APRIL 1975
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electronics TODAY INTERNATIONAL

HI-FI

HOW TO BUILD ELECTRONIC PROJECTS - SPECIAL ISSUE

AMBISONICS - SCOOP!

Registered for posting as a periodical — Category C.

LOW-COST FM ANTENNAS TO BUILD

electronics TODAY INTERNATIONAL

APRIL, 1975

Vol 5, No 4

project building guide

main features

projects

reviews

news & information

COVER: Special project building guide begins page 44 this issue.

NEXT MONTH

RADAR BURGLAR ALARM TO BUILD

ELECTRONIC POKER MACHINE PROJECT

HOW TO USE LM 3900N QUAD AMP ICs

PROJECT BUILDING GUIDE SECOND PART

The feature articles listed above are included amongst those currently scheduled for our May issue. However, unforeseeable circumstances, such as highly topical news or developments may affect the final issue content.

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news digest

TEKTRONIX DENY PHILIPS MERGER

Tektronix have taken us to task about our brief news item in our January issue — to the effect that Philips may take over the US Tektronix Corporation.

In a letter to our Editor, Tektronix say 'On Nov 21 1974, Howard Vollum, Chairman of the Board of Tektronix Inc. formally denied any discussions regarding a merger with Philips had taken place. Mr Vollum stated that Tektronix had had no merger discussions with Philips and do not plan to . . . '

Mr Vollum reported that 'We are not interested in talking to anyone about merger. We have held the historical position that we are not interested in a merger with another company, and we still feel same way'.

TEN MEGAWATT RECTIFIER

A solid-state rectifier capable of handling more than 4000 amps at 2500 volts has been developed by Westinghouse. The 70 mm diameter device has been surge tested at 26 000 amps and Westinghouse engineers believe that it is probably capable of withstanding 40 000 amps.

Applications for such devices are in fusion reactors, aluminium processing, electroplating and welding.

Work is also proceeding on a thyristor version of the device which consists mainly of a silicon disc separated by an extremely thin aluminium foil layer from a molybdenum backing plate.

"SEEING" OBJECTS UNDERWATER

The only deep-water tank in Australia for testing and developing submerged electronic devices is giving local scientists the opportunity to learn more about the scope of underwater detection and communication.

The tank, seven metres deep and containing 230 000 litres of water, has been built in a Sydney industrial suburb with funds from the Australian Government Department of Manufacturing Industries.

Electronics engineers of Plessey Australia are using it to evaluate equipment the Special Devices Business of the company is developing for the underwater detection and tracking of moving objects. This is a follow-on of earlier work Plessey Australia has done for the Australian Government on hydrophones.

When a hydrophonic device — the nerve-centre of all underwater detection systems — is lowered into the tank it comes under the complete physical control of an $80 000 system built around a PDP 11/15 mini-computer which performs the rapid analyses of the received and transmitted signals and prints the result. The system was also funded by the DMI.

No other country outside the United States and Europe has comparable facilities for developing and testing electronic devices to let those above the water learn what is below it.

The fully-enclosed tank and its linked computer service offers Australian organisations other than the Special Devices Business and the Advanced Components Research Laboratory of Plessey Australia the chance to develop and evaluate their own underwater electronics.

The potential of sonar devices in identifying and describing the presence of things below the surface goes beyond its obvious seaboard defence role.

They could, for example, be used immediately to locate sunken objects, such as those following the Hobart Bridge disaster, a ditched plane helicopter under-harbor debris such as boats or vehicles, schools of fish . . . in fact anything moving or stationary, suspected or unknown, under the surface.

A.P.O. APPROVES PUSH-BUTTON TELEPHONE DIALLER

The Australian Post Office has approved a new telephone number dialling device that provides push-button dialling and electronically stores, recalls and automatically dials up to ten telephone numbers. Called SpheriCall, it is to be marketed by Philips TMC Limited.

Using SpheriCall a telephone subscriber can:

Punch out a telephone number faster and more accurately than he can using a rotary dial. Can electronically store up to ten of the most frequently called telephone numbers (up to eighteen digits long — an important benefit for frequent users of the subscriber trunk dialling system). The number can be dialled by pushing a single button which corresponds to the number in storage. With the push of one button can "try again" any engaged numbers.

The unit is used with a normal telephone, no internal alterations are necessary to existing telephone equipment. It is expected to have widespread acceptance in Australian business commerce and even in private homes.

news digest

TRUE ONE-CHIP WATCH

Despite their manufacturers' claims of one-chip construction, most LED digital watches do in fact have at least two chips — separate ones being used for the segment and digit drivers — apart from the main electronics chip.

Now however a new chip from Intersil really does combine all functions onto one 125 square-mil chip. Not only does it contain the oscillator, divider, decoder and segment plus digit drivers — it also has an output for a nine-digit alphanumeric display as well as the standard seven-digit numeric display.

PLESSEY/NATIONAL SEMI-CONDUCTOR TO MAKE TV TUNERS.

