electronics today

MAY 1978 RNATIONAL

45p

ROBOTS
How close to reality?

ELECTRONIC IGNITION

HELPING HAND PROJECT

STAR TREK RADIO

CCD PHASER

MULTIPLE OFFERS INSIDE

TV TANK GAME

. . . NEWS . . . . PROJECTS . . . . MICROPROCESSORS . . . . AUDIO . . .

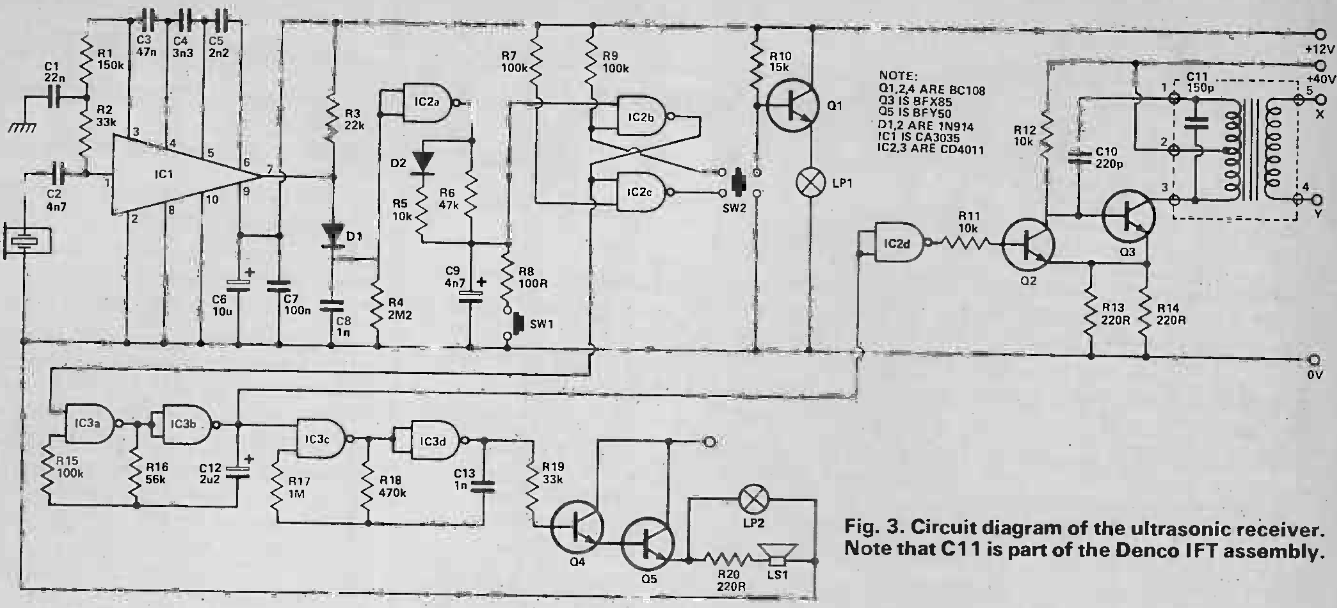


Fig. 3. Circuit diagram of the ultrasonic receiver. Note that C11 is part of the Denco IFT assembly.

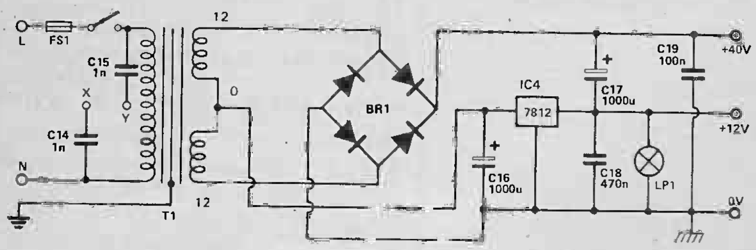


Fig. 4. The ultrasonic receiver's power supply.

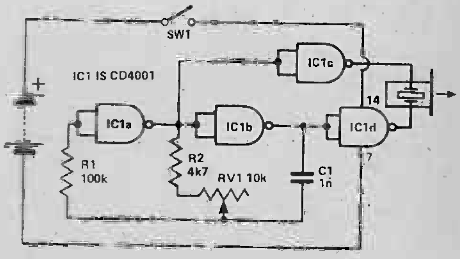


Fig. 5. The circuit of the ultrasonic transmitter

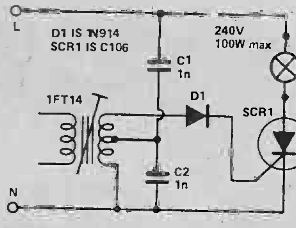
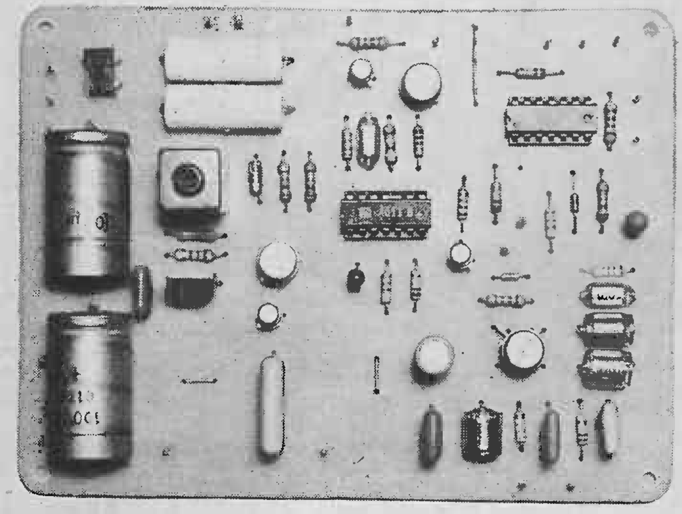


Fig. 6. Circuit of the mains adapter circuit.



The board of the ultrasonic receiver is shown above and to the left the modified mains adapter is displayed in all its glory.

PARTS LIST

MAINS ADAPTER

CAPACITORS
C1, 2, 1n 600V mixed dielectric
SEMI CONDUCTORS
SCRI C106
MISCELLANEOUS
Mains adapter, Denco IFT 14

ULTRASONIC TRANSMITTER

RESISTORS	
R1	100k
R2	4k7
POTENTIOMETERS	
RV1	10k
CAPACITORS	
C1	1n Polystrene
SEMICONDUCTORS	
IC1	CD4001
MISCELLANEOUS	
Ultra sonic transducer, PC8 as pattern.	

HOW IT WORKS

The transducer used in this circuit is forme from a piezo-electric crystal element that resonates at a frequency of about 40 kHz.

IC1a and IC1b form an oscillator whose frequency can be varied by means of RV1 to provide energy at the resonant frequency of the transducer used.

The oscillator produces two signals that are 180° out of phase.

These two waveforms are fed to the transducer via buffer ICs.

This method of driving the transducer results in an 18V (twice supply) drive. This increases the amount of energy radiated by the transmitter and provides a large useful range.

ULTRASONIC RECEIVER

The receiver transducer is matched to the one fitted to the transmitter and produces an EMF when energy at 40 kHz causes its crystal to resonate.

This EMF is fed via a DC isolation capacitor to the input of IC1, the CA 3035 high gain amplifier array.

It can be seen that this IC consists of three amplifiers and in this application the first stage is used as a simple high pass stage, this response being tailored by the feedback loop formed by R1, R2 and C1. The 40 kHz signal is coupled from this first stage via C4 and thence to the final stage by C5.

C6 and C7 decouple the IC's power supply pin.

The 40 kHz signal appearing at pin 7 of IC1 is rectified and smoothed by D1 and C8 before being fed to IC2a.

The output of this gate, is normally high and thus C9 is fully charged on receipt of a signal the output will go low and C9 will be discharged via R6 (D2 reverse biased) when the voltage at the junction of C9/R6 reaches the transition voltage of IC2b (one half of a flip flop) it will trigger this gate and initiate the sequence of events described below.

Note, however, that when IC2a returns high, C9 is charged up via R6 and R5 in parallel, D2 forward biased. This results in a faster charge than discharge time. This feature was incorporated to provide some protection against spurious triggering, as a brief signal will, although discharging C9 somewhat, have little effect as the capacitor is soon "topped up".

SW1 can trigger the circuit by taking IC2b low simulating an US input.

The flip flop formed by IC2b/IC2C can either provide a latching or non-latching operation.

Q1 and LP1 indicates the function selected, LP1 being lit if the latching option is selected.

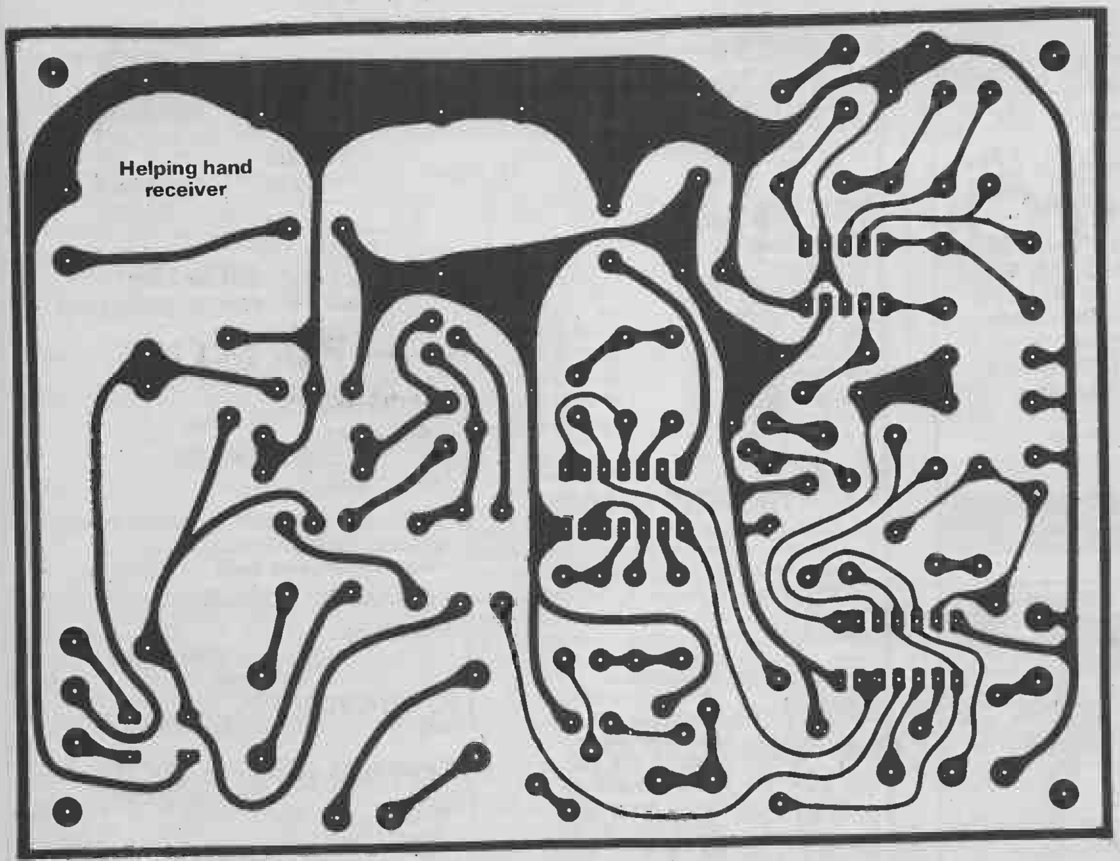
Whether latched on not as the output of IC2b goes high it enables the slow running oscillator formed by IC3a/IC3b. The output of this enables the tone generating section formed by IC3c and IC3d that provides an audio output from the speaker LS1 (driven from the Darlington pair Q4, Q5) and drives IC2d.

When the output of IC2d goes high it enables the Hartley oscillator Q3 via Q2.

This section provides a 470 kHz 40V peak to peak sine wave that is superimposed on the mains to trigger the remote receiver.

The power supply is a straightforward regulator circuit to provide the 12V rail with a smoothed 40V for the Hartley oscillator stage.

The remote receiver consists of a simple tuned circuit formed by C1, C2 and the IF transformer. This circuit resonates at 470 kHz, and any energy at this frequency is rectified by D1 and triggers thyristor SCR1 to light the load placed across the receiver's output.



Above is the foil pattern of the transmitter and to the right that of the receiver, both shown full size.

ROBOTS ~ THE FACTS

Dr Peter Sydenham, ETI Special Correspondent presents the factual side of Robots and analyses the many seperate factors needed in all Robots.

ROBOT DEVELOPMENT from the Middle Ages onward is simultaneous with the rise of man's ability to devise and build complex mechanical machines which grew once men realised that considerably more advancement was possible by employing experiment with theory. (The result of such men as Roger Bacon of the 13th century.)

The bulk of mechanical ingenuity and skill was expressed in clock-making of great sophistication. The very famous 1354 Strasbourg clock depicted the St. Peter denial of Jesus, a main feature being a cock that moved, stretched and crowed.

These skills were occasionally employed to make devices other than clocks. Jacques de Vaucanson, around 1750, constructed a well-documented duck automation toy. It stretched, took grain from the hand, swallowed and seemingly digested its food, leaving deposits behind. It consisted of hundreds of moving parts.

Robot development also has its beginnings in the form of calculating machines, such as the Pascal and Leibnitz instruments of the 17th century, and the later Babbage engines of the 19th century which included stored program and digital number processing.

We tend to think of the Babbage calculating engines as complete in what is exhibited today in the London Science Museum. In reality, however, they required an energy source of several kilowatts to drive them. A small steam-engine was to have been used by Babbage.

The first electrical digital computer, by Zuse in the late 1930s, used relays to perform logic. The first valve installation was in the middle 40s and it was much too large in size and too small in capacity to provide brain-power for a mobile robot device. Today things are much more favourable. We return to the feasible robots of near modern times at the end.

What Forms a Robot?

In the first half of the 17th century Descartes suggested that the physiological animal can be thought of as no more than a vastly complex machine. Intolerance of ideas, especially those that had religious implications, was extreme in those times and no doubt Descartes only spoke and wrote a little of his concept. Pascal, for example, was dangerously close to being the subject of a witch hunt after people saw his simple (to us!) add-and-subtract calculator — after all, it could do the tasks attributed then to a god.

The idea that animals are merely machines is known as the reductionist or mechanistic philosophy. As we cannot prove, by any means whatsoever, that there is more to man than man can ultimately devise, we cannot, at present, resolve the issue. Nevertheless, there is much about animal systems that is reducible to plain engineering. It is these known facts that suggest that many jobs that were considered as man-suitable in the past could well be done by machines instead. The justification is, to use a well-known quotation, "to make human use of human beings". If an automaton can do the same tediously repetitive task as is done now by a bored and dehumanised human operator, then there is a case to make use of it. This is the story of man's industrialisation, especially since the 18th century.

The human animal is a fine example of a general-purpose, mobile, self-repairing, self-reproducing machine, one that can adapt to new tasks and new environments as need arises. It is not perfect for all jobs, but does provide a fine basis for modelling robots of work, even though the materials and strategies used are different in practice.

Animals can be thought of as hardware systems, consisting of several kinds of sub-systems put together to form the whole system. The complete system is capable of many modes of behaviour. A diagrammatic representation is given in Fig. 2. Let us look at the building blocks first.

Fig. 1. Clocks, like this one made in 1512 in Munster, Germany, incorporated great mechanical craft. They provided need for mechanical skills used in robot devices.

Structural framework — This is the mechanical part holding everything together. Bones, skin, tissues in the animal can be equated to metal, wood or plastic frames of machines. The framework is developed to satisfy, as a compromise, requirements of lightness, rigidity, appropriate articulation, protection for vital parts, and correct location of one part with respect to another. Note that robot machines do not use the same materials that are found in animal systems. To date it has been more profitable to use quite different substances because man knows too little about the production of regenerative, self-repairing materials used by nature.

Actuators — On to the frames are added converters that change the available energy form into mechanical work. On animals these are the muscles; on robots they are usually electric, hydraulic or pneumatic motors. Again, although muscle-like devices have been made, robot actuators use different principles of conversion and different energy sources from animals. Actuators cause limbs to move, hands to hold, and the whole to translate where needed.

Sensors — Automata that, for instance, play music, are preprogrammed. Regardless of external influences, once set going, they will attempt to keep playing despite changes to their environment. Robots can be much more sophisticated for they possess sensors, or receptors, that observe what is happening around and to the robot. Sensors provide signals that, after data processing, tell the actuators how and when to work in a way that modifies an otherwise hardwired kind of performance.

It seems that many animal senses work on the basis of having a multitude of on-off digital sensors built into each sensing device, the combined, parallel, signal output being a measure of a sensor signal strength. Robot sensors rarely work this way for we are unable to handle so many parallel channels as nature uses. Robots usually incorporate analogue output sensors — the so-called linear signal in integrated circuit jargon. To detect the seat of a fire, an automatic robot fire extinguisher will use a proportional signal infra-red detector homing the robot towards the position of maximum signal output. In some cases man-made robots do use digital output sensors but not so commonly as analogue ones. An example might be a digital shaft encoder sensor mounted to measure an arm's angular position.

We cannot measure every variable that arises in the material world. Even so, literally thousands upon thousands of sensors have been devised so the robot designer of modern times can go a long way with what exists already, especially if one sticks to industrially marketed units in order to keep costs low.

Data Processing Centre — Signals from sensors are routed to DP centres. The brain is the central unit of humans. Not all animals have only one brain. Some early prehistoric animals are believed to have had two brain centres. Signal pre-processing goes on in animals before a stimulus reaches the brain. This can also be the case in robots. Robots can have local brain-power plus a central unit. We cannot make much of a comparison between DP of robots and animals, for we still have only a meagre idea of how the physiological brain operates. Insight that we do have is enough to say that robot brains will be quite different in physical structure from animal brains. We tend to opt for non-redundant data processing methods using a limited number of binary locations. The brain appears to make use of massive redundancy and enormous bit storage capaciy (10^{20} is an estimate).

Communication Links — Sensors feed signals to actuators via DP centres. The links we know and use in automatic machines are electric wires, optical fibres, air and oil tubes. Nature, however, uses the nerve links in which pulse signals are regenerated in mysterious ways by electrochemical methods. We can make use of Nature's concepts but not her hardware methods.

Energy Supply — Animals derive energy converting foodstuffs into energy by chemical means in muscular tissue. Robots cannot do it this way, but make use of the sources known to man at this time. Electricity can be generated by converting fuel to electric current. In mobiles a usual source of energy is electricity from storage cells. Restricted mobility and fixed robots can obtain power by an umbilical supply cable. Hydraulic and pneumatic systems derive energy from their compressor unit — the lines act as energy transmission links to the converter unit.

Robots that perform work will be somewhat inefficient for all energy systems will have losses. The human system consumes around 100W at a rest condition (of which most is lost as heat) and can provide about three times this power as work for limited periods. This would, by implication, suggest that a robot doing the full tasks of a man needs a 400W supply capability.

The man machine looks quite puny: 400W is not exactly powerful. Robots are not so limited: For a start, a man begins to tire after a few hours at 200W output — a machine equivalent can go on tirelessly. Robot manipulators can provide whatever power level is desired. They are made to lift huge loads. An example is a framework that a man fits into, giving him arms that follow his own with greatly increased load capability.

►

Terms

Robot — In Gothic it is akin to a word meaning "inheritance", in German to "work". An old Slavic word that is equivalent is "rabota" and in Czech and Polish "robota" means servitude or forced labour. Professor George's book (see list) says it is "a machine devised to function in place of a living agent".

Robotics — Gaining rapid acceptance, this term describes the discipline that designs and creates robot device structures and sub-assemblies. The following word is reserved for its system organisation.

Cybernetics — Study of multiple feedback loop, self-governing systems, usually of great complexity, as are found in living organisms and advanced man-made control systems.

Automation — Any device that has apparently spontaneous action. (Plural is Automata.)

Humanoid — Robot form of man.

Android — Automaton of man-like form.

Homunculus — Inferior robot form of man.

Prosthesis — Man-made, human body replacement parts.

Ecoskeleton — Robot frame that fits around human to give power to limbs.

Golem — Man-made creature not having man-like form.

Mobile — Robot device having mobility.

Manipulator — Handling device.

Telechiric — Derived from Greek for "distant hand".

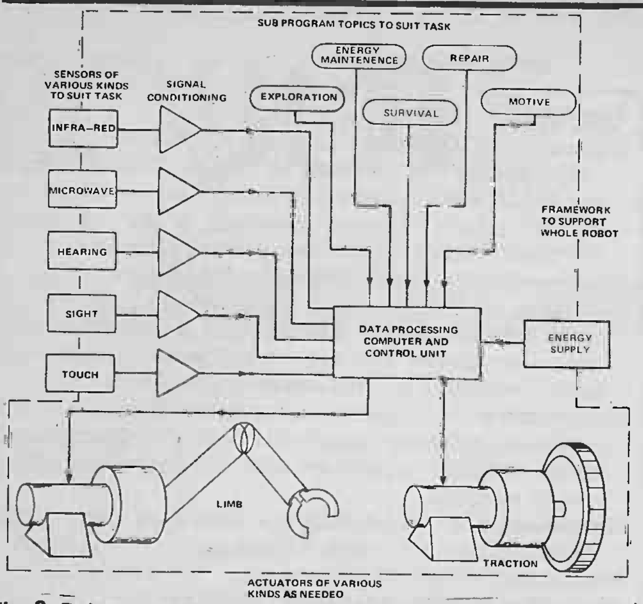


Fig. 2. Robot systems are made up from sensors, actuators, and data processing power operating together to satisfy a number of operational modes.

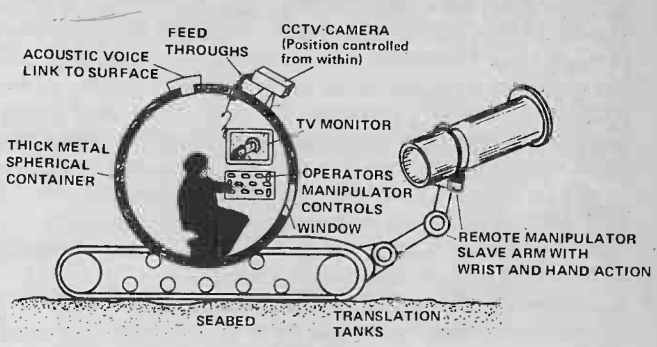


Fig. 3. Underwater a robot manipulator provides an operator with an effective ecoskin and increased ability to do work.

Motivational Mode — In-built must be some means that ensures that the robot constantly goes about the business for which it was created. This mode is temporarily given lower priority when circumstances dictate. As a simple example, a mobile designed to cut the grass of a lawn may need to divert its attention from grass cutting toward a battery recharge. After charge it must return to its duty.

Survival Mode — The programming basics must incorporate means to put the robot into behaviour modes that reduce and, hopefully, eliminate damage to the robot. The lawn cutter above must recognise that the concrete edging or stray stone must not be brought into contact with its blades. The survival mode must also extend to preventing the robot doing damage to its environment.

Energy Maintenance Mode — As well as the obvious need for the robot to ensure that it has power enough available for instantaneous load, it should also be able to prepare an energy budget of near future need. If it is a battery-fed mobile, it may well find itself out of energy enough to get back to the recharge point.

Exploratory Mode — Robots can have greater than one purpose. Such purposes may not exist all of the time and all in one place. When no purposeful sensor signals are received, actuators should be set by a sub-programme to cause the robot to go and look for a task. In animals this is seen as inquisitiveness. Without it humans are referred to as lazy and unmotivated, as would appear a robot.

Maintenance and Self-repair — The good robot is one that does not deteriorate in performance. This is not a reality, however, for although wear rates of mechanical implements can be reduced by better design and more expenditure, it usually can only be done at greatly increased cost. It is to be expected that robots, at least for many years yet, will require maintenance like greasing, bearing replacement and sliding surface repair.

The first thing the robot will need to do in this mode is to diagnose its own troubles, deciding what repair action is to be taken. Then it must organise some way to replace parts. This mode is probably more idealistic than real for most robots at present, but the software programmer and robot designer should, at least, give some consideration to this need.

Robots and People

In 1942 Isaac Asimov put into words three laws of robotics that have become famous in this field. They refer to the relationship between robots and people that designers should bear in mind for obvious reasons. The laws are:

(1) A robot may not injure a human being or, through inaction, allow a human being to come to harm.
(2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
(3) A robot must protect its own existence as long as such protection does not conflict with the First and Second Laws.

Asimov never intended the laws to be the one and only guide to robot designers — far from it, they were the result of science-fiction writing. They are not foolproof and do not extend to all situations, but do remind us of some basic ideals to consider in programming a robot's behaviour pattern.

Programming the Robot

A fully determined robot performance, that is, one that will obey instructions that are all preset before it begins to work, is little better than a special-purpose machine. It cannot do other than what is expected by its programmer. This basic level of performance is required of many robots, but is not the complete capability. It might be preset by a punched-tape or magnetic tape in the same way as many domestic knitting machines work. Most manipulator robots get these instructions via an initial man-operated run using special controls that allow the operator to run the manipulator through the required manipulative routine. Once done it becomes a stored programme routine.

Far better, if possible, is to servo the output required according to inputs of error. For example, to put a pin in a hole is better done by viewing the error between the pin and hole reducing the error to zero rather than presetting an arm to put a pin where the hole is expected to be.

The latter open-loop method assumes that all relative positions of limbs of the robot are held within the final tolerances needed to put the pin into the hole — which

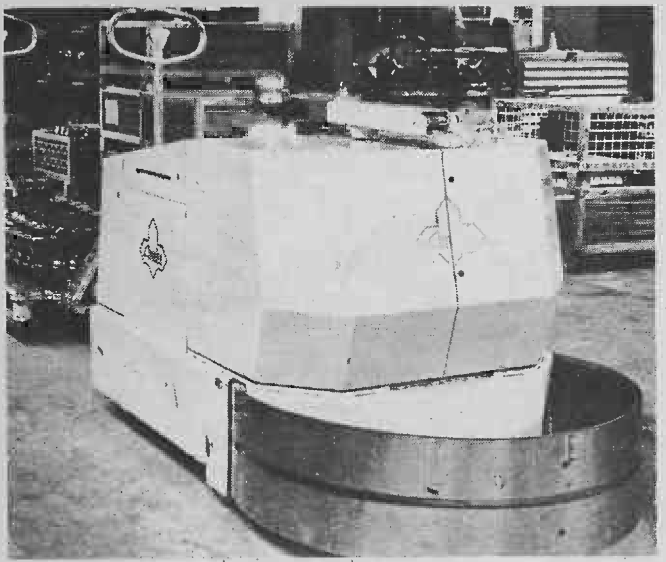


Fig. 4. The Ameise Teletrak driverless tractor train guides itself to follow a guide-wire set into the floor. One day it may be economic to provide the robot with navigational ability that compares with that of humans.

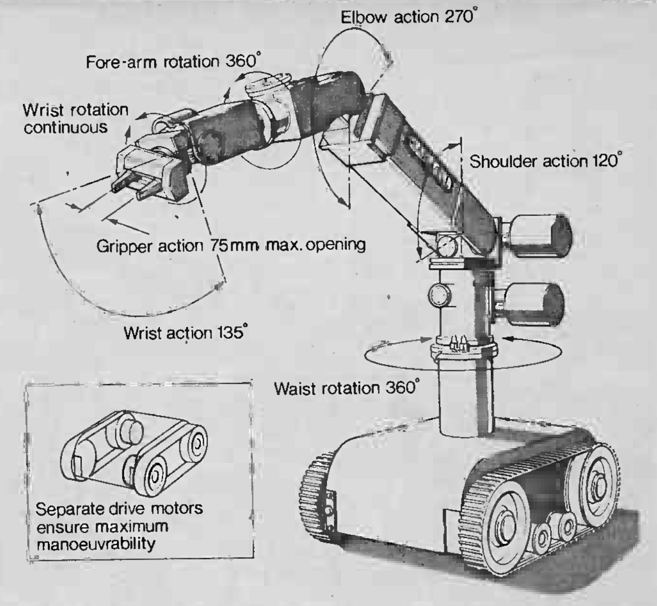


Fig. 5. ROMAN, a recent Harwell mobile, is made for use in hazardous industrial situations. It is electrically powered using cable control.

are extremely tight limits in many cases. The former method makes use of feedback and it is a feature of servo systems that actuation components inside the loop can be reasonably inferior in quality. This is a most important system concept — think of the problem of finding a place on a map by dead reckoning from a set of distances and bearings, as opposed to improving one's situation as you go by recognition of error still existing.

Recent Robots

Many authors on robotics include mention of a wide variety of inter-disciplinary automatic devices. This broadens the subject enormously and is a quite reasonable thing to do for robots can take any form. For reasons of space, we restrict ourselves here to mobiles and manipulators.

It is said that the term "robot" gained public acceptance as the result of a 1923 play by Karel Capek. It was at that time in history that ideas about automation began to flourish in earnest because of the favourable technological atmosphere. Electronic amplification was just available, mass production of consumer goods was established, sophisticated industrial control was emergent at a seat-of-the-pants level (theoretical considerations came later in the late 1940s).

Electrical computation began in the late 1930s, resulting in the first working vacuum tube system in the 1940s. Computer research no doubt stimulated interest in artificial intelligence, AI for short. Things were really happening by the 1950s. Studies of adaptive control, self-organising systems, AI and a new discipline called cybernetics were developing rapidly — research workers became very optimistic that machines would soon be able to design better machines. But they found over the successive years that it was not so easy!

Cybernetics was the term popularised by Norbert Wiener in 1957 for the discipline covering self-governing systems of all kind, seeing them basically as all the same thing, regardless of application. The term is derived from the Greek language and means the art of steersmanship. It is of interest to include the fact that Ampere had previously used the term to describe the science of government.

Theory of automata became an established pursuit a little later. Pattern recognition was another related area that became fashionable to work on. By the early 1970s the realisation that these ideas would not blossom so quickly, if ever, to give regenerative machines and robots replacing men in all their faculties, was accepted. Such goals are now seen to be much further away.

Today the past efforts of many people in the above fields have been tidied up, extended, ignored and much has been weeded out as irrelevant or false, leaving today's robot designers with a very useful and full theoretical and practical background to work from.

Mechanical design aspects of robots have advanced through work in prosthesis, in nuclear materials handling, in a relatively few academic engineering departments and within a small number of industrial groups.

Data processing for robotics concentrated on seeing what could be learnt from biological systems — maybe this was not so fruitful considering that designers have to work with different materials than nature uses. Then came the mini computer, almost small enough to build into a reasonable size robot device. Costs at first were prohibitive. Computing power and speed were very limited for operating robots at the motional speeds and precisions needed. Today we now have the quite cheap microprocessor, where the larger part of its sale price is for the market promotion, mechanical packaging and application notes.

Before Time

Advanced ideas usually meet opposition in a society. Bruno was burnt at the stake in the 1500s for suggesting astronomical theory was wrong. Pascal nearly went the same way for making his adding machine. Even Ohm had his simple law of the 1830s opposed by men of learning. The road car was held up in development for over 60 years by the need to walk in front of a vehicle with a red flag. Fear, preservation of the status quo, misplaced motives, politics and the natural and more healthy need for cautious acceptance usually emerge before a new concept finds acceptance.

So it has been with robots. Science fiction writers paint both gloomy and happy scenarios with robots. We tend to remember only the former. Robots are merely ►

Fig. 6. Four projects of the Warwick University Robot Laboratory. That on the left uses an inboard microprocessor. At the rear is a hand-like short arm manipulator. The tracked vehicle is originally sold as the army bomb-disposal unit — it acts as a ready made vehicle to conduct research on. (Keystone Press Agency)

machines of greater capability and versatility than man has made to date. As with all of man's technology, he has to learn to use them appropriately. We should not fear the robot but look deeply into its value to us.

Returning to earth from the levels of philosophy, it is quite certain that the robots we build over the next decade will not challenge our existence. We know too little at this time to build them with such powers. There are, however, numerous requirements where robot devices can replace men performing tasks too hazardous for men to do. Machines are the extension of man on earth and no force is likely to stop man's use of tools which has been part of his culture from the very beginning.

University Research

Robots of the future will make use of techniques discovered and developed in research groups working on artificial intelligence, robotics, computing science, electronics, plus many more areas.

The Science Research Council of Britain supports robot research. The main laboratory of the Robot group at Warwick University is shown in Fig 6. In the same room is the computer terminal to which the four projects shown are hooked-up to give them significant data processing ability. Around the walls are placed acoustic transducers used in positioning work.

A group at Edinburgh University work on putting artificial intelligence into robot devices. They have built a servo-controlled, computer-based, handling system.

A prime purpose of University research is to seek better ways to achieve goals. Theirs is not really a task of building devices that are totally engineered. For this reason one seldom sees a finished robot but more units in stages of change.

Never before has the field of robotics been so ready for development. Simple robots with quite sophisticated brainpower are in the price range of the non-professional. Amateurs can now enter the field knowing that the capability of their effort made now will be improved as efficient and powerful strategies are transferred to the general public domain at low cost via mass-produced integrated circuitry and software packages. A good comparison is seen by remembering that visual display units that write words were wonders of the time ten years ago. Now the equipment is reasonably standardized, far more advanced and within the price range and building capabilities of many teenagers.

Organisations

British Robot Association

Secretary, Dr. M. Larcombe, Robot Laboratory, Department of Computer Science, University of Warwick, Coventry, U.K. (A professional body with leading manufacturing companies as members.)

Robot Institute of America

20501 Ford Road, Dearborn, Michigan 48128, U.S.A. (This professional U.S. body has recently inaugurated a medal — the RIA Joseph G. Engleberger Award — for individual outstanding contributions to the science and practice of robotics.)

ETI

ROBOTS~ BRAIN POWER

Dr Mike Larcombe investigates the logic that makes a Robot think it thinks!

ROBOTS DO NOT HAVE BRAINS. 'Wet logic' technology — brains to you — is many orders more complex than the world's most complex machine (which is probably the International Telephone system, not any supercomputer). Robots are however extremely bright — for machines. They are much smarter than computers — which suffer from the so-called GIGO syndrome (Garbage In, Garbage Out). Unlike the dumb computer they answer back — ask a smart robot to walk through the wall and you will get the robot equivalent of a flea in the ear. Give them a reasonable task and they will carry it out — give an impossible task and they will either a) refuse to do it, b) try to do it for a while and then give up, c) have a seizure (badly designed robots only — as we do not yet really know what makes a good design, this means most of them).

Through A Robot's Eyes . . .

It is easy to be patronising while watching a robot at work — especially as their vision is either poor or non-existent. A few minutes attempting to perform the same task using the same robot body under remote control and using the robot's own sensors soon convinces the human that the robot itself is best qualified to control its body. Without direct visual feedback remote control becomes exceedingly difficult — when dealing with feedback from non-human sensors such as sonar or doppler radar, virtually impossible. In its own sensory environment the robot is a master of control. In our laboratory at Warwick where robots use sonar their behaviour in the dark is much superior to that of their designers.

