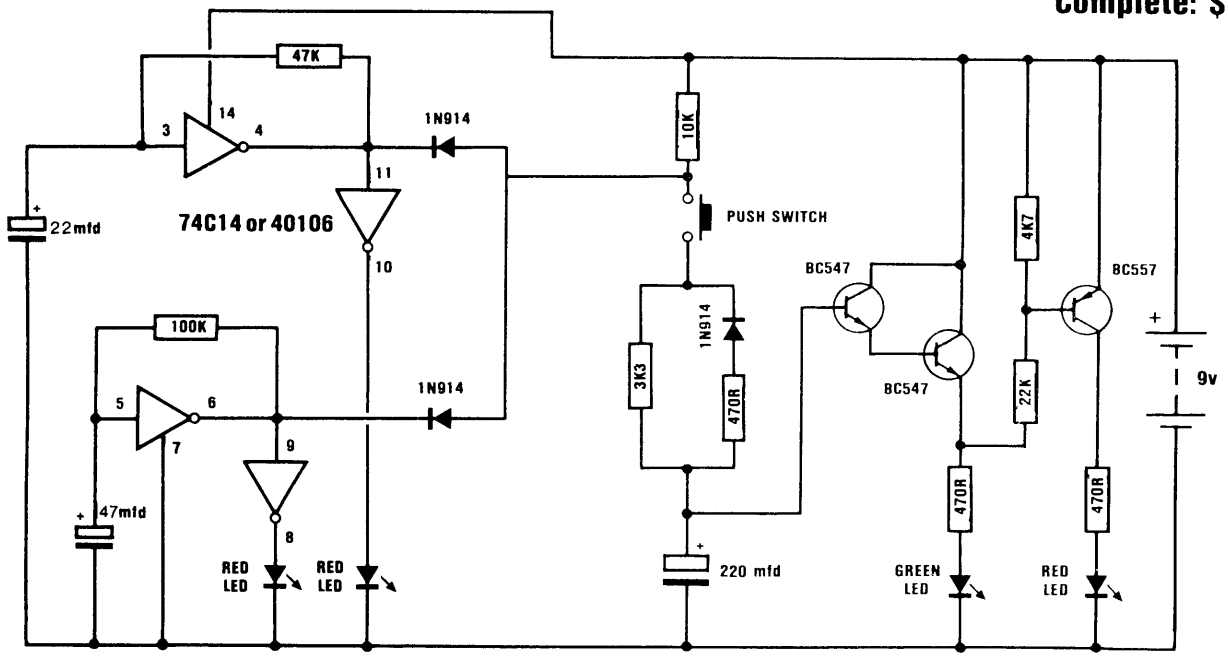


Fig. 9. A SATURATED transistor.

CO-ORDINATOR

A GAME OF SKILL AND PATIENCE

Kit of parts: $5.75
PC Board: $2.50
Complete: $7.95



CO-ORDINATOR CIRCUIT

Co-ordinator is a game of skill. It tests your reaction time and patience.

Patience because a certain condition appears only every few seconds and it corresponds to both indicator LEDs being OFF.

When the two LEDs are off, you must press the button and this supplies a little energy to a reservoir electrolytic. The voltage on this electro is detected by a high impedance amplifier and the result is shown on a "LED-pair". As the voltage rises, one of the LEDs in this pair gradually dims and its brightness is transferred to a LED of opposite colour.

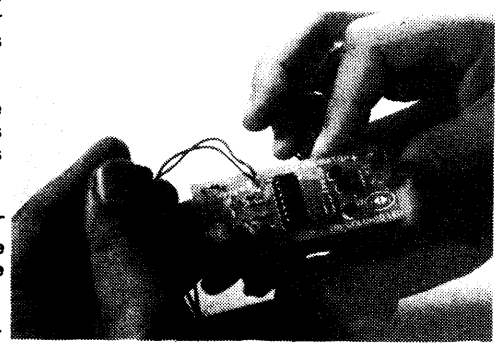
This process is very gradual and may take up to 20 or 30 pushes. But if your timing is out, all the achievement of these presses will be lost to the discharge circuit.

The time when it is safe to press and NOT press, is very abrupt and you have to be very careful not to extend into the "forbidden" zone.

The circuit consists of four sections or 'building blocks' and by describing each of these fully, we cover the complete circuit.

The first building block is the low-frequency oscillator, of which there are two. Each oscillator operates independently and its rate of flash is indicated on a LED. The LED is buffered by an inverter for one very important reason.

The voltage across a LED will not rise above about 1.7v (for a red LED) and if it were connected directly to the output of the oscillator, it would stop it from operating. This is because the output must rise to more than 66% of the rail voltage so that the input can detect a HIGH and change state, due to the function of the feedback resistor. The operation of this type of circuit has been covered in ELECTRONICS Stage-1, pages 77 and 78.



Colin playing with the Co-Ordinator. It's more difficult than you think to get the green LED to turn on fully.

The value of the timing components is not very critical and you will see one set is about half the value of the other. This gives a flash rate of about 4:1 and means the two output LEDs are both OFF for a very small fraction of the time.

The next block is the GATE, made up of two signal diodes and 10k resistor. This forms an AND gate and operates as follows: The circuit requires a HIGH on the end of the 10k resistor to charge the reservoir electrolytic and this is available ONLY when the cathode end of both diodes is HIGH.

This condition corresponds to both LEDs being OFF and thus the circuit is designed around the OFF state.

When the output of both oscillators is HIGH, the charging path for the electrolytic is via the 10k and 3k3 resistors and during the short period of time when this occurs, the button should be pressed. When either oscillator goes LOW, it brings the discharge path into operation.

The discharge path is made up of a 470R resistor and signal diode. This path has a much lower impedance than the charge path (the 3k3 resistor) and thus most of the good work done during the charging will be removed very quickly by one false move.

During charging, the diode (in series with the 470R) forms a 'blocking' effect and does not play any part in the charging.

Next we come to the high impedance 'detector' circuit. It is actually an emitter follower arrangement, designed to turn ON one of the indicator LEDs.

The question we ask is "Why use two piggy-backed transistors?"

In simple terms, the answer is to keep the LED illuminated between presses of the switch. This block is a good example of how a transistor operates. It shows that a current is required by the base, for it to supply collector-emitter current.

If we remove the top transistor, and connect the base of the lower to the electrolytic, the LED would gradually dim between pushes of the switch. This is because the base requires current for the transistor to operate the LED and it would draw on the electrolytic for this energy. The voltage on the electrolytic would gradually fall and the effect would be lost.

By placing another transistor as shown in the circuit, the current for the lower transistor is obtained from the positive power rail and thus the current drawn from the electrolytic is reduced by as much as 1/200 - 1/300th.

This circuit is called a SUPER ALPHA pair because the the alpha (or gain) of the transistors are multiplied together to produce an arrangement similar to a single transistor with enormous gain.

The output of this stage is also taken to another stage which is called a common-emitter arrangement (for a PNP transistor) in which the load is in the collector. This stage produces an effect which is opposite to the previous so that when one is OFF, the other is ON.

This is the entire circuit. It consists of one chip, 3 transistors, 4 indicating LEDs and a few passive components.

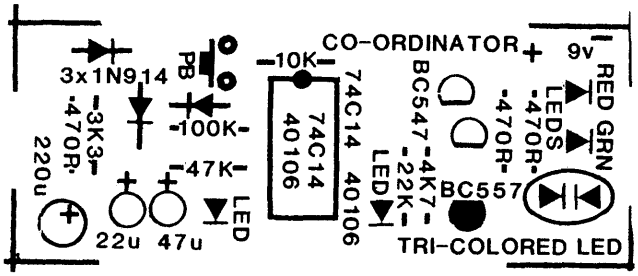
The circuit is supplied by a 9v battery and is designed to accept a tri-coloured LED or a red and green LED in the output.

Building the project will help you understand the circuit a lot more, especially if you come across a small difficulty which you solve yourself.

ASSEMBLY

Begin construction with the smallest components. They are easiest to fit when no other parts are on the board. Begin at one end and fit the 3 diodes and 9 resistors.

The overlay for Co-ordinator shows the positioning for all the components. You can use either a tri-coloured LED or a red LED and green LED. Note: the prototype in the photo below uses 5mm LEDs throughout, however the parts list suggests 3mm LEDs for the flashing indicators.



The 3 diodes must be fitted so that the cathode end (as indicated by a black band around one end) goes over the 'bar' shown on the overlay.

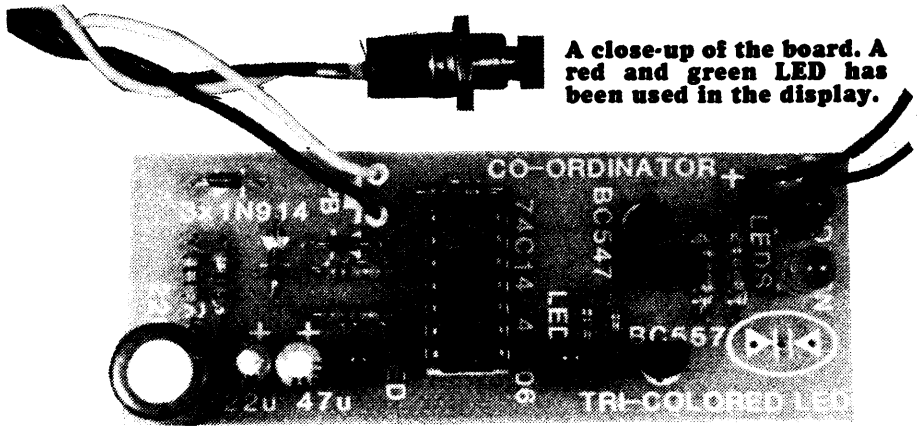
Next fit the 3 transistors. Two are NPN types and will be BC 546, BC 547 or BC 548. The other transistor is PNP and will be either BC 556, BC 557 or BC 558.

After this we fit the 4 LEDs. The two mini LEDs are 3mm types and the cathode lead must be inserted near the edge of the board. You have a choice of readout. It can be either a 5mm red and green LED or a single tri-coloured LED. Either of these arrangements can be fitted to the board. But NOT both.

Fit the IC socket so that pin 1 identification is towards the top of the board. This makes it easier to insert the IC correctly, after all the other components have been fitted. Solder the 3 electrolytics so that the positive leads go down the holes as marked on the board. The positive leads are generally the longer ones.

Mount the push switch on leads about 10cm long and solder them to the board at locations marked 'PB'.

Finally add the battery snap, push the IC into the socket and the project is ready for testing.



A close-up of the board. A red and green LED has been used in the display.

PARTS LIST

3 - 470R ¼watt
1 - 3k3
1 - 4k7
1 - 10k
1 - 22k
1 - 47k
1 - 100k

1 - 22uF 16v electro
1 - 47uF 16v electro
1 - 220uF 16v electro

3 - 1N 4148 diode
2 - BC 547 transistors
1 - BC 557 transistor
2 - 3mm red LEDs
1 - 5mm red LED
1 - 5mm green LED

1 - 74C14 or 40106 IC

1 - Push button
1 - Battery snap

1 - 14 pin IC socket

20cm Hook-up flex

1 - CO-ORDINATOR PC

TESTING

When the power is applied, the two 3mm LEDs should illuminate with random flashing and the red output LED should come on.

The LEDs are controlled by three separate sections of the circuit and if any do not work, you can go directly to the section responsible.

If the left-hand mini LED does not flash, the circuit components to check are: the 47k resistor and 47uF electroytic. If the right-hand mini LED does not flash, the 22k and 22uF electrolytic should be checked. The fault could also lie in the chip.

If the 5mm red LED does not come on, the fault will lie in the BC 557 and/or biasing components, comprising the 4k7, 22k, 470R and the green LED.

Try all your friends with the co-ordinator. Those who play video games will have a very good sense of judgement and will get the LEDs to change illumination without much difficulty.

There is a secret way of getting the circuit to charge the electrolytic without the need for any skill. We call it the test mode but you can call it the 'cheats' mode.

It consists of placing a diode across the switch so that the cathode faces the 3k3 resistor.

In this mode, the electrolytic will charge every time the outputs are HIGH (via the 10k and 3k3 resistors) and will not discharge when the outputs are LOW. And you don't have to push the switch!

I hope you enjoy this project and take advantage of the diode 'trick' to impress your friends!

SHOP TALK

No matter how long it takes to get an issue out, you can't say it's not worth waiting for. We have been waiting nearly 8 months for this issue. Let's hope the next is quicker.

As we get a little more streamlined and better organised, we have come to the decision that we can bring out a publication every three months.

At least that's the intention. A quarterly publication sounds acceptable and is within our capabilities.

As you can imagine, a magazine which doesn't have any advertising takes much longer to produce. It's very easy to slap together an issue which has 60% advertising and only 40% editorial.

And if the editorial is purely written copy, the task is even easier. Written copy is very easy to produce and although it may sound impressive, a good writer can churn out two or three pages in a day. It's when it comes to diagrams, photos and technical matter that the pace slows down.

Some of the pages, such as the programs for the Microcomp, represent 20 to 30 hours per page and it's nothing to see only 6 pages after a month's hard work. Maybe we aren't very fast but the daily requirements of running the business slows down the progress.

Because we have set our goals very high, we have suffered enormously. It has been our intention to keep the magazine relatively free of advertising and especially avoid breaking up the articles with meaningless ads. By this I mean the ones which tell you nothing about the product. Like lists of products and services, which never vary from one issue to the next. These are not my idea of excitement!

The other requirement is a regular publishing schedule. Up to now the issues have been released only when all the projects are tested and finalised.

Reader's don't want this. They want a monthly or bi-monthly journal or at least a known publishing date.

To this end we have decided upon a quarterly schedule and since we have a lot of projects ready for inclusion, we can see ourselves being very busy for many issues to come.

★★★★★★★

I think every person and every business gets hit with a shoddy purchase or workmanship at some time in their life and if we aired our grievences every time something went wrong, nothing would be bought.

But to know about someone elses bad dealings can be invaluable. It may save you falling into the same trap.

We hear about the extremes, from the man who sued an Australian match company for failing to suppy 50 matches in the match-boxes, to the scrap metal dealer who was duped out of thousands of dollars by a con man offering to sell the Eiffel Tower for scrap!

Thousands of people are being tricked every day; paying for goods and never receiving them.

The prospective swimming pool owner who paid $6,000 for a luxury pool and is still waiting for the hole to be dug, one year after paying the full price! Or the hundreds of Queensland farmers who paid for an electronic scarecrow which has yet to be delivered. And doesn't work anyway!!

With all this prior knowledge, we pride ourselves in knowing not to pay before delivery and thoroughly research a product before signing on the dotted line.

With this in mind, we offer you our latest lesson:

THE COPIER THAT DIDN'T COPY.

Every month we get deluged with advertising literature for photocopiers.

After doing without, for a number of years, we decided to invest in one.

One thing we have learnt in the past is the need to buy a well-known brand. Without the backing of a reputable firm you could be in serious trouble in a few years, if repairs were required.

The sales pitch we were given in the leaflets and from phone calls we made was the enormous reliability of modern photo-copiers and the low cost per copy. Also the copy quality rivalled off-set printing and thus for runs up to 100 or so, a photocopier was the answer.

Obviously one-offs were exclusively the relm of the copier.

After researching the field thoroughly we decided upon a C - - - - model 120. We cannot print the name but if you ring us, we will let you know. We asked every question in the book before signing on the dotted line - except one. The guarantee. Later we found out it was ONE MONTH!

When you consider how many photo-copies an average office makes in one month, it represents about 1 to 2 hours of operation!

Imagine if you sold a TV and quoted a guarantee of one hour!!

The management's answer to this was "The copier is only partly electronic and partly mechanical - you cannot compare the two."

You may not be able to compare the two but ONE MONTH is an indication of the faith they have in their product.

Within the guarantee period we were told the machine would be adjusted free of charge and so, within the 30 days, we phoned for a final adjustment.

This was duely done and had I not been present, we would have been charged $45.00 for the call. Only under insistence did the serviceman ring his superior and cancel the invoice.

Throughout the next weeks and months the copy quality gradually deterioriated until one day JET-BLACK copies emerged.

Fortunately the service centre is just down the road and I hopped into my car and called into the 'Serviceman's Club Rooms.'

At first they said point-blank that I needed a service call and would not help me any way at all. When I said I had adjusted some of the controls and made no improvement, they started rambling on with the most amazing load of rubbish about what could be the cause.

After about 10 minutes I could see I wasn't getting anywhere and decided to go back home and call head office.

Getting past the 'front desk' was a feat in itself and to get a feasible explanation to the fault was way beyond the scope of any of the personnel.

In desperation I took the front cover off the copier and was confronted with a series of pots - none of which were identified and it was only by remembering the controls touched by the previous serviceman, that we got any clue at all.

Even full adjustment of each and every control produced little better than an extremely dark copy.

Accepting defeat I rang for a service call.

Quite soon we had the pleasure of a smartly dressed servicememan who saw the name TALKING ELECTRONICS on the door and thought "What a load of twits - I'll fix this!

Faster than a rabbit down a hole, he had the cover glass off the machine and was merrily polishing the plate and lens system. Next he went to the corona wires and made them sing like a single string violin.

The excess toner container had a little in it and he promptly and eagerly dumped it onto a sheet of paper and wrapped the whole thing up like a 3 week old baby.

Then came the master's touch. He made a photocopy. Black as ink. Off came the cover. Fiddle, fiddle. Another copy. Black as ink. Out came the manual. Fiddle, fiddle. Another copy. Black again!

By now his quick, efficient antics had slowed and he made his first utterance: "I think the drum's gone." "Drums are on a pro-rata basis and a new one will cost xxx dollars.

Knowing I wouldn't be contributing a cent, I said "Go ahead." Half an hour later he had a new drum fitted and made a copy. Black as ever.

Now the chips were down. He wasn't as smart as he thought and started to talk to us.

I can't remember what he did next but about half an hour later he had changed the fluorescent tube which scans the page. Instant success. Copies came out perfectly.

It took about 30 minutes to replace the drum and adjust all the controls back to normal.

My point is this. Why did it take one hour and forty five minutes to locate the fault and then be charged nearly $100 for the job?

When you call the manufacturer you expect the get expert service. Not to have someone learning at your expense.

Repairs are one of the hidden costs when operating a piece of sophisticated equipment and especially when a firm has a monopoly on servicing.

There is absolutely nothing you can do. If we refused to pay the bill, the serviceman said we would be black banned.

The story doesn't end here. There's a little more.

At the time when the tube was replaced, we asked about some streaks down the page. The reply was the toner roller was worn and would cost about $120 to replace. He didn't look at the offending part and made no mention that it could be repaired.

At $120 we wern't interested and let the stripes remain.

Gradually these got worse and when it came to the time when an important photocopy was required, I decided to look into the fault.

To my amazement the toner roller assembly came away via a couple of screws and two clips.

Upon inspection I noted some of the powder had hardened and built up on the magnetic roller. A little solvent and some hard rubbing removed all signs of the build-up and when it went together, the copies were perfect.

Keeping quiet as to the remedy, I phoned the manufacturer and asked about the fault. I could get absolutely no further than 'a service call was necessary'.

Again I ask. Why didn't I get any assistance from either the servicemen or the service department?

If our experience is any indication of the treatment being offered by multi-national companies, it's no wonder they have a team of servicemen in each district.

If you are in the market to buy a copier, remember us. By the time you buy a machine, fill it with paper, toner and cough up for a few service calls, you will be better off going to the local chemist or library and paying 10c per copy!

THE POST OFFICE . . .

Some people wonder why I am so critical of the Post Office.

They want me to be "all smiles and jovial" when taking the packets of mail and bags of publications to the counter.

But I have been around longer than most of them and seen an enormous decline in the service and an alarming increase in the ignorance towards the dissemination of the printed word.

I have seen postal rates increase from ½c per item to 30c per item in a period of time when wages have increased only about 400%. All along, the Post Office has maintained that the distribution of registered publications has been a LOSING proposition and with this they have increased the rates to an extent that they are choking the Australian publisher out of business.

Do you realize it costs more to post a magazine than to have it printed!!Quite a rediculous situation.

But there is nothing more absurd than the reasoning and intelligence of the personnel behind the decisions in the marketing and pricing sections of the Aust Post Monolopy.

For the privilege of getting reduced rates for registered publications, they charge a $36.00 application fee each year! But the final straw broke last week when a parcel of publications cost MORE than a normal postal article. In fact to post large quantities of magazines interstate costs exactly the same as normal rates.

So much for the understanding of the spread of information.