Plessey Semiconductor and National Semiconductor (in the US) have jointly developed a digital TV tuner that will be marketed soon.

Full details are not available but we understand that Plessey will make the ultra-high frequency divider circuit whilst National will produce the remainder including the large scale integrated MOS circuit. Final assembly will be done by Plessey.

The unit will have a calculator style of keyboard — channel selection is made by pressing the appropriately numbered keys. Price is believed to be less than US$30.

INSTANT INFO

Home TV viewers may soon be able to call up news and information as required directly from international news service, Reuters.

The service has been developed by Information Dissemination and Retrieval Inc (a Reuters subsidiary) and is already in operation in Manhattan (USA).

At present the service is planned to operate through cable TV systems only.

EUROPE'S FIRST DIGITAL 'PHONE SYSTEM

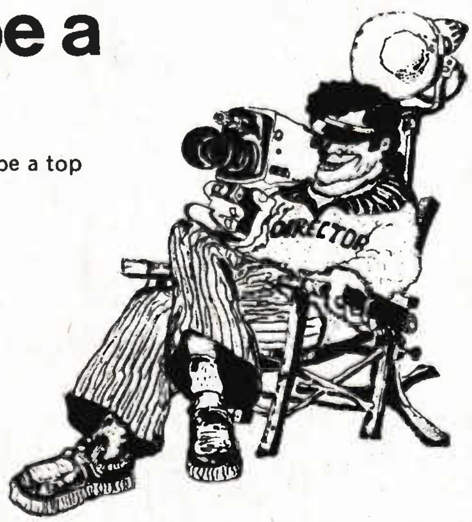
The British Post Office has developed a prototype high-speed digital telephone link.

The equipment, demonstrated by the British Post Office, works over a 66 km cable between Guildford and Portsmouth in southern England and transmits at the rate of 120 million signals a second. The line can accommodate 1,680 simultaneous telephone calls but it could handle a colour television channel, 336 sound programmes or — when they come into use — 14 channels for videophones.

The main advantage to the user is mainly clearer speech, but it offers the Post Office greater flexibility in being able to use cables for a mixture of services such as television, computer data and facsimile transmissions.

The basic principle of the system is to turn the wave-form of voice signals into electrical pulses. Telephone calls are sampled 8000 times a second and these samples are coded into trains of pulses and transferred to 'multiplexing' equipment. In this the signals from blocks of 30 calls are interwoven, speeded up and then transmitted down the line separated by minute periods of silence. Equipment at the other end sorts out the signals, decodes them and sends them to the relevent receivers.

(Continued on page 11)




music

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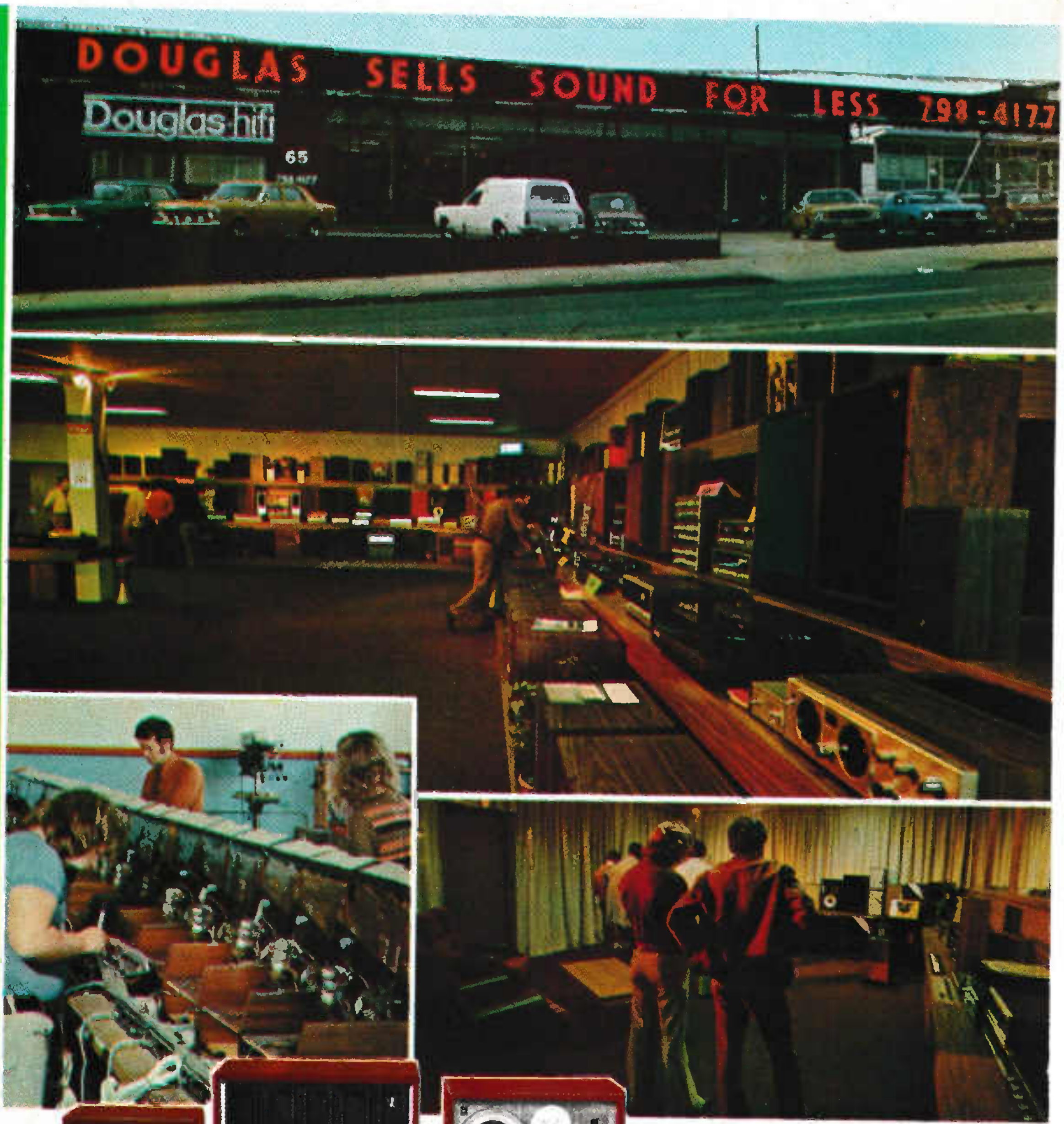
Great news for N.S.W. Douglas Hi-Fi have opened exciting new showrooms in Sydney. Here you can see all the world's leading gear—at Special low prices. We're the biggest Hi-Fi organisation in Australia, so we buy at better prices than anyone else. We do our own importing—in bulk. Often by the container load. And we pass the savings on to you. See, hear and compare all the great brands together, in a single showroom. More than 30 top brands, from 4 continents. Hundreds of different models, the most comprehensive range in Australia. All fully guaranteed, and backed by Australia's fastest, best equipped drive-in service centre. Douglas sells sound for less!