No undisclosed miracle of technology lies hidden within the robot's carapace — no 'positronic brain' is required. Most of the more advanced robots contain — or are controlled by — computer, and frequently by multiple computers. With the advent of reasonably powerful micro-computers with 16 bits or more to chew the computer power can now be contained within the robot body. The smaller 8-bit micro-processors tend to wheeze and groan under the processing load required for even a small robot. The really high IQ robots still tend to cling to the apron strings of a big computer but it is only a matter of five years or so before they can cut loose.

Now if you had been paying attention you would have noticed that in the first paragraph I was somewhat disparaging about computers. Yet computers control robots — how come the robot is smarter? Well the robot is a lot more than just computer — it has sensors and actuators and perhaps a boxful of specialist processing functions such as motor acceleration-deceleration control or positional servo systems. A small robot will have more input-output channels than many of the larger time-sharing computers. The robot's necessary data handling load may well exceed 10 Megabits/second — much too fast for a micro-processor by itself. Fortunately much of this load is trivial — such as limit switch logic — and is easily handled by special logic, but nevertheless it must be handled. The road to automatic control is littered with sad and pathetic figures who thought all they had to do was connect the wires into a computer and it would do it all, 10 Megabits/second requires a great deal of computer and a great deal of money!

Flexibility

A robot program is unlike an ordinary computer program such as a payroll program. A payroll program is a set of sequential steps moving data, making decisions and ultimately stopping. A robot program is attempting to weigh up a continuously changing 'situation' and assess what to do in that situation — much as an analog computer is continuously monitoring both its inputs and its internal state. It is no good having a robot which does not realise it is about to — or has — run into a wall because the program has not got to the wall bumping bit yet. (I am supposed to be a bit asbent-minded myself, but this is carrying 'thinking about something else' to extremes.)

Further distinctions between the payroll programs and the robot programs may be made. The payroll computer does not require any knowledge of the nature of space and time — indeed it has no 'knowledge' of what it is doing. In fact it is a classic GIGO program — input 'BLOGGS, F PAY RATE — 97.5' and poor old Fred, gets a negative pay packet and is unlikely to be

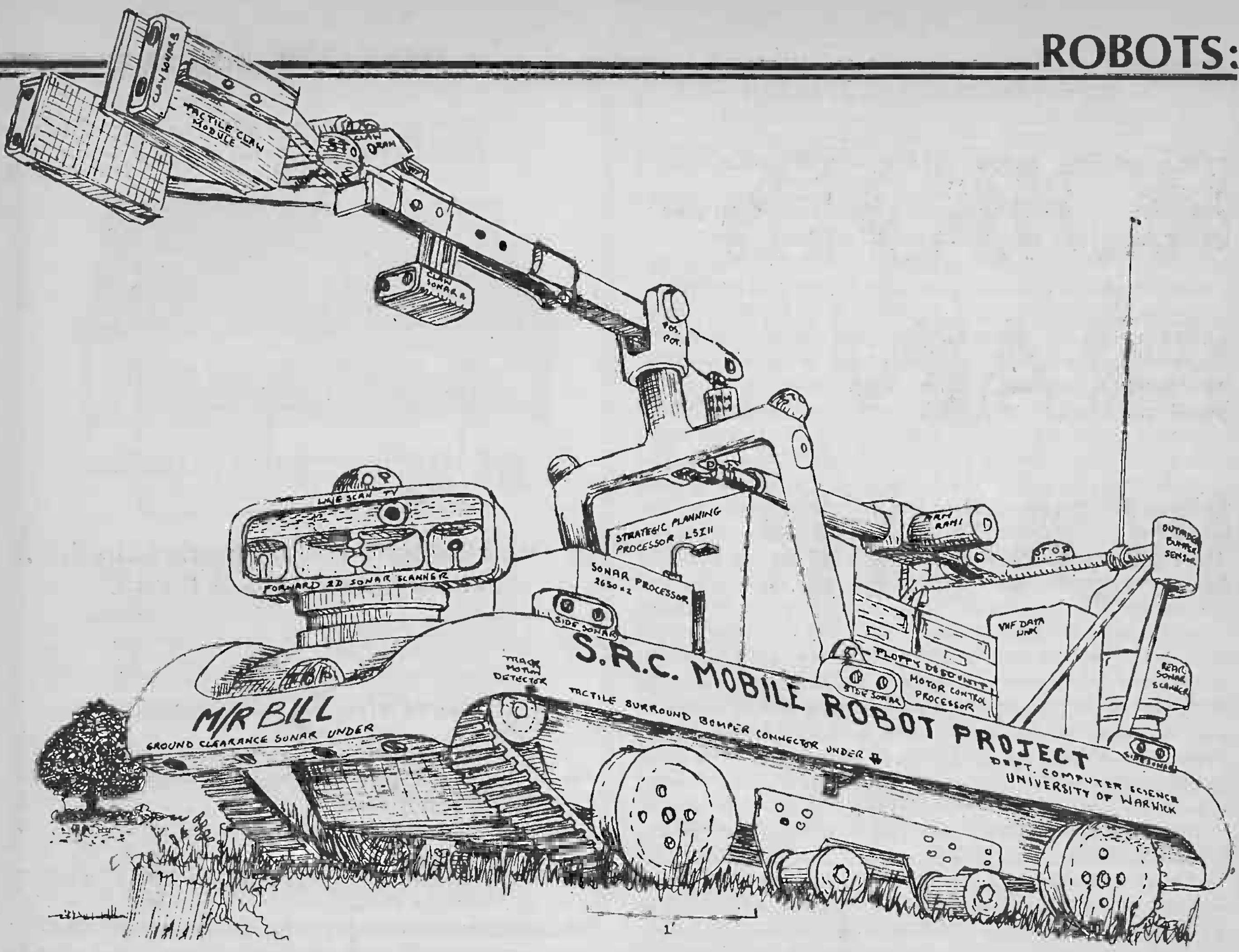


Fig. 1. Sketch of a possible research project under consideration at Warwick University, Robot Laboratory. All the various sensors have been proven individually, if they get enough money they want to prove them collectively!

mollified by the apparent tax rebate and returned National Insurance contribution. The program does not know about the positive nature of pay — much less the negative attitude of Fred.

Central to many robot programs is a set of stored information which is generally called the world model. The complexity of this model is chosen to give the robot some knowledge of the real world without giving useless information. It is no use informing a robot that trees and grass are green if it uses infra-red vision — whereas the information that grass is on the ground and trees stick out of it is useful.

The robot program need no longer take sensor or command data at face value. It compares incoming data with world model data for 'reasonableness'. If a well appears to be moving (program checks sonar range to expected wall with world model distance between computed position and wall position and finds continuous variation) the program can quickly check with other fixtures to see whether it is sliding about itself or an unknown flat intruder is present or the wall is actually moving (the latter two cases may not be distinguishable). If an external command to move forward occurs the program can first check with the world model to ensure that no obstruction is to be expected and then check during the movement that an unexpected obstruction does not exist.

The unexpected obstruction leads us into a really intriguing area of robot technology. Having found a palpably real 'thing' and perhaps having discovered a few useful facts about it (does it move if pushed? does it move by itself? is it round? how wide is it? can it be circumnavigated? does it emit ultrasound? does it emit light? etc., etc.) these facts may then be entered into the world model by the robot itself. This may seem a small step, but for robot-kind it is a giant wheel-turn. The robot's behaviour is governed by comparing the incoming data with the stored world model data, but the robot itself is modifying this data — therefore the robot is modifying its future behaviour. This is at the very least a form of learning — that is to say, it is to some extent unpredictable.

Free Will

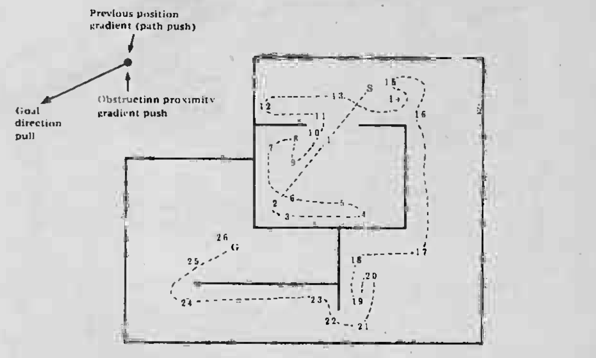
The robot is not deterministically programmed. There is an old saying about computers to the effect that the program is only as good as the programmer. In the case of robots this is no longer true in its original sense since two programmers are at work. In addition to the human programmer the totality of the robot's environment acts as a 'programmer'. Since the mechanics of the world are imprecise this second programmer never repeats is program exactly.

This indeterministic nature becomes clear when during a robot operation something surprising occurs and I am asked what is it doing. I usually have to say I do not know since the only way to find out for sure is to get the robot to explain in some way or to stop it and inspect its memory. Either way can take some time. There is a well known robot simulation program (illustrated) which deals with manipulations of stacks of geometric solids such as cubes and pyramids — the interest being that while you can stack cubes upon cubes and pyramids on cubes you cannot stack anything on a pyramid. This program has the advantage for the layman of communicating via a computer terminal in a reasonable facsimile of English. Having completed some long sequence of moves to stack a small blue cube on a big red cube (involving clearing everything on top of both cubes out of the way) the computer pauses and the programmer asks it: "Why did you move the green pyramid off the blue cube?": the computer answers 'To reach the blue cube.' The programmer probes further: 'Why did you move the yellow cube off the red cube?': the computer answers 'So that the blue cube may be placed on the red cube.' The programmer in great inquisitorial enthusiasm asks 'Why did you place the blue cube on the red cube?'. With the reserve only computers can muster, it replies 'Because you told me to.' This 'back-tracking' is relatively easy in a simulation program and the computer used was very large. However, in a small mobile robot program space is at a premium and exotic 'chatty' communication impossible. The same space premium forbids the storage of *all* events — it is necessary to build in methods of selectively removing surplus data — a forgetory if you like. This is akin to the short term memory system we appear to use: important stuff is kept and the junk is forgotten. This selective 'purging' may remove the data required for back-tracking and it may be impossible to determine why the robot behaved as it did in a particular situation.

The robot may be given a bag of problem-solving tricks for using in conjunction with its memory one of these may, for example allow it to solve the problems of getting about a maze-like environment as quickly as possible by 'mentally' finding the route before actually covering it (Fig. 2). There may be other specific strategems for manipulation and so on. At the moment of writing however, the robot is not really capable of learning new tricks for itself. This may require an extension of the world model concept to cover more of the dynamic and sequential aspects of task learning.

Here, Boy . . .

Robots are not yet capable of the full range of intelligence we expect even from an animal. They cannot learn new tricks, yet they can solve goal-seeking problems which would baffle a dog and can communicate in English with some degree of understanding. Clearly they do not fit into our usual categories for intelligence. The term 'machine intelligence' should be considered for the moment as standing apart from our normal spectrum of intelligence. When we know where to put it in that spectrum we will have learned much more about intelligence itself. Experiments with robots and in the field of Artificial Intelligence will help to elucidate this age-old puzzle of thinking. I suspect that just as in movement the robot is more likely to use wheels than legs it will use something dissimilar in structure to the brain for its 'thinking.' What is important is that as we understand the dynamic principles which govern both wheel and leg we also find the principles that govern both machine and biological intelligence. ETI



1 MAKES BEELINE FOR GOAL
2 WALL PROXIMITY DEFLECTS PATH
3 NEXT WALL PROXIMITY DEFLECTS PATH
4 PREVIOUS POSITION GRADIENT FALLS OFF AND OBSTRUCTION PROXIMITY & GOAL CAUSE TURNBACK
5 PATH AVOIDS PREVIOUS PATH
6 INERTIAL EFFECT OF PREVIOUS POSITION GRADIENT CARRIES IT ACROSS PREVIOUS PATH
7 CORNER CAUSES ROBOT TO TURN AGAIN
8 GOAL DIRECTION PULLING-PATH AT 7 PUSHING
9 TOO MUCH PREVIOUS PATH REPULSION ROBOT EXITS
10 AVOIDING WALL AND PREVIOUS PATH
11 GOAL PULL TURNS ROBOT
12 CORNER CAUSES FOLDBACK
13 THE DOORWAY 1 10 11 TOO FULL OF PREVIOUS POSITION REPULSION— INERTIA EFFECT CAUSES PATH CROSSING
14 15 16 DITHER CAUSED BY RAPID CHANGES IN RELATIVE IMPORTANCE OF GOAL PULL AND PATH OR OBSTRUCTION PUSH
17 CLEAR RUN DOWN WALL DIRECTED BY GOAL PULL AND OBSTRUCTION PUSH
18 19 20 FOLDBACK RESOLVED—PATH PUSH AND GOAL DIRECTION SORT IT OUT
21 22 DOORWAY NEGOTIATED BY GOAL PULL AND OBSTRUCTION PUSH
23 24 WALL FOLLOWING—INERTIAL EFFECT OF PATH PUSH OVERCOMES CHANGE IN GOAL DIRECTION
25 CLEAR HOME RUN
26 TWO JOULES OF DRAUGHT DC AND A PACKET OF CRISPS PLEASE!

Fig. 2. An example of what can happen when you tell a robot to travel from Start to Goal.

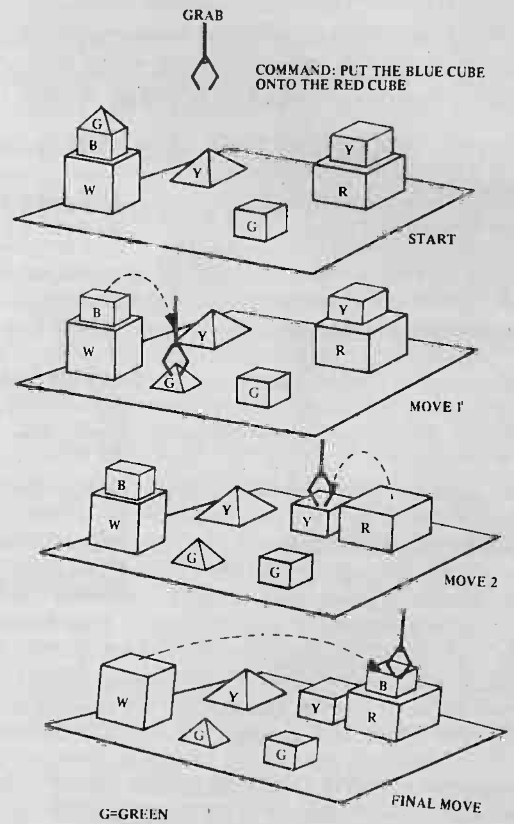
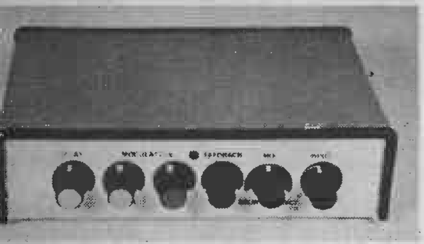


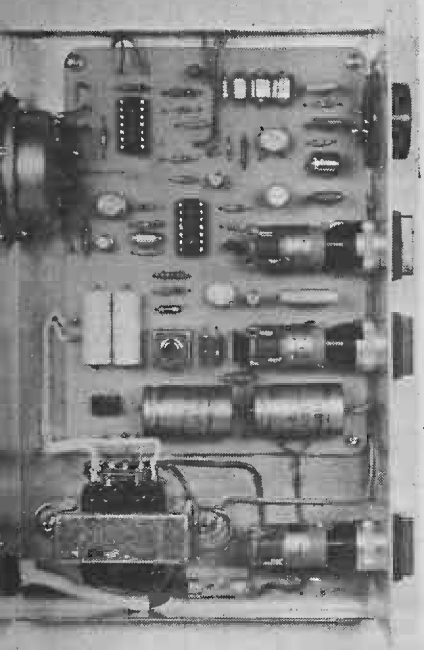
Fig. 3. The way a robot moves blocks around can lead to blunt replies from the computer.

electronics today

MAY 1978 VOL 7 NO 5 [redacted] INTERNATIONAL



CCD Phaser, page 57



Helping Hand, page 16

Our thanks to the MOD for providing the colour picture of the Cheiftain tank charging about our front cover.

FEATURES

PROJECTS

NEWS

INFORMATION

INTERNATIONAL EDITIONS

AUSTRALIA Collyn Rivers Publisher
Les Bell Acting Editor

HOLLAND Anton Kriegsman Editor-in-chief

CANADA Steve Braidwood Editor
Graham Wideman Assistant Editor

GERMANY Udo Wittig Editor

ABC

EDITORIAL AND ADVERTISEMENT OFFICE
25-27 Oxford Street, London W1R 1RF. Telephone 01-434 1781/2. Telex 8811896

Halvor W. Moorshead Editor
Ron Harris B.Sc Assistant Editor
Gary Evans Projects Editor
Steve Ramsahadeo, John Koblanski Project Development
Jim Perry Specials Editor
William King Editorial Assistant
Paul Edwards Technical Drawing
Margaret Hewitt Administration
Andrew Scott Office Manager
Kim Hamlin, Annette Main Reader Services
Tim Salmon, Brenda Goodwin
Mark Strathern (Manager), Tom Moloney Advertising

PUBLISHED BY Modmags Ltd., 25-27 Oxford Street, London W1R 1RF
DISTRIBUTED BY Argus Distribution Ltd. (British Isles)
Gordon & Gotch Ltd. (Overseas)
PRINTED BY QB Limited, Colchester

Electronics Today International is normally published on the first Friday of the month prior to the cover date.

COPYRIGHT: All material is subject to world wide Copyright protection. All reasonable care is taken in the preparation of the magazine to ensure accuracy but ETI cannot be held responsible for it legally. Where errors do occur a correction will be published as soon as possible afterwards.

ROBOTS~ BUILDING GUIDE

Dr Michael Larcombe of the Robot Laboratory, University of Warwick and ETI Special Correspondent Dr Peter Sydenham give a background into building your own robot.

PROBABLY THE MOST IMPORTANT thing to realise is that successful robots do not grow as can an electronic circuit development. Mechanical structures and components are vastly more time- and money-consuming to alter as changes are seen to be needed. Because of this the deficiencies of mechanical elements incorporated into a robot tend to be retained. Add a few of these shortcomings together and the device will not perform as expected.

Thus planning is vitally important from the word go. Many decisions must be made before money or time is committed to specific hardware. The ability to imagine and synthesise the finished product before it is built is the skill that humans have over the robot — so use it well.

Getting Under Way

The imaginative process of design is greatly aided by the use of diagrams, sketches, plans and written results. A tidy report file must be kept going from the start of the project.

After deciding what functions the robot is to fulfil, the next step is to develop a master system diagram of the whole, detailing the various sub-systems and their interaction with other sub-systems. Figure 1 is an example. Wherever practicable, try to develop the overall system as one built from basic system units that can be developed and tested as separate units in isolation.

Keep the master schematic block diagram updated each time major changes are incorporated. For each block, or group of blocks, there should be further diagrams showing more detail of the construction and circuitry. Even the simplest robots can soon become too complex to record as a whole. An orderly hierarchy of records is needed.

When the stage of realisation of adequately basic schematic diagrams is reached, the design can then progress to the creation of the blocks, designing each sub-unit to suit the specifications decided earlier. At this juncture (and later) several earlier decisions may turn out to be inadequate so, once the final change is agreed upon, go back and modify the master system and other blocks as is necessary.

It is always preferable to design the sub-units so that they can be tested easily. It helps build confidence in the design as they can be pre-tested before final assembly of the whole. It also makes good sense to be able to isolate a unit easily when a fault occurs that must be traced. Pre-testing gives useful test results for later comparison. Assembly should also be designed to allow all major subcomponents to be removed easily for maintenance and repair. There is nothing so frustrating as a fault occuring right down inside the structure where layer upon layer of mechanics and electronics must be removed to get to it. Make use of hinged panels, plug-in circuit boards, easily bolt-on drive and sensor assemblies with removable circuit connections. For one-off prototypes there is good sense in building in far more flexibility of assembly and disassembly than could be tolerated in a mass-produced, well-tested design. Where possible, build the working unit as a second one, retaining all developmental work for possible later comparison.

Always attempt to design sub-units so that they do not interact with other sub-units. For example, a manipulator arm must be sufficiently stiff in bending and torsion to retain its shape when loaded. If it bends, the position of the hand could differ from that indicated by position sensors which, in turn, will try to correct out an error that was not there by the ideal design standards. If the power supply droops when a load comes on to an actuator, this may alter the supply voltage to circuitry, altering the performance of other components. Where interaction results it may alter the fully-assembled units' performance in ways that are not easily discovered at the testing stage of the sub-units.

As sub-units are created their circuit drawings must be laid out neatly with all component values marked. Good mechanical sketches should be made. It is all too easy to forget that a few months later, after working on other aspects of the robot, one does not remember the detail tackled previously.

Choice of Components

As the sub-systems harden in design so will the specifications of the elements needed. They will generally be of optical, mechanical or electronic nature. At some stage each specific component must be located, if procurable, or made, if not. Circumstances will largely decide the choice. Optimally one chooses the best available unit, but in reality such factors as cost, availability, life and replaceability will force the designer to make compromises. The cheapest may suffice. Usually, but not always, the more expensive mechanical component is the best to use. Mass-produced components from construction kits and popular toys, such as aero models and model trains, are good value. Bicycles, domestic appliances and motor car parts are another source of quality low-cost assemblies. Specialised electromechanical construction kits, such as Meccano, Fisher-Technic, FAC and Presto, are easy to employ, but they can be expensive to get started with. They also can lack the rigidity of structure often needed.

One thing to avoid is the use of complex components (such as motors) that you possess already but which cannot be replaced or repaired easily.

Choice of alternatives is less important with electronics as most solid-state devices now have many roughly equivalent alternatives, but, even so, steer well clear of using devices that are not currently marketed at low cost on an extensive basis with double or more sourcing.

Structural Frames

The robot's functions are made possible through actuators and sensors causing the whole and the limbs to move as desired in a dynamic sense. The structures holding the limbs and the limbs themselves must be adequately stiff — that is, they must not deflect or twist more than is allowable under load. There is no such thing as a totally stiff structure, for no material known to man is inelastic. A basic aim of structural design for a robot is to provide an inelastic structure having minimum mass. This rule especially applies at the extremities of rotating arm-like structures where rotational inertia increases more rapidly than linear elastic deflection as the distance from the centre of rotation increases.

Elasticity of a structure can introduce many unwanted interactive couplings — weak gear train mounts may allow the gears to unmesh as the frame twists with increasing load. Smaller misalignments will usually introduce increased frictional losses.

The principle of triangulation enables rigid light structures to be built. It says that each segment of a panel or beam required to be stiff in the plane of its flatness is made from triangles of connected limbs. Open squares and rectangles must be made into triangles by the addition of a central cross member. Linear rigidity is relatively eacy to achieve; torsional rigidity is much harder to obtain for that mode of flexure requires stiffness at 45° to the linear axis.

Stiff and Floppy Members

Solid thin sheets obey the triangle rule and are always theoretically stiffer than a sheet which is lightened with holes or made from elemental bars. However, the solid, thin 2D members are rarely better than the same weight of the material re-arranged as a 3D member which will possess torsional rigidity as well.

Structures can be made incredibly stiff and light if the maker is prepared to put enough work and cunning into their design.

Triangulated structures work on the principle that members are either in direct axial torsion or compression. If in tension they can be as thin as their strength requirements allow, but if in compression a long thin member will buckle and fail well before it collapses through lack of compressive strength. Compression members are, therefore, kept as short as possible and have stiffness to increase their buckling strength. Tubes

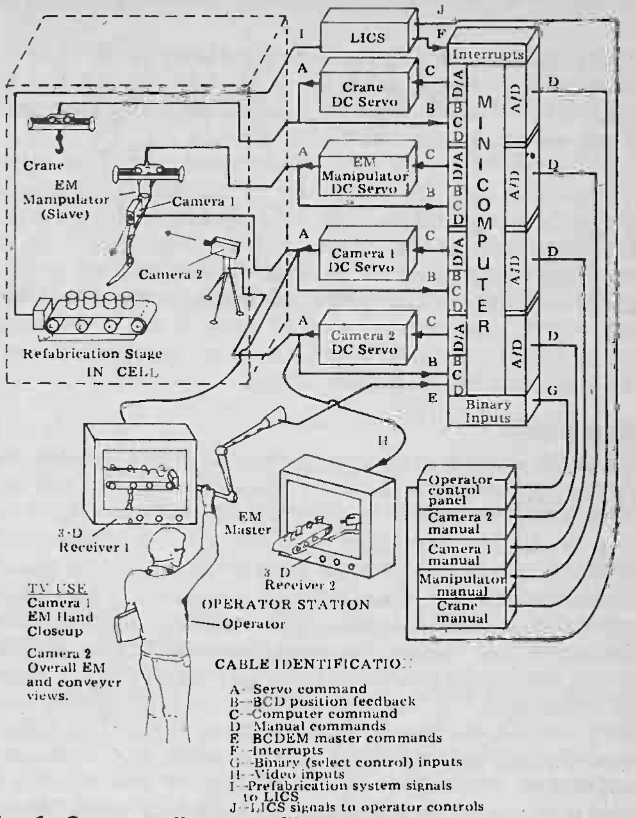


Fig. 1. Systems diagrams, like this of a manipulator for a high-temperature gas-cooled reactor in the U.S., must be kept up to date as development proceeds. Keep subsystems as seperate entities as much as possible.

and angles are commonly used. (Think of early aircraft structures using struts and wires.)

Structural Choice

The choice of materials is not always easy, for light strong materials, such as aluminium alloys, are not easy to join by the amateur — rivets or bolts must be used, as welding and soldering are not possible without special equipment. Avoid pure aluminium for structures — it is too soft. Aluminium does not need a protective coating but looks better if it has one.

Steel is more easily joined by welding and hand-soldering or brazing, but, although having the greatest stiffness of common metals, it is one of the heaviest. It corrodes easily — plating or painting is a must for all steel parts of a well-made robot. It is a mistake to think steel parts can always be painted after the robot is finished — there are usually too many wires and components attached to do a good job afterwards. So paint or plate as you proceed *before* assembly.

Plastics are a relatively new element of structural design. Very respectable jobs can be made using modern adhesives and plastic formulations. The catch is that they are comparatively flexible and heat-sensitive. As they get hotter, they may sag, will certainly get more elastic and, worse still, may deteriorate completely in the long term. Great care must be exercised about the choice of plastics used.

Wooden materials have their place, but always opt for waterproof qualities that are well seasoned or treated to retain shape.

Modern glues, such as instant-epoxy kinds and filler-based epoxy resins, are often an ideal choice for fastening members. But, again, care is needed in their use. If in doubt, conduct tests on test specimens before ▶

embarking on the real job. The simplicity of glues often leads one to make quick joints that are impossible to open when the unit requires disassembly. The easy path is not always the best in the long run.

An important point often overlooked is that the robot frameworks may be subjected to excessive loads and forces during the testing and development stage. Transportation of the whole, or merely picking it up or having limbs moved by external forces such as prying children's hands, can often break assemblies that are well within their design limits of need. If this is the case, try to incorporate safety features, such as clutch drives, that will slip for excessive load.

Motoring

Most DC motors used are cylindrical in nature and use permanent magnets to supply the field needed. They will have a relatively small number of commutator segments and are best run at quite high speeds. For slow speed shafts a gearbox is needed to reduce the motor speed and increase the drive torque available. High ratio gearboxes, however, introduce backlash and friction problems that reduce the effectiveness of tight servos. Avoid high-ratio gear trains and any other kind of drive with slop in it. Worm drives can also present problems as they cannot be driven by the output shaft. The better systems use anti-backlash gear wheels, but these are expensive. High gear-up ratios amplify the rotational load inertia seen by the motor, so keep high-speed loads light if good response is needed. Fastest energy exchange occurs when the load inertia seen by the motor equals its own value — similar to the energy transfer law for electrics.

The printed armature, radial shape, motor is well suited to robot work as it has many commutator segments, great overdrive capability for use in transients and excellent low-speed performance. Gears are often unnecessary with servos built of these. Inexpensive versions are available (car fans, for example), but they usually lack a second output shaft or an inbuilt tacho. Versions with inbuilt tachos are really satisfying to use but are priced for professional robot designs.

Simple DC motors from toys are rarely adequate for long. They are not designed to last. The extra cost of better motors will be found worthwhile.

Remote Control

Control from a position away from the robot can be had most easily by using a wire link in the case of fixed manipulator machines and limited movement mobiles. Wires are certainly the cheapest and most reliable link, but in the case of mobiles and some special applications, non-contact telemetry is needed to and from the robot.

Radio control would be the obvious choice as many marketed systems are available at reasonable prices. Model aeroplane control, and more recently model car and boat controls, are easily adapted to form command links. As most robots work at power levels greater than the actuators used in model planes, it will be necessary to add power amplifier stages (relays for simple on-off control, linear amps for proportional controllers) at some convenient output point of the telemetry system.

Acoustic senders working at around 30 KHz can be used for systems needing detection from any direction of robot orientation. Optical beams are restricted as links to situations where the beam remains aligned with the robot receptor.

See Me, Feel Me . . .

The basic senses of human beings are touch, sight, hearing, smell, taste. These provide many ideas for robot sensors. Other senses exist, such as ultrasound, radio waves, infra-red and ultra-violet radiation, that are not given to humans.

When finalising a sensor stage ensure that its output signal level, impedance and frequency response suit the stage, or stages, it must drive. Most sensor outputs need amplification, and it usually makes best cost sense to use an integrated linear circuit to obtain the gain. IC stages generally have low output impedance and set voltage swing limits. Typical values will be ± 10V with a zero bus for linear devices (higher are available but are more expensive), zero bus with +5V for TTL logic and a wide range of choice for CMOS logic. There are few standards so it is not possible to categorically define signal levels. Choice of levels is, however, worth serious study before the design goes too far, as the fewer the bus voltages used the better. They must also match the chosen supply source. Try to avoid the need to create numerous bus voltages from basic supply rails — zener and series regulator units waste power.

The cost of low resolution analogue to digital and digital to analogue converters (low resolution will usually be adequate in robots) is now such that the output form of the basic sensor can easily be converted to the other signal form if it is more appropriate.

Space permits only a brief account of a few typical sensors used in robot devices.

Touch Me . . .

Simple touch sensing is easily done with a light arm or feeler that operates either a microswitch for on-off control or a linear or rotary potentiometer for proportional control. Whereas virtually instantaneous signal changes can be created in electronic circuits, the same is not true of mechanical systems. A touch-bar moved as warning that the robot must stop immediately should be able to deflect sufficiently as the unit comes to rest. Either make the bar flexible or give it a spring joint where it can bend elastically. The amount of deflection needed depends upon braking effort, speed of robot and its mass. As a guide, a 20kg unit moving at walking pace and being braked by a reversed connection 100W motor may require as much as 50-100 cm of overtravel, depending upon the frictional force existing between its wheels and the surface it is on (decided by coefficient of friction, weight on the wheel and braking force on the wheel axle).

Tactile sensing, such as is needed to control the clamping force of a closing hand, requires proportional measurement of closure force.

A rubber or plastic tube filled with air makes a good protective buffer. Addition of a pressure-sensitive switch into an outlet enables the buffer to cut power supplies or reverse the velocity drive. Obviously, imagination and innovation can produce many more touch sensors.

See Me

Human sight is sensitive to only a very narrow band of the available electromagnetic radiation spectrum. Robot 'sight' can extend much further to make use of infra-red and radio frequencies as well as those in the visible region. Certain infra-red sensors can detect the thermal radiation of room temperature bodies and resolve them

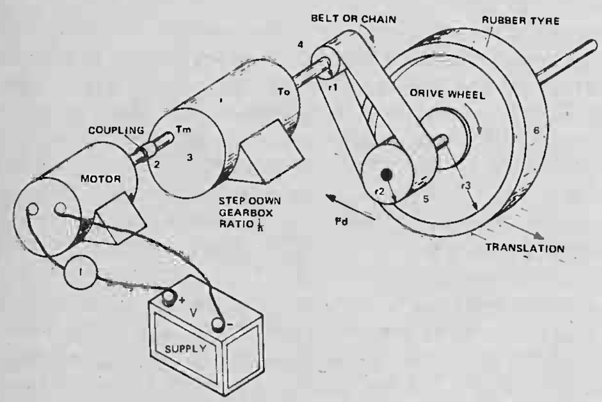


Table 2: Calculations for a hypothetical drive system

At 1 — Power input = V.I = W

At 2 — Power from motor = W. motor efficiency = W. Torque at output shaft Tm from data sheets

At 3 — Coupling may lose up to 5% of energy transfer, but not torque unless slip occurs

At 4 — Torque at gearbox output To = Tm × n

Shaft speed $= \frac{\text{Input shaft speed}}{n}$

Power available = Power at input × Gearbox efficiency

At 5 — Torque at wheel shaft = gearbox output torque $\frac{r_2}{r_1}$

Wheel speed = gearbox output shaft speed $\frac{r_1}{r_2}$

Power to move robot = power out of gearbox × efficiency of belt or cahin drive

At 6 — Force at wheel perimeter

$\frac{\text{shaft torque}}{r_3} = F_D$

Power available is as at 5 unless bearings lossy

Speed of robot translation = wheel speed $\times 2\pi r_3 \times$ slippage allowance

Force of translation = F_D × coeff of friction × load vertically on wheel

against backgrounds at a different temperature. If at the same temperature as the background, however, the object can go undetected. This effect, called 'washout,' exemplifies just one of the many kinds of sight problems that robots need to tackle. Most worthwhile seeing conditions resolve to those of pattern recognition once the 'visual' picture is transduced by appropriate sensors into electrical signals. In robots the higher order seeing problems to be tackled require extensive data processing facility. The microprocessor now promises to provide the kind of power needed at realistic prices for amateur robot projects.

The easiest to invent and build is the photodetector that responds to an increased intensity source using the DC level change as the sensed signal. This kind of sensor is suitable to move the robot toward or away from bright lights or to increase or decrease its activity as the ambient light level changes. It is of little value in applications where the robot has to seek out a certain 'marked' place or beacon or follow a moving light marker.

In these cases, the source light can be coded by amplitude modulating it to at least 10% depth at some convenient frequency which is not a multiple of mains frequency (or it may well fall in love with all fluorescent and incandescent mains-fed lights).

Similar principles work for infra-red and microwave and also for acoustic methods. Seeing is usually taken to mean line-of-sight working only. Strategies may have to be programmed to ensure the robot obtains a line of sight long enough for it to learn of the direction to move to. (A sample and hold store of position is a must for such applications.) Modulated systems, although generally unresponsive to moderate ambient background illumination, will usually be affected by severe ambient levels, for these may saturate the circuitry. In such cases the output produced should be a fail-safe kind. (Many a robot has been camera-shy when powerful flood lights are turned on for the public debut on television or film.)

Hear Me . . .

Sound waves behave in much the same way as electromagnetic waves, but with one big exception — they travel much slower. For this reason acoustic senses and senders are a popular choice for robot sense of position and for detecting presence. Their use is mostly based on the radar principle of sending a pulse (or continuous wave) and monitoring the time (or phase) delay of its return. Acoustic radars give good positional sensitivity at room and workshop size ranges. Use of ultrasonic (above the 20 kHz limit of human hearing) frequencies help avoid signal-to-npise ratio problems in acoustically noisy environments. Beware, however, of ultrasonic sources produced by machinery.