For a face-to-face discussion over some of the anomolies I had the pleasure of seeing the Field Manager for our local area. After a few attempts to explain the why's and wherefore's of how the prices were generated, he came up with a comment that absolutely floored me.

"I don't see why you publishers should get cheaper rates anyway," he said.

Can you imagine how I reacted! With a certain amount of cool I said, "Do you read a lot?"
"No."
"Do you get any journals?" "No."

If this type of reasoning prevails in our glorious Post Office administration, heaven help us in the future. They have already tried to squeeze the most out of the long-suffering customer, now they want to cripple him completely.

The Post Office has already lost many large contracts and they are in peril of losing many more.

They answer this with "some you lose, some you win," sort of attitude.

There are two further requirements of the Post Office for registered publications but they are so absurd you will only laugh.

I'll finish now, while I'm still smiling and leave you with some of the inside workings of our largest national monument.

Oh, by the way, I'M not allowed to sign the Editorial. They rang me 2 years ago and wasted half an hour of my time over this blatent disregard of the rules! You will notice I don't sign it any more. Take a look. See. I don't sign it any more. Aren't we obedient.

Last week we got a long letter to say the publication number must appear on the cover of the magazine. I don't want the cover filled up with junk inscriptions like this. But, as you know what bureaucracy can do, we have regretfully added the wording.

When you get this magazine, consider it a great privilege the Aust Post has condescended to handling it!

CAUTION for NZ READERS:

While on the topic of letting you know what and how we think, I must relay the dissatisfaction readers have had with one or more of the New Zealand suppliers as recommended in previous issues.

I have recieved nothing but complaints from our readers. The following excerpts from a letter is typical:

"I rote to the PC board supplier as suggested by you (NZ firm) for a TEC board and waited nearly 6 months! When it finally arrived the board had no overlay and no solder mask, even though it was the same price as if ordered from TE. It was really home-made!'

We have seen similar results from boards made in NSW. It had no overlay, no solder mask and no roll tinning! In fact it wasn't worth buying! If you compare ours to theirs, you will know what we mean.

Back to the NZ reader. After getting the board and sending for parts, it failed to work. So he rang us and asked if we could help. We said the TEC could be sent in for repair and it would be returned the same day. After picking himself up off the floor, he said he would do just that.

A few days later it arrived and was repaired. (I can't remember the fault). He rang to say he got it 3 days later and couldn't believe the service.

I don't like canning any firm but the NZ firms we recommended in previous issues have certainly not lived up to expectations.

I would be pleased to hear from them and get their side of the story.

cont. P.51.

. . . from P.20.

PHONE DIALLER Part III

EXPERIMENTING FURTHER

Phone dialler part III took about one week of part-time effort for Colin to write (He's not very quick!) and has been tidied and closed up for publication.

However there are a number of improvements that can be made to the program (apart from the auto re-dial extension). For instance, the first byte in the number table is not used and can be deleated, the **CP 0A** instruction at **09C6** is not valid, and a few others.

The six middle locations are used by the SCAN routine for displaying data onto the screen. The 7 arrows under the locations show how the data is shifted from one location to the next via the SHIFT routine. Locations **0A80** to **0A86** are the ones cleared by the CLEAR routine to blank the display.

The diagram below shows how the DISPLAY BUFFER operates.

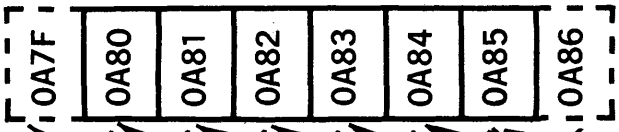


Diagram showing the DISPLAY area, the SHIFT procedure and address for NEW DATA.

NEW DATA

These will be your challenge and at the same time see how you can simplify the program by using higher level commands. If you can't, don't worry. Programs in the next issue will be at a higher level and will use logic operations to create the same result with fewer instructions.

New data is inserted at **0A85** and this location is cleared via the SHIFT routine prior to a value being inserted (refer to SHIFT on P. 18). This prevents rubbish being shifted into the location from **0A86** as this would appear on the screen as brief flashes of junk.

SCROLL

LD A,FF	09C0	3E FF	Load A with **FF** and transfer to the I register to detect
LD I,A	09C2	ED 47	when a key has been pressed.
LD A,I	09C4	ED 57	Look to see if a key has been pressed by comparing
CP 0A	09C6	FE 0A	the accumulator with **0E.** Return if the accumulator
NOP	09C8	00	is **0E.**
CP 0E	09C9	FE 0E	
RET Z	09CB	C8	
LD A,(HL)	09CC	7E	Load the value pointed to by HL into the accumulator.
LD D,20	09CD	16 20	Load D with a short delay value (for below.)
INC HL	09CF	23	Increment to the next location.
CP 10	09D0	FE 10	Look to see if end of table reached.
RET Z	09D2	C8	Return if end reached.
LD (0A85),A	09D3	32 85 0A	Load the byte of the table into the display buffer.
CALL SCAN	09D6	CD 80 09	Call SCAN for 32 loops (as determined by the D
DEC D	09D9	15	register.
JR NZ,09D6	09DA	20 FA	
CALL SHIFT	09DC	CD E1 09	Call SHIFT.
JR 09C4	09DF	18 E3	Jump to the start of the sub-routine.

SHIFT

LD B,07	09E1	06 07	Load B with 7.
LD IX,0A7F	09E3	DD 21 7F 0A	Load IX with location one lower than display buffer.
LD A,(IX + 01)	09E7	DD 7E 01	Load A with the value in the display buffer and transfer
LD (IX + 00),A	09EA	DD 77 00	it to the next lower location.
INC IX	09ED	DD 23	Increment the IX register.
DEC B	09EF	05	Dec B.
JR NZ,09E7	09F0	20 F5	and jump to above for 7 loops
RETURN	09F2	C9	Return.

at 0A00:

DISPLAY TABLE:

0 =	EB
1 =	28
2 =	CD
3 =	AD
4 =	2E
5 =	A7
6 =	E7
7 =	29
8 =	EF
9 =	AF
0 =	EB

The alphabet table on the right is used to produce the letters for the name. Two key presses are required for each letter.

The display table on the left is used by the program to produce the digits of the phone number. These hex vlaues can also be used in conjunction with the alphabet table if you want a digit to appear in the NAME.

A = 6F	N = 6B
B = E6	O = EB
C = C3	P = 4F
D = EC	Q = 3F
E = C7	R = 44
F = 47	S = A7
G = E3	T = 46
H = 6E	U = EA
I = 28	V = E0
J = E8	W = E1
K = 67	X = 26
L = C2	Y = AE
M = 65	Z = C9

at 0A0C:

E	C7
N	6B
T	46
E	C7
R	44
	00
I	28
N	6B
D	EC
E	C7
X	26
	00
N	6B
o	E4
	00
0	EB
0	EB
.	04
3	AD
6	E7
	00
P	4F
R	44
E	C7
S	A7
S	A7
	00
E	C7
	00
	00
	0
	00
10	10

at 0A2C:

	00
E	C7
N	6B
T	46
E	C7
R	44
	00
N	6B
A	6F
M	65
E	C7
	00
E	C7
N	6B
T	46
E	C7
R	44
	00
F	47
	00
E	C7
N	6B
T	46
E	C7
R	44
	00
P	4F
H	6E
O	EB
N	6B
E	C7
	00
N	6B
o	E4
	00
T	46
H	6E
E	C7
N	6B
	00
E	C7
	00

S	A7
P	4F
A	6F
C	C3
E	C7
=	84
F	47
	00
C	C3
L	C2
E	C7
A	6F
R	44
=	84
C	C3
	00
R	44
E	C7
T	46
U	EA
R	44
N	6B
=	84
A	6F
	00
D	EC
I	28
A	6F
L	C2
=	84
D	EC
	00
E	C7
N	6B
D	EC
=	84
E	C7
	00
	00
	00
	00
10	10

VIC-20 MAGAZINE

A letter from Cris Groenhout, Editor VIC-20 Magazine.

Despite the commercial demise of the very popular Commodore VIC-20 Colour Computer, there is still a great number of enthusiastic users remaining with absolutely no intention of disposing of their equipment. So, to support this large group of users, we have recently decided to continue publishing the Association's magazine 'VIC'.

'VIC' is now in its third year of publication with 16 bi-monthly issues under its belt. The magazine sells to subscribers and retail customers for $2.00, a price which, compared to similar magazines, is very low. The magazine is also entirely dedicated to the VIC computer with no advertising and very little space tied up by news, letters, etc.

The association also distributes public domain software for a small copying fee and maintains a library of about 900 programs. There are also a number of other services and if you are interested in more information, write to Cris, at 25 Kerferd St., Watson, ACT, 2602. Tel: (062) 412 316, and enclose 2 stamps for return postage.

SPECIAL!

STARTER PACK . . .
$40 VALUE FOR $28!!
Including Postage and Packing.

$28! VALUE!!

HURRY!! Only 40 Packs left!!

To get you started in electronics, we have arranged for special STARTER PACKS to be produced for readers of this issue. These packs represent extremely good value and will be ideal for the beginner, hobbyist and for school projects.

Each pack contains over $40 worth of books, parts and kits and costs just $28!! This includes post and packing!

The following is a list of the contents of the packs and you can make up your own pack by ticking the boxes of your choice. Otherwise we will make up a pack and send it to you.

Any items you already have, may be deleted from the list and the amount adjusted accordingly.

The contents of some packs may very slightly as new stock is always arriving and will be included at no extra charge.

Any TWO issues of TALKING ELECTRONICS: value: $2.50

- ☐ Issue 1
- ☐ Issue 2
- ☐ Issue 3
- ☐ Issue 4
- ~~☐ Issue 5~~

Any ONE issue of TALKING ELECTRONICS: Value: $4.00

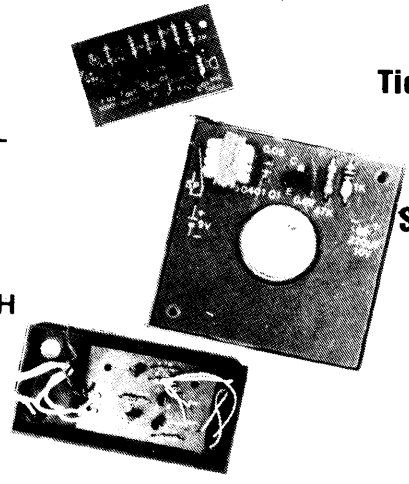
- ☐ Issue 6
- ☐ Issue 7
- ☐ Issue 8
- ☐ Issue 9
- ☐ Issue 10
- ☐ Issue 11
- ☐ Issue 12
- ☐ CMOS DATA BOOK

Choose ONE of these: Value: $3.00

- ☐ DIGITAL ELECTRONICS Revealed
- ☐ ELECTRONICS for MODEL RAILWAYS

Any TWO electronics kits from this list: value: $9

- ☐ MAGIC TOUCH
- ☐ FLASHER
- ☐ SLEEPING BELL
- ☐ METRONOME
- ☐ MORSE CODE
- ☐ RAIN ALARM
- ☐ SINGING BIRD
- ☐ TOUCH SWITCH



ONE Project Book from these: value: $4.00

- ☐ Mini Frequency Counter
- ☐ Cover Projects
- ☐ Dual Tracking Power Supply

Pack of Solder value: $1.00

Pack of ELECTRONIC PARTS value $4.00

TWO Printed Circuit Boards value: 4.00

Pack of SEMICONDUCTORS, DIODES, LEDS and IC's value: $4.00

ONE Prototype from our design laboratory - ideal for the parts it contains. . . . . .free.

100 MIXED ¼ WATT RESISTORS Value: $3.00

ONE Blank PC board Value: $1.50
ONE Pack of Hardware parts value: $1.00
ONE JIFFY BOX value: $2.20

Tick the boxes: ☑

Send $28.00 for your STARTER PACK to:

Talking Electronics Pack No 1,
Box 486,
Cheltenham, 3192.

ALL RESISTORS 4¢

☐ 1R	☐ 2k2	☐ 680k
☐ 2R2	☐ 2k7	☐ 820k
☐ 10R	☐ 3k3	☐ 1M
☐ 12R	☐ 3k9	☐ 1M2
☐ 15R	☐ 4k7	☐ 1M5
☐ 18R	☐ 5k6	☐ 2M2
☐ 22R	☐ 6k8	☐ 2M7
☐ 27R	☐ 8k2	☐ 3M3
☐ 33R	☐ 10k	☐ 3M9
☐ 39R	☐ 12k	☐ 4M7
☐ 47R	☐ 15k	☐ 10M
☐ 56R	☐ 18k	
☐ 68R	☐ 22k	
☐ 82R	☐ 27k	
☐ 100R	☐ 33k	
☐ 120R	☐ 39k	
☐ 150R	☐ 47k	
☐ 180R	☐ 56k	
☐ 220R	☐ 68k	
☐ 270R	☐ 82k	
☐ 330R	☐ 100k	
☐ 390R	☐ 120k	
☐ 470R	☐ 150k	
☐ 560R	☐ 180k	
☐ 680R	☐ 220k	
☐ 820R	☐ 270k	
☐ 1k	☐ 330k	
☐ 1k2	☐ 390k	
☐ 1k5	☐ 470k	
☐ 1k8	☐ 560k	

MINI TRIMPOTS 45¢

CAPACITORS

5p6	14¢
27p	14¢
47p	14¢
100p	14¢
220p	14¢
330p	14¢
1n	25¢
2n2	25¢
3n3	25¢
3n9	25¢
4n7	25¢
6n8	25¢
10n	25¢
22n	25¢
39n	25¢
47n	28¢
100n	28¢

ELECTROLYTICS

1u 63v	27¢
2u2 16v	27¢
3u3 16v	27¢
4u7 16v	27¢
10u 16v	27¢
22u 16v	27¢
47u 16v	30¢
100u 16v	45¢
220u 25v	60¢
220u 63v	75¢
470u 25v	70¢
1000u 25v	85¢
1000u 63v	1.70
2200u 25v	2.00

IC'c TTL:

7400	70¢
74LS04	70¢
74LS11	70¢
7420	95¢
7473	1.10
7476	1.10
74LS93	1.20
74123	1.30
74LS138	1.50
74LS273	2.25
74LS367	1.25
74LS373	2.25

CMOS

4001	70¢
4011	70¢
4013	99¢
4015	1.30
4017	1.50
4020	1.80
4024	1.10
4026	2.60
4040	1.80
4046	2.10
4047	2.10
4049	1.50
4051	1.98
4060	1.70
4069	80¢
4071	75¢
5410	2.10
4511	2.10
4514	5.60
4518	1.98
40085 or 74C85	2.95
74C14 or 40106	1.25
74C922	9.50
74C923	10.50
74C926	8.75

LINEAR

LM 380	2.80
LM 383 or TDA 2002	3.00
741	99¢
555	60¢

MICRO IC's

8255	7.50
2102	2.75
6116 (58725)	7.00
2732	7.90
Z-80A	6.50
TEC MONitor ROM	12.00
Microcomp-1 MONitor ROM	12.00
PRINT-2 ROM	10.00
Dedicated MICRO ROM	10.00

VOLTAGE REGULATORS

7805	1.10
7905	1.20
7812	1.10
7815	1.10
7915	1.20
7824	1.10

IC SOCKETS

8 pin	30¢
14 pin	40¢
16 pin	45¢
18 pin	45¢
20 pin	50¢
24 pin	65¢
28 pin	75¢
40 pin	95¢

DIP HEADERS + WIRE WRAP

16 pin dip header	1.80
24 pin dip header	3.50
24 pin wire wrap	2.95
40 pin wire wrap	4.95

SEMICONDUCTORS

1N 914	8¢
1N 4002	9¢
BC 547	20¢
BC 557	20¢
BC 338	32¢
BD 139	80¢
BD 140	80¢
2N 3055	1.30

OPTO DEVICES

3mm RED LED	16¢
3mm Green LED	23¢
3mm Orange LED	28¢
3mm Yellow LED	28¢
5mm Red LED	18¢
5mm Green LED	23¢
5mm Orange LED	28¢
5mm Yellow LED	28¢
LDR	75¢
MEL Photo transistor	1.20
Flashing LED	60¢
TIL 313 com cath display	2.50
FND 560	2.90

MISC COMPONENTS:

FERRIC CHLORIDE	2.25
No 60 drill	1.95
2¼"speaker 8R	2.30
Mini speaker 80R (yes 80R)	2.50
SPDT mini slide switch	45¢
DPDT mini slide switch	60¢
8 way Dip switch	2.40
SPDT relays 1 amp rating	2.50
SPDT relay 3 amp rating	3.15
DPDT relay 1 amp rating	3.50
Mini U heatsink	90¢
TO-3 Heatsink	2.25
Battery snaps (9v)	25¢
Push Switch	55¢
PC-mount push switch	80¢
Solder 200gm spool	6.50
De-solder braid	2.45
Tinner copper wire 100gm spool	3.75
20 Transistors 10 BC547, 10 BC557	3.40
100 transistors 50 BC 547, 50 BC 557	14.00
50 assorted LED's	8.00
Resistor pack. 300 resistors	5.95
Greencap pack 50 greencaps	5.95
Ceramic pack 100 ceramics	5.95
Electrolytic pack 40 electro's	5.95

EXPERIMENTER PARTS Co.,
P.O. Box 334, Moorabbin, Vic. 3189.

Total enclosed: $_____
Pack & Post: $2.00

SUMMARY

THE FLIP FLOP FORMS THE BASIC ELEMENT OF THE SEQUENTIAL LOGIC CIRCUIT. THIS IS AN EXTREMELY VALUABLE BUILDING BLOCK AS IT POSSESSES:

1. MEMORY CAPABILITY
2. A DIVIDE BY TWO FEATURE

FLIP FLOPS CAN ALSO BE CALLED LATCHES, DIVIDERS OR MULTIVIBRATORS, DEPENDING ON HOW THEY ARE WIRED INTO A CIRCUIT.

THE MOST BASIC FLIP FLOP IS CALLED THE R-S FLIP FLOP. IT HAS 2 INPUTS CALLED S FOR SET & R FOR RESET. THE ONLY OTHER LINES ARE THE OUTPUT LINES. THESE ARE LABELED Q FOR THE NORMAL OUTPUT AND $\overline{Q}$ (Q-BAR) FOR THE COMPLEMENTARY OUTPUT.

WHEN THE NORMAL OUTPUT IS HIGH, THE FLIP FLOP IS SAID TO BE SET. WHEN THE NORMAL OUTPUT IS LOW THE FLIP FLOP IS SAID TO BE RESET.

FLIP FLOPS NORMALLY HOLD DATA FOR A SHORT PERIOD OF TIME & THE R-S FLIP FLOP IS OFTEN CALLED AN R-S LATCH.

BUT THE R-S FLIP FLOP SUFFERS FROM ONE LIMITATION. IF BOTH INPUTS ARE HELD LOW, THE OUTPUTS BOTH BECOME HIGH. THIS PRODUCES AN UNDESIRABLE RESULT AND THIS STATE MUST NOT BE ALLOWED TO OCCUR.

THE RESET-SET FLIP FLOP CAN BE USED TO DEBOUNCE A MECHANICAL SWITCH OR STORE DATA. IT IS AN ASYNCHRONOUS DEVICE AS THE OUTPUT CHANGES IMMEDIATELY THE INPUTS ARE ACTIVATED.

TO ACHIEVE A TIMING CONDITION A CLOCKED R-S FLIP FLOP HAS BEEN PRODUCED. THE INCLUSION OF A CLOCK LINE MEANS THE FLIP FLOP WILL NOT CHANGE UNTIL THE ARRIVAL OF THE CLOCK PULSE. — IT OPERATES SYNCHRONOUSLY.
HOWEVER IT DOES POSSESS AN UNDESIRABLE OR PROHIBITED STATE WHERE BOTH OUTPUTS GO HIGH. TO OVERCOME THIS CONDITION A "D" LATCH HAS BEEN PRODUCED. THE D FLIP FLOP HAS AN INVERTER FITTED TO THE RESET LINE & FEEDS FROM THE SET LINE SO THAT THE TWO INPUTS ARE ALWAYS OUT-OF-PHASE.

AT THE TOP OF THE RANGE IS THE J-K FLIP FLOP. IT OVERCOMES ALL THE LIMITATIONS OF THE PREVIOUS TYPES HOWEVER IT IS COMPLEX AND EXPENSIVE AND IS GENERALLY USED ONLY WHEN REQUIRED.

IT IS CAPABLE OF PERFORMING ALL THE OPERATIONS OF THE SIMPLER TYPES, AND MORE.