MELBOURNE: 191 Bourke St., City. Ph. 63-9321.
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PERTH: 883 Wellington St., Phone 22-5177.

Douglas Hi-Fi have the complete range of the fabulous JENSEN Speakers from **$99 to $1199 pair.**

news digest

Continued from Page 6

ELECTRIC BUS

A battery powered bus was last month driven non-stop from Birmingham to Manchester (UK) at an average speed of more than 45 km/h. The 138 km journey was undertaken in less than three hours.

Previous journeys undertaken by the bus included an 180 km run on the Motor Industry Research Association's flat test tracks and a 160 km trip through undulating countryside and along motorways, each being completed on a single battery charge.

The vehicle has been built and placed in operation with the Greater Manchester Passenger Transport Executive to act as a test bed for the experimental Lucas electric traction equipment, and it will enable engineers — in co-operation with the operators — to evaluate the equipment's performance and operating costs.

Based on a Seddon chassis with a composite light alloy, glass fibre body, the 34-passenger vehicle is powered by a 360 volt, dc motor which develops 130 bhp. This is mounted in the centre of the chassis, driving the conventional back axle through a propellor shaft, the motor being controlled by a Lucas designed SCR 'chopper' controller which is located at the rear of the vehicle and provides a sophisticated means of transferring the battery output to the motor.

The controller operates by connecting and disconnecting the power source to the motor through a solid state (SCR) switch so that the motor only sees the average of the resultant 'chopped' voltage. By changing the ratio of the open to closed times of the switch, the average voltage across the motor is varied. Additional solid state circuitry automatically adjusts the power to the motor so that it is appropriate to the accelerator pedal position set by the driver and the vehicle speed.

A typical traction battery gives some 10 watt-hours per pound of battery weight at a two hour discharge rate, the unit having a life expectancy of around 1500 useful charging cycles. The normal, hard rubber, SLI (starting, lighting and ignition) battery gives about 12 watt-hours per pound weight at the two-hour rate, and 100 cycles. Polypropylene SLI batteries, such as the Lucas Pacemaker give 13.6 watt-hours per pound at the two-hour rate.

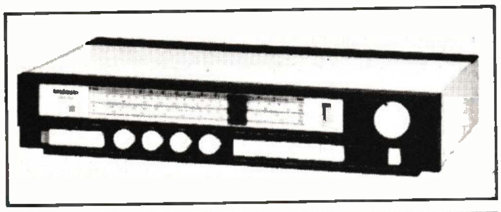
In order to achieve a competitive electric vehicle, a low cost, high energy density battery is required. The Lucas approach has been to take the polypropylene SLI design as a starting point and improve its cycle life to an acceptable level while at the same time making further advances in the energy/weight/volume ratios. The current research programme is aimed at producing a battery with a life of several hundred cycles.