An array of inexpensive piezo-electric crystal receivers mounted in a pattern across the breadth and width of the robot frame can, after some signal processing, detect the location of a single source. Two units mounted on a tracking robot antenna can be used as a binaural position sensor. A single send-cum-receive unit mounted on the robot is capable of locating obstacles for a survival mode of robot operation.

Smell Me, Taste Me . . .

Of the human senses these two have barely been developed in hardware form. Both are related to the presence of chemicals and therefore the methods of chemical analytical instrumentation are relevant. However, few analysers exist that are cheap enough for the hobbyist pocket. Certain measurements, such as CO_2, CO and O_2 detection, can be achieved cheaply by sensing a simple effect of these gases on the temperature of a heated resistance (CO_2, CO) or via the voltage generated by a special cell (O_2). Smoke is more easily sensed as an attenuator of light than by the presence of its chemicals. An analyser capable of detecting smells such as rotten fruit, individual people, or the finest perfumes requires the use of a mass spectrum analyser or other sophisticated methods costing huge amounts of ▶

money and weighing many kilograms. In short, smell and taste are not very profitable senses to use as yet. An exception is robots already made commercially that seek out the centre of fires for extinguishing purposes.

Acting Out a Role

Sensors produce the input signals tell the robot what is happening. To get the robot to act on such commands these signals are processed and used to drive power output devices, called actuators. These convert, in the main, the power source energy into mechanical work. Actuators for robots usually require electrical signal (analogue or digital) inputs providing linear or rotary motion via wheels, gears, belts, tracks and what have you to do work.

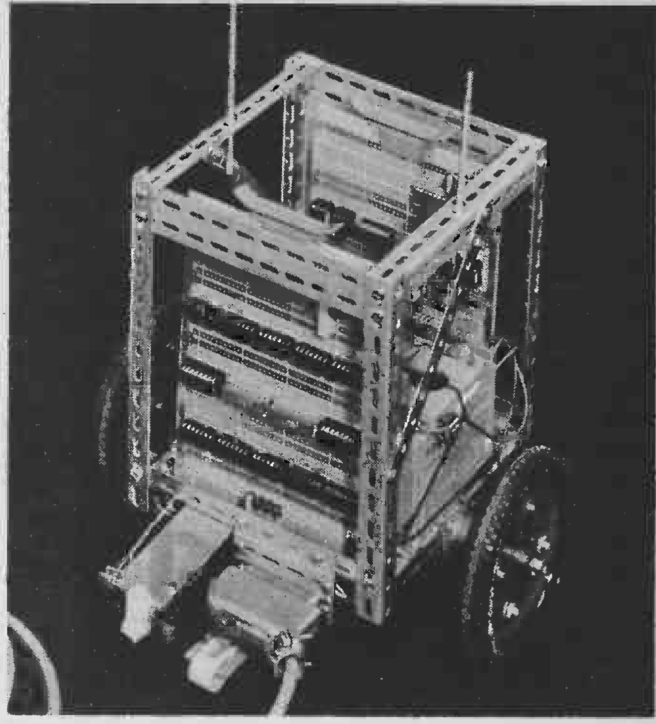
Robots require motions that give speeds and positions. Basic motions needed, depending upon use, are continuous linear motion (wheels driven by motors, cables would up by motors, rack and pinion), short-stroke linear motion (solenoids, restricted length rack and pinion), unlimited rotary motion (direct motor output, geared up or down motor motion), and limited angle rotation (rotary solenoids called torquers, pinion and wheel or rack). Chains, belts, pulley and flat flexible strips are elements used to provide various kinds of motion, including converting rotary motion to linear and vice-versa. The commonest and cheapest actuators are solenoids and motors. Where controlled variable torque is needed, DC systems are usually used.

Wheels are predominantly used to move mobiles. Walking is a spectacular method, but is far more difficult to design. Wheeled systems must be able to steer easily — car-like methods require intricate movements to escape a blind corner. Rapid response drives will require as much of the robot's weight on driven wheels as is possible. All wheels supporting weight but not being driven reduce the tractive effort available. The coefficient of friction of drive surfaces must be chosen to suit each application, or else excessive wheel spin will occur.

Open and Closed Loop

At this point it is worth devoting some time to the concept of closed-loop actuator systems, for all worthwhile robots use these. The reason is as follows: Consider a small motor coupled to drive a robot via wheels through a step-down gearbox. To get the robot moving requires more initial power than when it is running under steady load because friction of the static drive is greater than when running. Thus, as soon as it begins to move, the input must be reduced or else it tears away. Also, when the robot comes to a rise, the input voltage setting must be increased to give more power. This kind of controller is called an open-loop case. The real aim is usually to have the robot run at any given time at a steady known speed, over the range from zero to full speed, for all conditions of load.

This is done in a closed-loop system by sensing the actual speed of the motor (in electrical terms, by generating a voltage with a separate generator called a tacho coupled to the motor shaft) and comparing this value with that which represents the desired speed. The difference, called the error signal, is used to increase (or decrease) the motor current so as to bring the speed up (or down) to the correct value, where the generator output equals the reference level. Motor speed will,



within available power limits, be held closely at that set by the input reference voltage level, despite changes in load. If the motor current can be reversed by the circuitry, a command for zero speed (zero reference voltage) given at, say, full speed, will attempt to reverse the motor giving quite impressive braking. As the speed approaches zero due to the braking, the error falls to zero and the motor comes to rest.

Good servos can provide tight control with rapid response to new commands. Their slight disadvantages are a need for a more sophisticated (but well worthwhile) system that costs a little more if the right motor is chosen, the chance of instability if it is too highly tuned and the possibility of having too responsive an action that may shear parts and slop liquids (but at least this is easily slugged or smoothed by appropriate integration of the error signal within the control loop). Overall, however, the performance of a closed-loop servo is vastly superior to the open-loop equivalent.

Position Servo-Systems

Position controls also should be closed-loop in operation. Here the actuator that brings about a positional change is fed an error signal generated from a position-sensitive sensor. An arm elbow joint, for example, would have a potentiometer rotating at its pivot axis. The voltage produced by the potentiometer is compared with the given reference signal providing the error to drive the actuator accordingly. This servo will ensure that the arm goes to the angle desired by the input reference voltage value, regardless of load (within limits of maximum load capability). If the arm overshoots the correct position, the error reverses bringing it back by reversing the actuator. Servos can be adjusted to approach the final value in a quick fashion with overshoots, or slowly without overshoot.

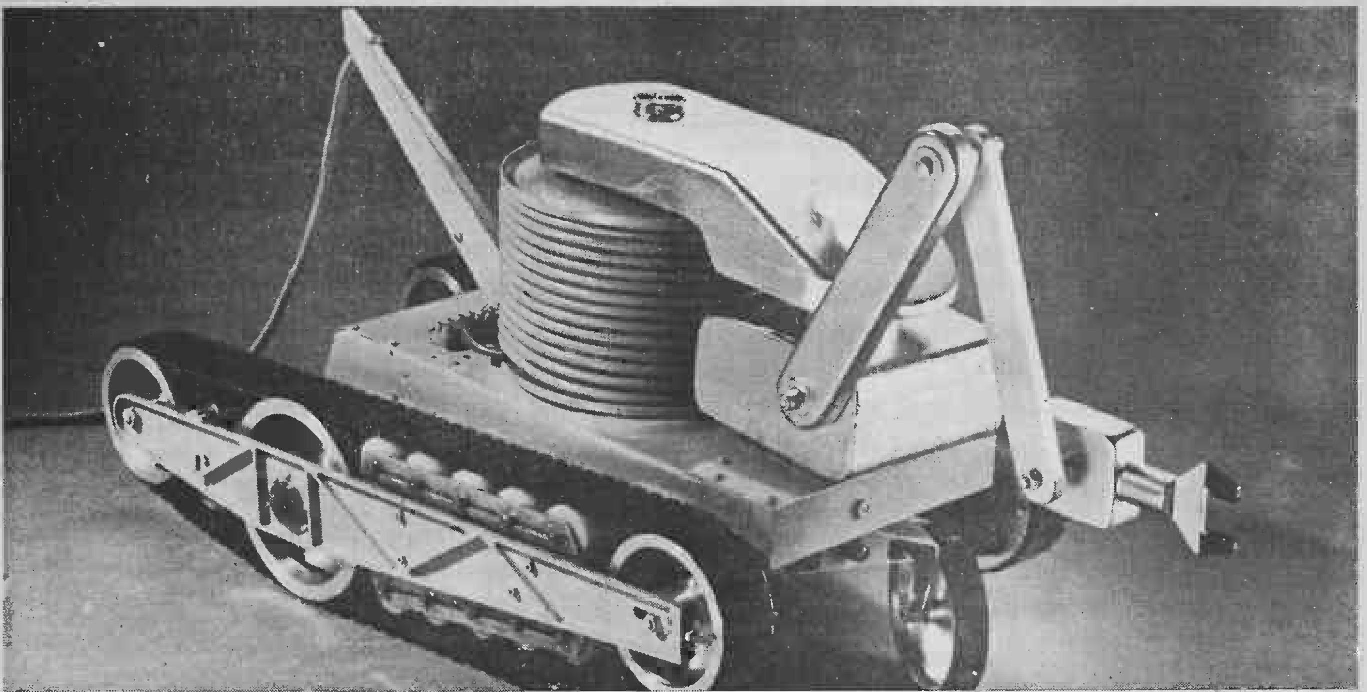


Fig. 2. (left). HORACE, a Warwick University Robot Laboratory mobile, is simple to make and uses commercial parts. Robots like this are well within the scope of amateurs. Note the ease of access to parts.

Fig. 3. This working model of RIVET explores an ingenious method of transport. It can go over obstacles twice its own height

Position servos benefit by the use of a tachogenerator driven by actuator. The tacho signal is used to feed a rate of error reduction signal into the closed loop, making it move faster when wildly wrong in position and slower when nearly at the correct place, thereby giving it a chance to stop at the right place. This mechanism is known as damping.

As the gain around the servo loop is increased, the response gets tighter, smartening up. However, a point is eventually reached when the loop will begin to oscillate, first giving small dither around the correct place and then as the gain is further increased, rising to massive oscillations. Reducing the gain is the easiest way to combat this but not the cleverest. Compensation is the technical name used for the process of adding an integration and/or derivative of the error signal to the error so as to obtain higher gain with reasonable stability. The tacho of a position-servo does just that. Explanation of this is beyond this account, but is well treated in many books on linear control systems. The above explanation is somewhat simplistic but adequate as a basis. In reality the velocity servo described will run at slightly lower speeds than called up, as an error must exist to generate the torque needed to hold the speed.

Final Testing and Maintenance

The development of the robot should proceed in an orderly manner, each sub-unit being pretested and made as acceptable as thought necessary before final assembly begins. As each unit is added to the final whole, checks should be run to see that it still works as it should. See that the other units still work properly, as unexpected interaction is common in robot development. It is much easier to test for this as you go from stage to stage than to try and find which unit alters what at the end. As defects are detected — bugs always occur — rectify them before moving on. There is a natural tendency to rush on to the apparent end, only to be disappointed because it does not work properly. In other words, be patient; it is worth it.

Once the whole robot is "all systems go", the next stage is to conduct some field-trials. Put it through its paces doing the tasks it was intended to, but in situations where damage is minimized if the behaviour is not as expected.

Monitor the initial hours of work carefully looking for overheating of electronic and mechanical components, and listening for odd mechanical noises that indicate too much slop or friction. These may lead to premature failure if left unmodified. Limbs and other members that appear weak are more easily strengthened before they break than after! Smoothness of operational sound is a good indicator of satisfactory mechanical design.

Unlike electronic circuits that, once made, are initially maintenance-free except for faults, dynamic mechanical systems require regular attention. Lubricate bearings, slides, cables and pivots regularly, but do not overdo the oil or grease. Dry graphite may be better than oil in some applications. Areas of wear will need adjustment with use. Build this into the design to begin with, where possible, as retrofit is always harder.

Too often ignored is the final documentation. When the project is seen as complete, go back to the master diagram and files on the whole system and sub-system modules and update them to the latest stage. If you feel the robot will be used regularly over several years, or if it was built for the use of someone else, it is imperative that the documentation is readable, neat and complete enough to be a good guide to someone else at a time after its details have been forgotten by its builder.

Creating a robot is fascinating and rewarding. How well it operates is a matter of your design sense plus ability to execute the design in a professional manner. We hope the above, albeit brief, introduction will help, and wish all robot constructors rewarding, successful projects. ETI

ROBOTS~ THE REAL THRING!

Specials Editor Jim Perry travelled to Queen Mary College, London, to interview one of the pioneers of Robotics — Professor M. W. Thring.

Could you give ETI readers a short autobiography?
Well, I started life as a combustion expert, concerned with the combustion of coal and other fuels, also furnace design.

Then I became Professor of Fuel Technology and Chemical Engineering at Sheffield University, about twenty years ago. I began to get interested in robots; well, I was, strictly speaking, interested in robots as a small boy! I used to design them when I was quite young — but of course in those days there was no electronics, so they were all mechanical. Complex devices so that vibration into an ear released triggers and things.

Then I came back to it again at Sheffield. I was very concerned with the very real problem of highly trained men having to spend a large part of their lives doing work that did not use their intellectual training to the full. Especially in the case of the housewife, so I tried to design a domestic robot. I thought about it for many years and it has had one or two good applications. The most important of which was the fact that I developed a stair-climbing wheelchair for cripples. This was because I realised that a domestic robot would have to climb stairs!

The more I thought about the idea of a domestic robot, the more I decided to go in a different direction, for two reasons — one is that I'm very, very impressed by the incredible skill of the trained human hand/eye/body combination, which takes ten to twenty years to train and then can do sophisticated things. These capabilities are far away from anything we could do with a computer or artificial intelligence. This was a problem too difficult to hope to solve in my lifetime.

Secondly I have become more and more concerned with the unemployment problem. The principle object of robots, at present, is to throw people out of work by replacing them with robots.

I realised that the most important thing I could aim for in my life would be to try and get a method of mining solid coal without men underground.

This being a dangerous task and you having experience in coal technology?
Yes, up to four-fifths of the coal deposits are beyond the reach of conventional mining techniques.

So this led you to specialise in Telechirics?
Yes, Telechirics — or 'hands at distance' — was a solution that already existed. Although the primary development had been for nuclear work, also in space work and more recently undersea.

I would say that Telechirics is in the same position that computers were in about 20 years ago. Ultimately they could be of greater value to humanity than computers have been.

What other uses for Telechiric machines can you envisage?
One other use will be for microscopic work. Where you would have hands one tenth the size of a mans, with a magnification system, so that the operator would see and feel an object ten times larger than it was.

Another very important application will be in the field of surgery. Not only could you have the magnification, you could also have the patient in a sterile room.

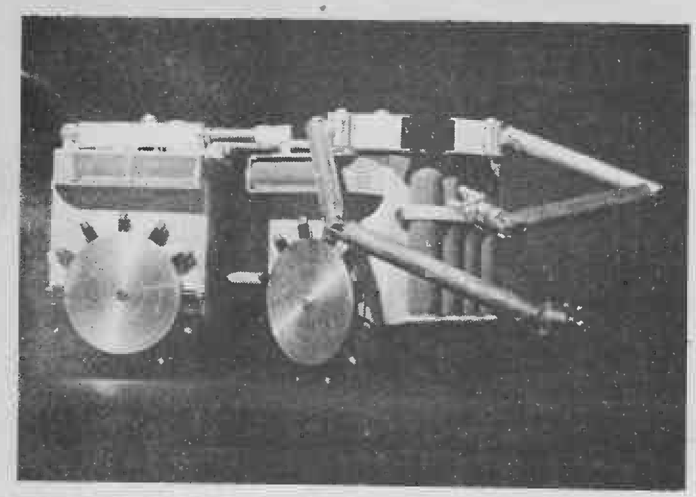


Fig. 1. A model of one of Professor Thring's robot coalminers.

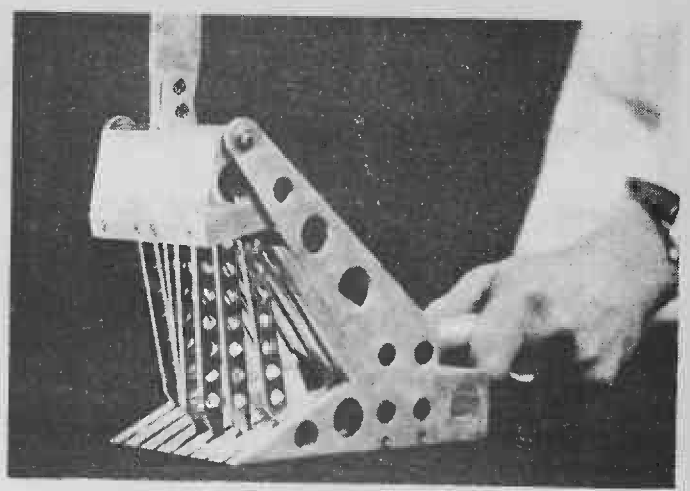


Fig. 2. Prototype mechanical hand for use with robots.

The techniques used in Telechiric machines have applications in the broader field of Robotics, how advanced is the mechanical side?

A great deal of work has been done on this, although I would say not enough yet. The biggest problem is that hydraulic systems are probably the best way of replacing human muscles — but on the other hand the control system must be electronic. We need much more work on the interface between them.

Where is research and development being done?

In Telechirics there is not nearly enough research, in fact there is practically no research in this country at all, at the moment. There is a great deal in France and America with some being done in Japan — most of this research is being done in connection with nuclear work.

What is the main advantage of Telechiric machines over Robotic machines?

Robots and automated machines breakdown, and they always breakdown in unexpected ways. Telechiric machines have the advantage that a human operator is there, at the other end, and can take appropriate corrective action.

How would you define the various Robotic and Telechiric machines?

I define all kinds of humaniod machine under three categories. First of all artificial limbs, including exoskeletons which can give great strength, where the human is in a one to one relationship with the machine.

The second group is Robotics, where there is a computer as the fundamental brain of the system. The computer carries out programs written by humans. A limitation is that we can never put the emotional brain of a human into a computer, also it will be very difficult to get the visual/mechanical relationship as good as a human's.

Perhaps most important, Robots will not be able to cope with the unexpected. Human beings have a remarkable ability to improvise in unexpected circumstances. I do not think that you will ever be able to put this into a computer and therefore into a Robot.

The third group is Telechirics, there may well be a large element of Robotics connected with the Telechiric machine. For example you may give it a small computer, so that when the man on the surface tells it to go in a certain direction — it will for example count obstacles and possibly even avoid them.

Do you think we will ever be able to use materials similar to the body in construction of machines?

As for as constructional materials are concerned, we have available engineering materials — which are much stronger and capable of exerting much greater forces than the human system.

The human system has some things that we will probably never be able to build. A muscle can carry out chemical reactions in every single cell of it, to produce work without heat — which the engineer can not do.

But it is the brain of the human that is way ahead of anything we can ever do — by brain I mean both intellectual and emotional brain.

What do you consider the best example of Telechirics or Robotics?

Well there are many, many what I call 'senseless robots' in use all over the place, the first example was the Unimate. There is a great deal of work on 'sensed Robots', in fact it has been going on for 20 years. I don't know of a 'sensed' Robot that is doing a complete job.

As far as Telechirics are concerned I think the one developed by General Electric in America, and the one which was started by various people in America and now is being developed in Paris are the most advanced.

What do you think about amateurs experimenting in Telechirics and Robotics?

I've seen several people who have done remarkable things in this way at home. It is a very fascinating hobby. But it is a bit like say, designing your own computer and making it at home. You cannot really compete with the large organisations because of the rather sophisticated engineering needed. As a hobby for fun yes, but I do not see it as a real solution to the problem.

Thank you for your time, Professor Thring, it has been a most interesting talk.

ELECTRONIC IGNITION

IN spite of the many advantages of CDI, relatively few cars use this electronic system. Get ahead of the Joneses and fit our electronic box of tricks to your car.

IN SEPTEMBER 1973 we published a design for a capacitor discharge ignition system. Since then over 15,000 units have been built to that basic design — CDI must have something going for it.

The original design did however have a number of disadvantages. It was built on tag strip, which made construction awkward and it could sometimes give trouble on starting from cold.

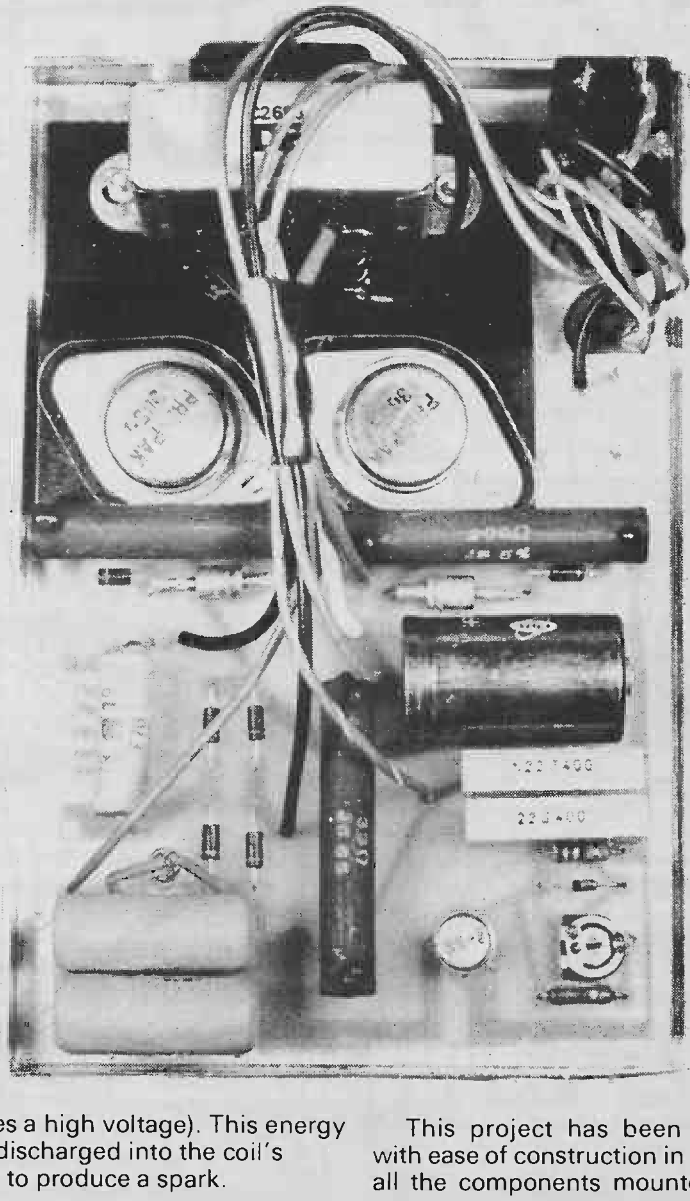
Stirling Sound have made a few improvements, the major ones being the design of a PCB to ease the task of construction, and a simplification of the switching incorporated in the 1973 design.

Why CDI?

Much has been written about the advantage/disadvantages of CDI systems. We make no claims about vastly increased performance or of dramatic reductions in petrol consumption although improvements in both these areas will be noted on most cars. What we do say, however, is that plug life will be extended and points will need far less frequent adjustment. These two facts are more than enough to justify the fitting of CDI for a lot of people.

For a full description of the principles behind CDI you should refer to our April 75 or September 73 issues but briefly the battery voltage is no longer applied directly to the coil primary (via contact breaker) to provide the HT spark required by the plugs. Instead a capacitor is used to store energy (provided by an inverter that produces a high voltage). This energy is then discharged into the coil's primary to produce a spark.

View of the completed system. Note the insulating washers under each of the two transistors.



This project has been designed with ease of construction in mind with all the components mounted on the

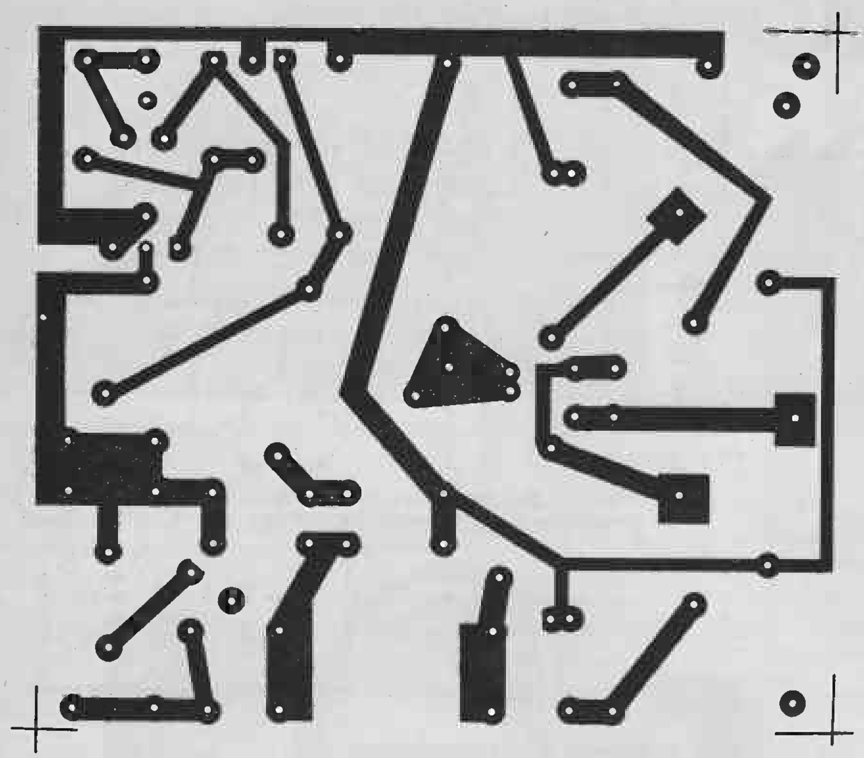


Fig 1. Foil pattern for the ignition's PCB.

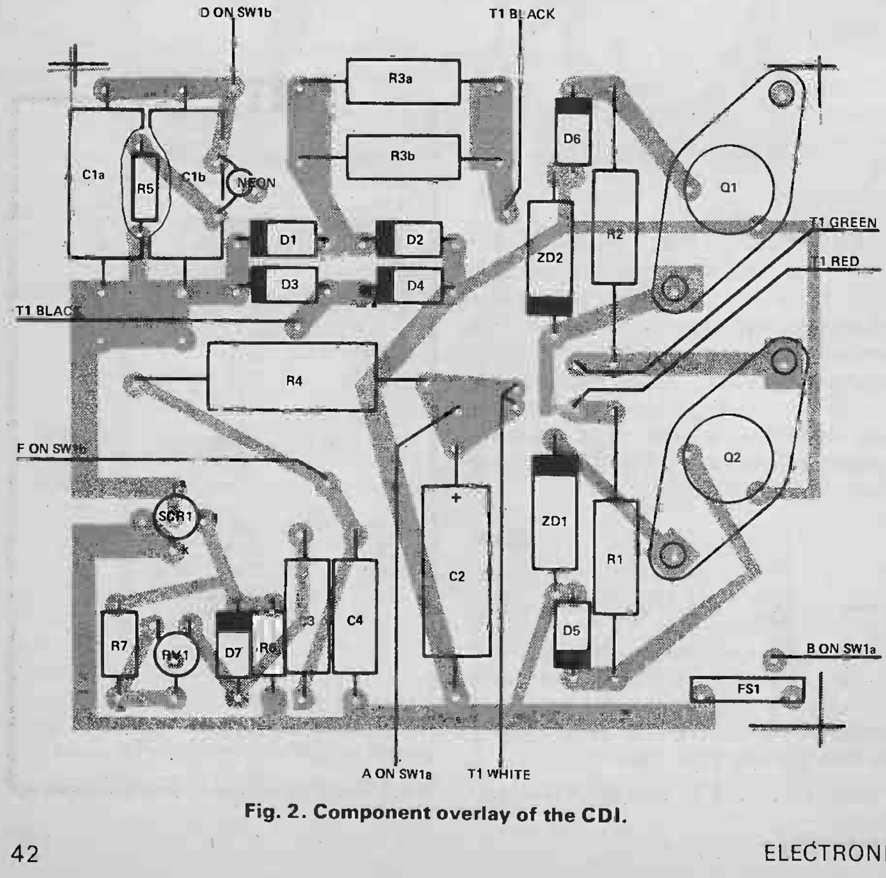


Fig. 2. Component overlay of the CDI.

HOW IT

THE inverter section of the ignition is based on a two transistor multibrator formed by Q1 and Q2 with the centre tapped primary windings of T1 forming the collector load of each device.

Circuit action is as follows. At switch on the transistor with the highest gain (Q1 say) will conduct. Its collector is thus pulled down to the negative rail so ensuring that Q2 receives no base drive.

As the centre tap of T1 is connected to the 12V supply, transformer action will cause the collector of Q2 to rise to a potential of 24V. This ensures continuing drive for Q1.

Collector current of Q1 will increase at a rate that is dependant on the value of the inductance of the section of T1 that forms its collector load.

At some stage the value of Q1's collector current will exceed the product of its base current and current gain.

At this point the voltage at Q1's collector will start to rise as the transistor comes out of saturation. This will begin to turn on Q2 which will in turn reduce the base drive to Q1. Thus Q1 and Q2 will rapidly drive each other and respectively and the cycle begins again.

This produces a 48V pp square wave across T1's primary which is stepped up by transforming action to provide an output of some 300 to 400 volts at the transformer's secondary.

Diodes D5 and D6 protect the transistors in the event of reverse power supply connections, ZD1 and ZD2 against high voltage transients.

The high voltage AC output from the transformer is rectified by diodes D1-D4. The resistor(s) R3 in series with the AC side of the bridge circuit ensure that the inverter does not "look into" a short circuit, as it would do at switch on and every time SCR1 were triggered without the resistor. The current is limited to 30-40 mA with the value of resistor shown.

The DC voltage from the bridge is taken to the energy storage capacitor(s), one side of which is effectively connected to earth via the coil.

A neon with series resistor is connected

The complete unit. As stated in the text the change over switch can be mounted remotely from the unit.

news digest. . . . .

helping hand

Some time ago ETI ran a design competition in conjunction with the Royal National Instutute for the Deaf (RNID). They provided us with three specific problems that the deaf are faced with and for which there may be electronic solutions. The prize to the winners was a silver trophy, especially designed for the competition.

The winning project is presented in this issue and we arranged a presentation ceremony recently at which Jack Ashley M.P. (who, as most people will know, is totally deaf himself) very kindly handed over the trophy to John Howden and Clive Musgrove, whose joint entry was unanimously awarded the prize by the judges.

At the same time ETI handed over a cheque for £250 to the RNID for their technical department.

Two other trophies were also passed over to the RNID which will be awarded in the autumn for the two best entries to a contest that they are running for Deaf Schools and colleges for the best craftsmanship in the workshops.

More details are given with the article itself. The whole presentation ceremony was filmed by the BBC and shown on News Review on BBC-2 on Sunday February 26th.

'the secret war'

By Brian Johnson
Published by the BBC
Hard cover, £6.50

"A few years ago it wouldn't have occurred to (any of us) that a 'Boffin', a gentleman in grey flannel bags, whose occupation in life had previously been something markedly unmilitary such as biology or physiology, would be able to teach us a great deal about our business." So said one Air Marshall about the work done in WWII by the back room boys.

It has been said that WWI was fought by chemists and WWII by physicists. 'The Secret War' describes just how true this was. The author, Brian Johnson, was the producer of the extraordinarily good BBC-TV series of the same name and has here described in greater detail the material covered.

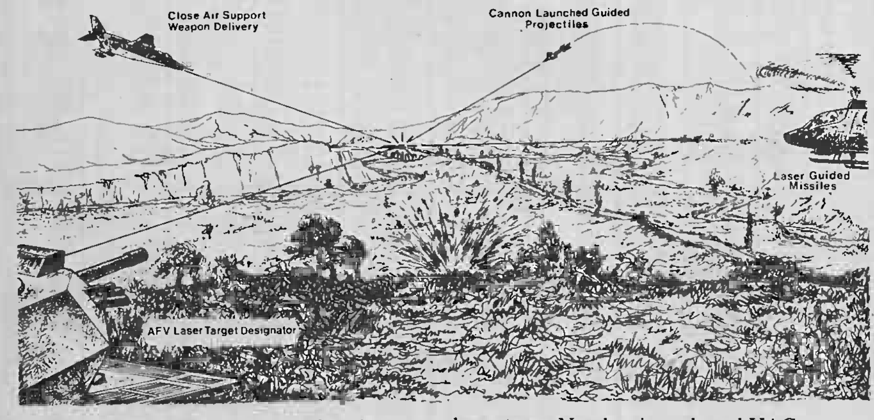
The work by both British and German scientists has been recognised for some time but much of it has not been disclosed until now and surprisingly some of the work remains classified. It has only just become known — to almost everyones amazement — that in 1943 we had the world's first electronic computer — called Colossus and using 1500 valves; it was used in breaking the most secure of the German secret codes.

The chapters cover the same topics as the individual TV programs; The Battle of the Beams (the setting up and jamming of aircraft navigation beams), Radar, Terror Weapons (largely the German rockets), The Battle of the Atlantic, Misfortunes of War (a collection of oddities and failures) and Enigma (the cracking of the German's 'unbreakable, codes).

The whole book is fascinating reading, not only for the military historian, but for anyone interested in technological advance.

HWM

ferranti think tank



More from 'Star Wars' Ferranti — this time a laser system for tanks. The applications of the laser transceiver include automatic ranging and laser target designation (in which a beam fired from the tank is scattered from the target and picked up by a guided missile). The specifications of the system are:

laser type: Neodymium-doped YAG
wavelength: 1.064 microns
energy output: 100 mJ
divergence: 0.15 milli-radians (!)
range: 200 to 10 000m
ranging accuracy: ± 5 m (!!)

We're beginning to think our tank battle game is unrealistic — it's too difficult!

you win!

About a year ago we started to send postal subscriptions out in a wrapper instead of an envelope — the latter being very expensive. We reckon now that there's some pressure group somewhere organising protests about this. Well, we give in gracefully — subs now go out in envelopes so you can have a crumple-free issue.

credit where it's due

Smack-Bottoms for the ETI staff. Our main feature last month was the 200W amp and we already know from the reader questionnaire enclosed that this was the top rated feature. Yet we did not tell you who designed it — what's worse is that it sounds as though *we* did in our own labs — but we owe the credit elsewhere. In fact the amp was designed for us by Richard Becker and he's the man who spent hours at the drawing board and at the workbench. It's naughty of us to steal his thunder.

Powertran are supplying complete kits of this and own the copyright on the PCB, so we are sorry that we can't send out the patterns as we suggested in the article.

WORKS

across C1 to provide an indication that the CDI system is operating correctly.