DEPENDING ON THE STATE OF THE INPUTS, THE OUTPUTS WILL PRODUCE 4 DIFFERENT EFFECTS:

1. FREEZE.
2. REMAIN OR CHANGE TO SET. CONDITION
3. " " " " RESET CONDITION.
4. TOGGLE.

THE TOGGLE FEATURE CAN BE USED TO PRODUCE A DIVIDE-BY-2 STAGE AND THE FLIP FLOP CAN BE CASCADED TO PRODUCE LONG LINES OF DIVISION STAGES. THESE SOON BECOME EFFECTIVE. WITH 7 STAGES THE DIVISION IS 128 AND 12 STAGES PRODUCES A DIVIDE-BY-4096 COUNTER.

THIS IS THE TOPIC FOR THE NEXT SECTION.

QUIZ:

1. WHEN A LATCH IS STORING A BINARY 1 IT IS IN THE ____ (SET, RESET) MODE.

2. DRAW THE BLOCK DIAGRAM FOR AN R-S FLIP FLOP.

3. IF A FLIP FLOP IS RESET THE $\overline{Q}$ OUTPUT IS ____ (HIGH, LOW)

4. THE NORMAL OUTPUT OF A FLIP FLOP IS Q, $\overline{Q}$ ____.

5. FOR AN ACTIVE LOW R-S FLIP FLOP, SUPPLYING THE R LINE WITH A _____ (HIGH, LOW) WILL _____ (CLEAR, SET) THE Q OUTPUT TO A _____ (0, 1)

6. ASSUME AN R-S LATCH IS SET. A LOW TO THE S INPUT WILL:
   (a) DO NOTHING.
   (b) CHANGE THE FLIP FLOP TO RESET.

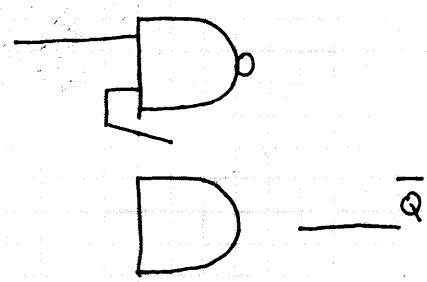
7. BOTH INPUTS OF A NOR LATCH ARE HIGH. THE STATE OF THE LATCH IS:
   (a) SET
   (b) RESET
   (c) UNDESIRABLE OR PROHIBITED
   (d) CAN'T TELL, NOT ENOUGH INFORMATION

8. WHEN THE NAND LATCH IS IN THE "LIMBO" CONDITION BOTH OUTPUTS WILL BE: _____ (HIGH, LOW)

9. Q & $\overline{Q}$ OUTPUTS SHOULD ALWAYS BE:
   (a) THE SAME
   (b) LOW
   (c) HIGH
   (d) COMPLEMENTARY.

10. STATE 2 USES FOR A LATCH:

11. COMPLETE THIS DIAGRAM OF A NAND GATE LATCH.



12. A FLIP FLOP OPERATING IN STEP WITH A CLOCK IS SAID TO BE OPERATING:
   (a) SYNCHRONOUSLY.
   (b) ASYNCHRONOUSLY.

13. WHAT DOES "R-S" STAND FOR?

14. DRAW THE BLOCK DIAGRAM FOR A CLOCKED R-S FLIP FLOP:

15. A CLOCKED R-S FLIP FLOP OPERATES:
(a) ASYNCHRONOUSLY.
(b) SYNCHRONOUSLY.

16. THE Q OUTPUT IS HIGH WHEN THE CLOCK IS ____ (HIGH, LOW) & THE SET OUTPUT IS ____ (HIGH, LOW) & THE RESET LINE IS ____ (HIGH, LOW)

17. THE $\overline{Q}$ OUTPUT OF A D FLIP FLOP IS LOW. THE FLIP FLOP IS SAID TO BE IN THE ____ (SET RESET) STATE.

18. DATA AT THE D INPUT IS TRANSFERRED TO THE Q OUTPUT ON THE H-TO-L OR L-TO-H ____ TRANSITION OF THE CLOCK PULSE FOR A NAND GATE D FLIP FLOP.

19. FOR A D FLIP FLOP THE S&R LINES ARE ALWAYS:
(a) HIGH
(b) LOW
(c) OUT-OF-PHASE.

20. THE CLOCK LINE DETERMINES THE STATE OF THE FLIP FLOP.
(a) TRUE
(b) FALSE.

21. WHY DOES A D FLIP FLOP HAVE AN INVERTER AT THE INPUT OF ONE LINE?

22. DRAW THE LOGIC SYMBOL FOR A J-K FLIP FLOP:

23. LIST THE 4 SYNCHRONOUS MODES OF OPERATION OF THE J-K FLIP FLOP:
A.
B.
C.
D.

24. THE TWO INTERNAL SECTIONS OF A J-K FLIP FLOP ARE:
(i)
(ii)

25. NAME 2 FLIP FLOPS WHICH HAVE A CLOCK INPUT LINE:
1.
2.

26. THE OUTPUT STATE OF A J-K FLIP FLOP IS DETERMINED BY THE MASTER OR SLAVE LATCH?

27. IF THE $\overline{Q}$ OUTPUT GOES HIGH-LOW-HIGH-LOW, THE FLIP FLOP IS IN WHAT MODE OF OPERATION:
A:

28. A J-K FLIP FLOP IS CAPABLE OF PROVIDING A DIVISION. HOW MANY ARE REQUIRED TO PRODUCE A DIVIDE-BY-32.

29. IF THE J-K INPUTS ARE HIGH. WHAT IS THE MODE?

30. CAN THE J-K FLIP FLOP PRODUCE THE PROHIBITED OR UNDESIRABLE STATE?

ANSWERS:

1. SET. 3. HIGH. 4. Q 5. LOW, CLEAR, 0. 6. (a) 7. (c) 8. LOW 9. (d) 10. MEMORY, DIVISION, DEBOUNCE 12. (a) 13 RESET-SET. 15 (b) 16. HIGH, HIGH, LOW. 17. SET. 18. L TO H. 19. (c) 20 (b) 21. TO PRODUCE OUT OF PHASE S & R LINES. 23. HOLD, SET, RESET, TOGGLE. 24. MASTER LATCH, SLAVE LATCH. 25 D, J-K, CLOCKER R-S. 26. SLAVE. 27. TOGGLE. 28. 5. 29. TOGGLE 30. NO.

25/30 OR HIGHER IS EXCELLENT.

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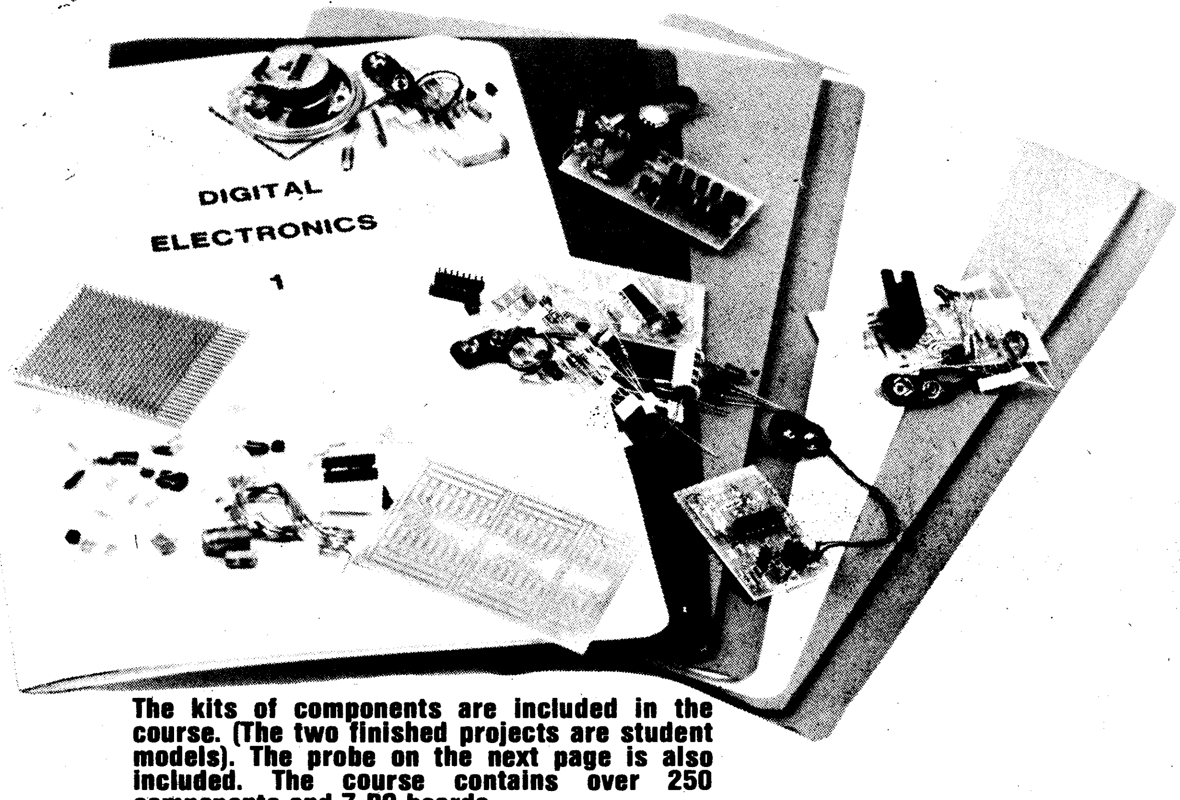
THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL



The kits of components are included in the course. (The two finished projects are student models). The probe on the next page is also included. The course contains over 250 components and 7 PC boards.

The Australian Digital Electronics School course has been very popular from its inception and many of the students who have completed the course have asked for additional lessons.

We are pleased to say a new lesson has now been included.

It is a TTL lesson based on the book **STARTING IN TTL** and includes the Trainer Deck, text book, answer sheets for the questions in the text and a separate test that is sent in to the school for correction. This is lesson number 6 in the course and can be purchased separately for $30.00 incl postage.

As we have mentioned previously, the price of the course has been set to rise for some time and it is now $120.00 for the first 5 lessons or $25.00 per lesson. Lesson 6 is $30.00 incl postage, making the six lesson course $150.00 incl postage.

This course is still far cheaper and the most informative course available on the market and hundreds of successful students can attest to this.

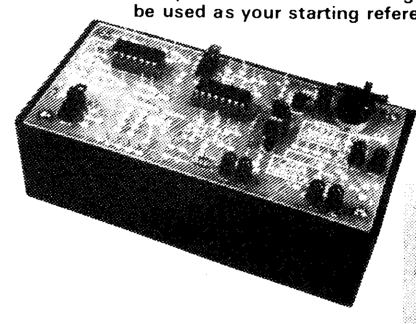
The course starts with a preliminary parts identification and soldering ability test. From there you will be guided through 3 interesting projects of which two are sent into the school for marking. These will be returned and remain your property.

A test accompanies each lesson and these are also sent to the school to be corrected by your instructor.

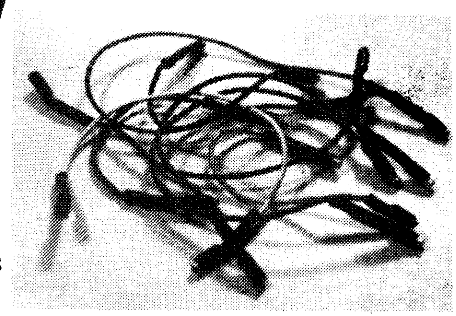
Individual attention will be given to each student and you progress at your own rate. This is the most important aspect of the course. You can repeat any section untill it is fully understood and you can ask for any additional help relevant to the topic.

Don't delay. This may be the turning point for you. You may think you know electronics, but until it is put to the test and you receive an assessment, you may have some incorrect concepts.

The next page contains a sample of the PRELIMINARY TEST that will be sent with the first lesson. You will be asked to answer the questions without seeking any outside assistance as it will be used as your starting reference level.



The TTL Trainer Deck is lesson 6.



20 jumpers for use on the DECK.

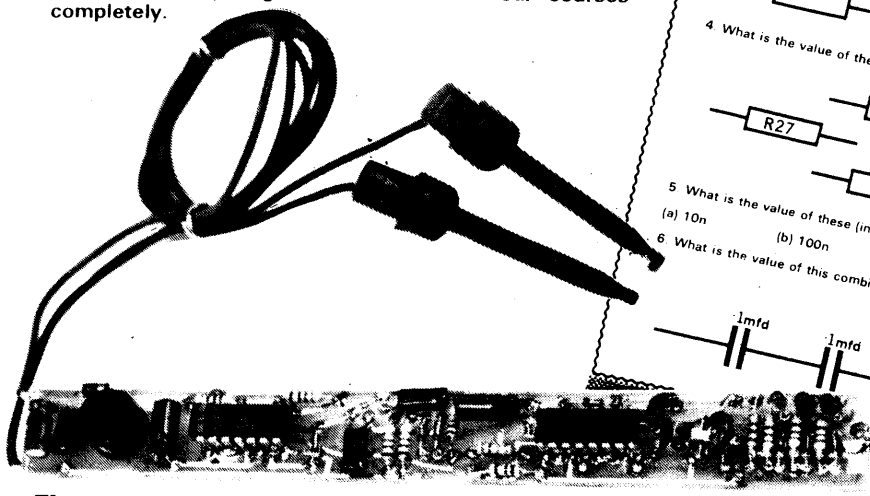
THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL,
Box 334, Moorabbin, Victoria, 3189.

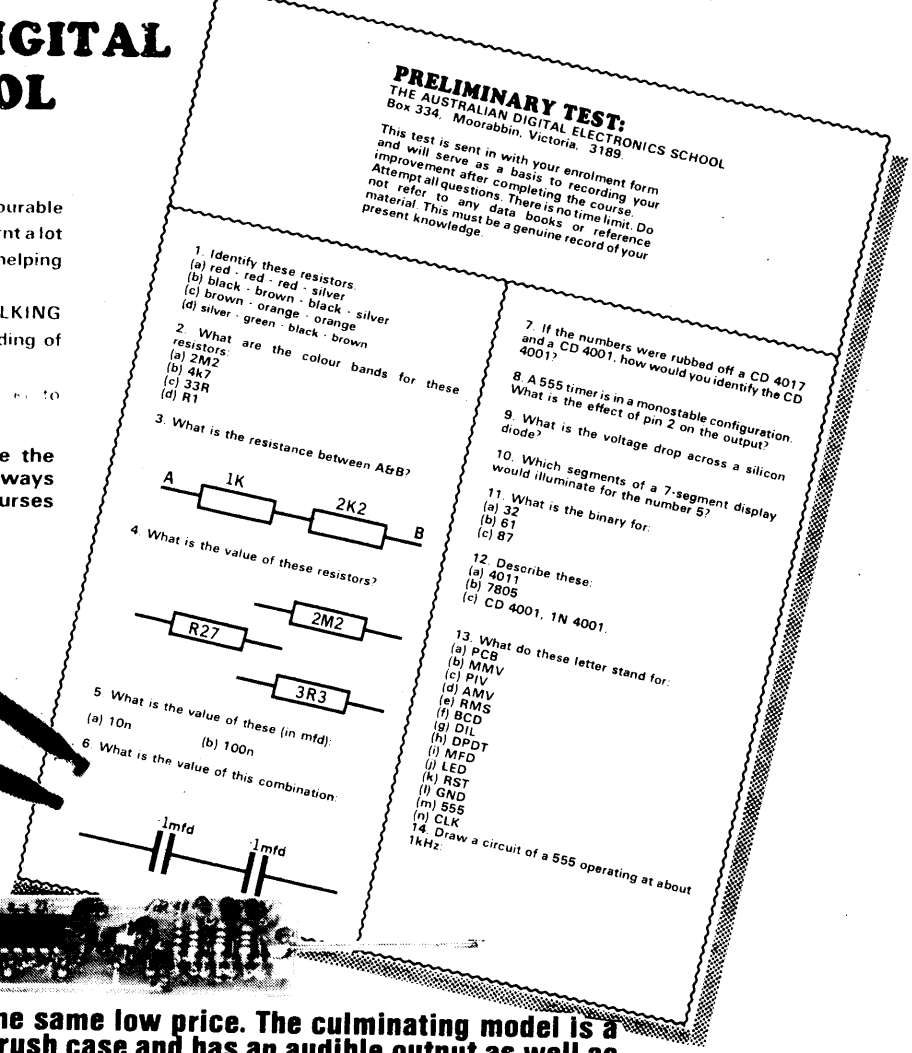
THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL

We have received many letters and favourable comments about the course already. Things like: I've learnt a lot from the first lesson, please send lesson 2, this course is helping me at school I will be able to get a better job now. Another student wrote "It's up to the high standard of TALKING ELECTRONICS and It's given me a new understanding of Digital Electronics.

[illegible] but test yo[illegible] to k[illegible] what you are lo[illegible]

It's so good it's guaranteed. If you don't find the the course is for you, it can be returned for refund. We always guarantee everything because we back our courses completely.





PRELIMINARY TEST:
THE AUSTRALIAN DIGITAL ELECTRONICS SCHOOL
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This test is sent in with your enrolment form and will serve as a basis to recording your improvement after completing the course. There is no time limit. Do not refer to any data books or reference material. This must be a genuine record of your present knowledge.

1. Identify these resistors.
(a) red - red - red - silver
(b) black - brown - black - silver
(c) brown - orange - orange
(d) silver - green - black - brown

2. What are the colour bands for these resistors:
(a) 2M2
(b) 4k7
(c) 33R
(d) R1

3. What is the resistance between A&B?

4. What is the value of these resistors?

5. What is the value of these (in mfd):
(a) 10n (b) 100n

6. What is the value of this combination:

7. If the numbers were rubbed off a CD 4017 and a CD 4001, how would you identify the CD 4001?

8. A 555 timer is in a monostable configuration. What is the effect of pin 2 on the output?

9. What is the voltage drop across a silicon diode?

10. Which segments of a 7-segment display would illuminate for the number 5?

11. What is the binary for:
(a) 32
(b) 61
(c) 87

12. Describe these:
(a) 4011
(b) 7805
(c) CD 4001, 1N 4001.

13. What do these letter stand for:
(a) PCB
(b) MMV
(c) PIV
(d) AMV
(e) RMS
(f) BCD
(g) DIL
(h) DPDT
(i) MFD
(j) LED
(k) RST
(l) GND
(m) 555
(n) CLK

14. Draw a circuit of a 555 operating at about 1kHz.

The course now includes 3 models for the same low price. The culminating model is a DIGITAL LOGIC PROBE. It fits into a toothbrush case and has an audible output as well as HIGH - LOW and PULSE via three 3mm coloured LEDs.

ENROLMENT FORM:
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Photocopy this page or apply on a plain sheet of paper. You will be sent a PRELIMINARY TEST sheet by return mail.

Name: .....

Address:.....post code:.....

I wish to enrol for the DIGITAL ELECTRONICS course:

( ) I enclose $120 for lessons 1-5.
( ) I enclose $150 for lessons 1-6.
( ) I enclose $25.00 for the first lesson.
( ) I enclose $.....for ..... lessons.

( ) **Please send lesson 1 COD. I will pay the postman $29.00**

You can order 1, 2, 3, 4, 5, or 6 lessons or pay for one lesson at a time.

Please debit my bankcard: $ .....

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

signature:.....

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2: %
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4: %
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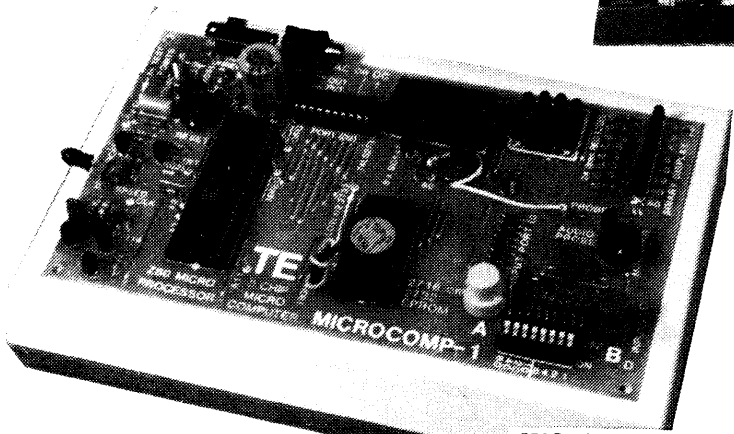
MICRO COMP

A 3-CHIP Z-80 COMPUTER

$59.95 COMPLETE
COMES WITH FREE STORAGE BOX!!



MICROCOMP CASE $15.00

COMPLETE MICROCOMP MOUNTED ON RETEX CASE RA-1.

