# electronics today INTERNATIONAL

JANUARY 1974

20p

## FULL SCALE SYNTHESIZER TO BUILD

## HOW TO REPAIR CALCULATORS
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Here's how:

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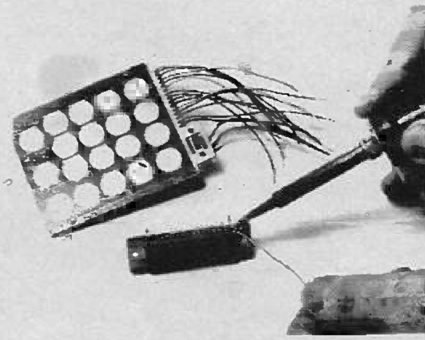
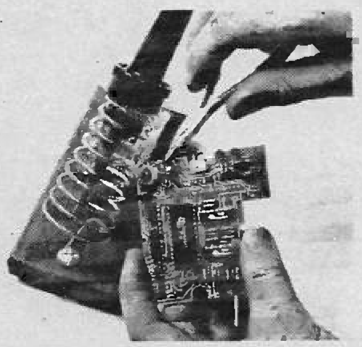
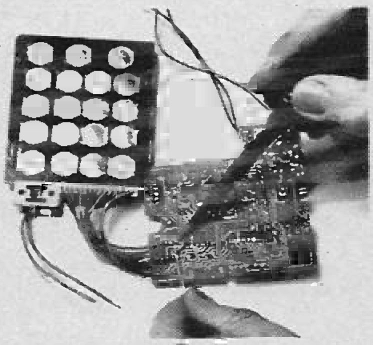


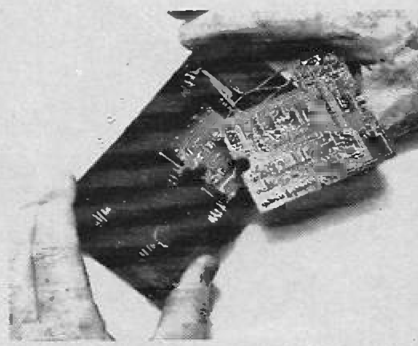
Now solder the connection wires to the keyboard and display board. (The wires are pre-cut, stripped and tinned so that's easy.)



The printed circuit board assembly is simplicity itself. And the component locations are clearly marked.



Next, wire the printed circuit board to the keyboard. Just 17 connections in all.



The final assembly uses only 2 nuts and one screw to secure the self-clipping case.

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Do this and you'll have a sophisticated calculator which, apart from being compact and strong, gives you the four functions plus a constant and a fixed floating decimal point facility.

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## Advance Calculators

Advance Electronics Ltd., Calculator Division
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electronics TODAY INTERNATIONAL

JANUARY 1974 Vol.3 No.1

## main features



## projects



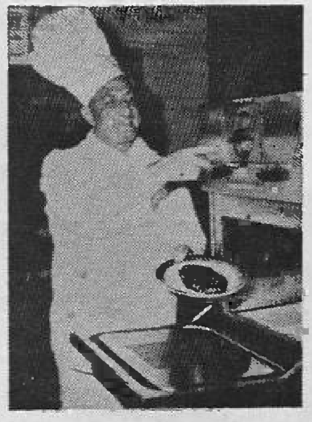
## product tests



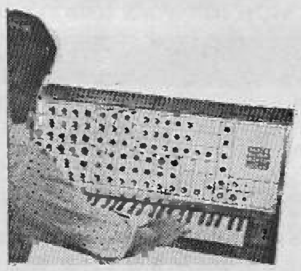
## news & information



Cover: Featured this month is Electronics Today International's Model 4600 MUSIC SYNTHESIZER. (Full details describing the construction of this unit commence on page 20 — this issue).



page 10



page 20

page 28

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# POWER PROBLEMS

In our September 1973 issue we carried a major and detailed article on the energy crisis: The Solar Solution. In this we avoided conclusions, we only put the arguments.

Since this issue was published, the situation has changed dramatically: At the time of writing the miners are operating an overtime ban, the electricity power supply is being threatened because of other industrial action and the aftermath of the recent middle east war is being reflected in our oil supplies. This has made us actually aware of our dependence upon power and how much we have taken it for granted. It also shows us how vulnerable we are. We have always maintained the Armed Services to ensure the nation's security and interests yet both of these are in jeopardy when our power supplies are threatened. Serious and sustained interruption of our energy sources could do far more damage to us than a major war.

The oil producing nations are unlikely to reverse their decision to hold output to its present level (an additional problem to that brought about by the Arab-Israeli war) and this means that to maintain growth some other energy source must be expanded — and very rapidly.

An abundance of energy supplies until very recently has meant that we have not taken an overall look at the problem for the simple reason that there hasn't been one. Energy conservation, such as we are now pursuing, is only a short term answer.

It is time that we looked at the whole question of energy supplies for the future and devote the necessary resources to finding a secure solution. We value our national security to the tune of £2,500 millions a year spent on the Armed Services and yet the energy crisis could do to us what no enemy has ever been able to do — bring us to our knees. — H.W.M.

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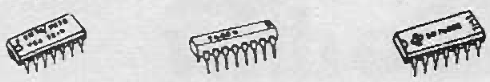

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| SN7403N | 0·20 | 0·18 | 0·16 |
| SN7403AN | 0·38 | 0·38 | 0·33 |
| SN7404N | 0·24 | 0·21 | 0·18 |
| SN7405N | 0·20 | 0·18 | 0·16 |
| SN7405AN | 0·44 | 0·44 | 0·38 |
| SN7406N | 0·40 | 0·38 | 0·35 |
| SN7407N | 0·40 | 0·38 | 0·35 |
| SN7408N | 0·25 | 0·22 | 0·19 |
| SN7409N | 0·33 | 0·33 | 0·28 |
| SN7409AN | 0·44 | 0·44 | 0·38 |
| SN7410N | 0·20 | 0·18 | 0·16 |
| SN7411N | 0·25 | 0·23 | 0·21 |
| SN7412N | 0·28 | 0·28 | 0·25 |
| SN7412AN | 0·38 | 0·38 | 0·33 |
| SN7413N | 0·30 | 0·27 | 0·25 |
| SN7414N | 0·72 | 0·72 | 0·63 |
| SN7416N | 0·30 | 0·27 | 0·25 |
| SN7417N | 0·30 | 0·27 | 0·25 |
| SN7420N | 0·20 | 0·18 | 0·16 |
| SN7422N | 0·28 | 0·28 | 0·25 |
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| SN7423N | 0·37 | 0·34 | 0·32 |
| SN7425N | 0·37 | 0·37 | 0·32 |
| SN7427N | 0·37 | 0·37 | 0·32 |
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| SN7430N | 0·20 | 0·18 | 0·16 |
| SN7432N | 0·37 | 0·37 | 0·32 |
| SN7433N | 0·43 | 0·43 | 0·38 |
| SN7433AN | 0·57 | 0·57 | 0·50 |
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| SN7438N | 0·43 | 0·43 | 0·37 |
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| SN7454N | 0·20 | 0·18 | 0·16 |
| SN7460N | 0·20 | 0·18 | 0·16 |
| SN7470N | 0·33 | 0·30 | 0·27 |
| SN7472N | 0·38 | 0·38 | 0·34 |
| SN7473N | 0·44 | 0·41 | 0·37 |
| SN7474N | 0·48 | 0·48 | 0·42 |
| SN7475N | 0·59 | 0·55 | 0·51 |
| SN7476N | 0·45 | 0·36 | 0·32 |
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| SN7493N | 0·75 | 0·70 | 0·63 |
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| SN74107N | 0·51 | 0·51 | 0·45 |
| SN74110N | 0·57 | 0·57 | 0·50 |
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| SN74116N | 2·16 | 2·16 | 1·89 |
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| SN74120N | 1·05 | 1·05 | 0·92 |
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| SN74123N | 1·44 | 1·44 | 1·26 |
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| SN74147N | 2·30 | 2·30 | 1·83 |
| SN74148N | 2·01 | 2·01 | 1·63 |
| SN74150N | 2·30 | 2·30 | 2·01 |
| SN74151N | 1·15 | 1·15 | 1·00 |
| SN74153N | 1·09 | 1·09 | 0·95 |
| SN74154N | 2·30 | 2·30 | 2·01 |
| SN74155N | 1·15 | 1·15 | 1·00 |
| SN74156N | 1·09 | 1·09 | 1·00 |
| SN74157N | 1·09 | 1·09 | 0·95 |
| SN74159N | 2·44 | 2·44 | 2·14 |
| SN74160N | 1·58 | 1·58 | 1·38 |
| SN74161N | 1·58 | 1·58 | 1·38 |
| SN74162N | 1·58 | 1·58 | 1·38 |
| SN74163N | 1·58 | 1·58 | 1·38 |
| SN74164N | 2·01 | 2·01 | 1·76 |
| SN74165N | 2·01 | 2·01 | 1·76 |
| SN74166N | 2·16 | 2·16 | 1·89 |
| SN74167N | 4·10 | 4·10 | 3·59 |
| SN74170N | 2·88 | 2·88 | 2·52 |
| SN74172N | 5·76 | 5·76 | 5·04 |
| SN74173N | 1·66 | 1·66 | 1·45 |
| SN74174N | 1·80 | 1·80 | 1·57 |
| SN74175N | 1·29 | 1·29 | 1·13 |
| SN74176N | 1·44 | 1·44 | 1·26 |
| SN74177N | 1·44 | 1·44 | 1·26 |
| SN74180N | 1·44 | 1·44 | 1·26 |
| SN74181N | 5·18 | 5·18 | 4·53 |
| SN74182N | 1·44 | 1·44 | 1·26 |
| SN74184N | 2·16 | 2·16 | 1·89 |
| SN74185AN | 2·16 | 2·16 | 1·89 |
| SN74188N | 6·48 | 6·48 | 5·67 |
| SN74190N | 2·30 | 2·30 | 2·01 |
| SN74191N | 2·30 | 2·30 | 2·01 |
| SN74192N | 2·30 | 2·30 | 2·01 |
| SN74193N | 2·30 | 2·30 | 2·01 |
| SN74194N | 1·72 | 1·72 | 1·51 |
| SN74195N | 1·44 | 1·44 | 1·26 |
| SN74196N | 1·58 | 1·58 | 1·38 |
| SN74197N | 1·58 | 1·58 | 1·38 |
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| SC35B | 200v | 85p |
| SC35D | 400v | 90p |
| SC35E | 500v | £1·20 |
| SC45B | 200v | £1·15 |
| SC45D | 400v | £1·45 |
| SC45E | 500v | £1·85 |

**6 AMP RANGE**

| Type | P.I.V. | Price |
|---|---|---|
| SC40A | 100v | 90p |
| SC40B | 200v | 95p |
| SC40D | 400v | £1·20 |
| SC40E | 500v | £1·50 |

**10 AMP RANGE**

| Type | P.I.V. | Price |
|---|---|---|
| SC45A | 100v | £1·05 |

**15 AMP RANGE**

| Type | P.I.V. | Price |
|---|---|---|
| SC50A | 100v | £1·45 |
| SC50B | 200v | £1·65 |
| SC50D | 400v | £1·95 |
| SC50E | 500v | £2·25 |

**TRIACS Additional Types**

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| 40669 | TRIAC (Plastic) | 90p |
| 40486 | TRIAC (T05) | 75p |

3 Amp T043 — 15 Amp T048

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|---|---|---|
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| CRS 1/20AF | 200v | 35p |
| CRS 1/40AF | 400v | 45p |
| CRS 1/60AF | 600v | 55p |
| **THREE AMP (T048)** | | |
| CRS 3/05AF | 50v | 40p |
| CRS 3/10AF | 100v | 40p |
| CRS 3/20AF | 200v | 45p |
| CRS 3/40AF | 400v | 55p |
| CRS 3/60AF | 600v | 65p |
| **FIVE AMP** | | |
| CRS 5/400 | 400v | 60p |
| **SEVEN AMP (T048)** | | |
| CRS 7/100 | 100v | 60p |
| CRS 7/200 | 200v | 67p |
| CRS 7/400 | 400v | 85p |
| CRS 7/600 | 600v | 95p |
| **SIXTEEN AMP (T043)** | | |
| CRS 16/100 | 100v | 70p |
| CRS 16/200 | 200v | 75p |
| CRS 16/400 | 400v | 85p |
| CRS 16/600 | 600v | £1·10 |

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| 115 | 8 watt Amplifier | 3·90 |
| 120 | 12 watt amplifier | 4·70 |
| 125 | Stereo control unit | 5·70 |
| 130 | Mono control unit | 3·60 |
| 605 | Power supply for 115 | 4·55 |
| 610 | Power supply for 120 | 4·55 |
| 615 | Power supply for 2 x 120 | 6·73 |
| 230 | AM/FM aerial amplifier | 2·83 |
| 240 | Auto packing light | 5·90 |
| 275 | Mic. preamplifier | 6·08 |
| 570 | LF generator 10Hz-1mHz | 15·80 |
| 575 | Sq. wave generator 20Hz-20Khz | 14·80 |
| 590 | SWR meter | 12·85 |
| 620 | Ni-CAD Charger 1·2-12v | 8·00 |
| 630 | STAB Power supply 6-12v 0·25-0·1A | 8·15 |
| 690 | DC motor speed Gov. | 2·87 |
| 700 | Electronic Chaffinch | 7·00 |
| 705 | Windscreen wiper timer | 6·80 |
| 760 | Acoustic switch | 10·75 |
| 780 | Metal Detector (electronics only) | 9·65 |
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| 840 | Delay car alarm | 6·15 |
| 875 | CAP. Discharge ignition for car engine (-Ve Earth) | 13·15 |
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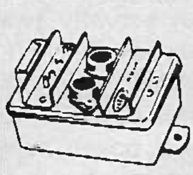
| 255 | Level indicator | 6·15 |
| 525 | 120-160mHz VHF tuner | 11·30 |
| 715 | Photo cell switch | 7·70 |
| 795 | Electronic continuity tester | 4·30 |
| 860 | Photo timer | 13·25 |
| 371 | Slide projector auto. feed control | 7·15 |
| 235 | Acoustic Alarm for driver | 7·60 |
| 465 | Quartz XTAL checker | 8·76 |



ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY

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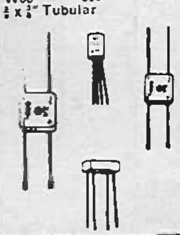

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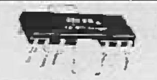

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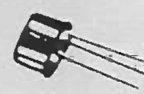

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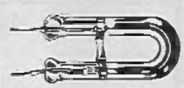

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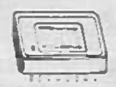

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## SATELLITE TO BEAM ATMOSPHERIC SOUNDING DATA

Global atmospheric temperature soundings will be beamed directly to nations around the world for the first time by a new RCA-built satellite launched by NASA from the Western Test Range in California on November 8.

The spacecraft, designated ITOS-F for Improved TIROS Operational Satellite-F, will become the primary weather watcher in the worldwide system. It will join a sister spacecraft, NOAA-2, which recently marked its first anniversary. NOAA-2 was launched on October 15, 1972, and is fully operational.

The operational environmental satellite system is managed and operated by the National Oceanic and Atmospheric Administration (NOAA)' After achieving orbit, the satellite will be renamed NOAA-3.

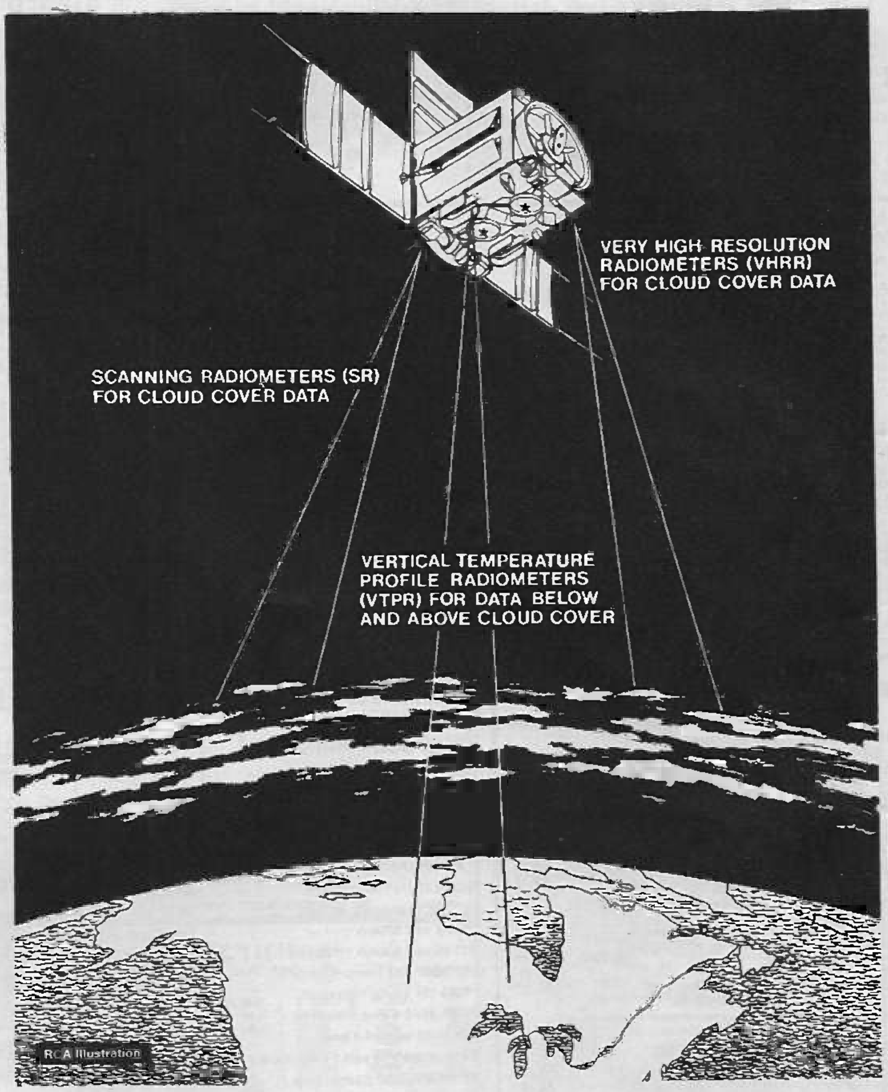
Among the countries preparing to receive atmospheric sounding data directly from the satellite are France and Norway.

Other countries besides the United States will be able to receive direct vertical temperature readings and use this vital weather information in the preparation of local weather forecasts. The vertical measurements are valuable because they permit the determination of the approximate moisture content in the lower portion of the atmosphere observed as well as the temperature profile from sea level to 20 miles above the earth. These soundings are taken automatically over the entire planet on a daily basis.

NOAA-3 was modified to permit atmosphere sounding data to be broadcast directly by beacon transmitter as well as being recorded and then transmitted to NOAA's Command and Data Acquisition Stations (CDA) in Virginia and Alaska.

In addition to sending direct, real-time temperature information, the satellite records cloud imagery and sea surface temperature gradients for delayed transmission.

Orbiting the globe once every 116 minutes, NOAA-3 will observe every portion of the earth twice a day, thus supplying scientists and meteorologists with global images, data and soundings of the atmosphere every 12 hours. NOAA-2 and 3 carry the same advanced sensors and are the first of the operational environmental satellites to be completely equipped with infrared heat sensing instruments. Primary sensors aboard the satellite include the Very High Resolution Radiometer (VHRR), Vertical Temperature Profile Radiometer (VTPR) and the Scanning Radiometer (SR). Each sensor has a redundant system for operational reliability.




The VTPR takes the temperatures in the atmosphere over land and ocean in clear areas up to an altitude of 20 miles. It has a resolution of 30 by 30 miles.

The VHRR produces pictures that have about four times more resolution than those provided by the Scanning Radiometer, The resolution is such that objects as small as one-half mile long can be discerned in both visible and infrared imagery.

The SR has the capability of transmitting cloud cover pictures directly to 550 simple, inexpensive Automatic Picture Transmission (APT) stations located in 80 countries of the world. The imagery, both visible and near infrared, has a resolution of two to four miles.

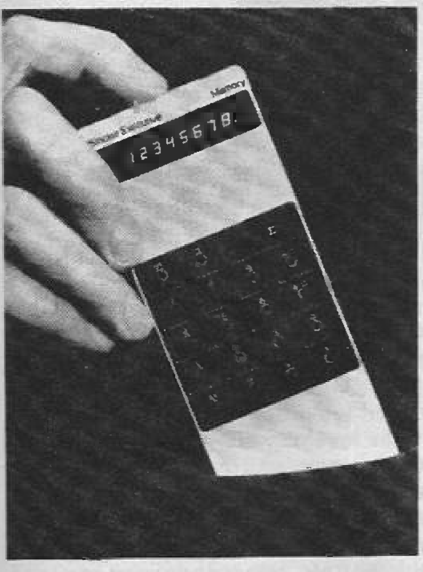
The TIROS Operational System of weather satellites first became

# news digest

operational on a daily global basis in 1966, and since then no major storm has gone undetected by satellite. By tracking and providing advance information of approaching severe storms, the operational satellites have helped to minimize deaths, injuries and property loss.

## NEW 'EXECUTIVE' CALCULATOR WITH MEMORY

The latest pocket calculator from Sinclair, who are Europe's largest makers of calculators, is the *'Executive Memory'* model. Retail price £49 plus VAT.




Housed in the original slimline 'Executive' case measuring 5½ x 2¼ x 3/8 inch and weighing 2½ oz, the 'Executive Memory' is identified by a new white styling. It embodies other features of the standard 'Executive' - bright 8 digit display; four function operation with constant, clear last entry button a new memory function.

The memory is operated by a slide switch on the front of the calculator case. By engaging this function sub-totals from any number of chain calculations are automatically retained in the calculator - the grand total being display after the 'M' button on the keyboard is pressed.

According to the company this additional feature enables the results of repeated multiplications to be totalled - for example in stocktaking calculations or currency conversions.

The price of the standard Sinclair 'Executive' has been reduced to £39 plus VAT.

## ELECTRONIC AID FOR THE HANDICAPPED

About five years ago, at the age of 21, Toby Churchill - a qualified mechanical engineer working for Lucas - contracted an unidentified virus disease which left him with a number of disabilities. These included a complete loss of the power of speech and a paralysed right arm.

He conceived the idea of a portable electronic device which would enable him to communicate with others easily and set about the task of putting his idea into practice. After reviewing the electronic components available, he knew that his ideas were not just a pipe dream but a practical possibility. The Engineering Department at Cambridge University heard of Toby's ideas and agreed that they would form the basis of a worthwhile project.

Very quickly the ideas became reality. A typewriter-like keyboard was coupled to a Burrough's 'self-scan' display system. Circuits were designed to allow the unit to be powered from rechargeable batteries.

Toby now 'talks' to people using the Keyboard: the letters, words and numerals appear in a very easily-read form on the self-scan display panel.

A number of people assisted with the development of the unit - which has been called the Lightwriter - in many different ways. Burroughs, keyboard manufacturers, Cambridge University and Burroughs' UK agents, Walmore Electronics Ltd, all played their parts.

As a result of pressure from friends and acquaintances with similar disabilities, a company - Toby Churchill Ltd - has been set up to manufacture the Lightwriter. The company has financial backing and production facilities, and it is expected that the first units will become available in the first half of 1974.

The heart of the Lightwriter is the self-scan display panel which is manufactured by Burroughs Corporation in America and available through the UK agents, Walmore Electronics Ltd. It was found that the self-scan display was the only display device available which successfully met all the Lightwriter's requirements.

The display unit consists of a long matrix of special gas-discharge tubes set in cavities. The display used in the Lightwriter has sufficient cavities to form 32 properly spaced alpha-numeric characters, each character being presented in a 5 x 7 dot matrix format. The self-scan display unit comes complete with all the necessary scanning circuitry, the display recirculating memory, an ASC11 code converter, a character generator and all the control logic.

The only inputs required are the ASC11 code for the required character, clock pulses, a strobe pulse and the necessary power supplies.

To produce the high voltage required for the gas discharge display from a battery, the Lightwriter employs a d.c. to d.c. inverter circuit.

Because of the versatility of the self-scan display, the Lightwriter offers a full upper-case set of letters; the punctuation marks and symbols ! * / @ $ & ? ( ) + - " ' : ; , . and the numerals 0 to 9. Back space facilities - for error correction - and erase display functions are also incorporated. Another feature of the Lightwriter is a 'buzzer', formed by a simple multivibrator, to attract attention.

*Continued on page 71*

**Speed is the main, but by no means the only, advantage of the microwave oven.**

**In this article, Dr. Sydenham describes this relatively recent addition to our ways of cooking food.**

# COOKING BY MICROWAVES

WE COOK our food for a variety of reasons. It becomes easier to chew, easier to digest, more palatable and often it is made freer from food infection. Knowledge of cooking is said to have helped the evolution of man.

It seems man has always known of the need to cook food: Peking man (500 000 years before present) had roasts before he could communicate. Palaeolithic man left very clear evidence of having cooking skills — many roasting devices have been dated to that period (200 000 — 30 000 years B.P.). Indeed it is asserted by some that the resultant easier chewing led to a reduction in jaw muscle structure enabling brain-power to develop instead. It has also been suggested that the developing delicate jawbone structure enabled more articulate speech to emerge.

Palaeolithic ovens were crude, but effective. Line a suitable hollow with stones and set a good fire. When hot, remove the burning wood and place in the food wrapped in leaves. Cover the earth and wait until done. Some primitive tribes still use this hot-stone cookery. It is not hard to understand why "haute cuisine" did not flourish in civilisations cooking by this means.

The finer aspects, or the art, of cooking arose with the Tigris based middle-eastern civilisations — the Assyrians, Persians and the Egyptians — but the earliest known cook-book is accredited to one Marcius Gravius Apicus (No, he did not invent gravy!) of 1st century A.D. Rome.

Sophistication of the culinary art implies that cooking technology exists, for most recipes demand precise control of cooking heat and duration. From the 17th century onward, cooking in closed range became more and more accepted; the open spits being reserved for large roasts. These early ranges were the forerunners of the modern relatively portable production-line produced ovens. Gas ovens were invented as early as 1830 but they were not generally accepted until the late 19th century. It was then that our modern concept of an oven was born.

Eating out became fashionable in the 19th century — many of the famous chefs lived at that time; Escoffier, Careme and Soyer come to mind. Here began commercial catering where people's livelihoods (and customers lives!) depend upon the chef's ability to produce cooked dishes as and when patrons demand them.

The oven developed as an enclosure wherein heat is trapped in order to provide a well-defined and predictable cooking environment. In a kitchen, heat lost can become uncomfortable and it is also expensive. Insulation was added to reduce heat loss.

Gas ovens were the first to have thermostats fitted so that the temperature was controlled — electric controls followed later. In the main, most ovens are either electric or gas, but hot air, steam and wood are used occasionally. Regardless of how they are heated, the conventional oven cooks by the provision of hot air that heats through the food via thermal

conduction. As most foods are poor conductors of heat, the cooking time and temperature must be chosen so that the inside is just cooked without burning the outside. This considerably restricts the speed at which food can be cooked.

## COOKING WITH RADIATION

Faster cooking is possible if the penetrating property of electromagnetic radiation is used to put heat directly into the food molecules, instead of relying upon thermal conductivity. As a general rule the longer the wavelength the deeper the direct penetration effect of a radiation. This fact combined with the energy absorbing properties of food (especially those containing water) leads to other ways to cook than by placing the food in a heated oven.

Infra-red heating would be the first to consider as a means for cooking with radiation. Special infrared heating elements and lamps, providing most of their radiated power in the 1-6 um wavelength region (see Fig. 1) can penetrate to depths of a few millimetres. They can, therefore, cook food a little faster and more uniformly. Infrared chicken roasters are a common sight in the instant food establishments.

The construction of an infrared oven is simple, and the principle of operation easily comprehended, for the only difference between it and a conventional electric oven is that the heating elements must radiate onto the food and be of different design.

If radiation with a longer wavelength is employed, the heating effect penetrates deeper giving more uniform heating with a subsequent reduction in cooking time. Moving across the Fig. 1. chart we see that the next useable longer wavelength radiation is centimetre or microwave energy. (There is a technological gap between the far infrared and microwaves – no high-power, inexpensive, generators exist). At this wavelength, 12 cm is commonly used (2450 MHz), penetration averages out at around 3 cm, so most foods are heated truly from within. Penetration depends upon the food being cooked – in sponge it will penetrate 8 cm whereas in steak only 3 cm.

The technology needed to build a microwave oven is more in the realm of a radio engineer than the handyman, for the generation and control of UHF radiation requires a special electronic oscillator (called a magnetron) and knowledge of waveguide techniques.

## PRINCIPLES OF MICROWAVE HEATING

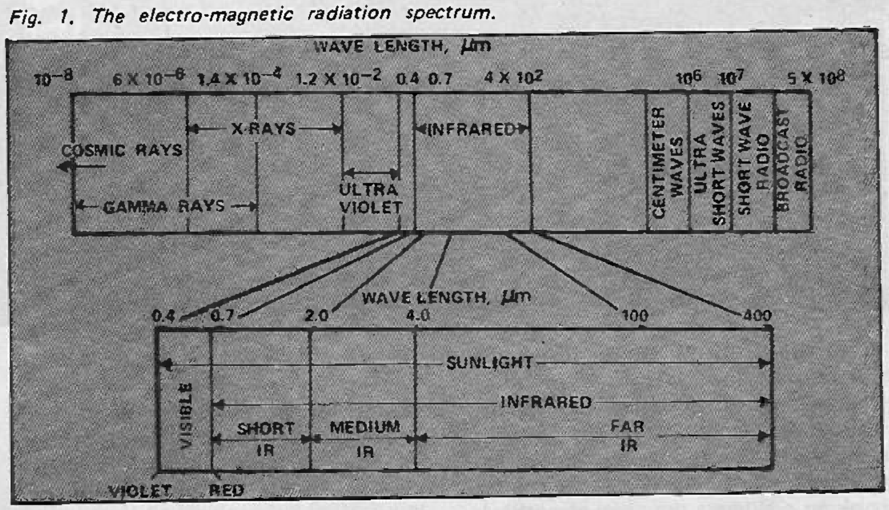
In order to understand microwave heating let us first consider heating of a dielectric material (food is such) using radio frequency ac current.

Plates formed on each side of the material form a capacitor, as shown in Fig. 2, with a dielectric in the gap. The quantity of power dissipated in the dielectric when energised by the source is related to the square of the applied voltage, the frequency of the source, the dielectric constant and the loss angle of the material. Loss angle is the slight phase-angle difference existing between the actual phase angle (which is close to 90° but not exactly so) and 90° – its value reflects the energy dissipated in the non-perfect dielectric.

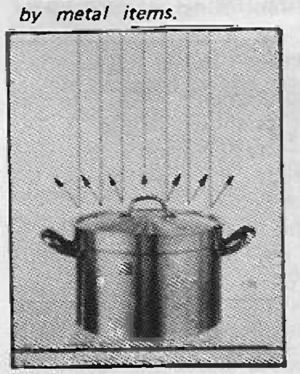
The important feature of dielectric heating is that the power absorbed by the dielectric materials depends on the dielectric constant of the material and this is usually high when the thermal conductivity is low. Hence this method will uniformly heat materials that will not respond well to conductive heating.

Basic relationships show that more power is dissipated as the frequency rises, and this logically leads to the use of the highest frequency possible that has a wavelength consistent with the

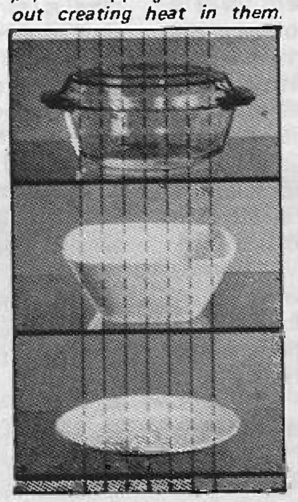
*Fig. 1. The electro-magnetic radiation spectrum.*



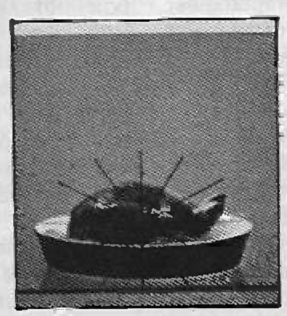

*Microwaves are reflected by metal items.*



*Microwave pass through such items as glass, china, high density plastics and paper wrappings – without creating heat in them.*



*Microwaves are absorbed by most types of food to varying degrees dependent on the cellular structure of the food. If we place food on a cool china plate and place it in a microwave oven the food becomes hot whilst the plate remains cool enough to be removed using a cloth.*



# COOKING BY MICROWAVES

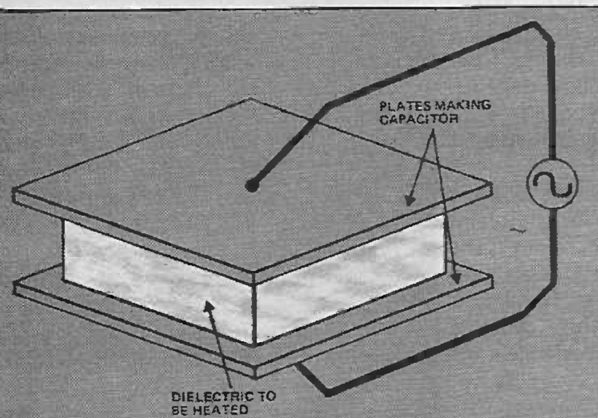



*Fig. 2. In R.F. dielectric heating, metal plates plus the dielectric material form a capacitor.*

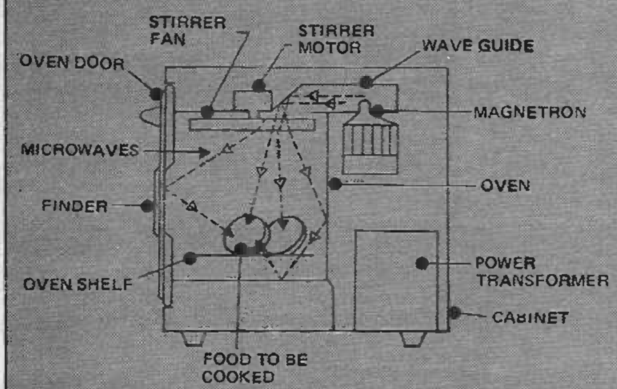



*Fig. 3. Cross-section of a typical microwave cooking oven.*

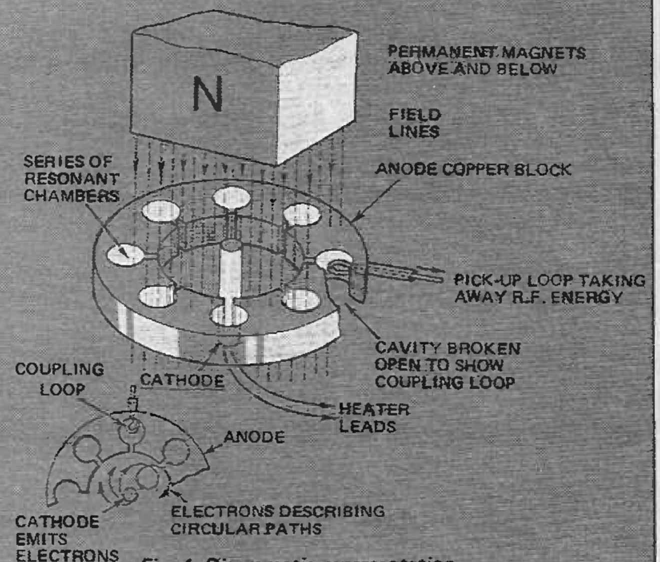



*Fig. 4. Diagramatic representation of the magnetron structure.*

size of the food. Microwaves. At radio frequencies the food size is much smaller than the wavelength, so the source can be coupled merely with the metal plates but this is neither convenient nor the most efficient for cooking. When the wavelength is comparable with object dimensions it is necessary to use waveguide techniques to couple to the food. This requirement slightly complicates the design of a microwave oven, for it is necessary to design the cooking cavity as part of the waveguide system.

The design of the cavity of a microwave oven is reasonably critical but a simple and economic enclosure can be made using a metal-lined rectangular box of approximate dimensions. This forms a resonant cavity into which the food is placed. The output of the microwave oscillator could be coupled directly into this but it is more usual to employ a short length of rectangular waveguide so that the oscillator valve can be placed behind the oven.

In telecommunication transmission, waveguides and cavities must be carefully designed to ensure that they operate only in specific modes. In an oven, however, it is, in fact, advantageous to have multi-mode operation for this liberates more power. The oven cavity, being many times larger than the wavelength, supports many modes providing numerous paths for the radiation to enter the food.

The walls and floor are made of metal in order to reflect the radiation. This is further aided by a metal fan that rotates in the roof of the oven, in front of the waveguide output. This creates a rotating microwave reflector that bounces the radiation around. Usually the fan, called a mode stirrer, is covered by a plastic cover and cannot be seen.

These requirements lead to an arrangement as shown in Fig. 3. The magnetron – its operation is described later – feeds the cavity via the cross-over waveguide.

Bearing the basic fundamentals in mind, we see that cooking in a microwave oven requires a different approach to that used in a normal oven. Firstly, any metal food container would upset the resonance of the cavity, detuning the system dramatically. Because of this, food is cooked in paper, glass or plastic dishes. The lower the dielectric constant of the container, the colder it stays. For example, air has a dielectric constant of 1, paper 2 to 3 and glass to 5 to 10. Water has a particularly high constant of 80, so it gets much hotter than the container it rests in (until conduction transfer takes effect). This is the reason why food heats so readily – it is mainly composed of water.

As nothing gets hotter than the food, materials used for constructing the oven need only be able to withstand a temperature a little hotter than the boiling point of water. Construction can, therefore, be very light, if desired, even being made entirely of plastic with a thin metal lining. For more detail of the use of microwave ovens refer to the books listed at the end of this article.

Let us now look at the magnetron valve in more details.

## THE MAGNETRON OSCILLATOR

Until the late 1940's there was no device available that could generate

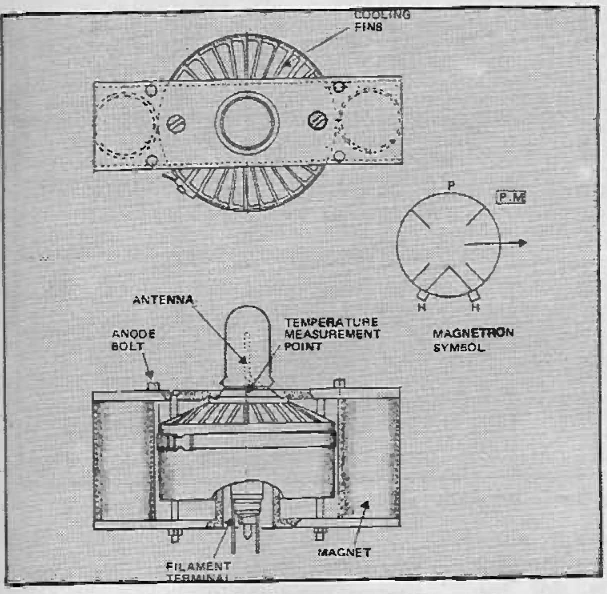



*Fig. 5. 2M90 magnetron used in 1300W Sharp oven.*

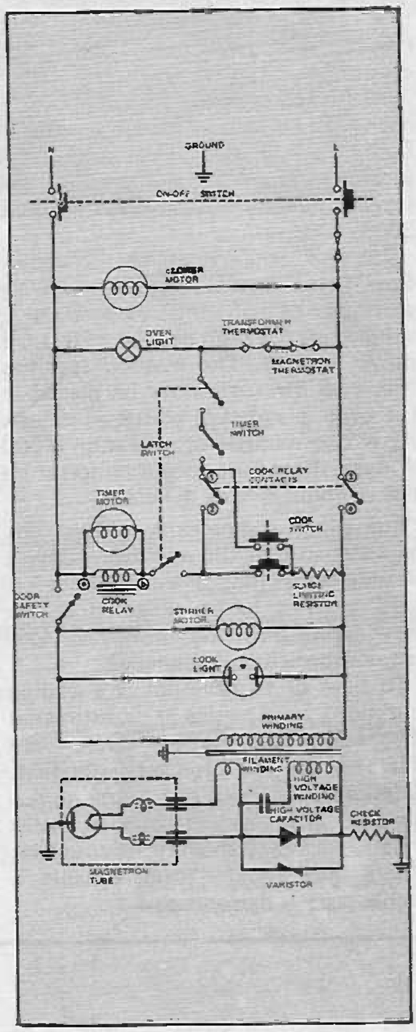



*Fig. 6. Simplified schematic wiring diagram of a Sharp oven.*

large-power microwave signals in the kilowatt region. Radar, which relies on the transmission of high power pulses was responsible for the development of a cheap oscillator just before 1945. As the valve combines the operation of electrons in a magnetic field it was called a magnetron. By 1945 the Raytheon Corporation of the United States had developed the first microwave oven.

The action of the magnetron is most easily understood by first considering the physical structure which is shown in Fig. 4. A copper anode, having circular cavities surrounds a central cathode which encloses a robust heater. Permanent magnets provide a magnetic field that passes through the anode and reaction space, running parallel to the cathode. One cavity has a pick-up loop to take out the microwave oscillations. The whole unit is evacuated.

In the absence of the magnetic field, electrons emitted from the heated cathode pass across to the anode because of the high anode voltage: this is the operation of a normal vacuum-tube diode. With the field applied, however, the electrons are forced to move in small, tight, circular paths on the way to the anode and, in doing so, set up microwave oscillations in each of the circular cavities. In essence, each cavity is a tuned L,C circuit, the inductance being a single turn of copper and the gap the capacitance. It is not necessary to collect power from all cavities as they operate together. In the practical device cooling fins are added to aid the dissipation of losses in the anode.

There are many shapes and sizes of magnetron but those used in ovens are similar to that outlined in Fig. 5. Air is forced up through the fins to further aid cooling.

The efficiency of magnetrons varies from 30 to 70 percent. It depends very much on the field strength, anode to cathode voltage and the impedance presented to it by the load. The unit shown in Fig. 5. can deliver 1750 W into a matched load, but in oven applications where optimum matching is not always obtained, its output power drops to 1300 W. The anode voltage is 1750 Vdc, anode current 675 mA and the cathode is heated by a 40 A, 4 V heater. Maximum dissipation is 2 kW hence the need for an efficient cooling system when the magnetron is loaded.

Other sizes in use include a smaller 600 W unit and a larger 2200 W. Oven efficiencies overall are typically 50 percent. That is, the figures quoted above need to be doubled to arrive at the approximate electrical consumption. This apparent inefficiency can be misleading for, compared with a conventional oven, they, in fact, use less power for a given cooking task as the cooking time is much less and there is less waste of heat in the oven itself.

## THE PRACTICAL MICROWAVE OVEN

The layout of the microwave oven is largely dictated by the magnetron and the cooking cavity. Other bulky components needed are the high voltage transformer and rectifier bridge, the filament transformer, a blower to cool the magnetron and a timing switch.

A number of safeguards and protective devices are required to obtain safe reliable operation. In all, the complete internal wiring adds up to be a small system. The schematic of a Sharp Model R-6500 600 W oven is given in Fig. 6.

Upon closure of the door, a whole series of switches and relays go into action to ensure that the door is closed, that the magnetron heater is up to temperature and that the blower and mode stirrer are going — before full high-tension is applied to the anode of the magnetron. The timer then runs, automatically cutting off the system in correct sequence after the required duration.

Both the magnetron and the main transformer are thermostated to cut them off if their temperature rises above preset limits: the magnetron temperature must not exceed 110°C. A door switch is important for two reasons. Firstly, because an open door detunes the system and, secondly, because close proximity to the microwaves can be dangerous.

When handling the microwave oven the manufacturer recommends that it is not knocked as this might reduce the magnetic field of the magnetron, resulting in lowered output. It is wise to keep a glass of water in the oven to act as a load in the event of it being turned on when empty, a condition that can damage the magnetron due to reflected energy arriving back in the output antenna.

When not actually cooking, most ovens can be left on standby — this is useful for commercial catering where seconds count, but it can be expensive, for the standby consumption is about 300 W.

Due to the relatively complex operation and possibly variable performance of the magnetron a simple test has been devised to test the power output. The method specifies that two litres of water be placed in the oven in a glass or plastic container. After two minutes of operation a 600 W oven should produce a temperature rise of about 8°C in the water.

For all this complexity it must not be assumed that the microwave device is unreliable. Indeed a life of several hard years is to be expected at the very least. Servicing, however, does require specialised knowledge.

To have or to have not is a leading question. In America it is estimated that 60 percent of ovens are microwave — this type is bought first. Sales there ran to around $3 \times 10^6$ units a year in recent years. Prices go as low as $190. Understandably in countries where they are not as fashionable, a higher price is demanded.