The capacity of the Lucas batteries fitted to the bus will enable it to operate *all day* on the Manchester city centre service. They are carried, in groups of six, by 10 pallets which are located along the sides and at the rear of the vehicle. The pallets can be removed for battery maintenance with the aid of a fork life truck. A charging point is located at the rear of the vehicle.

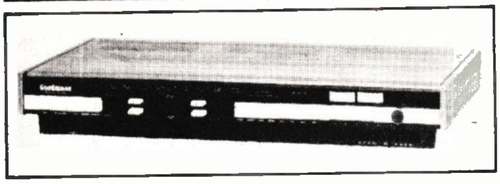
Continued on Page 13

Goodmans
Sound reasoning.

Dimension 8
Bi-directional 8-way loudspeaker system. Frequency range: 30 Hz — 22,000 Hz. Nominal power input 60 watts. Finishes: teak, walnut or white. Size: 30⅜" x 14" x 12½".

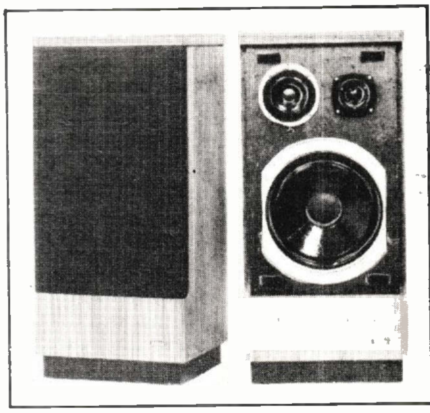


Model One Ten
AM/FM stereo tuner-amplifier. 50 watts RMS per channel into 4 ohms. Distortion: less than 0.01% at 30 watts per channel. Finishes: teak or walnut with brushed aluminium fascia or white finish with black and white fascia. Size 23" x 12" x 4½".



Module 90
AM/FM stereo tuner-amplifier. Pre-select FM tuning facility. 45 watts RMS per channel into 4 ohms. Distortion: less than 0.1% at 35 watts per channel. Finishes: teak, walnut or white. Size: 24⅛" x 11⅞" x 4".

Module 90 Compact
AM/FM stereo tuner-amplifier with integral record player. Turntable and drive: zero — 100SB. Distortion: less than 0.1% at 35 watts per channel. Finishes: teak or walnut. Size: 24½" x 15¾" x 8¼".

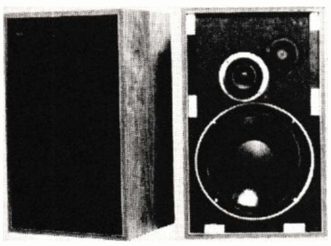


Goodwood Domestic Monitor 3-Way Loudspeaker System
Frequency range 55 Hz — 22,000 Hz ±3dB. — 10dB at 35 Hz. Power handling capacity: equivalent to peak source power of 60 watts RMS into 4 ohms. Finish: teak or walnut. Size: 30" x 14¼" x 10¾".

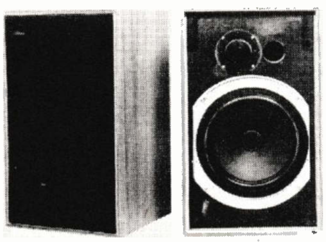
For further information contact Thorn Sales
348 Victoria Rd, Rydalmere, 2116 Tel. 638 9022.

THORN

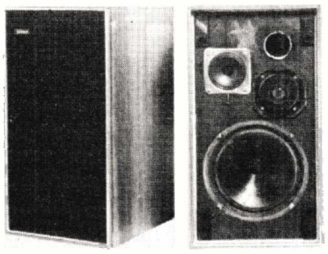
SL Range
Suitable for use with amplifiers of 4 ohms or 8 ohms output impedance. In teak or walnut veneers.



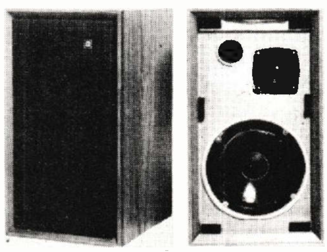
3-way system Magnum 35
22,000 Hz 60w



2-way system Mezzo 40
20,000 Hz 60w



3-way system Havant 45
22,000 Hz 20w



2-way system Minister 45
22,000 Hz 20w

AT11

news digest

Continued from Page 11

To extend the operating range of the bus, and minimise wear and tear on the mechanical brakes, a regenerative braking system is fitted. This utilises the kinetic energy of the vehicle to drive the traction motor when decelerating. Under these conditions the role of the motor becomes that of a generator, thus acting as a form of electric transmission brake, and providing a degree of charge to the batteries.

The bus interior is warmed by a liquid fuel heater which can be operated before the vehicle leaves the depot, thus providing the maximum degree of comfort in cold weather.

The Lucas vehicle can smoothly accelerate a full complement of passengers from 0-45 km/h in under 14 seconds while a top speed of nearly 75 km/h will ensure that it can quietly hold its own under the worst possible traffic conditions.

$14 MILLION COLOUR TV EQUIPMENT ORDERS FOR AWA

Introduction of colour television into Australia and New Zealand has resulted in AWA receiving equipment orders worth more than $14 million.