Kit of parts: $50.70
PC Board: $10.20
Complete: $59.95

Part 1

This is the second article on the Microcomp and by now we have whet a lot of appetites.

Some constructors have gone way beyond that covered in the first article and investigated many of the remaining programs in the EPROM.

One constructor even listed the entire contents by using the LOOKING AT DATA routine at 0200. There were a couple of mistakes in his listing where he forgot to change from PROGRAM to DATA. This is one of the problems when trying to disect a listing.

By now you will have some idea of how the bytes appear in EPROM. They come in a continuous string - without spaces or identification as to the beginning or end of a sequence. If you jump into the middle of a program and look at a byte, you will not know if it is an instruction, part of an instruction or a piece of data. That's why you must start at the beginning of a listing.

When trying to disect a program, write down the values, byte by byte and you will soon see groups which you recognise. From there you can place the others in groups and start to see a program emerging.

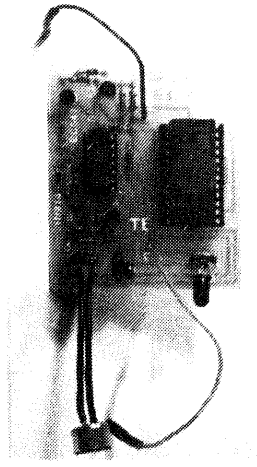
These values are called MACHINE CODE values and are used by the micro directly. It doesn't need spaces or stops and starts as it is pre-programmed within and knows exactly what to do.

The difficulty you would experience in disecting a program is understandable. You are not a micro and cannot keep track of the flow of the program. This is a very difficult direction to work in. The way we will be working is from IDEA-to-machine-code-listing. This is the forward direction and is much easier.

Most programs are made up of lots of small building blocks and the quickest way to learn about these is to study a few programs.

The Morse Trainer is our first add-on and will be covered in the next issue. It is capable of picking up morse from a comminications receiver and displaying the message on the displays. It separates the numbers from the letters and indicates the end of words. Speed of reception can be adjusted from 5 words per minute (or less) to about 17 words per minute.

TO BE RELEASED



MORSE TRAINER
$13.30 complete

In this article we will be continuing with a close study of each of the programs in the EPROM but before we do this we have designed a couple of games for those who want to do a little programming themselves.

If you have a TEC and either the non-volatile RAM or EPROM burner, these programs can be typed into memory and transferred to the microcomp for execution.

As designed, the programs are run at page ZERO however only a few changes are required and they can be run at any other location. The details of this are included with the programs.

The two games are titled: **TUG O' WAR** and **BLACK JACK.** Alongside each is a flow diagram showing what each part of the program does. Also we have explained each instruction with a simple sentence to show how we converted each idea into a computer instruction.

Getting back to the Microcomp, we have described a few more of the 'ins' and 'outs' of computer design and especially the tricks we used to simplify the circuit.

Notebook No. 3 has just been released and it contains a number of pages on the Microcomp design as well as Z-80 Machine Code values for assembly and Disassembly. It also includes the interpretation of each instruction and a listing of computer terms. This will help you with programming and the circuit design pages will help you with input and output decoding and how the Z-80 communicates with all the other chips.

TUG O' WAR & BLACK JACK

TWO programs for the MICROCOMP.

These two programs bring together the TEC computer, Non-volatile RAM and Microcomp. They show some of the techniques of displaying, inputting and running a program at a speed suitable for human involvement.

These games were developed on the above equipment and you can create similar programs or adapt them to suit your own requirements.

TUG O' WAR

Instead of making a TUG O' WAR game from a kit, you can create an improved version by producing a program and running it on a computer.

Initially we saw this game in a popular electronics magazine and liked the way it worked.

It used a row of 15 LEDs and by pressing one of two buttons, a single illuminated LED would move towards you. Seven LEDs were available for each player and your opponent had the same opportunity to make the LED travel towards himself.

The difficulty of play could NOT be adjusted and a player would win whenever he pressed his button seven times more than his opponent.

In our version, we have made it increasingly more difficult to reach the end by weighing the table of increments.

The lowest value has only one corresponding value in the table whereas the highest value requires nine steps before it will advance to WIN!

This can be seen by referring to the byte table and counting the number of bytes for each output value.

Not only does this program show you some new techniques in programming but will also save you a few dollars, if you already have the items mentioned above.

In a similar way, lots of other ideas and games can be produced and this will save you the expense of buying special PC boards and unusual chips.

Our version has nine steps and requires a total of 45 pushes for one player to win over his opponent.

This makes the game quite difficult and you have to introduce quite a lot of strategy to win.

DESIGNING THE PROGRAM

When designing a program, the first thing you have to consider is the hardware available. In our case this means the program has to be designed around two push buttons and two 7-segment displays. The row of 8 LEDs does not give us sufficient scope.

The two displays can be used to display numbers, letters, or individual segments. We opted to display the numbers 0-9.

The rest of the effect lies in the program.

This is how we went about designing it:

When the game starts, the two displays are illuminated with zeros. This requires a

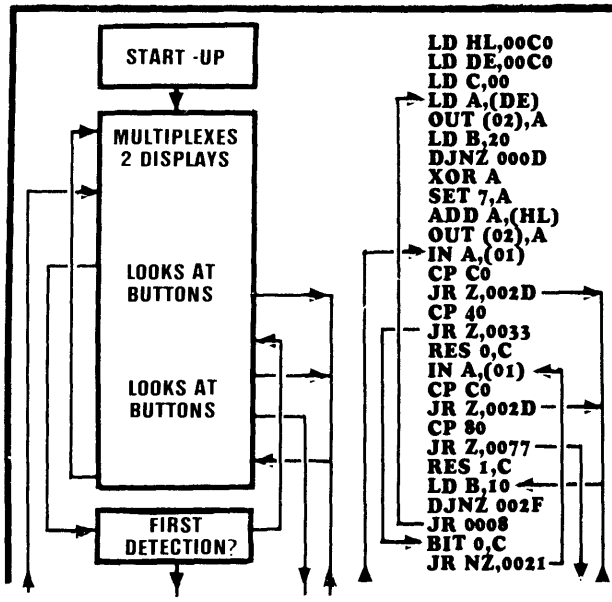
cont. P. 62 . . .

The TUG O WAR program starts below and continues on the next page. It requires a table of 46 bytes for the display and this is placed at **00C0:**

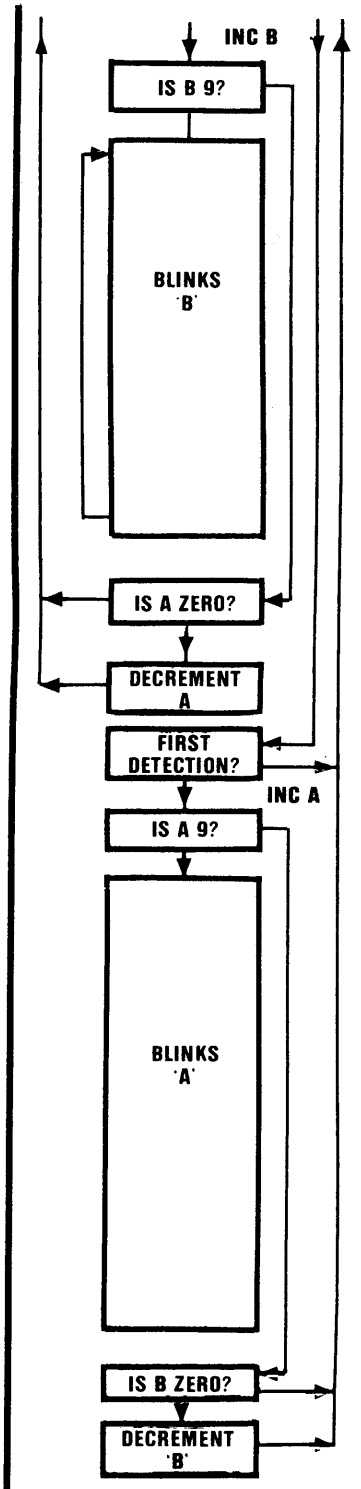
AT C0:

3F	7D
06	7D
06	7D
5B	7D
5B	7D
5B	07
4F	07
4F	07
4F	07
4F	07
66	07
66	07
66	07
66	7F
66	7F
6D	7F
6D	7F
6D	7F
6D	7F
6D	7F
6D	7F
7D	7F
7D	67

TUG O' WAR PROGRAM:



LD HL,00C0	0000	21 C0 00	Load HL with start of table for Left Hand display.
LD DE,00C0	0003	11 C0 00	Load DE with start of table for Right Hand display.
LD C,00	0006	0E 00	Load the BIT TESTING register with zero.
LD A,(DE)	0008	1A	Load the accumulator with the first byte in the table.
OUT (02),A	0009	D3 02	Output this value to the latch.
LD B,20	000B	06 20	Load B with a value for a delay routine.
DJNZ 000D	000D	10 FE	Create 32 loops of decrementing register B.
XOR A	000F	AF	Zero the accumulator.
SET 7,A	0010	CB FF	Set the highest BIT so that the LH display will illuminate.
ADD A,(HL)	0012	86	ADD the byte looked at by the HL register, to the accumulator.
OUT (02),A	0013	D3 02	Output to the latch.
IN A,(01)	0015	DB 01	Look at the switches.
CP C0	0017	FE C0	Compare **C0** with the accumulator to see if both switches are pressed.
JR Z,002D	0019	28 12	Jump if both switches are pressed.
CP 40	001B	FE 40	Compare the accumulator with **40** to see if B is pressed.
JR Z,0033	001D	28 14	Jump if B is pressed.
RES 0,C	001F	CB 81	Reset bit 0 of the C register.
IN A,(01)	0021	DB 01	Look at the input port.
CP C0	0023	FE C0	Compare the accumulator with **C0** to see if both switches are pressed.
JR Z,002D	0025	28 06	Jump if both are pressed.
CP 80	0027	FE 80	Compare the accumulator with **80** to see if A is pressed.
JR Z,0077	0029	28 4C	Jump if A is pressed.
RES 1,C	002B	CB 89	Reset bit 1 of the C register.
LD B,10	002D	06 10	Load B with 10 for a short delay.
DJNZ 002F	002F	10 FE	Create 16 loops of decrementing register B.
JR 0008	0031	18 D5	Jump to start of multiplexing routine.
BIT 0,C	0033	CB 41	Test bit 0 to see if it is the first time B is detected.
JR NZ,0021	0035	20 EA	Jump if not the first time.




```
SET 0,C
INC DE
LD A,(DE)
CP 67
JR NZ,006D
LD C,10
LD A,(DE)
OUT (02),A
LD B,10
DJNZ 0046
XOR A
SET 7,A
ADD A,(HL)
OUT (02),A
LD B,10
DJNZ 0050
DEC C
JR NZ,0041
LD C,10
XOR A
OUT (02),A
LD B,10
DJNZ 005C
XOR A
SET 7,A
ADD A,(HL)
OUT (02),A
LD B,10
DJNZ 0066
DEC C
JR NZ,0057
JR 003F
LD A,(HL)
CP 3F
JR NZ,0074
JR 0015
DEC HL
JR 0015
BIT 1,C
JR NZ,002D
SET 1,C
INC HL
LD A,(HL)
CP 67
JR NZ,00AE
LD C,10
LD A,(DE)
OUT (02),A
LD B,10
DJNZ 008A
XOR A
SET 7,A
ADD A,(HL)
OUT (02),A
LD B,10
DJNZ 0094
DEC C
JR NZ,0085
LD C,10
LD A,(DE)
OUT (02),A
LD B,10
DJNZ 00A0
XOR A
OUT (02),A
LD B,10
DJNZ 00A7
DEC C
JR NZ,009B
JR 0083
LD A,(DE)
CP 3F
JR NZ,00B6
JP 002D
DEC DE
JP 002D
```

```
0037  CB C1
0039  13
003A  1A
003B  FE 67
003D  20 2E
003F  0E 10
0041  1A
0042  D3 02
0044  06 10
0046  10 FE
0048  AF
0049  CB FF
004B  86
004C  D3 02
004E  06 10
0050  10 FE
0052  0D
0053  20 EC
0055  0E 10
0057  AF
0058  D3 02
005A  06 10
005C  10 FE
005E  AF
005F  CB FF
0061  86
0062  D3 02
0064  06 10
0066  10 FE
0068  0D
0069  20 EC
006B  18 D2
006D  7E
006E  FE 3F
0070  20 02
0072  18 A1
0074  2B
0075  18 9E
0077  CB 49
0079  20 B2
007B  CB C9
007D  23
007E  7E
007F  FE 67
0081  20 2B
0083  0E 10
0085  1A
0086  D3 02
0088  06 10
008A  10 FE
008C  AF
008D  CB FF
008F  86
0090  D3 02
0092  06 10
0094  10 FE
0096  0D
0097  20 EC
0099  0E 10
009B  1A
009C  D3 02
009E  06 10
00A0  10 FE
00A2  AF
00A3  D3 02
00A5  06 10
00A7  10 FE
00A9  0D
00AA  20 EF
00AC  18 D5
00AE  1A
00AF  FE 3F
00B1  20 03
00B3  C3 2D 00
00B6  1B
00B7  C3 2D 00
```

Set bit 0 of C before processing button B.
Increment pointer for RH display.
Load A with second byte in table.
Compare the accum. with 67 to see if end of table has been reached.
Jump if end of table NOT reached. Increment if reached.
Load C with 10 for multiplexing time-length.
Load the accumulator with data pointed to by DE.
Output to the latch.
Load B with 10 for short delay.
Decrement B 16 times.
Zero the accumulator.
Set the highest bit to turn on the LH display.
ADD the byte pointed to by HL, to the accumulator.
Output to the latch.
Load B with 10 for short delay.
Decrement B 16 times.
Decrement C.
Jump if C not zero. Increment if C is zero.
Load C with 10.
Zero A to turn off RH display to create BLINK.
Output to the latch.
Load B with 10 to create a short delay.
Decrement B 16 times.
Zero A.
SET the highest bit of the accumulator to turn on the LH display.
ADD the byte pointed to by the HL pair, to the accumulator.
Out put to the latch.
Load B with 10.
Decrement B 16 times.
Decrement C.
Jump if C not zero.
Jump to start of BLINKING ROUTINE.
Load A with data byte pointed to by HL.
Compare with **3F** to see if LH display is zero.
Jump if not zero.
Jump to start of program if zero.
Decrement player A pointer.
Jump to start of program.
TEST bit 1 of the C register.
Jump if bit 1 is SET. Increment to next instruction if not set.
SET bit 1 of the C register.
Increment player A pointer.
Load the data byte into the accumulator.
Compare the accumulator with 67.
Jump if the two are not the same. Go to next instruction if the same.
The next 25 instructions produce a multiplexing effect on the two displays so that the LH display turns on and off in a BLINKING pattern.

This section is very nearly identical to the instructions between **003F** to **006B.** Refer to the above for the explanations.

Load the accumulator with the value pointed to by DE.
Compare the accumulator with 3F to see if the RH display is zero.
Jump if player B is zero, increment to next instruction if not zero.
Jump to start of program.
Decrement player B pointer.
Jump to start of program.

loop in which the value for each display is looked after by a separate register pair. The left hand display is looked after by the HL register pair and the right hand display by the DE register pair.

This choice is goverened by the fact that the HL pair has a larger number of op-codes available to us and thus it is more versatile.

You will see the need for this later.

Numbers produced on the right hand display can be created on the left hand display simply by turning on the highest line at the same time. This is done by adding '80' to the value of data. The same effect can be created by SETTING bit 7 of the accumulator and then ADDing the value of the right hand display. This is what we have done. The data required to produce a number in the right hand display has been added to the accumulator after the highest bit has been SET, with the result that the number appears on the left hand display.

Before this can be done, there is one point which must be remembered.

The accumulator must firstly be cleared so that all bits are zero. SETTING a bit and ADDing to the accumulator does not clear out any initial junk.

Using these facts, and a short DJNZ delay, will produce a loop program which will illuminate both displays.

Also in this loop we must include an instruction to look at the input port and detect 3 things:

We must detect if button A is pressed, button B and also if both buttons are pressed at the same time.

Detecting button A will cause the program to branch to a sub-routine, button B to another sub-routine and both buttons will cause the program to jump over the other branch-instructions.

When the micro jumps to either sub-routine, there are 4 instructions which must be taken into account.

Firstly it looks to see if it is the first time the sub-routine has been jumped to (during this press of the button). It does this by checking the debounce BIT in the C register. We must create a debounce condition so that the displays will increment only one byte in the table for each press of the button. This is achieved by resetting the BIT(s) in the C register while executing the main program. When a button is pressed, the micro goes to the sub-routine and looks at the particular bit in question.

If it is in a RESET state, the micro runs through the sub-routine and SETs the bit. It then increments the pointer register to look at the next byte in the table. It then compares the value with 67 to see if the end of the table has been reached. If it has, it goes to a loop program which flashes the winning display.

If the end of the table has not been reached, the program looks at the opposition value to see if it is zero. If it is zero, the micro returns to the main program. If the opposition is not zero, it decrements the pointer register and jumps to the main program.

The effect on the screen may or may not be an increment or decrement, depending on the position of the pointer registers, however you can be assured the byte table has been decremented and/or incremented correctly.

All you have to do now is put these facts into a machine code program.

When doing this, it is very helpful to use arrows to incdicate where the program jumps to. You can also put labels and notes at various locations to indicate what the program is doing. This will assist you when debugging and tidying up.

Study the program on the previous 2 pages and see how it's done.

BLACK JACK

This program is designed around Paul's Black Jack in issue 11.

The concept of the program is to deal a hand of random values exactly like playing cards.

It then keeps a tally of your hand and adjusts the total to your advantage when one or more ACES are dealt.

It is the feature of the Ace being equal to 1 or 11 which adds interest to the game and brings a little strategy into the program.

Apart from the normal requirements, the program must keep track of an ace. When one is included, BIT 7 of the C register is SET. The C register is our TEST REGISTER.

The computer keeps dealing cards until a value over 21 is reached. It then looks to see if an ace is included by testing BIT 7. If this bit is SET, it subtracts ten from the total, making the ace equal to one.

Further cards are dealt and once again a score is kept, in an attempt to reach 21.

When exactly 21 is reached, the program jumps to a routine which flashes '21' and at the same time looks at the input port for button B being pressed. If it is pressed, the program returns to the start.

The other important feature to remember when producing a program is TIMING. By this we mean the length of time for the things to be done, such as the numbers appearing on the screen.

If they appear for too short a duration, it will be annoying. A long duration will slow down the game.

These periods are controlled by a delay routine which is inserted into the program to 'waste computer time'.

The length of these delays depends on the clock speed and since we have a very slow clock frequency, we have delay routines to match.

Our maximum clock speed is 35,000 cycles per second so that if we waste 35,000 clock cycles, we produce a delay of 1 second.

The simplest way of producing a delay is to use **DJNZ** The maximum DJNZ delay is produced by loading B with FF and this wastes 13 x 255 cycles (3315 cycles) or about 1/10th sec. Longer delays can be obtained by using 2 DJNZ's and shorter delays by decreasing the value of B.

The other way to create a delay is to run through a loop which gradually decrements a delay value. This type of program is necessary when multiplexing is required.

The only way of obtaining a suitable value for the delay is to study some of the examples.

If you are unsure, insert '80' and trim the value during final testing. '80' represents a mid-value and you can increase or decrease it later.

INDEXED ADDRESSING

Black Jack uses a table (located at the end of the program) which does three things. Firstly it determines the character to appear on the right hand display, then the character for the left hand display and finally the equivalent hex value.

This requires 3 bytes which we have grouped together to form a 'block'.

Even when the left hand display is not showing a value, it is being accessed with a zero output so that uniform illumination is produced when a value such as '10' is displayed.

To pick up the 2nd and 3rd byte in each group, we have used INDEXED ADDRESSING.

This is a handy way of jumping down a table without incrementing the register.

If you were to increment it, you would have to decrement it before the start of the next loop and this would involve extra instructions.

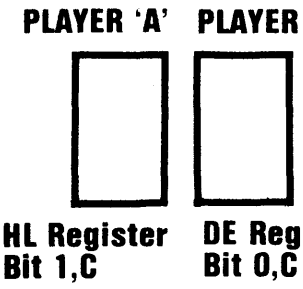
In our program, the register in charge of the table is incremented only after a multiplexing operation (which may involve a number of passes of a loop).

When the register is incremented, it is incremented 3 times so that it looks at the first byte of the next group. That is the 1st, 4th, 7th 10th byte etc.