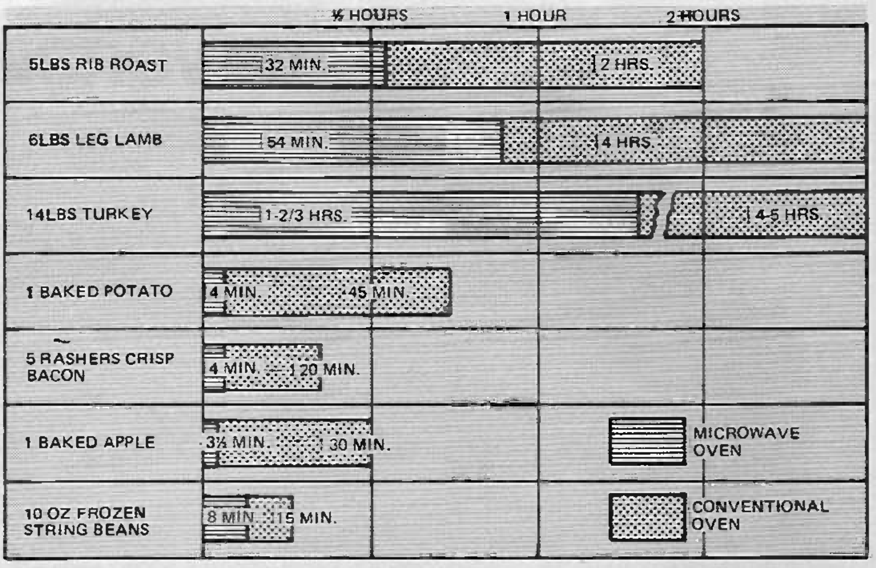



*Fig. 7. Comparative cooking times of 600W microwave and conventional oven.*

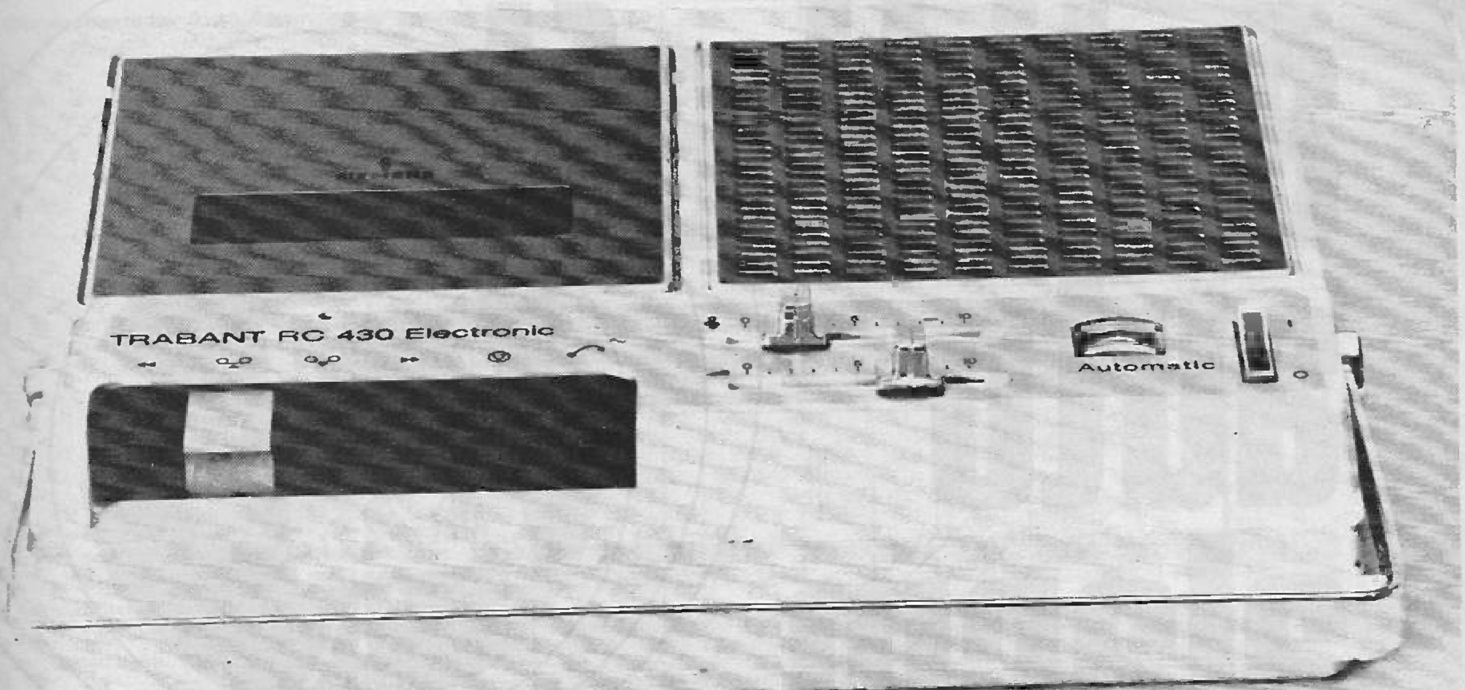
It is not entirely correct to compare them with normal ovens, for the cooking time is so much faster (see Fig. 7) that a commercial situation may well warrant their cost.

Finally, it can be seen that microwave heating is not confined to cooking food. It has been used to vulcanise rubber, dry adhesive coatings on rubber and plastic strips, and to dry glue on the spines of books — 15 seconds compared with several hours for air-dried binders. In essence, microwave heating is applicable whenever the material has poor thermal conductivity.

## SUGGESTED READING:

"A Guide to Microwave Catering" — L. Napleton, Northwood Publications, London, 1971.

Continuing issues of "Microwave News", Philips Electrical Industries.




# SIEMENS TRABANT

electronics TODAY INTERNATIONAL **product test**

The RC403 is a compact cassette portable recorder for battery or mains operation and for use with C60 or C90 tape cassettes. It has a number of extra but useful facilities such as automatic or manual recording level control, auto monitor switch-off at end of tape, a combined battery voltage check and recording level meter and rapid tape rewind in either direction. All control, including tape cassette ejection, is by means of push buttons, the only variable controls being one for record or replay level and one for tone control both of which are slider type. Manual or automatic recording level is selected by a switch.

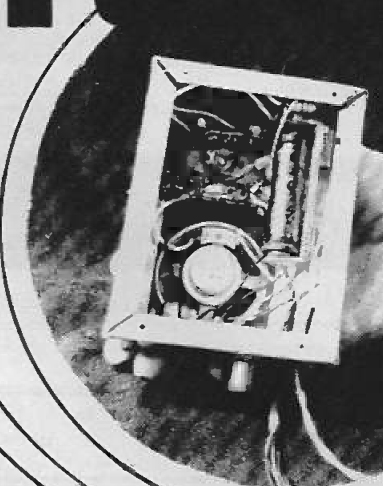
Playback is made via two built-in loudspeakers, one for mid-range and bass and the other for the treble range both being powered from a 0.7W push-pull output stage. The recorder is very attractively styled, being housed in a white plastic case with contrasting coloured control buttons, chrome trim and a chrome carrying handle. The tape drive mechanism is operated from a centrifugally regulated motor with a belt drive to an integrated flywheel/capstan. The RC 430 is not supplied with tape but accessories include a dynamic microphone and stand adaptor so the microphone can be held or situated on a table. The recorder can be stopped or started in either the record or replay mode from a switch on the microphone. There is also a mains supply lead with plug and a DIN plug cable for connection to external equipment.

*continued on page 18*

### MANUFACTURERS SPECIFICATION

| | |
|---|---|
| Power Supply: | 6V (4 SP11 cells) or 230V 50Hz mains |
| Output: | 0.7 watts |
| Inputs: | Mic and external amplifier or radio etc. |
| Output: | For external amplifier |
| Frequency Response: | 80 – 10,000Hz |
| Tape Speed: | 1 7/8 ips (standard cassette speed) |
| Wow and Flutter: | 0.3% rms |
| Signal and Noise: | 45dB |
| Price UK: | £41.09 inc. VAT |
| UK Distributors: | Interconti Electronics Limited. Albany House, Petty France, London, S.W.1. |

# anti-theft auto alarm



THIS UNIT OPERATES from the vehicle supply, and is a real deterrent to the unauthorised opening or taking away of the car to which it is fitted. This, in itself, can scare away an intruder as it is clear that some electronic means of protection is present. When this tone is heard, the owner has a few seconds in which to operate a master switch, the location of which is known only to himself. A pre-set control allows this "delay" to be adjusted. If the master switch is not operated, after this delay interval the vehicle horn is switched on -- and closing the door, with the would-be thief either in the car or outside, will not stop the horn.

The whole circuit is quite straightforward and for convenience can be divided into three sections. The *whole* circuit is shown in Fig. 1.

## 1. CAR WIRING

This is shown in thick lines in Fig. 1. The 12V accumulator supplies the interior light, which has its integral switch S1. The two door switches, S2 and S3, are in parallel, and operate automatically when a door is opened. None of this wiring has to be disturbed in any way.

## 2. TONE OSCILLATOR

Apart from its deterrent effect, this warns the legitimate user that the circuit is in operation. He can thus remember to operate the master switch S4 if he wishes to keep the door open, or to use the interior light during darkness. The tone also reminds him that the circuit is in use, when getting out of the car.

Q1 and Q2 form the tone oscillator, operating a small speaker contained in the case. When S2 or S3 are closed by a door being open, 12V appear across the interior light, and leads A (negative) and B (positive) make this available for the oscillator.

## 3. HORN SOUNDER

Q3 and Q4 operate in this part of the circuit. When the 12V supply is present across A and B, C2 commences to charge through R2 and RV1. When Q3 conducts, the base of Q4 is moved positive, causing Q4 to conduct, and drawing on the relay. Relay contacts RC1 close. The relay is then energised from circuit B (positive) through R5 and circuit C (chassis and negative) so that the relay remains locked on even if the door is closed, opening S2 or S3. The second set of contacts RC2 completes the circuit to the horn.

If the door is closed before the relay locks on, the charging of C2 ceases, and the horn is not operated. This is necessary in order that the owner can get out of the car without starting the sequence.

When S4 is opened, this prevents the warning circuit working. The delay is adjustable, as mentioned, but RV1 can be set to give about 5 seconds or so. S4 is placed in an inconspicuous position, under the parcel shelf, or elsewhere, and it is unlikely that anyone could find this switch and operate it in the short time available.

The rectifier in the negative lead A is required because if the horn sounded when the owner entered the car, and the door were closed opening S2 or S3, and S4 were also opened, a path for positive supply would then exist through the interior light itself, holding on the relay. (Eg., with S1, S2 or S3 closed, circuit point A is negative. But with S1, S2 or S3 open, point A is positive via the lamp filament.)

## TAG BOARD

The components are assembled on a tag board about 2 x 1½in. as in Fig. 2. Emitter E, Base B and Collector C wires of the transistors are identified from the underside views in Fig. 2.

Solder on two short flexible leads from C Q3 and C Q4, to take to the relay coil tags. Also provide leads from E Q1 and R2, to take to RV1. Further short leads are necessary for the speaker, and rectifier negative.

## CASE

A 5 x 4 x 2in. metal box is suitable. A 1¾in. or 2in. hole is cut or punched for the speaker. This hole is covered on the inside with fabric or perforated metal to protect the speaker.

Mount the tagboard with long bolts and spacers or extra nuts so that it is clear of the metal. RV1 is fitted to one end of the case.

The small tag strip holding the rectifier and forming a junction point for S4 and B leads is bolted to the side of the case.

Components for Auto Alarm.

| | | | | |
|---|---|---|---|---|
| | Resistor | | | |
| R1 | " | 680k | 5% | ¼W |
| R2 | " | 27k | " | " |
| R3 | " | 10k | " | " |
| R4 | " | 100 ohm | " | ½W |
| R5 | " | 82 ohm | " | " |
| RV1 | | 100k linear carbon pot. | | |
| | Capacitor | | | |
| C1 | " | 1000pF tubular. | | |
| C2 | " | 100μF 15V electrolytic. | | |
| Q1 | | AC128 | | |
| Q2 | | BC108 | | |
| Q3 | | BC107 | | |
| Q4 | | BC107 | | |
| D1 | | GJ5M or other 1A 25V or higher rating. | | |

**Relay, 100 ohm surplus type; S4 Toggle on/off switch; 75 ohm or similar 2in. to 2½in. speaker; Box 5 x 4 x 2in. (Home Radio, Mitcham, universal chassis box suitable; Tag board, tag strip, coloured flex, etc; Small knob.**

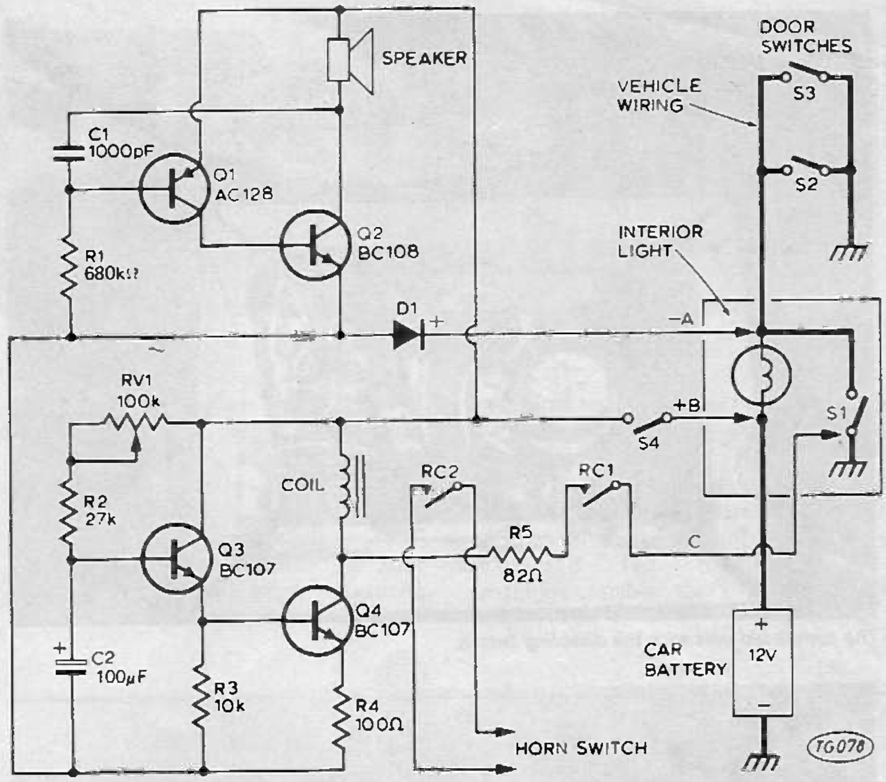



*Fig. 1. Complete circuit of the Auto Alarm*

## EXTERNAL LEADS

These are most readily arranged by using three separate cords – a twin for the horn switch circuit, a twin for the master switch S4, and a 3-core for the circuits A, B and C. The latter is best made from thin single bell wire, or thin 7/0076 coloured flex, as this will result in a thin cord which can be inconspicuously run up to the interior light. Black is best for A (negative), with red for B (positive) and green or some other colour for chassis connection C. Chassis connection C could be taken to some other part of the vehicle chassis, but as it is available at S1, it is felt that the 3-core cord is more convenient.

## RELAY

This is bolted to the end of the case. Numerous other contacts will be found on some relays, especially surplus types. Only two sets of "On" contacts are needed. These close when the relay is energised. It should pull on at a current of about 30–40mA or so.

## VEHICLE CONNECTIONS

Figure 3 shows actual connections for the 850 Mini Saloon and this should prove of aid with other vehicles.

This switch is returned to the vehicle chassis by one of the fixing screws, so this forms a connecting point for lead C.

When S1 (or the door switches) is operated, this completes the circuit to A. The remaining contact of the lamp

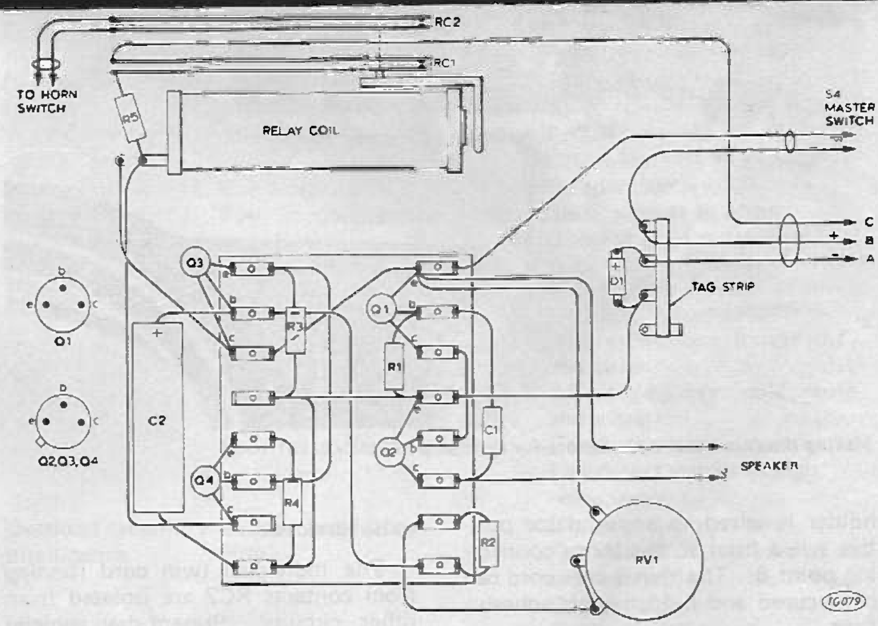



*Fig. 2. (Above) The component wiring.*

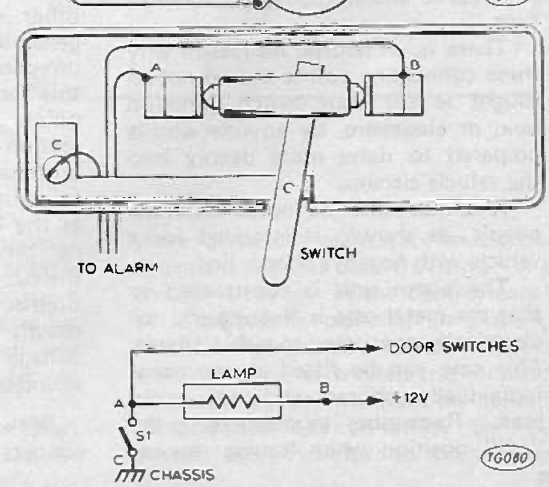
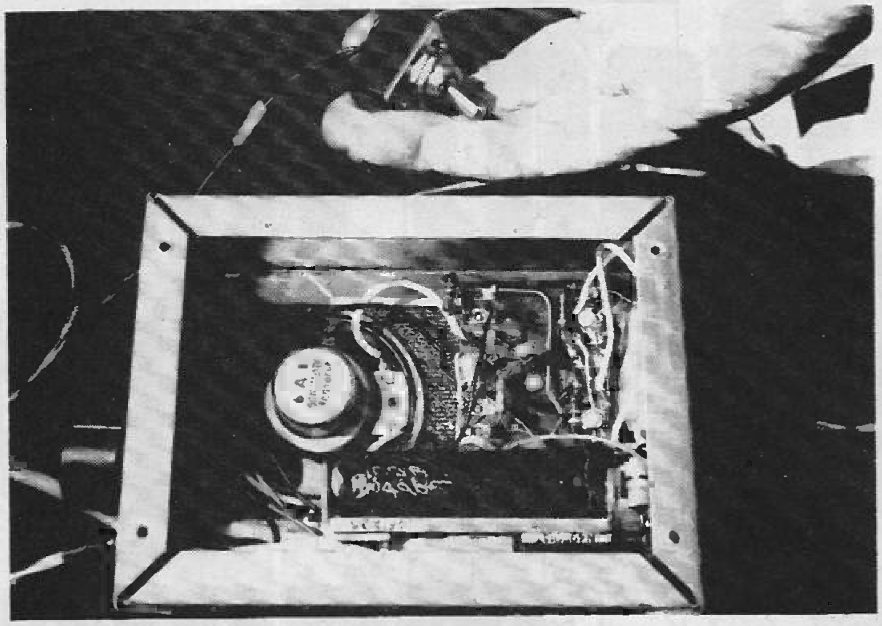
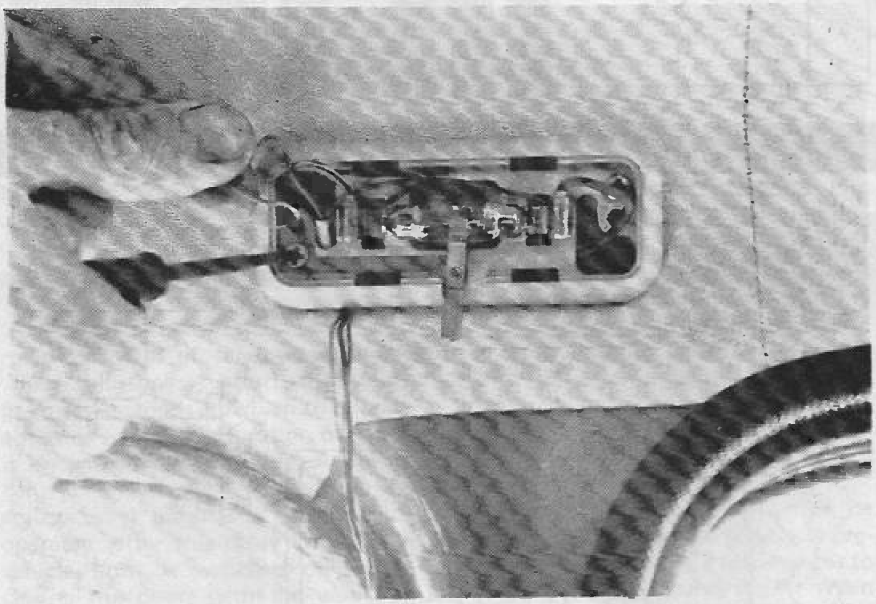



*Fig. 3. (Right) Guide to the interior light connections.*



*The completed unit with the disabling switch.*



*Making the connections to the interior light on a Mini.*

holder is wired to accumulator positive (via a fuse) so this forms connecting point B. The thin 3-core cord can be secured and hidden with adhesive tape.

There is, of course, no reason why these connecting points should not be sought at the door switch, junction box, or elsewhere, by anyone who is prepared to delve more deeply into the vehicle circuits.

It should also be noted that the circuit, as shown, is intended for a vehicle with negative chassis line.

The alarm unit is constructed so that the metal case is floating and not electrically connected to either circuit. This case can be fitted at any point individually chosen and not easily seen. Remember to place it in the "off" position when leaving the car to be serviced.

The individual twin cord running from contacts RC2 are isolated from other circuits. Present-day vehicles generally have a multi-purpose dip/direction-indicator/horn switch, and this forms a very awkward connecting point. However, the horn switch section is usually between one horn terminal and chassis. It is thus easy to run these leads to chassis and horn, at the horn. The correct horn terminal can be found, without following the circuits, with a meter or 12V lamp. Connect the meter or lamp from chassis to one horn terminal. If *no* voltage is shown when the horn is sounded, this is the correct terminal.

With a separate horn switch, merely connect these leads to its terminals.

# SIEMENS TRABANT

*continued from page 15*

The electronics are a mixture of discrete transistor and integrated circuitry, set out on a single printed circuit board and access to this and the tape drive motor and mechanism is gained by undoing four screws and removing the lower half of the case. There is a built-in mains power supply and the recorder will also operate from four SP11 cells housed in a recessed compartment in the lower section of the case.

## PERFORMANCE

For a small portable, the RC430 has a good performance and for the price, £41.09 inc. VAT, is good value for money, particularly in view of the inclusion of a quite good microphone and the features already mentioned. Recordings can be made directly via the microphone or from an external amplifier or radio tuner and replay can be made via an external amplifier with, I might add, very good reproduction indeed, particularly from prerecorded music cassettes.

The overall frequency response is substantially flat from 80 to 10,000Hz but the treble can be boosted, as is often necessary with cassette tape recordings, with the tone control. Signal to noise at 45dB relative to rated power output was comparable with that obtained from most cassette recorders of this nature and of course to specification.

The mechanical performance was very good indeed with a wow and flutter figure better than the quoted 0.3% (average for cassette portables without electronic motor control) and it has a fast and positive rewind. With some cassette machines rewind can not only be slow but may sometimes even stop as the tape nears the end, particularly on reverse rewind.

All in all, this is a handy portable suitable for all outdoor recording and interviews etc, for use in the car or caravan or as a music source because as it can be mains operated, its good quality performance lends itself for use with external amplifier and speaker system indoors. One final point, it is *not* suitable for use with chrome dioxide tapes but is designed for optimum performance with all other cassette low noise high output tapes. At the price the Siemens RC430 is a worthwhile proposition, particularly in view of its flexibility in use and accessories supplied. ●

# MAN & MACHINE

The human machine — will it ever be replaced entirely?

IN these times of increasing labour costs and available capital, the cry in industry is to replace labour by automation. For a while, back in the fifties, many people became alarmed at the then forecast capabilities of automation. It was portrayed as a demon that was slowly going to take over the human race. Such incidents as Schaffers "Robot", of the twenties, provided evidence for this line of thought, for "Robot", who could drive nails with a hammer, decided to do it on poor Schaffer's head.

Today we find that automatons are not much closer than they were then if we compare current performance attained with human capabilities. We do still regard automation as a worthwhile goal, but there is less panic about it overtaking us.

Upon reflection, now that we have experience with certain degrees of automation, it is not so bad a thing — machines appear unlikely to replace humans at everything. The experience has also revealed that automation usually requires an increased work-force, not a reduction. Reasons for this are that automation is economically acceptable, firstly, where a larger market (more labour in other ways) can be seen (and the costs of capital needed are therefore justified) and, secondly, where labour is so scarce that to automate is the only answer.

The most basic and relevant difference between the "its" and us at present are that we have been unable to give a chunk of hardware the ability to imagine and be intelligent. As far back as 1740, Lomethrie published writings on whether man is or is not a deterministic machine; in other words, given total knowledge of the human organism, can we predict the behaviour — is there a hidden factor never to be available to man? This question is unresolved.

Around the 1960's there was an upsurge in the idea of the intelligent machine — it always remains of course, but this period saw greater interest. The explosion of computer power and the almost ethereal rise of control theory into the higher levels of thought processes at that time aided visions of intelligent machines.

We view these ideas more soberly now. I am sure many people still believe in the possibility of man-made intelligence, but I feel their views are now tempered about the chances of real success in the near future.

It all boils down to the fact that computers — our most advanced machines — are good at some tasks — and the human at others. There is little overlap between the two. Each has a role. Somewhere in recent times a list of the relative abilities of each was devised. It is known as a Fitts List and is reproduced on this page.

Looking at this we see that even young children win hands down in many tasks. It is hard to envisage the machine replacing the human. We do not possess enough intelligence to know how to do it. (In fact, some things the human races do, show that we do not have ourselves in control!)

So with these thoughts in mind we should let machines do machine-capable tasks and men the more generalist aspects of existence. From the list it is clear that a man in a control-loop, say, at the control panel of a processing plant or an aircraft, must be regarded as a fallible machine who needs to be treated and serviced in certain ways to maintain the desired performance. His versatility can be pushed only so far to make him conform. ●

| | Machine | Man |
|---|---|---|
| Speed | Much superior | Lag 1 sec. |
| Power | Consistent at any level | 1500W for about 10 sec, 350 W for a few minutes, 150 W for continuous work over a day. |
| Consistency | Ideal for routine, repetition, precision | Not reliable — should be monitored by machine. |
| Complex activities | Multi-channel | Single channel. |
| Memory | Best for literal reproduction and short-term storage | Large store multiple access. Better for principles and strategies. |
| Reasoning | Good deductive | Good inductive. |
| Computation | Fast, accurate — poor at error correction | Slow, subject to error Good at error correction. |
| Input sensitivity | Some outside human senses, e.g. radioactivity | Wide range ($10^{12}$) and variety of stimuli dealt with by one unit, e.g. eye deals with relative location, movement and colour. |
| | Insensitive to extraneous | Affected by heat, cold, noise and vibration. |
| | Poor for pattern detection | Good at pattern detection. Can detect signals in high noise levels. |
| Overload reliability | Sudden breakdown | Graceful degradation. |
| Intelligence | None | Can deal with unpredicted and unpredictable. Can anticipate. |
| Manipulative abilities | Specific | Great versatility |

# INTERNATIONAL MUSIC SYNTHESIZERS

— designed and developed by Barry Wilkinson and Trevor Marshall

**eti** PROJECT 3600/4600

**This article is the first of a series that will describe the construction of two music synthesizers — the International 3600 and the International 4600.**

**The 3600 is a relatively inexpensive model that is basically designed as a portable, limited capability instrument for stage work. It does however offer a performance superior to most small synthesizers at present on the market.**

**The larger 4600 is a full scale unit. It uses the same electronics but has more modules, a programming patchboard and many additional features which make it more suitable for studio use.**

**The flexibility of both units, in particular the larger, allows individual constructors to tailor an instrument to their own requirements.**

EXPERIMENTATION in electronic music has been carried out since the earliest days of vacuum tube technology. One of the earliest pioneers in the field was B.F. Meisner who published the article "Design Considerations for a Versatile and simple Electronic Musical Instrument" in 1935. By the late 40's the electric piano and organ had become well established, but very few real advances were made. Even in the early 60's, the electronic-music studio consisted simply of a variety of tape recorders, filters and other devices which were used to modify the sounds of conventional instruments.

The first real breakthrough came in 1965 with the introduction of the first commercial Voltage Controlled Electronic Music Synthesizer designed by Robert Moog. Since then development has been rapid indeed, and in just eight years synthesizers have become one of the most versatile and flexible of electronic musical instruments. Today they are used extensively by both popular and classical musicians to create new and exciting sounds.

Very soon after Moogs' revolutionary voltage-control concepts were introduced, the use of a digital computer was proposed as a means of extending the basic system and providing real time control of synthesizer operation. During recent years much work has been pioneered on digitally generated "computer music". This concept however, despite its incredible potential, is still in its infancy, and dependent for advancement on further technological developments.

The basic genius of voltage control is its conceptual simplicity, and although the method of implementation has changed much since 1965, the concept itself has not. Moog proposed that the basic sound sources, such as electronic oscillators and random noise generators, be electronically generated and that these sources be modified in amplitude and frequency by other electronic devices. The resultant signals would then be processed conventionally with reverberation and multi-track tape techniques. This in itself was not revolutionary but Moog proposed that all these generation and modification functions be VOLTAGE CONTROLLED. He then designed such circuitry — and the Voltage Controlled Music era had begun.

Voltage control implies that the oscillator frequencies (and/or harmonic structure), the gains of mixer/amplifiers and the cut-off frequencies of timbral-determining filters could all be changed by a control voltage. It need not be a constant voltage, indeed one oscillator could control another's frequency which in turn could control another, and so on. The complexity of sounds thus generated defy classical description, some of them are subjectively very pleasant, some are not, but they *all* are creative. Conventional sounds that can be specified in terms of amplitude, frequency and timbre can now be artificially produced and, if desirable, the specifications can be changed to "improve" the basic effect.

It was indeed fortunate that much research had been previously conducted into the structure of conventional instrumental sounds and consequently musicians such as Walter Carlos (responsible for the recording "Switched on Bach") were able to speedily demonstrate the versatility of the voltage controlled synthesizer and thus ensure its widespread acceptance.

## DESIGN PHILOSOPHY

The International Voltage Controlled Synthesizer has been developed as a "state of the art" system. Extensive use has been made of digital techniques and CMOS has been used as the primary logic family.

No compromises have been made that would hinder expansion of the system to keep pace with the ingenuity or finances of its owner. The basic modules have been selected so that the unit will be just as suited to studio use as it is for a live "on-stage environment."

In the larger unit, a 484 point patchboard system is used to facilitate the rapid selection of various equipment configurations.

Separate headphone and main output level controls and switches are provided to ease on-stage cueing of the device.

All control voltages and generated waveforms have the same limits (zero and +5 volts), so that control and signal voltages are directly interchangeable.

The unit requires only a 240 volt ac supply (the synthesizer is not critically dependent on either the voltage or frequency of this supply), and an external power amplifier and speaker for normal operation. The headphone output will supply in excess of one watt. This is adequate to drive a small monitor speaker if an external amplifier is not available. Any dc offset voltages inherent in the circuitry are nulled in the initial construction. The keyboard intervals are also tuned during initial construction *and will not require readjustment* unless the unit is unusually roughly handled.

## VOLTAGE CONTROLLED OSCILLATORS (VCO)

Four VCO's are provided in the 4600 unit, three in the 3600 unit. Each VCO is switchable to the output waveforms listed below:—

Sine, Triangular, Sawtooth, Reverse sawtooth, Pulse wave (including square-wave with variable mark-space ratio).

The fourth oscillator (provided in the larger unit) can provide two simultaneous outputs. In all oscillators, great care has been taken in the design to ensure purity of waveform.

Each oscillator covers the frequency spectrum 0.1 Hz to 10 kHz in eight ranges. There are LO, 32ft, 16ft, 8ft, 4ft, 2ft, 1ft and ½ft. The seven top ranges are tuned exactly one octave apart and the "LO" range is provided to generate sub-audio frequencies for special effects.

The oscillators are completely linear over the upper 10 octaves of their range and several fed from the one control voltage will "track" accurately over the entire keyboard.

## CONTROLLER

The model 4600 has a Controller unit which provides an adjustable dc voltage and an ac coupled modulation level control.

In the model 3600 this facility is replaced by a Modulation unit which has the outputs of Oscillator 3, the transient generator and the noise generator available as modulation sources. Each function has a separate level control.

## THE KEYBOARD CONTROLLER

The keyboard is fully digital. Forty-eight separate voltages are generated as a four octave x 12 semitone matrix. These are normally adjusted to produce an equal tempered scale. The output voltages (and hence oscillator pitch) have negligible temperature dependence nor will they change significantly as the unit ages.

This method used for voltage generation is completely different from, and its performance superior to, all other keyboard controllers details of which have been previously published. Most other keyboard controllers generate a linear pattern of voltages which are then converted to the required semitone values in an exponential converter, or by using an exponentially controlled oscillator. These exponential converters usually rely upon the characteristics of a transistor emitter base junction in which the temperature drift is substantial, resulting in the semitone interval having to be retuned every time the unit is played.

On the larger unit only, a fully variable "glide" (or "portamento") facility is provided, with a companion on/off switch. An "Absolute Pitch" control allows continuous transposition over several semitones.

The keyboard also generates a trigger output which goes from -7 to +7 volts whenever a key is pressed and returns to -7 volts when the key is released. A sample and hold circuit acts as a "memory" to maintain the control output voltage at the value of the last key pressed. (This enables the oscillators to maintain the last pitch selected until another key is pressed).

## VOLTAGE CONTROLLED FILTERS

Two VCFs are provided in the large unit and one in the smaller unit. They provide three separate filter characteristics: lowpass, bandpass and highpass. The cut-off slopes in all modes are 40 dB decade, using easily reproduced two-pole active filters. The cutoff frequencies are a linear function of control voltage over a minimum range of 50 Hz to 5 kHz. Thus a filter and an oscillator fed from the keyboard (or, of course, any other control source) will track each other automatically. This also, is a feature not usually availabe in commercial equipment.

The filter characteristics do not change with a change in control voltage, that is, the Q factor is independent of frequency.

## NOISE SOURCE

This generator produces an almost purely Gaussian white noise. A digital shift register with feedback is used to generate a pseudo-random binary sequence $2^{18}$ bits long (262 144 random points). Every second, about 30 000 are generated and these are integrated (filtered) to provide a random noise signal.

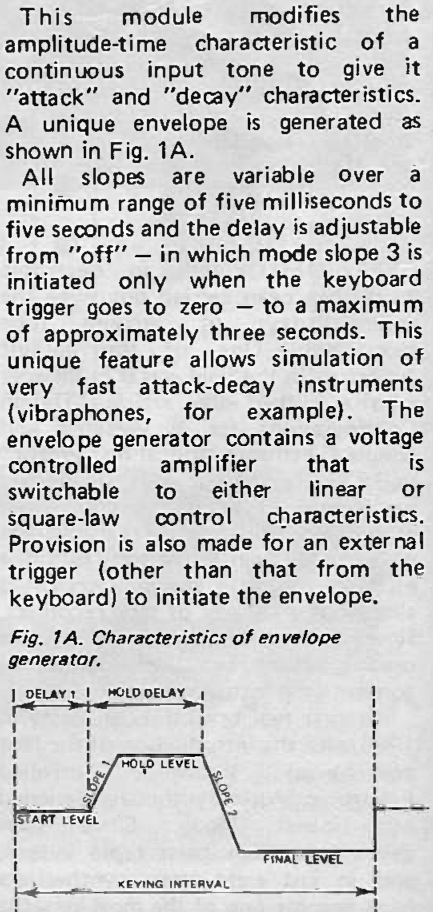
The spectral purity of this white noise is much better than those methods which use a Zener diode or noisy transistor as the source. In addition no component selection or tuning procedure is required.

## THE ENVELOPE GENERATOR

This module modifies the amplitude-time characteristic of a continuous input tone to give it "attack" and "decay" characteristics. A unique envelope is generated as shown in Fig. 1A.

All slopes are variable over a minimum range of five milliseconds to five seconds and the delay is adjustable from "off" — in which mode slope 3 is initiated only when the keyboard trigger goes to zero — to a maximum of approximately three seconds. This unique feature allows simulation of very fast attack-decay instruments (vibraphones, for example). The envelope generator contains a voltage controlled amplifier that is switchable to either linear or square-law control characteristics. Provision is also made for an external trigger (other than that from the keyboard) to initiate the envelope.

*Fig. 1A. Characteristics of envelope generator.*



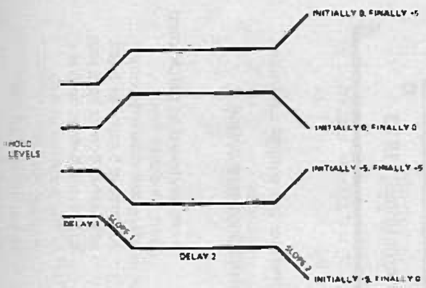



*Fig. 2A.*

### THE TRANSIENT GENERATOR

Two types of transient generator are used, type A and type B. Type A is primarily used to modulate the keyboard output voltage, such that transients can be generated on oscillator and filter outputs during the formation of a single note. The International 3600 has only one transient generator which is of type A. The 4600 has two generators, one type A known as TRANSIENT 2, and one type B known as TRANSIENT 1.

The type B generator is basically similar to the envelope controller but does not include a voltage controlled amplifier. Hence its output is a dc waveform and not a modulated envelope as in the envelope generator. This unit may be used as an envelope control if required in conjunction with one of the ring modulators.

The type A transient generator is a unique feature, as an infinite variety of output functions are available.

When a trigger is received, nothing happens until a preset delay (delay) has elapsed. Slope is then initiated until the hold level is reached. Delay 2 is initiated on the completion of delay 1 after which Slope 2 begins and continues until the final preset level is reached.

For example if the following settings are made:—

| | |
|---|---|
| START LEVEL | 0 |
| DELAY 1 | 2 |
| SLOPE 1 | 2 |
| HOLD LEVEL | +5 |
| HOLD DELAY | 2 |
| SLOPE 2 | 2 |
| FINAL LEVEL | -2 |

then the keyboard output voltage when a key is pressed would be modified as shown in Fig. 2A.

Such an output would, when applied to an oscillator, cause it to commence the note in tune, raise it say one octave higher and then drop one octave lower. This frequency modulation of the oscillator can create some very interesting and pleasing sounds. The number of semitones or octaves shifted up or down is uniform over the entire keyboard range, the design range is plus or minus two octaves. Usually however this signal would be used to control a VCF (in the bandpass mode) being fed from a complex waveform (considerable harmonic content). Upon pressing a key the above waveform would cause the filter to commence at the timbre as selected by the VCF "tune" control, sweep up to the higher overtones and finish on the lower components.

Although this diagram may be typical, the start hold and final levels may be varied as required.

This timbral change allows the simulation of instruments such as the piano as well as the generation of new sounds which are quite different to those from basic instruments.

### AMPLIFIERS 1 AND 2

These units are fitted to the International 4600 only and are in effect voltage controlled amplifiers which serve a dual function as selected by a mode switch.

When the "Ring modulator" mode is selected the unit effectively multiplies the two input functions. Thus if either is zero, the output is zero. If one input is a dc control voltage varying between zero and +5 volts then the output will consist of the other input function with an amplitude linearly controlled by the dc control voltage.

The other mode merely ac couples the input and in this mode the unit may be used as a general purpose amplifier.

### MIXERS

Five mixers are used in the 4600, all are direct coupled and hence may be used for control voltages or signals.

Mixers 1 to 3 are used solely for mixing the outputs of oscillators 1 to 4 and there is no access to their inputs. Mixers 4 and 5 have two inputs each, their outputs however may be paralleled to provide one four-input mixer.

A special mixing arrangement is provided in the 3600. This will be described in detail in a later article.

### JOYSTICK CONTROL

A joystick is fitted to the model 4600. It is accessible via the patch board and may be used to control, for example, two oscillators simultaneously, but differentially.

### OUTPUT EQUALIZER AND VOLUME CONTROL

The output section is identical in the 3600 and 4600 with the exception that inputs are via the patchboard in the 4600 but are hardwired in the 3600.

All signals are passed through a five section equalizer. This signal is then mixed with the same signal after passing through a spring reverberation unit. The reverberation control acts like a crossfader allowing the proportions of direct signal and reverberation to be controlled. The combined signal is then passed to an output amplifier and to a headphone amplifier each of which has an independent level control. A switch is provided to switch off output if required.

### NEXT MONTH

This series will continue next month when we will describe the construction of the keyboard, the oscillators, and the power supply. ●

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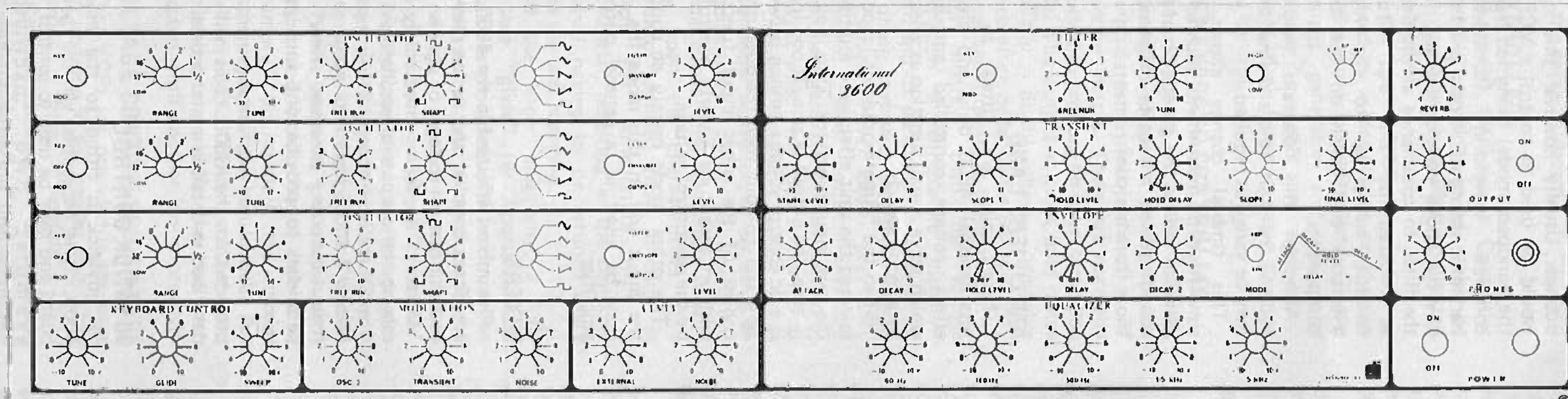
## SPECIFICATION INTERNATIONAL 3600 SYNTHESIZER

| | |
|---|---|
| **KEYBOARD** | |
| No of Keys | 48 (F to E monophonic) |
| Controls: | |
| Tuning | ±2 semitones |
| Glide | adjustable rate 0 to 10 seconds |
| Sweep | allows manual sweep, up or down, from the keyed note over any selected span. |
| **MODULATION** | |
| Provides source of modulation for oscillators other than from the keyboard. | |
| Controls: | |
| Oscillator 3 | selects Osc. 3 as source |
| Transient | selects transient generator as source. |
| Noise | Selects output of internal white noise generator as source. |
| **OSCILLATORS** | |
| Number | 3 |
| Controls: | |
| Input | selects keyboard or modulation unit as source of control off position provided. |
| Range | provides 7 ranges from ½' to 32' plus low frequency (0.01 Hz) special effects source. |
| Tune | tuning range of ±½ octave |
| Free Run | internal voltage source which manually adjusts oscillator over full range. |
| Shape | varies mark/space ratio of square wave output. |
| Waveform | selects sine, triangular, sawtooth, inverted sawtooth or square wave as output. |
| Output Switch | routes signal to filter envelope or direct to output stage. |
| Output Level | adjusts output level |
| **LEVEL** | |
| Provides control of noise and exteral input signals to input of the filter mixer. | |
| Controls: | |
| External | varies level of external signal from 50 mV to 2 V |
| Noise | controls level of noise to filter. |
| **FILTER** | |
| Type | active, voltage controlled. |
| Inputs | mixed signals from oscillators and level unit. |
| Cut off Rate | 24 dB/octave |
| Control Range | greater than 2 decades |
| Controls: | |
| Control Source | Keyboard, modulation or off (manual) by front panel switch |
| Free Run | provides manual control of filter cutoff |
| Tune | tunes filter to control source |
| High/Low | selects tuning range. |
| Mode switch | selects high pass, band pass or low pass filter characteristic. |
| **ENVELOPE** | |
| (see specification of model 4600) | |
| Input | direct from keyboard |
| Output | to modulation level control |

**EQUALIZER, REVERBERATION, OUTPUT and PHONES** same as model 4600.






## SPECIFICATION INTERNATIONAL 4600 SYNTHESIZER

| | |
|---|---|
| **KEYBOARD** | |
| Number of Keys | 48 (F to E monophonic) |
| Outputs to Patchboard | |
| Trigger | −7 V to +7 transition at each key press. Trigger is inhibited if more than one key is pressed. |
| Analogue (direct) | 0 to +5 volt |
| Analogue (modulated) | 9 to +15 volts |
| Inputs | transient generator No 2 patchboard. |
| Controls: | |
| Sweep | allows manual sweep, up or down from the keyed note over any selected span. |
| Glide | adjustable rate 0-10 seconds switchable. |
| **MIXERS 1, 2 and 3** | |
| Inputs | 5 (one from each oscillator output) each with independant level controls. |
| Level control | adjusts output level from each mixer. |
| Overload | Indicated by LED lamp. |
| Output | to patchboard. |
| **MIXERS 4 and 5** | |
| Inputs | two each from patchboard |
| Input levels | individually adjustable |
| Output level | adjustable with overload indication |
| Output | to patchboard. |
| **TRANSIENT 1** | |
| Basically similar to Envelope Generator but voltage controlled amplifier is omitted. Hold level may be adjusted to match keyboard output. | |
| **TRANSIENT 2** | |
| Trigger Input | from keyboard or patchboard |
| Levels | start hold and final adjustable 0 to +5 volts. |
| Delay 1 | adjustable 5 msec to 5 sec |
| Slopes 1 & 2 | adjustable 5 msec to 5 sec |
| Hold Delay | adjustable 5 msec to 5 sec or for duration of key contact closure. |
| Outputs | to patchboard and to keyboard control. |

| | |
|---|---|
| Transient | selects direct modulation of keyboard by transient generator No. 2. |
| Modulation | allows patchboard input to modulate keyboard to maximum of ±2 octaves. |
| Tune | tunes keyboard ±2 semitones. |

**OSCILLATORS**

| | |
|---|---|
| Number | 4 (oscillator 4 has dual output) |
| Controls: | |
| Range | provides seven ranges from ½' to 32' plus low frequency (0.01 Hz) special effects source. |
| Tune | tuning range of ±½ octave |
| Free Run | internal voltage source manually adjusts oscillator over full range. |
| Shape | varies mark/space ratio of square wave output. |
| Waveform | selects sine, triangular sawtooth, inverted sawtooth or square wave as output second output of oscillator 4 provides noise or controller output. |

**NOISE**
provides pink or white noise direct to the patchboard. Noise is also selectable by oscillator 4, second output.