Thyristor SCR1 controls the output of the ignition coil since when it is triggered it effectively discharges the energy stored in C1a/C1b into the ignition coil primary.

The coil and capacitor now form a parallel tuned circuit so that the primary current increases to a maximum, decreases to zero and then swings back again. Diodes D3 and D4 provide a route for this backswing current to partially recharge C1 ready for the next spark. The back swing also ensures SCR1 turns off enabling C1 to be charged by the invertor.

Transformer action of the coil provides the high voltage spark required by the plugs.

Note: although it might be thought that the specified 1A SCR would not be able to cope with the 100-150 A current pulses encountered in operation, the device is designed to deal with such peaks as long as the Peak Repetition Frequency (PRF) does not lead to an excessive RMS current.

The thyristor must be triggered (by a gate pulse that is positive with respect to its cathode) every time a spark is required, ie when the points open.

When the points are closed current will flow from 12V via R4 and the points to ground. This current, about 500mA, is to "burn off" any minute deposits of dirt or oil film present on the points (contact breakers switching smaller currents will cause problems).

As the points open, R4 pulls the junction of C3, C4 to supply. D7 provides a path for the positive pulse (caused by the differentiating action of C3, R6) to trigger SCR1.

The thyristor cannot receive a further trigger pulse until C3 is discharged. This capacitor cannot discharge until the points close and then only via the high resistance path formed by RV1/R7 (D7 is now reverse biased).

This system makes the system immune to contact bounce and, by increasing the value of RV1, can provide a rev limit control.

C4 is also included to prevent contact bounce.

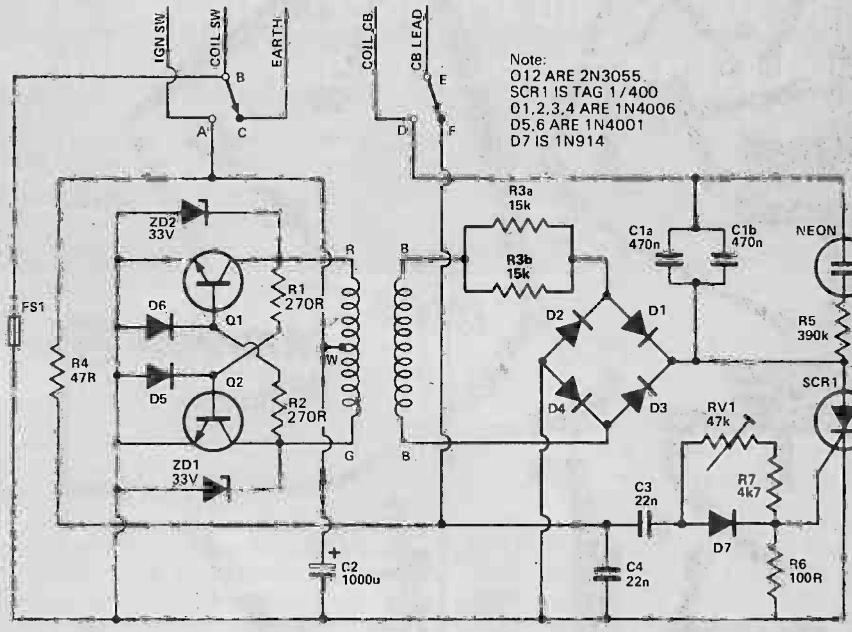


Fig. 3. Circuit diagram of the CDI, CB and SW refer to the connections on the car's coil.

PCB according to the overlay, the board can be mounted in the aluminium box as shown in the photographs.

When complete the system should be mounted in the engine compartment of your car. Mount the unit as near to the coil as possible but not where it would be subject to intense heat.

Connect the unit to the car's electrical system as indicated on the circuit diagram and switch on. The neon should light and should not dim if the engine is revved. The unit will emit a high-pitched whistle when operating normally.

With the system installed why not treat your car to a new set of points and plugs? These items will probably not have to be replaced for a long time as the CDI system treats them with care.

Remote Switching

The switch that changes the system from CDI to conventional operation, although shown mounted on the box containing the circuitry, could well be mounted remotely. If mounted in the car, this would allow comparisons between the electronic and conventional performance to be made on the move.

ETI

BUYLINES

Sterling Sound have arranged to offer ETI readers the electronic ignition at a special introductory price of £9.95 all in. This offer will last until June 30.

PARTS LIST

RESISTORS		
(All ½w 10% unless stated)		
R1, 2	270R	2W
R3a, R3b	15k	2W
R4	47R	5W
R5	390k	
R6	100R	
R7	4k7	
POTENTIOMETERS		
RV1	47k	
CAPACITORS		
C1a, C1b	470n	600V DC
C2	1000u	18V DC
C3, 4	22n	Polyester
SEMICONDUCTORS		
Q1, 2	2N3055	
SCR1	TAG 1/400	
D1, 2, 3, 4	1N 4006	
D5, 6	1N 4001	
D7	1N 914	
ZD1, 2	33V 1W	

MISCELLANEOUS
PCB as pattern, inverter transformer, DPDT switch, neon, case to suit.

TANK BATTLE TV GA

WHEN it comes to TV games — from now on think tanks because at last the tank battle chip from GI is here.

Ball and paddle games (yawn), stunt riders — less than stimulating, but tanks — *great*.

Tanks A Lot

The tank battle gives each of the participating war mongers control of a tank (there's power for you), each of which can move forwards or backwards at three speeds and be rotated through 360°.

To move forwards the appropriate button on the hand-held unit must be pressed. After a short delay the tank will begin to move and if the button is kept pressed, the tank will select second gear and then top gear. If the control is released at any time the tank will continue to move at the selected speed, it being necessary to engage reverse to stop the beastie.

Whether still or in motion the tank may be rotated in an anticlockwise or clockwise direction by means of the rotation controls.

Mined Where You're Going

Having mastered the motion controls and got under way, you will come across two types of obstacle. The white blocks on screen are fixed barriers and your tank will not go through them. The black objects are mines — if you run into one of these fellows your tank will be blown up and your opponent score a point.

Tanking Up

Now the object of the game — to blast your fellow man into the ground. The means of achieving this aim is your tank's gun. This impressive weapon fires not so much shells but more guided missiles. After leaving the tank the trajectory of these offensive weapons can be changed by means of the tank's rotation controls. The range of the shell is about two thirds of the TV screen. ►

ME

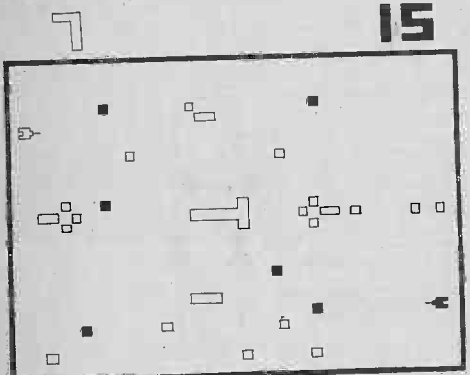
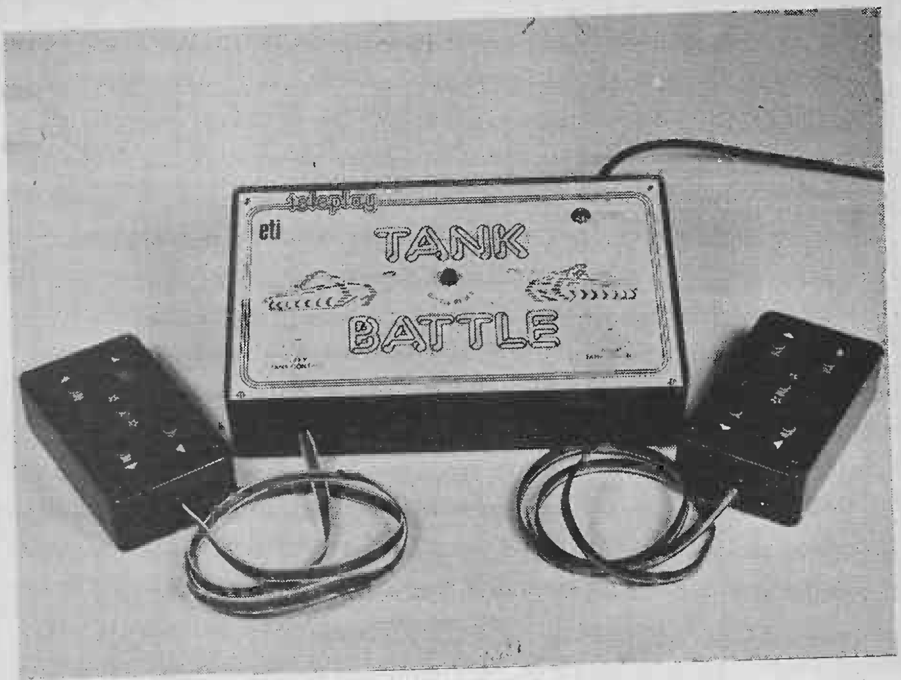
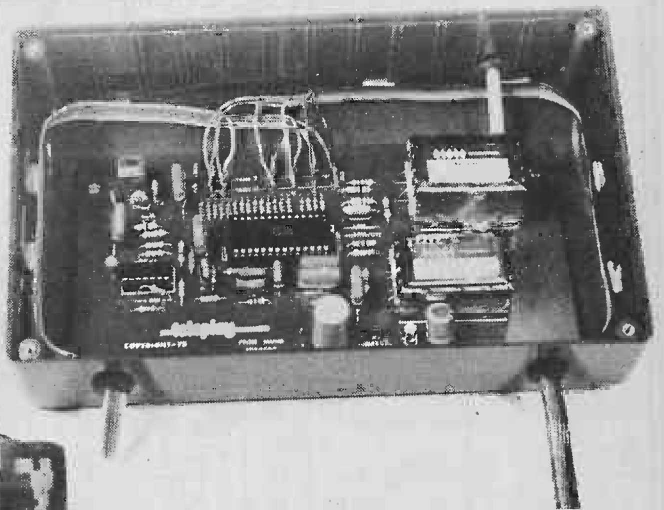


Fig 1. A simulated version of the display produced by the tank chip. See text for an explanation of the various obstacles.



thanks to the Ministry of Defence for photographs used throughout this le. The AFV illustrated is the Cheftain e tank, arguably the best in the world, NATOs main front line tank.



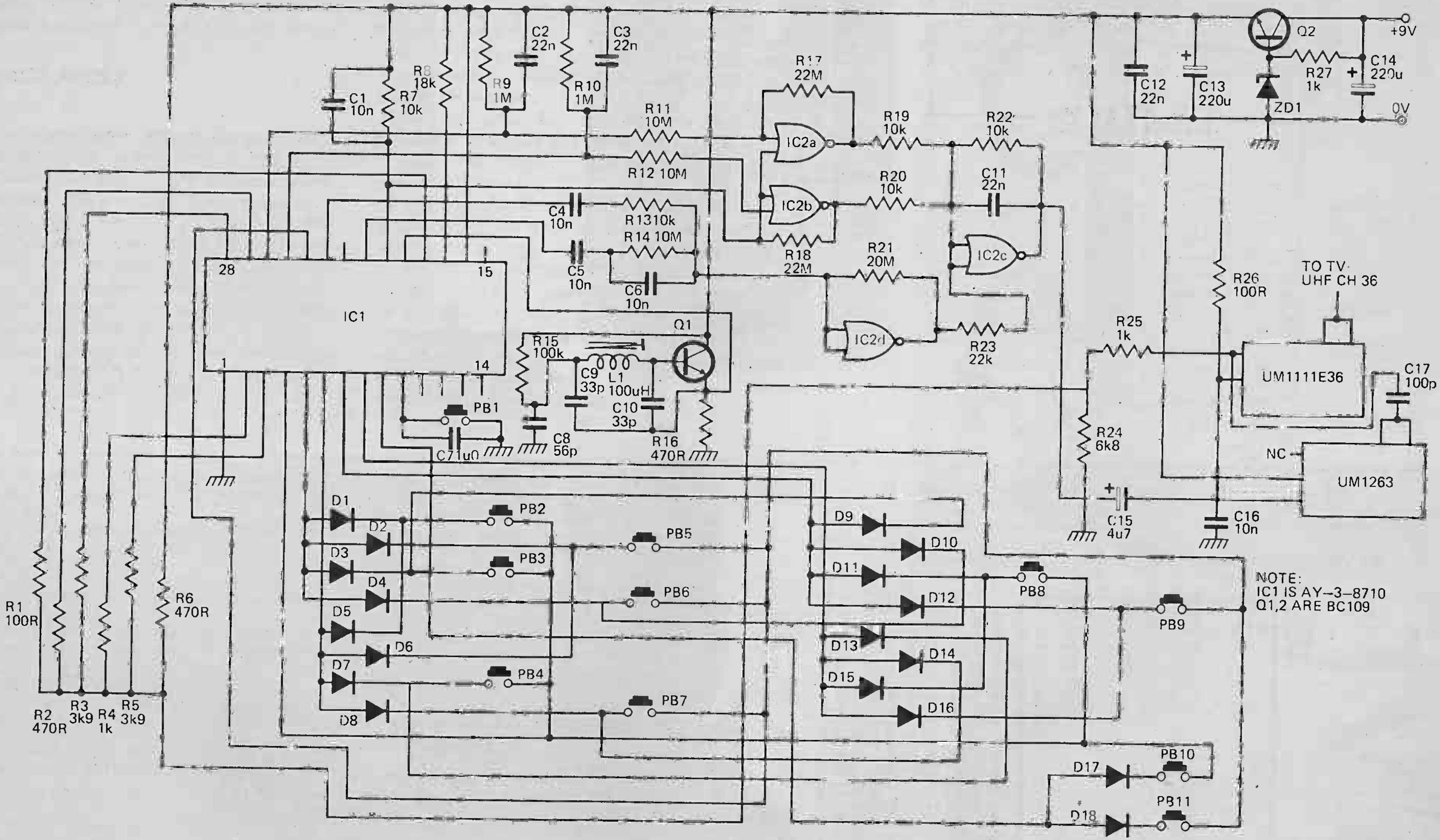


Fig 2. Circuit diagram of the tank game.

HOW IT WORKS

The twenty-eight pins of the AY-3-8710 can conveniently be grouped according to function, i.e.; video output pins (including sync), sound outputs, control inputs and a miscellaneous group including the clock signal, power supply and a number of pins to which there is no connection.

VIDEO OUTPUTS

Five video outputs are provided: Sync, white video, black video, grey and blanking.

The sync output (pin 18) provides a composite (line and frame) sync signal with equalization pulses to produce a fully interlaced display on the TV screen.

The white video output (pin 28) generates the left player's tank, shell, shell burst and score as well as the fixed barriers and borders.

The black output (pin 27) is responsible for the right player's tank, shell, shell burst plus score and for the mines.

The grey background appears at pin 2 while the composite blanking signal is taken from pin 3.

These video signals are mixed in the appropriate proportions to form a composite video signal that is fed to the UHF modulator. Note that the UHF transmission standard in this country is such that peak white corresponds to minimum carrier energy while sync tips correspond to maximum. Hence while the mixed sync signal is fed via R1 (100R) to the summing junction of R24, R25, the white output is attenuated by R13 (3k9) and the greay and black levels are set by resistors between these two extremes.

SOUND OUTPUTS

The sound circuits are responsible for producing the gunfire, explosion and tank movement sounds.

The tank sounds are produced at pin 21 (left tank) and pin 23 (right tank). Each tank's sound is fed via a frequency shaping network to IC2c which acts as an amplifier.

The gunfire and explosion sounds are produced by gating a digital noise source that is available at pin 20.

The gunfire envelope appears at pin 25 and is gated with the noise source in IC2b while the explosion envelope is produced at pin 26 and is gated with the noise in IC2a.

The three resulting sound outputs are fed via mixing resistors to IC2d which performs a frequently shaping and amplification function.

From IC2d's output the sound is fed, via C8, to the sound modulator.

In order to reproduce the sound over the TV's loudspeaker we must generate a signal that is a frequency modulated about 6MHz. This can then be added to the video signal before this is fed to the UHF modulator.

This mixing is done by C16.

CONTROL INPUTS

These inputs control the direction of movement that each tank adopts, the firing of a tank's gun and the reset at the end of a game.

The reset is straightforward. Taking pin 10 low will reset the game. Due to the limits imposed by pin out restrictions, however, the other functions are more involved.

These functions are controlled by inputs A, B, C and D (pins 5-8), by the fire gun input at pin 9 and by the two strobe signals (tank 1 at pin 4 and tank 2 at pin 24).

In order to move tank 1 (for example) forward it is necessary to connect strobe 1 to inputs A and B, for reverse to inputs D and C, to move counter clockwise A and C are connected to the strobe while B and D will produce clockwise movement. Connecting strobe 1 to the fire input will fire the tank's gun. The dioes D1-D16 ensure that connections appropriate to the action are generated upon pressing any of the ten control switches.

Pin 22 (barrier interaction select) is connected to ground. With this pin held high the tanks can drive through the fixed barriers producing a game that is not very interesting.

MISCELLANEOUS

The 4MHz clock required by the game is generated by Q1 and associated components and fed to pin 19 of IC1.

Q2 together with ZD1 and R26 form a simple series pass power supply to provide power for the modulators and the 8710 (pin 16—pin 1 is ground).

No connections should be made to pins 11, 12, 13, 14 and 15.

The only pin not mentioned thus far is pin 17 — this is a colour burst locator signal and is not used in our application.

The game continues until one person has scored sixteen points, when the score will begin to flash and funny things will begin to happen.

All this action on screen is accompanied by various bangs, squeaks and grumbling from the TV's loudspeaker.

One word of warning, although not part of GI's plans, tanks can get stuck in the sand dunes that form the game's borders. The bottom right hand corner is particularly prone to this risk so steer clear of the borders.

Construction

Construction of the tank game is made easier if the PCB is used (those kinky people amongst you can try it on veroboard — but we would not recommend it). IC1 — the tank chip — is an expensive CMOS chip and it makes sense to use a socket for it.

IC2 is an A series device. A in this case means its one of the early CMOS designs and does not have any protection diodes on its input. This means that it should be treated with care, earth yourself before touching it, use a socket etc.

Other than that, construction should be an easy matter. Just make sure everything goes in the right way round (eighteen diodes in back to front is no joke).

We used ribbon cable to connect the main input to the hand held controls although any six-way cable would be suitable.

The cost of providing an on-board power supply was not thought to be justified because as the game does not consume much current it can be run from batteries, or perhaps, a calculator's mains unit.

When complete, connect up to the ariel input of your TV set, turn on and tune to channel thirty-six. Press reset and let the war begin.

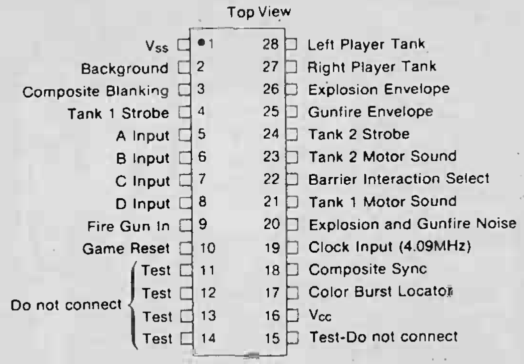


Fig 3. 8710 pinout.

BUYLINES

Complete kits for the tank game are to be produced by Teleplay and Watford. The tank chip itself will be available from a number of different suppliers — look through the ads in this issue. IC2 must be an A series device for correct operation so ensure the device you buy is not a more common B series type.

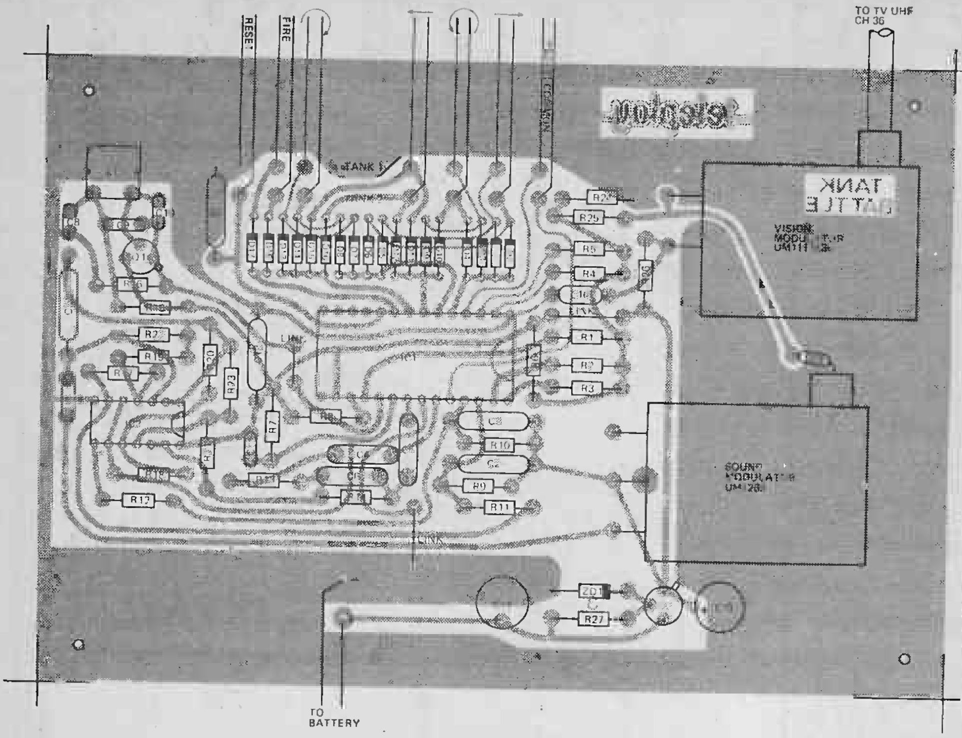


Fig 4. Tank game overlay.

PARTS LIST

RESISTORS

R1, 26	100R
R2, 6, 16	470R
R3, 5	3k9
R4, 25, 27	1k
R7, 13, 19, 20, 22	10k
R8	18k
R9, 10	1M
R11, 12, 14	10M
R15	100k
R17, 18, 21	22M
R23	22k

CAPACITORS

C1, 4, 5, 6, 16	10n polyester
C2, 3, 11, 12	22n polyester
C7	1µ0 10V tantalum
C8	56p polystyrene
C9, 10	33p polystyrene
C13, 14	220µ 16V electrolytic
C15	4µ7 10V tantalum
C17	100p polystyrene

IC1	AY-3-8710
IC2	CD4001 AE
Q1, 2	BC109
D1-18	1N914
ZD1	6V8 400mW

SWITCHES

PB 1-11	push to make

MISCELLANEOUS

UM 1111 E36 (video modulator), UM1263 (sound modulator), PCB as pattern, cases to suit.

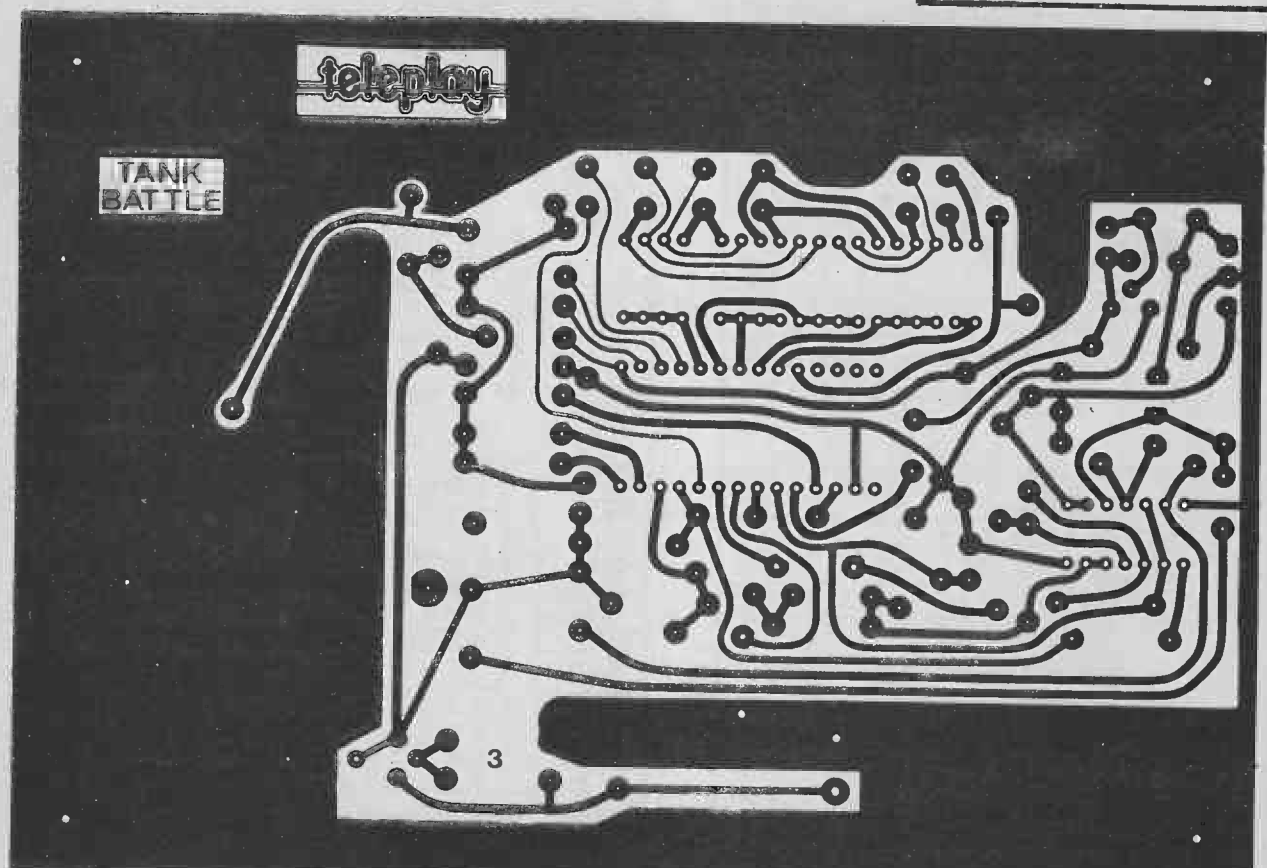


Fig 5. Foil pattern of the tank board. The copyright for this board is held by Teleplay who will supply the board separately as well as in a complete kit of parts.

CCD PHASER

Astound your ears with this solid-state phaser using the latest CCD technology. Designed by David (White Noise) Vorhaus, inventor of the musical drainpipe!

PROBABLY THE MOST sought after effect in rock music is 'jet plane' sound — or phasing as it is properly called. The effect is very distinctive, and lots of firms have produced units that imitate it. The reason we say imitate is because of the way 'real' phasing is produced — which up until recently required three tape decks, a lot of skill and even more patience!

The Real McCoy

To produce phasing in a studio you record a sound onto two tapes, then replay both tapes simultaneously via a mixer onto the third machine. Because of slight variations in playback speed (usually introduced by physical slowing of a spool), the two signals shift slightly relative to each other — this produces phase differences over the entire spectrum of the sound.

This gives the 'real' phasing that musicians know and love. Too much slowing of a spool results in echo. Obviously you cannot use this technique in real time on stage, so various other ways have been devised to produce a similar effect. However, none of the imitations are as good as the real McCoy!

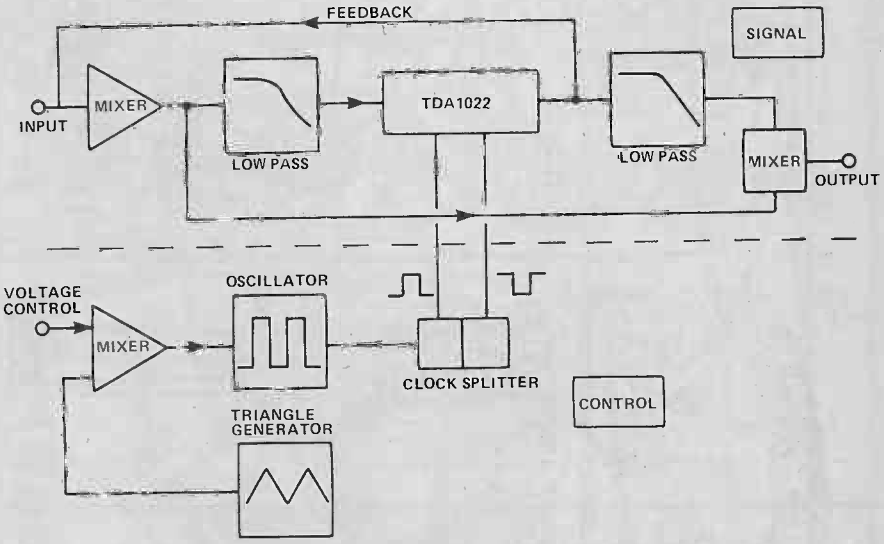


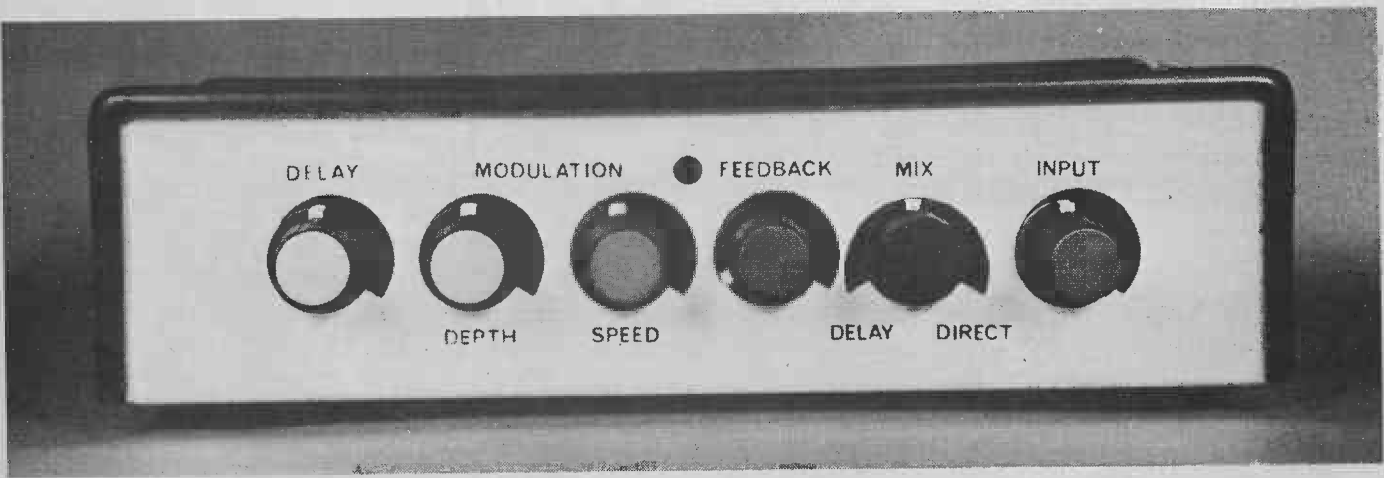
Fig 1. Block diagram of the unit, note how it can be broken into signal path and control section.

To the Rescue

With the advent of analogue delay lines came the opportunity to produce phasing in real time. By feeding the signal through a delay line and mixing the output with the undelayed input you get instant real phasing.

By adding various controls, such as input/output mix and delay length, the versatility of such a unit is increased enormously.

This phaser unit is capable of producing numerous effects — the controls permit variation of all the possible parameters. Phasing, flanging, stereo simulation are just some of the things you can do with it.



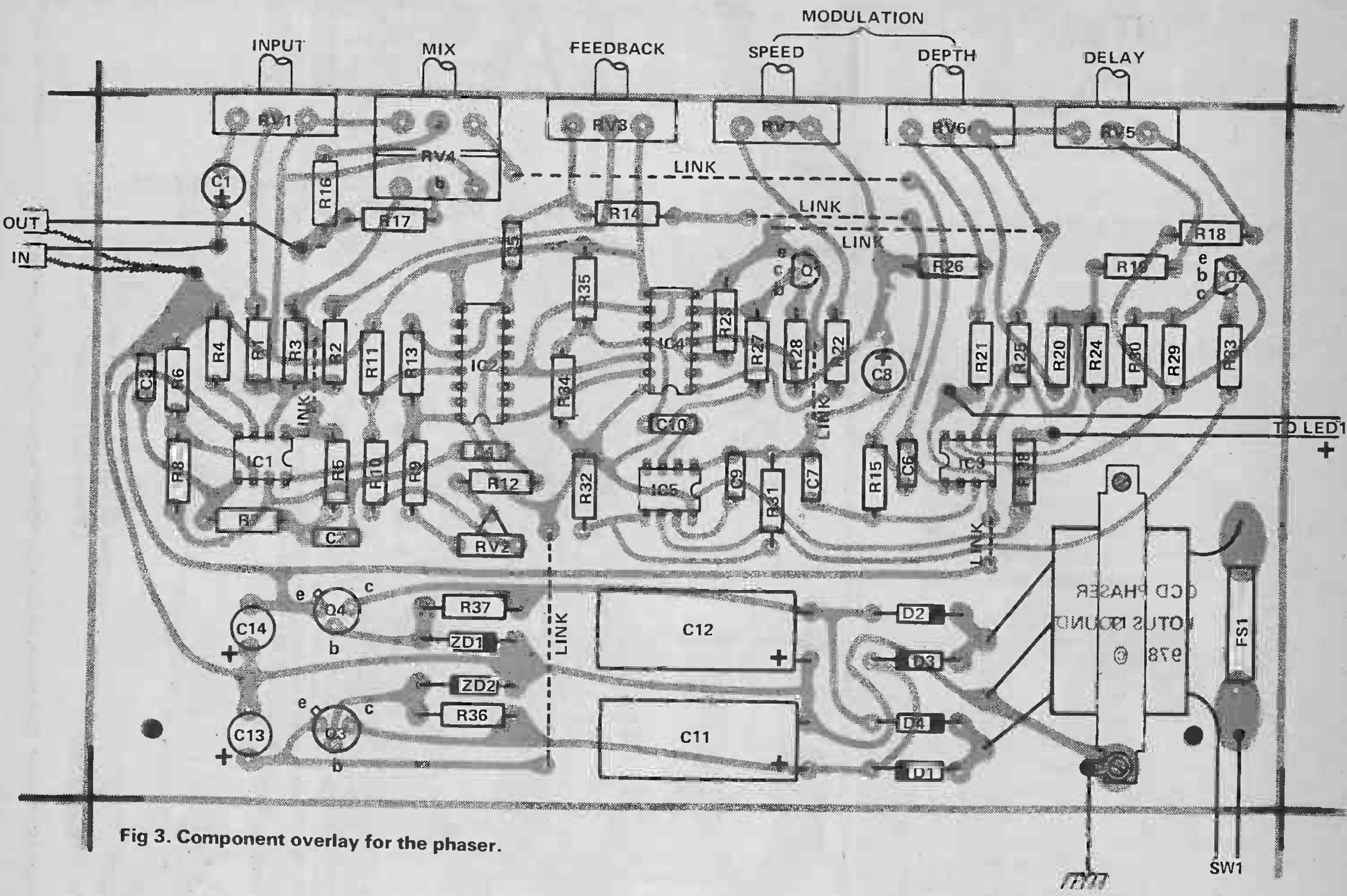
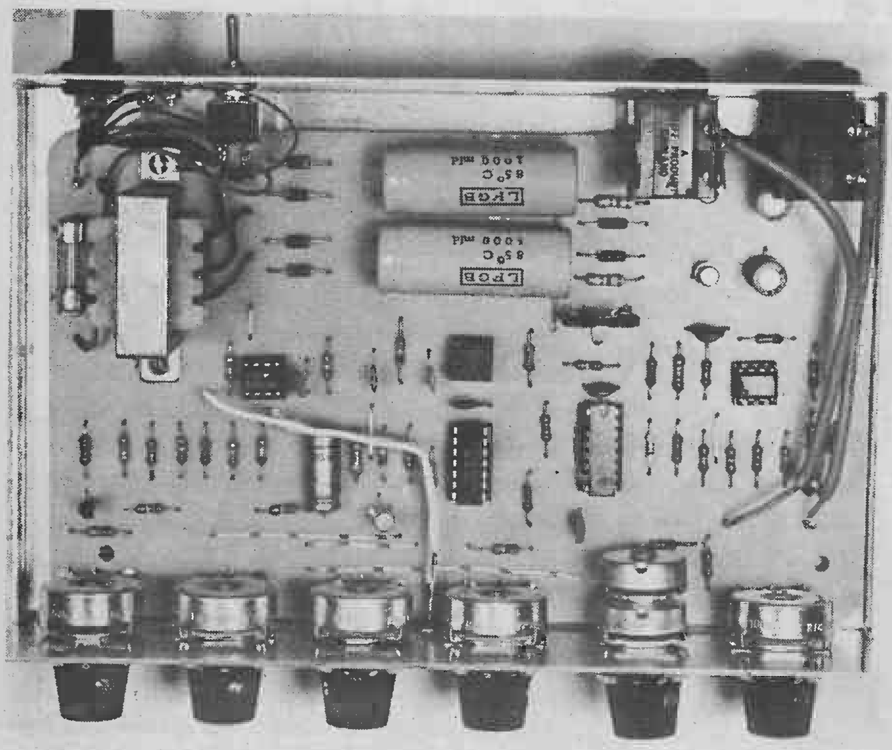


Fig 3. Component overlay for the phaser.