AWA, with its associate, Marconi Communication Systems Limited, of England, has supplied a large proportion of the Australian and New Zealand colour equipment.

Sales include 122 Marconi Mk VIII automatic colour cameras, which represent nearly half the total number of colour cameras required by both countries have been supplied by AWA.

NEW CONVERTER IMPROVES SATELLITE TELEVISION LINKS

A major improvement in satellite television transmissions and a greater world-wide exchange of television programmes will result from a new British-designed picture converter.

Marconi have signed the sole manufacturing and marketing rights of DICE — digital intercontinental conversion equipment — developed by engineers of the Independent Broadcasting Authority (IBA).

This latest version of DICE can convert colour pictures consisting of 525 lines as used in the United States and Japan, into 625 line pictures as used in most other parts of the world, and vice versa.

The standards conversion is essential for live relays by satellite and where programme material or videotape is exchanged between countries working to different television picture standards.

DICE also solves the technically complex process of conversion between systems using 30 pictures a second (as in North America and Japan) and those using 25 pictures a second (as in Europe) — entirely electronically and without picture distortion.

HIGH COSTS OF BUYING COLOUR TV AS AGAINST RENTING

Expensive repair bills and higher prices when buying receivers on hire purchase are forecast for Australians who own their colour TV sets instead of renting them according to Mr Albert Gill, who has 15 years experience in the United Kingdom, Europe and the United States in colour television rental and servicing.

Mr Gill has come to Australia from the United Kingdom as managing director of Rentacolor Pty Ltd, which has been formed by the international groups, Consolidated Home Industries, Jardine Matheson, and the Australian financiers, United Dominions Corporation.

news digest

Mr Gill said that overseas experience had shown that color TV sets require more service calls than black and white ones.

"Our experience in the United Kingdom indicates that the incidence of service calls for colour sets in some 70% higher than that for monochrome," he said.

"In addition to serious breakdowns, viewers of colour programmes will not put up with the wide range of minor faults they accept in black and white sets.

"Owners should also be careful of untrained, inexperienced servicemen. The various Australian training institutions have done a very good job, but there are just not enough suitably skilled people around.

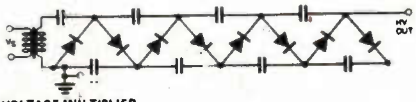
"Skilled servicemen can identify the causes of problems and correct them faster than unskilled operators who often cause additional problems by faulty work.

"Renting colour TV rather than buying has become extremely popular overseas, to the extent that estimates for the United Kingdom today indicate some 85% of new colour TV sets are rented rather than purchased outright."

ERRATA & ADDENDA

Mast-head Amplifier
December 1974
page 51,
parts list, transformer DSE 2581 should read DSE 2851 or PF 2851.

Voltage Multiplier
March 1975
page 110,
high voltage output should be as shown below.



VOLTAGE MULTIPLIER

Transistorized fishcaller
January 1975
page 111.

This project 'Ideas for Experimenters' item has been found to work more effectively if a 10 k pot is connected between the positive rail and the base of the right-hand BC 108.

WARNING
The item in 'Ideas for Experimenters' concerning 'Finishing Front Panels (page 134, Oct 1974) contains a potentially dangerous procedure.

Several readers have pointed out that adding hot water to caustic soda is extremely dangerous. Heat is generated and strong alkili may be splashed into your eyes.

The correct way is add the caustic soda to the water slowly stirring all the time.

LOW BATTERY WARNING
February 1975
page 61.

The circuit shown was intended to indicate the general operating principles of the device. However a number of readers have asked for specific component values. Here then are the values that would be used to obtain the operating characteristics described in the original article.

Resistors — ¼ or ½ watt 5%

R1	2k2
R2	100k
R3	18k
R4	18k
R5	300 ohms
RV1	10k 1in pot.
C1	2.2μF 25V
C2	1.0μF tantalum
ZD1	Zener 4.3V 400 mW
Q1	2N6027 PUT
Q2	BC 107

amcron

Crown International U.S.A.

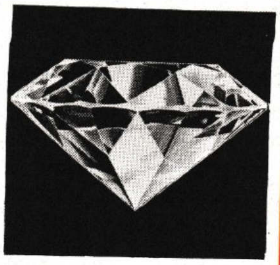
BY CROWN INTERNATIONAL

If diamonds are the epitomy of value and quality in the realm of gems, then the Amcron IC150 control unit and D150 power amplifier is its *equal in the sphere of electronics.*

The superb craftsmanship required in cutting and polishing a diamond, is equal to the highest degree of craftsmanship employed at Amcron, where quality is a creed, not just a mere claim.

Unlike the price of diamonds, Amcron equipment is not sold by the carat (or watt), and the IC150/D150 amplifier combination is a reasonably priced superlative product.

You are assured of Amcron's unwavering and uncompromising dedication to excellence, when you consider the IC150/D150 combination, as the amplifier to grace your home. Your ears deserve Amcron.