**CONTROLLER**

| | |
|---|---|
| Input | from patchboard |
| Output | to patchboard and output switch of oscillator 4. |
| Controls: | |
| Level | sets dc level, that is, centre frequency of controlled oscillator. |
| Modulation | controls level of modulation source selected via patchboard. |

**FILTERS 1 and 2**

| | |
|---|---|
| Type | active, voltage controlled |
| Inputs | 0-5 volt signal from patchboard |
| | 0-5 volt control from patchboard |
| Controls. | |
| Mode | selects high pass, bandpass or lowpass filter characteristics |
| High/low | selects tuning range |
| Tune | tunes filter to control source. |
| Level | controls output level with overload indication. |
| Cutoff Rate | 24 dB/octave |
| Control Range | 2 decades |

**AMPLIFIERS 1 and 2**

| | |
|---|---|
| Type | voltage controlled, ac or dc coupled |
| Input Signal | via patchboard (0 to + 5 volts) |
| Input Control | via patchboard (0 to + 5 volts) |
| Mode | |
| Mod | dc coupled functions as voltage controlled amp |
| Amp | ac coupled function as ring modulator |
| Output | to patchboard level controlled and with overload indication. |

**ENVELOPE**

| | |
|---|---|
| Input Trigger | from patchboard or keyboard direct. |
| Attack Decay 1 and Decay 2. | all adjustable from 5 msec to 5 sec. |
| Hold Level | adjustable 0-5 volts. |
| Delay | adjustable 5 msec to 5 sec, or duration of key contact closure as selected. |
| Control Mode | linear or exponential voltage controlled amplifier with a range of 60 dB. |
| Output | to patchboard. |

**EXPONENTIAL CONVERTER**

| | |
|---|---|
| Input | 0 to + 5 volt from patchboard. |
| Output | 0 to + 5 volt to patchboard. |

converts linear input to exponential output.

**JOY STICK**
2-axis control of any two functions linear or exponential output as required 0 to + 5 V.

**EXTERNAL SIGNALS**

| | |
|---|---|
| Number of Inputs | 2 signals 50 mV to 2 V |
| Input Impedance | 10 k ohms. |

**OUTPUT EQUALIZER**

| | |
|---|---|
| Number of Stages | 5 |
| Centre Frequencies | 60 Hz, 160 Hz, 500 Hz, 1.5 kHz. |
| Type | Active filter |
| Range of Adjustment | > ±10 dB. |

**REVERBERATION UNIT**

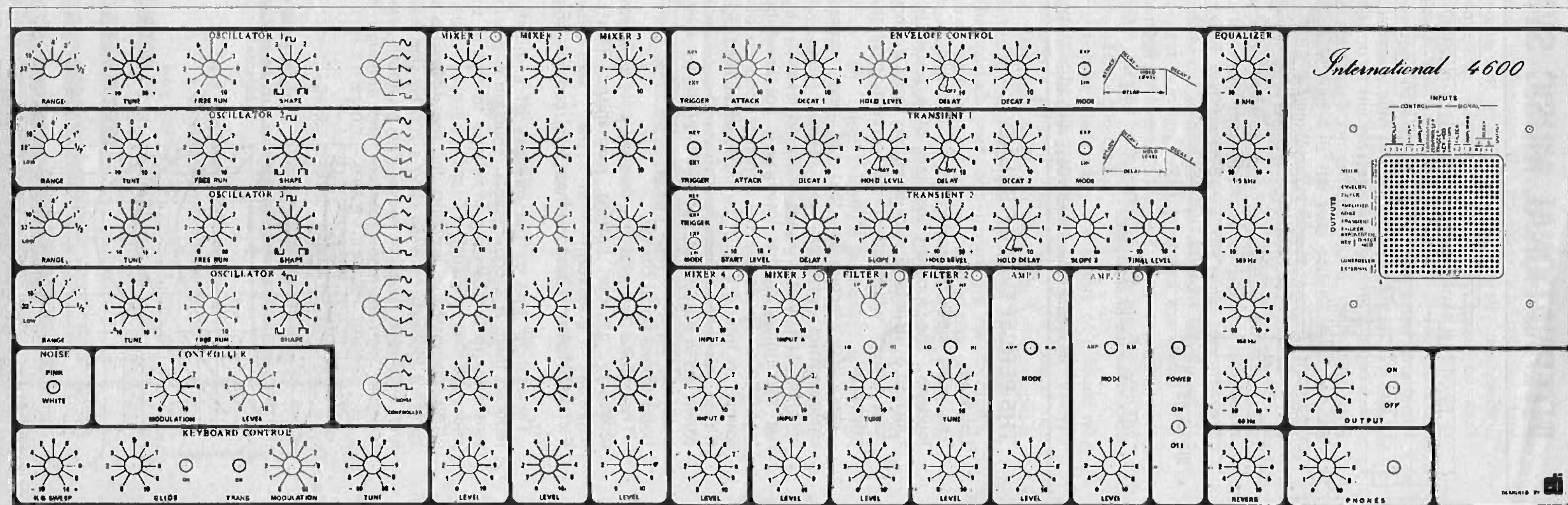
| | |
|---|---|
| Type | multi-spring |
| Output | adjustable mix-fader from full reverb. to original sound without reverb. |

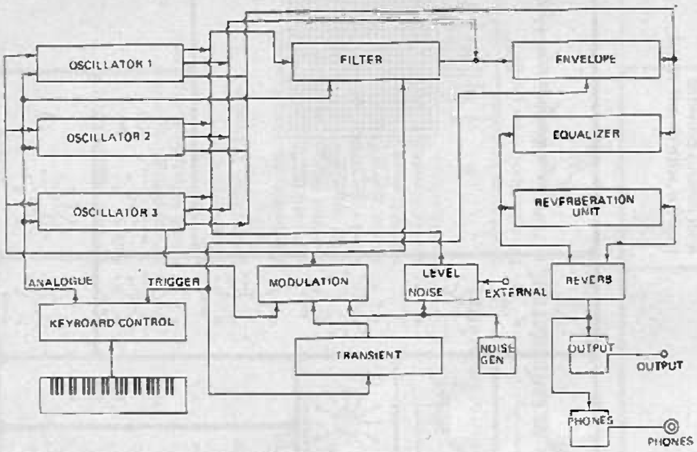
**PHONE OUTPUT**

| | |
|---|---|
| Power Output | 1 watt |
| Load Impedance | 8 ohms |
| Output Level | control provided. |

**SIGNAL OUTPUT**

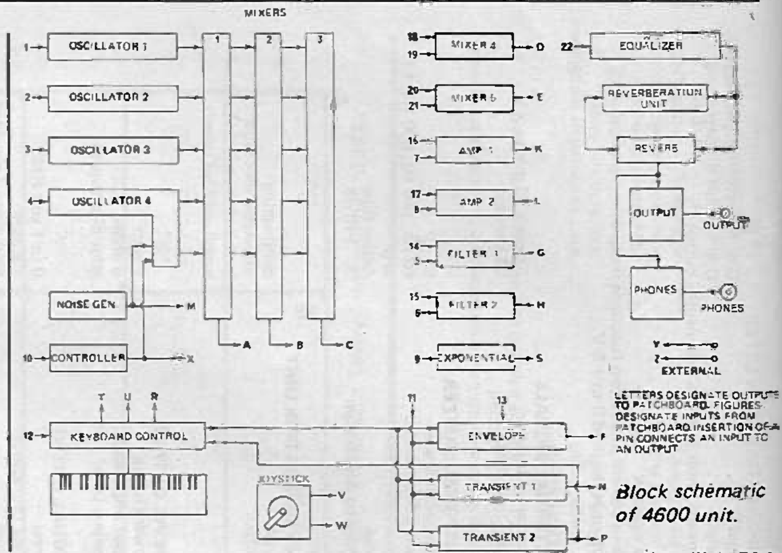
| | |
|---|---|
| Level | 0 to 1 volt RMS |
| Load Impedance | 1 k ohm |
| Level | level control provided together with on/off switch. |






*Block schematic of 3600 unit.*






*Block schematic of 4600 unit.*



## THE PERCEPTION OF SOUND

**Loudness**

The most basic characteristic of a sound is its loudness. The apparent loudness of a sound is a function of its intensity, or level, but there are three main factors which affect our perception of that intensity.

The first factor is that of the response characteristics of the ear. Our hearing can accommodate a huge range of sound intensity, but our perception of that intensity is not linear but logarithmic. To double the apparent loudness of a source, its intensity must be increased at least eight times. This is the reason for the use of exponential converters in the synthesizer, they are there to change a *linear* signal change to a *subjectively linear* (logarithmic) signal change.

The second factor is the *frequency – dependent sensitivity* of our hearing mechanism. This is expressed graphically in the well-known Fletcher-Munson equal loudness level contours (Fig. 1).

These show that as the intensity of a sound is reduced there is a considerable reduction in hearing sensitivity in the bass region relative to that in the midrange.

This phenomenon accounts for the difference in apparent loudness between (say) a 200 Hz sine wave and a 200 Hz sawtooth wave. The sawtooth wave contains high harmonic content and although its overtones are not the same intensity as the fundamental, our hearing is more sensitive to them. As the effective loudness of a complex sound is dependent on the algebraic sum of the loudnesses of each component of that sound, we hear the sawtooth as being much "louder" than the sine wave, although their amplitudes may be identical.

The third factor affecting perceived loudness is the *duration* of the sound. It takes a finite time for our hearing to react to the presence of a sound and to analyse its characteristics.

Sounds which are very short in duration (.01 seconds, or 10 milliseconds) are perceived as being of lower loudness than they actually are (in addition very little pitch information is gathered from such a short burst of sound). Further, when the ears have become conditioned to the presence of a sound there is a gradual drop in apparent loudness.

When we synthesize very short attack transients we must allow for this lack of sensitivity and this means a much larger overshoot is required than would otherwise seem necessary.

**Absolute Pitch** Although perception of pitch is not precisely logarithmic, an exponential characteristic comes fairly close to producing equal subjective pitch change from a linear input. (Fig. 3.).

**Musical Pitch** Two tones whose frequencies differ by a factor of 2 are said to be *one octave apart.* This octave is usually divided into twelve increments, known as semitones which differ from each other by

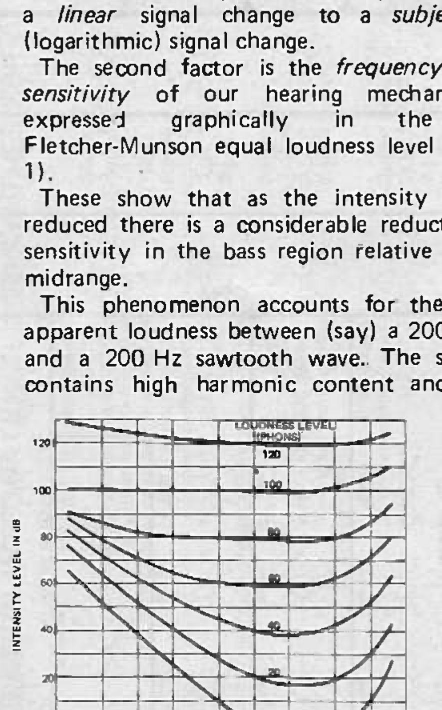



*Fig. 1. Equal loudness contours (Fletcher-Munson)*

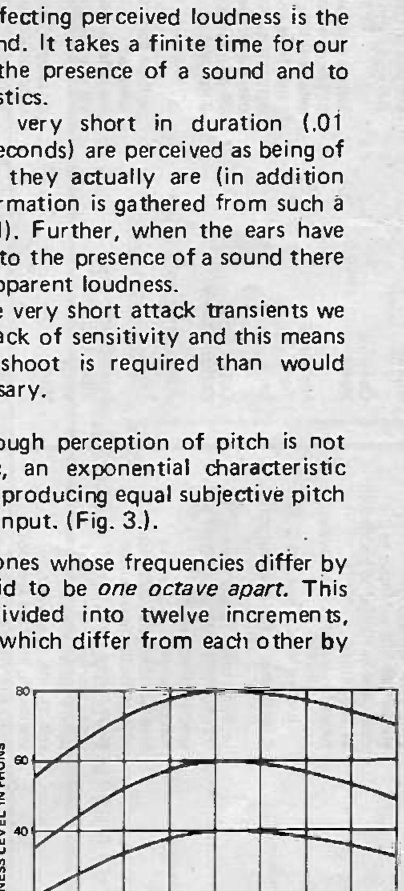



*Fig. 2. Relation between loudness level and duration time.*

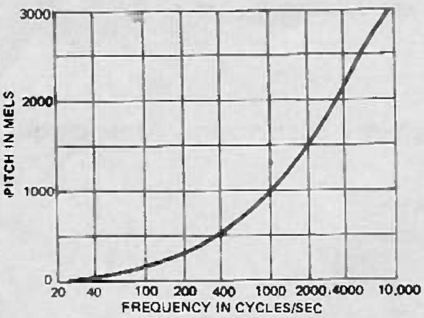



*Fig. 3.* PITCH Vs. FREQUENCY

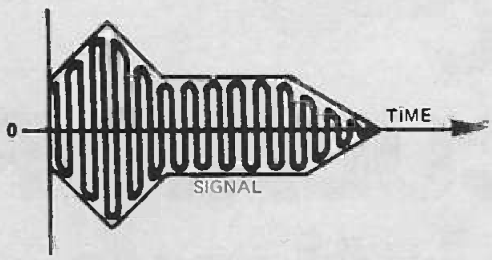



*Fig. 4 The 'envelope' of a sound is the variation of its intensity with time.*

a factor of the twelth root of 2 (12√≈1.059463).

Such a musical scale is termed "equal-tempered" and is used for all keyboard instruments. There are also several so called "just" or "true" scales that are based on harmonic structure. A musical textbook should be consulted if further information on these scales is required.

All previous voltage controlled synthesizer designs have been able to obtain "equal tempered" intervals only. The digital keyboard incorporates in both the synthesizers described in this series *can* be adjusted to these "just" scales, this should only be considered by a competent musician and is generally unnecessary. Frequencies of the fundamental tones of each semitone in the effective musical scale are shown in Table 1.

**Envelope** The envelope of a sound is the variation of its intensity with time as shown in Fig. 4. The rate of variation of the envelope is very slow compared with the time variation of the sound itself (sine wave shown in Fig. 4 is the base sound.) Although the envelope is symmetrical about zero it is usually referred to in terms of the modulus.

**Timbre** The timbre of a musical sound is the characteristic that makes it possible to distinguish between two tones having the same intensity and fundamental frequency, but different waveforms. It expresses our ability to recognize the sound of a violin as different from that of a trumpet, even though the two instruments may be playing with the same pitch and loudness.

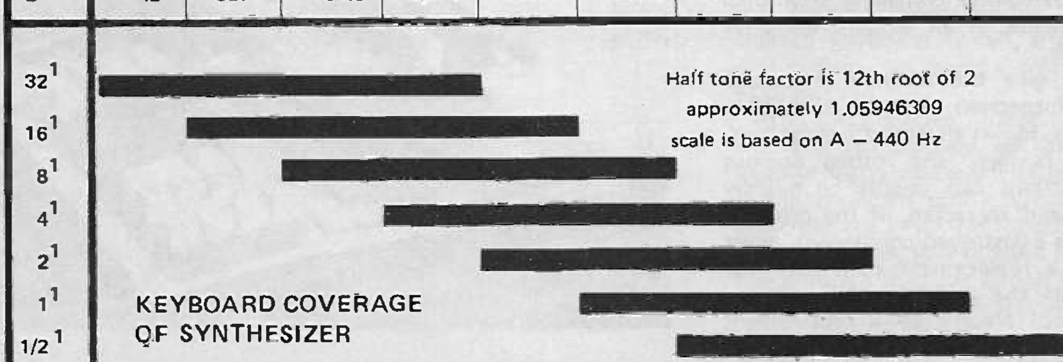
To describe analytically the timbre of a sound we must specify the frequencies of all the constituent components (termed "Partials") of that sound and their respective envelopes. (This group of envelopes is referred to as the 'Complex Envelope' of a sound).

The partials may not necessarily be harmonic, indeed many natural sounds have partials which are inharmonic. For example, the frequency of the fifteenth overtone of middle C on a piano, is greater than sixteen times the fundamental frequency (middle C).

With an electronically generated waveform, however, the overtones are direct multiples of the fundamental, and so a miscellany of different oscillators must often be used when attempting to simulate the sound of a "natural instrument". ●

**TABLE 1** **THE TEMPERED SCALE**

| | OCT 1 | OCT 2 | OCT 3 | OCT 4 | OCT 5 | OCT 6 | OCT 7 | OCT 8 | OCT 9 | OCT 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| F | 21.8 | 43.7 | 87.3 | 174.6 | 349.2 | 698.5 | 1396.9 | 2793.8 | 5587.7 | 11175.3 |
| F# | 23.1 | 46.2 | 92.5 | 185 | 370 | 740 | 1480 | 2960 | 5920 | 11839.8 |
| G | 24.5 | 49 | 98 | 196 | 392 | 784 | 1568 | 3136 | 6272 | 12543.9 |
| G# | 26.0 | 51.9 | 103.8 | 207.7 | 415.3 | 830.6 | 1661.2 | 3322.4 | 6645 | 13289.8 |
| A | 27.5 | 55 | 110 | 220 | 440 | 880 | 1760 | 3520 | 7040 | 14080 |
| A# | 29.1 | 58.3 | 116.5 | 233.1 | 466.2 | 932.3 | 1864.7 | 3729.3 | 7458.6 | 14917.2 |
| B | 30.9 | 61.7 | 123.5 | 246.9 | 493.9 | 987.8 | 1975.5 | 3951.1 | 7902.1 | 15604.3 |
| C | 32.7 | 65.4 | 130.8 | 261.6 | 523.3 | 1046.5 | 2093 | 4186 | 8372 | 16744 |
| C# | 34.6 | 69.3 | 138.6 | 277.2 | 554.4 | 1108.7 | 2217.5 | 4435 | 8869.8 | 17739.7 |
| D | 36.7 | 73.4 | 146.8 | 293.7 | 587.3 | 1174.7 | 2349.3 | 4698.6 | 9397.3 | 18794.5 |
| D# | 38.9 | 77.8 | 155.6 | 311.1 | 622.3 | 1244.5 | 2489.7 | 4978 | 9956.1 | 19912.1 |
| E | 41.2 | 82.4 | 164.8 | 329.6 | 659.3 | 1318.5 | 2637 | 5274 | 10548.1 | 21096.2 |



Despite their apparent complexity, electronic calculators are relatively easy to repair. This article shows you how.

by Patrick N. Godding.
Micro Instruments & Telemetry Systems Inc. Albuquerque, New Mexico.

# ELECTRONIC CALCULATORS -how to repair them

SMALL electronic calculators require more sophisticated trouble-shooting techniques than those used to service many other kinds of electronic equipment. In addition to the basic procedures used in discrete transistor circuits, calculator servicing requires some understanding of integrated circuits and logic.

To service a defective calculator you will need a pencil-type soldering iron (30 to 40 watts at about 700° F), small screwdrivers, solder remover, sharp knife, diagonal cutters, and needle-nose pliers. A multimeter and oscilloscope are the only mandatory pieces of test equipment, but a frequency counter can come in handy at times. Some problems can be solved with no test equipment at all or possibly a multimeter alone.

## BASIC REPAIRS

A few general procedures will save lots of time and reduce the prospects of inadvertently damaging additional components in an already defective machine.

First, give the machine a careful visual inspection. Burned or bubbly resistors, blown electrolytic capacitors, solder bridges, and other obvious malfunctions can usually be quickly found and corrected. If the problem involves a destroyed component, never install a replacement part until the cause of the problem is found and corrected. Never use a replacement

## CHART OF COMMON FAULTS

| SYMPTOM | TROUBLESHOOTING PROCEDURE |
|---|---|
| No display or entry | Check: Power Supply<br>Clear Circuit<br>Clock Circuit |
| Overflow works but no display | Check: Power Supply<br>LSI Chips (output) |
| Display always on or off | Check: Display Digit Driver<br>Soldering<br>LSI Chips (output) |
| Segment always on or off | Check: Segment Drivers<br>Soldering<br>LSI Chips (output) |
| More than one segment or display device on | Check: Soldering |
| Keyboard Switch failure | Check: Keyboard<br>LSI Chips (input) |
| All digits on or off | Check: Power Supply |
| Random segments on | Check: LSI Chips (output)<br>Segment Drivers |
| Function key failure | Check: LSI Chips (arithmetic) |
| Entries not possible (display normal) | Check: Keyboard<br>LSI Chips |
| Constant function always on | Check: Constant Circuit and Switch<br>LSI Chip (input) |
| Display flickers | Check: Power Supply |
| Error indicator on and no entries possible | Check: Power Supply |

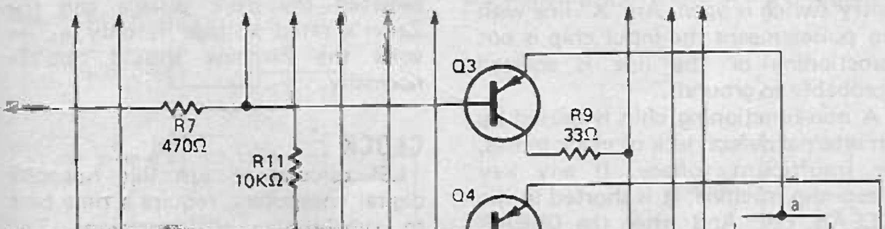



*Fig. 1 Partial schematic of driver circuit for a seven-segment digital readout device. In the problem discussed in the text, the "C" segment of the readout does not light.*

component of poorer quality than the original one.

Next time it may be necessary to turn on a calculator to find the symptoms of a problem, never leave a malfunctioning machine on longer than necessary.

A good example is the overflow indicator. If the readout devices don't light, multiply two numbers whose answer will give an overflow indication. If the "Error" signal is displayed, the problem is not in the input, control, or arithmetic sections of the machine. In this manner possible causes of the trouble can be quickly identified.

Finally, if a thorough visual inspection fails to reveal the problem, begin troubleshooting at the point of the improper indication and work backwards, checking each associated component. If more than one problem exists, begin with the simplest, since it frequently leads to the major trouble spot. Here's a typical example:

In Fig. 1, the "C" segment in the display fails to light. Follow these steps to isolate the trouble:

(1) Check continuity from the "C" segment to Q5's emitter.

(2) Check Q5's base for proper incoming signal.

(3) Check Q5

(4) Check R15

(5) Check R14

To cover as many troubleshooting procedures as possible, the remainder of this article is divided into subsections describing the problems and symptoms common to the various calculators. The accompanying troubleshooting chart summarizes this material and helps pinpoint many trouble sources.

### KEYBOARD

The keyboard consists of an array of switches either connected directly to the input LSI chip or connected as a matrix which is scanned by the input chip. The latter technique is usually used in multi-chip calculators.

In the direct input technique such as the one shown in Fig. 2, the 0-9 digit keys are connected to a diode matrix which provides a BCD (Binary Coded Decimal) output. An open or shorted diode will cause incorrect segments on the display readouts to light. A shorted keyboard switch, either digit or function, can cause a great variety of symptoms.

After eliminating other possible causes of the problem, disconnect the keyboard and make entries manually. If this cures the problem, check each switch in the keyboard for continuity. If only one key fails to work properly, the problem is in the switch itself, an open line to the input section, or the

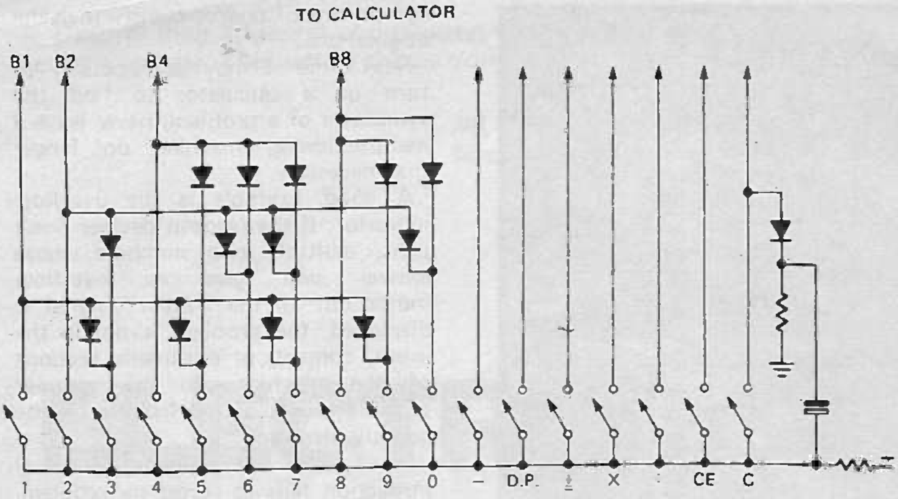



*Fig. 2 — Direct-input keyboard with the 0 to 9 keys connected through a diode matrix that provides a BCD output. An open or shorted diode causes errors in readout indication.*

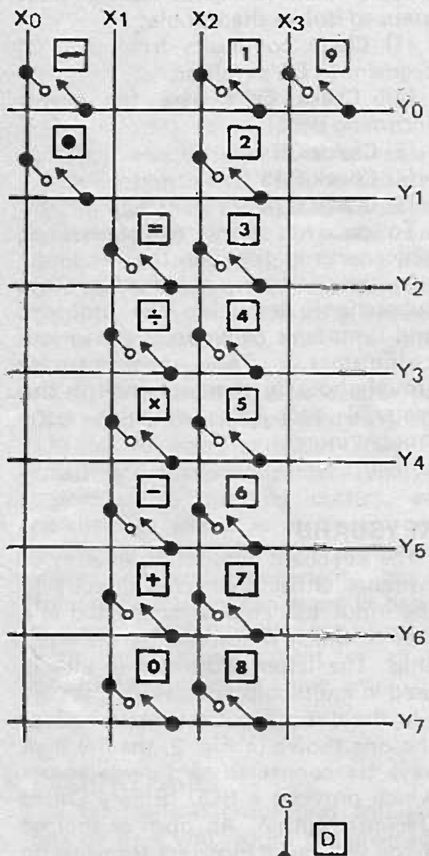



*Fig. 3. Matrix-type keyboard. Closing a key places pulses on the associated 'Y' line.*

input LSI chip. Another possible cause of trouble is input lines from the keyboard shorted to one another. This problem can be identified by using a multimeter to check for shorts.

In most multi-chip calculators, the input chip scans a keyboard matrix to detect entries. In Fig. 3 (the keyboard matrix for a MITS 816 desk calculator) the "X" lines are pulsed by the input chip and the "Y" lines are at a negative voltage. When a key is depressed there will be pulses on both lines common to the closed switch.

The pulses can be seen on an oscilloscope, and, if not present, the problem is either in the keyboard or the input chip. If pulses are seen on a "Y" line with no keyboard entry, that particular line is shorted to one of the "X" lines at the keyboard, the input chip, or one of the interconnection lines. When no pulses appear on the "Y" line with a correct entry, the entry switch is open. An "X" line with no pulses means the input chip is not functioning or the line is shorted (probably to ground).

A non-functioning chip is caused by an internal defect, lack of clock pulses, or insufficient voltage. If any key clears the machine, it is shorted to the CLEAR key. And when the CLEAR ENTRY key is shorted the normal display will be on, but the machine will not accept entries.

## POWER SUPPLY

Usually consisting of a transformer and one or more bridge rectifiers, some of which are regulated by either a transistor or Zener diode, the power supply is the major source of trouble in most electronic equipment. A close visual inspection is important when a malfunction points to the power supply. A shorted supply line, for example, is indicated by a burned or bubbly series resistor and is usually caused by a shorted regulator, shorted filter capacitor, or possibly a short in the LSI circuitry.

LSI chips generally require two regulated voltages, $V_{GG}$ and $V_{DD}$. $V_{GG}$ is a higher voltage and if open or shorted, no entries are possible and an error indication is sometimes seen. With a missing $V_{DD}$, there is no display and no entries can be made.

If the regulated driver voltage is shorted or open, the condition of the driver circuitry determines whether the display readouts are all on or off. But one of these malfunctions will be present.

Both gas discharge and electro-fluorescent readout devices require a large anode voltage with the latter also requiring a filament voltage. The entire display is off when either of these voltages is open or shorted.

Fig. 4 shows a typical power supply for a calculator using electro-fluorescent readout devices. The +45V is anode voltage and the -2.4V is for the filaments. The -26V and -14V are $V_{GG}$ and $V_{DD}$ respectively, and the -5V is the segment and digit drive bias voltage. If a bridge rectifier diode shorts, the output voltage is reduced. If an input filter capacitor opens, the readout tubes receive unfiltered voltage and appear to flicker on and off. If a capacitor shorts, its voltage line is at zero potential and one or more bridge rectifier diodes may short.

Three of the lines shown in Fig. 4 use Zener diodes for regulation. If the output is open, the total current in the line goes through the Zener diode, sometimes causing it to short and the series resistor to bubble. The voltage line reads higher than normal if the Zener opens. This may or may not cause a problem, and if the difference between the peak voltage and the Zener's rated voltage is only a few volts the machine should operate normally.

## CLOCK

LSI calculators, just like full-scale digital computers, require a time base to synchronize all operations. The timing pulse generator is called the clock, and it usually consists of an astable or free-running multivibrator or series of gates in a TTL chip. The former approach is used mainly in LSI calculators that require a two-phase clock. These are usually one or two-chip machines. If the timing pulses are missing at the output of the clock IC, the problem is either in the chip or its associated components, or the chip's supply voltage is open or shorted.

A representative TTL clock is shown in Fig. 5. The clock pulses are fed through a buffer for interfacing with

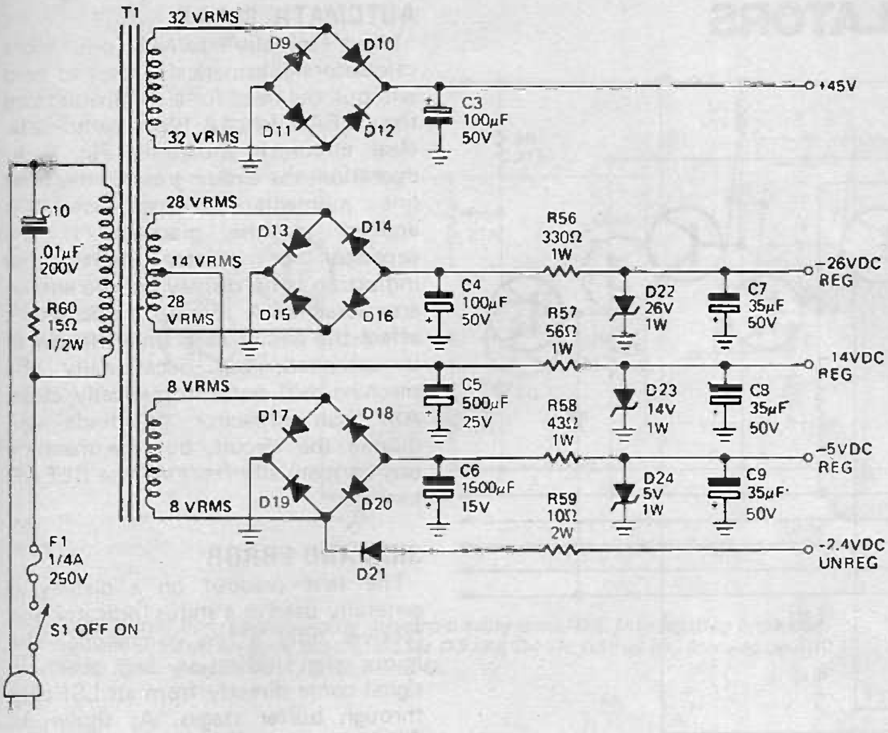



*Fig. 4 A typical power supply for a desk-type electronic calculator. The one shown is for the MITS model 816 and uses Zener diodes to deliver regulated voltages.*

the LSI chips, and the absence of pulses can frequently be traced to the buffer transistor. Check for proper voltage at both the transistor and the chip. If voltages are correct, check the clock chip in an IC tester or try it in another calculator. CAUTION: *To avoid possible damage to the IC, never substitute a good chip for a bad one until the problem is discovered and eliminated.*

## DISPLAY DRIVERS

The driver system for a display consists of switching transistors which are sometimes arranged in a Darlington configuration for added current gain. At any one time, a driver transistor is either on or off. Driver circuits are required for the various digits and the segments within a digit. Both are described below.

## DIGIT DRIVERS

The digit drivers are fed from the output LSI chip, and their output goes to the anode of the display device. Fig. 6 shows a typical Darlington configuration used in most drivers. Initially the base of Q15 is positive with respect to its emitter and is driven into saturation. This turns Q16's base negative, turning off Q16 and the digit. When the proper command is received, the digit line output goes negative. This turns Q15 off, which forces Q16 into saturation, and the digit turns on.

A digit which is constantly on can be caused by a faulty output LSI chip, open interconnect leads from the chip to driver, Q15 open, Q16 shorted, or the readout anode shorted to +V. Conversely, a digit that never turns on is caused by the opposite of any of the above problems.

## SEGMENTS DRIVERS

The same basic circuit shown in Fig. 6 is used to drive the segments of the readout devices, but a separate driver is required for each segment. The information coming from the output chip is fed through a BCD to seven-segment converter and then is sent to the segment drivers.

In some driver circuits, such as the one shown in Fig. 7, a shorted transistor can cause the gate in the converter feeding it, to short. This is a good example of why a good IC should never be randomly substituted for a defective one. If at all possible, test it in another calculator or in an IC

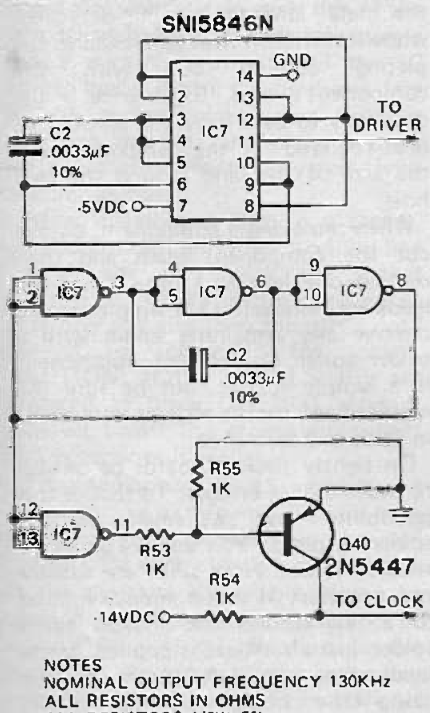



*Fig. 5. Timing pulse generator is known as a 'clock' in calculator terminology.*

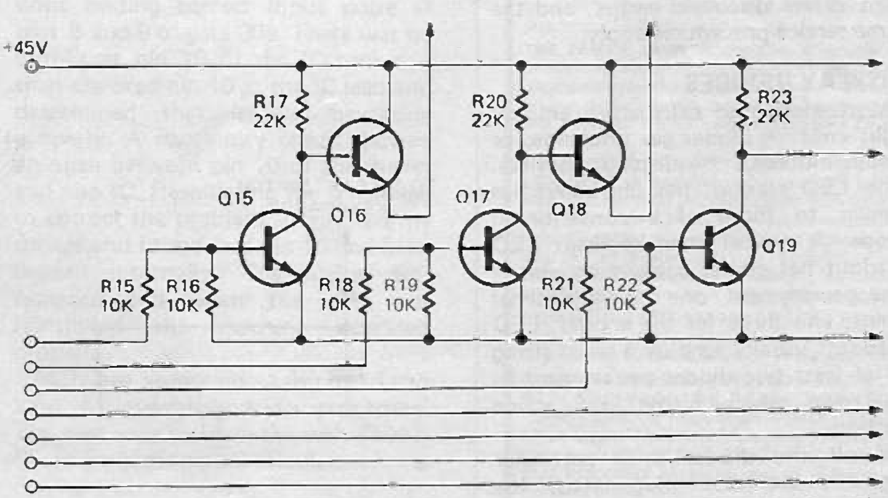



*Fig. 6. The Darlington configuration used here is typical of the amplifiers used in the digit drivers in calculators. A similar arrangement is used in some segment drivers.*

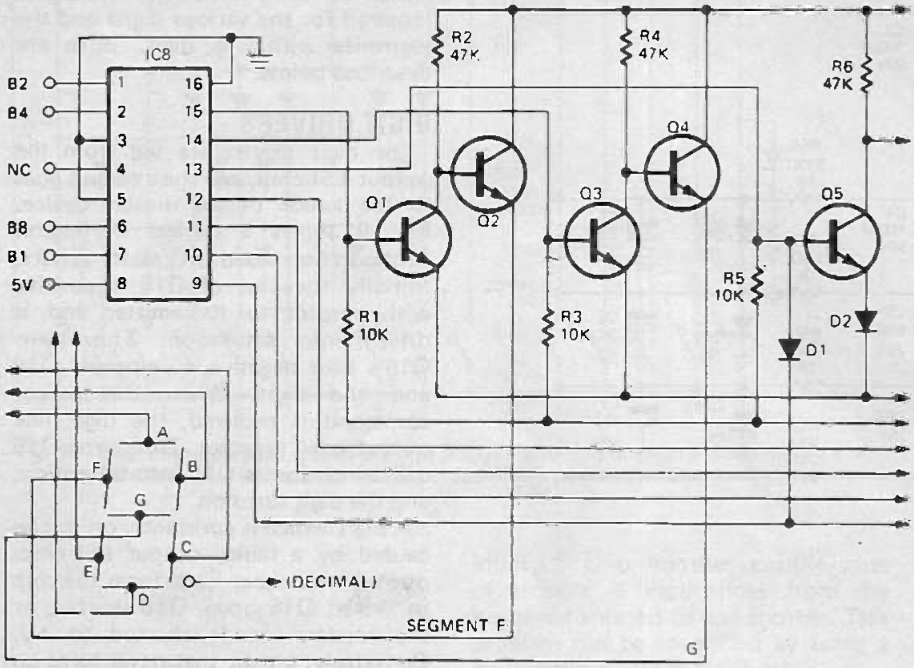



*Fig. 7. BCD to 7-segment decoder. BCD input to IC8 (on pins 1, 2, 6 and 7) is converted to 7-segment data on pins 9-15. Transistor-pair drivers for segments F and G are shown.*

tester. If it's bad, find the cause of the problem before trying a new chip.

Operation of the driver in Fig. 7 is as follows: With no segments illuminated, the output BCD lines are at -5V and the converter outputs are at 0V. If a 2, for example, is entered on the keyboard, it will appear on the four BCD lines as: B1 = -5V; B2 = 0V; B3 = -5V; and B4 = -5V. This code at the input of the BCD converter forces the A,B,C,D,E, and G outputs to go to -5V and the remaining segments stay at 0V. The -5V signal at Q1's base cuts off Q2, turns Q2 on, and causes the appropriate segment to be illuminated. This circuit is virtually identical to the digit driver discussed earlier, and the same service procedures apply.

### DISPLAY DEVICES

Most electronic calculators employ light emitting diodes, gas discharge, or electro-fluorescent display devices. The LED readout has characteristics similar to those of a conventional diode. A typical seven segment LED readout has eleven connection pins — one per segment, one for the decimal point, and three for the anodes, LED readouts usually employ a series string of at least two diodes per segment to give dots which merge into a line pattern.

If all the diodes in a particular segment are not illuminated, the readout is defective and should be replaced. When two segments in an LED readout are shorted together internally, isolating the bad readout from others in the display may prove difficult. One way to find the bad readout is to measure the resistance between the two segments on each readout with a high-sensitivity ohm-meter such as a bridge comparator. A second method is to remove each LED readout from the display and test it individually until the defective unit is located, a messy procedure if the readouts are soldered in place. If a segment fails to light in only one readout, either the device or the solder joints at one or more of its pins are defective.

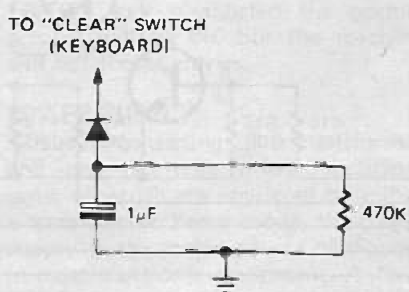



*Fig. 8. Typical automatic clearing circuit. Clear line is earthed momentarily when power is first applied to the calculator.*

### AUTOMATIC CLEAR

When initially turned on, most calculators automatically reset to zero without the need for a command from the CLEAR key. A typical automatic clear circuit is shown in Fig. 8. In operation, the circuit grounds the clear line momentarily after power is applied to the machine. If the capacitor or resistor shorts, the indication is no display and no entries are possible. A shorted diode won't affect the circuit each time the power is activated, but occasionally the machine will not automatically clear. An open capacitor or diode will disable the circuit, but the machine can be manually reset via the CLEAR key.

### SIGN AND ERROR

The first readout on a display is generally used as a status indicator and receives only a few commands. The minus sign indication and overflow signal come directly from an LSI chip through buffer stages. As shown in Fig. 9, there are four active components involved with these functions in a typical circuit. Troubleshooting procedures previously described also apply here.

### CIRCUIT BOARD AND SOLDERING

Very small calculators frequently use double-sided printed circuit boards with plated-through holes. When a component is being removed from a plated-through hole, careful de-soldering procedures must be followed. Too much heat can cause the metal land to become detached, while insufficient heat can result in the plating coming out with the component's lead. Experience is the only way to determine the amount of heat required for the component and the size of the land around the lead hole.

When removing a component, always cut the component leads and then remove one lead at a time. Once the leads are removed it's a simple task to remove any remaining solder with a solder puller. Component replacement is a simple matter, but be sure the replacement part is at least equivalent in value and tolerance.

On tightly packed boards be careful to avoid solder bridges. To reduce this possibility use a small wattage soldering pencil iron and 24-gauge or smaller solder. Heat sinks are usually not necessary if solder time is limited to a few second and if you apply solder just after heat is applied. Metal lands that run very close together along the board are particularly susceptible to shorts caused by small slivers of metal.

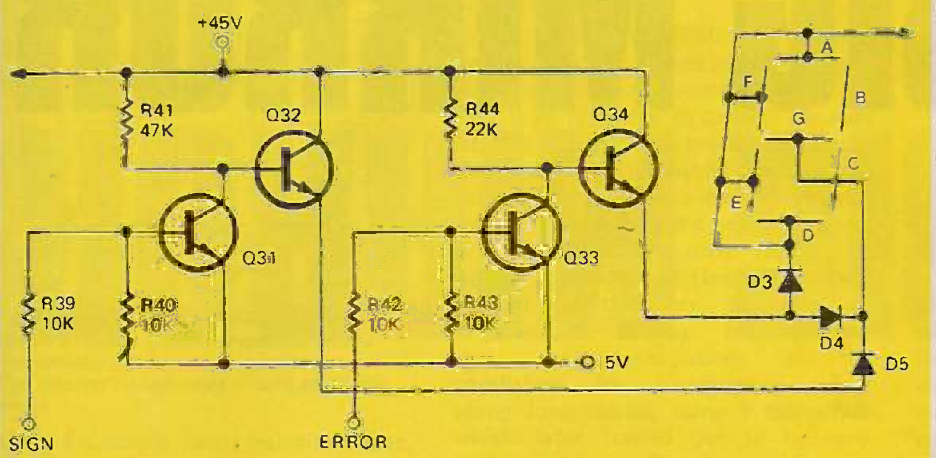



*Fig. 9. Minus sign is produced by forward-biasing diode D5, thus lighting indicator segment G. When an error occurs, diodes D3 and D4 are turned on, forming on 'E' by lighting segments A, D, E, F and G.*

## MOS LSI HANDLING PRECAUTIONS

So long as they are in the circuit, MOS (Metal Oxide Silicon) LSI (Large Scale Integration) IC's are practically trouble-free. When the chips are improperly handled, however they become susceptible to damage from static electricity and mechanical pressure.

When removing a chip from a socket, ground the fingers on the calculator ground line (making sure the machine is not on) and pry up each side of the IC package with a screwdriver, using a gentle rocking motion until the IC comes loose. When the IC comes free of the socket, pick it up without touching the pins and place it on a piece of Styrofoam covered with aluminium foil.

When installing a chip in a socket, ground yourself and then carefully line up all the pins with the socket receptacles. Apply gentle pressure at first one end and then the other until the IC is secure in the socket. CAUTION: If the MOS LSI IC's are soldered in place DO NOT attempt removal unless the proper equipment and experience is available.

Troubleshooting the LSI portion of a calculator is extremely difficult if a block diagram showing inputs and outputs for each chip is not available. If the diagram is available, it can be used to work from the output chip, or section of a chip, backward to the input of the input of the preceding chip. The procedure is more difficult in multi-chip calculators since some chips invariably receive feedback input information from other chips.

## CASE HISTORY

The MITS 1440 is a multi-function desk calculator with square and square root capability. The machine can also store a 14 digit word in memory. The unit uses fourteen readouts in its display and six LSI chips. A machine came in for service in which the overflow indicator worked but the display failed to operate. The power supply voltages and the pulses on the digit lines and BCD lines from the output chip to the display buffer were all good. From here on let's quote from the servicing technician's report:

"Having no other place to go I began looking at the input and output signals around the output chip. I started at the outputs of the circuit (pins 4 and 10 of IC11), found they were not present, and began working backwards until finding correct input pulse at pins 8 and 9 of gate 30a. There was no output at pin 10 of the IC socket. I then checked pin 10 at the IC lead and determined that it was operating properly. A continuity check showed an open between pin 10 of the socket and the IC. Resoldering the pin failed to correct the problem. I removed the socket and found that pin 10 had been broken internally. The socket was replaced and when the chip was reinstalled the machine operated properly."