BUYLINES

Lotus Sound are marketing a complete kit (designer approved) see their advertisement in this issue. For those of you who would prefer to buy all the bits separately, most parts are widely available. The only difficult parts may be the PCB pots — try Electrovalue, and the delay line — Watford and Marshalls should have it.

Fig 4. Internal view of one of the prototypes, note that the control spacing has been changed on the final version.

PARTS LIST

RESISTORS (all ¼W 5%)

R1, 4	22k
R2	180k
R3	220k
R5, 7, 20	15k
R6, 12, 14, 15, 19, 23, 24, 26	100k
R8, 18	56k
R9	2k7
R10	6k8
R11, 33, 36, 37	1k0
R13	47k
R16, 17	5k1
R21	270k
R22	470R
R25	27k
R27, 32	10k
R28	680k
R29	330R
R30	8k2
R31, 38	1k5
R34, 35	1M1

POTENTIOMETERS (all PCB mounting)

RV1, 6	100k log
RV2	4k7 preset
RV3	100k lin
RV4a, b	10k log/antilog
RV5	50k lin
RV7	25k antilog

CAPACITORS

C1	10u 10V tantalum
C2, 3	1n0 polyester
C4, 5	100n polyester
C6	200p ceramic
C7, 9	100p ceramic
C8	100u 12V electrolytic
C10	10n polyester
C11, 12	1000u 25V electrolytic
C13, 14	10u 16V electrolytic

SEMICONDUCTORS

Q1	2N5172
Q2	2N3906
Q3	BC108
Q4	BC178
IC1, 3	LM1458
IC2	TDA1022
IC4	CD4013
IC5	NE566
D1-4	1N4001
ZD1, 2	12V 400mW
LEP1	TIL 209

MISCELLANEOUS

FSI	100mA 20mm + holder
SW1	DPST 240V
T1	12-0-12V 100mA

PCB, Case, 6 collet knobs, IC sockets, 2 jack sockets, etc.

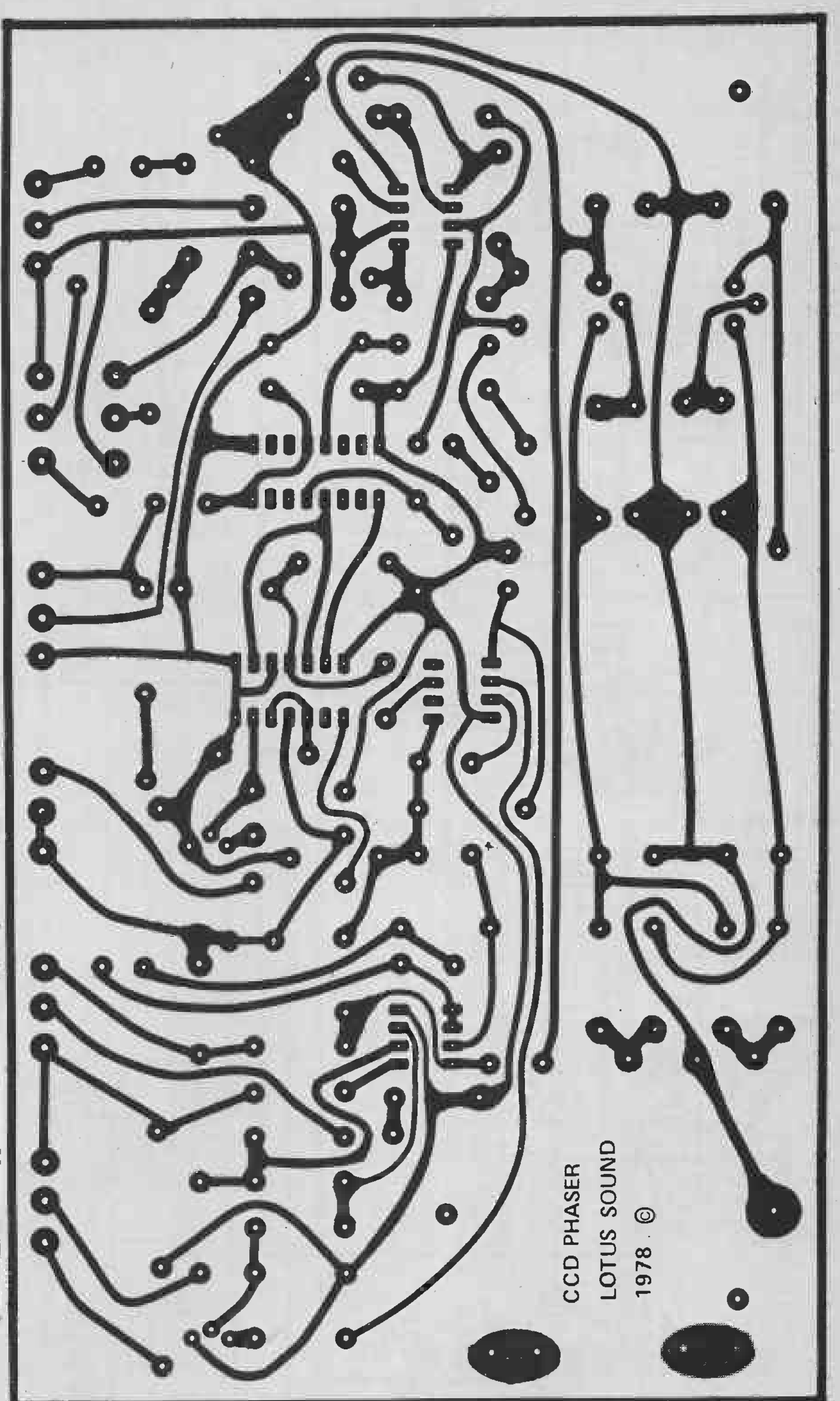


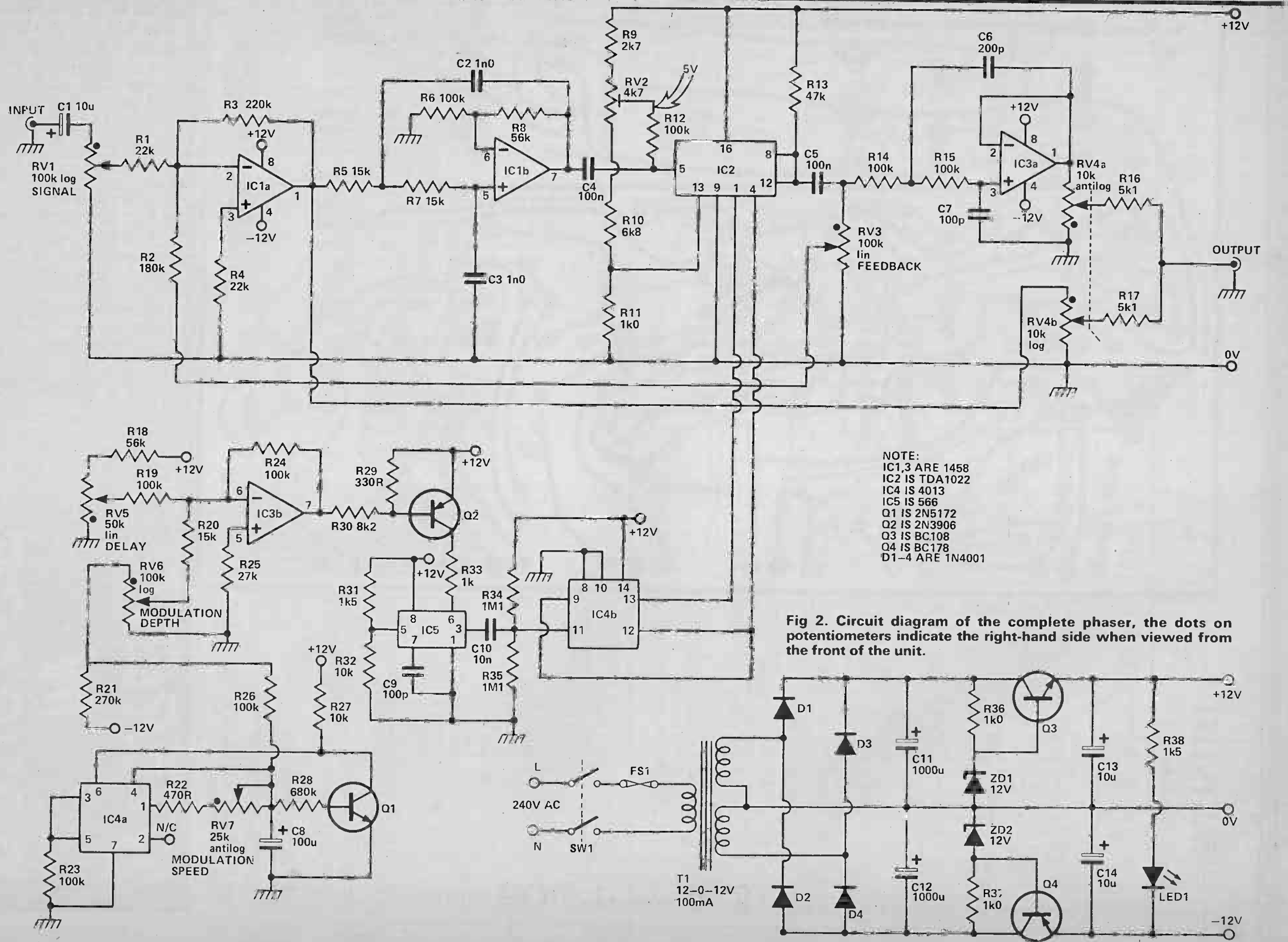
Fig 5. Full size PCB layout for the phaser (195mm x 115mm).

INTERESTED IN BONDAGE?

We've got something to interest you if you're that way inclined. Sorry, it's got nothing to do with kinkiness if that's what you thought, but if you want your old copies of ETI under bondage, we've got the perfect binder for you.

P.S. Just in case, binders are sent under plain cover.

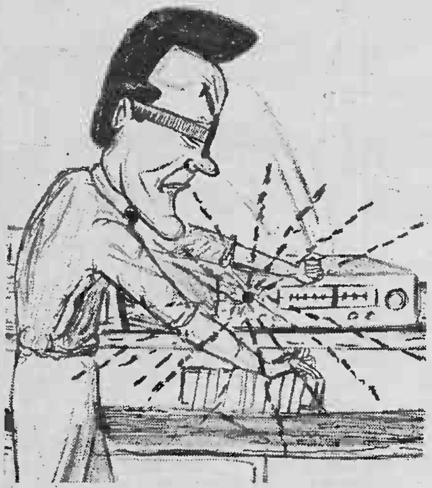
Send £3.00 (which includes VAT and postage) to:
ETI Binders,
25-27 Oxford Street,
London W1R 1RF.



NOTE:
IC1,3 ARE 1458
IC2 IS TDA1022
IC4 IS 4013
IC5 IS 566
Q1 IS 2N5172
Q2 IS 2N3906
Q3 IS BC108
Q4 IS BC178
D1–4 ARE 1N4001

Fig 2. Circuit diagram of the complete phaser, the dots on potentiometers indicate the right-hand side when viewed from the front of the unit.

. . news digest . . .



bbc employ full-time pilot

LED-watchers may already have noticed that the BBC no longer turn off the VHF stereo pilot tone during mono transmissions. This is because of the loud click this produces on some receivers. The continuous pilot tone transmissions began on 27th February . . . remember those heady days when the LED first lit up?

offensive caller all hung up

The Post Office has revealed that it made use of a "special device" to trace the source of indecent and threatening calls made to a woman in Lanarkshire — *after* the caller had hung up.

Mr Alistair Duff, in prosecuting, said: "Post Office engineers installed a special device on the telephone. When the woman received her next call from the man she pressed a button on the device which activated it and held open the line, enabling the Post Office to trace the call back to the man's home".

The man had been making the indecent calls over a period of six months and had threatened to harm the woman's seven-year-old daughter.

rca terra tactics

It seems that the SI system will be stretched to its limits by the electronics industry. RCA have announced the introduction of a new FET dual op-amp — the CA 3240 — which has an input impedance of 1T5 (that's 1.5 x 10^{12} ohms!). Other specs include:

Miniumum supply voltage: 4V (useful!)
max. supply voltage: 30V
unity gain bandwidth: 4.5 MHz
slew-rate: 9V/μs
common-made input voltage range down to 0.5V *below* negative voltage.

We're not sure what the SI for 10^{15} is (or even if it exists!), but the chances are it'll be in use sooner or later — perhaps Brussels had better extend the system!

WATFORD ELECTRONICS

(Continued from opposite side)

DIODES

AA119	15
AAZ15	15
AEY11	60
BA100	10
BY100	24
BY126	14
BY127	14
OA9	75
OA47	12
OA70	12
OA79	12
OA81	15
OA85	12
OA90	6
OA91	6
OA95	8
OA200	9
OA202	8
IN914	4
IN916	5
IN4001/2*	5
IN4003*	6
IN4004/5*	6
IN4006/7*	7
IN4148	4
IS44	20
3A/100V*	18
3A/400V*	20
3A/600V*	27
3A/1000V*	30
6A/600V	50

ZENERS
Rng:3.3V-33V
400mW 9
1.3W 17

ALUM. BOXES with lid*

3x2x1"	45
2¾x5¼x1½"	68
4x4x1½"	68
4x2¼x1½"	60
4x5¼x1¼"	78
4x2½x2"	64
5x4x2"	82
6x4x2"	88
7x5x2½"	114
8x6x3"	148
10x7x3"	172
10x4½x3"	142
12x5x3"	165
12x8x3"	210

SPEAKERS

8Ω 0.3W	
2"; 2½"	65
2.5: 3"	58
40 Ω 2.5"	65
64 Ω 2.5"	65
8Ω 5W	
7" x 4"	190
8Ω 3W	
6" x 4"	160

OPTO ELECTRONICS*

LEDS + Clip	
TIL209 Red	13
TIL211 Grn	23
TIL212 Yellow	27
0.2" Red	17
0.2" Yellow, Grn, Amber	21
ORP61	84
ORP12	63
2N5777	54

7 Segment Displays

5-LT-01 Futaba	460
TIL312 .3" C.An	125
TIL313 .3" C.Cth	125
TIL321 .5" C.An	140
TIL322 .5" C.Cth	140
DL704 .3" C.Cth	99
DL707 .3" C.Anod	99
DL747 .6" An	180
FND357	149
XAN351 .3" Green	180
XAN625 .6" Green	250
MINITRON 3015F	240
Liquid Crystal Display 3½ or 4 digit	975

OPTO ISOLATORS

TIL111/2	105
TIL114	110
TIL117	164

VOLTAGE REGULATORS

TO3 Can Type	
1A +ve: 5V, 12V, 15V, 18V	145 each
LM309K	135
LM323K	625
MVR5 or 12	180
1A –ve: 5V, 12V	220
Plastic Case	
+ve 0.1A (78L) 5V 6.2V, 8.2V, 12V, 15V	51
+ve 1A (780) 5V, 12V, 15V, 18V, 24V	99
Plastic (79L)	
–ve 0.5A: 5V, 6.2V, 8.2V, 12V, 15V	95
–ve 1A: 5V, 12V	175
LM320-12 –ve	165
LM320-15 –ve	165
LM341-15 +ve	99
VARIABLE TYPE	
723 +2 to +37V	45
LM304H 0 to +40V	240
LM317H +1.2 to 37V	100
LM317K +1.2 to 37V	350
LM325N ± 15V	240
LM326N ± 12V	240

SWITCHES*

TOGGLE 2A 250V	
SPST	28
DPST	34
DPDT	38
4 pole on off	54
SUB-MIN TOGGLE	
SP changeover	59
SPST on off	54
SPST biased	85
DPDT 6 tags	70
DPDT C/OFF	79
DPDT Biased	115
SLIDE 250V	
1A DPDT	14
1A DPDT C/O	15
½A DPDT	13
4-pole 2-way	24
PUSH BUTTON Spring loaded	
SPST on off	60
SPDT C over	65
DPDT 6 Tag	85
MINIATURE Non Locking	
Push to make	15
Push Break	25
ROCKER: (Black) on/off 10A 250V	23

SCR's* Thyristors

1A50V	38
1A100V	42
1A200V	47
1A400V	52
1A600V	70
3A50V	38
3A100V	43
3A200V	60
3A400V	110
3A600V	120
5A400V	120
7A400V	125
8A400V	150
BT106	150
C106D	55
TIC44	25
TIC45	45
2N4444	140

ROTARY: Make your own multiway Switch. Adjustable Stop Shafting Assembly. Accommodate up to 6 Wafers 69
Mains Switch DPST to fit 34
Break Before Make Wafers. 1 pole/12 way. 2p/6 way. 3p/4 way. 4p/3 way. 6p/2 way 47
Spacer and Screen 5
ROTARY: (Adjustable Stop)
1 pole/2 to 12 way. 2p/2 to 6 way. 3 pole/2 to 4 way. 4 pole/2 to 3 way 41
ROTARY: Mains 250V AC, 4 Amp 45

TANK BATTLE
Build this fantastic T.V. Game with realistic battle sounds generated from your T.V. speaker, steerable tanks, controllable shell trajectory and minefields to avoid. A really exciting and skilful game simply constructed with our easy to follow instructions. Order now — avoid disappointments.
Basic Kit (just add controls) price only £19.50 inc. VAT
Complete Kit (including controls) price only £26.25 inc. VAT
I.C. AY-3-8710 £10.50 inc. VAT

TRIACS*

6A400V	88
6A500V	95
8A400V	99
8A500V	110
10A500V	140
15A400V	165
16A400V	185
16A500V	210
40430	125
40528	150
40669	95

DIAC*
[illegible]

TANK BATTLE IC
AY-3-8710
Only £10.50 inc. VAT

DIGITAL PANEL METER
Intersil Evaluation Kit £21.52*
(P&P insure'd add 30p)
All parts as per ETI £23.85*
(P&P insured add 30p)
ICL7 106/7107 . . . . £9.75*
LCD 3½ or 4 Digits £9.95*

ETI PROJECTS: Parts available for the following ETI Projects.
Multi-option Clock, House Alarm, Hammer Throw, Race Track, Accentuated Beat Metronome, Porch Light, IB Metal Locator Mk. 2, Shutter Speed Timer, Ultrasonic Switch, True RMS Voltmeter, LCD Panel Meter, Gas Monitor, PHASER, Star Trek Radio, Helping hand, Tank Battle, Electronic Ignition.
Please send SAE plus 5p per list.

***BRIDGE RECTIFIERS** (plastic case)

1A/50V	20
1A/100V	22
1A/200V	25
1A/400V	29
1A/600V	34
2A/50V	35
2A/100V	44
2A/200V	46
2A/400V	53
2A/600V	65
4A/100V	72
4A/200V	75
4A/400V	79
4A/600V	105
4A/800V	120
6A/100V	73
6A/200V	78
6A/400V	85
BY164	56
VM18	40

LAMP HOLDERS AND LAMPS*
LES HOLDER Dome shaped, Red, Blue, Green, Yellow, White 18
LES BULBS 6v and 12v 11
MES HOLDERS Chrome cover, Red or Amber, Jewelled top 50
LES OR MES Batten Holders 10
MES BULBS 3.5V 6V 12V 11
NEONS Mains, Sealed with Resistor, Sq. Top, Red or Grn, Round Top Red 24
Neon Open with leads, 95V AC 9

FERRIC CHLORIDE*
1lb bag Anhydrous **65p** + 30p p. & p.

DALO ETCH RESIST PEN* + spare tip 75p

VARICAPS

MVAM2	135
MVAM115	95
BA102	25
BB104	40
BB105B	40
BB106	40

COPPER CLAD BOARDS*

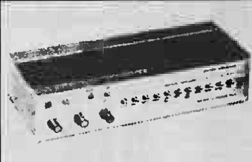
Fibre Glass	Single-sided	Double-sided	SRBP 8"x10.5"
6"x6"	75p	90p	75p
6"x12"	130p	175p	

DIL SOCKETS * Low Profile (TEXAS)
8 pin 10; 14 pin 12; 16 pin 13; 18 pin 20; 20 pin 27; 24 pin 30; 28 pin 42; 40 pin 55.

SOLDERCON PINS*
100 pins 50p; 1000 pins 350p

Noise Diode
Z5J 105

TERMINALS*—Screw type insulated. Red, Black, Yellow, Green, White 21



RHYTHM GENERATOR
Build this *PE* (Jan. '78) Easibuild Low cost Rhythm Generator. We are the sole suppliers of the complete Kit including the case, pre-drilled printed front panel and the printed Circuit Boards.
Complete Kit price incl. VAT **£49.95 only** (p&p £1).
Ready Built add **£15.00.**

RHYTHM GENERATOR demonstration at our Shop.
Send S.A.E. for leaflet.

JACK PLUGS			SOCKETS	
	Screened chrome	Plastic body	Open metal	Moulded with break contacts
2.5mm	12p	8p	8p	
3.5mm	15p	10p	8p	
MONO	23p	15p	13p	20p
STEREO	31p	18p	15p	24p
Din		Plugs	Sockets	In line
2PIN Loudspeaker 3, 4 & 5 pin Audio		13p	8p	20p
CO-AXIAL (TV)		14p	14p	14p
PHONO			6p 1-way	–
assorted colours		10p	8p 2-way	–
metal screened		12p	15p 3-way	–
BANANA	4mm	10p	10p	–
	2mm	10p	10p	–
	1mm	8p	8p	–
WANDER	3mm	8p	8p	–

VEROBOARD* Pitch

	0.1 (copper clad)	0.15 (copper clad)	0.15 (plain)
2½ x 3¾"	41p	33p	22p
2½ x 5"	49p	45p	28p
3¾ x 3¾"	49p	45p	–
3¾ x 5"	56p	60p	39p
2½ x 17"	152p	121p	78p
3¾ x17"	195p	163p	107p
4¾ x 17"	252p	–	165p
Pkt of 35 pins			30p
Spit face cutter			76p
Pin insertion tool			99p

VERO WIRING PEN 365p
We are stockists of all Vero Products. Send SAE for our free list.

BLOB BOARDS*
We now stock thr full range of Blob Boards

HOW IT WORKS

The heart of the unit is a 512 stage CCD (Charge Coupled Device) type TDA1022. This particular IC was the subject of our May 1977 data sheet, and the theory of CCDs was covered in the September 1977 edition. Reference should be made to these articles for a description of the TDA 1022 operation. However, even though the TDA1022 is the heart, the rest of the circuitry is the body and will be described in detail.

Figure 1 shows a simplified block diagram of the whole unit, as can be seen, the circuit can be divided into two sections — signal path and control circuitry.

SIGNAL PATH

First the signal path starting with RV1 which is a straightforward 100 k logarithmic level control. From its wiper the signal passes into IC1a, which is connected as an inverting amplifier with a gain of ten (set by the ratio of R1, R3). RV3 (feedback) is also connected to IC1a — the reason will be explained further on.

The output of IC1a is fed into IC1b and also to RV4b (direct level). IC1b is connected as a second order Butterworth low pass filter, with its upper —3dB point at 10kHz and a gain of approximately 4 dB in its passband. There are two reaons for this configuration. Firstly, if the input to the delay line has a frequency greater than half the delay line's clock frequency, the result is distortion. The delay line will operate with clock frequencies as low as 5 kHz — as this would limit input frequencies to below 2.5 kHz a tradeoff has to be made. The clock (described later in the control section) works in the range of 5 kHz to 400 kHz, but as the most useful effects are above 20 kHz, 10 kHz was chosen as the input cut-off frequency.

The 4dB gain is required because the delay line has a typical loss of 4dB — if the gain is introduced before the CCD the signal to noise ratio at the output is improved by 4dB.

The input of the delay line is pin 5 which IC1b feeds via C4. The resistor chain R9, RV2, R10, R11 is to hold pin 13 approximately 1V above OV which produces maximum dynamic range in the delay line. RV2 is used to set the DC voltage at pin 5 for class A operation, which minimises distortion. Pins 1 and 4 of the CCD are its clock inputs, which must be 180° out of phase. R13 loads the output, as the line likes a nice standard load to ensure consistent operation. The output feeds via C5 to RV3 (feedback) and IC3a.

The feedback control (RV3) is to enable recirculation of the delayed signal output fed back to the input, via R2. The output filter is IC3a, which is similar to the IC1b filter, in that it is again a second order Butterworth low pass filter, but has unity gain and a —3 dB point of 20 kHz. The cut-off frequency is chosen to eliminate any clock frequency that may be present in the output from the delay line, and hence prevent HF overload of any subsequent equipment.

The output control RV4a,b, enables the user to mix from delayed signal to normal signal, the output from the twin control is resistively mixed by R16, 17. A log/antilog control is used to give a smooth transition with no 'dead band' in the centre of rotation.

CONTROL CIRCUITRY

All of the second section has one purpose — to alter the clock frequency, and hence the delay time, of the CCD. IC4b is a D flip-flop which is wired to give the required two phase input to the delay line. Pin 11 is the clock input to IC4b, this is fed a stream of pulses from IC5 via C10. IC5 is a 566 voltage controlled oscillator, except it is wired as a current controlled oscillator! Pin 5 (the voltage input) is held at 10.5 volts by R31, 32 and pin 6 is fed a variable current provided by Q2. With the values shown the 566 will oscillate over the range 10 kHz to 800 kHz, which produces a clock frequency (after the divide by two of IC4b) of 5 kHz to 400 kHz.

The current injected by Q2 into the 566 is dependent on the voltage from IC3b, fed to its base. This voltage is controlled in two ways. Firstly from the delay control (RV5), the 56 k resistor R18 is to ensure that the control is useful over most of its travel — otherwise the 566 (IC5) could stop oscillating when RV5 was at its positive end.

IC4a and Q1 also control the frequency of the 566 via RV6 (modulation depth) and RV7 (modulation speed). They are connected up as a triangle generator, the frequency being controlled by RV7. The timing function is dependent on the rate of charge (and discharge) of C8, which is directly controlled by R22 and RV7. The triangle waveform produced is mixed with the voltage from RV5 via RV6 and hence changes the voltage at Q2 base — and therefore the delay time.

Construction. 1, 2, 3 . . .

Install the seven links and six terminal pins first. Follow with all the resistors and capacitors — double check polarities on the electrolytic capacitors. Soldercon sockets or moulded sockets should be used for the 4013 and TDA1022, and for the hell of it the other three ICs — ever tried to unsolder one? Put them in now anyway.

Cut the control spindles to length **before** you mount them.

The six front panel controls can now be mounted on the board one at a time, and after careful alignment soldered in place. If you don't use the specified PCB mounting controls — you have to be accurate and cunning, or you'll end up with a dog's hind leg (just like the original prototype — yes folks, even ETI can make mistakes!).

After the control pots comes the transformer, fuse holder and preset RV2, followed by the diodes and transistors.

Insert the two standoffs into the base of the box, then spindles first (not women and children) place the board into the box — it should click into place (if you drilled your holes in the right place).

Nearly there now, fit the mains switch, jack sockets and mains cable. Make sure you wire the live mains lead into the fused side of the transformer.

The LED, nuts and knobs, ICs and you've done it . . . light the blue touch paper and . . .

Set all the controls fully anticlockwise **except** for the delay control (on the left) which should be fully clockwise. Feed in an audio signal (preferably a sine wave) and put the output through an amplifier.

Rotate the level control (on the extreme right) clockwise, until the signal comes through at the same level it is going in. If all is well rotate the mix control clockwise — as you do so the sound should 'phase'. With the mix control fully clockwise, adjust RV2 for either 5V at its wiper, or symetrical clipping of the output when viewed on an oscilloscope with 2V5 peak to peak going into the delay line.

When RV2 has been set the delay line is operating at its optimum bias point.

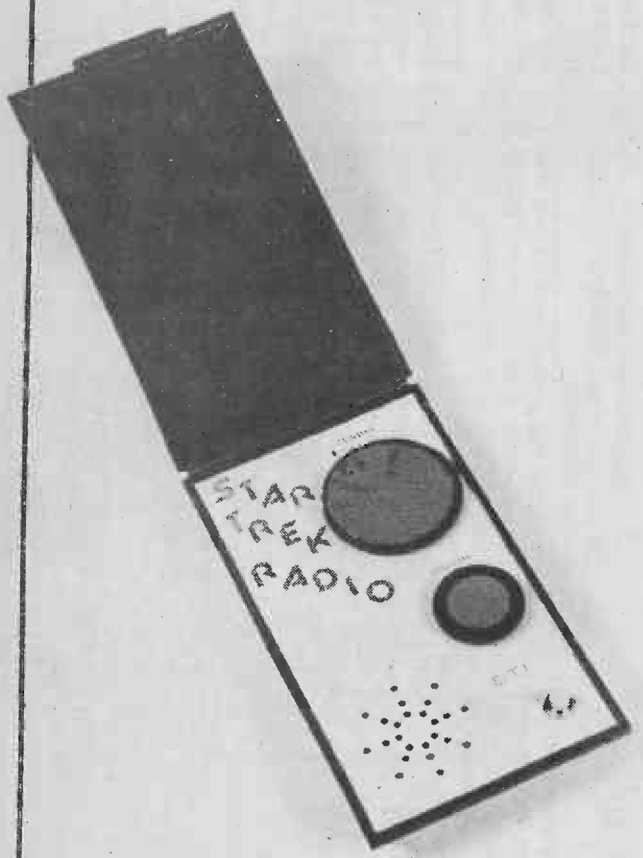
The delay control can now be checked, turning it anticlockwise should alter the output signal and near the end of its range a whistle should break through — and the signal should deteriorate into a very 'crunchy' sound, but not disappear completely. If it does stop increase R18 until it appears again.

The modulation control comes into effect when turned clockwise. Modulation speed is increased by clockwise rotation of the speed control. Make sure the delay control is set clockwise initially. With the mix control halfway a regular 'phasing' will occur as the modulation depth is increased, faster as the modulation speed is increased.

Now you can play with a real signal — white noise is particularly nice to feed into the system (fuzz guitar has a lot going for it as well).

ETI

STAR TREK RADIO



MEMO

To: All Starfleet personel
From: Star Fleet Command
Re: Field Equipment item — Radio

The importance of maintaining the integrity of the star fleet command communications network must once again be stressed. Pursuant to this matter details of an approved personal communications system are appended.

This device, capable of being tuned over the section of the electromagnetic spectrum termed medium wave and possesing an audio output that is adjustable to suit local field conditions, will enable approved star fleet data transmissions to be recieved.

Personnel should note that as an aid to security certain wavelengths will carry data in a code that, to the untrained ear, will sound like a series of loud repetitive off key musical notes not unlike 20th century pop music.

The need to keep in contact with your local command station is important at present with the Intergalactic Pirates Corps (IPC) on the increase. Remember, trek boldly with your Star Trek Radio.

Star Fleet engineers have designed the communications receiver in such a way that the item of equipment can be built with the parts available in most parts of the galaxy.

After securing all the necessary components assemble same according to the PCB overlay appended. Take care that all polarity sensitive devices are installed correctly.

A small size energy rod (that's soldering iron) with a small bit is essential when constructing the radio in view of the small size of the finished unit.

When the receiver is complete, apply power and tune to the command channel you have been assigned.

BUYLINES

See ETI Market Place on page fifty-five for a good deal on the ZN414. The box that "makes" the project is one of a new range from Vero.

The normally closed switch we used was very expensive but there is no reason why a cheaper slide switch cannot be used. But of course, in this case, the radio would not "bleep" automatically as the lid is opened.

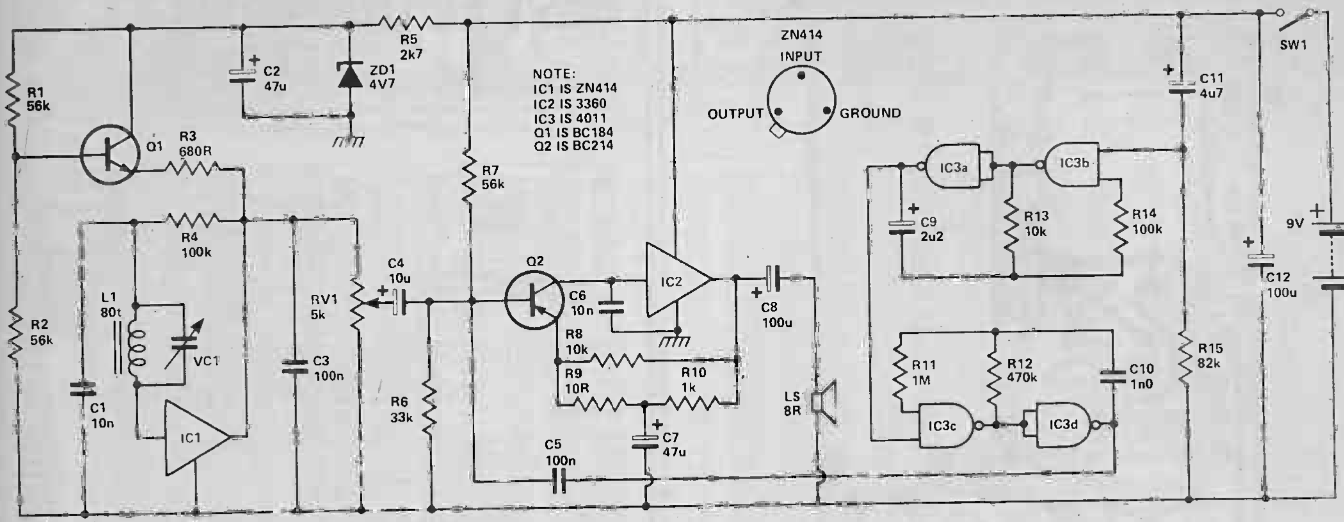


Fig. 1. Circuit diagram of the Star Trek radio.