AVAILABLE FROM:

QLD:
Stereo Supplies – Brisbane 213-623.
Brisbane Agencies Audio Centre – Valley 219-139.

NSW:
Douglas Hi-Fi – Sydney 799 – 4177.
Arrow Electronics – Sydney 29-8580.

VIC:
Douglas Trading – Melbourne 639-321.

TAS:
Quantum Electronics – Hobart 281-337.
Audio Services – Burnie 312-390.

SA:
Sound Spectrum – Adelaide 223-2181.

WA:
Douglas Trading (W.A.) Perth 22-5177.

SPECIFICATIONS:

IC150

Frequency Response:— HI-LEVEL ±0.6 db 3 Hz-100 kHz; PHONO ±0.5 db of RIAA, calibrated. **Hum and Noise:—** HI-LEVEL 100 db below 2.5V, "A" weighted; PHONO 80 db below 10 MV input. **Distortion:—** THD essentially unmeasurable; IM .003% at rated output. **Phono Input:—** Sensitivity 1MV at 1kHz for 2.5V out; Overload 33-330 MV at 1kHz (adjustable). **Output:—** Rated at 2.5 volt, typically 10V before overload. **Volume Control:—** Over 60 db dynamic range with calibrated tracking. **Loudness:—** Excellent simulation of Fletcher Munson curves down to 60 phono, co-ordinated with volume control. **Phase Shift:—** Typically + 1° to —12° 20Hz to 20 kHz. **Tone Controls:—** ± 15 db at 30 Hz to 15 kHz. **Filters:—** (High and low filters).

D150

Frequency Response:— ± 0, 1 db 20-20 kHz at 1 watt into 8 ohm; ± 1 db 4-100 kHz. **Power Output:—** 100 watt RMS into 8 ohm, both channels operating. **Power Bandwidth:—** ± 1 db, 5-20 kHz at 75 watt RMS into 8 ohms. **Distortion:—** THD typically 0.002%. (At .01 to 75 watts) IM typically 0.005%. **Damping Factor:—** Greater than 200 from zero to 1 kHz 8 ohms. **Weight:—** 25 lbs.

THE AMCRON PHILOSOPHY

"While the plastic generations of audio equipment come and go, the steadfast performance, the unflinching quality, and the unparalleled construction of all Amcron equipment will remain."

Audio Magazine said:— "IC150 – We were all able to measure hum and noise levels of approximately – 93 db below 2.5 volts output, and phono noise of about .50 microvolts – D150 – at a typical output of 75 watts (8 ohms) IM was measured at 0.002%, by implication, THD might be expected to be approx. 0.0005% which neither Amcron nor we could measure. If you want the very best, our endorsement of the IC150/D150 is completely given without any reservations.

Stereo Review said:— IC150 "We found the frequency response to be down only 0.3 db at our lowest limit of 5 Hz and 1 db at 225 kHz. The RIAA equalization was so accurate (±0.25 db) that we may have been checking the residual errors in our setup."
D150 – "There are not many speaker systems capable of absorbing the full output of the D150, but since its distortion at any level, can only be measured with the most advanced test equipment, one would expect it to sound first rate, and indeed it did."

AUSTRALIAN DISTRIBUTORS:

BJD Electronics Pty Ltd.
202 Pelham St., Carlton, 3053 Vic. Ph. 347-8255
65 Parramatta Rd., Five Dock, NSW 2046. Ph. 799-3156

RADIO -the true pioneers

A definitive history of the early days – second and final part – by Peter Sydenham M.E., Ph.D., M.Inst. M.C.

UNTIL FARADAY'S DISCOVERY, in 1831, that the rate of change of current (or rate of change of magnetic field) with time was the crucial factor relating magnetism to electrical generation, experimenters thought of and used only steady-state effects of direct currents. Ohms had just related (1827) current to voltage by the parameter, 'resistance', laying down the rules of dc circuits.

The advancement of the cable telegraph managed satisfactorily within this scant knowledge of electrical circuits. Multiple frequency working and other ac methods were refinements that came much later. Provided the receiving end got a pulse on its relay when the tapper made contact at the sending end the system provided communication at a rate far faster and cheaper than any competitive system.

Wire-less communication, using electro-magnetic EM waves, depends much upon knowledge of alternating circuit theories and resonant effects in circuits containing inductance and capacitance. These came more slowly, for the principles are more complicated.

By the 1830's experimenters had a useable knowledge of resistance and how to make resistors (not in our modern day discrete form until a little later than this date); they had the Leyden jar which was used to hold charge – we now call this type of component a capacitor (or condenser in early electrical parlance); they had the electro-magnet which is an inductor, and they had the transformer, due to Faraday's work.

Another line of development running concurrently with the development of the telegraph was the newly establish interest in electro-magnetic machines. This arose once Faraday had shown (in 1821) that a current-carrying conductor reacting against a magnetic field can be made to revolve – thus founding the motor and generator industry.