There are numerous examples of this kind of troubleshooting procedure. The best way to learn the technique is to service some actual calculators. ●

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# THE BIG MIRROR

BY IAN SINCLAIR

**Our knowledge of how and why radio waves act as they do is not yet complete. Our existing knowledge has been built up from the work of a large number of pioneers and this article outlines the history.**

SIR ISAAC NEWTON in the middle of the seventeenth century, thought that light consisted of a stream of small particles. Jan Christian Huygens, working at the same time, thought that light was a waveform. The evidence which turned up over the new century or two favoured the wave theory; but, as we know now, both were right; light is a set of pulsed waves and the pulses, containing millions of cycles of wave motion, behave like particles. Before this was clearly understood, there was much confusion over why a ray of light should sometimes seem to act as a stream of particles (as when it releases electrons from a photocathode) and sometime as a wave (as when it is polarised); one point was, however, agreed on.

Whether wave or particle, light travelled in perfectly straight lines over distances which were long compared with its wavelength and past objects large compared to its wavelength. The comparison with wavelength is important, as any wave will roll merrily past objects which are about the size of a wavelength or smaller, and interference effects, caused by waves meeting in or out of phase can be detected when this happens. The wavelength of light is around 500nm (nanometer = $10^{-9}$m or one millionth of a millimetre), and so for all practical purposes travels in straight lines over distances which we can see. It is this point of size relative to wavelength, incidently, which makes it impossible for an ordinary microscope, no matter how powerful, to see atoms or other very small objects.

For a very long time light, together with infra-red (causing strong heating effects) and ultraviolet (tanning skin and causing chemical changes) were the only waves of their kind known. Sound is not the same type of wave, because it needs some material to travel in, whereas light appears to travel across empty space. The speed of light, estimated first by an astronomer in the 17th century, is 300 *million* metres per second compared to the 330 metres per second of sound in air, and the wavelength of light is much smaller than the wavelengths of sound.

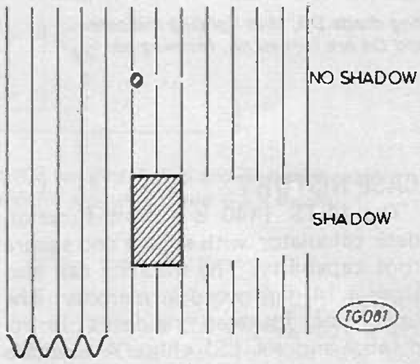



*Fig. 1. In a stream of waves (the lines represent the peaks of the waves) small objects cast no shadow for more than a few wavelengths away. Small in this respect means small compared to the wavelength ... even a house is small compared to a 200m wavelength radio signal.*

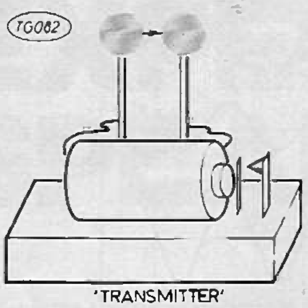
## MAXWELL AND HERTZ

Little more was learned until the middle of the 19th century when a Scottish Physicist, Maxwell, started to worry about a missing equation. He was looking at the equations linking electricity and magnetism; one showing that electric current in a wire caused a magnetic field, another showing that a changing magnetic field caused a voltage. Maxwell felt that there *should* be another equation, one which linked a changing electric field (change of volts) with magnetism in space with no wire present; the equations seemed to form an incomplete set unless the last one existed.

He assumed that it did and examined the set of equations. With the missing one inserted, the equations had a solution in the form of the equation of a wave motion, travelling at a speed which depended on the capacitance and inductance of the material through which the waves were travelling. At the time, because of the system of units used for electrical and magnetic measurements, it was not realised that capacitance and inductance were involved, not that space could have capacitance and inductance but it was possible to work out the speed of Maxwell's theoretical waves. It was exactly the speed of light.

Many people were sceptical, they doubted that light could be electrical or magnetic in nature, despite the fact that Faraday and others had shown that magnetic fields and electrical fields both affected light. The greatest difficulty was that the equation did not simply imply that light was electromagnetic, it also implied that there should be an infinite variety of waves of the same type, differing only in wavelength and frequency, but that the quantity: wavelength x frequency should be constant and equal to speed. No such other waves had been detected, nor was there any method of measuring the frequency of light waves, only their wavelength. Meanwhile, not suspecting any connection, electrical engineers had discovered that a combination of inductance and capacitance could tune to a definite frequency of electrical oscillation.

Twenty years passed with no direct experimental evidence to back up Max-



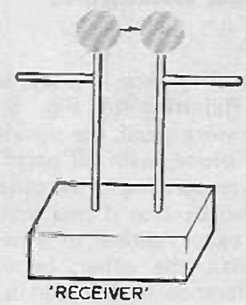




*Fig.2. Hertz's apparatus. When a spark passed between the metal spheres on the 'transmitter', sparks could also be seen at the 'receiver' which used a form of dipole aerial.*

well's Equations, until Heinrich Hertz, in a series of experiments using what we would now call a spark-gap transmitter and receiver, generated transmitted, and received electromagnetic waves of short wavelength, about 5 ins or so. By the end of the 19th century, radio waves were established as part of a family of electromagnetic waves, differing only in frequency and wavelength, of which light formed only a very tiny portion. Later other waves with wavelengths even shorter than that of light would be discovered.

## THE STRAIGHT LINE PROBLEM

Since the newly discovered radio waves were of the same family as light, it was logical to suppose that they would, allowing for the wavelength difference behave in the same way as light. They were used for very short range communications at first, but then as technology progressed, longer wavelengths which could pass round obstacles started to be used for longer distance communications. It was quite obvious, however, to men of the stature of Sir Oliver Lodge, that communication from one side of the Earth to the other was quite impossible, since an aerial long enough to launch a wave of the required wavelength would be long enough to stretch round the earth anyway! Marconi was less convinced. Having done many experiments in long distance communication he was sure that, for some reason, the straight line arguement was falling down. When it came to the crunch, he was the better experimenter. He tried the transatlantic transmission and it worked.

But *why* did it work? The answer was important because of the possible problems it posed. Was there something wrong with wave theory? Was light, after all, different from radio waves in some other way? Or was there some other quite unsuspected effect operating which caused radio waves to travel farther than expected?

Oddly enough, the problem had been solved and hardly anyone knew it.

## HEAVISIDE

Oliver Heaviside (1850-1925) was a genius who was almost incapable, temperamentally, of communicating the results of his work to others. Because of this much of his work was unpublished and the published fraction was largely ignored by his comtemporaries either because they did not understand it or because Heaviside would not answer criticism. Heaviside's best known contribution to electrical engineering during his lifetime was the formulation of the conditions for transmitting pulses along long cables, using a technique which later turned out to be very useful in radar. One less well known exercise was a theoretical study of the effects caused outside the Earth's atmosphere by particles emitted by the Sun. At the temperature of the sun, and even at considerably lower temperatures, materials ionise splitting off electrons from the atoms to leave, positively charged particles. Heaviside argued theoretically that these ions should be trapped by the earth and should form a layer round the Earth considerably beyond the atmosphere. Furthermore because the particles were charged, the layer should act as a reflector for electromagnetic waves of more than a metre or so in wavelength. What Heaviside visualised was no less than a huge mirror for radio waves completely surrounding the Earth and reflecting back any wave beamed towards it. No-one paid much attention to this idea before Marconi's successful experiment. Everyone paid considerable attention to it afterwards, and the layer was later named the Heaviside Layer in posthumous honour of the man who had the vision to imagine it.

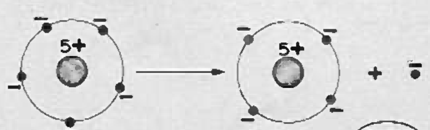



*Fig.3. Ions. When an atom parts with an electron (by heating or collision) both particles left are charged. The electron carries a negative charge and the ion (the remains of the atom) carries a positive charge.*

## USES AND PROBLEMS

Even when it was realised that radio waves were transmitted over long distances by a process of reflection from the Heaviside layer, the full implications of Heaviside's Theory were still ignored. The wavelengths most favoured for long distance communication were the very long wavelengths of several thousand metres, though these were not very efficient. The wavelengths of a hundred metres and less were allocated to amateur use, since it was thought that these were too close to the limit of reflection. The official attitude at the time was rather like that of tossing a bone to a dog.

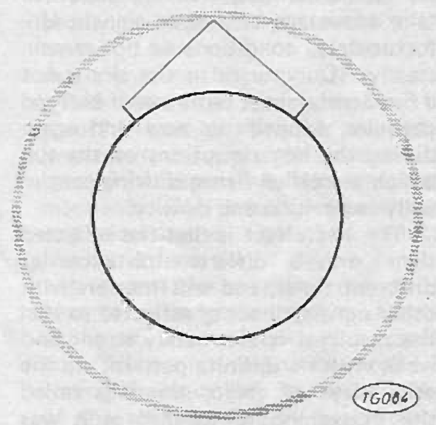



*Fig. 4. How long-distance communication could be achieved using reflection at a layer of ions (not to scale!)*

A closer study of Heaviside's work together with some measurements would have revealed that the region of 100m to 1m was probably the most efficiently reflected of all, a fact which was very quickly shown by amateurs who soon devised techniques of transmitting and receiving at these wavelengths. The result was that Governments all over the world promptly reclaimed the short-wave bands, leaving only a few small portions for amateur use "for all time" as a mark of gratitude. It seems clear now that the phrase "for all time" actually means "until we want it".

The reflections which made long-distance radio possible also bring problems, however, and fading is the worst. On any particular transmission it is highly likely that there will be more than one possible path of rays in straight lines from transmitter to receiver so that more than one signal from a given transmitter will be received at one time. Unfortunately, these signals will have travelled different distances, so that there will norm-

## THE BIG MIRROR

ally be a difference in phase between them. Referring to Fig. 5 if the distances were equal, the signals would arrive in phase, with all parts of one signal corresponding to the other. This would also be true if one signal path were an exact number of wavelengths longer than the other, because the only difference in the signals would be an insignificant time difference.

With waves travelling at 186,000 miles per second, it takes a large distance difference to cause a noticeable echo effect in this way. The usual problem arises when the distance is not an exact number of wavelengths, and the signals tend to cancel each other. This would be no great problem if the conditions remained steady as we could always site an aerial to take advantage of a good signal. Unfortunately, conditions do not remain steady. Our mirror in the sky is not a fixed metal sheet but a sea of charged particles, topped up now and again during the huge eruptions on the sun which are called flares, shifting continually in position and density.

The net effect is that the reflected signal travels different distances at different times, and will interfere with other signals, direct or reflected so that the resultant is alternately strong and weak with no definite pattern. In the early days of radio, this was called the "Luxembourg Effect" as it was most noticeable to ordinary listeners (as distinct from hams) when tuned to Radio Luxembourg, the first commercial station whose broadcasts could be received in England.

For domestic receivers the answer was AGC - automatic gain control, which varied the gain of the receiver to match the fluctuations of the signal. For professional communications, this was not sufficient, and the answer was diversity reception, where several aerials at different sites feed to receivers tuned to the same frequency and an automatic switching device keeps the output connected to the strongest signal available. Both of these methods are still used but the best answer to the fading problem has proved to be most expensive one of all, the use of very short wavelengths which pass easily through the ionised layers together with repeater satellites which retransmit the beamed signals.

### MODERN TECHNIQUES

We still have to live with the big mirror, though an increasing fraction of radio communication is done by means of satellite. The Heaviside layer is not the only ionised layer,

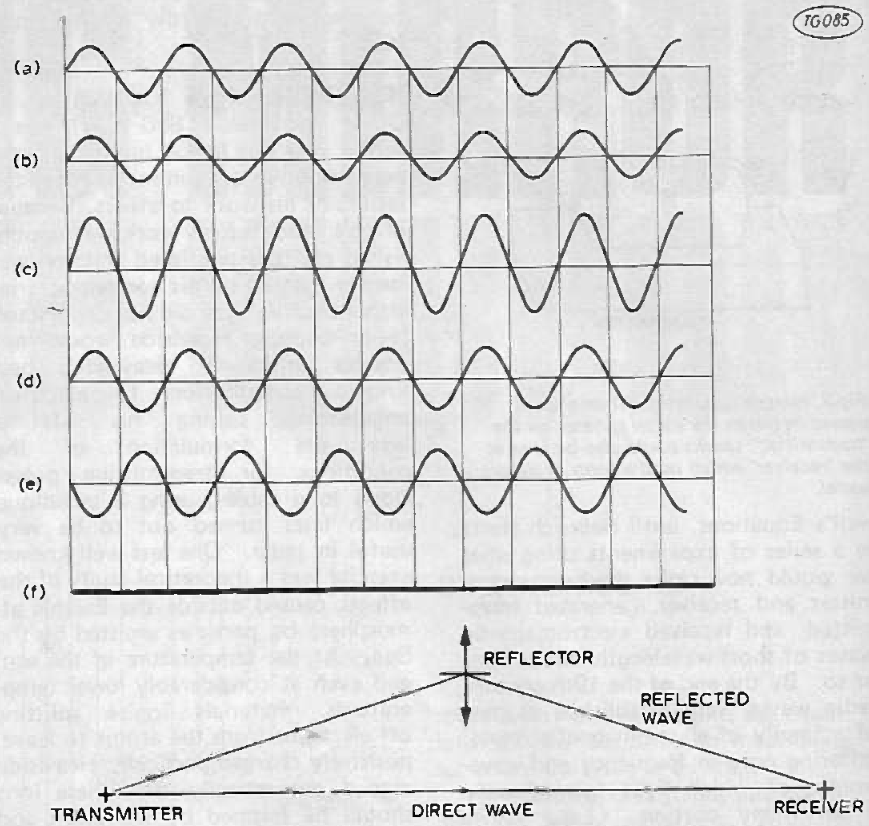



*Fig.5. Waves in and out of phase. a) Wave. b) Second wave in phase. c) result of adding a and b as happens at the receiver. d) and e) show waves out of phase, the resultant of adding f. g) shows how the reflected wave travels a greater distance than the direct wave, and the distance travelled varies as the height of the reflecting layer varies.*

*Interference also occurs between two reflected waves which are reflected from different places.*

research into the regions above the atmosphere by Appleton resulted in the discovery of the layer which now bears his name, and new belts of ionised particles (Van Allen belts) were

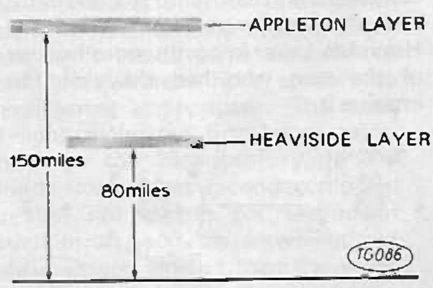



*Fig.6. Relative heights of layers.*

discovered as a result of satellite investigations.

For the radio channels which still rely on reflection from the layers, a "weather forecast" for the Heaviside and Appleton layers is as essential as conventional weather forecast to an airport, and ionospheric research stations are positioned all over the globe. These use radar techniques to find the position and movement of the shifting layers; sending pulses of carriers of different frequency vertically upwards and monitoring the time for reflection. The results of this work are interpreted as a forecast a reflection conditions and sent to long-range radio stations all over the world.

Exceptional ionospheric conditions can still cause problems, however, Television and other services using wavelengths of a few metres and less are hardly affected by reflection; the normal range is the straight line range. On occasions, however, a solar flare up causes such a high intensity of ions in the layers that the amplitude of reflected signal becomes large, and long distance television reception becomes easy.

Long distance reception is always possible, particularly on the longer wavelengths, because there is always some reflection, but the direction properties of the receiving aerial usually prevent the reflected signals from being picked up on domestic receiver. Under solar flare conditions, though the reflected signals from distant transmitters may be strong enough to overcome the directional bias of the aerial and cause picture and sound disturbance. At time, with a suitable receiver and aligned aerial, very long distance hops are possible and have been well documented. The UHF bands are less likely to be affected than the VHF in this respect. ●

# EXPERIMENTAL SPEAKER

**Using bass reflex enclosures for low resonance speakers — by Nelson Pass, Design Engineer, Electrostatic Sound Systems Inc., Sacramento, California.**

A FEW years ago, bass speakers commonly had free air resonances around or above 40 Hz, and they were often used in bass-reflex enclosures, where the output of the port helped to compensate for the speaker's decreased output below the resonant frequency. Today however, speakers having a subsonic resonance of 15 Hz are not unusual, and it is generally regarded that a bass-reflex enclosure is impractical or unusable for two reasons.

Firstly the so-called "optimum volume" for such a speaker is calculated to be of the order of ten cubic feet using standard bass reflex design. Secondly, for an enclosure of more convenient dimensions, it would require a long and narrow duct to tune the enclosure to such low frequencies. Such a duct would cause the enclosure to behave more as a closed box and would serve no useful purpose.

These conditions arise from the premise that tuning the enclosure to match the free air resonance of the speaker will result in optimum response. This is true of speakers having resonances above 30 Hz, but it becomes impractical and unnecessary for speakers resonant below 25 Hz.

When a bass-reflex enclosure is tuned to the resonant frequency of the speaker, the back wave of the speaker passes through a low-pass filter (the enclosure volume in conjunction with the inertia of the air in the duct) and emerges through the duct to join the radiation off the front of the speaker. The enclosure allows low frequencies through but blocks higher frequencies (Fig. 1). At the same time, this acoustic circuit shifts the phase of the back wave, so that at frequencies above resonance, the out-of-phase back wave is shifted into phase with the front wave by the time it emerges from the duct. This, being in phase, this wave increases the amount of bass energy radiated from the system. At the resonant frequency of the enclosure, the wave from the duct begins to lose its phase shift, and below resonance it becomes detrimental to the output. (Fig. 2).

The bass-reflex design lowers the cutoff frequency a few Hz and just as important, increases the load on the speaker at resonance, dampening the resonance. This results in lower cone excursion and greatly reduced harmonic distortion.

It is possible to make use of the bass-reflex design to lower the amount of harmonic distortion in a speaker with subsonic resonance, not by tuning the enclosure to the resonance of the speaker, but by tuning above that frequency.

As the frequency goes down, the excursion of the speaker must go up to provide the same power output (Fig. 3). For a 12 inch woofer, that can mean that it must travel 3 inches to

*Fig. 1. Typical acoustic output of duct versus frequency.*

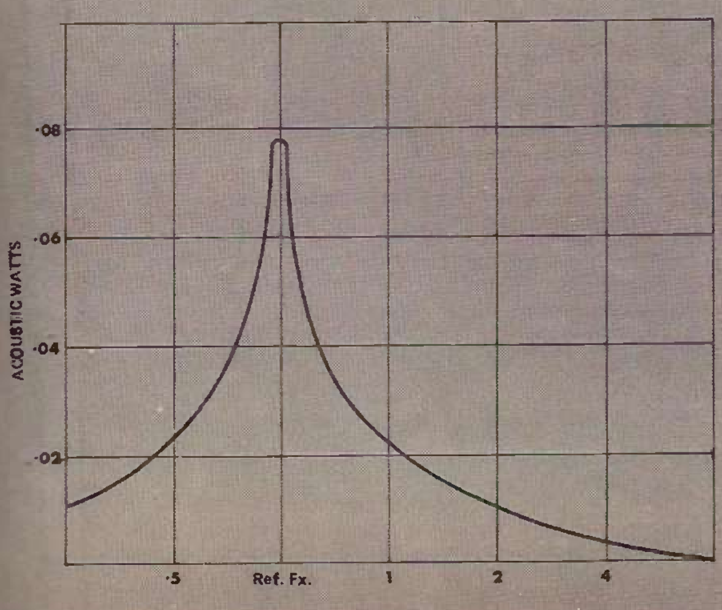
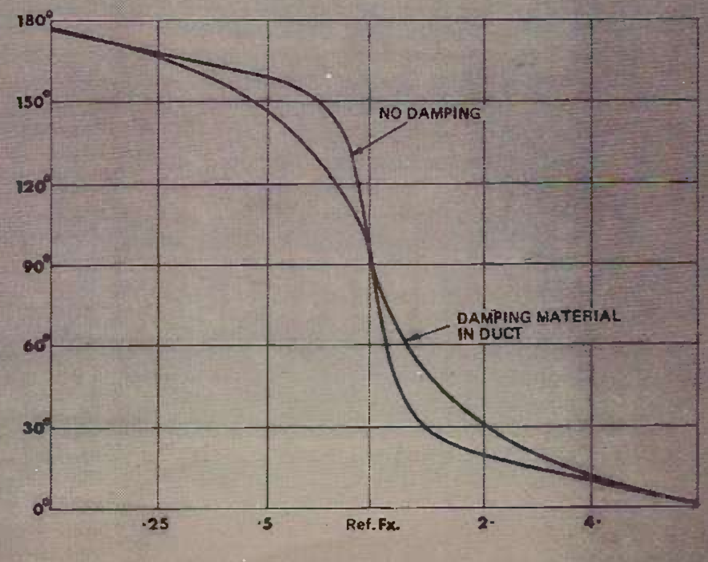



*Fig. 2. Typical phase difference between speaker and port output as a function of frequency.*



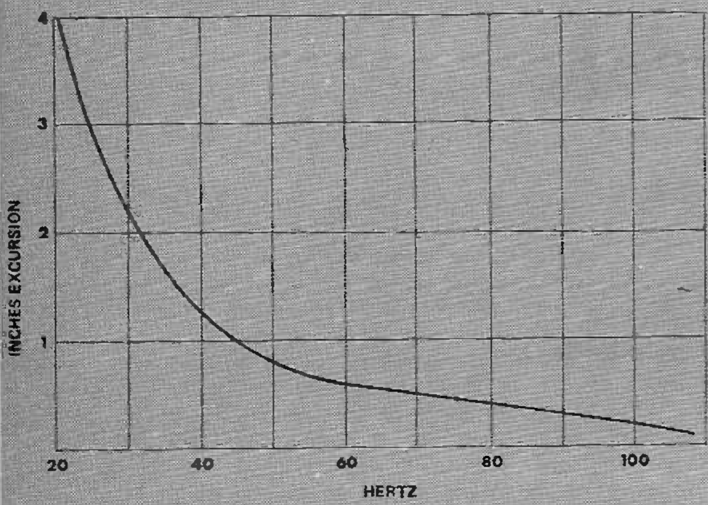



*Fig. 3. Peak to peak excursion for 25cm (12") speaker versus duct length.*

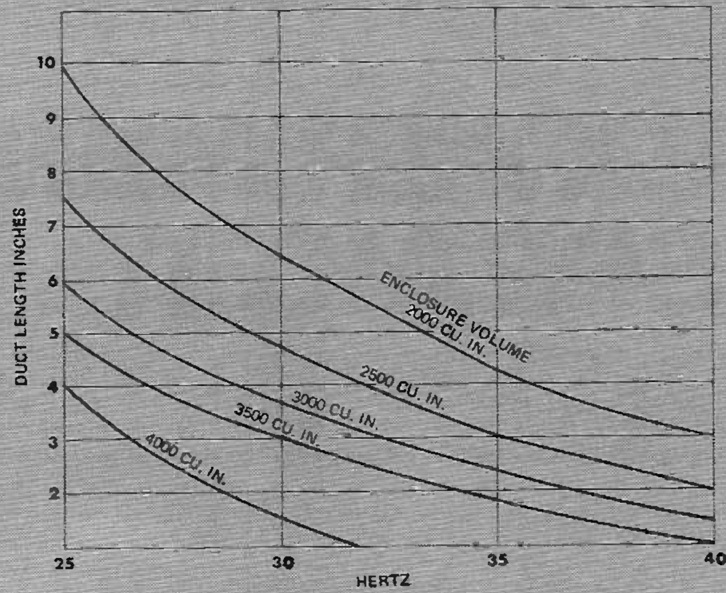



*Fig. 4. Resonant frequency versus duct length.*

generate one acoustic watt at 30 Hz. Even very good speakers will distort long before that. But if we could make efficient use of the power radiated off the rear of the cone, we could reduce this excursion to almost half, greatly reducing distortion.

I have found that by tuning the enclosure as high as 35 Hz, with a speaker of 15 Hertz resonance, the frequency response of the speaker is virtually unchanged, but the amount of distortion in its low frequency sinusoidal output can be varied radically depending on the duct. If the enclosure is tuned too high, for example 40 Hz, the waveform may look like a staircase instead of a sine wave at several watt power levels. If it is tuned below 30 Hz, it may exhibit notching at the peaks due to high excursion.

There is another advantage to this acoustic circuit. The very low resonant frequency of the speaker leaves the designer free to make as much use as possible of the high damping factors now available in solid state amplifiers. A high damping factor will damp out much of a speaker's output at resonance. This is detrimental to the frequency response of the speaker whose resonance occurs between 40 and 100 Hertz and where the acoustic circuit is often designed to take advantage of that resonance. But it is not detrimental to the output of a speaker with subsonic resonance — just the opposite. A high damping factor will lower the subsonic excursion and reduce the harmonic distortion. It will also smooth out the smaller resonant peaks and dips caused by the speaker and by standing waves in the enclosure. The greatest benefit will be due to improved transient response from the increased control the amplifier will have over the speaker. To make use of the high damping factor, the crossover network and connecting cables must be designed to have as little resistance as possible.

The optimal enclosure volume for a given speaker should be determined experimentally, but for those without the inclination or finances to perform such experiments, I would recommend approximately 45 cubic inches volume for every square inch of cone area (about 3,000 cu. in. for a 12 inch speaker, 2,600 for a 10 inch, and 1,900 for an 8 inch speaker). Note that these values are for the enclosure volume before the speaker has been mounted in place.

Since the enclosure resonance is not as low as the speaker's, there is no difficulty in using a duct with a two inch diameter. A smaller diameter would render the duct inneffective and is not recommended. The resonant frequencies for two-inch ducts of various lengths is given in Fig. 4. If you wish to use a duct of a different diameter, the resonant frequency of the enclosure is given by the formula:

$$Fr = 2155 \frac{Ad}{(Ve - Vd)\,(ld + .96\sqrt{Ad})}$$

Fr = enclosure resonant frequency
Ad = cross-sectional area of duct inches $^2$
Ve = volume of enclosure inches $^3$
Vd = volume of duct
ld = length of duct

The enclosure should be as solid as possible and filled lightly with fibreglass or dacron to dampen standing waves. Tuning the enclosure is an involved task and will require the use of a microphone whose output can be viewed on an oscilloscope. The speaker should be tested out of doors by applying a few watts of sine wave (30-50 Hz) and viewing the output of the speakers on the oscilloscope while varying the duct length until a length is found that results in the least distortion. The worst distortion will occur at 30Hz, so that the best duct length for 30 Hz will probably also be the best for the higher frequencies.

As mentioned before, the duct changes appear to produce very little difference in actual frequency response, but it is possible with experimentation to produce as little as 1 percent harmonic distortion at a 10 watt power level at 50 Hz, a value that few other speakers can match. ●

# WHAT TO LOOK FOR IN FEBRUARY

## IN THE BEGINNING...

Beginner's series? Every one that we have seen until now has taken the same traditional approach. The reader is assumed to be an idiot in most things but is expected to deal with atomic theory in the first part or chapter ... no wonder a lot of people are put off!

We aren't even calling our new series a beginner's one, rather an introduction to the subject. It is written in down-to-earth language, takes the mystery out of electronics — explaining it as the logical, fundamentally simple, yet far-ranging subject that it is. Title of the series? Electronics — its easy!

## SPECIAL OFFER!

Use the coupon in next month's issue to buy one of the Decon-Dalo 33 p.c.b. marker pens. Normally these retail for rather more than a £1 but our 50p offer also includes VAT and postage!

**50p**

## ELECTRONICS AND YOUR EYES

Both pathological and refractive ophthalmic work increasingly is using electronic methods, enabling the ophthalmic optician to undertake his tasks more effectively.

Our major report in next month's issue is right up-to-the-minute and has been commissioned exclusively for Electronics Today International.

ON SALE MID-JANUARY—20p

THE FORTHCOMING ARTICLES MENTIONED ON THIS PAGE ARE, AT THE TIME OF THIS ISSUE GOING TO PRESS, IN AN ADVANCED STATE OF PREPARATION. HOWEVER, ETI TAKES A PRIDE IN BEING REALLY UP-TO-DATE AND TOPICAL ARTICLES MAY REPLACE THOSE SCHEDULED.

electronics today INTERNATIONAL


eti PROJECT 520

# DIGITAL STOP WATCH

**Measure elapsed time electronically with this digital system.**

ALTHOUGH entirely adequate in many situations, conventional stopwatches have a number of limitations which preclude their use – or at least their accuracy of timing – in many applications.

This is particularly true of sporting applications, where the start line may be in a different geographical location from the stop line, and where timing accuracy to within hundredths of a second may be required.

Another serious drawback of many conventional stopwatches is that the display consists of multiple hands and/or dials, the readings of which must be added together to give elapsed time. At best this arrangement is clumsy – at worst it may be misread.

Apart from the form of display, another serious limitation of conventional watches is that human reflex time may cause errors in the measured time by a (variable) amount. Delays of 0.1 to 0.5 seconds are typical. Clearly this last limitation makes readings to anything better than 1/10th second virtually impossible – even though some watches are capable of this degree of resolution.

For these reasons, international sporting bodies are turning to digital timers that are started and stopped by electronic means, such as light beams (horse and motor racing), or touch plates (swimming).

Whilst extremely effective and reliable, commercially built systems of this sort are generally very costly and well beyond the means of the average car, motorcycle or athletic club.

The ETI Digital Stop Watch has been designed specifically to fill this low-cost need, whilst still providing the required accuracy and flexibility of operation. With suitable inputs, the standard instrument will provide a resolution of one hundredth of a second. Accuracy is one two hundredth of a second (±½ digit).

A unique overflow arrangement allows the four digit display to read times up to 3999.9 seconds in tenths of a second, or 399.9 seconds in hundredths of a second.

It is also possible to modify the unit to read to one millionth of a second for short time interval measurements (such as are occasionally required in science and industry). The necessary changes for this are detailed in Table II.

Three different modes of operation are provided to cater for practically any application. These are:–

MODE 1

STOPWATCH – In this mode a single push-button (either internal or external) provides the functions, Press to start, Press to stop, Press to reset – just as with a conventional watch.

MODE 2

REMOTE START/STOP – In this mode three push-buttons may be used at separate locations to Start, Stop, and Reset the timer. This mode would be very useful for timing events such as 50-metre swimming, motor car standing start quarter miles etc.

MODE 3

LAP TIMER. – Here a single push-button is used to provide separate lap times. The counter

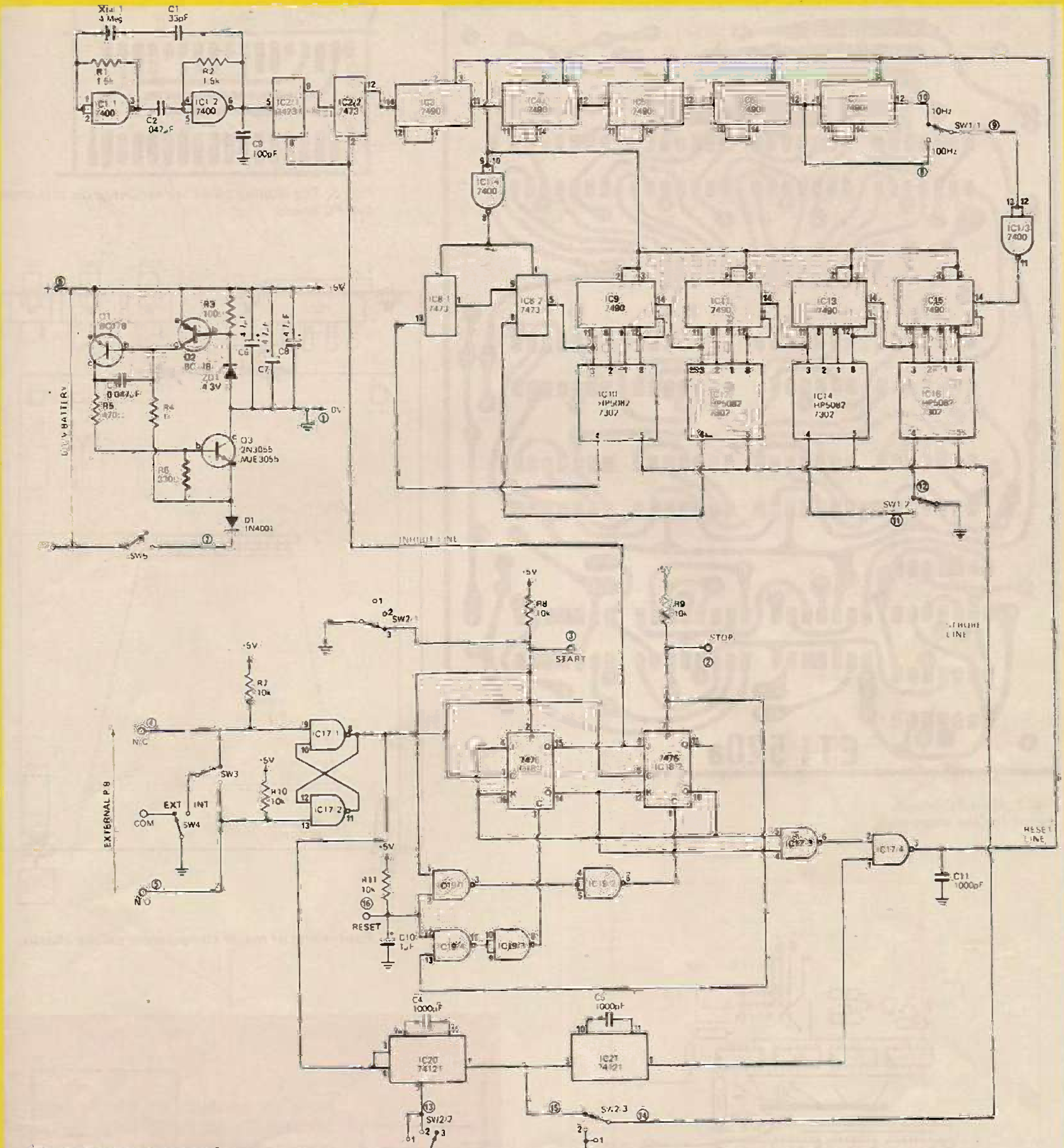


*Fig. 1. Circuit diagram of the digital stop watch.*

## SPECIFICATION

| | |
|---|---|
| **RESOLUTION** (selectable by slide switch) (if modified) | 0.1 or 0.01 sec<br>1.0$\mu$ sec |
| **DISPLAY** (overflow indication to 39999) | 4 digits |
| **ACCURACY** (crystal controlled timebase) | ±1/2 digit |
| **CONTROL** | internal or external push buttons, or external electronics at TTL levels |
| **POWER REQUIREMENTS** (External battery) | 6-16 volts<br>700 milliamps |
| **OPERATING MODES** | |
| Mode 1 | normal stop watch |
| Mode 2 | remote stop/start |
| Mode 3 | lap timer |

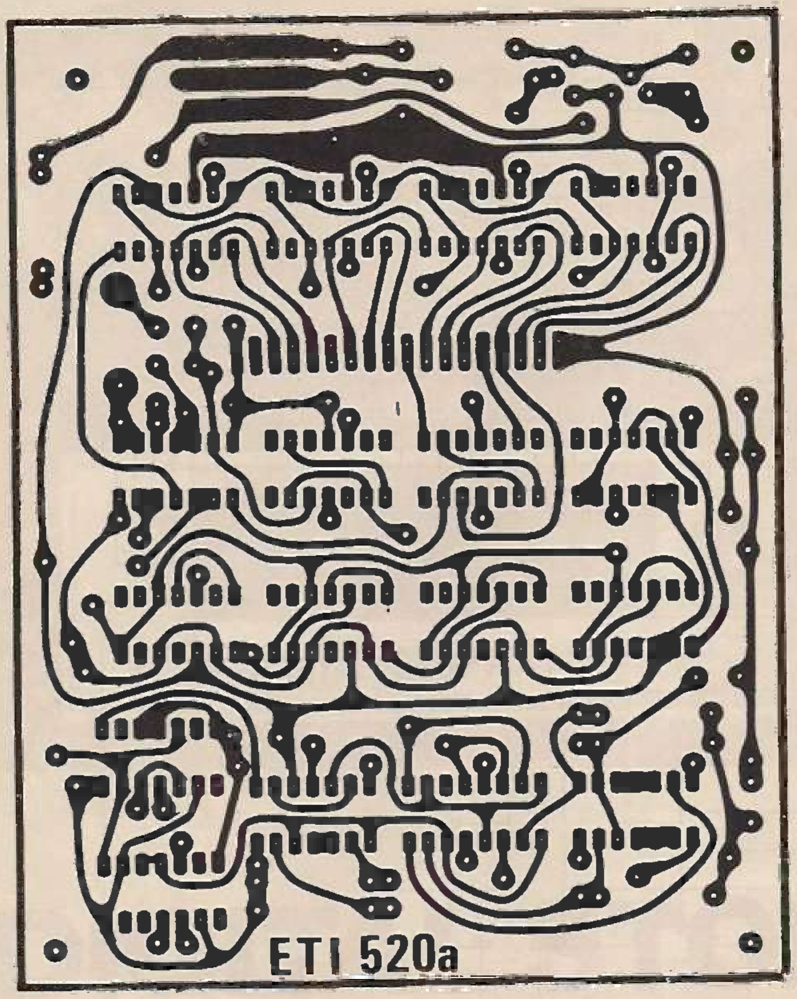



Fig. 2. Main PC board layout for the stopwatch.

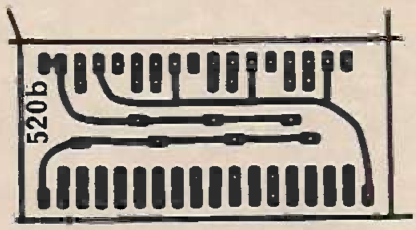



Fig. 3. The display chips are mounted on this small sub PC board.

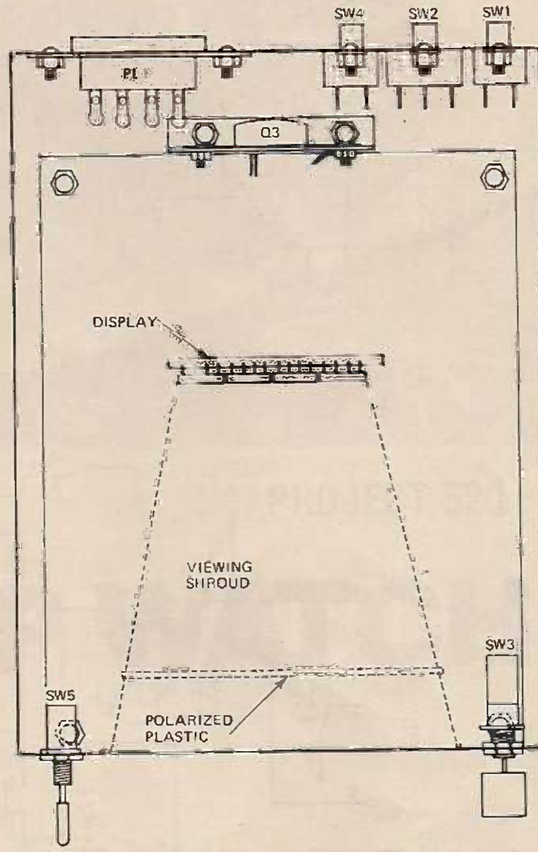



Fig. 5. Positioning of major components on the chassis.

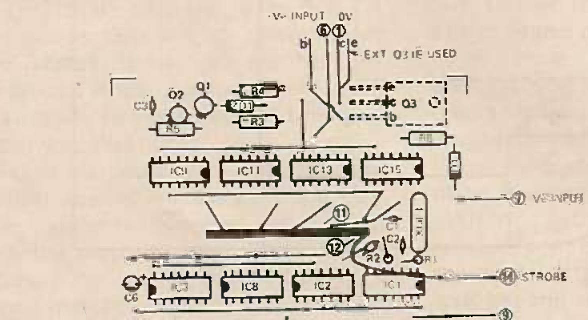



Fig. 4. Component overlay for main board.

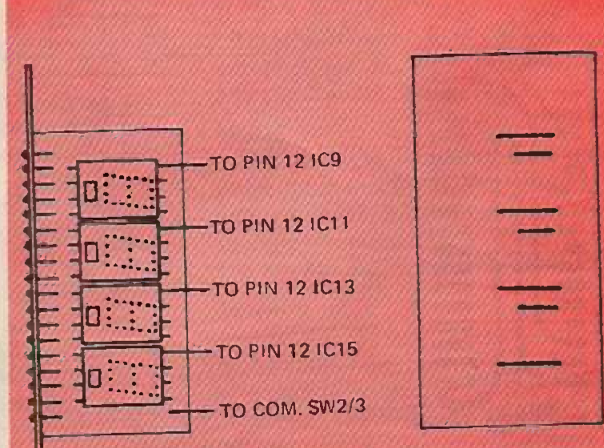



*Fig. 6a. Links must be inserted as shown on component side of board before displays are fitted (26 gauge tinned copper). 6b. The displays are mounted as shown with the chip towards bottom of board.*

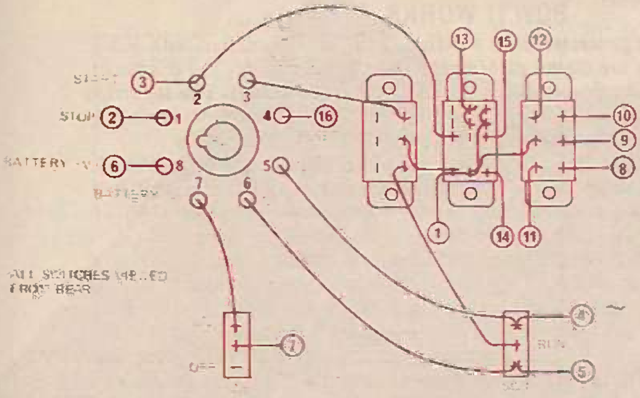



*Fig. 7. Wiring to switches and power/control socket.*

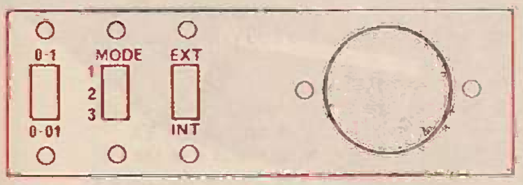



*Fig. 8. Rear panel layout.*

*Internal view of the stop watch.*

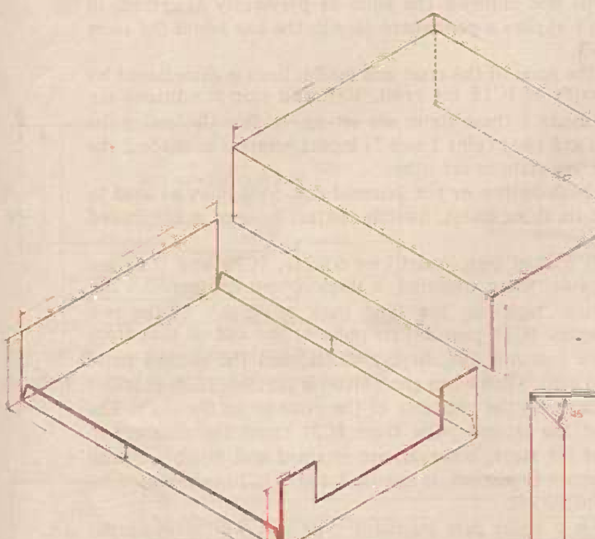


*Fig. 9. Case dimensions.*

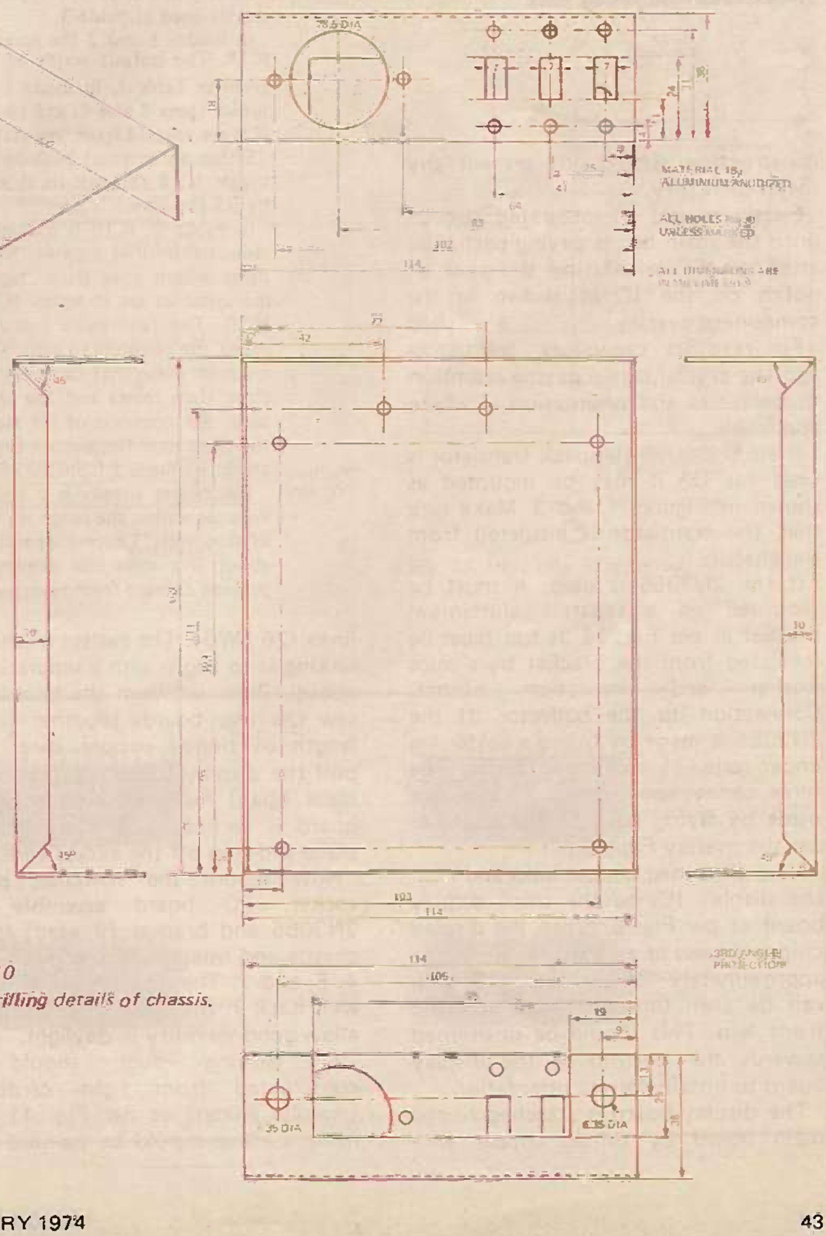



*Fig. 10 Drilling details of chassis.*

displays the time elapsed between successive presses of the button, hence there is no timing error due to time lost whilst taking readings.