PARTS LIST

RESISTORS

R1, 2, 7	56k
R3	680R
R4, 14	100k
R5	2k7
R6	33k
R8, 13	10k
R9	10R
R10	1k
R11	1M
R12	470k
R15	82k

POTENTIOMETERS

RV1	5k

CAPACITORS

C1, 6	10n Polystyrene
C2, 7	47u 10V Tantalum
C3, 5	100n Polyester
C4	10u 10V Tantalum
C8	100u 10V Electrolytic
C9	2u2 10V Tantalum
C10	1n0 Polystyrene
C11	4u7 10V Tantalum

VARIABLE CAPACITOR

VC1	150p

SEMICONDUCTORS

IC1	ZN414
IC2	3360
IC3	4011
Q1	BC184
Q2	BC214
ZD1	4V7 400mW

MISCELLANEOUS

PCB as pattern, 8R loudspeaker, Vero flip top box, push to break switch, ferrite rod, 32 SWG wire.

HOW IT WORKS

The radio's "front end" is based on Ferranti's ZN414. This is a ten transistor Tuned Radio Frequency (TRF) circuit that contains a complete RF amplifier, detector and AGC circuit.

The ZN414 operates with a supply of between 1.2 and 1.6 volts. This is provided by Q1.

R3 sets the AGC characteristics of the receiver.

To obtain good selectivity it is essential that the input to the ZN414 is fed from a high Q coil and capacitor combination. This requirement is met by the network formed by L1 and CV1 (tuning control)

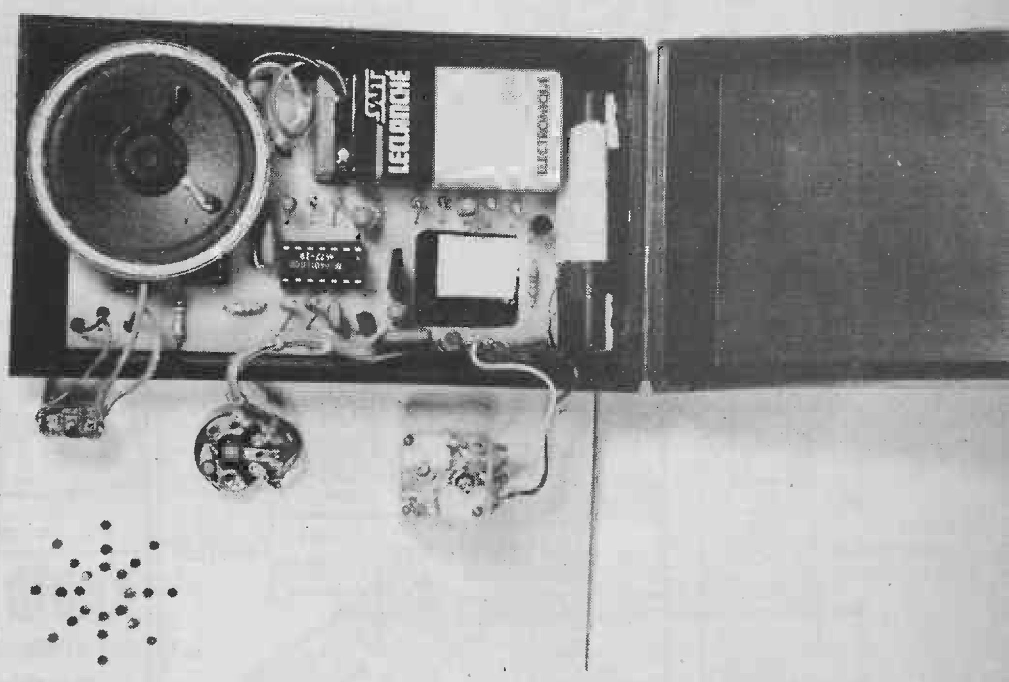
C3 decouples the audio output at RF frequencies leaving us with an audio signal that is fed, via volume control RV1, the audio amplifier stage.

The audio amplifier consists of IC2, Q2 and related components. Q2 provides gain with a response that is shaped by the feedback loop formed by R8, R9, R10 and C7. The output of the amplifier is fed via DC isolating capacitor C8 to the loudspeaker.

The "bleep" effect produced at switch on is generated by IC3. The gates of this package are configured as two oscillators, one running at a high frequency (IC1c and ICId), the other at a low frequency (IC1a and IC1b).

The latter is gated on when the junction of C11 and R15 is high. This is the case at the instant of switch on, however, C11 soon "charges down" inhibiting operation.

The slow running oscillator gates the bleep produced by the IC3c and IC3d oscillator. The bleep is fed to the audio output stage via C5.



audiophile......

A standard is a standard is not non-standard — or shouldn't! However, DINs are difficult to pin down! Ron Harris explains.

FROM THE QUESTIONS I've had sent in to the Audiophile service, it is clear that the good ole DIN standard is still far from being all things to men (or plugs) and is still causing widespread confusion. Tape to tape connectors, for instance, have in two cases been responsible for near murder of silent and brooding hi-fi, whilst unbeknownst to all the missing signal was hiding away on different pins of the plug.

Speaking as someone who much prefers the simpler, but more bulky, solution of phono plugs where possible, DIN problems are usually solved with a pair of wire cutters! However, there are times when a five pin DIN is much more convenient (such as when the manufacturer of your equipment just doesn't fit phono sockets at all).

Since the five-pin plug and socket is by far the most popular, it is this we concern ourselves with in the main. DIN speaker plugs are simply not to be considered unless there is no choice, and NEVER with high power amps unless you wish to check the protection circuit.

Making a DIN

In all cases where a five pin DIN plug is used, the common earth is connected to Pin 2 — the central pin of the five. The earth is carried via the braid (or shield) of the coaxial cable. When making the lead yourself, the earth is connected by making a small nick in the braid and drawing the other signal-carrying leads out through the nick. The braid can then be worked tight and soldered to the pin.

When used for a turntable, twin core coaxial cable may be used rather than the more fragile four core cable. The braid is connected to Pin 2; the signal lead for the right channel is connected to Pin 5; and the signal lead for the left channel is connected to Pin 3. The DIN socket at the amp or at the turntable should be wired in the same way, with the signals going to the same numbered contacts — that is the right channel is fed through Pin 5 and the left through Pin 3.

For tape decks, four core coaxial cable must be used to obtain the full record and replay facilities for both channels. The earthing braid is prepared in the same way as for turntables, and again is connected to Pin 2. At the tape deck, the standard wiring configuration for the DIN plug is that Pin 1 carries the input lead for the left channel, and Pin 4 carries the input lead for the right channel. The output for the left channel is via Pin 3, and the output for the right channel is carried by Pin 5.

The left and right channels for a function (record or replay) always occupy adjacent pins, and the functions are separated by the earth pin.

When making up a lead to connect the tape deck to the amplifier the conductors within the coaxial cable are connected to the same pins at each plug — that is Pin 1 is connected to Pin 1 at the second plug, Pin 2 is connected to Pin 2 and so on.

It is important to remember that this lead is only suitable for linking a tape deck to an amplifier; it CANNOT be used between two decks when dubbing is required.

In the dubbing process, the output from one deck must be transferred to the input of the second, so it is necessary to connect Pin 1 at each plug to Pin 3 at the other and, similarly to connect Pin 4 at each plug to Pin at the other.

The table below gives the possible connections to be found lurking inside the plastic outer.

	Pin connections				
Application	1	2	3	4	5
Microphone (balanced)	Left-live	Screen	Left-return	Right-live	Right-return
Microphone (unbalanced)	Left	Screen	Right	–	–
Turntable (mono)	–	Screen	Signal	–	Signal
Turntable (stereo)	–	Screen	Left signal	–	Right signal
Tape recorder (mono)	Input	Screen	Output	Input	Output
Tape recorder (stereo)	Left input	Screen	Left output	Right input	Right output

Where pins have the same designations, they are commoned together. All DIN plugs the pin numbers written next to the pins. Table numbers are as marked there.

Reviewing Reviews (and Viewing 'em)

This island fortress of ours is blessed with quite a flock of hi-fi publications of the monthly and 'one-off' variety, and since most people tend to keep magazines longer than is *absolutely* justifiable, wouldn't it be nice to have some overall index to allow immediate identification of that article a few months ago, the title of which you're not sure of, and the exact issue for which escapes you?

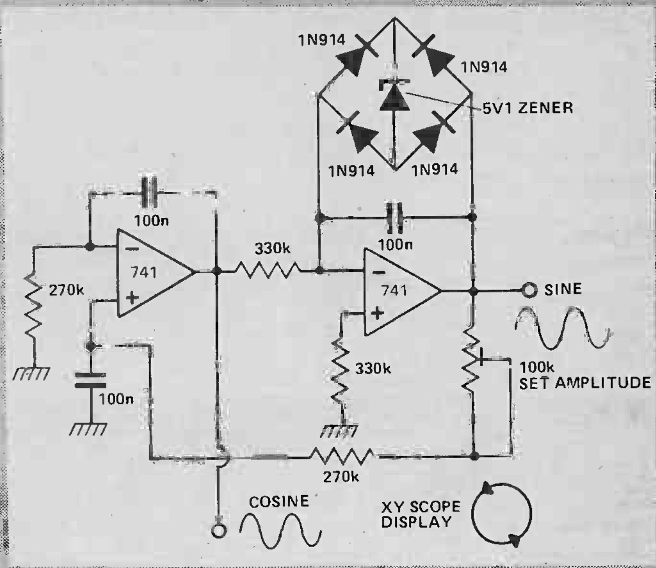
Well such a thing exists (else why would I be rattling on about it?) and is titled Sound Verdict. An annual publication, it lists and classifies all the audio articles, including reviews, which have been set to print in the preceding year from fourteen source publications.

To bring this order into your life will cost you £1 from the Director of Libraries and Arts, Holborn Library, 32-38 Theobalds Road, London WC1. ETI

AUDIOPHILE has its own query service, independent of ETI's reader enquiry system. This is intended solely for those who may be having problems with hi-fi — be it choosing it or using it! Please mark the envelope "Audiophile" and include relevent details.

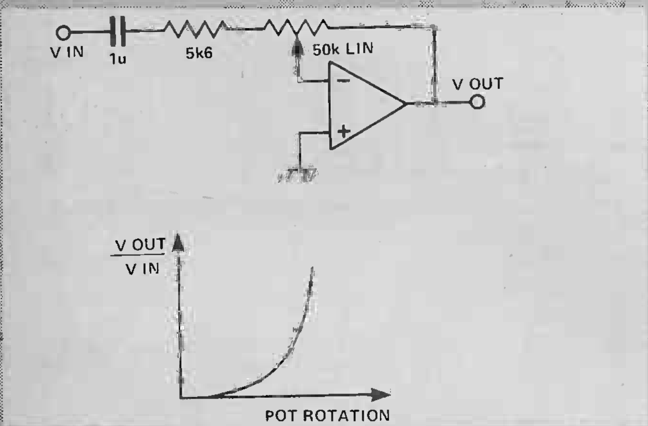
OP-AMPS PART 4

Tim Orr concludes his series by offering up circuits for some unusual applications.



Drawing circles on a scope

The circuit is that of a quadrature sine and cosine oscillator. Two integrators are employed and there is overall positive feedback. Thus the system oscillates producing sinusoids. Amplitude stabilisation is obtained with a diode bridge and a zener diode. The process of integration produces a 90° phase shift. Therefore if there is a sine wave being put into an integrator, a cosine will appear at its output. Quadrature oscillators can be used to generate circular displays on oscilloscopes by connecting the two outputs to the X and Y inputs. Other uses include quadrature panning in voltage controlled audio systems and they are also used in audio frequency shifters.

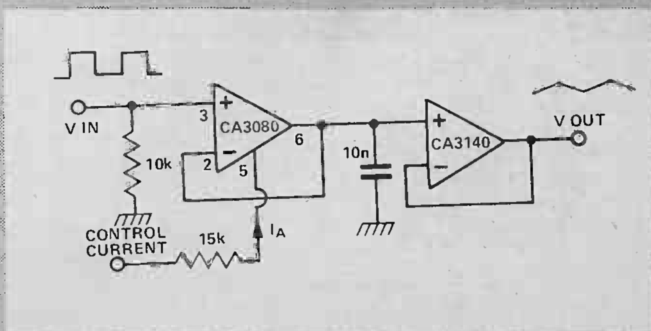


Turning a Linear Pot into a Log Pot

By using the virtual earth characteristic of an op amp, a linear pot can be made to have the characteristics of a log pot. It seems to be fair to say that low cost linear pots are far more linear than log pots are logarithmic. Thus the linear pot can be turned into a better log pot than the actual log pot itself. By varying the resistor ratio 5k6 to 50k, other laws can be produced, such as something in between log and linear or maybe a law that is even more extreme than a log law.

Controllable Slew Limiter

The current output of a CA3080 can be used to produce a controllable slew limiter. The 3080 is used as a voltage follower, but with a capacitive load. Thus it is possible for this stage to correctly follow small signal variations but to slew limit when the input signal is larger. The speed of the slew limiting is determined by the current I_A. A high input impedance voltage follower (CA3140) is used to buffer the signal. This circuit is sometimes used as a non-linear filter to limit fast signals; also, it can be used as a portamento circuit for a music synthesiser.



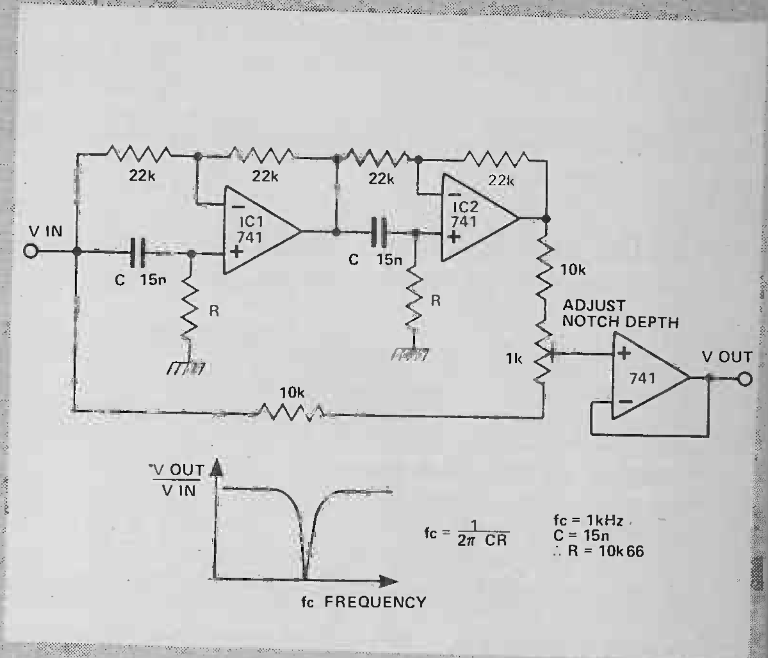
▶

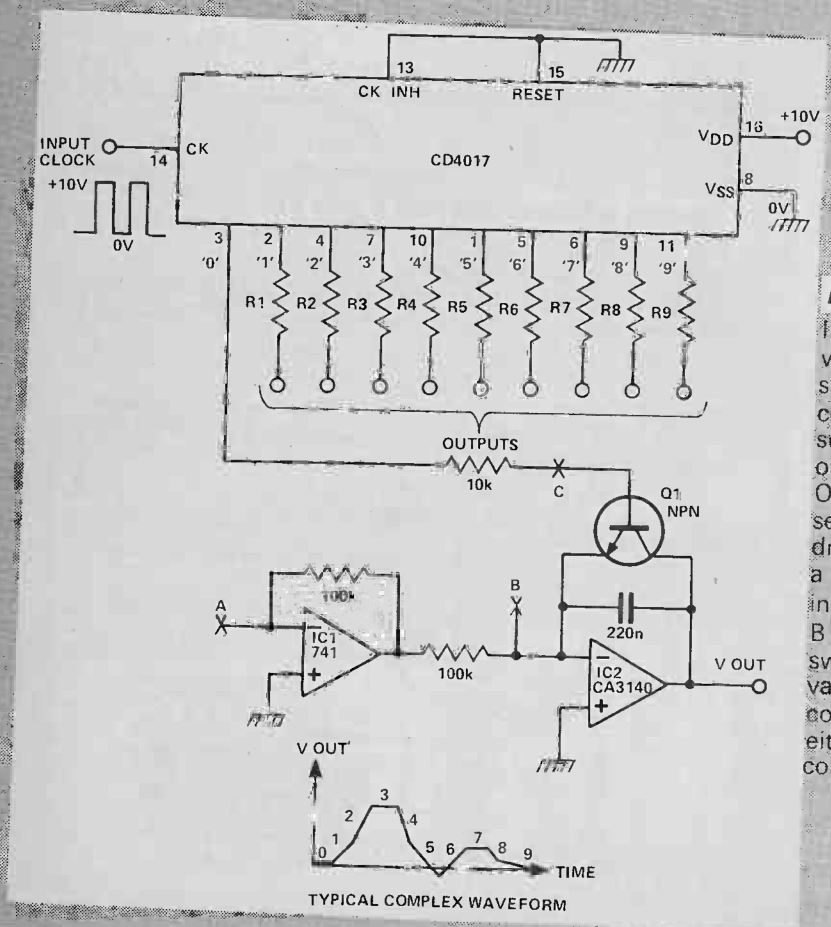
All Pass Notch Filter

Sometimes when processing analogue signals there is a constant tone which is causing a nuisance and so an active filter is called upon to 'notch' it out. The filter can be tuned so that its notch is at exactly the same frequency as this signal so that it can be selectively attenuated. This method is sometimes used to remove unwanted mains hum from poor quality recordings. The circuit works as follows. IC1 and 2 are a pair of all pass filters. These filters have a flat frequency response, but their phase changes with frequency. Their overall maximum phase shift is 360°, a phase shift of 180° occurring at a frequency of 1/2CR Hz. At this frequency the signals are inverted. Thus, by mixing the phase delayed signal with the original, cancellation can be produced which forms a notch in the frequency response. The preset is used to get the deepest notch available. The operating frequency can be changed by varying the two resistors R. For instance for 50 Hz operation, R should be —

$$10.66k \times \frac{1000}{50} = 213.2k$$

Nearest E12 fit is 220k





Analogue Linear Segment Drawer

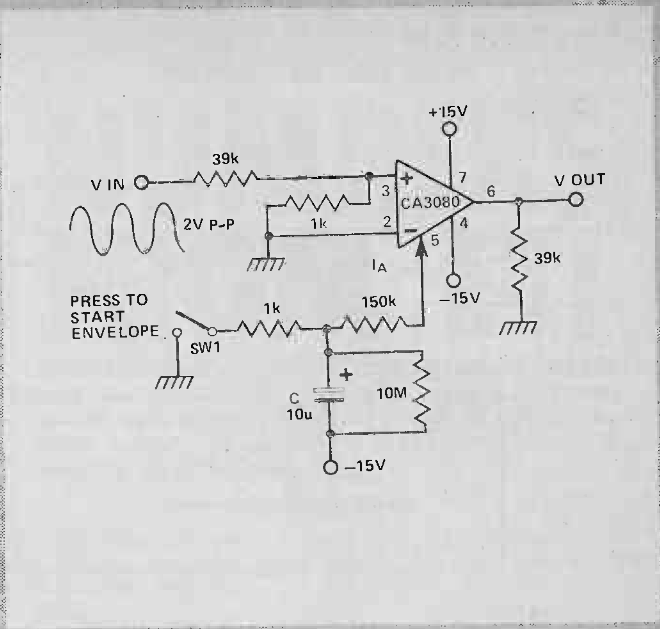
If you want to draw, repeatedly, a complex analogue waveform with up to 9 discrete sections then the circuit shown will enable you to do it. The CD4017 is a decade counter/decoder. A clock is applied to its input and a sequence of decoded outputs is generated. That is output 0 goes high, then output 1, then output 2, etc. Only one output is high at any point in time. This is the sequence generator. There is also an inverter (IC_1) which drives an integrator (IC_2) which can be reset to zero by a switch. Thus, if we connect output 1 to A, the integrator's output will ramp upwards, if we connect it to B it will ramp downwards and if we connect it to C the switch will clamp the output to 0V. Also, by varying the values of R1 to 9, the integrator's ramp rate can be controlled. Thus by selectively routing the outputs to either A, B, or C and by selecting the resistor values, a complex 9 segment waveform can be drawn out.

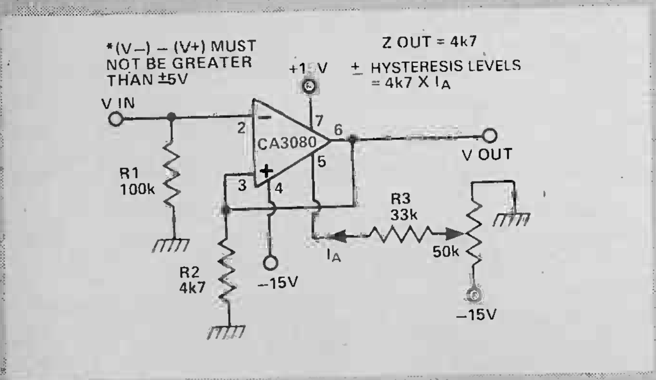
Simple Musical Envelope Generator

A simple generator can be constructed using the CA3080, made by RCA. This circuit will also enable the use of any audio waveform the harmonic structure of which will not be significantly affected as it is modulated. The CA3080 is an op amp with a difference. It has a current output and an extra input into which a current, I_A is fed. The output is the product of the input voltage X I_A. Thus the I_A can be used to control the amplifier's gain.

Also the input voltage range for low distortion operation is very low, of the order of ± 25 mV.

In this circuit, the CA3080 is being used as a two quadrant multiplier. A small voltage, (± 25 mV), is applied to its non-inverting input. When the switch S1 is closed, the capacitor C is charged up and a current of about 150 µ A flows into the I_A input terminal. When S1 is opened, C discharges through the 150k resistor into the I_A input. This current dies away exponentially. As the output is the product of the input voltage X I_A, then an exponential envelope is generated. Breakthrough after the decay is very good, better than −80 dB.



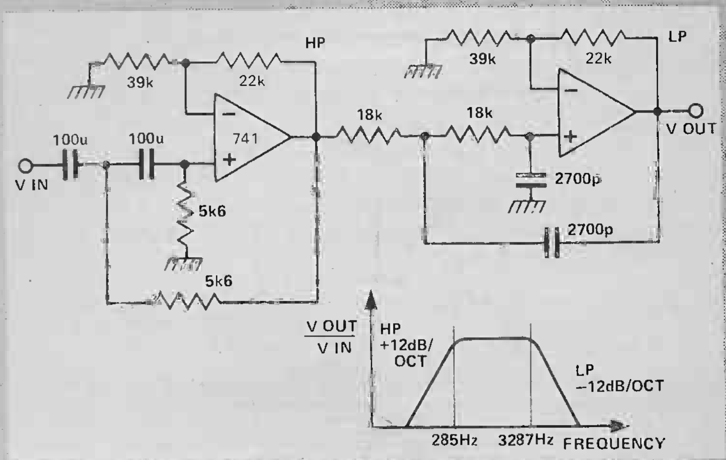


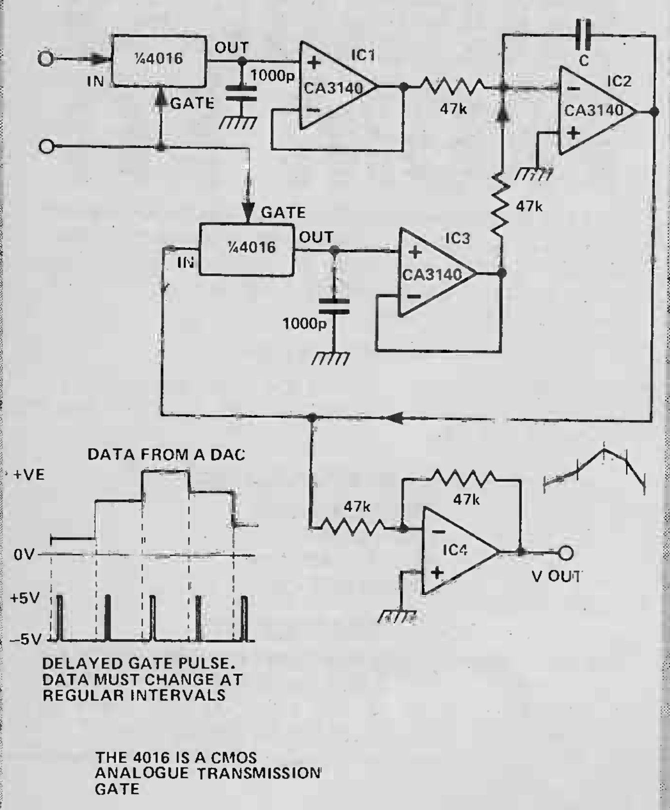
Simple Schmitt Trigger with Programmable Hysteresis

Again the multiplier qualities of a 3080 can be used to produce a versatile schmitt trigger. DC positive feedback is used and so a schmitt trigger action is produced, although the size of the hysteresis levels is determined by I_A. All of the I_A current flows out of the amplifier's output and through R2, thus setting up the hysterysis level. Therefore increasing IABC will increase this level and visa versa. The positive and negative hysteresis level. Therefore increasing I_A will increase this level and vica versa. The positive and negative hysteresis levels are symmetrical about 0 V. Take care

Simple Speech Filter

The telephone system has been designed for speech communication. The bandwidth of the system is 300 Hz to 3400 Hz, which has been arrived at after many years of experimentation. Thus, it is true to say that much of the information in speech is contained between these frequency limits. The circuit shows a filter structure that will simulate the telephone bandwidth. It could have many uses, for instance as a 'speech filter' for noisy radio reception or land line communications, or as a voice detector for a light show.





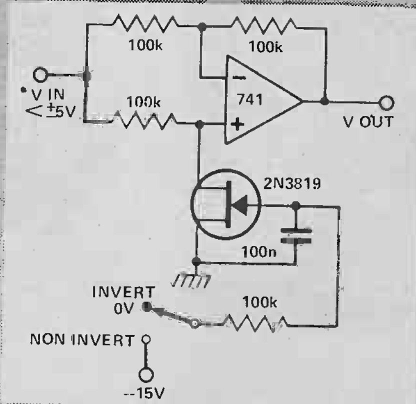
Cleaning Up Digitally Generated Signals With 2 Sample and Holds and an integrator

The output from a digital to analogue converter (DAC) is composed of a series of steps which have been selected by a series of binary numbers. The output of the DAC may represent the result of some computation done by a microprocessor or the contents of a digital memory. If the number of bits that control the DAC is low (less than 8), then the output will look like a series of descrete steps, plus lots of digital 'glitches'. Therefore, if this signal is to be displayed on an oscilloscope, the overall picture quality will be very poor. One way to clean up things would be to join up all the steps with straight lines and if done successfully a great improvement can be obtained. The only problem is that the distance between steps is continuously varying and so the slope of the straight lines will need to be variable as well. This process is known as linear point interpolation and can be achieved with two sample and holds and an integrator.

A delayed gate pulse is generated, so that once the DAC's output has settled the sample and hold switches momentarily open, sample the information and then close. The output of the first sample and hold (IC1) drives an integrator (IC2), the output of which drives the second sample and hold (IC3). The second unit provides negative feedback around the integrator, but it is delayed by one time interval. Thus a momentary positive going signal will pass through the first sample and hold and cause the integrator to ramp in a negative direction. When the next time interval arrives, the first sample and hold returns to 0V, and the second obtains a negative voltage. This then makes the integrator ramp positively. The size of the integrator's capacitor C should be chosen to suit the clock speed of the DAC. An inverter, IC4 has been included to correct the invertion caused by the integrator.

Digitally Controlled Invert/Non-Invert

The FET is digitally controlled to be either ON (a few hundred ohms shorting the non-inverting input of the IC to ground), or OFF (an open circuit). When the FET is OFF, the circuit is that of a voltage follower. When the FET is ON, the non inverting input is, to all intents and purposes, grounded, and so the circuit is that of a virtual earth amplifier with a voltage gain of −1, that is, an inverter.

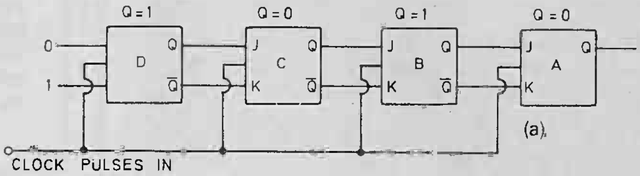


IF CIRCUITS ARE YOUR INTEREST, WHY NOT TAKE A LONG LOOK AT PAGE 56 FOR NEWS OF OVER 100 CIRCUITS WHICH ARE BEING OFFERED AT LESS THAN 2P EACH? (AND THAT INCLUDES POSTAGE!)

DIGITAL ELECTRONICS

A SHIFT REGISTER is a set of flip-flops, each of which can be set by its PRESET terminal to store a 1 or 0, so that the complete set stores a "word," (complete number). For example, four flip-flops could store numbers such as 0101, 1000, 1101, and so on. In addition, we can apply clock pulses to all of the flip-flops and so cause the stored numbers to shift from one flip-flop to the next in line on each clock pulse; several designs make this possible in either direction (right-left shift).

Fig. 2 shows an example of this in action. We start with the number 1010 stored, so that LEDs on the B and D outputs will be lit. The input of the first flip-flop is connected with J=0; K=1, so that at the clock pulse its Q output will change to zero. The two outputs of the first flip-flop, however, are connected to the J and K inputs of the next flip-flop in line (compare the Johnson counter, which is very simply obtained from a shift register). With J=1 and K=0 on the second flip-flop, from the outputs of the first, the clock pulse will cause the output of flip-flop C to change from 0 to 1. Similarly, with Jb=0, Kb=1, flip-flop B is forced to change from 1 to 0, and flip-flop A is forced to change from 0 to 1. The effect is as if a zero had been forced in at the left-hand side and has caused all of the stored numbers to shift one place along.



CLOCK PULSE	QD	QC	QB	QA
0	1	0	1	0
1	0	1	0	1
2	0	0	1	0
3	0	0	0	1
4	0	0	0	0

(b)

Fig 1. A shift register made up from J-K flip-flops. (a) Arrangement of the flip-flops. (b) Truth table, showing the effect of clock pulses.

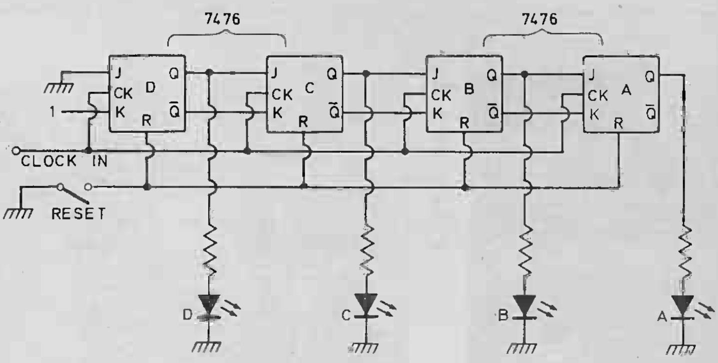


Fig 2. Connections of 7476 flip-flop to form a shift register on the 8-IC Blob-board.

A Simple Shift Register

Use the two 7476 J-K flip-flops (Fig. 2) on your blob-board to make up a four-stage shift register. Connect the clock inputs to one of the spare pads of the blob-board, and run a line from this pad to the output of the slow oscillator or the debounced switch. Blob short connecting wires from each Q output to the next J input, and from each $\bar{Q}$ output to the next K input. Blob a wire from Ja to the earth line, leaving Ka floating. Connect the reset pins to a reset line (a spare blob-pad) and so to the reset switch so that pressing the reset switch will earth the reset pins. Finish off by connecting LEDs and resistors so that the state of each Q output can be read.

Now switch on. One or more of the LEDs may light, but can be extinguished by using the reset switch. Now set up a number by using the preset terminals. By temporarily bridging from each preset pin to earth, using a wire bridge, set two of the flip-flops to 1, preferably so that 1010 is stored. Now apply clock pulses and observe what happens; this is easier to follow if the debounced switch is used.

Now switch off, and disconnect Ja from earth. Connect Ja to Qd and Ka to $\bar{Q}$d. Switch on again, reset, and set to a display of 1010 again. Now apply clock pulses. What happens? Can you see the possible applications for storing a sequence of operations, such as a traffic lights sequence?

S BY EXPERIMENT PART 8

Types of Shift Register

The shift register made up using 7476s can be used as a PISO or SIPO type. PISO means parallel in, serial out; the information is set up on each flip-flop, perhaps at the same time, and is read out in sequence, one digit for each clock pulse. In a SIPO shift register (serial in, parallel out), a number of clock pulses equal to the number of flip-flops is applied at the same time as a varying signal (0 or 1) applied at the input J-K terminals, starting with an empty register. With the register filled, the voltages at the Q terminals can be read (using LEDs for example) in parallel. Each type is important; we need numbers in parallel form for operations such as addition, but in serial form for transmitting down a single wire, or for recording on tape. We can, of course, have SISO (serial in- serial out) and PIPO (parallel in-parallel out) shift registers, and a set of flip-flops can be arranged to act in any one of these ways.

The 7494 Shift Register

This has been chosen as one example (Fig. 3) of the very wide variety of shift registers that are available. Like most integrated shift

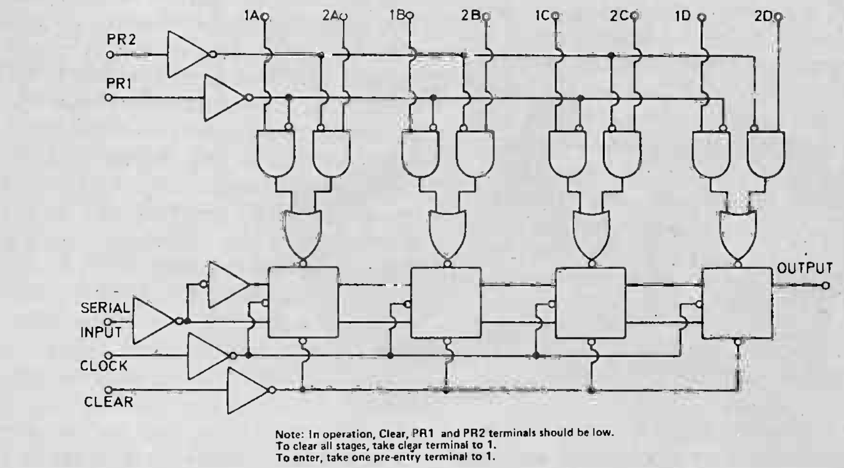


Fig 4. Schematic diagram of the 7494 shift register. Compare the number of flip-flops gates and inverters in this single chip with the number pf packages needed to make this from 7400's and 7476's.