One of the first forms of specially designed generators was the one made by Pixii in 1832. Originally these were not built as generators in the modern sense, for the output was fed to an inbuilt spark gap without any attempt being made to connect the apparatus to other devices. The role of the first machines was to give the experimenter a device in which the generator effect was present so that it could be studied. What interests us about these is that the very first forms of electro-magnetic machine, in which a coil was moved past the end of a magnet in a rotary manner, produce alternating current and this made the scientists consider ac circuit behaviour. Within months of building his first device Pixii added a commutating switch arrangement to provide dc current instead of ac thus showing he appreciated what was happening. So, by the 1830's, natural philosophers were aware of the existence of alternating current of quite low frequency but not of higher frequencies in the megahertz region needed for radio. Such high frequencies could not be sensed by any available device of the day and the mood of the times provided no reason to consider such phenomenon. That was, until Henry made a chance contribution in 1842 that may have slowly influenced other workers.

It was normal practice (as we said in the previous part) in those times to discharge Leyden jars with the spark being near an iron needle in order to magnetise the needle. To use Henry's own words, he observed *"a reflexive action of discharge of the Leyden jar"*. He, of course, did not see the oscillation of light intensity in the spark (around 1 MHz) but realised it was happening because the needles were sometimes nagnetised in one polarity direction and sometimes in the opposite sense. He was on the track of a new phenomenon – resonance – but he took it no further. We now know that the Leyden jar provides capacitance and the spark-gap horns provide inductance, the two forming a very-high-frequency resonant circuit whilst the spark exists.

Another notable experimenter to mention the phenomenon was Helmholtz who in 1847 wrote in an essay on the conservation of force that a *"back and forward discharge, dying down"* occurred in the discharge. This statement shows recognition of the damped nature of the spark discharge (due to internal resistance in the circuit). Because of the lack of ability to sense the actual signal amplitude/to time relationship – adequate recorders were not invented until the end of the nineteenth century – it required mathematical methods to unravel what was probably happening.

Around 1850 Helmholtz told Lord Kelvin (then still William Thomson)

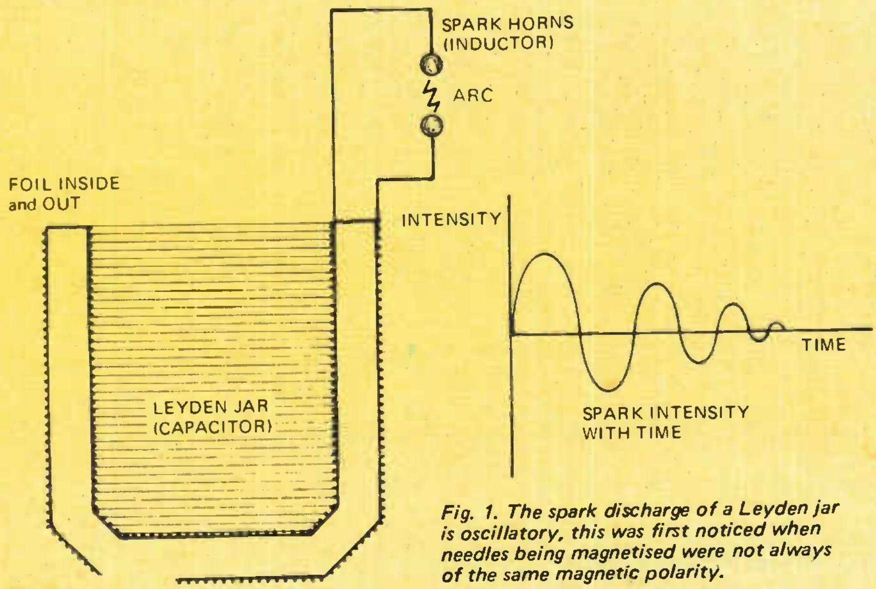
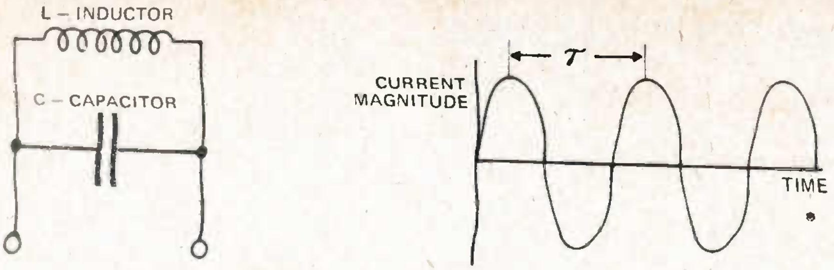


Fig. 1. The spark discharge of a Leyden jar is oscillatory, this was first noticed when needles being magnetised were not always of the same magnetic polarity.



$$f = \frac{1}{\tau} \qquad f\ \text{natural} = \frac{1}{2\pi\sqrt{L.C.}}$$

Fig. 2. In 1852 Lord Kelvin proved, using mathematics, that a single relationship exists between the resonant frequency, inductance and capacitance of the resonant circuit.

about the needle magnetising experiment (noticed first by Henry but probably not communicated to Helmholtz) adding remarks about the wire of the circuit being wound around the Leyden jar. Kelvin could not immediately explain this phenomenon but set too to develop a mathematical model that explained what was happening to the circuit current at any instant of time. In 1852 he presented his ideas, tidied up, in a paper entitled "Oscillatory discharge of a Leyden jar". Although the mathematical analysis was complicated it fortunately produced a simple formulae – see Fig.2 – relating the resonant frequency with the circuit component values of inductance and capacitance.