The whole unit operates from a single five volt supply, hence an inbuilt regulator is provided enabling the unit to be run from any six to 16 volt battery – or any other source capable of providing 700 mA – without the need for switching. A series diode is included in the power circuit to prevent damage in the event of inadvertent reversed battery polarity.

## CONSTRUCTION

This is not really intended as a suitable project for absolute beginners, nevertheless if the recommended printed circuit board is used,

### PARTS LIST

R1, R2 resistor 1.5 k ½W 5%
R3, resistor 100 ohm ½W 5%
R4, resistor 1 k ½W 5%
R5 resistor 470 ohm ½W 5%
R6 resistor 330 ohm ½W 5%
R7-R11 resistor 10 k ½W 5%
C1 capacitor 33 pF ceramic
C2, C3 capacitor 0.047pF polyester
C4, C5, C11 capacitor 0.001uf polyester
C6, C7, C8 capacitor 4.7µF 10V electrolytic
C9 capacitor 100pF ceramic
C10 capacitor 1µF 10V electrolytic.
Q1, Q2 transistor BC178 or similar
Q3 transistor 2N3055 or MJE3055
D1 diode 1N4001
ZD1 zener diode BZY88C4V3
IC1, IC17, IC19 Integrated circuit 7400
IC2, IC8 integrated circuit 7473
IC3, 4, 5, 6, 7 Integrated circuit 7473
IC9, 11, 13, 15 integrated circuit 7490
IC10, 12, 14, 16 integrated circuit HP5082-7302
IC18 Integrated circuit 7476
IC20, 21 integrated circuit 74121.
(Note that the prefix of 74 series ICs depends on manufacturer.)
XTAL 1 crystal 4MHz 30pF capacitance
PC boards ETI 520A and ETI 520B.
SW1 switch DP DT slide
SW 2 switch 3P3T slide
SW3 switch SPDT push button
SW4 switch SPDT slide
SW5 switch SPDT toggle
Metal box to Fig. 10. Heatsink to Fig. 14 (if required) 8 pin octal valve base, piece of polarized plastic (preferably circular polarization) as per Fig 12.
4 ¼" long spacers for PC board (3 only if MJE 3055 is used).

IC10, 12, 14 and 16 are available from Celdis Ltd. 37–39 Loverock Road, Reading, Berks.

## HOW IT WORKS

Basic timing is generated by a 4 MHz crystal, in conjunction with ICI/1 and ICI/2 which are digital gates operated in a linear mode. The output of ICI/2 is divided by four in IC2/1 and IC2 to provide 1 MHz. This is further divided to 10 Hz by IC3 – IC7. The 10 Hz or the 100 Hz output from IC6 is selected by SW1/1 as the basic 0.1 second or 0.01 second timing.

The selected clock frequency is inverted by ICI/3 and counted by ICs 15, 13, 11 and 9. Inverter ICI/3 is used to give the clock an initial ½ digit lead in order that the accuracy should be ±½ digit rather than the usual +0 –1 digit in conventional digital instruments.

The display ICs provide a visual indication of the counter's contents. These ICs contain a store as well as decoders and drivers for the display. A four bit binary code is used where digits 10 to 15 are not used, and a control line or strobe is used to gate counter data into the store. If this line is low (less than 0.8 V) the information at the four inputs will be decoded and displayed. If the line is high (greater than 2.4 V), the store will still register the last input, and the counter state may change without affecting the display.

Only four display chips are used but by using the two most-left-hand decimal points as overload indicators, the full range is extended to 39 999 rather than 9999. There is no indication of overflow beyond 39 999 but the timer will continue to recycle and multiples of 40 000 can be added to obtain the correct time.

Three control lines are used for the counters. These are:–

1. The Reset Line: This line is used to stop the counters, reset and hold the counter to zero whenever it is in the high state (greater than 2.4 V).

2. Inhibit Line: This line stops the clock divider whenever it is in the low state (less than 0.8 V). Thus it stops the counting and freezes the display without resetting it.

3. Strobe Line: This line controls the store as previously described. In modes 1 and 2 SW2/3 applies a permanent zero to the line hence the store is only used in mode 3.

In modes 1 and 2 the state of the reset and inhibit lines is determined by IC18. The output states of IC18 for reset, start and stop conditions are given in Table 1. In mode 1 these states are set up by directly setting the preset (pins 3 and 8) and clear (pins 2 and 7) inputs whereas in mode 2 the IC's are toggled from one state to the other.

Either an external push-button or the internal one, SW3, may be used to toggle IC18 through its three states. Switch contact bounce is eliminated by RS flip-flop IC17.

In mode 3, IC18 is locked into "start" by SW2/1. IC20 and IC21 are monostables that provide, when triggered, a single, one-microsecond-wide pulse which goes from 'high' to 'low' and back to 'high'. As the two monostables are in series, IC21 provides its pulse at the end of that from IC20. The first pulse controls the display stores, and the second pulse resets the counters to zero. Thus when the button is pressed, IC20 provides a strobe pulse that transfers the contents of the counter to the store. The store then closes and the second pulse from IC21 resets the counters to zero; the contents of the store, however, are retained and displayed until the next time the button is pressed. In modes 1 and 2 IC20 is inhibited by an earth on pin 5 from SW2/2.

The power supply is a series pass regulator type and will accept input voltages within the range six to 16 volts whilst providing the correct output of five volts. Correct operation will be maintained on batteries down to about five volts but display brilliance drops off. Diode D1 is used to prevent damage from reversed input polarities.

construction should not present any major difficulty.

Firstly mount all integrated circuits onto the main board paying particular attention to orientating the spot or notch on the IC as shown in the component overlay.

Fit resistors capacitors, transistors and the crystal, again paying attention to polarities and orientation – where applicable.

If an MJE3055 flat-pack transistor is used for Q3 it may be mounted as shown in Figures 4 and 3. Make sure that the transistor is insulated from the chassis.

If the 2N3055 is used, it must be mounted on a separate aluminium bracket as per Fig. 14. It too must be insulated from the bracket by a mica washer and insulation bushes. Connection to the collector of the 2N3055 is made by fitting a solder tag under one of mounting bolts. The three connections to the 2N3055 are made by flying leads to the board as per the overlay Fig. 4.

Next fit tinned copper links and then the display ICs to the small display board as per Fig. 6. When the display chip is viewed at a particular angle, the approximately 3mm square IC chip can be seen through the red plastic front lens. This should be positioned towards the bottom of the display board to obtain correct orientation.

The display board is attached to the main board by tinned copper wire links (26 SWG). The easiest method of linking is to begin with a separation of about 12mm between the boards and sew the two boards together with a length of tinned copper wire. Then pull the display board down onto the main board making sure the display board is vertical. Solder the wires in place and snip off the excess wire.

Now mount the switches, power socket, PC board assembly and 2N3055 and bracket (if used) to the chassis and interconnect as per Figures 4, 5, and 7. The displays are mounted well back in the body of the timer to allow good visibility in daylight.

A viewing duct should be constructed from light cardboard (manilla folder) as per Fig. 11. The inner surface should be painted matt black and a piece of polarized plastic (as per Fig 12) inserted in the duct where indicated by the slot markings.

## USING THE TIMER

The timer draws around 700 mA and therefore, should be operated from a car battery (or similar) supplying a minimum of 6 volts and a maximum of 16 volts.

Although the timer operates extremely well as a hand operated stop watch, the major advantages of the unit are only realized in lap timing (which does not require further explanation) and in the remote start/stop mode. In this latter mode the full accuracy of the unit is realized by using light-beam (or other electronics) start/stop control.

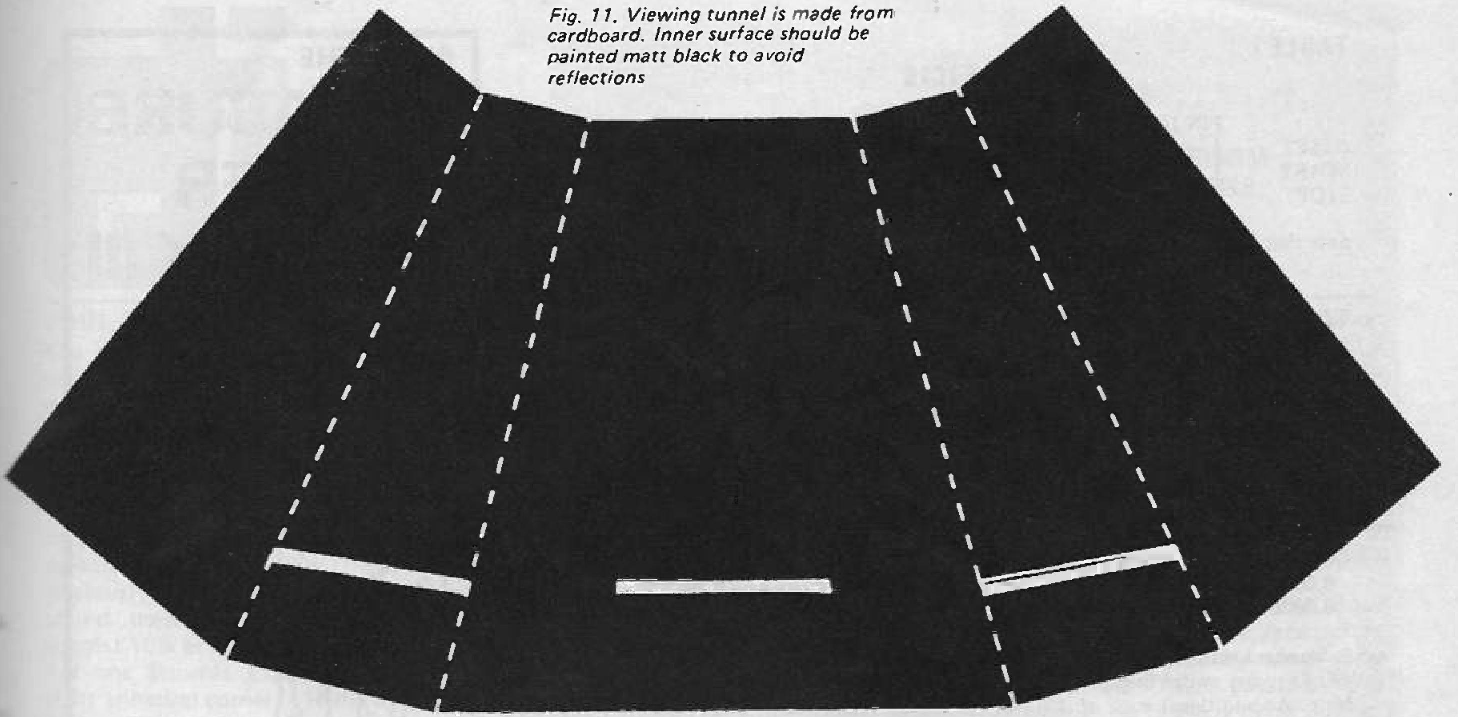


Fig. 11. Viewing tunnel is made from cardboard. Inner surface should be painted matt black to avoid reflections

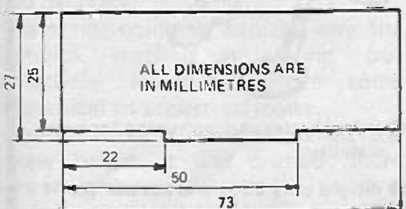



Fig. 12. Dimensions of polarized plastic window (fitted in slots of viewing tunnel).

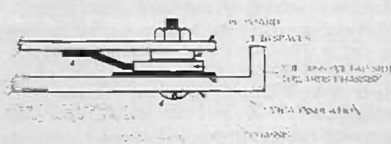


Fig. 13. Mounting details of MJE 3055.

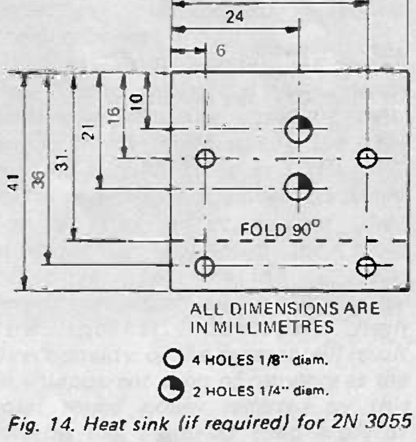



Fig. 14. Heat sink (if required) for 2N 3055

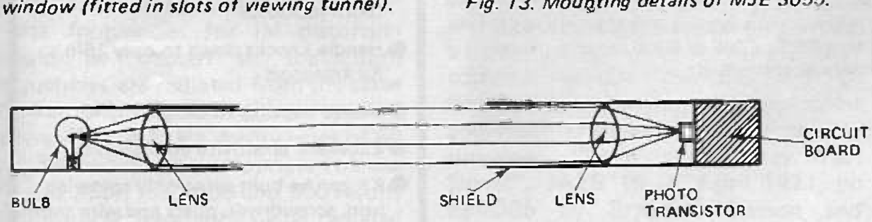



Fig. 15. Arrangement of light beam transmitter and receiver.

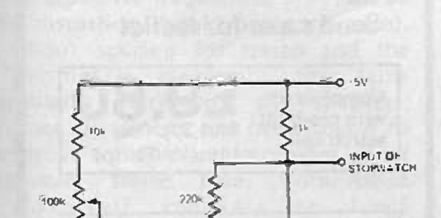



Fig. 16. Circuit of a suitable light-beam detector for electronically controlled stop watch.

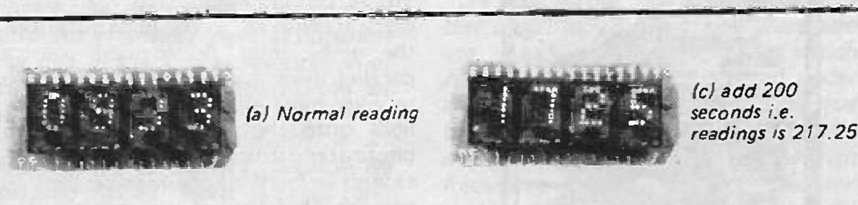



Fig. 17. Method of extending timing range.

### TABLE I

**STATES OF IC18**

| | PIN 10 | PIN 11 | PIN 14 | PIN 15 |
|---|---|---|---|---|
| RESET | 1 | 0 | 1 | 0 |
| START | 1 | 0 | 0 | 1 |
| STOP | 0 | 1 | 1 | 0 |

note that 1 means $>$2.8 V, 0 means $<$0.8 V

### TABLE II CONNECTIONS FOR DIFFERENT RESOLUTIONS

| RESOLUTION (SECS) | MAXIMUM & INDICATED TIME | CONNECT TIME BASE OUTPUT (SW 1/1) TO | CONNECT DECIMAL POINT TO |
|---|---|---|---|
| * 0.1 | 3999.9 secs | PIN 12 of IC7 | PIN 4 of IC16 |
| * 0.01 | 399.99 secs | PIN 12 of IC6 | PIN 4 of IC14 |
| 0.001 | 39999 msecs | PIN 12 of IC5 | NO CONNECTION |
| 0.0001 | 3999.9 msecs | PIN 12 of IC 4 | PIN 4 of IC16 |
| 0.00001 | 399.99 msecs | PIN 12 of IC 3 | PIN 4 of IC14 |
| 0.000001 | 39999 μsecs | PIN 12 of IC2 | NO CONNECTION |

* Standard on stop watch as published. All ranges may be included by using a rotary switch in place of SW1.

Note: An additional error of ±½ digit occurs on 1 μsec range. In laptime mode 3, IC20 and IC21 contribute a 2μ sec delay. Mechanical switches are not suitable for very short resolutions, electronic means must be used.

### TABLE III

| 1ST POINT | 2ND POINT | READING | |
|---|---|---|---|
| OFF | OFF | as indicated | (a) |
| OFF | ON | add 100 seconds | (b) |
| ON | OFF | add 200 seconds | (c) |
| ON | ON | add 300 seconds | (d) |

*The four-digit display is capable of reading to 99.99 seconds (0.01 sec resolution) after which it recycles to zero and commences a new cycle. The maximum reading however is extended to 399.99 by using the two leftmost decimal points to count display cycles.*

*The count cycle is given in Table III and Fig. 17 where the decimal points are numbered from left to right.*

*When on 0.1 second resolution the maximum displayed time is 999.9 seconds and thus 1000, 2000 or 3000 seconds must be added as appropriate.*

*The viewing tunnel in position.*

A typical light beam set-up is illustrated in Fig. 15, and a suitable transistor detector/amplifier in Fig. 16. A certain amount of mechanical work is required, as the light output of the globe must be focused into a parallel beam by a lens. A lens in the receiver must also be used to focus the light onto the "active spot" of the photo-transistor. A light shield should extend in front of the receiver lens to prevent operation of the detector due to sunlight etc.

After the transmitter and receiver are mechanically aligned the 100 k potentiometer should be adjusted to provide about 1.5 volts across the photo-transistor. When the beam is broken the voltage across the photo-transistor should rise to four volts or more. Almost any available NPN photo-transistor may be used.

# eti INPUT GATE

LETTERS FROM OUR READERS

## PAUL KLIPSCH COMMENTS

The review of the Klipschorn speakers (November 1973) in general was well done and appreciated.

It was stated that I claim 50% efficiency. Back in 1940-1941 using the Bostwick methods (JASA, 2, 243, 1930) using motional and blocked impedances, the efficiency was calculated to be 50%. But this obviously is not corroborated by sound pressure measurements which suggest 10% as more realistic.

If one assumes a point source in a right trihedral corner, 116 dB SPL at 4 feet equates to approximately one watt output. We get about 106 dB for one watt input so efficiency is down about 10 dB from 100%. (Altec uses 118 dB at 4 feet for a solid angle of 90 x 60 degrees).

I am not going to explain why the Bostwick method is wrong, but tentatively it must ignore some mechanical to acoustical losses.

I wish I could have examined the review before it was printed; there were some errors.

I do not claim "28 Hz"; using IRE Standards of 1935 I can justifiably claim "down 10dB at 35 Hz".

Test frequencies for IM distortion should be chosen so that both frequencies are radiated from the same speaker unit. Thus if a bass speaker covers 40 to 400 Hz, frequencies of 50 and 350 would be appropriate (we use 41 and 350); use of 50 and 500 results in the upper frequency being radiated from the midrange, and negligible IM distortion occurs. (One maker of a 4-way speaker uses 50 and 5000 Hz; two crossover frequencies intervene so IM distortion should be nearly zero).

About spacing for stereo and the "geometry problem": the same problems exist with any speakers; corner placement has been found to improve tonality and geometry of *all* speakers tested here, from small bookshelf speakers to large free-standing "cabinet" type speakers. The article misquotes me in recommending 3 x 5 x 8 metres; we use the long wall (7.9 metres) for the array, with a centre speaker to "put a leg chain on the soloist"; the bridged centre speaker was another Bell Telephone Laboratories teaching (Symposium, 1934). Many satisfactory installations using large and small speakers are much smaller than this. (Note 3 x 5 x 8 is nearly "golden mean" ratio; the terms are in the low range of the Fibbonocci Series).

The "complaint" about impedance variations is invalid. One can always mismatch a high impedance load to a low impedance generator. As for tubes (valves) disliking such impedance level, remember the speaker system was developed before solid-state devices existed, and amplitude response curves and distortion tests were made using "valves". One could write a whole thesis on speaker impedance matching and mismatching. I think Wente and Thuras (Bell Telephone Laboratories Symposium, 1934) should be read before adversely criticizing a speaker for its impedance variations. If an amplifier "likes" 4 ohms, it will like 40 ohms even better. Our HERESY speaker goes up to 120 ohms.

The amplitude response curve reproduced in your review resembles closely what we get with a sweep oscillator, X-Y recorder, and a "fast sweep" relative to the X-Y recorder writing speed. We get a trifle better response beyond 8 kHz, and the difference may be due to dispersion and the "pink noise" technique. Our experience with Pink Noise corroborates Dr. Saponas' (et al) finding that the best test signal for amplitude response is the gliding sinewave, "Plain and Fancy Test Signal", JAES 19, 4, April 1971, pp 294-305 by Saponas, Matson and Ashley. Paul Klipsch, Klipsch and Associates, Hope, Arkansas, USA.

*Paul Klipsch' letter is objective and raises a number of interesting factors.*

*Firstly, he points out that original claims for efficiency were in apparent error due to a lack of corroboration of technique with the practicalities of measurement.*

*Paul's comment concerning a 28 Hertz cut-off is justified, because we measured a 28 Hertz cut-off and inadvertently stated this as the cut-off frequency claimed by him.*

*With regard to intermodulation distortion tests, Paul Klipsch' criticism is objective and we accept it. Next time we perform this type of test we will be particularly careful to make sure that the two test zone frequencies both lie within the pass-band of the speaker being evaluated.*

*The recommendation of separation for adequate stereo was taken from a pocket facts document which came with the Klipschorn. This refers to adequate stereo spacing and suggests a minimum of 17 feet and points out that the Bell Telephone Laboratories use 42 feet which led us to believe that Klipsch and Associates are proposing that something between these spacings would be about optimum.*

*With regard to the comment about impedance variations, we referred to this possibility bothering some valve amplifiers. We have observed this phenomena particularly in many of the small valve amplifiers in use twenty years ago. These had neither the capacity nor the stability to cope with extreme variations in impedance on the output load of the amplifier under sustained drive conditions.*

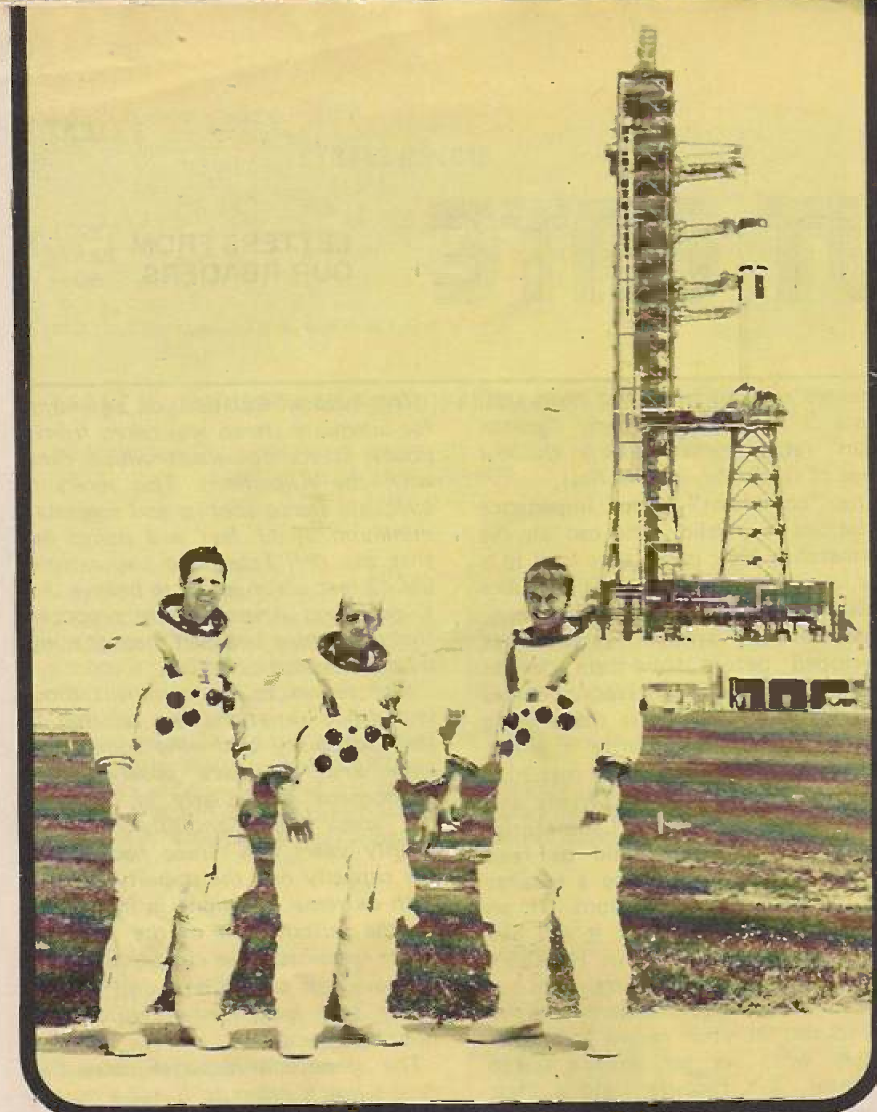
*I have not seen Wente and Thuras' paper and look forward to reading their comments.*

*The amplitude response curve that Paul Klipsch refers to is not a normal on-axis frequency response, but as our article clearly points out, is the total sound power measured in a 340 cubic metre reverberant chamber, corrected for spatial effects, and then subsequently corrected for room response, to provide a total reverberant sound power response for the speaker. Obviously high directionality of the tweeter will result in an apparent drop of response as the total sound power radiated by this tweeter has a smaller solid angle of radiation and as a consequence the total sound power at the top end of the spectrum must drop.*

*We also favour the Plain and Fancy test signal of a gliding sine wave and use it extensively on speakers which can be more readily evaluated under anechoic conditions. It would be true to say that those speakers would also show a comparable drop in the high frequency response when measured under the same conditions as the Klipschorn.*

*Although Klipsch did not see the review before publication, we did in fact telephone his company in the USA and asked if they would care to comment. These comments were published at the end of the review.*

*Louis A. Challis,*
*Audio Consultant to ETI.*



Skylab 2 astronauts, from left to right, Dr. Joseph P. Kerwin, science pilot; Charles Conrad, Jr., mission commander; and Paul Weitz, pilot, pause in front of the Saturn IB space vehicle that launched them to Earth orbit from Complex 39B.

# NASA - the first 15 years

**A resumé of past achievements and future plans of the American Space Agency.**

FIFTEEN years ago, on the 29th of July 1958, President Eisenhower signed into law the National Aeronautics and Space Act of 1958. As a direct result of this legislation the National Aeronautics and Space Administrations — NASA, was officially born two months later on October the first.

Prior to this time, research into rocket technology in the United States was fragmented among the military services and NASA's predecessor the National Advisory Committee for Aeronautics (NACA). This fragmentation and its resulting jealousies prevented any real progress being made.

Russia's Sputnik I, launched Oct. 4, 1957, put 184 pounds of scientific instruments into orbit and seriously challenged the United States' reputation for technological superiority. Congratulatory messages had hardly stopped pouring in to the U.S.S.R. when the Soviets on Nov. 3 launched another Sputnik with six times the payload of the first one. This one also carried the first space passenger, a dog named Laika.

From the public and official concern arising from these events the United States realized that they needed a space programme built on a foundation of well-formulated basic policy and planning, effectively organized, adequately funded, and given high priorities.

The outcome was a civilian space agency, the National Aeronautics and Space Administration, whose policy was "that activities in space should be devoted to peaceful purposes for the benefit of all mankind."

When NASA celebrated its 15th birthday on the first of October, the U.S. had orbiting the Earth every 90 minutes a 100-ton space station, Skylab. By contrast, the first US satellite, Explorer 1, launched Jan. 31, 1958, weighed just a little over 30 pounds. For all its small size, Explorer 1 was scientifically productive. It discovered the Van Allen Belts, areas of high energy particles that surround the Earth.

Skylab, manned by three crews of three astronauts each for periods of up to two months, is conducting solar astronomy, Earth resources, medical and other scientific and technical investigations.

It is hoped that the Skylab experiments in space will provide new knowledge for the improvement of life on Earth and that its investigations and experiments will help develop new methods of learning about the Earth's environment and resources, and provide new ways to evaluate programmes directed at preserving or enhancing those resources throughout the world.

Following are summaries of the major space programmes undertaken during NASA's first 15 years.

## MANNED SPACE FLIGHT

In manned space flight the Russians were again first in the field. Yuri Gagarin, in his space ship Vostok, was the first man in space making an orbital flight in April 1961.

The United States' manned space flight programme, Project Mercury, was established in October 1958 and in May 1961 Alan Shepard became the first American in space. He made a suborbital flight of 15 minutes, successfully landing in the Atlantic ocean 302 miles down range from Cape Canaveral.

On February 20, 1962, John Glenn became the first of four Mercury astronauts to be placed in Earth orbit thus accomplishing the major goal of the programme.

Following Mercury, the Gemini Program extended manned spaceflight activities by the development of a two-man spacecraft designed for long duration flights. From March 1965 to November 1966, ten manned Earth-orbital Gemini flights were flown for missions of from 5 hours to 14 days.

In the late sixties and early seventies, the Apollo lunar landing project dominated the space programme. In December 1968, with the flight Apollo 8, man first circled the Moon and returned safely to Earth. Starting with the flight of Apollo 11 and Neil Armstrong's first step on the lunar surface July 20, 1969, twelve astronauts were eventually to explore the Moon until December 1972 when the flight of Apollo 17 officially ended the programme. But the five scientific stations established on the Moon continue to relay information to Earth, and it will take years to completely analyze the hundreds of pounds of lunar material returned to Earth.

Following 1973, the year of Skylab, the next major manned flight programme will be the joint Apollo-Soyuz Test Project — the first manned international space effort. American astronauts, in an Apollo spacecraft, will rendezvous, dock, and visit an orbiting USSR Soyuz spacecraft. In turn, Soyuz crewmen will pass through the docking module and return the visit to Apollo. Target date for the launch is July 15, 1975.

Toward the end of this decade, the Space Shuttle will be ready for its major role in space. Needed to make space operations less complex and less costly, the reusable Space Shuttle is designed to carry out various missions in Earth orbit at a fraction of the cost that present day launch vehicles demand.

## SPACE SCIENCES

Through the use of unmanned spacecraft, the exploration of space has provided man with a better understanding of his own planet and an opportunity to see other planets, stars, and galaxies, unhindered by the Earth's obscuring atmosphere.

Earth-orbiting satellites have discovered and mapped in detail the highly complex magnetosphere surrounding Earth and the effect of solar radiation on Earth's ionosphere and atmosphere. Other spacecraft have looked far into space to study ultraviolet, infrared, X-ray and gamma-ray radiation to learn more about stars, galaxies and the little-understood pulsars, quasars and black holes.

Instrumented spacecraft have orbited Mars and have been sent toward Venus and Jupiter. The information from these probes will contribute to an understanding of those planets and why they are different from the planet Earth. Other far-ranging spacecraft mapped the Moon in detail and observed the Sun and the solar wind from widely separated points in the solar system.

In NASA's first 15 years, some 300 satellites have been sent into Earth orbit and interplanetary space. Milestones include:

1. Rangers, Surveyors and Lunar Orbiters: these unmanned spacecraft launched in the early 1960's paved the way for man's first landing on an alien body, returning thousands of closeup pictures of the lunar surface and scientific data on its composition.

2. Mariner: A family of planetary probes designed to investigate Mars and Venus. Orbiting the Red Planet in 1971, Mariner 9 provided man with his first closeup look, returning more than 7,000 pictures and other important scientific information. The information obtained by Mariner 9 has provided valuable data for planning the 1975 landing of Viking life-detection laboratory on the Martian surface.

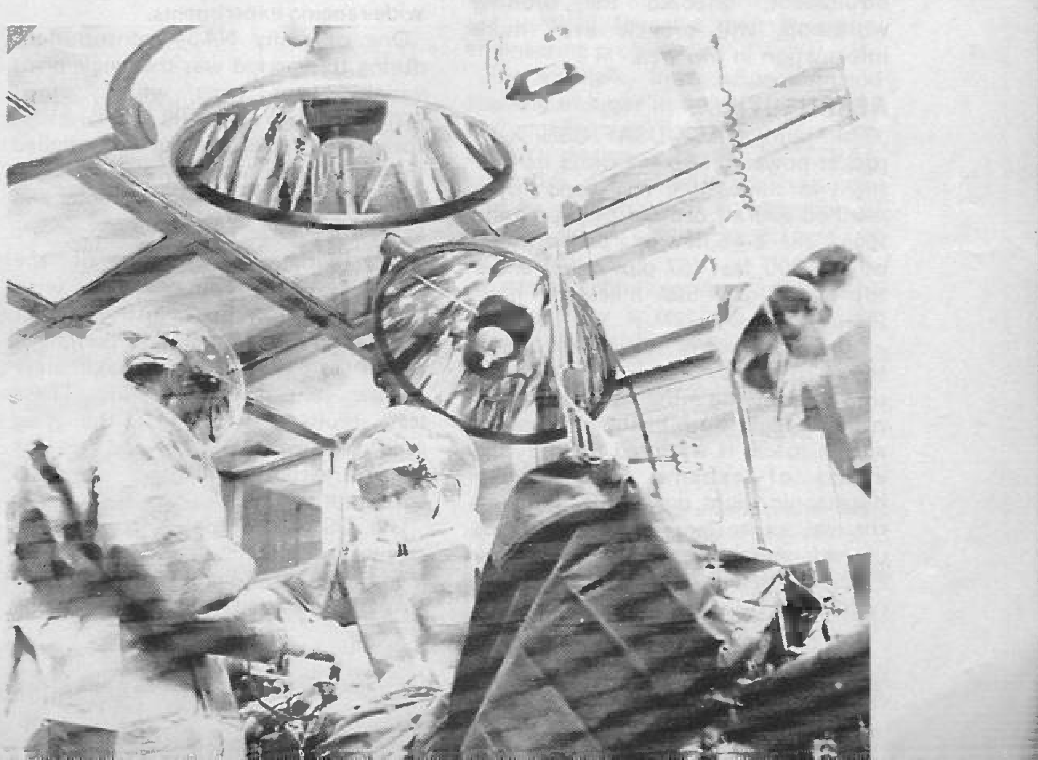
3. Pioneer 10: Launched in 1972, Pioneer 10 will make the first reconnaissance of giant Jupiter in December, 1973, before becoming the first manmade object to escape the solar system. Pioneer 10 completed the first successful passage through the asteroid belt during its 600-million-mile journey. A second Jupiter probe, Pioneer 11, is scheduled to reach the planet in December 1974.

## APPLICATIONS

In the area of direct benefits to mankind as a result of space activity, the groundwork was done in the early '60's with passive and active communications satellites and early meteorological spacecraft.

The Echo balloon satellites launched in 1960 and 1964, and seen by more people than any other man made objects in history, were some of the early stepping stones to the billion dollar global commercial communications satellite industry. They were followed by the Telstar, an active communications repeater, developed by American Telephone and Telegraph Corporation in 1962 and 1964, and NASA's Relay satellites in 1962 and 1964. With the launching of the synchronous orbit satellites, Syncoms 1 and 2 in 1963, it was apparent that the commercial capability required for the Communications Satellite Corporation, incorporated in 1962, was available.

NASA is now phasing out its conventional communications satellite research and development activity, leaving future endeavours to private



*A surgery team at St. Luke's Hospital in Denver performs a hip-joint replacement in a new clean room facility which helps lessen the danger of infection to the patient. The surgery is being performed in a foldable clean room which can be stored when not in use. Air is forced in a gentle breeze from the rear of the room to the open front. Team members "upwind" of the patient wear astronaut-type helmets and garments which are impermeable to bacteria. Team members "downwind" of the patient are not required to wear the special gear, since the air around them is circulated away from the patient. Application of the clean room technique for surgery was developed by Martin Marietta Corporation's Denver division for the National Aeronautics and Space Administration and is being evaluated at St. Luke's.*

# NASA -the first 15 years

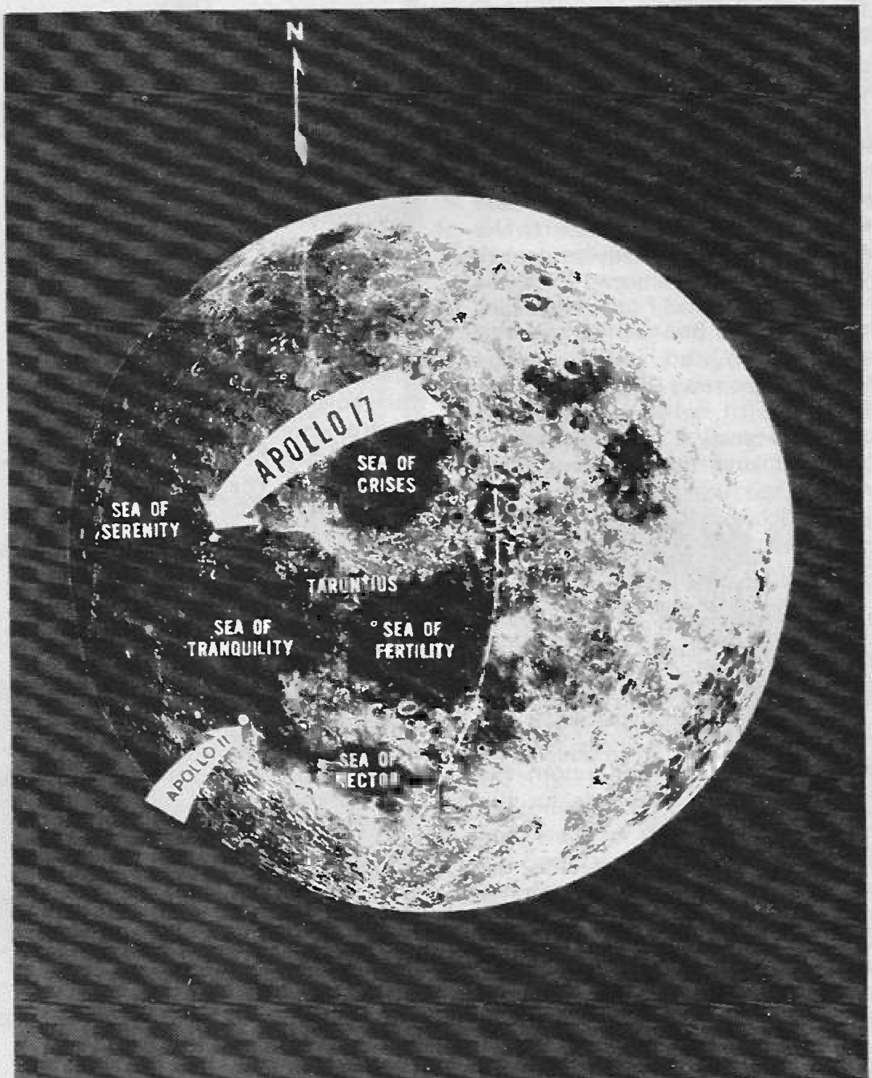
industry. The last and largest communications satellites developed by NASA, ATS-F, will be launched early next year to pioneer in even more advanced areas of communications technology. These satellites will be used for experimental broadcasts of instructional and educational television to remote regions, experiments dealing with such things as air and sea traffic control and satellite-to-satellite communications.

The first meteorological satellite, Tiros-1, was launched in 1960, followed by a rapid succession of similar spacecraft in following years. These resulted in the establishment in 1966 of the first operational meteorological satellite system. Weather satellites have observed every major storm or hurricane since the launching of the first TIROS and improvements in such spacecraft flow from research performed with NASA's Nimbus and Applications Technology Satellites.

In 1972, the first Earth Resources Technology Satellite, ERTS-1, was launched and continues to return information of great importance in managing the Earth's resources and observing its environment. More than three hundred investigators are using data from this spacecraft in experimental applications to these fields.

It is said that the ERTS project will help mankind solve some of the most pressing social and economic problems from one end of Earth to the other.

The photos and data on earth resources brought back by the Skylab astronauts from a battery of more sophisticated Earth observation equipment, onboard the orbiting workshop, will provide even more information in this area.




*This photo, taken by the Apollo II crew on their way home from the moon, shows both the first landing site and the last — that of Apollo 17.*

*It was taken from a distance of 16,000 kilometres after the Apollo II crew had fired their engines on the back side of the moon to place them in a correct trajectory for earth return.*

*To the right of the dotted line is the side of the moon which cannot be seen from earth. The darker left hand side is that which is normally visible.*

## AERONAUTICS

The joint NASA/USAF/USN X-15 rocket powered airplane made its first flight in June 1959. The world's only manned aircraft capable of hypersonic flight, the X-15 flew to a peak altitude of 354,200 feet (67 plus miles) and a top speed of 4,520 miles per hour (Mach 6.7).

During the nearly 10 years of flight, the X-15 made major contributions to understanding the problems of manned flight both in the atmosphere and in space. It was used to study the effects of extreme conditions of hypersonic flight on skin friction and thermal expansion, it pioneered the use of ablative coatings, aided the efficient design of structures, and fulfilled its workhorse test-bed role encompassing approximately 40 wide-ranging experiments.

One of many NASA contributions during this period was the single-pivot variable-swept wing which allows efficient flight at both high and low speeds. This concept was first applied to the Air Force F-111 and has since been adopted for the F-14 fighter and the B-1 bomber.

The initial flight tests of the NASA-developed supercritical wing have successfully demonstrated that the new shaped airfoil does permit an F-8 aircraft to operate approximately 15 per cent more efficiently. These test results showed that the wing produces higher speed and greater range without increases in fuel consumption.

The US Air Force contractors are currently designing two Advanced Medium STOL Transport prototype aircraft employing supercritical wing technology and also propulsive-lift concepts derived from NASA technology. The propulsive-lift concepts use engine exhaust air to provide additional lift to the aircraft, permitting low approach and takeoff speed, to facilitate short field operations. NASA's Quiet Propulsive-Lift Technology programme promises to contribute significantly to reducing congestion and noise impact at existing civil airports and would enable use of smaller, more conveniently located, quiet-ports near city centres.

The experimental Quiet Engine Programme, started in 1969, has demonstrated jet engine noise levels significantly below the US Federal Aviation Regulation requirements. Aircraft noise is currently constraining growth of civil aviation but the quiet engine technology development programme aims at making aircraft quieter and thus, more acceptable to the community environment.

## TECHNOLOGY UTILIZATION

NASA's Technology Utilization Office has been assigned the task of making certain that any technology developed by the agency would be made readily available to any who want to use it for peaceful purposes. The office currently operates six Regional Dissemination Centres or technological data banks located around the US. By consulting any one of these computer-controlled data banks, a potential user has ready access to all of the other five in getting answers to his technical problems.

The dissemination centres contain more than one million individual publications deal with technology over a wide range of disciplines. These materials represent new developments and inventions resulting from more than $45 billion worth of contracts with more than 400,000 separate companies during NASA's first 15 years. There is, in addition, a vast body of new technology developed by the space agency in its own government-operated laboratories and research centres.

Since 1970 more than 2,000 firms, ranging from small businesses employing less than 50 people to very large industrial complexes, have used the services of the Dissemination Centres annually.

The field of medicine has put more NASA-developed technology to use than any other discipline – mainly because of space age advances in miniaturization and sophisticated electronics circuitry. This is well illustrated by the following notable cases.

A compact, fully automatic gas analyzer is now on the commercial market. The gas analyzer measures the composition of air breathed in and exhaled from the lungs as an aid in monitoring pulmonary and cardiovascular activity in human patients. It affords prompt information on human respiratory and metabolic functions, previously unavailable or too time consuming to obtain.

In hospital intensive care units, the instrument can be used to monitor the breathing of acutely ill patients, signaling the need for changes in therapy more efficiently than previous methods. In surgeries, the anaesthesiologist can monitor the patient's progress, checking inhaled and exhaled concentrations of anaesthetic gas.

Ultra-clean laminar air-flow techniques developed by NASA for assembling spacecraft and their components are helping surgeons avoid infection in hospital surgeries. Ultra-fine filters purge dust and particles from the air during surgery, and the doctors and surgical team wear helmets resembling those worn by astronauts, plus specially treated surgical garments that bacteria cannot penetrate. The number of these special "clean room" surgeries has risen from less than 50 two years ago to more than 200 today.

Eye-operated switches, devices operated by breath controls, and ultra-sensitive pressure devices have been incorporated in a specially-equipped hospital room in a Huntsville, Alabama, hospital, designed to test various applications of NASA-developed technology in aiding quadriplegics (patients with no use of their arms or legs).

A patient unable to use either his hands or feet may one day be able to control the total environment of his room using devices developed initially for the space programme.

Immobile patients in the room are able to open and close doors and windows, control room temperature, change radio stations, dial a telephone, adjust the position of their beds, signal the nurse at a remote station, turn pages in a book and perform various other tasks necessary for their comfort and convenience.

Some of the other "spinoff" space benefits presently in daily use outside the aerospace field are:–

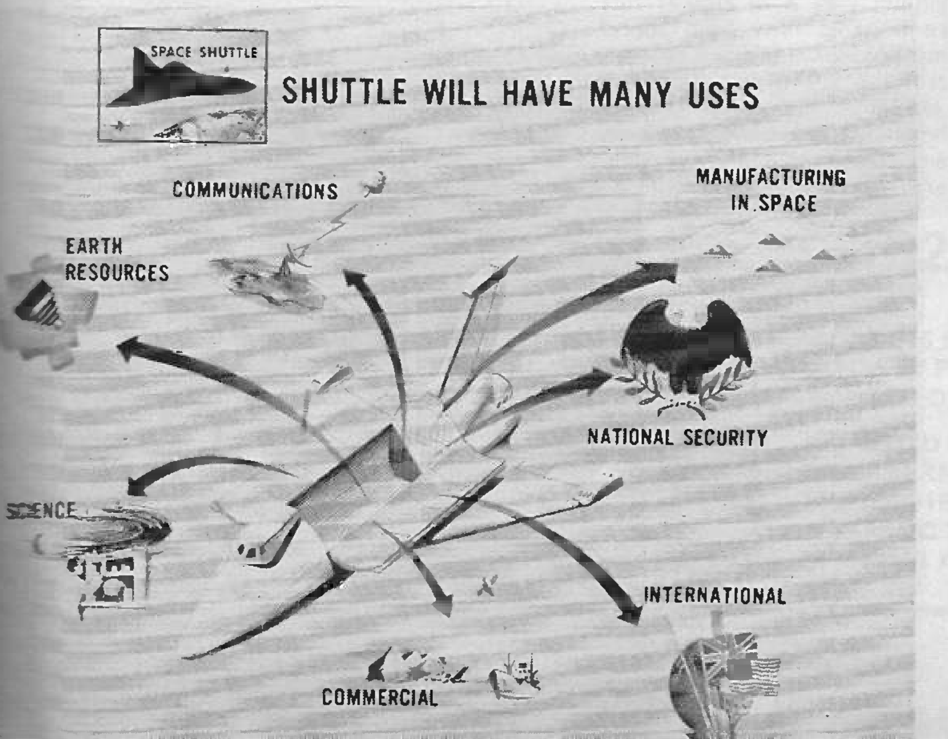
More and more nondestructive testing techniques developed by NASA are gaining widespread industrial use. A good example is a rapid-scan infrared tyre tester being used daily by a major US tyre manufacturer. The ultra-sensitive infrared optical device affords a nondestructive testing method for checking new designs in aircraft and automobile tyres.