The 2nd and 3rd bytes of each group are looked at via the indexing feature which uses a displacement value. For instance (IX + 01) looks at the second byte and (IX + 02) looks at the 3rd byte.

RELOCATING THE PROGRAM

Although the program is designed for the Microcomp and to be run at page zero, it can be shifted to any other location by simply changing all the absolute address values.

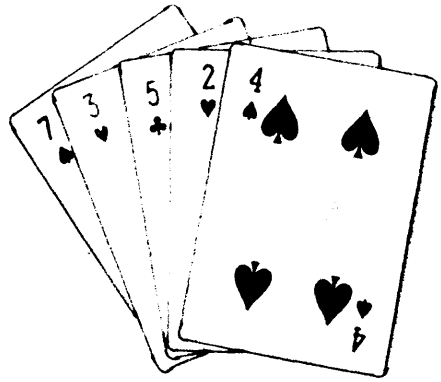


The diagram shows the two displays and their associated register pair. The Debounce is done in register 'C'.

There are two main types of addressing. ABSOLUTE and RELATIVE. Relative values refer to locations by using a displacement value in the program and whenever the program is shifted, these values remain unchanged.

However absolute address values must be changed whenever a program is shifted as the values refer to specific locations.

In our program, the absolute values include the address of the tables and jumps which are over 80 hex bytes away. (Relative jumps can only cope with jumps less than 80 hex bytes away, in either direction).



The '5 CARD HAND' which wins if 21 is not obtained. Our program does not take this into account but it would be a simple matter to make it do so.

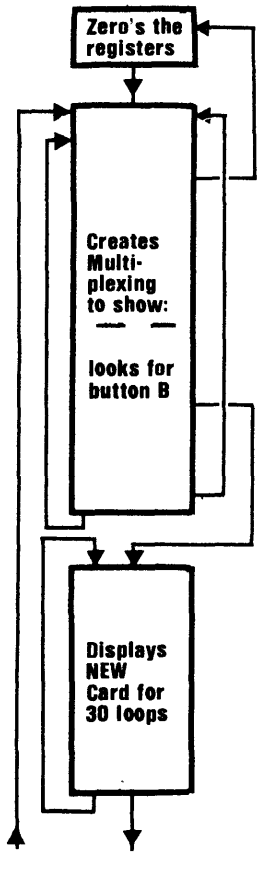
Here's the program: Type it on the TEC, hold it in the non-volatile RAM and play it on the Microcomp.

At 0100:
Each hex value produces a number from 0 to 9:

3F	0
06	1
5B	2
4F	3
66	4
6D	5
7D	6
07	7
7F	8
67	9

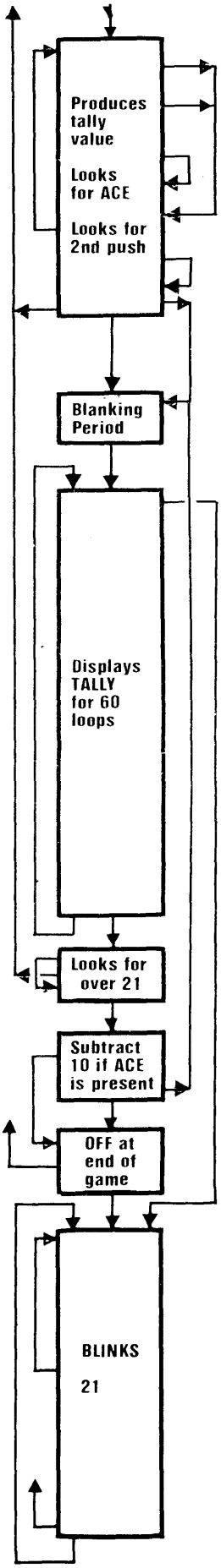
At 0110:
The first two bytes produce the 'CARDS' and the third byte holds the value of the card.

40	-	7F	8
40	-	00	
00		08	
5B	2	67	9
00		00	
02		09	
4F	3	77	A
00		00	
03		0B	
66	4	1E	J
00		00	
04		0A	
6D	5	3F	10
00		06	
05		0A	
7D	6	3F	10
00		06	
06		0A	
07	7	3F	10
00		06	
07		0A	




```
XOR A
LD I,A
LD E,A
LD C,A
LD IX 0110
IN A,(01)
CP 40
JR Z,0000
LD IY,0113
LD H,0D
LD A,(IX + 00)
OUT (02),A
LD B,08
DJNZ 001C
XOR A
SET 7,A
ADD A,(IX + 01)
OUT (02),A
IN A,(01)
CP 40
JR Z,003B
LD B,04
DJNZ 002E
INC IY
INC IY
INC IY
DEC H
JR NZ,0015
JR 000F
LD D,30
LD A,(IY + 00)
OUT (02),A
LD B,20
DJNZ 0044
XOR A
SET 7,A
ADD,(IY + 01)
OUT (02),A
LD B,20
DJNZ 0050
DEC D
JR NZ,003D
```

0000	AF	Zero the Accumulator.
0001	ED 47	The I register must be loaded via A. I reg. detects 2nd push of button.
0003	5F	Zero E. Reg E is our tally register to detect '21' etc.
0004	4F	Zero C. Reg C is our TEST register for ACE detection.
0005	DD 21 10 01	Load IX with start of DISPLAY TABLE.
0009	DB 01	Button B must not be pressed when micro passes this point otherwise
000B	FE 40	program will jump to start of routine. This prevent cheating if
000D	28 F1	the button is kept pressed.
000F	FD 21 13 01	Load IY with start of table for displaying value of card.
0013	26 0D	H counts the number of groups of bytes in the table. There are 0D
0015	DD 7E 00	Load the accumulator with the first byte in the table. groups.
0018	D3 02	Output this value to the output latch.
001A	06 08	Load B with a value to produce a short delay.
001C	10 FE	Create 8 loops of decrementing register B.
001E	AF	Zero the accumulator before advancing to the next two operations.
001F	CB FF	SET the highest BIT in the acc. so that the LH display will illuminate.
0021	DD 86 01	ADD the value of the second byte in the table to the accumulator.
0024	D3 02	Output the result to the latch. The LH display will illuminate.
0026	DB 01	Input the value on the switches to the accumulator.
0028	FE 40	Compare the accumulator with '40'.
002A	28 0F	Jump if the accumulator is equal to 40.
002C	06 04	Load B with 04 ready for a short delay.
002E	10 FE	Create 4 loops of decrementing reg B to display the LH digit.
0030	FD 23	Increment the IY register 3 times so that it looks at the start of the next
0032	FD 23	group. This register is our random number generator and increments
0034	FD 23	constantly, while the displays are displaying.
0036	25	Register H will detect the end of the byte table.
0037	20 DC	Jump to displaying RH then LH digit, if H is not zero.
0039	18 D4	When H is zero, IY and IX register go to start of table.
003B	16 30	D will govern the length of time for displaying the random number.
003D	FD 7E 00	The accumulator is loaded with the display value for the random No.
0040	D3 02	This value is outputted to port 02.
0042	06 20	The RH display will illuminate for a delay determined by the value of B.
0044	10 FE	
0046	AF	The accumulator is zeroed ready for the next two instructions.
0047	CB FF	Bit 7 is SET to turn on the LH display.
0049	FD 86 01	The value of the second byte in the group is added to the accumulator
004C	D3 02	and outputted to port 02.
004E	06 20	The LH display is illuminated for a period of time as determined by the
0050	10 FE	value of B.
0052	15	D is decremented by one and the program loops again.
0053	20 E8	When D is zero, the micro advances to the next instruction.




```
LD A,(IY + 02)
INC E
BIT 1,E
JR Z,0066
BIT 3,E
JR Z,0066
LD B,06
INC E
DJNZ 0063
DEC A
JR NZ,0058
LD A,(IY + 00)
CP 77
JR NZ,0072
SET 7,C
LD A,I
INC A
LD I,A
CP 02
JR NC,007D
JR 0009
LD D,60
XOR A
OUT (02),A
LD B,FF
DJNZ 0084
LD HL,0100
LD A,E
CP 21
JR Z,00D4
AND 0F
ADD A,L
LD L,A
LD A,(HL)
OUT (02),A
LD B,10
DJNZ 0097
LD A,E
RRA
RRA
RRA
RRA
AND 0F
LD HL,0100
ADD A,L
LD L,A
LD A,(HL)
SET 7,A
OUT (02),A
LD B,08
DJNZ 00AC
DEC D
JR NZ,0086
LD A,E
CP 22
JR NC,00B9
JP 0009
BIT 7,C
JR Z,00C4
SUB 10
LD E,A
RES 7,C
JR 007D
XOR A
OUT (02),A
LD B,FF
DJNZ 00C9
DJNZ 00CB
DJNZ 00CD
DJNZ 00CF
JP 0000
LD C,10
LD A,06
OUT (02),A
LD B,10
DJNZ 00DC
LD A,DB
OUT (02),A
LD B,10
DJNZ 00E4
DEC C
JR NZ,00D6
XOR A
OUR (02),A
LD B,FF
DJNZ 00EE
IN A,(01)
CP 40
JP Z,0000
JR 00D4
```

```
0055  FD 7E 02  Load A with the 3rd byte in the group. We know the byte must have a
0058  1C        value of one or greater and so we can safely INCrement E.
0059  CB 4B     Register E is our TALLY register. We require it to add the values of the
005B  28 09     cards and hold the result in decimal form. The problem comes when
005D  CB 5B     you add one to 9. The register will show 0A. We must convert 0A to ten.
005F  28 05     This can be done by a DAA instruction or by software. We have opted
0061  06 06     for software. We detect 0A via bit 1 and 3 being HIGH and then
0063  1C        increment the E register 6 times. Each time the tally register is
0064  10 FD     incremented (apart from the decimal adjusting loop), the accumulator
0066  3D        is decremented and when the accumulator is zero, the program
0067  20 EF     advances.
0069  FD 7E 00  Load the accumulator with the first byte of the group.
006C  FE 77     Compare 77 with the accumulator. We are looking for an ACE.
006E  20 02     If the accumulator is not 77, the micro will jump to LD A,I. If the
0070  CB F9     accumulator is 77, the program will advance to the next instruction
0072  ED 57     and SET bit 7 of the C register.
0074  3C        The I register counts the number of presses of the B button. We are
0075  ED 47     looking for 2 or more presses so that the tally can be displayed. This is
0077  FE 02     the advantage of using the CARRY command.
0079  30 02     The micro jumps when I is 2 or MORE.
007B  18 8C     Jump to start of program (button B has been pressed once.)
007D  16 60     Register D produces the time for the tally to appear.
007F  AF        Blank the display.
0080  D3 02     Output to latch.
0082  06 FF     Load B with maximum delay value.
0084  10 FE     Perform FF loops of decrementing register B.
0086  21 00 01  Load HL with start of display values.
0089  7B        Load the tally register into the accumulator.
008A  FE 21     Compare 21 with the accumulator.
008C  28 46     If accumulator is 21, the micro jumps to 'BLINKING 21'
008E  E6 0F     If not 21, remove high nibble by ANDing with 0F.
0090  85        L contains '00' from address above, ADD 00 to accumulator.
0091  6F        Load the result back into L so that the micro looks at one of the
0092  7E        addresses of the table. Load the value it finds, into A.
0093  D3 02     Output the byte to the latch.
0095  06 10     Load B with a low value.
0097  10 FE     Create 16 loops of decrementing register B.
0099  7B        Load the tally register into the accumulator.
009A  1F        Rotate the accumulator right, effectively bringing the 4 bits of the
009B  1F        HIGH nibble to occupy the 4 lower places.
009C  1F
009D  1F
009E  E6 0F     Remove the 4 high bits by ANDing with 0F.
00A0  21 00 01  Load the HL register with start of display table.
00A3  85        ADD L to accumulator to create a new value for L so that we look at one
00A4  6F        of the addresses in the table.
00A5  7E        Load the byte from the table into the accumulator.
00A6  CB FF     Set bit 7 of the accumulator so that the LH display turns on.
00A8  D3 02     Output this value to the latch.
00AA  06 08     Load B with a short delay value.
00AC  10 FE     Create 8 loops of decrementing register B.
00AE  15        Decrement D and go to start of multiplexing loop. When D is zero,
00AF  20 D5     increment to next instruction in program.
00B1  7B        Load the tally register into the accumulator.
00B2  FE 22     Compere with 22.
00B4  30 03     If tally is 22 or MORE, increment to next instruction.
00B6  C3 09 00  Jump to start of program. If tally is less than 22, jump to BIT 7,C.
00B9  CB 79     Test bit 7 of the C register to see if an ACE has been dealt.
00BB  28 07     Jump if no ACE. Increment if an ACE is present.
00BD  D6 10     Subtract ten from tally, making ACE equal to ONE.
00BF  5F        Load the new tally into the tally register.
00C0  CB B9     Reset bit 7 to show ACE has been turned into ONE.
00C2  18 B9     Jump to displaying new tally.
00C4  AF        Zero the accumulator.
00C5  D3 02     Output to latch for a delay period equal to 4 DJNZ's (with B =FF) to
00C7  06 FF     indicate END OF GAME.
00C9  10 FE
00CB  10 FE
00CD  10 FE
00CF  10 FE
00D1  C3 00 00  Jump to start and re-load all registers.
00D4  0E 10     Load C with 10 for 16 loops of multiplexing '1' and '2'.
00D6  3E 06     Load A with 06 to create '1' on RH display.
00D8  D3 02     Output this to latch.
00DA  06 10     Create short delay.
00DC  10 FE     Decrement B to zero.
00DE  3E DB     Load the accumulator with DB to create '2' in LH display.
00E0  D3 02     Output to latch.
00E2  06 10     Create short delay.
00E4  10 FE     Decrement B to zero.
00E6  0D        Decrement C and if not zero, jump to start of multiplexing the displays.
00E7  20 ED
00E9  AF        Zero A
00EA  D3 02     Output to latch to turn off both displays.
00EC  06 FF     Load B with FF to produce a short delay for the OFF time.
00EE  10 FE     The only way of jumping out of 'BLINKING 21' is to push button B or
00F0  DB 01     reset the computer. The program inputs from the set of buttons and if
00F2  FE 40     B is pressed, the program jumps to 0000. Otherwise the program
00F4  CA 00 00  keeps looping.
00F7  18 DB
```

Before we continue our disection of the program for the Microcomp, let us pause for a discussion on a number of related topics. These will help you to understand how a micro system goes together and how it functions.

PROGRAMMING THE 2732.

The 2732 in the Microcomp kit comes ready programmed with a set of experimental programs and only the lower half of the ROM has been filled.

This leaves the upper half vacant, for use in any way you wish.

There are two ways in which the upper half can be filled. One is by using an EPROM programmer and burning the locations yourself. The other is to write the program and have someone else burn the ROM.

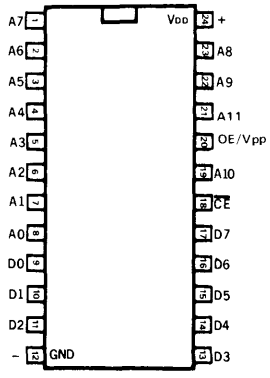
Burning a program is only done after you are thoroughly satisfied with its performance, as it is very difficult (if not impossible) to change the program, once it is burnt. For this reason it is best to get the program up and running via a medium which can be easily altered, as a program quite often has to go through lots of changes and modifications before you are completely satisfied.

The most logical way is to use some form of RAM memory, in which the locations can be altered as many times as you like. The only difficulty with RAM memory is it will lose its contents when the power is switched off. If the RAM is backed up with a battery, the contents will be retained.

This arrangement can then be used to generate programs without the fear of loss, should the computer be turned off.

The program can then be transferred from the programming computer to the Microcomp.

The Microcomp sees each half of a 2732 as a separate 2k block of memory.



2732 PIN-OUT

The program-accessing routine at 0000 must be written for both the lower half and upper half and this will enable you to start at any address, providing it is an even hex value.

Burning can be carried out on the TEC EPROM BURNER and full details of this project can be found in issue 13.

Memory is divided into PAGES and each page consists of 256 bytes. When programming, all address values are written in hexadecimal form and one page contains FF bytes. See P. 16 of issue 11 for the hex table and details on understanding hex notation. A 1k block of memory has 4 pages and a 2k memory chip such as 2716 has 8 pages. A 4k memory chip such as 2732 will hold 16 pages of bytes.

A program can range from only a few bytes to many pages and to give you an idea of the compactness of machine code, the two previous games, TUG O' WAR and BLACK JACK, occipied about 1 page each. Obviously a more complex game with a more complex display (such as a video screen) would require more instructions but one page has the capacity to hold about 100 instructions.

This means a 2k ROM will hold about 8 simple programs.

Programs are not fast to be produced and it may take 10 to 50 hours to create a one-page program. A 2k ROM may take weeks or even months to fill!

Once you are satisfied with the performance of a program, you are ready to burn it into an EPROM.

Before this can be done there are two things you should do.

Firstly you should determine where you are going to place the program. This is important as it will be in a different location to where it was being created and the absolute address values will not apply.

Often the program is created at address 0000 and all jump instructions relate to this. Any address values which have been defined are called absolute and must be changed when the program is shifted to a new location.

When you have determined the new location, you should BLOCK TRANSFER the program to the same address in the non-volatile RAM, using the following program:

at **0C00:**

```
11 ____ ____   TO: address + 1000H
21 ____ ____   From: address + 1000H
01 ____ ____   No of bytes.
ED B0
C7
```

For example, if you have produced a 148 byte program at 0000 in the non-volatile RAM and need to shift it to 0280, here is the Block Transfer program:

at **0C00:**

```
11 80 12
21 00 10
01 48 01
ED B0
C7
```

At the beginning of the RAM you need a jump routine:

```
06 00
DB 01
21 00 00
6F
29
29
29
29
E9
```

This is entered at 0000 in the non-volatile RAM, which is ADdress 1000 on the TEC (to access the start of the expansion port socket)

Now you must change all the absolute address values (such as the start of a table, a jump instruction etc.)

Change the switch on the non-volatile RAM card to 'ROM' and switch the TEC off. Transfer the non-volatile RAM to the Microcomp and load '28' on the input switches. Turn the comp on and push reset. The program will run.

You should now remove all traces of the lower program so that you are sure the new one is the only one being run. This is done on the TEC by loading **FF** into each location of the old program

The program is now ready for transfer to EPROM. You have confirmed its operation and run it at its new location - nothing more need be done.

Refer to the EPROM BURNER project in issue 13 for the actual transfer procedure.

When you have completed a program and burnt it into EPROM, it should be fully documented by writing it out as shown in our examples.

It is important to use arrows to indicate the jumps and even a block diagram explaining what is happening at various locations.

A description of the program including which buttons are doing what, will also help as it's very easy to forget how the game is played, after a few months.

Give the program a name and fill out the log below to assist in identification.

If you follow these rules you will be able to use parts of the program when creating new ideas and save generating everything afresh.

Sw. Positions:	Address:	Name of Program:

RAM and ROM

RAM is the abbreviation for RANDOM ACCESS MEMORY.

It is tempory storage memory in which data is only retained while the power is applied.

When the power is removed, the contents are lost. This is because data is stored via a flip flop or single MOS transistor and these require power (although very little) for the data to be retained.

There are two forms of Random Access Memory. **STATIC and DYNAMIC.**

Static Memory uses a flip flop for each bit of information and this will hold the HIGH or LOW as long as the power is connected to the chip.

Dynamic Memory uses only a single MOS transistor in which a charge on a substrate indicates the presence of data. Since this charge has the tendency to leak away, it must be replenished every 2 milliseconds. This requires additional circuitry and is inconvenient in a small system; although it is the cheapest way to purchase blocks of memory.

RAM is also called Read/Write memory as it can be written into and read during the process of executing a program.

A micro system which does not have any RAM is called a dedicated system and is limited to running a program contained in ROM memory.

The need for RAM varies enormously with the task. Sometimes you only need a few bytes of RAM to store tempory values and the same locations can be written into again and again.

Othertimes you need a large amount of RAM to store a whole screen of information.

With as little as one page (256 bytes) a system can be designed to perform quite complex tasks as the data can be updated and written-over constantly.

The Z-80 requires only two very small sections of RAM for it to become a 'thinking' computer. These two areas are called SCRATCHPAD and STACK.

The scratchpad or BUFFER zone needs only a few bytes where such data as displays values are kept. This frees registers for carrying out program commands.

The other area is STACK and this is where bytes are loaded (in pairs) so that the contents of a particular register can be saved. The stack is unusual in that it grows downwards as more bytes are added and it is essential to keep removing bytes at the same rate as they are added so that the stack does not grow too large.