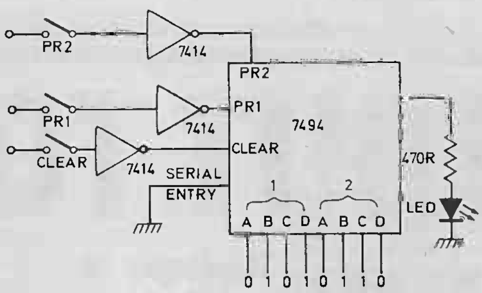


Fig 5. Connecting up the 7494 on the blob-board. Note that inverters have to be used on each switched line, as the preset and clear lines must be held at logic 0 for normal operation.

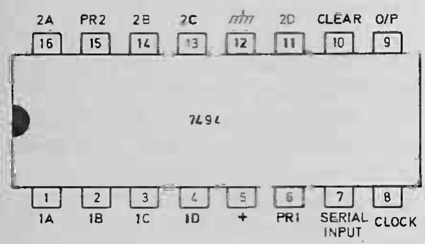


Fig. 3. Pinouts of the 7494

registers, it is constructed using the clocked S-R type of flip-flops, but the action is the same as that of our J-K flip-flop model; the schematic of the IC is shown in Fig. 4. Four flip-flops are used, with a common clock to each, and a clear input which will reset each flip-flop. A serial input is also available.

The interesting feature of the 7494, however, is the gated parallel inputs labelled 1A, 2A, 1B, 2B and so on. These act through a set of gates on to the preset inputs of the flip-flops, so that they are independent of the clock pulses. The gating is arranged so that either one or the other set of inputs can be "read" into the register. For example, imagine that the inputs with the 1 prefix are each connected to a signal input, 0 or 1, and that the inputs with the prefix 2 are each connected to another set of signals. We can use the pins marked preset 2 and preset 1 now to select which set of inputs is chosen and placed in the register. Imagine that preset 1 is at logic 1 and that preset 2 is at logic 0. Because of the inverters connected to the preset inputs, all the inputs with the 1 prefix are gated through to the OR gates which control the flip-flop presets. Because all the inputs with the 2 prefix are gated out, there will no no input from these gates. The opposite process takes place if preset 2 is at logic 0 and preset 1 is at logic 1. Note that these inputs must be operated so that both do not enter at the same time. The inputs should remain at logic zero during normal operation.

The output from the register is from pin 9, and will consist of one bit, 0 or 1 for each clock pulse fed in to the clock input, and at the leading edge of the clock. ▶

Greenbank Electronics

CMOS

Cut prices for Amateur users and Export only. Note: Industrial Users — No % discount available on these prices, instead use franchised distributors standard prices, list available on request.

Mostly Motorola, RCA

4000	15p	4050	52p	40107	68p	4514	£2.65
4001	17p	5051	75p	40108	£5.36	4515	£2.99
4002	17p	5052	75p	40109	£1.02	4516	£1.08
4006	£1.05	4053	75p	40181	£3.39	4517	£3.82
4007	18p	4054	£1.20	40182	£1.40	4518	£1.02
4008	92p	4055	£1.34	40192	£1.40	4519	51p
4009	58p	4056	£1.34	40193	£1.40	4520	£1.08
4010	58p	4057	£25.70	40194	£1.18	4521	£1.88
4011	19p	4059	£4.80	40257	£1.48	4522	£1.08
4012	18p	4060	£1.15	4160	£1.08	4524	N/S
4013	55p	4061	£15.67	4161	£1.08	4526	£1.08
4014	99p	4062T	£10.00	4162	£1.08	4527	£1.52
4015	93p	4063	£1.09	4163	£1.08	4528	99p
4016	52p	4064	N/S	4174	£1.08	4529	£1.14
4017	99p	4065	N/S	4175	99p	4530	85p
4018	99p	4066	57p	4194	£1.17	4531	£1.45
4019	60p	4067	£3.80	4408	£6.59	4532	£1.27
4020	£1.02	4068	22p	4409	£6.59	4534	£5.13
4021	94p	4069	22p	4410	£5.73	4536	£3.69
4022	86p	4070	23p	4411	£9.58	4537L	£13.23
4023	20p	4071	21p	4412VL	£17.14	4538	£1.25
4024	76p	4072	21p	4412FL	£12.92	4539	91p
4025	19p	4073	21p	4415V	£7.50	4541	£1.14
4026	£1.80	4075	23p	4415F	N/S	4543	£1.59
4027	55p	4076	£1.05	4419	£2.68	4549	£3.69
4028	81p	4077	23p	4422	£5.00	4552	£10.55
4029	£1.09	4078	21p	4431	TBA	4553	£3.87
4030	58p	4081	22p	4433	£11.32	4554	£1.19
4031	£2.30	4082	21p	4435	£7.93	4555	78p
4032	£1.00	4085	74p	4440L	£11.58	4556	78p
4033	£1.45	4086	73p	4450	£2.67	4557	£3.86
4034	£1.96	4089	£1.50	4451	£2.67	4558	£1.14
4035	£1.20	4093	63p	4452	TBA	4559	£3.69
4036	£2.45	4094	£1.90	4490FP	£6.54	4560	£1.84
4037	£1.00	4095	£1.05	4490VP	£4.92	4561	65p
4038	£1.08	4096	£1.05	4700	£1.75	4562	£5.33
4039	£2.45	4097	£3.72	4500	£5.56	4566	£1.59
4040	£1.05	4098	£1.10	4501	17p	4568	£2.38
4041	86p	4099	£1.90	4502	91p	4569	£2.57
4042	81p	40061	N/S	4503	75p	4572	25p
4043	94p	40100	2.50	4506	£5.71	4580	£5.74
4044	90p	40101	£1.61	4505	51p	4581	£2.62
4045	£1.45	40102	£2.12	4507	55p	4582	98p
4046	£1.30	40103	£2.12	4508	2.48	4583	76p
4047	99p	40104	£1.09	4510	£1.29	4584	43p
4048	58p	40105	£1.06	4511	£1.38	4585	£1.01
4049	52p	40106	71p	4512	81p	4599	£2.06

74C00 Series (National)

74C00	26p	74C107	£1.31	74C904	74p	74C925	£8.28
74C02	26p	74C150	£4.17	74C905	£7.71	74C926	£8.28
74C04	26p	74C151	£2.63	74C906	74p	74C927	£8.28
74C08	26p	74C154	£3.93	74C907	74p	74C928	£8.28
74C10	26p	74C157	£2.36	74C908	£2.63	80C95	£1.20
74C14	£1.51	74C160	£1.49	74C909	£1.74	80C96	92p
74C20	26p	74C161	£1.49	74C910	£7.20	80C97	87p
74C30	28p	76C162	£1.49	74C914	£1.50	80C98	92p
74C32	26p	74C163	£1.49	74C918	£2.90	88C29	£6.21
74C42	£1.20	74C164	£1.31	74C920	£11.83	88C30	£6.21
74C48	£2.37	74C165	£1.31	74C921	£11.83		
74C73	74p	74C173	£1.21				
74C74	63p	74C174	£1.21				
74C76	74p	74C192	£1.49				
74C83	£1.97	74C193	£1.49				
74C85	£1.97	74C195	£1.31				
74C86	69p	74C200	£7.20				
74C89	£4.65	74C221	£1.50				
74C90	92p	74C901	74p				
74C93	92p	74C902	74p				
74C95	£1.31	74C903	74p				

'VEROBOARD'

0.1" Pitch with copper strips

2½" x 1" (pack of five)	52p
2½" x 3¾"	36p
2½" x 5"	43p
2½" x 17"	£1.34
3¾" x 3¾"	43p
3¾" x 5"	48p
3¾" x 17"	£1.73
4.7" x 17.9"	£2.22

0.1" Plain board (no strips)

3¼" x 2½"	28p
3¼" x 5"	45p
3¼" x 17.9"	£1.28
Terminal pins	£1.50/500
V-Q DIP board	89p
DIP breadboard	£2.42
Spot face cutter	69p
Pin insertion tool	89p

SOLDERCON PINS

100	50p
1000	£3.50

DIL SOCKETS
8/14/16 pin 10p/12p/13p

TIMER ICS
NE 555/556 36p/72p

OP-AMPS

CA 3130 (COS/MOS)	94p
CA 3140 (B1 MOS)	95p
741 Minidip	22p

LED DISPLAYS
FND 500/507 Jumbo 0.1" 7-segment £1.30
FND 357 0.35" c.a. 7-segment £1.40

"E" LED DISPLAYS. Class II devices, but fully guaranteed by us for 'even' segment brilliance, etc. — money back or exchange if not satisfied.

DL-704 0.3in cc	85p
DL-707E 0.3in ca	85p
DL-728E 2 x 0.5in cc	£2.00
DL-727E 2 x 0.5in ca	£2.00
DL-750E 0.6in cc	£1.80
DL-747E 6in ca	£1.80

LIQUID CRYSTAL DISPLAY
4 x 0.5in digital 40 pin DIL £9.83

CLOCK CHIPS

AY-5-1224A	£3.50
MK 50253	£5.50
MK 50362/50366	£6.95
MC 14440 (LCD)	£11.58

SIX DECADE COUNTER
MK 50395/6/7 £8.75

TIMEBOX. Digital Clock Case, 56 x 131 x 71.5 mm with red acrylic window. Choice of case colour, white, red, orange, blue. **£2.06.**

QUARTZ

32.768 KHz (Motorola)	£4.50
32.768 KHz (Equivalent)	£2.95
100.0 KHz	£3.62
200.0 KHz	£3.92
204.8 KHz	£3.92
240.0 KHz	£3.62
262.144 KHz	£3.62
307.2 KHz	£3.62
312.5 KHz	£3.92
455.0 KHz	£3.62
1.0 MHz	£3.23
1.8432 MHz	£3.23
2.0 MHz	£3.23
2.097152 MHz	£3.23
2.4576 MHz	£3.92
2.5625 MHz	£3.92
3.2768 MHz	£3.23
3.579545 MHz	£2.95
4.0 MHz	£3.23
4.032 MHz	£3.23
4.096 MHz	£3.23
4.194304 MHz	£3.62
4.433619 MHz	£1.50
4.608 MHz	£3.23
4.8 MHz	£3.23
4.9152 MHz	£3.23
5.0 MHz	£3.62
5.12 MHz	£3.62
10 MHz	£3.62
100 MHz	£3.62
etc. etc.	

TTL

7400	14p	7437	30p	7492A	53p	74150	£1.18	74192	£1.40
7401	14p	7438	33p	7493A	35p	74151A	75p	74193	£1.40
7402	16p	7438A	41p	7494	85p	74153	75p	74194	£1.40
7403	16p	7440	17p	7495A	70p	74154	£1.40	74195	95p
7403A	20p	7441	74p	7496	82p	74155	82p	74196	£1.18p
7404	20p	7442A	68p	7497	£2.62	74156	82p	74197	£1.18
7405	22p	7443A	£1.15	74100	£1.25	74157	80p	74198	£2.48
7406	38p	7444A	£1.12	74104	62p	74159	£2.25	74199	£2.48
7407	38p	7445	94p	74105	62p	74160	£1.16	74221	47p
7408	20p	7446A	94p	74107	33p	74161	£1.16	74222	60p
7409	20p	7447A	82p	74109	54p	74162	£1.16	74223	£1.06
7409A	25p	7448	78p	74110	54p	74163	£1.16	74225	47p
7410	15p	7450	17p	74111	70p	74164	£1.21	74246	£1.30
7411	24p	7451	17p	74112	90p	74165	£1.30	74248	£1.46
7412	23p	7453	17p	74116	£1.98	74166	£1.41	74249	£1.46
7412A	26p	7454	17p	74118	90p	74167	£1.98	74251	90p
7413	37p	7460	17p	74119	£1.75	74170	£2.40	74265	47p
7414	74p	7470	32p	74120	£1.15	74172	£6.25	74273	£2.24
7416	35p	7472	28p	74121	28p	74173	£1.75	74278	£1.34
7417	39p	7473	32p	74122	48p	74174	£1.13	74279	82p
7420	16p	7474	32p	74123	70p	74175	90p	74283	£1.06
7421	33p	7475	42p	74125	65p	74176	£1.20	74284	£4.70
7422	24p	7476	30p	74126	60p	74177	£1.16	74285	£4.70
7422A	28p	7480	50p	74128	77p	74178	£1.02	74290	38p
7423	32p	7481A	97p	74132	73p	74179	£1.02	74293	88p
7425	30p	7482	82p	74136	73p	74180	£1.42	74247	£1.32
7426	36p	7483A	93p	74141	72p	74181	£2.99	74298	£1.46
7427	36p	7484	95p	74142	£2.80	74182	£1.27	74365	66p
7428	38p	7485	£1.10	74143	£3.14	74184	£2.25	74366	66p
7430	18p	7486	36p	74144	£3.14	74185	£1.46	74367	66p
7432	32p	7489	£3.20	74145	85p	74188A	£6.50	74368	66p
7433	40p	7490A	36p	74147	£1.75	74190	£1.40	74390	£1.34
7433A	50p	7491A	80p	74148	£1.43	74191	£1.40	74393	£1.34
								74490	£1.34

MICROPROCESSORS

MPU chips and PIA etc

SC/MP I PMOS	£12.00
SC/MP II NMOS (5V)	£10.00
MC 6800 CMOS	£15.97
MC 6820 PIA	£8.02
Z80 — CPU	£28.44
Z80 — CTC	£12.80
Z80 — PIO	£12.80
MC 14500B CMOS ICU	£5.56

UV Eraser
For erasing EPROMS £95.00

RAM — I/O for SC/MP II

(i.e. 128 × 8 static RAM + 2 × 8 bit peripheral ports.) In conjunction with a ROM chip and the SC/MP II a 3-chip microprocessor system can now be constructed:

ISP-8A/650 RAM-I/O £7.50

R OM Character Generator
MK 2302 (5 × 7 ASCII) £15.20

Static RAMS

1101 256 × 1	TBA
2101-2 256 × 4	£3.00
2102-2 1024 × 4	£2.10
2111-2 256 × 4	£3.00
2112-2 256 × 4	£3.00
2114 1024 × 4	£15.00

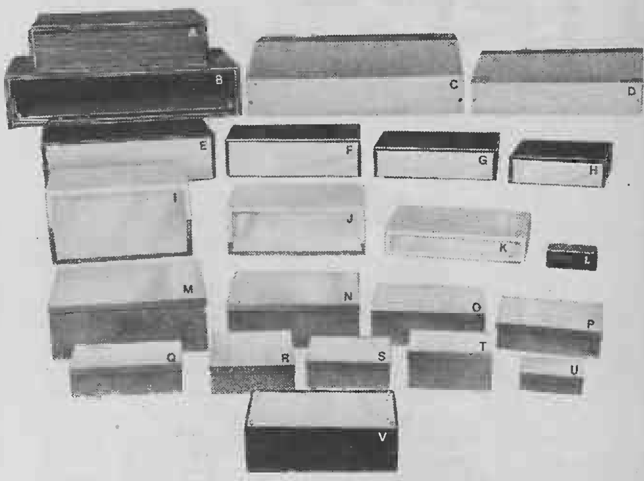
UV Erasable EPROMS

MM 5204	TBA
1702A 256 × 8	£10.80
2708 1024 × 8	£31.15

CATALOGUE. Free on request
Terms: CWO. Add VAT to all prices at 8%
Post, etc.: UK 25p (+ 2p = 27p) per order. Export add 75p (Europe), £2.50 elsewhere, no VAT.
Polys, universities, govt. depts., etc., can telephone their orders for immediate despatch

GREENBANK ELECTRONICS (Dept. T5E)
94 New Chester Road, New Ferry, Wirral, Merseyside L62 5AG England. Tel. 051-645 3391

cases galore



It's been pointed out that in the April issue Casings Survey we missed out one of the major suppliers in the country-Bi-Pak. As this was neither a service to them, nor the reader, we show their complete range above.

Types A and B are teak cabinets and sleeves, suitable for any project but designed specifically for Bi-Paks own range of amplifiers and tuners. C and D are general-purpose sloping front types. These are available only from Bi-Pak, as is the heavy gauge black plastic box (V).

Bi-Pak also carry a number of other cases (E-U) giving an excellent selection. Prices and dimensions are given in their catalogue.

Bi-Pak, Dept ETI, P.O. Box 6, Ware, Herts.

viewdata ahead of it's time

Viewdata will now be avilable in early 1979 — a year ahead of schedule. The Post Office is also to spend £5 M on setting up ten additional Viewdata centres — bringing the number to fourteen. Initially, the service will cover parts of London, Birmingham and Norwich, but a further £18 M has been made available to extend it to Cardiff, Leeds, Edinburgh and Manchester.

Amongst nearly one hundred companies to show an interest in supplying information to the system are Guinness, IPC, Exchange and Mart, Reuters and Fintel (a new organisation formed by the Financial Times and Extel). The charge to information suppliers will be £250 + £1 per 'page' per annum. The initial system will allow users access to 60 000 pages of information and the system will have a capacity of 250 000 pages. The Post Office have said that they expect to make a profit from the system, but do not yet know how large this profit may be.

radiant about contract

RCA have been awarded a contract to develop a range of CMOS ICs for use in the American space program. The main requirement of the devices is that they should be able to withstand radiation levels of up to one million rads. RCA was already a leading supplier of CMOS for levels of 100 000 rads for use in the Voyager series of long-duration space probes, which should pass Jupiter in 1979 and Saturn in 1981. As the effects of radiation on CMOS are cumulative, it seems likely that the US plans to use the new devices on even longer missions.

microfile.......

Gary Evans, ETIs micronaut, has been looking at the very latest in MPU based TV games, at a development kit for the G302 MPU and looks forward to an event up North.

GENERAL INSTRUMENTS, trail blazers in the dedicated TV games business (8500 — say no more), have recently released details of the work they have been doing in conjunction with EMI over the past few years.

This joint research effort has been aimed at developing a sophisticated microprocessor based TV game. GI have supplied the semiconductor know-how — MPU plus various interface and control devices — while EMI have come up with the means by which programs are loaded into the system.

ROM Out

Plug in ROM cartridges were rejected at an early stage — too expensive and, at present, limited in size — in favour of the standard audio cassette.

Here too current techniques (CUTS et al) were rejected and EMI started work on their own data coding format. The description of what they have come up with is impressive to say the least.

The bit density achieved by the system is said to be four times greater than CUTS with 1.2 million bits, together with a necessary 0.4 million control bits, capable of being stored on thirty minutes of tape.

The format is also said to be very tolerant of tape drop outs. Uncorrupted data can still be returned with a small section of tape oxide removed completely.

Naturally EMI are not saying a lot about the system as patents are still being sought. Hopefully, though, when the legal side of things is sewn up we may learn more about the exact specifications.

KIM1 together with the three excellent manuals supplied with the kit, the "wall chart" circuit diagram and the MPU reference guide.

Watery Grave For Pirates

The recording system has another feature that is note worthy. It incorporates the EMI "watermark." This, as I understand it, is some form of signal superimposed on the tape in such a way that it does not interfere with the storage of data, yet can be detected by the playback system. The watermark will not prevent copying of a tape of software, the hardware of the games unit will, however, not read the data from the copy as it is not watermarked (good word).

This, EMI hope, will prevent the software pirates that have almost become part of the scenery in the computing world.

I saw a system incorporating all of the above features. It was very good.

Loading from the tape means that a (separate) audio track can be reproduced as program data is being loaded. This track can give instructions for playing the game for example. This is another reason for using a tape system rather than ROMs as the audio feature is seen as being a strong selling point.

The TV display is impressive — I saw everything from dog fights to crosswords all displayed in high definition colour.

GI hope that the system will be on sale towards the end of this year but as GI and EMI will not be manufacturing complete systems but leasing rights, the speed with which this new toy gets into the shops depends on the game manufacturers.

The price is expected to be around the £100 mark for a simple unit with cassettes selling for £3-4. At this sort of price it can't fail.

Personal Games

Before leaving the subject of the games unit it is interesting to note just how similar this system and personal computers are.

Both have a TV display, control unit, tape retrieval system, keypads for data entry etc. The main difference is in the language the machine "talks."

GI are, however, marketing their product firmly as a TV game — might be a sound policy considering the competition in the home computing field.

Kimee Kimee

If you are a regular reader of this column you show a great deal of taste and as well as that might have gathered that I am not too impressed with the various MPU development kits I have so far done battle with. I say done battle with, because, with most of these boards, if you want to do anything other than flash a few LEDs, you're stuck.

Expansion is made difficult by partial memory decoding, control signals that are not brought anywhere near the edge of the board let alone an edge connector. However, over the past few days I have been playing with a system that shows just how things should be done.

The item in question is the KIM-1 and although it has not made much of an impact in this country to date, in the USA it's a different matter, with KIM being by far the most popular development kit.

This means that there is a lot of software around for KIM as a reader of the American computing mags will testify to. However, before we mention expanding KIM and the available software — we'd better look at the minimal system.

KIM-1 comes ready built to a very high standard — KIM is sold to many industrial users and is made to high standards throughout.

To get KIM up and running all that is necessary is a +5 volt 1 amp, +12 volt 100mA power supply and a few feet of wire.

KIM-1 is based on the MOS Technology 6502 MPU — again not seen a lot in this country, but it's used in PET so it can't be bad.

KIM, with its 2K monitor and keypad, enables programs in 6502 machine language to be entered into the 1K of onboard RAM, debugged (with the aid of a single step capability if required), and run with if not ease (machine code programming is never easy) at least convenience.

KIM-O-Savee

So far, so good, but what makes KIM so much better than other such systems.

Well, firstly an onboard cassette interface that allows loading and dumping of data to and from RAM. The interface is easy to use and is very reliable.

The board also provides a 20mA current loop serial output. This is designed for a TTY, but will equally well, with perhaps very slight modifications, drive any other serial orientated devices (printers, Modems, VDUs etc).

Now to, perhaps, KIM's major selling point — it's easy to expand.

All the signals likely to be required in any system expansion are brought out to one of two buses at the side of the board. Partial decoding was not used — indeed all the decoding necessary for an additional 4K memory block is already present.

So here we are, we've got all the signals we want — a versatile 2K monitor but just how do we go about interfacing and expanding.

Here is where KIM's other major plus comes in — the documentation. None of your badly Xeroxed scruffy bits of paper but three thick reference books describing the 6502 MPU plus support devices from both the hardware and software viewpoints and the third dealing with KIM-1 in great detail including a simple interface example that allows KIM to produce 128 different notes in response to a binary code set up on seven switches.

I briefly mentioned the 6502 support devices above and some of these chips are almost as powerful as the MPU. For example, KIM features two 6530 peripheral interface/memory devices. This device includes two eight bit bi-directional ports, a programmable interval timer, 1K of ROM and 64 bytes of RAM amongst other things. KIM uses the 2K of ROM provided by the two 6530s for the monitor and uses the 128 bytes of RAM as a scratchpad.

Well that's the KIM-1 and when you're familiar with it you're bound to want to expand the basic system. To guide you here, as I've said, you have the excellent manual, but I would suggest that before going any further the First Book Of KIM is begged, borrowed or

YOUR LETTERS

Modifications to the ETI System 68.

A few notes on my experiences in constructing the system 68 first the VDU circuit. The clock oscillator needs improving, either use a spare gate on the board as a buffer or make up another using a 7413 on veroboard. I.C. 13 is not counting quick enough, the only proper solution is to make a counter on veroboard with 2x7493 to replace it. This is very easy because all polarities are the same and the six column wires can be transferred onto the veroboard, so leaving only four wires to fix to the pcb. The brightness of the display can be altered by changing the value of R5. Other mistakes have been pointed out in ETI. But I found the modifications involving I.C.14 latch pin 4 and the reroute of I.C.7 to I.C.12 via a 7474 latch did not work, it was the two 7493s that gave the answer to displays such as ETIBU and ETIBOG.

There is a basic design fault in the CPU board, when the ROM or I.C.6/7 RAMs were in the read condition the oversimplified decoding also switches on I.C.10/11 so we have the outputs of the on board memory connected to the on board L.S. buffers so the buffers must win and you get garbage on the data lines to the CPU. Simplest way out is to remove I.C.10/11 and replace with 8 wire links. Final solution, rewire I.C.5b to give four outputs, on card read-write and off card read-write. There was a pcb fault; clock p1 and 2 were crossed over so that a VMA/p1 signal is generated to correct cut lines to the MPU chip and cross them over using 22 ohm resistors, this gives VMA/p2.

To anyone starting from scratch I would say make up a single board for VDU, CPU with plenty of room for decoding and other modifications and leave room for two 31 way connectors. These two parts are not likely to need changing once the bugs have been ironed out and this single board could reduce a lot of interconnections and let you use a "proper" 16 bit address bus which will be needed in a full system.

B. Hewart,
95 Blakelow Road,
Macclesfield,
Cheshire, England

stealed — save your money for hardware and feeding the dog.

The First Book Of KIM is just one of the many items that appear in print dealing with KIM, but it's one of the best. It deals with machine coding, game programs, utility routines, interfaces and expansion.

One can expand memory by obtaining KIM-2 (4K static memory block), KIM-3 (8K block). KIM-4 is a mother board that provides a home for the various extra boards.

With a serial VDU hooked up to KIM, 8K of memory and a basic interpreter (of which there are many about — witness PET) you have a personal computer that will perform with the best of them but, if you do it yourself, cheaper than ready built units.

Marshall Gets Kim

KIM has been available from GR Electronics, Newport, Gwent for some time and is now, in addition, sold by Marshalls of Cricklewood; Edgware Road; Glasgow; tomorrow . . . the world?

Good news as well — the price of KIM is down by £50, from £199 to £149 plus VAT.

By the way, if you were wondering why KIM — Keyboard Interface Monitor. A name derived from the software — nice to see recognition of the fact that software is, perhaps, the most important feature of any system.

I'm told that there is life to be found north of Watford, in fact a number of ETI's staff come from T'North and while its sometimes difficult to tell whether they're alive or not, presumably there are others living in that hazy area north of the gap. I'm not the only person to share this startling piece of news a Lynx, the people who distribute the NASCOM 1 are to give a seminar in Manchester on April 1st.

It's to follow the pattern set by their very successful Wembley meeting of last year. The subjects covered should interest anyone "into" home computing.

There are still a few tickets left but remember — get in quick. Observant readers will notice that this ETI isn't due out until April 7th, however because of Easter a substantial number *may* be out in time for you to take advantage.

North Of The Gap

Finally, two quick items — first the Heathkit computers are to be launched on April 1 — much more about them next month.

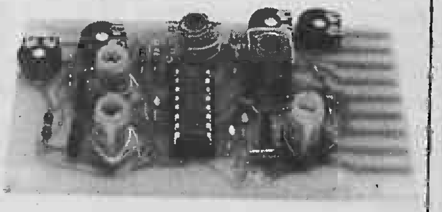
Last Word

Second, an apology to the design team responsible for the NASCOM 1. When I reviewed this machine I gave the impression that the design was solely due to Dr Shelton. It was in fact a joint Lovell team effort with Paul Johnson and John McFerran making major contributions — sorry lads.

ETI

THE WORLD'S FINEST FM TUNER MODULES OK?

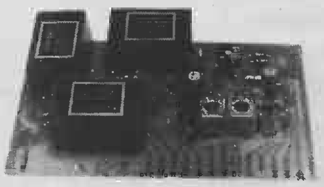
The EF5400, a 4 stage varicap tunerhead, tuning 88-108MHz with a bias swing of just 2 - 8 volts DC. A single IC provides all functions, including PIN diode AGC drive, balanced mixer, RF amplifier. All this and edge connection too ! £9.75 built.



We've said it before, and we'll say it again;
We offer the Largest and the Best range of FM Tuner modules in the UK, Europe and we believe in the World. (Please advise us if you know differently.) We gasp when we read the unsupportable claims of other 'suppliers', describing things like deviation muting, which we have been offering in our 7030 FM IF system for ages. Long before most others gave it a thought . To read some adverts, you might imagine somebody had just discovered the wheel. Furthermore, we believe good signal processing is more important than rows of pretty lights and numbers, don't you?

ALL NEW CATALOGUE

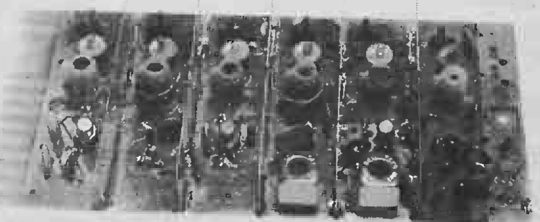
To celebrate our new range of ICs, components, coils, filters, FM and AM modules etc., we are presenting an entirely new catalogue, which is free if you send an A4 SAE (15p stamp on it pse), and the front page from one of our old catalogues. This offer ceases on May 31st 1978, when the normal price of 45p will apply. The new catalogue contains radio and wireless features centred on our new developments with Sprague, Telefunken and RCA, with the TDA1083 MW/LW/FM/Audio all-in-one IC system, the TDA1062 4 stage IC tunerhead, the CA3189E IF system, the Hitachi HA11219 FM noise blanking system and other radical new technology announced in the past few months. We are certain this will be of great value and interest to anyone concerned with radio and RF design.



Always in the leading group, here is Ambit's 73189 IF system: optional 2 or 3 6pole linear phase IF filters, 2xMOSFET IF AGC stage, with the CA3189E. £16.25 built and aligned.

The rest of our new range includes resistors, capacitors and many items that now complete our range for the electronics enthusiast and designer. We naturally carry the very latest in radio semiconductors, and are pleased to report many new developments in the past six months, that are now readily available, with technical backup, from Ambit. But quite apart from our technical capability, we think you will find our prices attractive, and our product always first quality.

Examples from the range of components, modules etc.:
Resistors ¼ watt types in E12 series, 1 ohm to 10M ohms (Mullard/Iskra/piher) 15p/10
Minimum order 10 per value please. Minimum resistor-only order £1.50.
Ceramic plate and disc capacitors: only miniature and compact types eg. 10nF: 35p/10
CA3189E: RCA's new IF system, £2.75 inc. detector coil and 22uH choke.
TDA1083: Sprague/Telefunken AM/FM/Audio IC. 800mW output max £2.55
TDA1062: Telefunken FM tunerhead IC, good for 200MHz, £2.75
Modules as previously advertized, plus these new ones: EF5803, 93189, EF5400, MPX decoder:
91196B: The superior HA1196 now with a 2W monitor amplifier, and optional adjacent or alternate channel notching facility, as well as a 55kHz low pass filter, pilot tone filters etc. £16.45
New from TOKO: CFM2 series 4 section ladder filters for 455kHz 6 & 12kHz versions £1.35 each, CFM2 2 section mechanical filters for 455kHz, same size as CFS series filters! Plus others.............



The EF5803 here is shown less the tinplate shielding can normally supplied

The EF5803: the ultimate? 2x low noise MOSFET RF stages with AGC, MOSFET mixer, very loose stage coupling for super high Q. Amplified local osc output. Used in conjunction with the 73189 system, provides 35dB S/N with 0.63uV PD input. And all these modules are British Made. EF5803: £19.75.

ambit INTERNATIONAL
2 GRESHAM ROAD BRENTWOOD ESSEX

Prices exclude VAT. Postage 25p per order. 'Catalogue (see text) 45p. Telephone (0277)216029. Parking outside the front of our building.

electronics tomorrow......

by John Miller-Kirkpatrick

ONE OF THE PROBLEMS with the use of a standard commercial audio cassette recorder as a data and/or program storage medium for microcomputers, is the slow access time — considering that the data file which you want to access could be at the far end of a C60 cassette. If the MPU is to do its own search then nearly half an hour could elapse before the file is found and loaded. One obvious answer is to use human intervention to wind the tape on at a fast speed until the approximate location is located from a counter or physical marker on the tape or cassette. Another alternative is to have a lot of cassettes with short files on each so that the maximum automatic search time does not exceed five minutes, this idea is expensive in tapes and requires a large manual filing system for the cassettes.

The idea of using a standard cassette recorder deck modified for MPU use is a little better. Here the Fast Forward, Rewind, Play/Record features available are run from solenoids and/or relays which in turn are controlled from the MPU. The tapes can now be logically divided into smaller lengths by physically marking the tape every 20 ft or so with reflective tape or some similar system so that a sensor can recognise an 'Inter Record Gap' (IRG). If the first record or records on the tape contain an index to the rest of the cassette then we could assume that the MPU can work out where the required record is relative to the start of the tape. Similarly we would have an identification on each record to denote its relative position on the tape and we can assume that the MPU can thus work out the position of the required record relative to the known present position of the tape.

Basic Operating Requirements.

First we have to modify our tape recorder to operate the speed and direction of the tape from TTL compatible logic signals. We need:

1. Stop/Go. A logic 1 is required to initiate any movement, a logic 0 will cause the tape transport to stop as quickly as possible.

2. Fast/Slow. A logic 1 will cause the tape to be passed by the R/W and erase heads at the fastest possible speed, a logic 0 will initiate the normal cassette operating speed.

3. Forward/Reverse. A logic 1 will cause the tape mechanism to be reversed as in a rewind instruction, a logic 0 will initiate forward tape direction.

4. Read/Write. A logic 1 will allow data to be written onto the tape and the previous data to be erased, a logic 0 will cause data to be read from the tape into the MPU.

5. Data In. When in the Write mode data is input to this point in either digital or audio form for recording onto the tape.

6. Data Out. When in the Read mode the data is available on this output in either digital or audio mode.

7. IRG Sensor. This output will go to logic 0 whenever the sensor finds a reflective marker or transparent tape to indicate an inter-record gap. It would not be difficult to arrange that a half inch reflective strip indicated an IRG and a one inch strip indicated the end or start of the tape.

8. Ready. This output from the cassette deck would only be at a logical 0 if the unit was powered up, had a cassette in it and was otherwise ready to run, a logic 1 would indicate that manual intervention was required for one reason or another.

Operation of the Unit.

When the MPU recognises that a new tape has been loaded, or under other instruction, the tape unit will be wound forward at fast speed for a couple of seconds in case the cassette was positioned right at the beginning of the tape. Fast rewind is now selected until the Start Of Tape one inch strip is recognised by the MPU—even at fast rewind speed the MPU will be able to differentiate between an EOT or SOT one inch marker and the half inch IRG marker. The tape can now be read at the slow forward speed until the SOT marker disappears at which point the tape is stopped and in theory is positioned at the start of the first record on the tape. We will assume that each change of direction or other command requires a stop and a short wait before issuing a new command, these waits and direction changes would be functions of the cassette control software routines as would be the recognition of the SOT/EOT/IRG markers.