The device produces a real-time cathode ray tube picture of the heat in tyres as they spin rapidly on the testing rig – up to 320 kilometres per hour in the case of automobile tyres and as fast as 640 kilometres an hour for aircraft tyres. The camera is capable of reading the heat from 600,000 points on a tyre every second, presenting an infrared "heat picture" of the tyre, in which flaws or hot areas appear as bright spots.

NASTRAN, a computer program designed by NASA to analyze the behavior of structures under stress, is now a design tool familiar to more than 1,000 American engineers outside the space agency. Hundreds of industrial firms, universities, laboratories and government agencies are using it to solve their structural engineering problems.

For example, front suspension and steering linkages in a line of American automobiles and light trucks are now being designed with NASTRAN assistance. NASTRAN analysis can also be applied in the construction of bridges, power plants, skyscrapers and airplanes.

Battery technology developed by the space agency is reaching the market daily in the form of better,




*The man-operated space shuttle orbiter will deploy in Earth orbit all types of scientific and applications satellites weighing up to 29,500 kilograms (65,000 pounds) and thereby replace most of the expendable launch vehicles currently used.*

# NASA - the first 15 years

longer-lasting battery power sources.

New successful lines of high-energy-output batteries appeared on the commercial market during 1972, providing sure, fast starts for portable power tools and sports equipment, thanks to battery technology originally developed by NASA.

These new products include both lead-acid and nickel-cadmium batteries, capable of being recharged 90 to 100 times faster than existing batteries. Compared with most commercial batteries requiring 14 to 16 hours for full recharge, the new batteries can be recharged in 15 to 20 minutes without damage to the cells. Some nickel-cadmium units can be recharged in as little as six minutes.

Another device benefitting average citizens daily is the "heat pipe" concept, developed jointly by NASA and the US Atomic Energy Commission:

A self-contained, fully automatic heat recovery and transport system, the heat pipe was first used in NASA spacecraft and in cooling nuclear reactors. This highly efficient equipment can transport heat at approximately 500 times the rate possible with the best solid conductors, with minimal temperature loss.

The heat pipe has recently been applied domestically in recovering and recirculating heat from chimney flues, increasing the efficiency and economy of many types of home heating plants approximately 10 per cent. The firm developing this household application expects to market the device widely in the near future.

A heat pipe application now on the market and familiar to many housewives is a "cooking pin" for distributing heat evenly through meat during the roasting process. A heat pipe for lowering the lubricating oil temperatures in motorcycles is now being offered commercially.

## INTERNATIONAL PROGRAMMES

The first international cooperative satellite was launched in 1962. Called Ariel I, and developed jointly with the United Kingdom, it carried scientific ionospheric experiments.

In the following years NASA has conducted 18 cooperative satellite and probe joint projects with Canada, France, Germany, Italy, the United Kingdom and the ten-nation European Space Research Organisation (ESRO).

Since orbiting the first foreign experiment on Explorer 20 in 1964, NASA has flown 25 international experiments on its satellites and spacecraft. Since its early development of communications satellites, NASA has successfully orbited 12 such spacecraft which form the Intelsat system of global communications.

The first cooperative sounding rocket launch in 1961 was a joint effort with Italy. Since then, NASA has participated in more than 790 such international sounding rocket projects.

From small beginnings NASA's international programmes have – over these years – developed to the present stage when 94 countries and international organizations are cooperating with NASA in some form and NASA has entered into more than 500 agreements for international space projects.

Among other developments more than 350 foreign scientists have been involved in the analysis of lunar surface samples.

The European Space Research Organization has established a special project for the study and development of a Sortie Laboratory to operate as an integral part of the NASA Space Shuttle.

The Apollo-Soyuz Test Project, a joint US/USSR experimental mission to test compatible rendezvous and docking systems, is on schedule for a 1975 launching. Meanwhile, US/USSR working groups are exchanging results and defining coordinated joint projects in space science and applications.

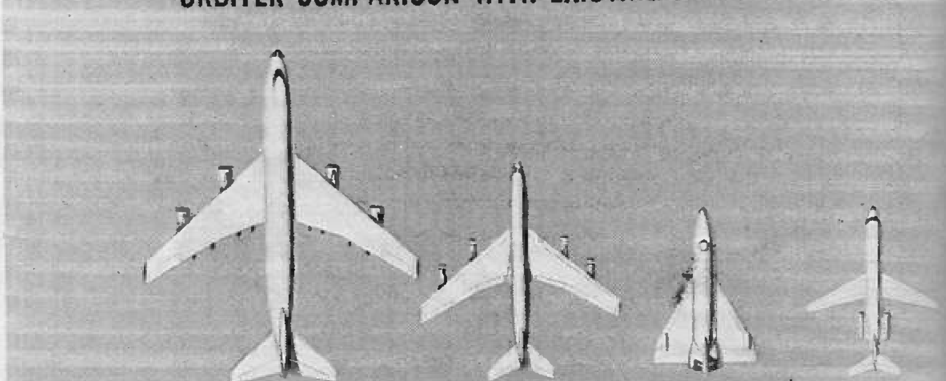
In addition, tracking, communications, and data acquisition have been effected with the cooperation of 22 countries. And cooperative international aeronautics research is being conducted with four countries.

Promising cooperative ventures for the future include a satellite instructional television experiment with India and joint satellite projects with Canada, Federal Republic of Germany, Netherlands, Spain, and United Kingdom. ●

*Technicians make final adjustments to Pioneer F spacecraft. Pioneer F, now on its way to Jupiter, is the first spacecraft designed to travel into the outer solar system and operate effectively there, possibly for as long as seven years and as far from the Sun as 2.4 billion kilometres (1.5 billion miles). Pioneer F's primary objective will be to take the first close-up look at Jupiter. It will return data on about 20 aspects of the big planet, its moons and environment.*

*The Space Shuttle will be a manned reusable space vehicle which will carry out various space missions in Earth orbit. It will consist of two stages. The first stage booster will be an unmanned liquid or solid-fueled rocket. The second stage orbiter will look like a delta-winged airplane and will be piloted by two men who will fly it back to Earth for an airplane-like landing.*

**ORBITER COMPARISON WITH EXISTING AIRCRAFT**



| | 747 | 707 | SHUTTLE ORBITER | DC-9 |
|---|---|---|---|---|
| WINGSPAN | 59.6 M (196 FT) | 43.4 M (142 FT) | 22.8 M (75 FT) | 28.7 M (94.3 FT) |
| LENGTH | 70.5 M (231 FT) | 46.6 M (153 FT) | 36.6 M (120 FT) | 36.4 M (119.3 FT) |
| OPER. WT. EMPTY | 165,920 KG (365,800 LBS) | 61,236 KG (135,000 LBS) | 63,400 KG (140,000 LBS) | 26,000 KG (57,210 LBS) |
| LANDING SPEED | 140 KNOTS | 140 KNOTS | 160 KNOTS | 112 KNOTS |

# CREATIVE AUDIO

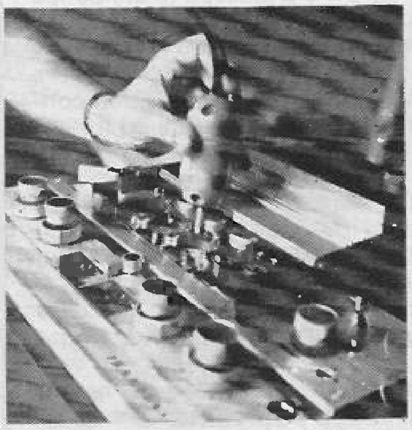


*Fig. 1 Using a Defluxer to degauss the record head of a Ferrograph tape recorder.*

## PART TWO

**A practical guide to creating and producing your own sound by Terry Mendoza, B.Sc. (Hons).**

COMMON to all forms of creative recording is the making of taped copies from original 'master' tapes. This process is known as 'dubbing'. Although apparently straightforward, it is in fact impossible to render an *exact* tape copy from an original.

There are a number of reasons why this should be:

The transients on a master tape may inadvertently have been allowed to enter overload conditions momentarily, thus introducing a typical 3% distortion (a VU meter may not even indicate this incursion into distortion); because of this many broadcasting engineers prefer the 'Peak Programme Meter (or PPM) which traces programme transients. If this overload level occurs over short periods the resultant distortion may be acceptable, but if such a tape is *copied* to an equal flux level, so that 0 dB on the copy tape corresponds to 0 dB on the master tape, the transient periods will again have been subjected to 3% distortion, thus on the copy all peaks will be marred by a now unacceptable 6% distortion.

If the record gain control is reduced to combat distortion so that the peaks alone provide 100% modulation of the tape, the soft passages will now be recorded to a much lower level than before, and tape hiss and thermal noise originating in the electronics will become obtrusive.

Tape copying has also to contend with various forms of external breakthrough that may be present, radio pick-up, induced mains hum (or its harmonics) and 'impulse' interference (experienced when for example, a refrigerator thermostat switches on or off).

Radio breakthrough is more common when the recording equipment is used in the vicinity of a strong radio signal, close to a transmitter for instance. It happens when the input of the equipment functions, albeit poorly, as a detector circuit and aerial. Transistorised input stages often resemble a junction diode detector circuit and unscreened, or inefficiently screened, connecting leads provide the necessary signal input facility with the result that AM and even FM signals are detected and passed into the system where they undergo further amplification.

The first line of attack against external interference, is the use of good quality, tightly-braided screened lead for equipment interconnections. Suitable cable should have a nominal impedance of about 50 ohms and a core/screen capacitance of not more than 100 pF/metre.

Mains transformers and fluorescent lighting inductors are both sources of powerful magnetic fields and for obvious reasons signal carrying cables should not be allowed to trail close to them. (Tapes should also be guarded against the hazard of powerful magnetic fields — failure to take precautions results in partial erasure, high noise levels and massive print-through of signals from adjacent tape windings).

Radio breakthrough can be alleviated by tying the base of the troublesome first stage transistor to its emitter with a low value capacitance (47 to 100 pF). Audio signals will pass through normally whereas any HF radio signals will 'see' a short circuit and not pass into the system.

Tape heads should be adequately protected from stray magnetic fields — if it is evident that the screening is insufficient mu-metal shields can be constructed. A special foil for this application is manufactured by Telcon, but care must be taken to avoid sharp angles when working the material or its efficiency will be impaired.

The well-documented "hum-loop" is a further cause of high level of mains interference due to incorrect equipment-earthing methods.

Care should be exercised in the construction of audio equipment; it is better to run individual wires from the 'earthy' side of relevant components to a single earth potential point on the chassis rather than festoon an earthing wire from component to component around the apparatus.

It is evident that a tape copy walks a tightrope between hiss and miscellaneous interference on quiet passages, and distortion on louder transients.

Considering the foregoing in terms of programme compilation one should always try to preserve, as clearly as possible, the character of the original material. Thus this covers the rectification of deficiences on the master during the copying process; this may entail filtering or boosting selected frequency bands, expanding or compressing the dynamic range of the recording, or adding reverberation or echo onto a 'dry' master. The adjustment of characteristics, often in a very drastic form, is the major tool in impressionistic recording as utilised in modern plays, music concrete, and electronic music.

### HISS AND NOISE

Thermal amplifier noise and tape noise are the two principal causes of hiss which, except by using expensive Dolby A Noise Reduction equipment, is impossible to eliminate completely. Furthermore, when carrying out multitrack recordings (to be dealt with in a later article), these imperfections become cumulative and, in conjunction with peaking distortion, limit the number of re-recordings that it is feasible to make.

In order to extend these limiting boundaries, it is logical to restrict the number of amplifying (and resistive) stages between the replay head of the master machine and the record head of the recording machine. The use of a hi-fi preamplifier interposed between replay head and record head is therefore deprecated if it is going to raise the hiss level to any appreciable degree.

For the same reason it is usual to tap the output of a tape recorder between the preamplifier and main amplifier stages; this feed is variously termed 'line out', 'cathode follower', 'low level' or 'monitor' output. The output is connected to the 'line in' or 'radio' input of the recording machine having taken account of the stated input impedance (this figure gives the limit of load that may be applied to the input without fear of degradation of recording quality due to excessive load impedance).

If there is a control governing the output level of the replay machine, this should be set to between half and three-quarters of maximum gain. This setting ensures the replay amplifier will not be overloaded but nevertheless supplies plenty of signal to the recording machine.

Should the recording machine 'see' an inadequate signal level, the sensitivity of its recording amplifier has to be set near maximum with resulting amplifier noise increase. Conversely the replayed signal should not exceed five times the sensitivity of the recording machine.

## CHOICE OF MAGNETIC TAPE

It is common to find the operator's manual supplied with tape machines specifying particular brands of tape as 'suited' to the recorder. The reason for the recommendation is that all tapes possess different characteristics (measurable differences may even occur between subsequent batches of the *same* brand of tape) that require different ac bias settings for optimum recording quality.

Thickness of the magnetic oxide on the tape largely governs the tape maximum output level. Finer magnetic powders incorporated in the paint that is applied to the plastic base may impart the finished tape with low noise, or low noise/high output properties, but again bias changes may be necessary for the best results. It has been shown that an increase in the high frequency bias modulating the audio signal, results in the high treble bias-modulated signals registering *within* the tape oxide, away from its head-contact surface. This means that on replay the oxide registering the treble frequencies is not intimately contacting the tape head, and a muffled treble-end results. On the other hand, a reduction in the bias value limits the maximum signal possible at low audio frequencies.

This explanation largely oversimplifies the situation as it ignores modulation noise, tape noise, distortion and related problems. However it does reveal the quandary confronting the recorder manufacturer; to enable the lay user to achieve good results with the recorder, the manufacturer must set the bias and record pre-emphasis to suit a particular tape brand, hence the recommendation in the operator's manual.

Considering a three-head recorder, it is not an unduly difficult task for an enthusiast to set the bias on his machine for a particular type of tape. Basically the method involves metering the output from the replay head whilst feeding a steady tone to the line input. Many recording studios use a 1 kHz sinewave tone although one authority recommends a 10 kHz signal for line-up purposes. The bias level control is cut back, the tape set in motion and the bias gradually increased. The meter at first registers the increasing bias with corresponding increase in signal gain – indicated on the meter. A plateau is reached which is then followed by increasing bias leading to decreasing signal output. The correct bias setting is achieved when the signal output drops by 2 dB to 5 dB.

One advantage resulting from bias adjustment is that it allows specialized tapes, not normally considered for domestic use, such as BASF LR56 and LGR, to be brought into service. Tapes of this nature can be recorded at a higher signal level than normal so that the signal to tape noise ratio is more advantageous, thus requiring less amplification with an attendant reduction in replay amplifier noise. In addition, correct bias 'tweaking' gives a wide flat frequency response combined with minimum distortion.

(The reader should study this subject more deeply before attempting to re-align his own equipment – alternatively some service departments can do it for him).

The rationale dictating maximum tape area per second has already been covered in the first article in this series. The condition of the tape heads themselves is also a major quality-determining factor and hence warrants regular attention. Regular use of a defluxer (degausser) prevents a gradual build-up of head magnetization which otherwise causes an increase in background hiss levels, even affecting *later* replay of master tapes by the magnetized heads. In use, the defluxing device is placed against each head in turn (see Fig. 1) and the current switched off when the defluxer has been safely removed from the vicinity of the tape machine. This avoids the possibility of the switching transient inducing further residual fields in the heads.

The tape copying process itself can be considered from the two separate aspects, dynamic range and tonal modification possibilities.

## DYNAMIC RANGE

Programme material is compounded of a continuously varying pattern of different loudnesses and to produce taped copy of the dynamic range of sound reaching the microphone, the recording gain controls *could* be set to an average loudness value and then left alone.

This however is unsatisfactory as tape hiss becomes clearly audible when the programme level falls, and conversely, during louder periods the recording will be distorted. To keep the signal in the useable band, the simplest way is continuously to monitor the input level, smoothly adjusting the record gain control accordingly. Gradual operation of the control is essential, as even if rapid operation is not revealed on the recorded programme material itself, it will make itself evident by the abrupt pulsation of the background sound level.

With an orchestral work, or other known programme material, the gain should be gradually decreased a few seconds before an expected peak so that when the crescendo actually occurs, the large dynamic change will be registered without incurring distortion. If skillfully carried out, even a tutored ear will remain blissfully ignorant of the operation.

Although this simple manual control may be used to produce quite technically adequate recordings with single or two channel recorders – it becomes impracticable with multi-channel machines.

Professional recording studios, for example, may use several banks, each of as many as 24 microphones, connected to individual mixer/amplifiers and thence to separate tape tracks.

It is obviously impractical manually to adjust the levels of 24 amplifiers in an attempt to maintain optimum signal-to-noise ratio on each tape track, and because of this, automatic devices are used to this end.

## COMPRESSORS

These devices effect a continual gain reduction, so that instead of the output level following the input in a 1:1 ratio, it becomes 2:1, 3:1 or, in some cases, even tighter slopes. The nearer the slope approximates a 1:1 condition, the greater will be the resemblance of the output dynamics to the original signal (see Fig. 2).

## LIMITERS

Acting similarly to compressors, these too alter the relationship between input and output levels. However they operate only at the 'loud' end, to limit transients exceeding a preset peak volume. Tighter compression ratios are used, usually greater than 10:1 and these are combined with a fast 'release' characteristic, so the heavy compression ceases simultaneously with the transient leaving the softer programme material that follows unaffected.

The 'release' time is often manually variable so that it can be suited to the

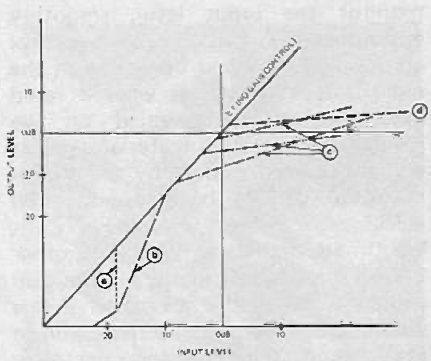



*Fig. 2. Gain characteristics of various control devices: (a) noise gate — switching in as input passes — 18 dB; (b) low level signal expander; (c) compressors and compressor/limiters; (d) limiter.*

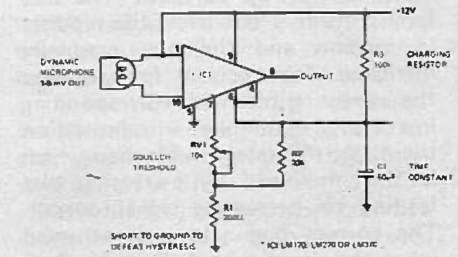



*Fig. 3. Squelch preamplifier (with hysteresis) — from National Semiconductor Linear Application Notes, AN-51, Sept. 1971.*

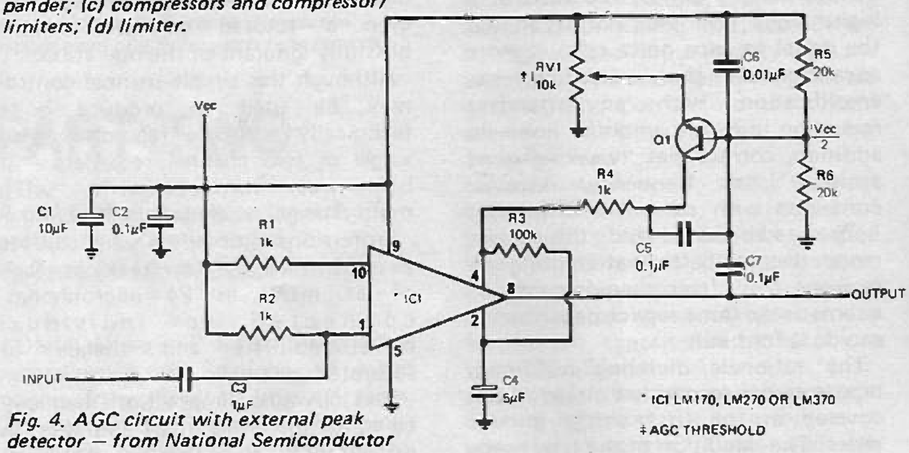



*Fig. 4. AGC circuit with external peak detector — from National Semiconductor Linear Application Notes, AN-51, Sept. 1971.*

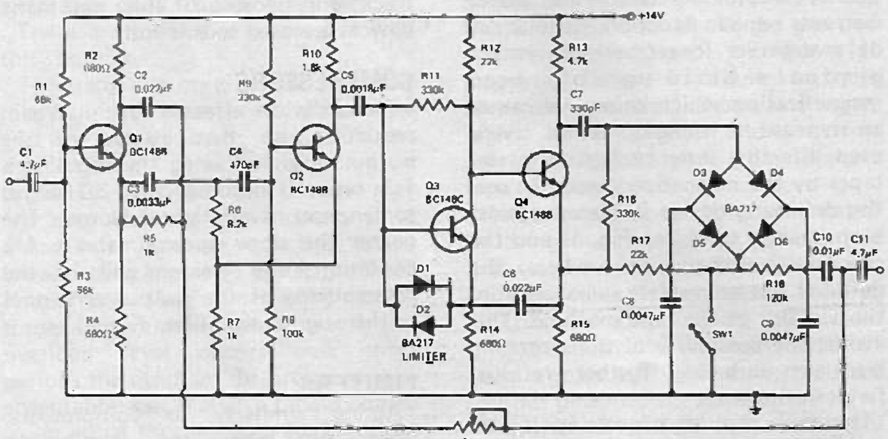



*Fig. 5. Complete circuit of Philips dynamic noise reducer. Capacitors $C_1$, $C_2$ and $C_3$ form part of the high-pass filter. Diodes $D_1$ and $D_2$ and capacitors $C_4$ and $C_5$ form a peak detector providing a control potential to attenuator diodes $D_3$ and $D_4$.*

type of programme material; if the release time is set too long it gives rise to a 'hole' immediately following the limited transient. Often, it is only by trial and error that the right release characteristic can be chosen for the material being recorded.

The threshold above which the limiting action takes effect, can also be altered and, for the most natural effect, this is set into operation just prior to the point of maximum tape modulation. The dynamic range up to this point is thus unaffected and, although distortion will occur on *very* loud peaks, it will be of a much lower severity than would be the case without the limiter in circuit.

## EXPANDERS

Dealing with the quiet sounds, at the other extreme of the dynamic range, expanders increase signal *output* level at a more *rapid* rate than the signal *input* increases. These units drag soft signals rapidly out of the danger zone — where they would have to compete with tape and amplifier hiss — swelling the signal with something like a 3:1 ratio.

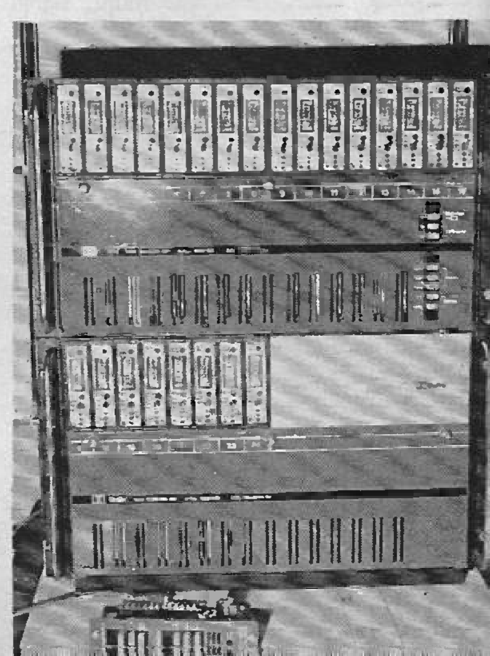
Noise gates act in the same region, but rather more drastically, with ratios of around 100:1; they perform as automatically switched attenuators, operating at a preset low level threshold.

These units have for a long time been much used in communications applications where their operation is descriptively termed a 'squelch' facility.

National Semiconductors have developed a very interesting integrated circuit designed specifically for automatic gain control and squelch applications. Figures 3 and 4 show circuits, using this IC, that may serve as a starting point for the experimenter in this field.

*Fig. 6a. Dolby A Professional Noise Reduction System.*

*Fig. 6b. Bank of 24 Dolby A noise reduction units for use with 24-track tape machine.*



## NOISE LIMITERS

Philips have designed a 'dynamic noise limiter' intended primarily for cassette tape replay (See Fig. 5). This circuit is based on the premise that the louder a musical instrument is played, the greater will be the number of high frequency harmonics produced (when played quietly, few instruments emit fundamentals above 500 Hz). A detector circuit identifies material lacking in upper harmonics and when such material occurs, the detector introduces a steep low-pass filter, thus blocking the high frequency, (hopefully) without altering the actual (lower frequency) programme content.

A final classification covers complementary processor and deprocessor units, the Dolby system being a prime example. They reduce noise emanating from the parts of the signal chain between the input to the processing stage and the eventual output from the deprocessing unit – such noise includes tape noise, print-through effects and amplifier noise.

In units such as these, the upper end of the dynamic range is passed through completely untreated, as loud sounds mask the much lower level background noise. The low-level signals at the input are expanded during the processing stage so they are recorded well above the inherent system noise, but still left at a slightly lower level than the untreated 'loud' band.

When the processed signal passes through the deprocessor the differential volumes will be sensed and the lower-level signals subjected to compression, this restoring the former dynamic range.

System noise in these passages will also undergo the same compression, effectively giving the same signal to noise ratios in the soft passages as in the loud ones.

The domestic Dolby B system concentrates on progressive hiss reduction in a band stretching upwards from 600 Hz, and achieving 10 dB noise reduction above 3000 Hz.

The Dolby A system, nowadays almost universally used in recording studios , works on the same principles, but use four separate frequency bands each with its own processor/deprocessor for smooth operation throughout the frequency spectrum. (See Fig 6a and 6b).

## EXPERIMENTAL CIRCUITS

The reader may find the photo-electric limiter – compressor circuit shown in Fig. 7 useful for a variety of applications – adjustment of the threshold dictates whether limiting or compression occurs. To set up, VR2 is set to maximum resistance and VR3 adjusted so that the bulb just glows in the darkness. If metering is used VR5 is set to full scale deflection with no signal present.

For optimum performance, the bulb should be in contact with the cadmium sulphide cell.

Different release times are obtained by employing switched capacitances between 1 $\mu$F and 10 $\mu$F in place of C2.

One advantage of this circuit is that there are no active noise-generating components in the actual programme chain.

A more elegant circuit is based on the use of a FET as a voltage dependent resistor in one arm of a potential divider across the input to an amplifier.

The compressor circuit shown in Fig. 8 works in a similar fashion, the MOSFET deriving its power from the audio signal itself. When -3V is applied to the MOSFET, its resistance is 10k, dropping to 300Ω (maximum compression) with -10V.

The transformer turns ratio should be at least 20:1.

Varing the base bias of transistors in push-pull configuration is one sensitive means of varying the amplifier gain. The 'electrical level control' illustrated in Fig. 9 must initially have the output balance adjusted *to minimize* the dc shift at the output with applied control voltage. After this the gain balance is trimmed to give minimal second harmonic (at the output) due to the input signal – using a sine wave input rather greater than normal, the gain balance is moved to provide the most symmetrical output waveform.

A general purpose expander-compressor is shown in Fig. 9a, this utilizes the electrical level control combined with a logarithmic rectifier.

Simultaneous compression before, and expansion after, a noisy device is possible using a complementary electrical level control configuration; dynamic range is not affected whilst the deleterious effects of the noisy device are much reduced or eliminated (Fig. 9b).

When any stereo signal is to be limited or compressed, the attenuation must be carried out synchronously to *both* channels using a 'tandem' system of dc control voltage. Altering the gain of one channel only results in the stereo panorama surging to and fro in a false and obvious manner.

Despite its many advantages, it must be emphasised that limiting is not the complete panacea for all recording level problems, as, especially with classical music, limiting can be extremely obvious and unpleasant – particularly to the musically trained ear.

## SIGNAL MODIFICATION DURING DUBBING

A second aspect of the copying process is the manual modification of the *frequency* characteristics of the signal before it enters the second recorder. The term 'manual' has been used here to differentiate from such automatic modifying devices as dynamic noise limiters.

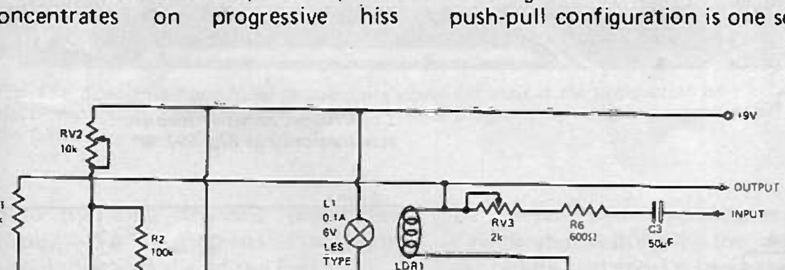
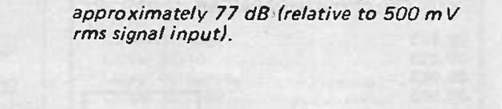



*Fig. 7. Photo-electric limiter-compressor.*

*Voltage controlled amplifier/attenuator, this circuit, intended primarily for experimenters, has a maximum gain of 13 dB and maximum attenuation of approximately 77 dB (relative to 500 mV rms signal input).*



## CREATIVE AUDIO

This includes various filtering processes which are used to attain, or alter the flat frequency response characteristic, to compensate for deficiencies in the recording environment, to enhance or increase the definition of an instrumental sound.

When treble boost is desired, it is advantageous to apply it before the material gets onto the master tape, because boosting at the copying stage also boosts tape hiss.

Subject to noise limitations imposed by the amplifier, treble or bass boost/cut may economically be applied to a signal by passing it through a domestic hi-fi amplifier (retrieving the signal at the 'tape-out' or 'low-level out'). Alternatively, for treble and bass modification, it may be worthwhile utilising the simple active tone control circuit shown in Fig. 10.

Tonal modification is due to the frequency dependant 'feedback' network between the collector and base of the transistor. The input is 40 kΩ at 1 kHz with the controls flat, and the output a usefully low 180Ω. (This circuit was developed by Mullard Ltd).

Many signals demand more specialised treatment than is provided by circuits which just tweak the two ends of the frequency spectrum.

An octave filter bank is the answer in such cases. Unfortunately such devices are usually priced well out of the range of the amateur enthusiast.

However the equaliser described as part of the ETI Master Mixer may be used to perform at least some of the functions of a full octave equaliser (ETI, May 1973).

### MAKING THE COPY

The equipment should be given five to ten minutes to warm up before actually making any tape copies, especially if the equipment has been kept in a cold room. To assist the warming-up process, recorders can be placed in the fast-wind mode.

Opening and closing input level controls a few times clears any possible 'noisy' patches on the fader tracks.

During the warm-up process, the duration of the piece to be copied may be timed, noting any extra-loud or soft passages to be negotiated.

The recording and replay tapes can now be threaded up on their relevant machines and the initial recording levels set by a trial recording.

Copying 'proper' should take place after both machines have reached full speed; to give adequate run-up time, the replay tape should be set back a little way before the required passage. The recording machine is started before starting the replay machine, any unwanted gap being edited out of the copy later. A neat result can be gained by editing leader tape up to the start of the wanted material on the replaying tape. Similarly, having noted the initial levels required, it is preferable to start the recording machine with the inputs closed, then rapidly fade up to the previously noted levels.

Commencing copying, the sequence of events will thus entail: (1) Start record machine with controls fully closed: (2) Start replay machine: (3) Rapidly fade up recording gain controls to the predetermined levels in time to catch the commencement of the required passage.

If a slow fade-in is warranted, adjustment of the control is initiated as the leader on the replaying master is seen to finish.

Material compilation will be covered later in this series, but an important rule relating to 'fades' is that they should be conducted as near to the end of the programme chain as possible, preferably when dubbing

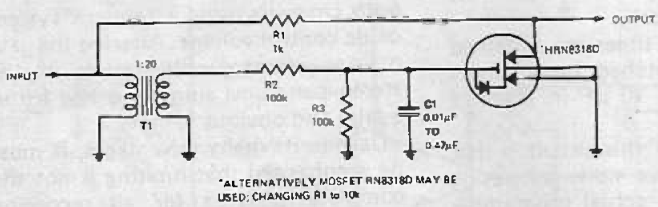



*Fig. 8. MOSFET Volume compressor (requires no power supply).*

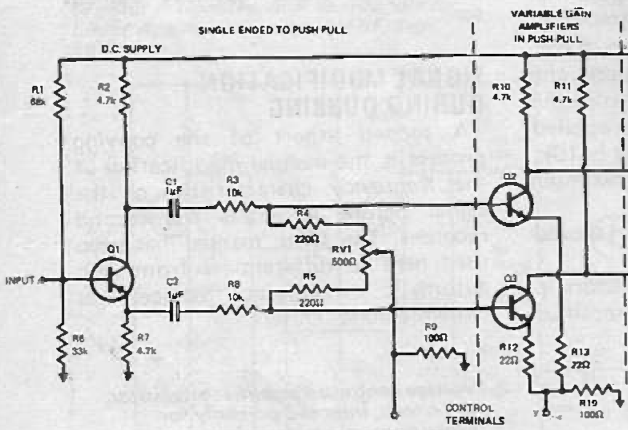
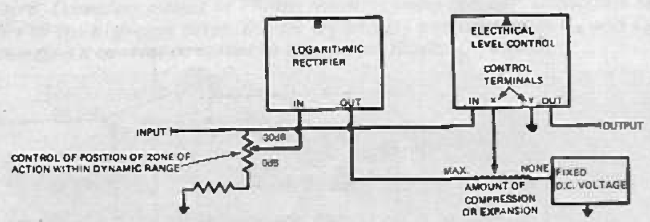



*Fig. 9. Electronic level control.*




*Logarithmic rectifier (shown schematically in Fig. 9a).*

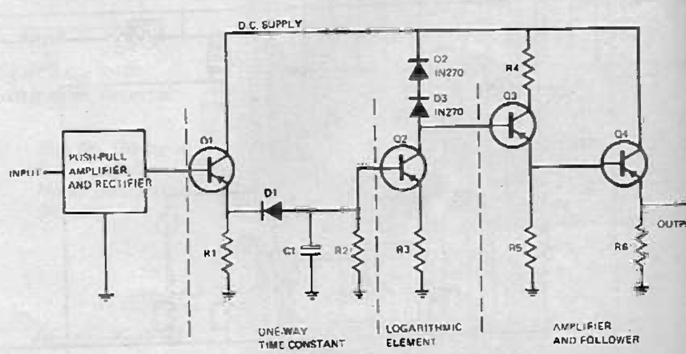



*Fig. 9a. General purpose expander-compressor (the circuit of the logarithmic rectifier, indicated as 'B' is shown inset).*

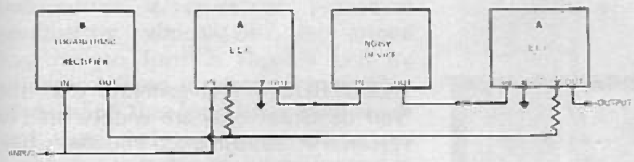


*Fig. 9b. Simultaneous compression before and after a noisy device.*

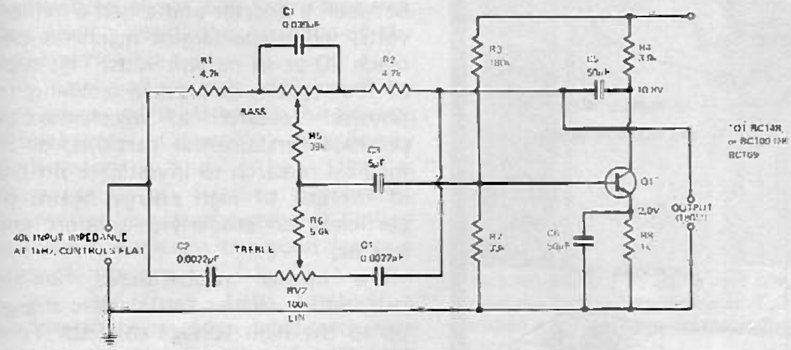



*Fig. 10. Active tone control circuit.*

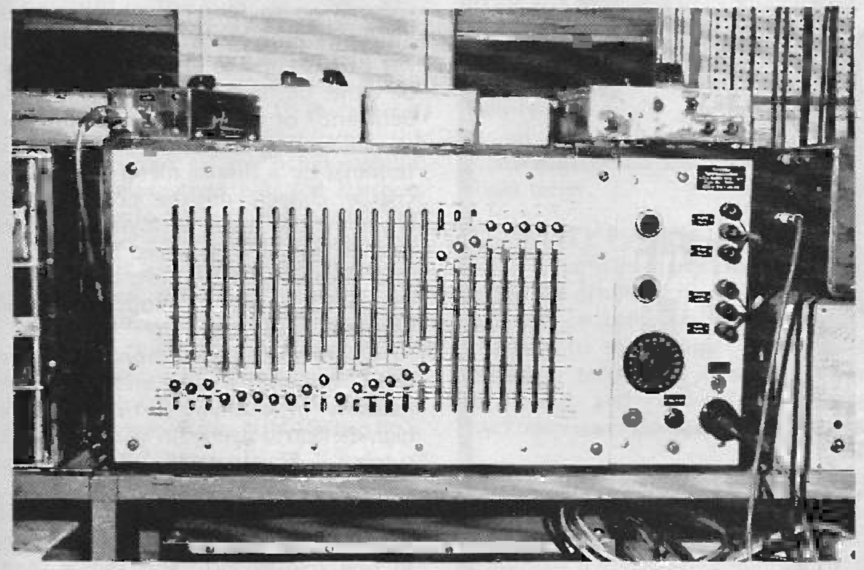


*Fig. 11a. Specialised one third-octave band equalizer used in the production of electronic music. Rotary control on right enables progressive insertion or removal of the filter.*

onto the final 'finished' programme tape. This retains maximum signal-to-noise ratio at the fade.

When copying other than multiple generation (copies of copies) dubbing, it is beneficial to record extreme peaks 2 dB lower than on the original. Carefully riding the gain control in quiet passages will give the impression of a dynamic range equivalent to the original.

Finally, when a number of recordings are to be sequentially copied onto a tape, or only selected passages are to be re-recorded (sometimes called "electronic editing") the following procedure will reduce unwanted clicks and produce a polished result: At the finish of the copying of each selected passage, the recording machine should be placed in the 'pause' position. The recording tape is manually rewound just an amount sufficient to cover the effects due to the tape being halted and the next selected piece dubbed, released the 'pause' at the right moment as the master tape plays. ●

*To be continued*

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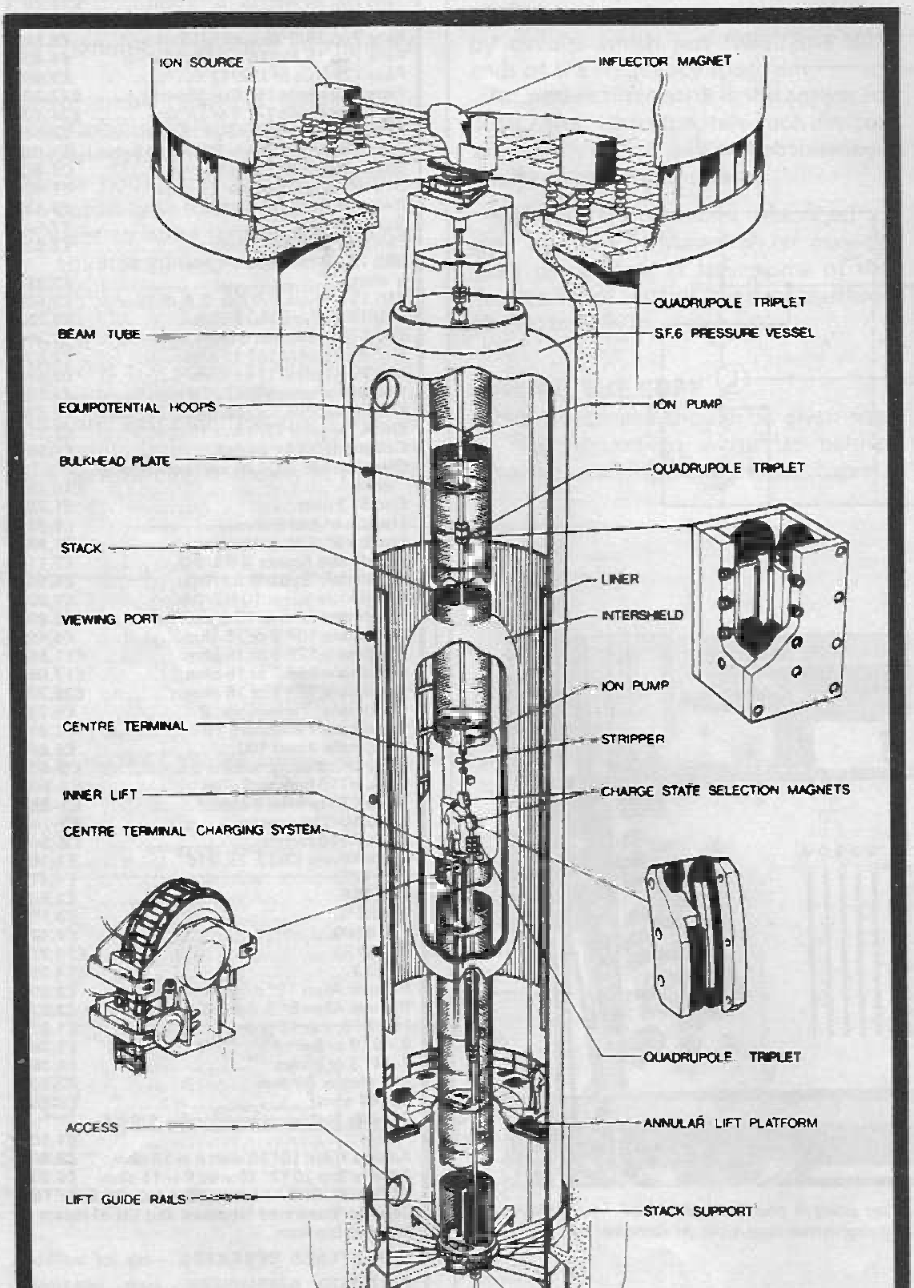



*Diagram of large Van de Graaf generator proposed for Daresbury.*

ELECTROSTATIC generators of the Van de Graaf type are widely used in research establishments, in universities, in schools and in hospitals to provide a source of small direct current of relatively high voltage. School machines, for example, can attain between a quarter and a half a million volts, while the largest machines can reach 20 or so million volts. This type of facility can be used in teaching, in physical research to accelerate or produce fundamental particles, or in medical research to investigate the use in therapy of high energy beams of particles for irradiating tumours and lesions.

The normal rubber-based flexible belt, which carries the electric charge up to the high voltage collector, runs in the vertical plane round two insulated pulleys, separated by up to 50 feet, and has an electric charge sprayed on to its surface by a corona discharge between a metal comb and the belt itself. The charge, which may be either positive or negative (that is, a deficiency or a surplus of electrons), is carried up and collected at the upper terminal by a similar metal comb. The charge collects on the dome-shaped cover on the upper terminal until the rate of arrival is balanced by the rate loss through corona discharge, when the voltage of the upper terminal becomes steady.

By suppressing the corona discharge from the dome by enclosing the machine in a chamber filled with a high-dielectric-strength gas such as sulphur hexafluoride ($SF_6$), the voltage can be increased substantially.

Rubber-based belts of the normal type can carry charging currents of up to one milliampere, and this is their main advantage. But they do have a number of basic disadvantages: for example, inhomogeneities in the insulator material lead to fluctuations in the terminal voltage and the belts have a very limited life because they can easily be torn to pieces by violent high voltage discharges. They also create a great deal of dust — anathema to the maintenance engineer — and the method of charging can lead to the production of unpleasant gaseous breakdown products in machines working in a high pressure $SF_6$ atmosphere.

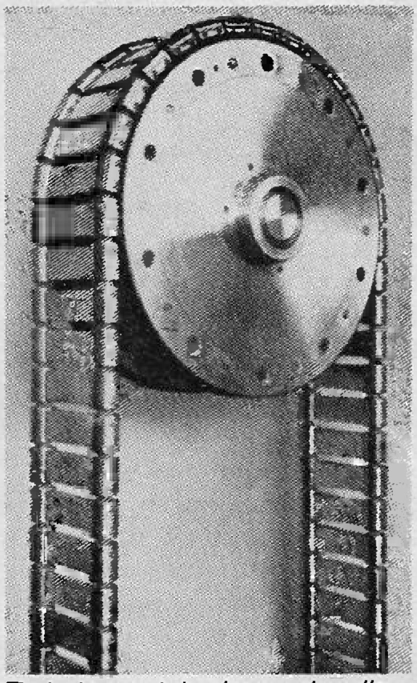
## BEST OF BOTH WORLDS

The most acceptable alternative is a system in which the electrical charge is induced in a series of individual conductors which can be joined together to form a flexible belt by suitably shaped insulators. A number of belts of this kind have been made and tried and they have all proved successful in terms of durability and in providing stable operating conditions. But they have all suffered from a low maximum current-carrying capacity, somewhere about 100 micro-amperes, less than a tenth the capacity of the original flexible belt.