The other peculiar feature about the stack is the access you have to its contents. It is a LAST-ON FIRST-OFF arrangement and only the top byte (and the next) is accessible and this is another reason for keeping the stack manageable.

The main purpose of the STACK is to free registers for other operations and then be able to re-load them with the value that had been saved.

Our Microcomp does not have RAM memory and thus the stack and scratch-pad features are not available.

The alternative to scratch-pad is to use a register pair to hold 2 bytes of data and this has been done in many of the programs. This severly limits programming as the working registers are held-up as memory cells.

Without a stack, programs have to be designed differently and may take more programming steps, but they work just as well.

IX, IY, HL and DE register pairs and also the alternate A, BC, DE and HL registers can be used to get around the storage problem.

Some of the programs for the Microcomp show how the registers have been used in this way.

ROM

ROM is Read Only Memory.

This memory is used to store instructions which do not have to be altered. Data in ROM remains fixed and stable, even when power is removed. It is permanent.

There are different types of ROM memory. One is programmed by the manufacturer and cannot be changed, the other is erasable memory and can be programmed by the client. It can also be erased if the contents are not required, by exposing to ultra violet light for about 15 minutes.

In the Microcomp project, a 2732 EPROM has been used. This is the most economical size for the job and is capable of holding 4k of information. 4k is equivalent to 4096 bytes and would be a very long program if it contained a single program!

If we assume an instruction takes an average of 2 bytes, the program will extend for 2048 lines! A program of this length would take many weeks to produce and the number of things it could do would be quite impressive.

In the Microcomp, the 2732 is accessed in two halves. This is done via a jumper. The lower half contains a range of programs which we are currently investigating and by taking the jumper lead to the lower pin on the PC board, the upper half of the EPROM is accessed.

The upper half is blank and you can fill it with programs of your own. The first 10H bytes must contain a jump routine identical with the lower half to allow you to jump to the start of each program.

In the near future you will be able to send in your EPROM for filling with additional routines. The programs for the 'add-ons' will be loaded into the upper half and many of these are already finalized. But firstly we want to fully explain the lower half and get you aquainted with the concepts.

One question we have been asked is why the Microcomp has only 11 address lines whereas the 2732 requires 12!

The answer is we are creating the 12th address line via the jumper lead. When the 12th line is LOW, the lower 2k is accessed. When the jumper is HIGH, the upper 2k is accessed. Since this is a manual operation, a program cannot cross the 2k border and routines in the lower half cannot be accessed by those in the upper section. (If you wish to cross the 2k boundary, place the jumper on A11).

Because of our arrangement, the 2732 can be considered as two separate 2k blocks, each of which is equivalent to a 2716 EPROM. In fact you can use 2716's without the need for any modifications.

Each 2k block is addressed in hexadecimal notation. It starts at **0000** and goes to **07FF**. The next 2k starts at **0800** and finishes at**0FFF**. There are 8 pages in 2k and these are: Page 0, 1, 2, 3, 4, 5, 6 and 7. Each page contains **FF** bytes as explained previously.

All address values, data values and Jump Relative values are Hex values and you need to think in HEX notation when writing Machine Code programs.

Using the Microcomp will familiarize you with hex and encourage you to think in this notation.

BASIC vs MACHINE CODE

Everyone has heard much about BASIC. It introduced many of us into the world of microcomputers and it deserves its reputation for being the best language for teaching computers to beginners.

And true enough, Basic has enabled beginners to perform tasks which would have been absolutely impossible otherwise.

But basic isn't the solution to all programming. When you need a simple program for sequencing or timing, you don't need basic. When you need high-speed graphics, you don't use Basic. And when you want to design your own system, you can't include Basic.

In fact you don't use any high level language at all. You use only the codes which the microprocessor understands; and these are called MACHINE CODES.

That's the language or instruction set we are teaching: MACHINE CODE or MACHINE CODE PROGRAMMING.

With Machine Code you can perform all the operations and effects available to the Basic programmer except you have to create them all yourself.

Remember that all the work and skill put into compiling the set of Basic instructions would represent years of effort and we would never be able to attain this level of development via a simple model.

For us, we will have to be satisfied with starting at the beginning and learning some of the simplest forms of programming. Even these will achieve an amazing variety of effects and you will be quite impressed with the results.

We are not rubbishing Basic but let's say it is completely removed from the field we are covering. Machine code is is up to 10,000 times fast and takes up to 500 times less memory. But Most impressive is a Machine code system can be created without any external assistance. You become the master - designing your own system and only requiring a list of Machine code instructions for you to be able to complete anything from a sequencer to a robot.

HOW TO START PROGRAMMING

All programs start with an idea. The idea may be vague at first or you may be lucky enough to know exactly what you want to achieve.

Vague or concrete, the way to start programming is by getting a sheet of paper and jotting down notes.

Start with sketches, scribbles and bits of data.

Put a date on the sheet and think up a name for the project. Names and labels help identify and strengthen your ideas.

These jottings will look feeble when you look back on them, but at the beginning they form the groundwork on which to build. It's the only positive way of getting the facts together.

Put down all you know and all you want to do, then go away and sort it over in your mind.

Your brain can actually put things together much better after you have cleared it first by writing down all the preliminaries.

Don't be afraid to use paper. It will take about 6-10 pages to produce one page of finished work.

At first the best idea is to use parts of existing programs and modify them to suit. Later you can think about creating complete programs of your own.

Lastly, don't be disappointed if the program doesn't work first go. We have trouble with all of ours. They rarely work first time.

But that's the wonderful part about programming. The micro picks up your mistakes and fails to operate.

When this happens, you can spend hours trouble-shooting the fault.

The best advice in this situation is to give the program to a friend aquainted with programming and ask him to check it. A fresh mind is more able to spot a silly mistake.

If you don't have anyone in this category, you will have to work through it yourself.

If the displays fail to light up, you will not know how far through the program the processor has gone.

Start at the beginning and look for the first OUT command. Immediately after this instruction place a HALT command. This will let you know if the micro has travelled this far through the program.

If the display still fails to light up, you will have to investigate each of the steps and instructions very carefully. Work backwards through the program using the DISASSEMBLY codes on the back of issue 12 (and also in Notebook No 3) and make sure you get the same instructions as in the original production of the program.

Next check the JUMP and JUMP RELATIVE values to confirm that the microprocessor is actually landing on the address intended. Read the section on Jump Relative in issue 12 of TE, because these are the trickiest bytes to add to a program. Remember, they are the LAST bytes to be inserted as you need to count the number of bytes between the present address and the address to be jumped to.

Machine Code programming allows you to create your own system - with pen, paper and op-codes.

When creating a program, you will not know the value of a displacement byte initially and it is important to put a line in place of the byte thus: _____ so that it can be inserted later. This line lets you know that one byte must be counted when working out the displacement values.

If the display still fails to illuminate, you can create your own display value by loading the accumulator and outputting it to the display and then adding a HALT instruction. This is a last resort! and lets you know how far the program is progressing.

I hope you don't have troubles of this complexity but if so, this will get you out.

Start with simple programs and get your ideas flowing. It's not as difficult as you think to convert ideas into visual effects and its very rewarding to see them running.

When writing a program for the Microcomp, you start at address 0000. This is where the processor naturally starts when the reset button is pressed.

It can then be shifted to a higher location and a jump routine used to access it.

Creating a program which RUNS takes a certain amount of skill. By 'runs' we mean it completes one pass of the program and displays the appropriate information on the displays. After you get it to run you can concentrate on adjusting the values of timing to achieve the most pleasing effects.

But the main problem is getting the program to run and we have already mentioned how to get into the program and force it to display. There are a couple of other points which we forgot to mention and they involve the placing of tables.

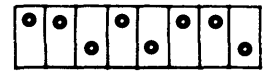
Tables should be placed well away from the program so that you don't run out of room. When everything works perfectly, they can be moved up and the pointers changed accordingly.

The idea is to get everything into a compact block and relative addressing uses less bytes than absolute addressing, so use it whenever possible. . Also remove any **NOPs** and any holes or spaces. Closing up a program and neatening it up takes time but it makes it much more presentable in the end.

We will now continue with the programs in the monitor, explaining each and every instruction and how the program is intended to work.

FROM INPUT PORT TO 8 LEDS

This routine is located at 0290 and is addressed by switching the switches ON thus:



This program is very handy for checking the operation of the computer in the early stages. This may be too late for some constructors, but for those with a problem in the displays, it will help locate the fault.

The program checks each line of the input port and outputs it to the displays.

Each time you turn an input switch ON, the corresponding LED, in the row of 8 LEDs, will be illuminated.

If this does not happen, you can trace through the particular line and locate the fault.

The program at **0290** contains 6 bytes. That's all, just 6 bytes! It inputs the data on the input port and loads it into the accumulator. It then outputs it to port 2 to turn on the appropriate LEDs and then jumps back to the start of the program.

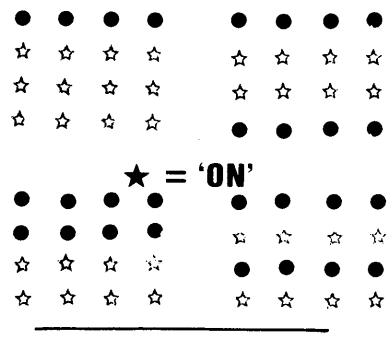
This means it is rapidly looping around the program and will update the displays as soon as the input values are changed.

The program can also be used to compare between the row of 8 LEDs, the 7-segment display(s) and the 4x4 matrix.

Experiment by inputting a hex value and see the effect you get on each of the displays.

In this way you can create any effect you want on the 4x4 (within limits).

Create these effects on the 4x4 matrix:



FROM INPUT PORT TO 8LEDS

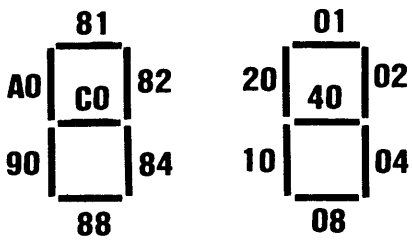
```
IN A,(01)     0290   DB 01   Looks at input switches and places the value in the accumulator.
OUT (02),A    0292   D3 02   Outputs accumulator to the latch.
JR 0290       0294   18 FA   Jumps to start of program.
```

From this program you will see:

1. The value of each LED in the row of LEDs corresponds to a switch. The lowest value is 01, then 02, 04, 08, 10, 20, 40, 80, and this can be confirmed by the values written on the PC board.

2. The value of each switch also corresponds to a segment in the 7-segment display. Turn on various switches and see the effect(s).

Prove the following:



Adding '80' to a value will make the display jump to the 10's display. Note that 80 by itself does not turn on ANY display.

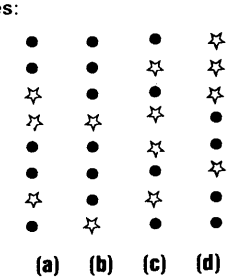
Button 'A' is connected to **80** and will make the figures jump from one display to the other.

3. The 4x4 matrix has been wired so that each column is turned on by a LOW value. These values are: 01, 02, 04, and 08. This will cause all the LEDs to come on. Each of the rows can be turned OFF and this is done via the values 10, 20, 40 and 80.

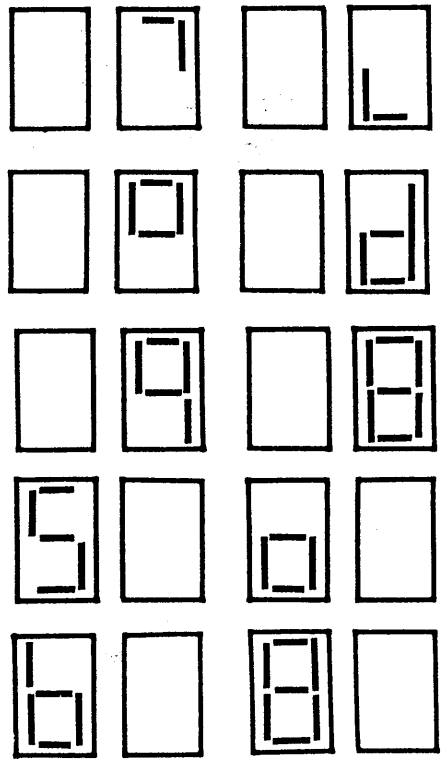
There are some limitations as to what combinations of LEDs can be turned on and this is something you must be aware of.

Experiments:

Create these effects by using the input switches:

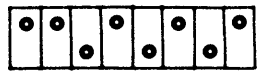


Create these on the 7-segments displays:



INCREMENT via BUTTON A

This program at 02A0 increments the display each time button A is pressed.

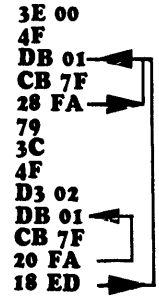


```
LD A,00       02A0   3E 00   Load the accumulator with zero.
LD C.A        02A2   4F      Load zero into C.
IN A,(01)     02A3   DB 01   Input the value on the switches to the accumulator.
BIT 7,A       02A5   CB 7F   Test BIT 7 of the accumulator to see if button A is pushed.
JR Z 02A3     02A7   28 FA   Jump to 2A3 if NOT pressed. Go to 2A9 when pressed
LD A,C        02A9   79      Load C into the accumulator.
INC A         02AA   3C      Increment the accumulator.
LD C,A        02AB   4F      Load the answer into the TALLY register 'C'.
OUT (02),A    02AC   D3 02   Output the accumulator to the displays.
IN A,(01)     02AE   DB 01   Input the switches to the accumulator.
BIT 7,A       02B0   CB 7F   Test BIT 7.
JR NZ 02AE    02B2   20 FA   Jump to 2AE if A is pressed. Go to 2B4 when released.
JR 02A3       02B4   18 ED   Jump to 2A3.
```

This will enable you to see the effects on the display without having to manually input values via the switches.

The accumulator is required for two functions. It outputs the value of the count and then looks to see if a switch is pressed. That's why we need another register to hold the value of the count, so that the accumulator can be loaded with other information. Thus the C register has been used for temporary storage.

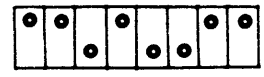
The program contains two small loops and the micro is constantly executing the top one when button A is not pressed and the lower one when the button is pressed. The micro jumps from one loop to the other during the time when the button is travelling from one state to the other.



This is a very simple way of creating a debounce condition and prevents more than one count being registered on each press of the button.

AUTO INCREMENT (fast)

This program is located at **02C0** and lets you sit back and watch the displays



increment automatically. You will be interested to know that the program takes 256 steps before it repeats!

Compare the effect on the row of 8 LEDs with the 4x4 and seven segment displays.

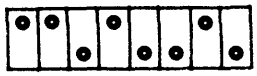
Notice that they produce entirely different effects due to the placement of the LEDs and this can be remembered when designing displays for advertising etc.

```
LD A,00       02C0   3E 00
INC A         02C2   3C
OUT (02),A    02C3   D3 02
DJNZ 02C5     02C5   10 FE
DJNZ 02C7     02C7   10FE
DJNZ 02C9     02C9   10 FE
JR 02C2       02CB   18 F5
```

The first instruction loads the accumulator with zero. You will notice this address is not used again by the program. Thus we call it a START-UP value. The accumulator is then incremented on each pass of the program and the value outputted to the latch. The next three instructions are **DJNZ's** in which the B register is decremented to zero during each instruction. After the 3 DJNZ's the program jumps to **02C2** and outputs the next higher value.

AUTO INCREMENT (variable)

This program is located at 02D0 and the speed with which the computer



02D0

completes one cycle depends on the setting of the input switches.

LD D,01	**02D0**	**16 01**	Load the TALLY register with 01.
IN A,(01)	**02D2**	**DB 01**	Input the switch value to the accumulator.
LD C,A	**02D4**	**4F**	Load the accumulator into 'C' for the delay value.
LD A,D	**02D5**	**7A**	Load the TALLY into the accumulator.
OUT (02),A	**02D6**	**D3 02**	Output the tally value to the displays.
DEC C	**02D8**	**0D**	Decrement register C.
JR NZ 02D8	**02D9**	**20 FD**	Jump to 02D8 if register C is not zero.
INC D	**02DB**	**14**	Increment the tally register.
JR 02D2	**02DC**	**18 F4**	Jump to the start of the program.

'D' is the tally register and holds the value to be displayed on the screen, so that the accumulator can be used for other things.

'C' is the delay register and it is decremented very similar to a **DJNZ** statement, where FF produces the longest delay and 01 the shortest delay.

This is not quite correct, however, as you will find out for yourself.

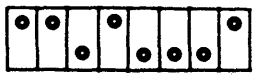
Load the value **01** and compare it with **00. 00** is a much longer delay and it appears to be as long as **FF!** In fact this is the case! The longest delay is produced when a register is loaded with **00** since the first operation to be performed on the register is to decrement it. The result is **FF** and that's why it takes **FF** loops to bring it to zero.

The program is designed to start with an output value of 01 and increment automatically to FF. The ON time (the delay time) is adjustable via the setting on the input switches.

Note: We don't have any control over the values appearing on the screen, just the speed of the increment.

AUTO DECREMENT

By changing one byte of the program at 02C0, we produce a decrementing



02E0

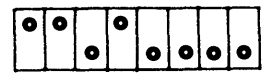
counter. The best effect of decrementing can be seen on the 8 LEDs. Adjust the speed control to view the effect in slow motion.

AUTO DECREMENT

LD A,00	**02E0**	**3E 00**	Load the accumulator with zero.
DEC A	**02E2**	**3D**	Decrement the accumulator.
OUT (02),A	**02E3**	**D3 02**	Output the accumulator to the latch.
DJNZ 02E5	**02E5**	**10 FE**	Decrement register 'B', FF loops,
DJNZ 02E7	**02E7**	**10 FE**	" " " "
DJNZ 02E9	**02E9**	**10 FE**	" " " "
JR 02E2	**02EB**	**18 F5**	Jump to start of program.

AUTO DECREMENT (variable)

This routine is located at 02F0 and decrementes the display when button A is pressed. It has a fixed rate of decrementing and is not variable.

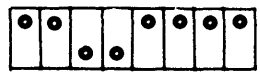


02F0

LD E,FF	**02F0**	**1E FF**	Load the COUNT HOLD register with **FF**.
LD A,E	**02F2**	**7B**	Load the Count Hold register into the accumulator.
OUT (02),A	**02F3**	**D3 02**	Output the accumulator to the latch.
DJNZ 02F5	**02F5**	**10 FE**	Create a short delay with the B register.
IN A,(01)	**02F7**	**DB 01**	Input the bank of switches to the accumulator.
Bit 7,A	**02F9**	**CB 7F**	Test bit 7 of the accumulator to see if A is pressed.
JR Z,02F2	**02FB**	**28 F5**	Jump to **02F2** if it is not pressed. Go to next line if pressed.
DEC E	**02FD**	**1D**	Decrement register E.
JR 02F2	**02FE**	**18 F2**	Jump to **02F2.**

4x4 DISPLAY

As the name suggests, the program at **0300** is designed for the 4x4 DISPLAY. It



0300

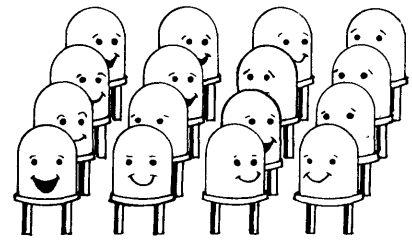
will produce almost no interpretable effects on either of the other displays.

The routine we have presented is only just the start of what you can do with a set of LEDs in an array. Our 4x4 can be multiplied-up many times to produce an enormous array of LEDs or globes and obviously the ultimate is to produce a video screen with coloured globes to duplicate a TV. But the cost of this kind of venture is enormous as the parts alone would cost a fortune and the time taken to wire it up would be too much for an individual constructor.

That's why we have concentrated on a manageable module.

One of the decisions you have to make when outputting to LEDs, is the method of turning them ON. One is to connect each output of a latch directly to a LED. The other is to multiplex the display and scan it. The multiplex method uses the least number of chips and is obviously the cheaper.

The relative merits of each will be covered in future articles and for the moment we will study the effects which can be produced with a display connected in MULTIPLEX mode.



The program at **0300** is an OUTPUT ROUTINE in which a value is loaded from a table into the accumulator and outputted to the display. The display remains illuminated for a delay period and then the next byte is picked up from the table. This is done until all the bytes have been used.

When the end of the table is reached, the program starts again. This is repeated for 8 loops and then the micro advances to the second part. This is identical to the first except for the byte table. It has entirely different values and the effect is completely different. At the conclusion of the second byte-table, the micro jumps back to the start of the program and the first pattern is outputted.