Each of our logical records would be sub-divided into:
1. Header record of about 40 characters to contain a record position indicator, record name or label and possibly such information as a creation date, password protection, etc.
2. Data record.

Using this approach an old data record can be overwritten with a new version without necessarily having to change the index record. A gap of a couple of seconds between the Header and Data records would allow the MPU to identify the record from the HEADER record, stop the tape and be ready to read the Data record or to write a new Data record in its place.

Initialisation and Indexing.

After a cassette has been modified it can now be loaded into the recorder and have dummy Header records written at the start of each 20ft unit of tape. Any tape, whether new or having data records on it can be Auto-Indexed by using a simple program which will read all of the Header records on the tape into a RAM area and then rewind the tape and put out this RAM area as the first data record on the tape, ie the Index record. This facility would allow all tapes to be correctly indexed after use and before removal from the machine. If a printer is available then the index could be printed and stored with the physical cassette.

Anyone with ideas or comments please contact me.

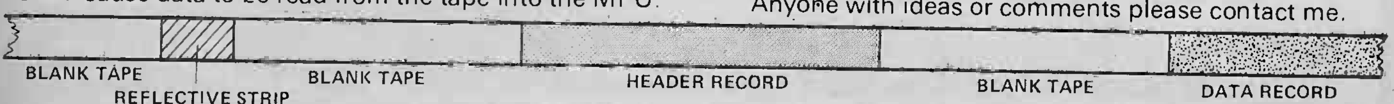


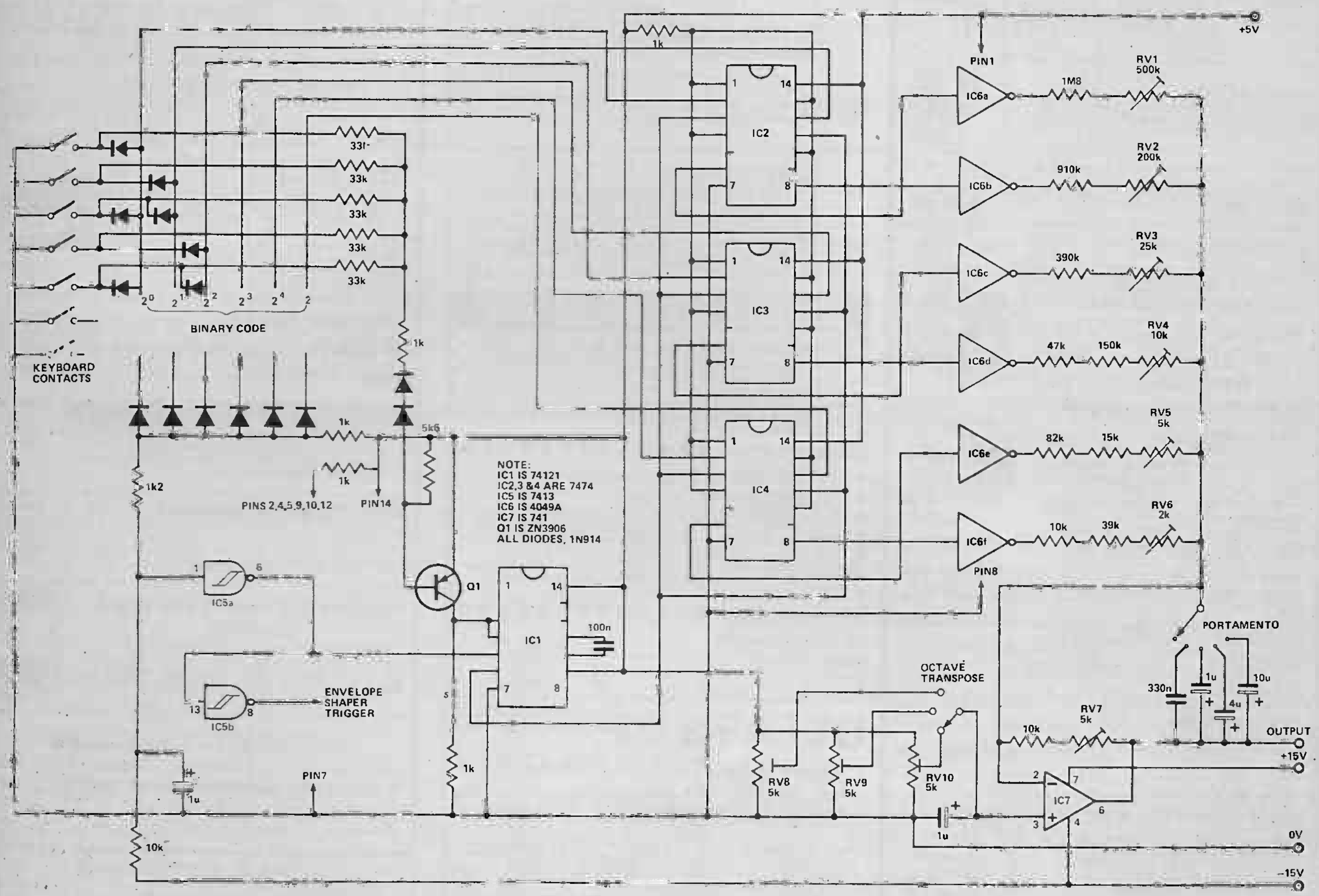
Fig 1. Typical start of record sequence, on one cassette track.

ETI

tech tips

Digital Keyboard Controller

P. Williams



This circuit was designed to overcome all the problems associated with resistor ladders and analogue memories normally found in synthesisers. The key depressions cause a diode matrix to set up binary patterns which are memorised on a bank of flip-flops.

The main advantages of this method are infinite memory hold; more accurate output since there are only six main tuning resistors (it is economical to make them variable). If more than one key is depressed at a time, no "out of tune" notes will be produced because of a multiple key depression detector. Only one set of single make contacts is required for the keyboard. Octave transpose and portamento is included.

When a key is depressed, the binary code set up by the diodes is clocked into the flip-flop (IC2-IC4) by the monostable (IC6). IC7 along with its associated resistors forms a D/A converter. The 33K resistors along with Q1 form the circuit which inhibits further data being clocked into the flip-flops if more than one key edge to trigger envelope shapers.

Up to 63 semitones (over five octaves) can be catered for using six data bits as shown, although more bits can be added.

RV1 to RV6 should be adjusted so that each successive bit causes twice as much change in the output voltage. RV7 adjusts the voltage/frequency relationship. RV8-10 adjust the starting voltage; they should be set to give the required octave shifts on the transpose control.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.

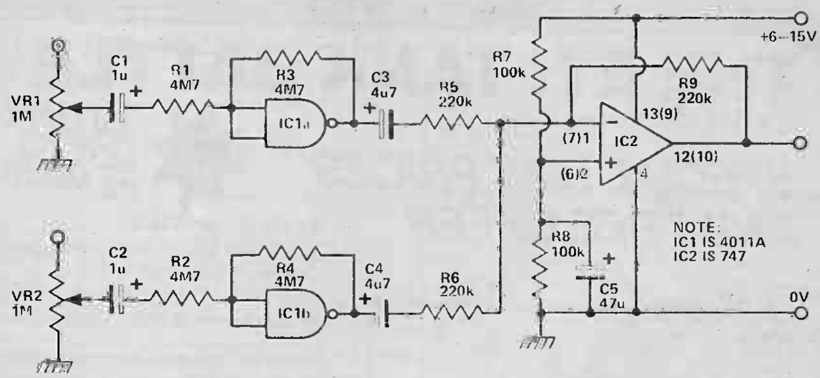
Hybrid Mixer

J. Macauley

This circuit shows one channel of a stereo mixer, the other channel being identical. The input signal is applied to the volume controls RV1&2 and from thence to the nand gates via the blocking capacitors and R1&2. These gates are first used as inverters by strapping both their inputs together, and are biased into the linear region by the feedback resistors, R3&4. In this way the gates act as high impedance, high quality, unity gain amplifiers.

The output from the gates are summed by the mixer, IC2. This IC is a dual op-amp of the same specification as the commoner 741, which could be used instead. As a single power supply is used the non-inverting input must be biased at half the supply voltage. This is done by the potential divider, R7&8, C5 decouples this point to earth.

The output impedance of this IC when used in the manner described is less than 1 ohm and so can be fed directly into a line socket. This circuit will only work with 'A' series 4011's as the B series contains protection circuity which will prevent it working in the linear mode.

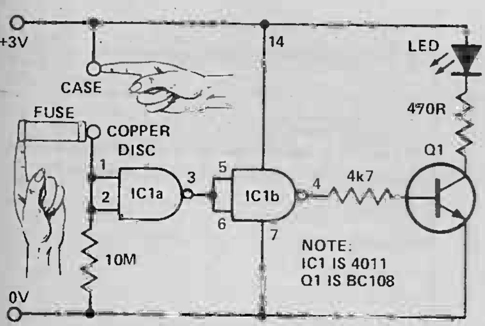


Fuse Tester

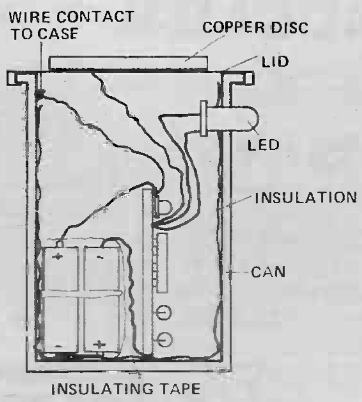
R. Heggie.

This circuit can be used for testing fuses, and has the advantage of being much smaller and easier to use than an ohm meter. The circuit is built into a 35mm aluminium film can, and is powered by two small mercury cells. An old penny glued to the plastic lid of the can forms one of the touch contacts, and the case forms another.

To test a fuse, the case is held on one hand and the fuse in the other, the end being touched onto the copper disc, if the fuse is OK a small current will flow through to the first gate of ICla taking the input high and the output low. This is inverted by IClb, which turns Q1 on, lighting the LED. As current consumption with the LED extinguished is almost negligible, a battery switch is not required.



IMPORTANT: All unused inputs on ICI should be grounded.



Constant Current Source

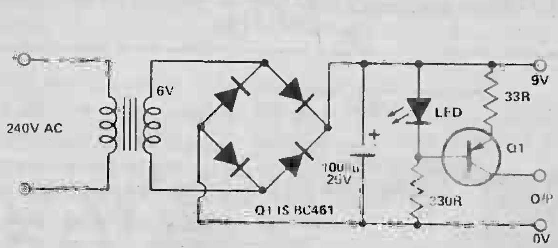
S. Callaghan

This circuit uses a standard panel mounting LED to provide a constant reference voltage for a transistor in a constant current generator.

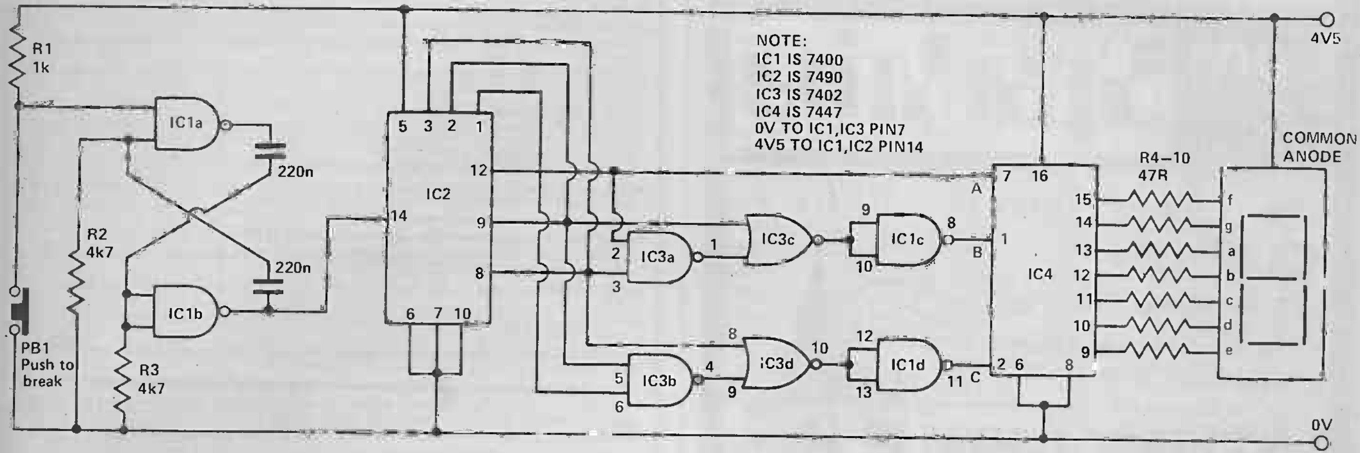
The output current I, is given by the equation

$$I = \frac{V_{LED} - V_{BE}}{R_E}$$

When the circuit is not connected to a load, the LED is extinguished, giving a visible indication of when the circuit is operating.

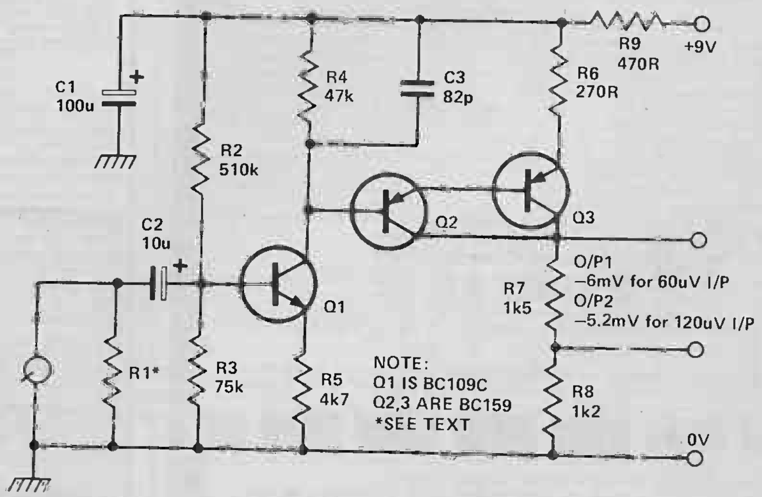


Digital Die
A. Slimming



ICla and IClb form an oscillator running at a few kilohertz. The output is fed to a 7490 binary counter which is wired to produce an output of 0 to 5 in BCD. So that the display is the same as a dice the display must read 1-6 and not 0-5, when the output of the 7490 is all '0's, the display must be made to show 6. IClc, d and IC3 perform this task, and convert an output of 000 from IC2 to 110 (b). IC4 is a BCD to 7-segment decoder which drives the display through the current limit resistors R4-R10.

Moving Coil Cartridge Preamp.
J. Macauley



Although moving coil cartridges undoubtedly give better reproduction from disc they usually require an expensive step up transformers to enable them to be used with conventional RIAA equalisation.

The reason for this is that most cartridges of this type have outputs of 60-150uV and like to 'see' an input impedance between 60-330R.

The circuit shown was developed to cater for a particular cartridge of this type although by modifying the value of one component, R1, it is possible to cater for the complete range of inputs detailed above.

Input signals are coupled to the base of Q1 via the isolating capacitor C1. R1 damps the input impedance to the correct value to match the particular cartridge in use. R2 and R3 bias Q1 which is employed in the common emitter mode. Heavy local AC and DC feedback is introduced by R5 and this defines the gain of the stage at 20dB. To minimise noise a BC109C is used here operated with a low collector current, 50uA. The output stage of this amplifier is the darlington pair Q2 and Q3, Output signals being taken from across R7, R8.

R1 should be determined by experiment but can be initially found by using a 470R preset in the R1 position and adjusting this for optimum sound quality by ear.

digest...

brief news in brief...

NASA have received weak signals from Skylab for the first time in four years. The possibility of sending it deeper into space is being considered....

★ A study by the American National Institute for Occupational Safety and Health (Niosh) has concluded that VDUs in use in the offices of the New York Times are not responsible for cataracts developed by two copy editors working there....

★ A computer system capable of controlling the lighting and heating in up to one hundred buildings has been set up in London by Honeywell. The system, called BOSS, is the first of its kind in the UK ...

★ What is believed to be the world's first garage for electric vehicles has been opened in Acton, West London. It is sponsored by the GLC and the DOI....

★ The High Fidelity 78 Spring Exhibition is to be held in the Cunard International Hotel, Hammersmith, London from the 2nd to the 6th of May. Exhibitors include Amstrad, Goldring, Marrantz, ITT, KEF, Shure, Tandberg and Uher....

★ A new generic specification within BS9000 has been published, dealing with single and double sided PCBs: BS9760, 9761, 9762, and 9763....

★ Optimisation Toys Ltd. of Bishop's Stortford have announced a national "Electronic Gamesman of the Year" competition. The organisers hope to gain TV and newspaper coverage....

★ The University of Leeds is to hold the 1978 Leeds Electronics Exhibition on the 27th, 28th and 29th of June. There will be over 180 exhibitors at the exhibition, claimed to be the largest outside London....

★ NASA claim that it will be possible to generate microwaves directly from sunlight using a superconducting cavity covered by a flexible piston(?). More details on this when we receive them....

★ Goddard Space Flight Centre has proposed that digital signals could be passed through capacitive connectors — two metal films separated by an insulating layer. This would pass digital pulse signals without contact resistance problems....

lightning-powered radio

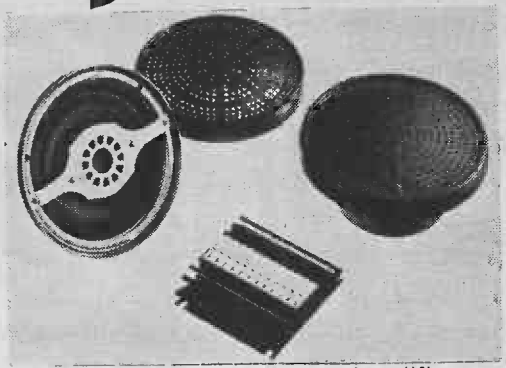
During the recent freeze/flood in southern England, the BBC opened an emergency radio station — Radio Taunton — within twenty-four hours of the idea being suggested at the parent station in Bristol. Four reporters and an engineer set up a studio in Taunton County Hall during an afternoon — the Home Office had given it's approval the same morning.

Radio Taunton operated on 224 m and had reportedly been picked up as far away as Okehampton in west Devon.

icarus?...

Hughes Aircraft in the US have built a series of solar-powered model aircraft. The Astro Flight Model 7404 is designed to fly at high altitudes where the Sun is unlikely to be obscured. It is controlled by a 72 MHz radio transmitter and carries solar sensors for navigation. The wingspan is 10 m and the upper wing surface is covered with solar cells, producing a total of 450 W. The design target is a full-sized solar-powered aircraft. I'll take a dozen.

THE DYNAMIC DUO



The C15/15 is a unique Power Amplifier providing Stereo 15 watts per channel or 30 watts Mono and can be used with any car radio/tape unit. It is simply wired in series with the existing speaking leads and in conjunction with our speakers S15 produces a system of incredible performance.

A novel feature is that the amplifier is automatically switched on or off by sensing the power line of the radio/tape unit, hence alleviating the need for an on/off switch.

The amplifier is sealed into an integral heatsink and is terminated by screw connectors making installation a very easy process.

The S15 has been specially designed for car use and produces performance equal to domestic speakers yet retaining high power handling and compact size.

C15/15
15 watts per channel into 4Ω
Distortion 0.2% at 1kHz at 15 watts
Frequency Response 50Hz-30kHz
Input Impedance 8Ω nominal
Input Sensitivity 2 volts R.M.S. for 15 watts output
Power Line 10-18 volts
Open and Short Circuit Protection
Thermal Protection
Size 4 x 4 x 1 inches
C15/15 Price £17.74 + £2.21 VAT P&P free

Data on S15
6" Diameter
5¼" Air Suspension
2" Active Tweeter
20oz Ceramic Magnet
15 watts R.M.S. Handling
50Hz-15kHz Frequency Response
4Ω Impedance

S15 Price per pair £17.74 + £2.21 VAT P&P free

TWO YEARS GUARANTEE ON ALL OF OUR PRODUCTS

Please supply ....
Total Purchase Price ....
I enclose cheque ☐ *Postal Order* ☐ *Money Order* ☐
Please debit my Access Account ☐ *Barclaycard Account* ☐
Account Number ....
Name & Address ....
....
Signature ....

ELECTRONICS LTD

Crossland House,
Nackington,
Cantebury, Kent
Tel (0227) 63218

COMPUTERISED DRAUGHTS!

YOU HAVE SEEN THE AMAZING CHESS CHALLENGER

NOW MEET

CHECKERS CHALLENGER

—The computer that challenges you at draughts.

★ 4 levels of play — top level, virtually unbeatable
★ Problem mode
★ Can change skill level **during** game
★ Random move selection
★ Does not permit illegal moves and **many** other features.

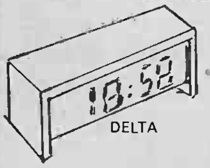
Rec. Retail Price **£99.95**
Our Price only .... **£79.95** inc.

BE FIRST WITH COMPUTER CHECKERS

Also available:
3 Level Chess Challenger. Only **£124.95**
Gammon Master II. Only **£155.00**

JAGBERRY LTD.
95 Ardwell Avenue
Barkingside, Essex
Mail order only

DIGITAL CLOCK KITS . . .
thousands sold



TEAK or **PERSPEX** cases
½" Red LED. 4 digit 12 hr. display. PM indicator. Mains frequency accuracy. Complete instructions. Power cut flasher. Real wood case or White, Black, Red, Blue, Green Perspex 6" x 2½" x 3".
Alarm: Pulsed tone. Auto brightness. 9 min. snooze.

Electronics only kit: Non Alarm **£10.00** Alarm **£13.00**
Complete with case: Non Alarm **£13.00** Alarm **£16.00**
Ready built. Tested Working. Add £1.00
Timer facility: Show seconds, stopwatch use. Sleep delay 50p

DISPLAYS: ½" Red LED FND 500 **£1.20** each, 6 for **£6.48**
NSB5LL30 ½" Red stick of 4 **£4.32,** 5LT02 stick of 4 Green **£5.40**

CLOCK CHIPS: MK50253N Alarm. 12/24 hr. 4/6 dig. **£5.40.** MM5385 **£4.32.** MK50362N Calendar **£7.56.** 6 Digit Counter 50395/6/7 **£9.18.**

MICRO PROCESSORS: Z80 CPU **£21.60.** CTC & PIO **£15.12.** MK4096N 300nS 4K x 1 Dyn RAM **£6.75.** 1702A UV PROM 450nS **£10.80.**

BATTERY RECHARGER SET: Mains Adaptor with 4 way plug. 4 x AA (1.2V) NiCads plus holder **£8.64.** AA NiCads separately **£1.20.**

BARON (ET) 6 GOWER ROAD, ROYSTON, HERTS
Tel. (0763) 43695 Use Access and Barclaycard

NEW MODULES

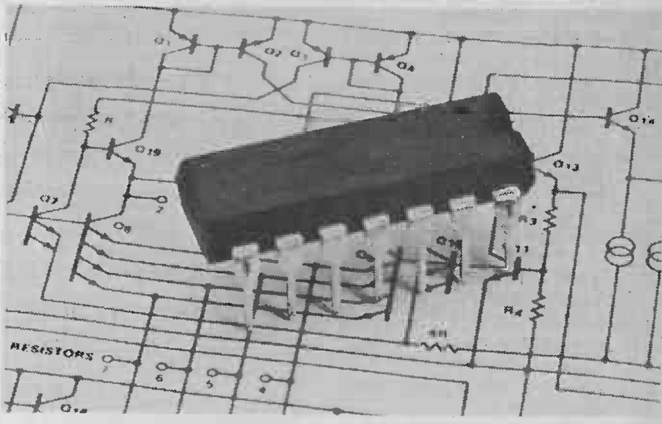
BY FAMOUS MANUFACTURERS ON P.C. BOARDS READY TO MOUNT IN PLINTH, ETC.

1. **STEREO AMPLIFIERS** 6½in. x 5¼in. P.C.B. 10w + 10w for 60mV input requires 20-22 V.A.C. TO POWER **£4.90**
2. **MATCHING PRE-AMP.** Normally powered from (1), four push-buttons gram, aux., tape in/out, on/off slider controls. Vol., Bal., Treble, Bass **£6.00**
3. **AMP AND PRE-AMP.** Ordered together **£10.00**
4. **ELAC L.S.** to suit 8in. 8 Ohm with tweeter cone. Pair for **£8.50**
5. **GRAM AMPLIFIER.** 12in. x 1½in. P.C.B. 3w + 3w for 100mV input. Controls, Vol., Bal., Treble, Bass. Requires 15v-25v DC, _Ω-16Ω L.S. **£5.90**
6. **MONO VHF-FM** Module 9½in. x 2½in. VARICAP Tuner, ceramic I.F. CA3089 I.C. amp-demod, AFC-AGC. Audio Op., approx. 250 mV. Requires 20 AC or DC. Few only **£4.65**

Prices inc. P&P and VAT. Cash with order

ELECTRONICAL SUPPLIES CROYDON
40 LOWER ADDISCOMBE ROAD, CROYDON, CRO 6AA
01-688 2950

news... ...digest



vco ic

A recently-announced VCO IC which has the facility of digital switching between specified frequencies could be very useful in the home computing field. The XR-2207 has four connections for timing resistors — two logic inputs determine which resistor is used. This makes the device very suitable for producing frequency shift keying (FSK) signals for the transmission or recording of digital signals. Other specifications include:

Outputs: square and triangular waveforms
Frequency range: 0.01 Hz to 1 MHz
External voltage frequency sweep ratio: 1000:1
Temperature drift: 20 ppm per deg. C
Duty cycle: 0.1% to 99.9%
Supply voltage: ± 4 V to ± 13 V
Supply voltage/frequency stability: 0.15% per volt

The XR-2207 is available from: Distronic Ltd., 50/51 Burnt Mill, Elizabeth Way, Harlow, Essex.

new service from eti

You can now get the latest news about ETI all night (technology permitting). We've installed a message service on **01-434 1781** which will be operating from about **6.00 pm until 9.00 am the next morning** — it is not operational at other times.

If there is something which we want to communicate to you, it'll be on the message; we envisage information on project errors (even if there are none, it's nice to be sure) any hold-up on orders (which is rare) plus any other news.

Try it out sometime — what we will have on there within a week of this issue being published is whether there are any vacancies for our seminars on May 12th and 13th.

This is an experimental service at this stage — we'll keep you posted as to whether it becomes permaanent. If you get a ringing tone or engaged signal, try later — the service is connected to an automatic switchboard and if the message service is in use, your call will be routed to another line (you'll get an engaged signal if two people are trying).

HELPING HAND

In our October 1975 issue we announced a competition which we were holding in conjunction with the Royal National Institute for the Deaf. We presented readers with three problems for which we felt that there may be an electronic solution.

The winning entry, submitted jointly by John Howden and Clive Musgrove of Bristol was for Problem 1:

"A sick person is looked after by a deaf person. The deaf person has no useful hearing and requires to know whether the sick person is all right and above all needs to know if the sick person is in a state of distress anywhere in the sick room".

The competition winners built up a working prototype which has been somewhat modified subsequently though it uses exactly the principles and ideas described by John and Clive.

More details are given in News Digest.

THE SOLUTION to the problem posed by the competition was to provide the sick person with a small hand-held unit, capable of (in the original prototype) emitting a piercing two-tone note. When the sick person requires attention, by activating the noise generator, they trigger a control unit which is elsewhere in the sick room.

The control unit, after picking up the noise via a microphone, superimposes a high frequency signal upon the mains. This high frequency signal is coupled, via the house wiring, to a modified mains adaptor. This detects the signal and switches on the load (usually a lamp) connected to it. This attracts the deaf person's attention.

Because the mains adaptor is small and inexpensive, it is possible to install such devices throughout the house so that the deaf person is always in touch with the sick person.

Different Approach

This then was the first prototype. Its ideas were incorporated in the final design — the major difference being that the final circuit uses an ultrasonic instead of audio link between the control box and hand-held trigger.

The original unit featured a two-tone audio transmitter in order that the control unit did not respond to ambient sounds but only to the specific two-tone note. This however involved some complex filtering and decoding.

Ultrasonics had originally been rejected because the sick person would have no confirmation that a signal had been sent. This problem was solved by fitting an audio mimic to the control unit to confirm that a signal has been received.

The final system thus comprises an ultrasonic transmitter, receiver and adaptor.

The receiver has two modes of operation. With the latch control out, the unit will be activated only for the duration of the transmitted signal. With the latch in, the unit, once triggered, will continue to send its signal down the mains. The unit also has a local call button that can send out the call signal.

Construction

The transmitter was mounted in a hand held torch case. The ultrasonic transducer replacing the lamp assembly, and the PCB and battery occupying the original battery compartment.

Most of the receiver is mounted on the large PCB. Take care that all the polarity conscious components are mounted correctly.

We used fairly expensive switches in our unit, but considerable savings could be made in this area by using cheaper panel lamps and separate switches.

The adaptor components are so few that it was not thought necessary to design a PCB, the components are "birds nested".

When complete the frequency of the oscillator should be adjusted in order that it oscillates at the resonant frequency of the transducer.

This can be done by monitoring the waveform across the transducer on a scope and adjusting RV1 for maximum output. This adjustment can also be performed by adjusting RV1 to provide for maximum voltage at the D1 / C7 junction.

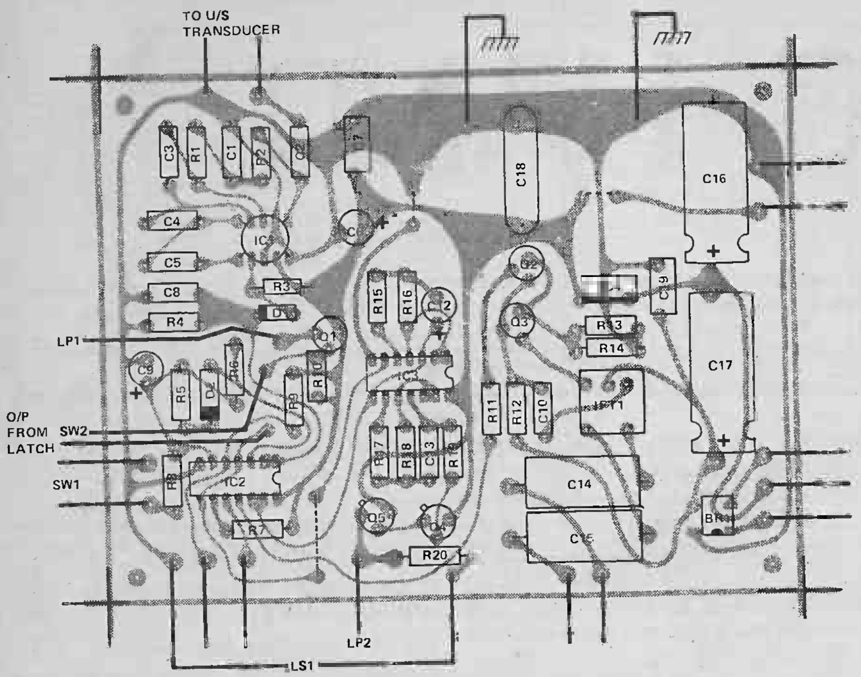
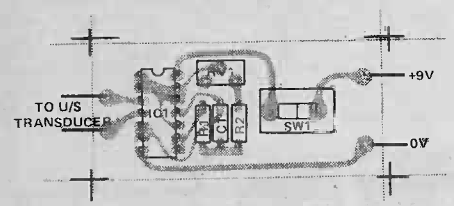


Fig. 1. Overlay of the ultrasonic receiver board.



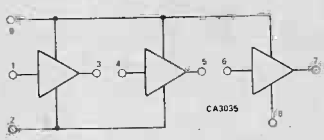


Fig. 2. The ultrasonic transmitter board.

BUYLINES

Arrow Electronics at Leader House, Coptford Road, Brentwood, Essex, will be selling a complete kit of parts for the helping hand. Price is £20.97 excluding case and switches. The switches cost £14.56, but as mentioned in the text cheaper alternatives could be found.

The ultra sonic transducers are now stocked by most of the larger mail order firms.

PARTS LIST

ULTRA SONIC RECEIVER
RESISTORS (all ¼w 5%)

R1	150k
R2, 19	33k
R3	22k
R4	2M2
R5, 11, 12	10k
R6	47k
R7, 9, 15	100k
R8	100R
R10	15k
R13, 14, 20	220R
R16	56k
R17	1M
R18	470k

CAPACITORS

C1	22n Polyester
C2	4n7 Polystyrene
C3	47n Polyester
C4	3n3 Polystyrene
C5	2n2 Polystyrene
C6	10u 16V Electrolytic
C7	100n Polyester
C8, 13	1n0 Polystyrene
C9	4u7 10V Tantalum
C10	220p Polystyrene
C11	Supplied with IFT 14
C12	2u2 10V Tantalum
C14, 15	1n0 600V Mixed Dielectric
C16	1 000u 16V Electrolytic
C17	1 000u 35V Electrolytic
C18	470n Polyester

SEMICONDUCTORS

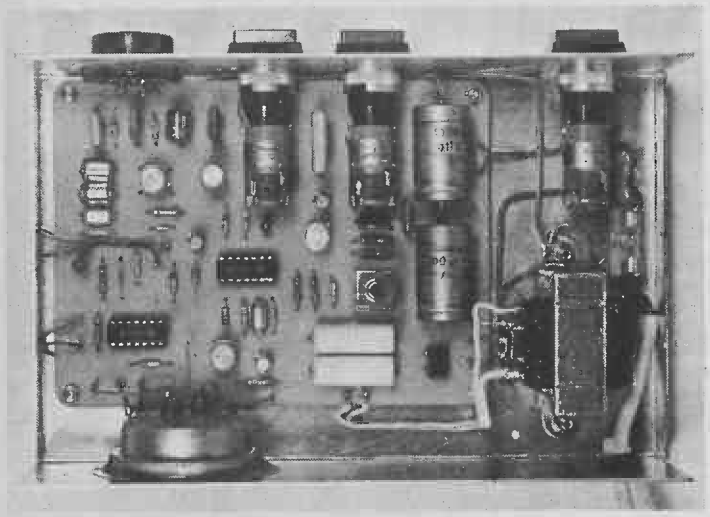
IC1	CA3035
IC2, 3	CD4011
IC4	7812
Q1, 2, 4	BC108
Q3	BFY85
QJ	BFY50

SWITCHES

SW1	Push to make (momentary)
SW2	Change over (latching)

MISCELLANEOUS

Ultra sonic transducer, Denco IFT14 coil, PCB as pattern, 12-0-12 volt transformer, GPO insert.



To the left we see the ultra sonic receiver from above. We glued the ultrasonic transducer in place but it would be preferable to insulate this from the rest of the case with foam rubber. The picture on the right shows the transmitter out of its shell.