A new belt, jointly developed by engineers and scientists at the Science Research Council's Daresbury Laboratory and the Physics Department of Reading University, overcomes the disadvantage of limited current but retains the good features of earlier designs.

One of these belts, called a Laddertron', has been tried with new driving mechanisms and charging arrangements on the one-million-volt Van de Graaf machine at Reading University. Working in an $SF_6$ atmosphere at 100 pounds/inch$^2$ (gauge), a charging current of 550 micro-amperes was achieved by a belt 12.7 cm wide running 15 metres per second — more than five times the charging current of any other metallic belt and more than half the currents achieved with rubber belts. Larger Van de Graaf machines will require wider belts and it is expected that these will achieve even higher currents than the rubber belts on the largest machines.

The new type of belt will be used in the 60-million-volt machine designed to take the place of the Daresbury electron synchrotron NINA when it is phased out in 1978. It will be a Van de Graaf working in the tandem generator mode and designed to produce initially 20 million volts at the centre terminal; it will be uprated eventually to 30 million volts at the centre terminal mainly through improvements in design and by developments in the technology of manufacture of the flight tubes.



*The Laddertron belt going over the pulley where the charge is removed as it passes through a mirror image of the induction process.*

## STABILITY PLATEAU

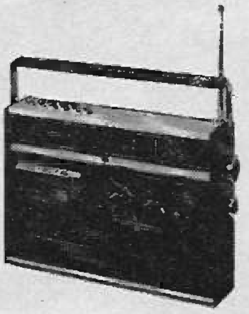
For a tandem generator, two flight tubes are provided, one above and one below a central high voltage terminal charged to 20 million volts. If the centre terminal were charged positively, and if negatively charged hydrogen ions (protons carrying two electrons) were introduced at the top of the upper and highly evacuated flight tube, they would be accelerated towards the centre terminal and arrive with an energy of 20 000 000 ev (20 Mev). If both electrons were stripped off, leaving positively charged protons, these would be repelled by the centre terminal and accelerated down the lower flight tube to arrive at the target at ground potential but at 40 Mev.

In its fully developed state the machine will supply 50 Mev protons for investigating aspects of nuclear structure. It will also be used for producing high energy heavy metal ions — for example, highly charged atoms like barium or lanthanum with atomic numbers around 50, 60, or 70 with a surplus or deficiency of electrons. Such ions, with energies of around 500 Mev or higher, can be used to bombard targets of similar atoms in order to stick atoms together and so synthesise new, trans-uranium elements. One atom of atomic number 50 added to another of 60 could produce a new atom of atomic number 110.

One point of great interest will be to investigate the so-called stability plateau said to exist at atomic numbers near 120. Previously most of the known transuranic elements were valued for their radioactive properties, which make them suitable for a variety of jobs ranging from tracers to alpha-particle sources and materials to power nuclear batteries.

But if interest lies in these elements metallurgical properties they will need to be stable (non-radioactive). The new Van de Graaf machines should not only help to create the high number atoms but also provide a means of studying them. ●

# TAPE NOW, PLAY LATER



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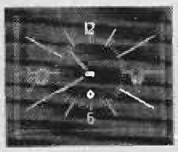

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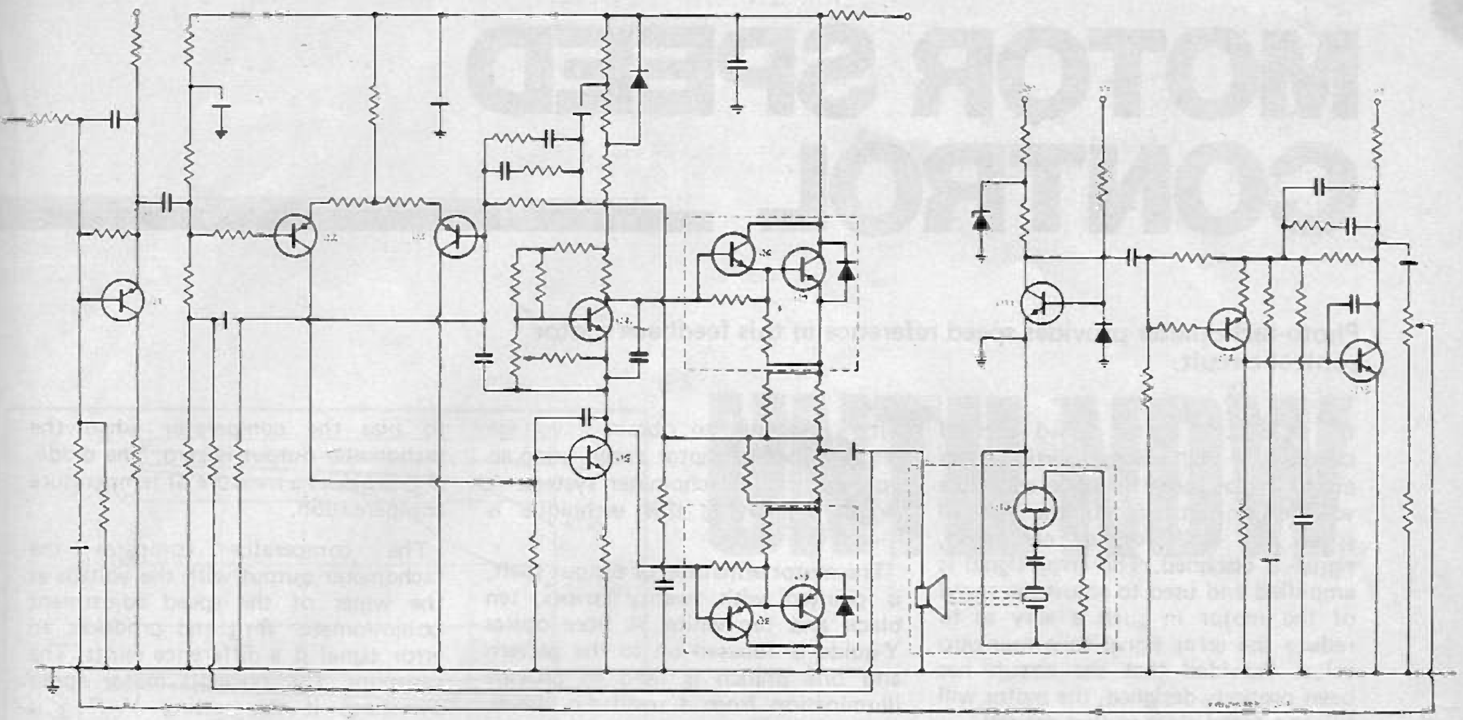


# MOTIONAL FEEDBACK

**New technique from Philips uses motional feedback to improve bass response.**

PHILIPS have developed a technique for applying motional feedback to a loudspeaker/amplifier system with the aim of producing better bass response from small speaker enclosures.

In this technique, an electrical signal, proportionate to the movement of the loudspeaker cone, is compared with the input signal to the amplifier. If there are any discrepancies, a corrective signal is generated that forces the cone to move in the correct fashion.

The basic principle is by no means new, in fact a number of commercial systems using motional feedback have been marketed in the past two decades.

Common to all these systems is the requirement to obtain an electrical signal proportional to speaker cone movement. This may be done by sensing the voltage across the voice coil, by using a second (signal) winding on the voice coil, or, as Philips have done it, by using an acceleration transducer clamped to the cone itself. The transducer used by Philips is a ceramic device that produces a voltage proportional to acceleration. In principle it is not unlike a ceramic pick-up cartridge.

The loudspeaker enclosure used by Philips is very small (380 x 285 x 220mm). This enclosure houses crossover networks, feedback circuitry, and the power amplifiers used for the bass, the mid-range and treble drive units.

The motional feedback circuit is used only for the 200mm (8") bass driver and its associated 40 watt amplifier. The circuit of this section of the amplifier/speaker combination is shown in Fig. 1.

The feedback signal from the ceramic transducer is fed to an adder, together with the original input signal, the combined signal is then taken to a comparator where it is compared with the current that flows through the loudspeaker voice coil. If there is any difference between the two signals, this difference is then amplified and used to correct the discrepancy.

To protect the bass driver from damage caused by the feedback control loop attempting to force the speaker cone to generate long excursion, very low frequency movements, the band of frequencies fed to the bass driver is limited to 35 Hz – 500 Hz. This is achieved by a 12 dB/octave low pass filter and an 18 dB/octave high pass filter in the input circuitry.

Further circuitry is used to in effect 'tailor' the feedback response to the characteristics of the drive unit used.

In practice the Philips motional feedback system works well – the bass response is comparable to that formerly obtainable from much larger enclosures.

Reference:-

Klaassen, J.A. and de Koning, S.H. "Motional feedback with loudspeakers". Philips Technical Review, Vol 29, pp. 148 – 157. ●

# MOTOR SPEED CONTROL

**Photo-tachometer provides speed reference in this feedback motor control circuit.**

IN MOST dc motor speed control circuits, a voltage proportional to actual motor speed is compared with a voltage proportional to the desired speed and an error, or correction, signal is obtained. The error signal is amplified and used to adjust the speed of the motor in such a way as to reduce the error signal to a near-zero value. Provided that the circuit has been properly designed, the motor will run at a speed close to that desired.

The voltage supplied to the motor will determine the output power or torque, as well as the speed, so that at low speeds very little torque is produced. The normal method of overcoming this problem is to supply the motor with constant voltage pulses with a duty cycle proportional to the error voltage so that the full torque is produced at low speeds.

There are a number of ways that can be used to derive a voltage proportional to motor speed. One method which has been favoured in the past, involves measuring the back emf of the motor. This can lead to problems, as both the input and the output are obtained from the same point, namely the motor.

It is possible to obtain a voltage proportional to motor speed using an opto-electronic tachometer system. A circuit employing this technique is shown in Fig. 1.

The motor armature, or output shaft, is pointed with twenty stripes, ten black and ten white. A fibre optics Y-guide is focused on to the pattern and one branch is used to provide illumination from a small d.c. driven lamp. The other branch of the Y-guide feeds light reflected from the pattern to a photo-transistor, $Q_1$. The output of $Q_1$ will be a signal with a frequency proportional to motor speed as ten pulses will be produced for each complete rotation of the armature.

The transistor $Q_2$ is a pulse shaper which feeds a tachometer circuit giving an output directly proportional to input frequency and therefore motor speed.

The FET, $Q_4$, acts as a buffer to minimise the loading on the tachometer circuit and provide a fairly low output impedance, which is appropriate to the differential comparator which follows it. In addition, $Q_4$ acts as a level shifter to ensure that there is sufficient output to bias the comparator when the tachometer output is zero. The diode, $D_3$, provides a measure of temperature compensation.

The comparator compares the tachometer output with the voltage at the wiper of the speed adjustment potentiometer $R_{13}$ and produces an error signal if a difference exists. The capacitor, $C_3$, prevents motor speed overshoot if the setting of $R_{13}$ is changed rapidly.

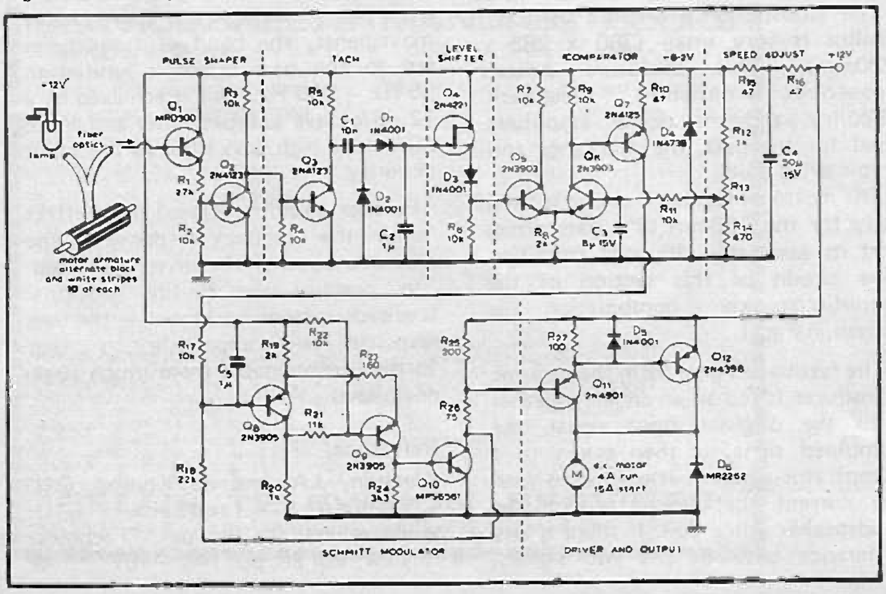
The network $R_{15}$, $R_{16}$, $C_4$ and $D_4$ forms a voltage-stabilising supply circuit for these circuits.

If an error signal exists because the potential at the wiper of $R_{13}$ is higher than the output of the tachometer, it means that the motor is rotating too slowly. The pulse width modulator formed by a Schmitt trigger circuit will trip and full power will be supplied to the motor. As the motor speed increases the error signal will fall until it is almost zero. At this point the Schmitt trigger will remove power from the motor. The process is continuous and the motor is supplied with a train of pulses, the width of which will be proportional to the error in the motor speed, or the load on the motor.

Feedback for the circuit is obtained by directly measuring the motor speed, and results in accurate speed control over a wide range of output powers, as can be seen in Fig. 2. This drawing also shows the effect of power supply voltage variations. Fig. 3 indicates the effect of temperature variations.

Temperature compensation may be improved by removing diode $D_2$ and connecting one or more diodes in series with $R_9$. ●

*Fig. 1. Circuit diagram of complete motor speed controller.*

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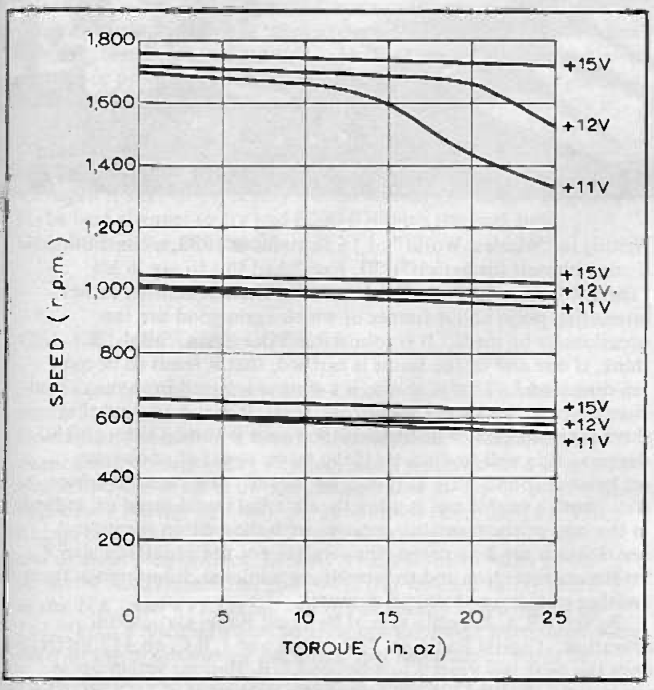



*Fig. 2. How motor speed varies with changes in load and supply voltage for circuit described.*

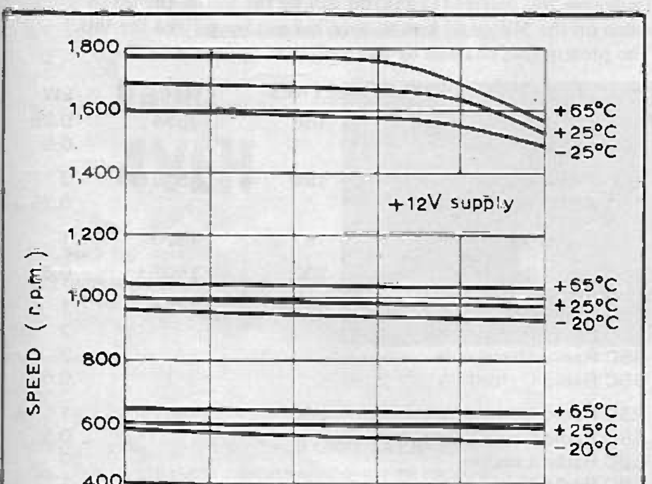



*Fig. 3. How temperature affects motor speed using the circuit described.*

# DX MONITOR

Compiled by Alan Thompson

THAT PHOTOGRAPH of me at the "wheel" of my shack rather belies the state of chaos which prevails as these words are being written! Currently, all is in a state of turmoil as the whole shack is being moved two storeys nearer Heaven and the chance is being taken to iron out some of the less brilliant design ideas which havecrept into switching arrangements over the two years since I last had a major upheaval. I hope to let you see what the new set-up looks like in a couple of months times: meanwhile page after page of sketches and diagrams are slowly turning into collections of coax sockets, multi-pole switches, jack plugs and all the masses of other bits and pieces required to connect several receivers and their associated equipment to three tape-recorders. So far (!) nothing transistorised has gone up in a puff of smoke with 240V a.c. being applied to an audio input socket, but fingers will remain crossed until all is safely in its new positions and operational again.

The turn of the year is, traditionally, the time when one sits back and takes a cool look at the year that has just ended and wonders what the year ahead is likely to bring. 1973 will certainly not be a vintage year for the short-wave DXer as it has been one of the most disappointing for a very long time: no new countries have emerged to engage the attentions of U.K. DXers and reception has, in general, been poor with very few startling openings to the Far East or, indeed, to the African continent. In some ways this is characteristic of a year which falls near the trough of the sunspot cycle but we have not been rewarded with the bonus of low atmospheric noise which characterised the similar period 11 years ago. That was the era when many unusual receptions were recorded (albeit the stations were heard at low strength they were usually free of a high static level) and difficult-to-hear DX from the other side of the world became fairly common-place. Such was certainly not the case in 1973 and we can only hope that 1974 will bring better conditions for the DXing hobby as the level of solar activity continues to fall towards the turn of the sunspot cycle.

Recently, some radio magazines of the 1930 era came into my possession after being unearthed from a dusty attic where they had lain untouched for some 40 years. If you have any radio magazines or books of the pre-1960 era which you no longer require, I shall be very glad to hear from you as they deserve a better fate then ending their days on the local council's rubbish dump. Particularly interesting to me are copies of the "World Radio Handbook" of the 1947–1964 period so, please, have a hunt through any old radio books in your possession and drop me a line if you are willing to part with them.

Medium-wave DXing needn't necessarily mean chasing stations across the Atlantic or those located in Africa and the Middle East – the advent of local radio in Britain means that there are plenty of opportunities to test one's DX skill on the new stations that have appeared on the MW band. A "loop" or "frame" aerial is almost a necessity for chasing these stations and the construction of one is not too difficult an exercise. Radio Nederland, P.O. Box 222, Hilversum, Holland, have a leaflet describing such an aerial and a copy of it may be obtained by writing to that address.

Writing in "Wireless World" of 16 September 1932, a contributor signing himself (or herself?) "D. Exer" had this to say in his "Distant Reception Notes" feature: "...There is another rather interesting point about frames of which again good use can occasionally be made. It is found sometimes, particularly, I think, if one end of the frame is earthed, that it tends to become uni-directional. That is to say, if a station is tuned in to maximum strength by pointing the frame towards it, it may be found that there is an increase or decrease if the frame is turned through 180 degrees. It is well to discover if the frame aerial of one's own set behaves in this way, as it may be useful". This is something well worth a trial if one is using the external frame aerial or, indeed, in the case of the transistor receiver with the built-in ferrite rod aerial which can be rotated (the receiver not the aerial!) to give maximum reception and to remove, or minimise, interference from another station on the same channel.

So far, I.B.A. has only two of its Local Radio stations in operation: Capital Radio on 539 metres and L.B.C. on 417 metres. Over the next few years a number of I.L.R. stations will increase apace and a detailed list will follow in a later issue of "DX MONITOR". However, at present, the DXing interest is on the BBC local radio stations, 19 of which have now taken the air on MW: Radio Derby on 260 metres (1115kHz) will be the last of the 20 to come on the MW-band but no date has yet been given for this. The present list, channel by channel, is as follows:-

| STATION | METRES | kHz | kW |
|---|---|---|---|
| BBC Radio Solent (relay) | 188 | 1594 | 0.25 |
| BBC Radio Leicester | | | 0.5 |
| BBC Radio Bristol | 194 | 1546 | 2 |
| BBC Radio Teesside | | | 0.25 ϕ |
| BBC Radio Nottingham | 197 | 1520 | 1 |
| BBC Radio Stoke-on-Trent | 200 | 1502 | 0.5 |
| BBC Radio Brighton | 202 | 1484 | 1 |
| BBC Radio Humberside | | | 2 |
| BBC Radio Merseyside | | | 2 |
| BBC Radio Oxford | | | 0.5 |
| BBC Radio Birmingham | 206 | 1457 | 1 ϕ |
| BBC Radio Carlisle (relay) | | | 0.5 |
| BBC Radio London | | | 20 |
| BBC Radio Manchester | | | 1 ϕ |
| BBC Radio Newcastle | | | 2 |
| BBC Radio Leeds | 271 | 1106 | 1 |
| BBC Radio Medway | 290 | 1034 | 0.5 |
| BBC Radio Sheffield | | | 1 |
| BBC Radio Solent (main) | 301 | 998 | 1 |
| BBC Radio Blackburn | 351 | 854 | 0.5 ϕ |
| BBC Radio Carlisle (main) | 397 | 755 | 1 |

ϕ denotes that power is to be increased at a later date

Just to avoid any confusion! If you live in the vicinity of Dundee you are likely to hear Radio 3 relay on 188 metres: in Bournemouth (Radio 1), Dundee, Edinburgh, Glasgow and Redmoss (Radio 2) 2kW transmitters operate on 202 metres: in Torquay 351 metres has a 1kW transmitter carrying the Radio 4 South West Region VHF programme. Finally, if you are within a reasonable distance of Barnstaple or Plymouth, the Radio 4 South West Region VHF programmes are carried on 439 metres (683kHz) and 206 metres (1457kHz) respectively: the Barnstaple transmitter being one of 2kW and that at Plymouth 1kW.

What about sending along a photograph of one of your prized QSLs for our "QSL Collectors Corner"? A good *black and white* 'photo (with lots of contrast) is what is required, not bigger than postcard size. Add a few details of the QSL on a separate sheet of paper and don't forget your name and address. We'll pay £1 for each QSL used in the feature so get that camera snapping! Photographs can not be returned, sorry, and, *please* don't send original cards. Send your 'photo to me – Alan Thompson, 16 Ena Avenue, Neath, Glamorgan SA11 3AD – together with any queries or problems you may have about DXing. However, if you want a personal reply, a self-addressed, stamped envelope is a *must*, and, even then, some delay may occur now and again.

More DX news for SW-buffs next time round, but, meanwhile, what about trying to add 4VEH to your catches if you haven't managed it yet? It's not easy due to co-channel usage but 11835 is the best channel to try and 0200-0300-ish the best time. Goodluck - it's a nice catch!

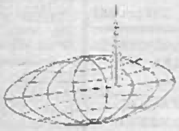
## QSL COLLECTORS CORNER

*HAITI is a land of mystery, little-known to those who have not studied it's culture and history. Located in the Caribbean with the Dominican Republic it's "next-door-neighbour", Haitians speak French and Creole, whilst Voodoo is still practised on a large scale. Radio Station 4VEH is owned and operated by the Oriental Missionary Society and may be heard announcing itself as "The Evangelistic Voice of the West Indies" in English, French, Creole and Spanish programmes. Strictly 4VEH is the call-sign of the 31 metre band transmitter (on 9770kHz) which is rarely heard in the U.K., and 4VEJ is the call of the usually heard outlet on 11835kHz, a channel which varies a few kiloHertz from day-to-day. Most of the programming has a religious emphasis as might be expected from a station controlled by a Missionary Society. Reports are QSLd (if accurate) but reply postage is essential, and, even then, delays of several months are usual.*

"LOCATED BENEATH THE SHADOW OF THE CITADELLE"

**RADIO**
**4VEH**

Box 1
CAP HAITIEN, HAITI
WEST INDIES



**RADIO 4VEH**

THE EVANGELISTIC VOICE OF THE WEST INDIES
BOX 1, CAP HAITIEN, HAITI, WEST INDIES

Alan Thompson
Neath, Glamorgan, Great Britain

We gratefully confirm your report of reception of
RADIO STATION 4VEJ on 11835 mcs/kcs
with a power of 2500 watts.
DATE 3-24-68 at 0205-0230 GMT
Signed Mrs. Kent Ragsdale
Short Wave Department

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| AC122 | 0·13 | AF117 | 0·27 | BC159 | 0·13 | BD140 | 0·66 | BF197 | 0·16 |
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| AC132 | 0·16 | AF127 | 0·31 | BC169 | 0·13 | BD178 | 0·72 | BF259 | 0·94 |
| AC134 | 0·16 | AF139 | 0·33 | BC170 | 0·13 | BD179 | 0·77 | BF262 | 0·61 |
| AC137 | 0·16 | AF178 | 0·55 | BC171 | 0·16 | BD180 | 0·77 | BF263 | 0·61 |
| AC141 | 0·20 | AF179 | 0·55 | BC172 | 0·16 | BD185 | 0·72 | BF270 | 0·39 |
| AC141K | 0·32 | AF180 | 0·55 | BC173 | 0·16 | BD186 | 0·72 | BF271 | 0·33 |
| AC142 | 0·20 | AF181 | 0·55 | BC174 | 0·16 | BD187 | 0·77 | BF272 | 0·88 |
| AC142K | 0·28 | AF186 | 0·55 | BC175 | 0·24 | BD188 | 0·77 | BF273 | 0·39 |
| AC151 | 0·17 | AF239 | 0·41 | BC177 | 0·21 | BD189 | 0·83 | BF274 | 0·39 |
| AC154 | 0·22 | AL102 | 0·72 | BC178 | 0·21 | BD190 | 0·83 | BFW10 | 0·66 |
| AC155 | 0·22 | AL103 | 0·72 | BC179 | 0·21 | BD195 | 0·94 | BFX29 | 0·30 |
| AC156 | 0·22 | ASY26 | 0·28 | BC180 | 0·27 | BD196 | 0·94 | BFX84 | 0·24 |
| AC157 | 0·27 | ASY27 | 0·33 | BC181 | 0·27 | BD197 | 0·99 | BFX85 | 0·33 |
| AC165 | 0·22 | ASY28 | 0·28 | BC182 | 0·11 | BD198 | 0·99 | BFX86 | 0·24 |
| AC166 | 0·22 | ASY29 | 0·28 | BC182L | 0·11 | BD199 | £1·05 | BFX87 | 0·27 |
| AC167 | 0·22 | ASY50 | 0·28 | BC183 | 0·11 | BD200 | £1·05 | BFX88 | 0·24 |
| AC168 | 0·27 | ASY51 | 0·28 | BC183L | 0·11 | BD205 | 0·88 | BFY50 | 0·22 |
| AC169 | 0·16 | ASY52 | 0·28 | BC184 | 0·13 | BD206 | 0·88 | BFY51 | 0·22 |
| AC176 | 0·22 | ASY54 | 0·28 | BC184L | 0·13 | BD207 | £1·05 | BFY52 | 0·22 |
| AC177 | 0·27 | ASY55 | 0·28 | BC186 | 0·31 | BD208 | £1·05 | BFY53 | 0·19 |
| AC178 | 0·31 | ASY56 | 0·28 | BC187 | 0·31 | BDY20 | £1·10 | BPX25 | 0·94 |
| AC179 | 0·31 | ASY57 | 0·28 | BC207 | 0·12 | BF115 | 0·27 | BSX19 | 0·17 |
| AC180 | 0·22 | ASY58 | 0·28 | BC208 | 0·12 | BF117 | 0·50 | BSX20 | 0·17 |
| AC180K | 0·32 | ASY73 | 0·28 | BC209 | 0·13 | BF118 | 0·77 | BSY25 | 0·17 |
| AC181 | 0·22 | ASZ21 | 0·44 | BC212L | 0·12 | BF119 | 0·77 | BSY26 | 0·17 |
| AC181K | 0·32 | BC107 | 0·12 | BC213L | 0·12 | BF121 | 0·50 | BSY27 | 0·17 |
| AC187 | 0·24 | BC108 | 0·12 | BC214L | 0·16 | BF123 | 0·55 | BSY28 | 0·17 |
| AC187K | 0·25 | BC109 | 0·13 | BC225 | 0·28 | BF125 | 0·50 | BSY29 | 0·17 |
| AC188 | 0·24 | BC113 | 0·11 | BC226 | 0·39 | BF127 | 0·55 | BSY38 | 0·20 |
| AC188K | 0·25 | BC114 | 0·17 | BC301 | 0·30 | BF152 | 0·61 | BSY39 | 0·20 |
| ACY17 | 0·28 | BC115 | 0·17 | BC302 | 0·27 | BF153 | 0·50 | BSY40 | 0·31 |
| ACY18 | 0·22 | BC116 | 0·17 | BC303 | 0·35 | BF154 | 0·50 | BSY41 | 0·31 |
| ACY19 | 0·22 | BC117 | 0·20 | BC304 | 0·40 | BF155 | 0·77 | BSY95 | 0·14 |
| ACY20 | 0·22 | BC118 | 0·11 | BC440 | 0·34 | BF156 | 0·53 | BSY95A | 0·14 |
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| ACY22 | 0·18 | BC120 | 0·88 | BCY30 | 0·27 | BF158 | 0·61 | C111E | 0·55 |
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| ACY28 | 0·21 | BC126 | 0·20 | BCY32 | 0·33 | BF160 | 0·44 | C407 | 0·28 |
| ACY29 | 0·39 | BC132 | 0·13 | BCY33 | 0·24 | BF162 | 0·44 | C424 | 0·28 |
| ACY30 | 0·31 | BC134 | 0·20 | BCY34 | 0·28 | BF163 | 0·44 | C425 | 0·55 |
| ACY31 | 0·31 | BC135 | 0·13 | BCY70 | 0·16 | BF164 | 0·44 | C426 | 0·39 |
| ACY34 | 0·23 | BC136 | 0·17 | BCY71 | 0·22 | BF165 | 0·44 | C428 | 0·22 |
| ACY35 | 0·23 | BC137 | 0·17 | BCY72 | 0·16 | BF167 | 0·24 | C441 | 0·33 |
| ACY36 | 0·31 | BC139 | 0·44 | BCZ10 | 0·22 | BF173 | 0·24 | C442 | 0·33 |
| ACY40 | 0·19 | BC140 | 0·33 | BCZ11 | 0·28 | BF176 | 0·39 | C444 | 0·39 |
| ACY41 | 0·20 | BC141 | 0·33 | BCZ12 | 0·28 | BF177 | 0·39 | C450 | 0·24 |
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| OC19 | 0·39 | 2G373 | 0·19 | 2N2368 | 0·19 | 2N3393 | 0·16 | 2N4062 | 0·13 |
| OC20 | 0·70 | 2G374 | 0·19 | 2N2369 | 0·16 | 2N3394 | 0·16 | 2N4284 | 0·19 |
| OC22 | 0·52 | 2G377 | 0·33 | 2N2369A | 0·16 | 2N3395 | 0·19 | 2N4285 | 0·19 |
| OC23 | 0·54 | 2G378 | 0·18 | 2N2411 | 0·27 | 2N3402 | 0·23 | 2N4286 | 0·19 |
| OC24 | 0·62 | 2G381 | 0·18 | 2N2412 | 0·27 | 2N3403 | 0·23 | 2N4287 | 0·19 |
| OC25 | 0·42 | 2G382 | 0·18 | 2N2646 | 0·52 | 2N3404 | 0·31 | 2N4288 | 0·19 |
| OC26 | 0·32 | 2G401 | 0·33 | 2N2711 | 0·23 | 2N3405 | 0·46 | 2N4289 | 0·19 |
| OC28 | 0·55 | 2G414 | 0·33 | 2N2712 | 0·23 | 2N3414 | 0·17 | 2N4290 | 0·19 |
| OC29 | 0·55 | 2G417 | 0·28 | 2N2714 | 0·23 | 2N3415 | 0·17 | 2N4291 | 0·19 |
| OC35 | 0·46 | 2N388 | 0·39 | 2N2904 | 0·19 | 2N3416 | 0·31 | 2N4292 | 0·19 |
| OC36 | 0·55 | 2N388A | 0·61 | 2N2904A | 0·23 | 2N3417 | 0·31 | 2N4293 | 0·19 |
| OC41 | 0·22 | 2N404 | 0·22 | 2N2905 | 0·23 | 2N3525 | 0·83 | 2N5172 | 0·13 |
| OC42 | 0·27 | 2N404A | 0·31 | 2N2905A | 0·23 | 2N3614 | 0·74 | 2N5294 | 0·60 |
| OC44 | 0·17 | 2N524 | 0·46 | 2N2906 | 0·17 | 2N3615 | 0·82 | 2N5457 | 0·35 |
| OC45 | 0·14 | 2N527 | 0·54 | 2N2906A | 0·20 | 2N3616 | 0·83 | 2N5458 | 0·35 |
| OC70 | 0·11 | 2N598 | 0·46 | 2N2907 | 0·22 | 2N3646 | [illegible] | 2N5459 | 0·44 |
| OC71 | 0·11 | 2N599 | 0·50 | 2N2907A | 0·24 | 2N3702 | 0·13 | 2N6121 | 0·75 |
| OC72 | 0·16 | 2N696 | 0·14 | 2N2923 | 0·16 | 2N3703 | 0·13 | 2S301 | 0·55 |
| OC74 | 0·16 | 2N697 | 0·15 | 2N2924 | 0·16 | 2N3704 | 0·14 | 2S302A | 0·46 |
| OC75 | 0·17 | 2N698 | 0·27 | 2N2925 | 0·16 | 2N3705 | 0·13 | 2S302 | 0·46 |
| OC76 | 0·17 | 2N699 | 0·39 | 2N2926(G) | 0·14 | 2N3706 | 0·13 | 2S303 | 0·61 |
| OC77 | 0·28 | 2N706 | 0·09 | 2N2926(Y) | 0·12 | 2N3707 | 0·14 | 2S304 | 0·77 |
| OC81 | 0·17 | 2N706A | 0·10 | 2N2926(O) | 0·11 | 2N3708 | 0·09 | 2S305 | 0·86 |
| OC81D | 0·17 | 2N708 | 0·13 | 2N2926(R) | 0·11 | 2N3709 | 0·10 | 2S306 | 0·86 |
| OC82 | 0·17 | 2N711 | 0·33 | 2N2926(B) | 0·11 | 2N3710 | 0·10 | 2S307 | 0·86 |
| OC82D | 0·17 | 2N717 | 0·39 | 2N3010 | 0·77 | 2N3711 | 0·10 | 2S321 | 0·62 |
| OC83 | 0·22 | 2N718 | 0·27 | 2N3011 | 0·16 | 2N3819 | 0·31 | 2S322 | 0·46 |
| OC139 | 0·22 | 2N718A | 0·55 | 2N3053 | 0·19 | 2N3820 | 0·55 | 2S322A | 0·46 |
| OC140 | 0·22 | 2N726 | 0·31 | 2N3054 | 0·51 | 2N3821 | 0·39 | 2S323 | 0·62 |
| OC169 | 0·28 | 2N727 | 0·31 | 2N3055 | 0·55 | 2N3823 | 0·31 | 2S324 | 0·77 |
| OC170 | 0·28 | 2N743 | 0·22 | 2N3391 | 0·16 | 2N3903 | 0·31 | 2S325 | 0·77 |
| OC171 | 0·28 | 2N744 | 0·22 | 2N3391A | 0·18 | 2N3904 | 0·33 | 2S326 | 0·77 |
| OC200 | 0·28 | 2N914 | 0·16 | | | 2N3905 | 0·31 | 2S327 | 0·77 |
| OC201 | 0·31 | 2N918 | 0·33 | | | 2N3906 | 0·30 | 2S701 | 0·46 |
| OC202 | 0·31 | 2N929 | 0·23 | | | 2N4058 | 0·13 | 40361 | 0·44 |
| OC203 | 0·28 | 2N930 | 0·23 | | | 2N4059 | 0·11 | 40362 | 0·50 |
| OC204 | 0·28 | 2N1131 | 0·22 | | | 2N4060 | 0·13 | | |
| OC205 | 0·39 | 2N1132 | 0·24 | | | | | | |
| OC309 | 0·44 | 2N1302 | 0·16 | | | | | | |
| OCP71 | 0·48 | 2N1303 | 0·16 | | | | | | |
| ORP12 | 0·48 | 2N1304 | 0·19 | | | | | | |
| P20 | 0·55 | 2N1305 | 0·19 | | | | | | |
| P21 | 0·50 | 2N1306 | 0·23 | | | | | | |
| P346A | 0·22 | 2N1307 | 0·23 | | | | | | |
| P397 | 0·46 | 2N1308 | 0·26 | | | | | | |
| ST140 | 0·14 | 2N1309 | 0·26 | | | | | | |
| ST141 | 0·19 | 2N1613 | 0·22 | | | | | | |
| TIS43 | 0·33 | 2N1711 | 0·22 | | | | | | |
| UT46 | 0·30 | 2N1889 | 0·35 | | | | | | |
| ZN414 | £1·20 | 2N1890 | 0·50 | | | | | | |
| 2G301 | 0·21 | 2N1893 | 0·41 | | | | | | |
| 2G302 | 0·21 | 2N2147 | 0·79 | | | | | | |
| 2G303 | 0·21 | 2N2148 | 0·63 | | | | | | |
| 2G304 | 0·27 | 2N2160 | 0·66 | | | | | | |
| 2G306 | 0·44 | 2N2192 | 0·39 | | | | | | |
| 2G308 | 0·39 | 2N2193 | 0·39 | | | | | | |
| 2G309 | 0·39 | 2N2194 | 0·39 | | | | | | |
| 2G339 | 0·22 | 2N2217 | 0·24 | | | | | | |
| 2G339A | 0·18 | 2N2218 | 0·22 | | | | | | |
| 2G344 | 0·20 | 2N2219 | 0·22 | | | | | | |
| 2G345 | 0·18 | 2N2220 | 0·24 | | | | | | |
| 2G371 | 0·18 | 2N2221 | 0·22 | | | | | | |

### DIODES AND RECTIFIERS

| Type | Price | Type | Price | Type | Price |
|---|---|---|---|---|---|
| AA119 | 0·09 | BY130 | 0·18 | OA5 | 0·23 |
| AA120 | 0·09 | BY133 | 0·23 | OA10 | 0·15 |
| AA129 | 0·09 | BY164 | 0·55 | OA47 | 0·08 |
| AAY30 | 0·10 | BYX38/30 | 0·46 | OA70 | 0·08 |
| AAZ13 | 0·11 | BYZ10 | 0·39 | OA79 | 0·08 |
| BA100 | 0·11 | BYZ11 | 0·33 | OA81 | 0·08 |
| BA116 | 0·23 | BYZ12 | 0·33 | OA85 | 0·10 |
| BA126 | 0·24 | BYZ13 | 0·28 | OA90 | 0·07 |
| BA148 | 0·16 | BYZ16 | 0·44 | OA91 | 0·07 |
| BA154 | 0·13 | BYZ17 | 0·39 | OA95 | 0·08 |
| BA155 | 0·16 | BYZ18 | 0·39 | OA200 | 0·07 |
| BA156 | 0·15 | BYZ19 | 0·31 | OA202 | 0·08 |
| BA173 | 0·16 | CG62 (OA91Eq) | 0·06 | SD10 | 0·06 |
| BY100 | 0·17 | CG651– (OA70–OA79) | 0·07 | SD19 | 0·06 |
| BY101 | 0·13 | OA5 | 0·39 | 1N34 | 0·08 |
| BY10[illegible] | 0·19 | | | 1N34A | 0·08 |
| BY114 | 0·13 | | | 1N914 | 0·06 |
| BY124 | 0·13 | | | 1N916 | 0·06 |
| BY126 | 0·16 | | | 1N4148 | 0·06 |
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| U 4 | 40 | Germanium Transistors like OC81, AC128 | 0·55 |
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| U11 | 25 | PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904 | 0·55 |
| U12 | 12 | Silicon Rectifiers Epoxy 500mA up to 800 PIV | 0·55 |
| U13 | 30 | PNP-NPN Sil. Transistors OC200 & 2S 104 | 0·55 |
| U14 | 150 | Mixed Silicon and Germanium Diodes | 0·55 |
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| U27 | 12 | NPN Germanium AF Transistors TO-1 like AC127 | 0·55 |
| U29 | 10 | 1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600 | 1·10 |
| U30 | 15 | Plastic Silicon Planar Trans. NPN 2N2926 | 0·55 |
| U31 | 20 | Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707 | 0·55 |
| U32 | 25 | Zener Diodes 400mW DO-7 case 3-18 volts mixed | 0·55 |
| U33 | 15 | Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series | 0·55 |
| U34 | 30 | Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4 | 0·55 |
| U35 | 25 | Silicon Planar Transistors PNP TO-18 2N2906 | 0·55 |
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| U42 | 10 | VHF Germanium PNP Transistor TO-1 NKT667, AF117 | 0·55 |
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| U44 | 20 | Sil. Trans. Plastic TO-5 BC115/NPN | 0·55 |
| U45 | 7 | 3A SCR. TO66 up to 600PIV | 1·10 |

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

## QUALITY TESTED SEMICONDUCTORS

| Pak No. | | | Price |
|---|---|---|---|
| Q1 | 20 | Red spot transistors PNP | 0·55 |
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| Q3 | 4 | OC 77 type transistors | 0·55 |
| Q4 | 6 | Matched transistors OC44/45/81/81D | 0·55 |
| Q5 | 4 | OC 75 transistors | 0·55 |
| Q6 | 5 | OC72 transistors | 0·55 |
| Q7 | 4 | AC 128 transistors PNP high gain | 0·55 |
| Q8 | 4 | AC 126 transistors PNP | 0·55 |
| Q9 | 7 | OC 81 type transistors | 0·55 |
| Q10 | 7 | OC 71 type transistors | 0·55 |
| Q11 | 2 | AC127/128 Complementary pairs PNP/NPN | 0·55 |
| Q12 | 3 | AF 116 type transistors | 0·55 |
| Q13 | 3 | AF 117 type transistors | 0·55 |
| Q14 | 3 | OC 171 H.F. type transistors | 0·55 |
| Q15 | 7 | 2N2926 Sil. Epoxy transistors mixed colours | 0·55 |
| Q16 | 2 | GET880 low noise Germanium transistors | 0·55 |
| Q17 | 5 | NPN 2 x ST.141 & 3 x ST.140 | 0·55 |
| Q18 | 4 | MADT'S 2 x MAT 100 & 2 x MAT 120 | 0·55 |
| Q19 | 3 | MADT'S 2 x MAT 101 & 1 x MAT 121 | 0·55 |
| Q20 | 4 | OC 44 Germanium transistors A.F. | 0·55 |
| Q21 | 4 | AC127 NPN Germanium transistors | 0·55 |
| Q22 | 20 | NKT transistors A.F. R.F. coded | 0·55 |
| Q23 | 10 | OA 202 Silicon diodes sub-min | 0·55 |
| Q24 | 8 | OA 81 diodes | 0·55 |
| Q25 | 15 | IN914 Silicon diodes 75PIV 75mA | 0·55 |
| Q26 | 8 | OA95 Germanium diodes sub-min IN69 | 0·55 |
| Q27 | 2 | 10A 600 PIV Silicon rectifiers IS425R | 0·55 |
| Q28 | 2 | Silicon power rectifiers BYZ 13 | 0·55 |
| Q29 | 4 | Sil. transistors 2 x 2N696. 1 x 2N697. 1 x 2N698 | 0·55 |
| Q30 | 7 | Silicon switch transistors 2N706 NPN | 0·55 |
| Q31 | 6 | Silicon switch transistors 2N708 NPN | 0·55 |
| Q32 | 3 | PNP Sil. trans. 2 x 2N1131, 1 x 2N1132 | 0·55 |
| Q33 | 3 | Silicon NPN transistors 2N1711 | 0·55 |
| Q34 | 7 | Sil. NPN trans. 2N2369. 500MHz (code P397) | 0·55 |
| Q35 | 3 | Silicon PNP TO-5 2 x 2N2904 & 1 x 2N2905 | 0·55 |
| Q36 | 7 | 2N3646 TO-18 plastic 300 MHz NPN | 0·55 |
| Q37 | 3 | 2N3053 NPN Silicon transistors | 0·55 |
| Q38 | 7 | PNP transistors 4 x 2N3703. 3 x 2N3702 | 0·55 |
| Q39 | 7 | PNP transistors 4 x 2N3704. 3 x 2N3705 | 0·55 |
| Q40 | 7 | NPN transistors 4 x 2N3707. 3 x 2N3708 | 0·55 |
| Q41 | 3 | Plastic NPN TO-18 2N3904 | 0·55 |
| Q42 | 6 | NPN transistors 2N5172 | 0·55 |
| Q43 | 7 | BC 107 NPN transistors | 0·55 |
| Q44 | 7 | NPN transistors 4 x BC 108. 3 x BC 109 | 0·55 |
| Q45 | 3 | BC 113 NPN TO-18 transistors | 0·55 |
| Q46 | 3 | BC 115 NPN TO-5 transistors | 0·55 |
| Q47 | 6 | NPN high gain transistors 3 x BC167, 3 x BC168 | 0·55 |
| Q48 | 4 | BCY 70 PNP transistors TO-18 | 0·55 |
| Q49 | 4 | NPN transistors 2 x BFY51. 2 x BFY52 | 0·55 |
| Q50 | 7 | BSY 28 NPN switch transistors TO-18 | 0·55 |
| Q51 | 7 | BSY 95A NPN transistors 300MHz | 0·55 |
| Q52 | 8 | BY100 type silicon rectifiers | £1·10 |
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| 50 | 0·22 | 0·27 | 0·39 | 0·39 | 0·52 | 0·55 | 0·58 | £1·27 |
| 100 | 0·27 | 0·27 | 0·52 | 0·52 | 0·55 | 0·63 | 0·62 | £1·54 |
| 200 | 0·27 | 0·32 | 0·54 | 0·54 | 0·62 | 0·67 | 0·67 | £1·76 |
| 400 | 0·32 | 0·42 | 0·59 | 0·62 | 0·67 | 0·83 | 0·77 | £1·93 |
| 600 | 0·42 | 0·52 | 0·75 | 0·75 | 0·84 | £1·07 | 0·97 | – |
| 800 | 0·63 | 0·70 | 0·88 | 0·88 | 0·99 | £1·32 | £1·50 | £4·40 |