The speed of presenting a pattern is controlled by the clock and the inbuilt delay value. The delay is fixed but the clock can be adjusted to slow-down or speed-up the effect.

```
LD B,08          0300   06 08
LD HL,0338       0302   21 38 03
LD C,18          0305   0E 18
DEC C            0307   0D
JR Z,0318        0308   28 0E
LD A,(HL)        030A   7E
OUT (02),A       030B   D3 02
INC HL           030D   23
LD DE,0080       030E   11 80 00
DEC DE           0311   1B
LD A,D           0312   7A
OR E             0313   B3
JR NZ,0311       0314   20 FB
JR 0307          0316   18 EF
DJNZ 0302        0318   10 E8
LD B,08          031A   06 08
LD HL,0350       031C   21 50 03
LD C,20          031F   0E 20
DEC C            0321   0D
JR Z,0332        0322   28 0E
LD A,(HL)        0324   7E
OUT (02),A       0325   D3 02
INC HL           0327   23
LD DE,0080       0328   11 80 00
DEC DE           032B   1B
LD A,D           032C   7A
OR E             032D   B3
JR NZ, 032B      032E   20 FB
JR 0321          0330   18 EF
DJNZ 031C        0332   10 E8
JR 0300          0334   18 CA
```

B is the COUNT REGISTER for the number of loops in the first program.
Load HL with the address of the start of the BYTE TABLE.
Load C with the number of bytes for the program (There are 24 bytes.)
Decrement the number of bytes remaining in the table to detect the end of table.
If no bytes remain, decrement the number of loops and start program again.
Load the accumulator with the byte pointed to b the HL register pair.
Output this value to port 2.
Increment HL to point to the next byte in the table.
Load DE with a short delay value.
Decrement DE.
Load D into A.
Logically OR the accumulator with E to see when BOTH D and E arezero.
Jump to **0311** if the answer is NOT ZERO.
Jump to **DEC C** and repeat for the second byte in the table.
Decrement the number of loops and start the byte table again.
Load B with 8 for the second part of the program.

This part is identical with that above except the byte table is longer and located at a different address. When 8 loops of this part have been executed the program jumps to the top program and the cycle repeats.

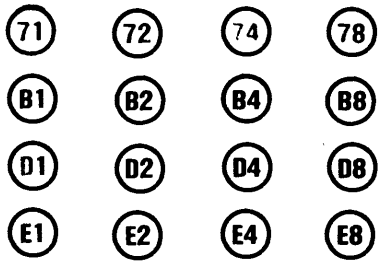
At 0338:		At 0350:		
01	CF	0F	B8	D4
02	3F	FF	D8	D2
04	CF	0F	E8	B2
08	3F	FF	E4	B4
EF	96	0F	E2	D4
DF	FF	FF	E1	D2
BF	96	0F	D1	B2
7F	FF	FF	B1	B4
03	33	71	71	
0C	CC	72	72	
03	C3	74	74	
0C	3C	78	B4	

An almost unlimited number of patterns and effects can be produced on the 4x4. However not every combination can be displayed due to the limitations of how the LEDs are accessed.

This means you will have to learn how to access the LEDs and get the patterns you want.

To turn on a LED, the cathode end must be taken to earth and the anode to positive.

This is the hex value required to illuminate an individual LED:



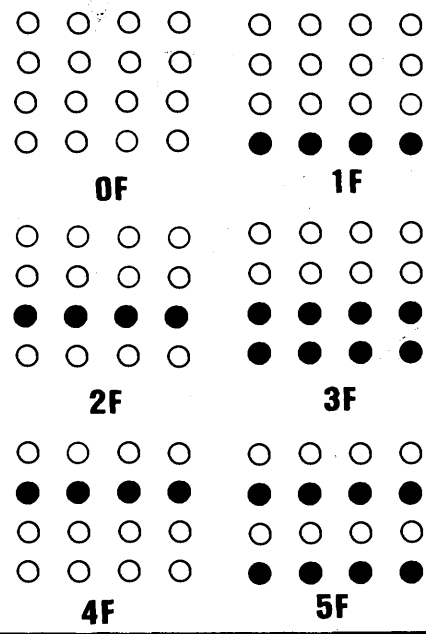
To access the LEDs we have separated the output latch into two halves with the 4 lower bits connected to the anodes and the 4 upper bits to the cathodes.

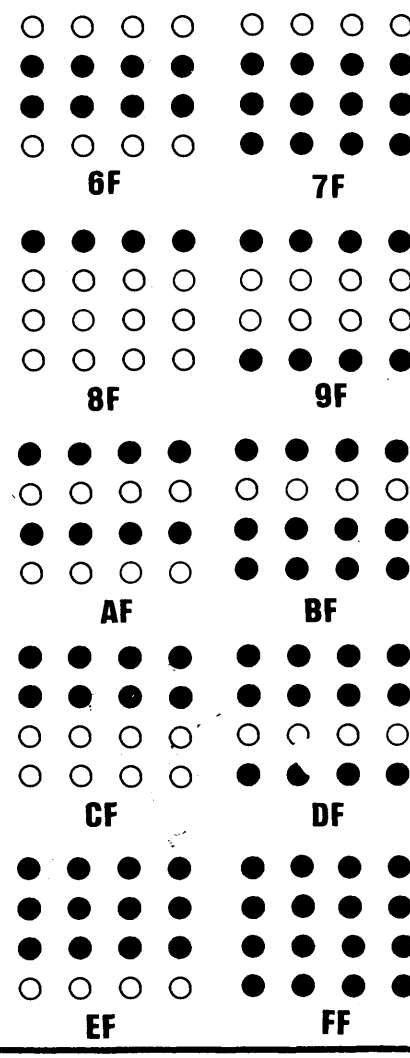
The following diagrams give you the values required to turn ON one or more LEDs:

ALL ON "0F"
ALL OFF "FF" or "00".

LEGEND:

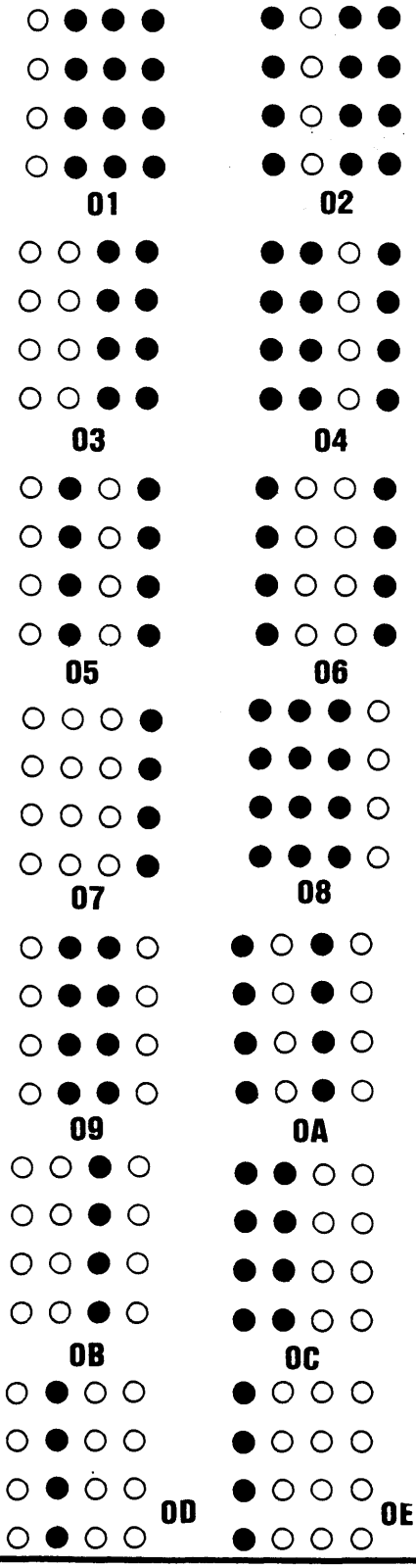
○ = ON.
● = OFF.

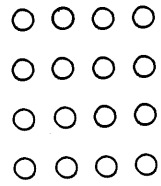




If you don't want all the LEDs in a row to be illuminated, refer to the diagrams on this page for the hex value needed to illuminate an individual column or column(s).

To use these values select from the first 16 diagrams to give the row(s) and from the following 16 diagrams for the column(s).



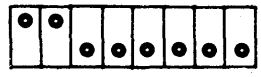


When the two diagrams are placed on top of each other, the LEDs that are common to both, will be illuminated. Due to the sinking and sourcing limitations of the output latch, all the LEDs in the 4x4 can not be illuminated at the same time.

Brightness can be improved by turning off the 7-segment display by shorting the base and emitter leads of the driver transistor together with a jumper lead. This transistor is directly below the second display and is the middle transistor.

VERY LONG DELAY

This routine, at **03F0**, is particularly unusual. Not only is it a very long duration



delay but is shows that a program can be split up and placed in two different parts of memory, and still run.

And this is what we have done.

Half the program is located at **03F0** and the other half at **045A**. This makes the Micro jump up and down in ROM as it executes the program.

The jumping back and forth does not occupy many clock cycles but it does increase the overall time by about 5%.

We calculated the time delay to be so long that you may never see the display increment! This is due to the low clock speed. At 70kHz, the Z-80 is operating far below its normal rate and a delay like this introduces many millions upon millions of clock cycles.

WHY DO WE NEED DELAYS?

Delays are very important in micro programs. Due to the high speed of the execution of machine code instructions, some parts of the program must be slowed down so that humans can be involved. This may be for the video aspect, so that the eye can see what is being outputted on a display or for the audio side, so that we can detect tones and beeps.

Delays are also needed to give a SUSPENSE EFFECT for games of chance or strategy to give the impression that the computer is taking time to think.

Or for a video game, to create rates-of-movement for objects moving across the screen.

The delays we are talking about are PROGRAM DELAYS or SOFTWARE DELAYS. They are produced when the micro 'wastes time'. The simplest way of wasting time is to fill a register pair with a large number and gradually decrement it to zero.

By decrementing a single register, the maximum number of loops which can be executed is 256. Each loop may take 20 clock cycles and at the normal running frequency of a system (about 1MHz), the delay time will be very short. By using a REGISTER PAIR, the time can be increased 256 times. The delay becomes more noticeable and will be about 2 seconds.

If we require longer delays we can add another register-pair and increase the delay to more than 131,000 seconds!

When the system is operating at only 70kHz, the delay time turns into hours, days and months!

There is one point to note here: When a micro is performing a very long delay, the entire computer time is being taken up with a COUNT DOWN sequence and this means the micro will not be updating information on the displays or looking at the input port.

If you require other operations to be attended to, they must be included in the loop, as can be seen in the clock program at **0630.**

LD A,01	**03F0**	**3E 01**	Segment 'A' will illuminate after a delay period.
LD I,A	**03F2**	**ED 47**	Save the 'TALLY' in the I register (Not part of IX).
LD DE,FFFF	**03F4**	**11 FF FF**	Load DE with the maximum value.
LD HL,FFFF	**03F7**	**21 FF FF**	Load HL with the maximum value.
DEC HL	**03FA**	**2B**	Decrement HL.
LD A,H	**03FB**	**7C**	Load register H into the accumulator.
OR L	**03FC**	**B5**	Logically OR the accumulator with L.
JP 045A	**03FD**	**C3 5A 04**	Jump to address **045A.**
JP NZ,03FA	**045A**	**C2 FA 03**	If register H and L are not zero, jump to **03FA.**
DEC DE	**045D**	**1B**	When HL (the inner loop) is zero, decrement DE.
LD A,D	**045E**	**7A**	Load register D into the accumulator.
OR E	**045F**	**B3**	Logically OR the accumulator with register E.
JP NZ,03F7	**0460**	**C2 F7 03**	If result is not zero, JUMP to **03F7** and DEC HL!
LD A,I	**0463**	**ED 57**	When both HL and DE are zero, time is UP!
OUT (02),A	**0465**	**D3 02**	Load the TALLY register into A and output it.
INC A	**0467**	**3C**	Increment A.
LD I,A	**0468**	**ED 47**	Load the new tally into the TALLY register.
JP 03F4	**046A**	**C3 F4 03**	Load the register pairs and start again!

When we use two register pairs to create a very long time delay, we do not place one pair after the other as this would only double the time delay. We place them ON TOP of each other so that the effect is MULTIPLICATION. This means one pair is INSIDE the other and we say it is HIDDEN or NESTED. This arrangement gives rise to the term NESTED LOOP. This is what we are creating in this section.

The simplest method of increasing the delay is to add the instruction: **10 FE.** This will have the effect of adding 256 cycles to the delay time. This is a **DJNZ** instruction and operates with the B register. The advantage of a **DJNZ** is it does not affect the accumulator. In the Microcomp we do not have any RAM and we cannot save the accumulator via a PUSH operation since we do not have any STACK. Thus it's an advantage not to alter the contents of the accumulator.

DJNZ loops are not nested loops but are additive and require the **B** register to be zero at the start of the delay routine to create the longest delay. At the end of a **DJNZ** the B register is zero and this is ideal for the next **DJNZ.**

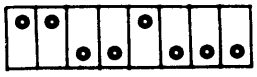
DJNZ's can be grouped thus:

```
DJNZ FE    10 FE
DJNZ FE    10 FE
DJNZ FE    10 FE
DJNZ FE    10 FE
DJNZ FE    10 FE
```

---

0 - 9 COUNTER

The first counter we are going to study is a 0-9 UP COUNTER. This is located at address **0370** and will show us how to



output numbers onto the display and how the INCrement operation is performed.

The main fact to remember with the program is the computer is NOT adding numbers. It is simply going through a table of values and it is the values it fetches that create the increments on the screen.

The table could be designed to produce letters or symbols and we would lose the effect of incrementing.

The requirements of a counter are these:

The computer must detect when a button is pressed and distinguish it from other buttons. In our design button A corresponds to BIT 7 and button B to BIT 6, of the accumulator.

The program must be running or LOOPING at all times ready to instantly pick up an input value.

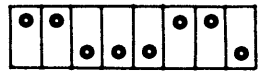
Because the program is running at high speed, we must include a DEBOUNCE feature to prevent more than ONE COUNT being registered when a button is pressed.

With these facts in mind, we have produced the 0-9 COUNTER.

The program contains 2 loops. One is executed when button 'A' is NOT pressed and the other when the button is PRESSED. We also have to detect when the end of the BYTE TABLE is reached.

0 - F COUNTER

This routine, at **0390**, increments the display each time button A is pressed.

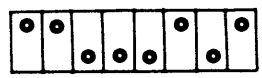


The main program for producing the letters on the display is located at **03A8** and the micro jumps to this address via the instruction **JR 03A8.** The main program is also used by the **A -Z, 0 - F** counter and shows how the same table and output program can be accessed by two different START-UP ROUTINES.

```
LD C,10          0390   0E 10
LD DE,03DF       0392   11 DF 03
LD HL,0390       0395   21 90 03
JR 03A8          0398   18 0E
```

A - Z, 0 - F COUNTER

This counter is located at **03A0** and



produces the letters **A - F** and hex values **0 - F** on the display via button 'A'.

```
LD C,2A          03A0   0E 2A
LD DE,03C5       03A2   11 C5 03
LD HL,03A0       03A5   21 A0 03
IN A,(01)        03A8   DB 01
BIT 7,A          03AA   CB 7F
JR Z,03A8        03AC   28 FA
INC DE           03AE   13
LD A,(DE)        03AF   1A
OUT (02),A       03B0   D3 02
IN A,(01)        03B2   DB 01
BIT 7,A          03B4   CB 7F
JR NZ,03B2       03B6   20 FA
DEC C            03B8   0D
JR Z,03BD        03B9   28 02
JR 03A8          03BB   18 EB
JP (HL)          03BD   E9
```

The 3 counters in this section use the table at **03C6.** The 0-9 counter uses only those bytes corresponding to 0-9. The 0-F counter uses bytes from 0 to the end of the table.

The A-Z,0-F counter uses all the table.

In addition, the 0-F counter uses most of the A-Z, 0-F program and that's why it has only 4 instructions.

At 03C6:

A	77	V	1C
B	7C	W	4E
C	39	X	4C
D	5E	Y	6E
E	79	Z	1B
F	71	0	3F
G	3D	1	06
H	76	2	5B
I	06	3	4F
J	1E	4	66
K	72	5	6D
L	38	6	7D
M	47	7	07
N	37	8	7F
O	3F	9	67
P	73	A	77
Q	67	B	7C
R	33	C	39
S	6D	D	5E
T	78	E	79
U	3E	F	71

By now you will be aware that certain combinations of hex values produce letters and numbers on the display.

Use the program at **0290** to produce the numbers 0 - 9 and letters A - F, by switching ON the correct switches. Use the output display values on P68 to assist you in this. Add the value on the switches and compare with the table at **03C6.**

---

0 - 9 COUNTER

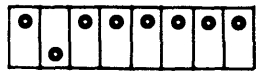
LD C,0A	0370	0E 0A	Register C is the counter for the BYTE TABLE. There are ten bytes.
LD DE,03DF	0372	11 DF 03	The DE register pair is loaded with the start-address of the byte table.
IN A,(01)	0375	DB 01	The input latch is looked at and the value it holds is placed into the accumulator.
BIT 7,A	0377	CB 7F	The only line (or BIT) which is tested is bit 7. This is the 8th line and is button A.
JR Z,0375	0379	28 FA	If it is HIGH (or SET) the program advances. If it is LOW (or RESET), it goes to: IN A,(01).
INC DE	037B	13	INCrement the DE register pair to look at address **03E0.**
LD A,(DE)	037C	1A	The byte at **03E0** is placed in the accumulator.
OUT (02),A	037D	D3 02	Output this byte to the display.
IN A,(01)	037F	DB 01	Look at the input port.
BIT 7,A	0381	CB 7F	Test bit 7 of the accumulator.
JR NZ,037F	0383	20 FA	Jump to address **037F** if button A is pressed. When button is released, advance to next line.
DEC C	0385	0D	Decrement the BYTE COUNT register.
JR Z,0370	0386	28 E8	If end of table is reached, JUMP to start of program. If not reached, go to **0375.**
JR 0375	0388	18 EB	

00 - 99 COUNTER

Counters and counting are a very important part of electronics. Business and industry needs counting. Whether it be to keep track of money or components, it needs to know the answers.

The counter program at **0400** shows the basics of how a counter operates and how the COUNT VALUE can be held in a single register pair.

Functions such as INCREMENT, DECREMENT and RESET can also be included. The most involved part of the program is debouncing the switches, to prevent the count automatically incrementing if the button is kept pressed.



0400

at 03E0:

3F
06
5B
4F
66
6D
7D
07
7F
67

The program basically consists of two loops. The top loop is executed when the buttons are NOT pressed and the lower when either of the buttons is pressed.

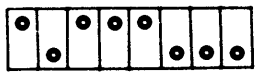
This is necessary to keep the displays illuminated while at the same time preventing the program from incrementing the displays if a button is kept pressed.

```
LD E,00          0400   1E 00      Register E holds the present COUNT VALUE in decimal form.
LD A,E           0402   7B         Load E into the accumulator so that it can be operated upon.
AND 0F           0403   E6 0F      Mask off the 4 HIGH ORDER bits. In other words, remove them.
LD HL,03E0       0405   21 E0 03   Load HL with the start of the BYTE TABLE that produces the display numbers.
ADD A,L          0408   85         Add the start of the byte table to the accumulator.
LD L,A           0409   6F         Load the accumulator into L to produce a new pointer value.
LD A,(HL)        040A   7E         Load the accumulator with the byte pointed to by the HL register pair.
OUT (02),A       040B   D3 02      Output this value to port 2.
LD A,E           040D   7B         Load E into the accumulator again, this time to produce the 10's value.
RRA              040E   1F         Shift the bits in the accumulator one place to the right.
RRA              040F   1F         Shift the bits in the accumulator another place to the right.
RRA              0410   1F         "  "  "  "  "  "  "  "  "  "  "
RRA              0411   1F         "  "  "  "  "  "  "  "  "  "  "
AND 0F           0412   E6 0F      Mask the 4 HIGH ORDER bits so that they are effectively removed.
LD HL,03E0       0414   21 E0 03   Load HL with the start of the byte table.
ADD A,L          0417   85         Add the value of L to the value in the accumulator.
LD L,A           0418   6F         A new pointer value is created.
LD A,(HL)        0419   7E         Load the accumulator with the byte pointed to by the HL register pair.
SET 7,A          041A   CB FF      SET bit 7 of the accumulator to '1' to turn on the 10's display.
OUT (02),A       041C   D3 02      Output the value of the accumulator to the latch.
IN A,(01)        041E   DB 01      Input the value on the switches to the accumulator.
BIT 7,A          0420   CB 7F      TEST bit 7 to see if button A is pressed.
JR Z,042A        0422   28 06      If it is zero, jump to 042A. If it pressed,increment to next instruction.
LD A,E           0424   7B         Load E into the accumulator, ready for an INCrement operation.
INC A            0425   3C         Increment the accumulator.
DAA              0426   27         Decimal adjust the accumulator. This means an A will be changed into 10.
LD E,A           0427   5F         Save the new count value by loading it into the E register.
JR 0432          0428   18 08      Jump to 0431.
BIT 6,A          042A   CB 77      From 0422, the program jumps to this address and tests for button B.
JR Z,0402        042C   28 D4      If not pressed, the program jumps to 0402. If pressed, the program increments.
LD A,E           042E   7B         Load the COUNT REGISTER into the accumulator.
DEC A            042F   3D         Decrement the accumulator.
DAA              0430   27         Decimal adjust the accumulator. This will change a zero into a 9.
LD E,A           0431   5F         Save the count value by loading it into the E register.
LD A,E           0432   7B
AND 0F           0433   E6 0F
LD HL,03E0       0435   21 E0 03
ADD A,L          0438   85
LD L,A           0439   6F
LD A,(HL)        043A   7E
OUT (02),A       043B   D3 02
LD A,E           043D   7B
RRA              043E   1F
RRA              043F   1F
RRA              0440   1F
RRA              0441   1F
AND 0F           0442   E6 0F
LD HL,03E0       0444   21 E0 03
ADD A,L          0447   85
LD L,A           0448   6F
LD A,(HL)        0449   7E
SET 7,A          044A   CB FF
OUT (02),A       044C   D3 02
IN A,(01)        044E   DB 01
BIT 7,A          0450   CB 7F
JR NZ,0432       0452   20 DE
BIT 6,A          0454   CB 77
JR NZ,0432       0456   20 DA
JR 0402          0458   18 A8
```

The remainder of the program keeps both displays illuminated by looping from **0432** to **0456** while either of the buttons remains pressed. As soon as the button is released, the program jumps back to **0402** and executes the top loop.

DICE

The DICE Program at **0470** introduces a few more programming skills.



The first of these is a RANDOM NUMBER GENERATOR. Random numbers are almost impossible to generate via a computer due to it being a very predictable machine. The only reliable way to get a random number is to introduce the human element.

This is what we have done in this program.

At the start of the program a running LED routine moves a single LED around the 4x4 matrix. The ON time for each LED is created by a delay routine that uses the B abd C registers. The C register is loaded with 6 and decrements to zero. Each time this is done, the B register is decremented and when it reaches zero, the LED jumps to the next location.

The random number is generated in the C register and we can exit from the program with a value remaining in C. Since C is the inside loop of the delay it is decrementing very fast and it is not possible to predict what value C will contain.

If it were the outside loop it would be a different matter. Players would gradually get to understand that pressing at the beginning of cycle would generate a low number and at the end of a cycle, a high number.

Owing to the unpredictability of the human reaction, an even spread of numbers from 1 to 6 is created with our routine.

The second feature of the program is the COMPARE and BRANCH.

After the random number has been obtained, a number of flashes are created on the screen and then the accumulator is compared with the random number before jumping to the display routine.

This routine is a very simple multiplexing routine in which three bytes are outputted for a period of 80 cycles.

The program then detects that the input button has been released and jumps to the start of the program.

If a button-check was not made, the same number would appear on the displays due to a constant number of cycles occuring in the program for each game.

At 04D3:

71	E(
72	E4
74	E2
78	E1
B8	D1
D8	B1

```
LD D,0C          0470  16 0C     C is the byte table counter for the 4x4
LD HL,04D3       0472  21 D3 04  HL will point to the byte table address
LD A,(HL)        0475  7E        A is loaded with the value of the first byte in the table.
OUT (02),A       0476  D3 02     The accumulator is outputted to port 02.
INC HL           0478  23        The byte table pointer is incremented.
LD B,15          0479  06 15     Load B with 15, for a delay value of 21 loops.
LD C,06          047B  0E 06     Load C with 6, for the dice values: 0-6.
IN A,(01)        047D  DB 01     Input from the input port to the accumulator.
BIT 7,A          047F  CB 7F     Check to see if button A has been pressed.
JR NZ,048D       0481  20 0A     If pressed, jump out of the delay routine.
DEC C            0483  0D        Decrement register C.
JR NZ,047D       0484  20 F7     If C is not zero, jump up, If C zero, advance.
DJNZ 047B        0486  10 F3     Decrement B and if not zero, jump up.
DEC D            0488  15        Decrement the byte table register D.
JR Z,0470        0489  28 E5     When D is zero, jump to start of program.
JR 0475          048B  18 E8     If not zero, continue DELAY ROUTINE.
LD D,06          048D  16 06     Load D with 6 for six flashes of the display.
LD A,0F          048F  3E 0F     Load A to turn on the whole 4x4 display.
OUT (02),A       0491  D3 02     Output to port 02.
DJNZ 0493        0493  10 FE     Register B is decremented to create a delay.
LD A,FF          0495  3E FF     Load A with a value to turn 4x4 OFF.
OUT (02),A       0497  D3 02     Output to port 02.
DJNZ 0499        0499  10 FE     Create a short delay with register B.
DEC D            049B  15        Decrement the flash-count register.
JR NZ,048F       049C  20 F1     Loop for 6 flashes.
LD D,80          049E  16 80     Load D for 80 loops for multiplexing routine.
LD A,C           04A0  79        Load our random number into the accumulator.
LD HL,04E0       04A1  21 E0 04  Load HL with address of table for multiplex routine.
CP 01            04A4  FE 01     Compare the accumulator with 1.
JP Z,045F        04A6  CA F5 04  If the accumulator is 1, jump to multiplex routine.
LD HL,04E3       04A9  21 E3 04  Load HL with start address for displaying '2'.
CP 02            04AC  FE 02     Compare the accumulator with 2.
JP Z,045F        04AE  CA F5 04  If accumulator is 2, jump to multiplex routine.
LD HL,04E6       04B1  21 E6 04  Load HL with start-address for displaying '3'.
CP 03            04B4  FE 03     Compare accumulator with 3.
JP Z, 045F       04B6  CA F5 04  If accumulator is 3, jump to multiplex routine.
LD HL,04E9       04B9  21 E9 04  Load HL with start-address for displaying '4'.
CP 04            04BC  FE 04     Compare the accumulator with 4.
JP Z,045F        04BE  CA F5 04  If accumulator is 4, jump to multiplex routine.
LD HL,04EC       04C1  21 EC 04  Load HL with start-address for displaying '5'.
CP 05            04C4  FE 05     Compare accumulator with 5.
JP Z,04F5        04C6  CA F5 04  If accumulator is 5, jump to multiplex routine.
LD HL,04EF       04C9  21 EF 04  Load HL with start-address for displaying 6.
CP 06            04CC  FE 06     Compare accumulator with 6.
JP Z,04F5        04CE  CA F5 04  Jump to multiplex routine is accum is 6.
```

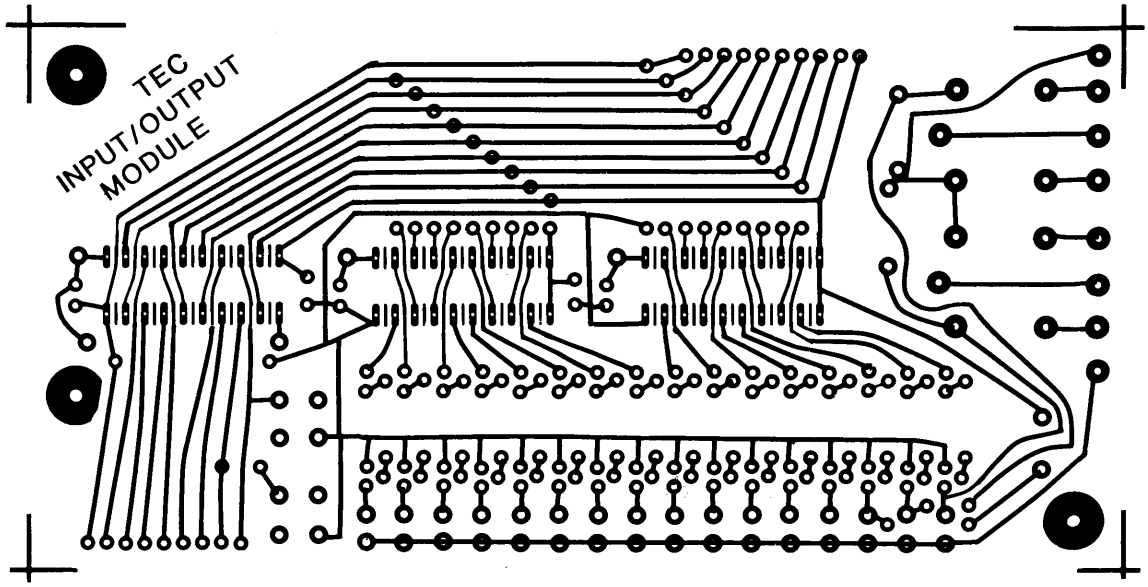
At 04E0:

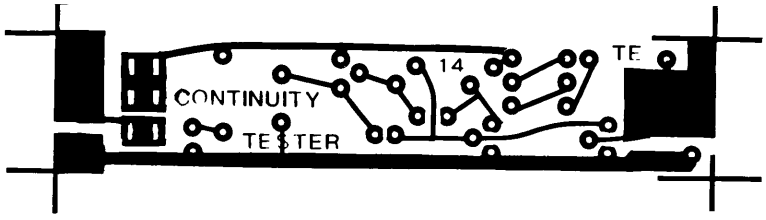
A jump value must be found and the micro jumps to the multiplexing routine below and produces a display on the 4x4 that is similar to the spots on the face of a dice. The routine runs for 80 loops , makes sure button A is not pressed, then jumps to the start of the DICE program.

B4	D2	72	52	52	52
00	00	B4	00	B4	54
00	78	D8	58	58	58

```
LD A,(HL)        04F5  7E        Load A with the value pointed to by HL.
OUT (02),A       04F6  D3 02     Output the value to port 02.
LD B,0A          04F8  06 0A     Load B with a short delay value.
DJNZ 04FA        04FA  10 FE     Create a short delay with register B.
INC HL           04FC  23        Point to next display address
LD A,(HL)        04FD  7E        Load the value pointed to by HL into A.
OUT (02),A       04FE  D3 02     Output to port 02.
LD B,0A          0500  06 0A     Load B with a short delay value.
DJNZ 0502        0502  10 FE     Create a short delay with register B.
INC HL           0504  23        Inc HL to look at next address.
LD A,(HL)        0505  7E        Load value pointed to by HL in the accumulator.
OUT (02),A       0506  D3 02     Output to port 02.
LD B,0A          0508  06 0A     Load register B with a short delay value.
DJNZ 050A        050A  10 FF     Decrement register B to zero.
DEC HL           050C  2B        Dec HL to look at start of display table.
DEC HL           050D  2B
DEC D            050E  15        Decrement multiplex routine loop counter.
JR NZ, 04F5      050F  20 E4     Loop again if D is not zero.
XOR A            0511  AF        Zero the accumulator and output to port 02 to
OUT (02),A       0512  D3 02     blank the display.
IN A,(01)        0514  DB 01     Look at the output port to see if button A is NOT
BIT 7,A          0516  CB 7F     pressed before re-starting the DICE program.
JR NZ,0514       0518  20 FA     Loop is A is pressed.
JP 0470          051A  C3 70 04  Jump to start of DICE program.
```

PC ARTWORK:


TEC
INPUT/OUTPUT
MODULE


14
TE
CONTINUITY
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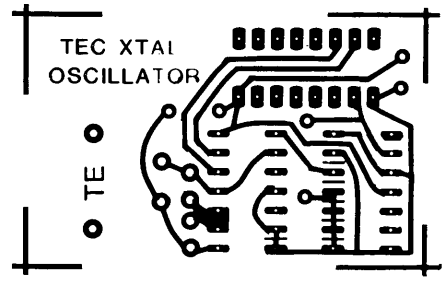
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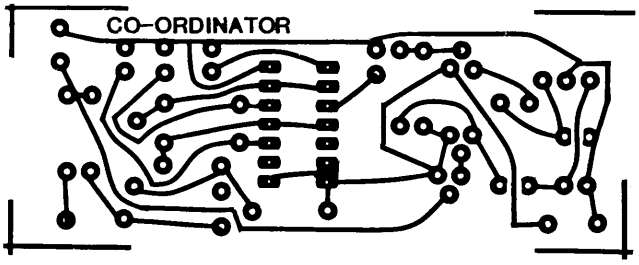
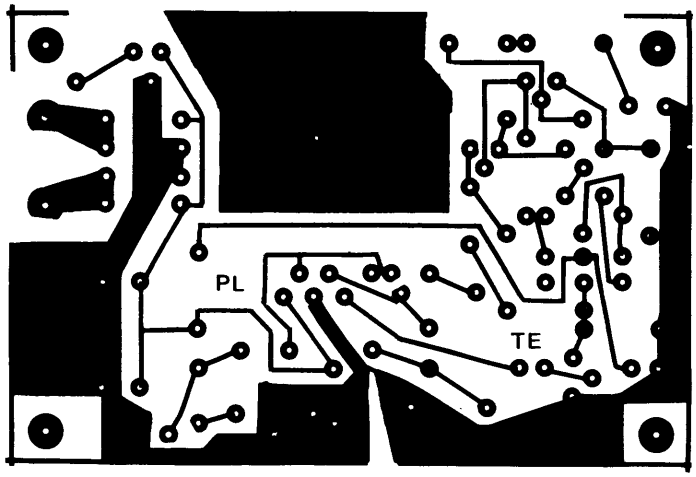

CO-ORDINATOR


PL
TE

Z80 Machine Codes EXPLAINED Part 11

NEG . . . . . Each bit in the accumulator is reversed sign. One's go to zero and zero's go to one. Then one is added to the result.

NOP . . . . . The NO OPERATION instruction. Only the Program Counter advances.

OR ( ) . . . The logic OR operation is performed between the accumulator and the contents of the memory location pointed to by the address in ( ).

OR A,B,C etc A logic OR operation is performed between the accumulator and a specified register.

OTDR . . . . Data from the memory location specified by the contents of the HL register is outputted to a port as specified by the contents of register C. The HL pointer has its value decremented after each transfer operation. The value of register B is decremented and if the result is zero, the Program Counter register is set back 2 units so that the instruction is re-executed.

OTIR . . . . . Same OTDR except that the HL pointer is incremented after each execution.

OUT (C),A etc The contents of A, B, C, D, etc are outputted to the port specified by the contents of register C.

OUT port,A . . The contents of the accumulator is outputted to the port specified.

OUTD . . . . Data is outputted from memory location specified by the contents of the HL register pair to the port specified by the contents of register C. (contents of register B will be decremented but no repeat operation will be performed.) HL register pair has its contents decremented after the conclusion of the operation.

OUTI . . . . . Same as OUTD except HL has its contents incremented at the conclusion of the operation.

POP AF . . . Two bytes are removed from the stack. The first byte is loaded into F and the second into A.

PUSH HL . . . Two bytes are placed onto the stack. The contents of the HIGH ORDER register are stored in the stack at the address of the stack pointer less one. The content of the LOW ORDER register are stored at the address of the stack pointer less two.

RES 0,( ) . . RESET BIT 0, 1, 2, 3, 4, 5, 6, 7 to the logic ZERO conditon of the specified register.

RET . . . . . The unconditional RETURN instruction

RET C . . . . Return from the sub-routine if the carry flag in the F register is true (1).

RET M . . . . The instruction will only be performed if the S flag (sign flag) is negative.

RET NC . . . The instruction will only be performed if the NON-CARRY condition is present. i.e. the CARRY FLAG is '0'.

RET NZ . . . The instruction will only be performed if a NON-ZERO condition is satisfied. i.e. the ZERO FLAG is '0'.

RET P . . . . The instruction will only be performed if the sign flag in the F register is positive. i.e. S = 1.

RET PE . . . The instruction will only be performed if the PARITY is EVEN. This means the P/V flag is SET (1).

RET PO . . . The instruction will only performed if the PARITY is ODD. This means the P/V flag is reset (0).

RET Z . . . . The instruction will only be performed if the ZERO flag is SET (1).

RETI . . . . . Return from INTERRUPT.

RETN . . . . Return from non-maskable INTERRUPT.

RL ( ) . . . The content of the memory location contained in ( ) is rotated to the left, through the carry bit.

RL A,B,C,etc . The contents of the register is rotated one bit position to the left, through the carry bit.

RLA . . . . . This is a one-byte instruction of **RL A** and rotates the contents of the accumulator one bit position to the left, through the carry bit.

RLC ( ) . . . The contents of a memory location pointed to by the contents of the location in ( ) is shifted one bit to the left but not through the carry. The C flag is set to the original status of the register's least significant bit.

RLC A,B,etc . The contents of the indicated register is shifted one bit position to the left. It does not shift through the carry bit but does set the C flag to the original status of the register's most significant bit.

RLCA . . . . This is a one byte instruction of **RLC A** and operates as above.

RLD . . . . The 4 low-order bits of a memory location (pointed to by the contents of register pair in brackets) are transferred to the 4 high-order bits of the same memory location. The 4 high-order bits are transferred into the 4 low-order bits of the accumulator. The previous 4 low-order bits of the accumulator are transferred to the 4 low-order bits of the memory location specified above.

RR ( ) . . . Rotate the contents of a memory location pointed to by the contents of the register in ( ) to the right, through the carry bit.

RR A,B,C etc Rotate the indicated register to the right through the carry bit.

RRA . . . . Rotate the accumulator right, through the carry bit.

RRC ( ) . . Rotate the contents of a memory location pointed to by the contents of the register in ( ) to the right but not through the carry bit. The C flag is set to the status of the register's least significant bit.

RRC A,B,etc Rotate register to the right but not through the carry bit.

RRCA . . . . A one-byte instruction for RRC A.

RRD . . . . The 4 high-order bits of a memory location (pointed to by the contents of register pair HL) are transferred to the 4 low-order bits of the same location. The 4 low-order bits are transferred to the 4 low-order bits of the accumulator. The previous 4 low-order bits of the accumulator are transferred to the 4 high-order bits of the memory location specified above. A special one-

RST 00 . . . A special one-byte subroutine call directive called RESTART.
RST 00 will restart at page zero, location 00. i.e. 00 00
RST 08 will restart at location 08. i.e. 00 08 etc.

SBC A,( ) . Subtract the contents of memory pointed to by the contents of the register pair in ( ) and the carry flag from the accumulator. Store the result in the accumulator.

SBC A,B . . The contents of the B register and the carry flag (the C flag in the F register) are subtracted from the contents of the accumulator. The result is stored in the accumulator.

SCF . . . . The carry flag (the C flag in the F register) is set to 1.

SET D,( ) . Bit 0, etc at the memory location pointed to by the contents of the register in ( ) is set to 1.

SET 0,B . . The indicated bit in the selected register is set to 1.

SLA ( ) . . SHIFT LEFT ARITHMETIC. Shift the contents of the memory location pointed to by the contents of the register in ( ) one bit to the left, resettng the least significant bit to 0.

SLA A,B,etc Shift the contents of the specified register left one bit, resetting the least significant bit to 0.

SRA ( ) . . SHIFT RIGHT ARITHMETIC. Shift the contents of a memory location pointed to by the contents of the register in ( ) to the right. The high-order bit is not altered. Bit 0 is shifted into the carry bit.

SRA A,B,etc Shift the contents of a register one bit to the right. High-order bit is unchanged. Bit 0 is shifted into the carry bit.

SRL ( ) . . SHIFT RIGHT LOGICAL. The contents of the memory location pointed to by the contents of the register in ( ) are shifted to the right. Bit 7 is reset to 0. Bit 0 is shifted into the carry bit.

SRL A,B,etc The contents of the indicated register is shifted one bit position to the right. Bit 7 is reset to 0. Bit 0 is shifted into the carry bit.

SUB ( ) . . Subtract the contents of the memory location pointed to by the contents of the register in ( ) from the accumulator.

SUB A,B,etc Subtract the contents of the specified register from the accumulator.

SUB dd . . . Subtract immediate data from the accumulator.

XOR ( ) . . Perform the Exclusive-OR operation on data pointed to by the contents of the register in ( ) with the accumulator.

XOR A,B,etc Exclusive-OR the contents of the specified register with the accumulator.

XOR dd . . . Exclusive-OR the immediate data with the accumulator.

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