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| 100 | 0·05 | 0·07 | 1N4001 | 0·05 | 0·10 | 0·17 | 0·23 | 0·75 |
| 200 | 0·06 | 0·10 | 1N4002 | 0·06 | 0·12 | 0·22 | 0·25 | £1·00 |
| 400 | 0·08 | 0·15 | 1N4003 | 0·07 | 0·15 | 0·30 | 0·38 | £1·35 |
| 600 | 0·09 | 0·17 | 1N4004 | 0·08 | 0·18 | 0·36 | 0·45 | £1·90 |
| 800 | 0·12 | 0·19 | 1N4005 | 0·10 | 0·20 | 0·38 | 0·55 | £2·10 |
| 1000 | 0·14 | 0·30 | 1N4006 | 0·11 | 0·25 | 0·48 | 0·65 | £2·50 |
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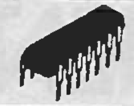

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| Type | 1 | 25 | 100+ | Type | 1 | 25 | 100+ | Type | 1 | 25 | 100+ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7400 | 0·18 | 0·17 | 0·16 | 7448 | £1·10 | £1·07 | £1·05 | 74122 | £1·50 | £1·45 | £1·40 |
| 7401 | 0·18 | 0·17 | 0·16 | 7450 | 0·18 | 0·17 | 0·16 | 74123 | £3·00 | £2·90 | £2·80 |
| 7402 | 0·18 | 0·17 | 0·16 | 7451 | 0·18 | 0·17 | 0·16 | 74141 | 0·85 | 0·82 | 0·79 |
| 7403 | 0·18 | 0·17 | 0·16 | 7453 | 0·18 | 0·17 | 0·16 | 74145 | £1·65 | £1·55 | £1·45 |
| 7404 | 0·18 | 0·17 | 0·16 | 7454 | 0·18 | 0·17 | 0·16 | 74150 | £2·90 | £2·80 | £2·70 |
| 7405 | 0·18 | 0·17 | 0·16 | 7460 | 0·18 | 0·17 | 0·16 | 74151 | £1·10 | £1·05 | £1·00 |
| 7406 | 0·39 | 0·34 | 0·31 | 7470 | 0·32 | 0·29 | 0·27 | 74153 | £1·30 | £1·20 | £1·10 |
| 7407 | 0·39 | 0·34 | 0·31 | 7472 | 0·32 | 0·29 | 0·27 | 74154 | £1·98 | £1·90 | £1·75 |
| 7408 | 0·20 | 0·19 | 0·18 | 7473 | 0·41 | 0·39 | 0·35 | 74155 | £1·50 | £1·45 | £1·35 |
| 7409 | 0·20 | 0·19 | 0·18 | 7474 | 0·41 | 0·39 | 0·35 | 74156 | £1·50 | £1·45 | £1·35 |
| 7410 | 0·18 | 0·17 | 0·16 | 7475 | 0·50 | 0·48 | 0·45 | 74157 | £2·00 | £1·90 | £1·80 |
| 7411 | 0·28 | 0·27 | 0·26 | 7476 | 0·44 | 0·43 | 0·42 | 74160 | £2·10 | £2·00 | £1·90 |
| 7412 | 0·39 | 0·34 | 0·31 | 7480 | 0·74 | 0·71 | 0·64 | 74161 | £2·10 | £2·00 | £1·90 |
| 7413 | 0·32 | 0·31 | 0·30 | 7481 | £1·30 | £1·25 | £1·20 | 74162 | £4·40 | £4·15 | £3·85 |
| 7416 | 0·48 | 0·44 | 0·42 | 7482 | 0·96 | 0·95 | 0·94 | 74163 | £4·40 | £4·15 | £3·85 |
| 7417 | 0·48 | 0·44 | 0·42 | 7483 | £1·20 | £1·15 | £1·05 | 74164 | £2·20 | £2·10 | £2·00 |
| 7420 | 0·18 | 0·17 | 0·16 | 7484 | £1·10 | £1·05 | £1·00 | 74165 | £2·20 | £2·10 | £2·00 |
| 7422 | 0·55 | 0·53 | 0·50 | 7485 | £3·50 | £3·40 | £3·30 | 74166 | £3·20 | £3·10 | £3·00 |
| 7423 | 0·55 | 0·53 | 0·50 | 7486 | 0·35 | 0·34 | 0·33 | 74174 | £2·50 | £2·40 | £2·30 |
| 7425 | 0·55 | 0·53 | 0·50 | 7489 | £4·00 | £3·75 | £3·50 | 74175 | £1·75 | £1·65 | £1·55 |
| 7426 | 0·50 | 0·46 | 0·44 | 7490 | 0·74 | 0·71 | 0·64 | 74176 | £1·85 | £1·75 | £1·65 |
| 7427 | 0·50 | 0·46 | 0·44 | 7491 | £1·10 | £1·05 | £1·00 | 74177 | £1·85 | £1·75 | £1·65 |
| 7428 | 0·55 | 0·53 | 0·50 | 7492 | 0·74 | 0·71 | 0·64 | 74180 | £1·50 | £1·40 | £1·30 |
| 7430 | 0·18 | 0·17 | 0·16 | 7493 | 0·74 | 0·71 | 0·64 | 74181 | £5·00 | £4·50 | £4·00 |
| 7432 | 0·50 | 0·46 | 0·44 | 7494 | 0·85 | 0·82 | 0·75 | 74182 | £2·00 | £1·90 | £1·75 |
| 7433 | 0·75 | 0·73 | 0·70 | 7495 | 0·85 | 0·82 | 0·75 | 74184 | £3·20 | £3·10 | £3·00 |
| 7437 | 0·70 | 0·68 | 0·65 | 7496 | 0·96 | 0·93 | 0·86 | 74190 | £2·15 | £2·10 | £2·00 |
| 7438 | 0·70 | 0·68 | 0·65 | 74100 | £1·50 | £1·45 | £1·40 | 74191 | £2·15 | £2·10 | £2·00 |
| 7440 | 0·18 | 0·17 | 0·16 | 74104 | £1·07 | £1·04 | £1·00 | 74192 | £2·15 | £2·10 | £2·00 |
| 7441 | 0·74 | 0·71 | 0·64 | 74105 | £1·07 | £1·04 | £1·00 | 74193 | £2·15 | £2·10 | £2·00 |
| 7442 | 0·74 | 0·71 | 0·64 | 74107 | 0·44 | 0·42 | 0·40 | 74194 | £2·98 | £2·86 | £2·75 |
| 7443 | £1·20 | £1·15 | £1·10 | 74110 | 0·60 | 0·55 | 0·50 | 74195 | £2·00 | £1·95 | £1·90 |
| 7444 | £1·20 | £1·15 | £1·10 | 74111 | £1·38 | £1·27 | £1·21 | 74196 | £1·95 | £1·90 | £1·85 |
| 7445 | £1·98 | £1·95 | £1·90 | 74118 | £1·10 | £1·05 | £1·00 | 74197 | £1·95 | £1·90 | £1·85 |
| 7446 | £1·20 | £1·15 | £1·10 | 74119 | £1·50 | £1·40 | £1·30 | 74198 | £5·00 | £4·75 | £4·50 |
| 7447 | £1·10 | £1·07 | £1·05 | 74121 | 0·50 | 0·48 | 0·45 | 74199 | £5·00 | £4·75 | £4·50 |

DEVICES MAY BE MIXED TO QUALIFY FOR QUANTITY PRICE& (TTL 74 SERIES ONLY) DATA IS AVAILABLE FOR THE ABOVE SERIES OF I.C.'s IN BOOK FORM. PRICE 35p.

### INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

| Pak No. Contents | Price | Pak No. Contents | Price | Pak No. Contents | Price |
|---|---|---|---|---|---|
| UIC00=12×7400 | 0·55 | UIC46=5×7446 | 0·55 | UIC90=5×7490 | 0·55 |
| UIC01=12×7401 | 0·55 | UIC48=5×7448 | 0·55 | UIC91=5×7491 | 0·55 |
| UIC02=12×7402 | 0·55 | UIC50=12×7450 | 0·55 | UIC92=5×7492 | 0·55 |
| UIC03=12×7403 | 0·55 | UIC51=12×7451 | 0·55 | UIC93=5×7493 | 0·55 |
| UIC04=12×7404 | 0·55 | UIC53=12×7453 | 0·55 | UIC94=5×7494 | 0·55 |
| UIC05=12×7405 | 0·55 | UIC54=12×7454 | 0·55 | UIC95=5×7495 | 0·55 |
| UIC06=8×7406 | 0·55 | UIC60=12×7460 | 0·55 | UIC96=5×7496 | 0·55 |
| UIC07=8×7407 | 0·55 | UIC70=8×7470 | 0·55 | UIC100=5×74100 | 0·55 |
| UIC10=12×7410 | 0·55 | UIC72=8×7472 | 0·55 | UIC121=5×74121 | 0·55 |
| UIC20=12×7420 | 0·55 | UIC73=8×7473 | 0·55 | UIC141=5×74141 | 0·55 |
| UIC30=12×7430 | 0·55 | UIC74=8×7474 | 0·55 | UIC151=5×74151 | 0·55 |
| UIC40=12×7440 | 0·55 | UIC76=8×7476 | 0·55 | UIC154=5×74154 | 0·55 |
| UIC41=5×7441 | 0·55 | UIC80=5×7480 | 0·55 | UIC193=5×74193 | 0·55 |
| UIC42=5×7442 | 0·55 | UIC81=5×7481 | 0·55 | UIC199=5×74199 | 0·55 |
| UIC43=5×7443 | 0·55 | UIC82=5×7482 | 0·55 | | |
| UIC44=5×7444 | 0·55 | UIC83=5×7483 | 0·55 | | |
| UIC45=5×7445 | 0·55 | UIC86=5×7486 | 0·55 | UICXI=25 Assorted 74's | 1·55 |

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

### LINEAR I.C's—FULL SPEC.

| Type No. | Case | | 1 | 25 | 100+ |
|---|---|---|---|---|---|
| 72702 | DIL | 14 | 0.50 | 0.48 | 0.45 |
| 72709 | DIL | 14 | 0.35 | 0.33 | 0.30 |
| 72710 | DIL | 14 | 0.45 | 0.43 | 0.40 |
| 72741 | DIL | 14 | 0.40 | 0.38 | 0.35 |
| 72741C | TO5 | 8 | 0.45 | 0.40 | 0.35 |
| 72741P | DIL | 8 | 0.38 | 0.36 | 0.34 |
| 72748P | DIL | 8 | 0.38 | 0.36 | 0.34 |
| SL201C | TO5 | 8 | 0.50 | 0.45 | 0.40 |
| SL701C | TO5 | 8 | 0.50 | 0.45 | 0.40 |
| SL702C | TO5 | 8 | 0.50 | 0.45 | 0.40 |
| TAA263 | TO72 | 4 | 0.80 | 0.70 | 0.60 |
| TAA293 | TO74 | 10 | £1.00 | 0.95 | 0.90 |
| TAA293A | TO5 | 10 | £1.85 | £1.80 | £1.70 |
| µA703C | TO5 | 6 | 0.28 | 0.26 | 0.24 |
| µA709C | TO5 | 8 | 0.35 | 0.33 | 0.30 |
| µA711 | TO5 | 10 | 0.45 | 0.43 | 0.40 |
| ZN414 | TO18 | 4 | 1.20 | | |

### DTL 930 SERIES LOGIC I.C's

| Type | 1 | 25 | 100+ |
|---|---|---|---|
| BP930 | 0.15 | 0.14 | 0.13 |
| BP932 | 0.16 | 0.15 | 0.14 |
| BP933 | 0.16 | 0.15 | 0.14 |
| BP935 | 0.16 | 0.15 | 0.14 |
| BP936 | 0.16 | 0.15 | 0.14 |
| BP944 | 0.16 | 0.15 | 0.14 |
| BP945 | 0.30 | 0.28 | 0.25 |
| BP946 | 0.14 | 0.13 | 0.13 |
| BP948 | 0.30 | 0.28 | 0.25 |
| BP951 | 0.70 | 0.65 | 0.60 |
| BP962 | 0.15 | 0.14 | 0.13 |
| BP9093 | 0.45 | 0.43 | 0.40 |
| BP9094 | 0.45 | 0.43 | 0.40 |
| BP9097 | 0.45 | 0.43 | 0.40 |
| BP9099 | 0.45 | 0.43 | 0.40 |

### DUAL-IN-LINE SOCKETS.

14 & 16 Lead Sockets for use with DUAL IN LINE I.C's TWO Ranges PROFESSIONAL & NEW LOW COST.

| PROF. TYPE No. | 1–24 | 25–99 | 100up. |
|---|---|---|---|
| TSO 14 pin type | 33p | 30p | 27p |
| TSO 16 | 38p | 35p | 32p |
| TO 24 | 75p | 70p | 68p |
| LOW COST No. | | | |
| BPS 8 pin type | 13p | 13p | 11p |
| BPS 14 | 16p | 14p | 12p |
| BPS 16 | 17p | 15p | 13p |

### NUMERICAL INDICATOR TUBES

| Type | Description | |
|---|---|---|
| 3015F | Minitron 7 Segment Indicator | £1.50 |
| MAN 3M | L.E.D. 7 Segment Display 0.127" High Characters | £1.90 |
| CD 66 | Side Viewing Nixie Type Tube 16 mm | £1.87 |
| GR 116 | Side Viewing Nixie Type Tube 13 mm | £1.70 |

### 3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO-3 Plastic Encapsulation O.P. 1.5 Amps.
µA7805 5V (Equiv. to MVR5V) £1.76
µA7812 12V (Equiv. to MVR12V) £1.76

*BI-PAK*
CATALOGUE AND LISTS
Send S.A.E. and 18p.

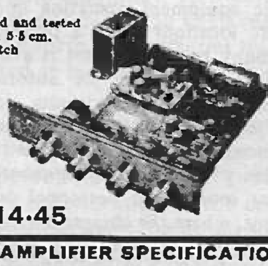
### TEAK VENEERED CABINETS for:

STEREO 20
TC 20. £3·95 p&p 30p.

MK 50 KIT
TC 100. £6·50 p&p 40p.

E.M.I. LEK 350 Loudspeaker System Enclosure kit in Teak Veneer, including speakers.
Rec Retail Price £45·50 per pr.
OUR SPECIAL PRICE £35·50 per pair p&p £1. *ONLY WHILE STOCKS LAST!*

## The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls. Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45

FRONT PANEL, 4 knobs. Headphone Socket, on/off switch and neon for PA 100/MK 50. FPK 100 £2·95.

### TRANSFORMERS

T461 (Use with AL10) £1·38 P & P 15p
T538 (Use with AL20) £1·93 P & P 15p
BMT80 (Use with AL30 & AL50) £2·15 P & P 25p

### POWER SUPPLIES

PS 12. (Use with AL10 & AL20) 88p
SPM 80. (Use with also AL30 & AL50) £3·25

### PA 12. PRE-AMPLIFIER SPECIFICATION

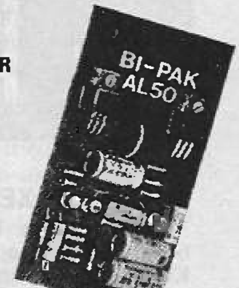
The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm. PRICE £4·35

Frequency response—
20Hz - 50KHz (- 3dB)
Bass control—
± 12dB at 60Hz
Treble control—
± 14dB at 14KHz
*Input 1. Impedance
1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance
30 K ohms
Sensitivity 4mV

FRONT PANEL FP12 with knobs £1·20.

## The AL50 HI-FI AUDIO AMPL 50W pk 25w (RMS)

### 0·1% DISTORTION! HI-FI AUDIO AMPLIFIER




- Frequency Response 15Hz to 100,000—1dB.
- Load—3, 4, 8 or 16 ohms.
- Supply voltage 10-35 Volts.
- Distortion—better than 0·1% at 1kHz.
- Signal to noise ratio 80dB.
- Overall size 63 mm × 105 mm × 13 mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

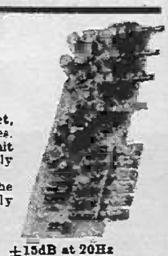
**BRITISH MADE. only £3·58 each**

## STABILISED POWER MODULE SPM80 £3·25

AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

**TRANSFORMER BMT80 £2·15 p. & p. 25p**

## STEREO PRE-AMPLIFIER TYPE PA100



Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

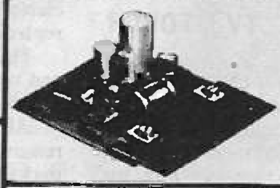
### SPECIFICATION:

| | | | |
|---|---|---|---|
| Frequency response | 20Hz—20kHz ±1dB | Bass control | ±15dB at 20Hz |
| Harmonic distortion | better than 0·1% | Treble control | ±15dB at 20kHz |
| Inputs: 1. Tape head | 1·25mV into 50KΩ | Filters: Rumble (high pass) | 100 Hz |
| 2. Radio, Tuner | 35mV into 50KΩ | Scratch (low pass) | 8kHz |
| 3. Magnetic P.U. | 1·5mV into 50KΩ | Signal/noise ratio | better than +65dB |
| All input voltages are for an output of 250mV. | | Input overload | +26dB |
| Tape and P.U. inputs equalised to RIAA curve | | Supply | +35 volts at 20mA |
| within ±1dB from 20Hz to 20kHz. | | Dimensions | 292×82×35 mm |

**SPECIAL COMPLETE KIT MK50 COMPRISING 2 AL50's, 1 SPM80, 1BMT80 & 1 PA100 ONLY £25·30 FREE p.&p**

**only £13·15**

## AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

| Parameter | Conditions | Performance |
|---|---|---|
| HARMONIC DISTORTION | Po = 3 WATTS f=1KHz | 0·25% |
| LOAD IMPEDANCE | — | 8 - 16Ω |
| INPUT IMPEDANCE | f=1KHz | 100 kΩ |
| FREQUENCY RESPONSE ⓔ 3dB | Po—2 WATTS | 50 Hz - 25KHz |
| SENSITIVITY for RATED O/P | Vs=25V. Rl—8Ω f=1KHz | 75mV. RMS |
| DIMENSIONS | — | 3" × 2½" × 1" |

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

| Parameter | AL10 | AL20 | AL30 |
|---|---|---|---|
| Maximum Supply Voltage | 25 | 30 | 30 |
| Power output for 2% T.H.D. (RL = 8Ω f = 1 KHz) | 3 watts RMS Min. | 5 watts RMS Min. | 10 watts RMS Min. |
| PRICE | £2·20 | £2·59 | £3·3 |

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# BI-PAK

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Postage and packing add 11p Overseas add extra for airmail
Minimum order 55p Cash with order please

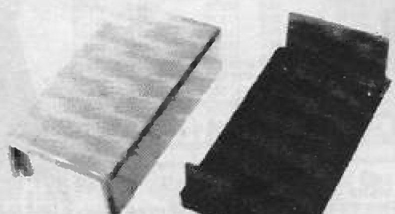
Guaranteed Satisfaction or Money Back

# EQUIPMENT NEWS

## PLASTIC BOXES

Vero Electronics Limited have recently become distributors for the Odenwalder Kunststoffwerk range of plastic products which include a range of plastic boxes. These are manufactured from high impact polystyrene, which is suitable for machining, engraving and silk screen printing. The upper portion of the box is coloured light grey and the lower portion, dark grey. The latter is provided with integral fixing points for circuit boards. The boxes can be free standing or wall mounting and should provide an attractive enclosure for reader's projects.

*Vero Electronics Limited, Industrial Estate, Chandler's Ford, Eastleigh, Hants.*



## CONTRACT FOR TV TOUCH TUNERS

Contracts worth £250,000 for their specially developed television touch tuner have been received by Emihus Microcomponents Limited. These are initial contracts and they have been placed with the company by leading television manufacturers in Europe.

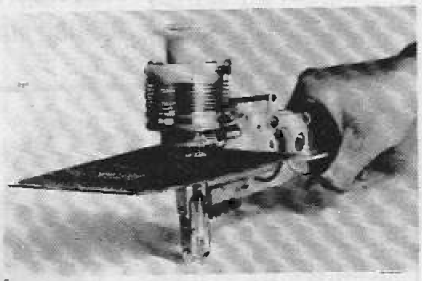
Negotiations are also in progress with three of the major television manufacturers in Japan for the supply of these television touch tuners.

The basic principle of the touch tuner is that the MOS integrated circuit, designed by Emihus, serves to replace push button controls by contact touch plates. The touch of a finger is all that is necessary to perform the functions previously done by the push button controls. One version produced by Emihus controls six channels, the other eight channels.

This technological breakthrough is of considerable significance for the television industry because of the main effect it has on the economics of maintenance and servicing of sets which will no longer need to have moving parts involved in push button controls.

*Emihus Microcomponents Limited, Queen's Road, Weybridge, Surrey.*

## DESOLDERING TOOL FOR INTEGRATED CIRCUITS



A hand operated tool that can remove a DIL package from a circuit board in less than a minute has recently become available from Siemens Ltd. It consists of a pair of jaws which are pressed around the component to be removed and a plier-type handle to control the tool. The top part consists of a spring-loaded suction pump and a heating head, and the lower part is a mechanism that grasps and removes the component from the board when it is free.

The operation of the tool is fairly simple: first the solder to be removed must be fluxed and the heater head tinned, then the tool is placed in position and heat is applied for five seconds. The suction pump is then released by a trigger on the handle which sucks the liquid solder into a chamber and leaves the pins free. The jaws are then opened, leaving the component held in the clamp and the board free and ready for a replacement component to be inserted.

The heater runs from a 10 to 12V supply, and uses about 45W. A power pack is available for use with ac mains voltages.

All 14 and 16 pin DIL packages can be removed, and there is a version for 24 pin packages as well.

*Siemens Limited, Great West House, Great West Road, Brentford, Middlesex.*

## FOOLPROOF POWER SUPPLY

With the increasing use of electrical and electronic equipment operating unmanned in remote locations using a power supply with standby batteries, there is a need for battery chargers which are automatically protected against short-circuits occurring through equipment failure or damage. A further need for a charger of this type has arisen due to the growing number of unskilled or semi-skilled personnel operating equipment, where the charger must be made "idiot-proof" to be protected against not only short-circuits but also incorrect connection of the battery.

To help combat this problem and to cater for the needs of modern systems requiring little or no periodic servicing, Photain Controls have recently introduced their new "Maintenance free" power supply type PS1.5. It has been designed primarily for fire and burglar alarm systems where a standby supply must be incorporated to maintain the operation of a system in the event of mains failure. The power supply may be connected to an infra-red beam, space protector or indeed any control unit in an alarm system. If the mains supply fails a 12V. 1.5 ampere hour capacity battery will automatically take over ensuring the continued operation of the unit and eliminating false alarms.

The power supply provides an output of 12V. d.c. ±1V. at 200mA. In the event of a mains failure a rechargeable sealed lead acid standby battery rated at 1.5A hours immediately takes over from mains and ensures a continued supply. If the mains are reconnected, the battery stops discharging and the mains supply takes over again. The battery is then automatically re-charged quickly back to full capacity. The entire operation is fully automatic thereby eliminating any form of maintenance. The initial cost of the unit is soon offset by the considerable saving in the cost of replacement batteries and labour.

*Photain Controls Limited, Randalls Road, Leatherhead, Surrey.*

## NEW 60MHz OSCILLOSCOPE

Tektronix has introduced a new general purpose oscilloscope line - the 5400 Series - in which flexibility, unique CRT readout and low cost are key design considerations. A wide range of measurement capabilities are provided by 17 plug-in units, permitting the user to select the performance he needs today with the assurance that this can be extended to meet future requirements.

For the full 60MHz bandwidth with the optional CRT Readout facility, the basic units are the 5403 three plug-in Mainframe, D40 non-storage Display Module, 5A48 Dual-Trace Amplifier, and 5B42 Delayed Sweep Time Base. The 5A48 provides 5mV/div sensitivity at 60MHz and 1mV/div at 25MHz. Two 5A48 Dual Trace Amplifiers can be used together for four-trace displays. The 5B42 Time Base features sweep rates up to 1µS/div and a X10 magnifier gives a fastest sweep rate of 10ns/div. Fifteen other plug-ins (without CRT Readout capability) include a dual trace sampling unit covering up to 1GHz at 1mV/div sensitivity, a Differential Amplifier offering 10µV/div sensitivity and a 100,000: 1 common mode rejection ratio, a Differential Comparator Amplifier with measurement accuracy up to 0.2% - and many others.

*Tektronix U.K. Ltd., P.O. Box 69, Beaverton House, Harpenden, Herts.*

# news digest

*Continued from page 9*

## PIONEER OF X-RAYS CELEBRATES 100TH BIRTHDAY

Happy Birthday to Dr. William D. Coolidge, who celebrated his 100th birthday on October 23rd. His name is inseparably linked with the X-ray tube that he invented. His "Coolidge tube", unveiled in 1913, completely revolutionised the generation of x-rays and remains to this day the model upon which all x-ray tubes for medical applications are patterned.

Coolidge was born in Hudson, Massachusetts, U.S.A., in 1873. He joined the General Electric Company of the USA's research staff in 1905, immediately taking up the search for an improved filament material for the incandescent lamp. After two years of intensive experiments, he produced the first ductile tungsten that man had ever seen. Two additional years of research made larger-scale production of the material practical.

The development of ductile tungsten for use in incandecent lamps led directly to a major improvement in x-ray tubes. By vacuum-casting copper around a wrought tungsten target, Coolidge was able to increase its heat conductivity permitting the target to absorb more energy and produce more x-rays. Today, tungsten is universally used for this purpose.

However, Dr. Collidge's greatest contribution to the science of x-rays was the design for a radically new type of tube. After Dr. Irving Langmuir, the GE(USA) Nobel laureate, demonstrated the possibility of a pure electron discharge in high vacuum, Coolidge developed an x-ray tube with the highest attainable vacuum and with hot tungsten filament replacing the cold aluminium cathode. Its output could be predetermined and accurately controlled. Patented in 1916, the "hot cathode" or Coolridge tube quickly superseded previous gas tubes. Coolidge also developed the first portable x-ray generator; self-rectifying x-ray tube; one and two-million volt x-ray machines; the "cascade" x-ray tube; and many more.

Dr. Coolidge - who holds 83 patents for his pioneering work - has received many honours including the Rumford Medal of the American Academy of Arts and Sciences (1914); the Potts Medal of the Franklin Institute (1926); the first Gold Medal of the American College of Radiology (1927); the Hughes Medal of the Royal Society, London (1927); The Edison Medal of the American Institute of Electrical Engineers (1928); the Faraday Medal of the Institution of Electrical Engineers of England (1939); the Duddell Medal of the Physical Society, London (1942); and the Franklin Medal (1944).

## RESEARCH INTO SODIUM-SULPHUR BATTERIES

A contract for improvement of sodium-sulphur storage batteries has been awarded by the Edison Electric Institute to the General Electric Company of the USA's Research and Development Centre.

The funds will help support an extensive research programme, begun several years ago, aimed at developing this relatively new type of battery for applications in bulk energy storage.

"Sodium-sulphur batteries, which potentially offer five times more storage capacity per pound than conventional lead-acid batteries, may hold a solution to electrical 'brown-outs' - those occasions when demand outruns the supply of electricity," Dr. Arthur M. Beache, GE(USA) vice president for research and development claimed recently.

"During early-morning hours, weekends, and other periods when the full generating capacity of power stations is not required, excess electricity could be stored in large sodium-sulphur battery installations," the GE(USA) executive said. "To reduce their environmental impact, such bulk energy storage stations could possibly be located underground," he pointed out.

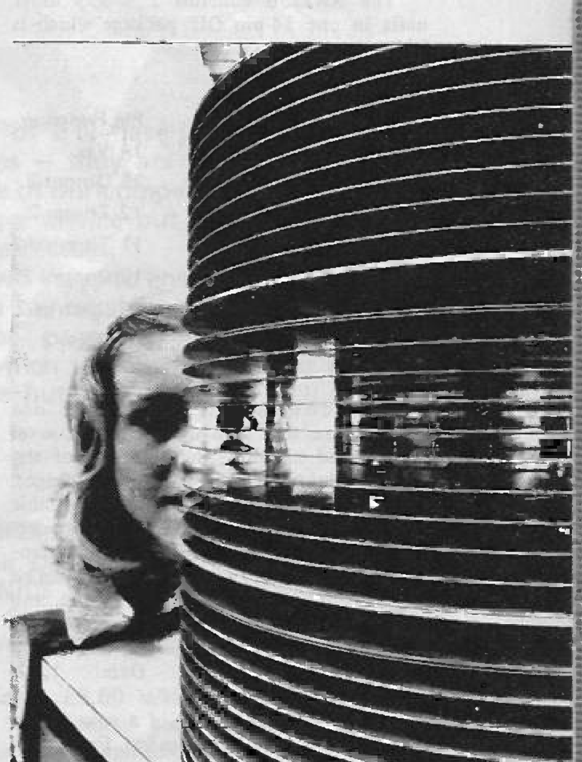
Conceived several years ago, sodium-sulphur batteries employ liquid reactants (liquid sodium and liquid sulphur) separated by a solid electrolyte (a ceramic compound of sodium, aluminium, and oxygen called beta alumina). To maintain peak efficiency and to keep reactants in liquid form, the batteries must be operated at high temperatures of 300°–350°C.

To date, the development of sodium-sulphur batteries has been beset by a number of problems, notably deterioration of the ceramic separator between the liquid sodium and the liquid sulphur.

Work under the contract, involves the modification and improvement of the ceramic electrolyte, the evaluation of factors affecting the life of solium-sulphur cells, and the design and testing of new cells having improved cell configuration and seals.

Sodium-sulphur batteries also may some day find application in certain types of electric vehicles. The widespread use of such vehicles within urban areas would eliminate the emissions now released to the atmosphere by internal combustion engines, thus reducing air pollution. Theoretically, an electric car equipped with sodium-sulphur batteries could travel as far on a single charge as a typical petrol-powered automobile on a tank of fuel.

Through the Edison Electric Institute and the recently formed Electric Power Research Insitute, the investor-owned electric utility companies in the United States are playing an increasingly active role in sponsoring research and development in the electric power field.



*EYE SPY ... Liz Bird peeks at a stack of computer disk packs ready for testing at a Honeywell factory. Resembling long-playing records, the disks are used to store data for Honeywell Series 6000 Computers.*

*Each disk pack has 19 recording surfaces, storing a total of 118 million characters of information - so that one pack could store the Bible (3,566,480 letters) 33 times over.*

# electronics tomorrow

BY JOHN MILLER-KIRKPATRICK

SEVERAL MONTHS AGO we told you to expect a new IC timing device from Signetics in the form of a double 555 timer. This device has now been released as the 556 timer and has already been second-sourced by another manufacturer. As we have no data on the Signetics 556 at present we are using the data provided by EXAR Integrated Systems on their **XR2556CP** and assuming that it is pin-to-pin equivalent to the Signetics device.

The XR2556 contains 2 x 555 timer units in one 14-pin DIL package which is laid out as:

| Pin | Function | Pin | Function |
|---|---|---|---|
| 1 | Output-1 | 14 | Vss |
| 2 | Trigger-1 | 13 | Output-2 |
| 3 | Thresh'd-1 | 12 | Trigger-2 |
| 4 | Control-1 | 11 | Thresh'd-2 |
| 5 | Disch'ge-1 | 10 | Control-2 |
| 6 | Reset-1 | 9 | Disch'ge-2 |
| 7 | Ground | 8 | Reset-2 |

The advantages of two 555s in one package are that it saves PCB space, saves money and matching and tracking of the 556 is superior to two separate 555 packages.

Just to remind you, the 555 is a stable controller capable of producing highly accurate time delays or oscillations from microseconds to hours. The supply voltage can be anything within the range 5-15V d.c. and changes in supply voltage do not seriously affect the timing of the device, output can source or sink 200mA. Data: 1, 2. Devices: 2.

The 555 timer is part of a new family of ICs which are being called **Functional Blocks**. These ICs contain several standard IC functions such as comparators, op-amps, flip-flops, 'discrete' transistors, etc. all combined to form a specific function. Most of these blocks, however, may be wired differently to give completely new functions and in some cases the internal units may be used separately whilst keeping the advantage of matching which can only be obtained from encapsulation. As an example of this versatility the author has recently used one 555 as a battery voltage monitor for NiCD cells and another 555 as the basis for a digital thermometer.

We have presented similar devices in this column in the September issue, the National Semiconductor LM322 and the Elremco LR171E. The LM322 has a floating transistor output capable of driving loads of up to 40V and 50mA. The supply voltage is 4-40V and the unit contains a voltage regulator to give 3.15V which is available to the user. The LR171E is made by Ferranti for Elremco Ltd and contains a divide section to divide the original oscillation by 1024, 2048 or 4096, thus giving a very stable timing sequence. A digital-to-analogue converter on the chip may be used with a simple meter to give an analogue time elapsed indication. Again this device could be rewired to give several different units with five driving outputs and can be run from 6-490V! A new device has just been announced by Ferranti which may well be based on the LR171E with restrictions on some of the functions. No detailed data has been received yet but the data so far is as follows. *'The ZN1034E is a single timer which offers a timing delay from 50msec to 4 weeks and can be operated from virtually any power source. Delay and interval timing sequences are available and calibration can be carried out very rapidly. The power requirements of the chip are low. allowing long battery life in portable applications'.* All of this would seem to indicate a very similar device at, we have been assured, a much more reasonable price than the LR171E. Data - LM322: 3, LR171E: 4, ZN1034E: 5, LM322s are available from: 6 at £2.50 plus VAT.

Another timer is the National Semiconductors LM3905, a monostable device for use in time-out and voltage interfacing applications. The power supply is 4.5-40V unregulated and timing periods are not affected by voltage changes. The output is a floating transistor with built-in current limiting and a logic reverse feature which may be programmed by the user to make the output transistor either on or off during the timing period. As in the LM322, a 3.15V regulated supply at 5mA is available to the user for a convenient reference for applications other than as a basic timer. One capacitor, two resistors and one potentiometer added to the LM3905 makes a good photographic type timer with an output suitable for driving a relay. Data: 3. Devices: 7.

A non-timer functional block is the LX1600 absolute pressure transducer. This is a highly accurate unit that contains diaphragm, vacuum reference, piezoresistive sensor, discrimator and amplifier. The action of the device is described as equivalent to the potentiometer, with a 12.5V supply and at 78°F the unit give 2.5V output at 0atm of pressure, 7.5V at 1atm and a straight line between. Changes in temperature may be overcome by an internal temperature sensor after the finished meter unit has been calibrated. The only additional component required for the basic system is a meter. One application that has already been suggested is that of a boat speed indicator, by adding some tubing and similar hardware to the LX1600 and meter, the device registers changes in hull pressures and presents this as a speed. Data: 3, Devices: 7, price is unfortunately just over £30.

Those of you who remember our comments on the Sinclair Cambridge kit in the November issue will be pleased to hear that Sinclair have now sent us a copy of their new assembly instructions. They explained that they checked the kit instructions by giving the kits to about 30 people to build from the instructions and to comment on the clarity. In some ways it is a shame that the electronics industry is moving so fast, products cannot be completely 'bug-proof' tested in the short time demanded by the market even if the 'bugs' are only in the instructions.

## REFERENCES


1 Signetics Int. Ltd, Yeoman House, Croydon Road, London, SE20.

2 Rastra Electronics Ltd, 275 King St, London W6 9NF.

3 National Semiconductors (UK) Ltd. The Precinct, Broxbourne, Herts.

4 Elremco, P.O. Box 10. Bush Fair, Harlow CM186LZ.

5 Ferranti Ltd, Gem Mill, Chadderton, Lancs.

6 Bywood Electronics, 181, Ebberns Rd, Hemel Hempstead, Herts.

7 Atlantic Components, 143 Loughborough Road, Leicester, LE4 5LR.


Please remember to mention ETI as an easy mutual reference source.

# BOOK REVIEWS

*REVIEWER: BRIAN CHAPMAN*


**THICK FILM CIRCUITS by Planer and Phillips, Published by Butterworths 1972. Hard covers 152 pages 215mm x 140mm. Price £4.00**

The uses of thick film microcircuits are widespread and they are finding ever increasing popularity as their advantages become more generally known.

They are particularly suitable for the manufacture of relatively small numbers of identical circuits. The plant cost is relatively small allowing small companies to have their own in-house facility which is relatively simple to operate.

It is expected that thick film techniques will progressively replace printed circuit board techniques for many commercial equipments as the technique provides greater mechanical and electrical stability (particularly at high temperatures), and since a large proportion of the thick film components are integrated with the substrate, higher power dissipation is allowable.

Moreover resistors and capacitors may be fabricated on the substrate with a far greater range of values, and what's more, may be readily trimmed for any desired accuracy.

Their greater ruggedness and reliability coupled with their small size and relatively uncritical manufacturing process make them particularly suited for aerospace or military applications. But they are now finding their way into computers and even into consumer fields such as washing machine control and automobile regulators.

This book provides a coverage of the basic theory, materials and processes of the technology to a depth adequate for those who require merely a better understanding of the devices or those who intend to design them into their own equipment. – B.C.

**UNDERSTANDING ELECTRONIC CIRCUITS by Ian R. Sinclair. Published by Fountain Press 1973. Hard covers, 205 pages 215 x 130 mm. Review copy supplied by publisher.**

**Price £3.50**

This book is a companion work to the previously published "Understanding Electronic Components" by the same author. It is intended for the middle-of-the-road reader; those who already have knowledge of components and elementary electrical theory and wish to extend their circuit knowledge.

Mr. Sinclair knows his electronics and has written many worthwhile articles in journals such as Wireless World. In this new book he covers the usual field – amplification and various types of amplifiers, oscillators, pulse circuits, logic and counting, power supplies and the whole oscilloscope. There is a lot of worthwhile information given and much of it would be of considerable interest and value to the practical serviceman or technician who is reasonably fresh to electronics.

Examining the book from the point of view of its intended audience and content, however, it would seem that the author has tried to cram too much information into too few words. As a result, although the information is there, and is correct, I feel that people trying to learn electronics from this book would find the task difficult.

The subject matter is simple but the style isn't. A great pity because it spoils what could otherwise be a good book. – B.C.

**COMPUTER SECURITY. By Peter Hamilton. Published by Cassell/Associated Business Programmes Ltd 1972. Hard covers, 122 pages 235 mm x 150 mm. Review copy supplied by publisher. Price £3.50**

In the technical press (and to some extent the popular press) there has been a increasing number of articles and editorials decrying the misuse of computer data banks. A less publicized issue, but one that should also be of great concern, is that of computer security.

The first issue concerns the protection of people from computer aided bureaucracy whilst the second, understandably less popular issue, is concerned with *protecting the computer from people*.

It is the latter issue which is the subject of this timely book by Peter Hamilton.

As a preface to examining crimes against computers and the means of combating them, an analysis is given of the trends and motivations involved in criminal activities resulting from the emergence of our technocratic society. It is pointed out that the crime rate is rapidly on the increase and that illegal activities are by no means restricted to those who are unintelligent.

In fact many cases have been reported where large sums have been misappropriated by the manipulation of computer programmes. In most cases detection of the crime have been purely a matter of luck (or bad luck depending on your point of view) and there must be many more cases where such activities have been carried out so expertly that the theft will *never* be discovered.

In addition to pure larcency, the book examines aspects such as the protection of the computer from arson or sedition. Many people see the computer as some kind of ogre which threatens their employment. Yet others see the destruction of data storage or tampering with programming as a means of getting their own back on the company. What would happen to a large company whose operation was controlled by computer, should the computer and/or its data bank be destroyed? No doubt the result would be utter chaos from which the company may take years (if ever) to recover.

Further the computer is very vulnerable to industrial espionage and indeed the book suggests that a computer based society may well be conquered by gaining access to and then ultimate control of, the nation's computer complex.

The surveillance of people and property as an aid to minimizing security risks is discussed from the conflicting aspects of the need for such surveillance, and the individual's entitlement to privacy. The best methods of implementing such surveillance for the protection of the computer complex is then discussed in detail and a full tabular assessment of the security risks and suggested remedial action is given in the rear of the book.

An extremely interesting and easy to read book which should be of vital interest to company management as it gives practical advice on the best methods and techniques of protecting a most vulnerable management tool. B.C.

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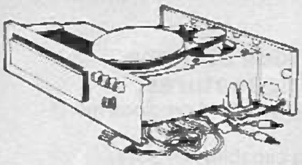

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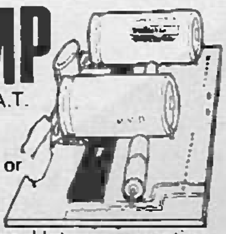

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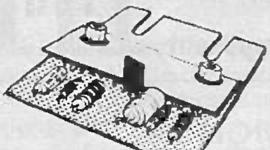

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# TECH TIPS

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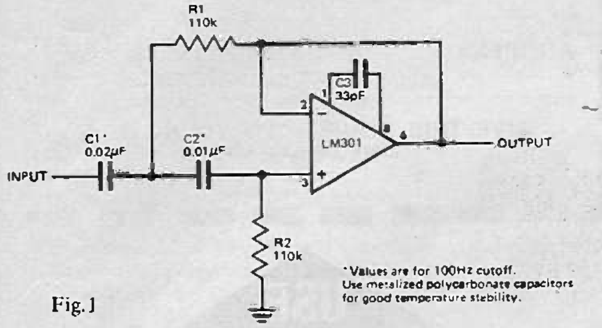



Fig.1

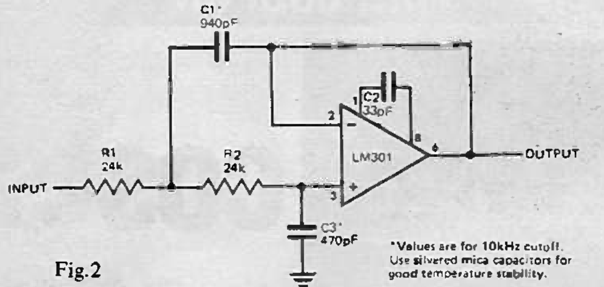



Fig.2

ACTIVE RC filters using operational amplifiers are increasingly being used to supplant LC filters because of the small size and ever-decreasing cost of integrated circuit operational amplifiers. Here are two useful general purpose circuits which may be readily incorporated into other circuitry where needed.

Figure 1 shows one of the simplest forms of filter, the low pass. The circuit has the same characteristic as two isolated RC filter sections with the additional advantage of a buffered low impedance output.

The attenuation is 12 dB per octave at twice the cut off frequency with an ultimate of 40 dB per decade.

There are two basic designs for this filter, the Butterworth (maximum flatness), and Linear Phase (minimum settling time for pulse input). The equations for the Butterworth design are:—

$$C_1 = \frac{R_1 + R_2}{\sqrt{2}\ R_1\ R_2\, \omega C}$$

and

$$C_2 = \frac{\sqrt{2}}{(R_1 + R_2)\, \omega C}$$

For the Linear Phase design simply substitute $\sqrt{3}$ for $\sqrt{2}$ in the above equations.

To make a high pass filter we merely substitute resistors for capacitors and capacitors for resistors, as shown in Fig. 2, and apply the same formulae.

## HIGH INPUT IMPEDANCE AMPLIFIER

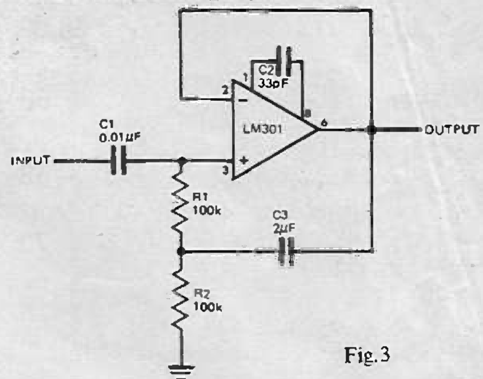



Fig.3

The LM301 may also be used to construct a simple high input-impedance ac amplifier as shown in Fig. 3. In this circuit even though the bias resistor is only 200 k, as required for good dc stability, the bootstrapping by C3 provides an input impedance of 12 M at 100 Hz increasing to 100 megohm at 1 kHz.

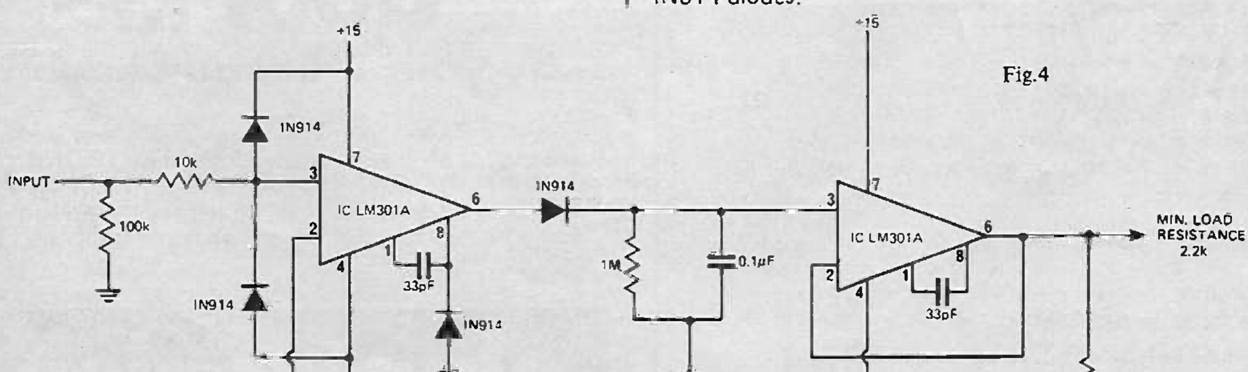
## POSITIVE PEAK DETECTOR

A positive-peak detector having gain may be constructed using two LM301As as shown in Fig. 4.

The output is the peak voltage at the input amplified by the ratio (R1 + R2)/R2. Typical error is 2 (R1 + R2)/R2 millivolts.

If unity gain is required R2 is deleted. The combined resistance of R1 and R2 should be in the range of 10 to 100 k and the minimum load resistance 2.2 k. Where negative peak detection is required reverse the polarity of both IN914 diodes.

Fig.4



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