With a capacitance value of many pico-farads and inductance of millihenries the frequency of oscillation in the spark gap of such an arrangement is roughly one megahertz.

We can now appreciate, with little difficulty, that the Leyden jar spark discharge is a short decaying burst of high frequency radiation. But in 1852 the implications were just not seen – and Kelvin's work lay stored away for nearly a decade.

It was one thing for Kelvin to predict what was happening but as no one could sense it, it lacked absolute credibility. No doubt the bulk of the scientists felt it was not very interesting anyway for sparks 'games' had been a popular and very familiar trick for over a century.

The person to first 'see' these oscillations was W. Fedderson (not to be confused with Fessenden, an American who appears in the story of radio in 1902 for sending the first voice communication). Working in Germany around 1860 Feddersen set up an apparatus that could record 1 MHz oscillations on film. The set-up used (the original still exists) a rapidly rotating mirror – a drehspiegel – to reflect the arc of the discharge across a fast moving film. This spread the light from the arc across the film enabling the exposure at each point to follow the light intensity – the first optical scanner and perhaps the first high speed recorder? He was able to verify the laws of oscillation frequency of the resonant circuit with this simple, yet powerful, means of extending our natural senses. This method of high frequency measurement was used until the early 1900's (one is shown in Fig.3).

Electromagnetic theory predicts the existence of radiation

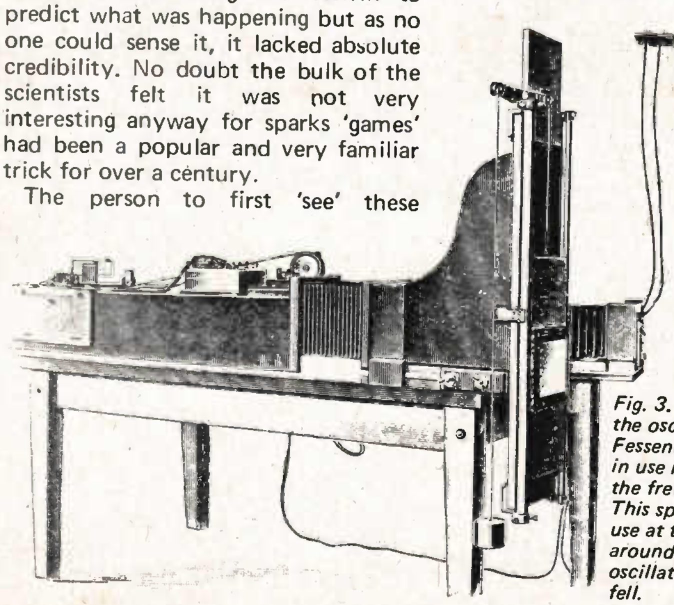
Thus by 1862 the scientific world now knew that sparks of this kind were oscillatory at very high frequencies and they knew how to tailor the circuit elements to produce the frequencies needed. But no one needed them, for they must have seemed worthless.

For the next and probably greatest step towards radio we look to the work of James Clerk Maxwell, a Scotsman born in 1831. In 1856 he took the Chair of Natural Philosophy at Marischal College in Aberdeen. He was 25 years old. Four years later he became Professor of Natural Philosophy at King's College London. In 1871 he moved to the Cavendish Laboratory at Cambridge. Using his experience gained in the study of light phenomena and Faraday's "lines of force" that appeared when iron fillings were sprinkled around magnets he gradually developed a most advanced and far reaching theory – his electro-magnetic equations.

Working on little more than Faraday's experimental findings – that magnetism, electricity and light were inter-related forms of energy (from experiment) and his own superb imagination and mathematical modelling ability, working on ideas of vortices and particles, he created a theory that *predicted* that electromagnetic waves actually radiate out from certain sources. He further predicted the existence of a whole range of EM radiation of which light and radio waves form a small part of the entire frequency spectrum available.

Maxwell first suggested this idea in 1863 and released his treatise "Electricity and Magnetism" on the subject in 1873.

Slowly, but surely, the implications that waves could be radiated reached all ears – not so much the theory behind it for that was complex indeed. They were certainly being observed in this period but it took until 1886 for both generation and detection to be realised in controllable conditions. One such chance observation is credited to Edison in 1875. A biographer of Edison (Garbedian) relates how Edison observed a spark jump across a carbon contact (spanning the top of a U-shaped magnet core) whenever a closed current circuit was interrupted. Edison called this



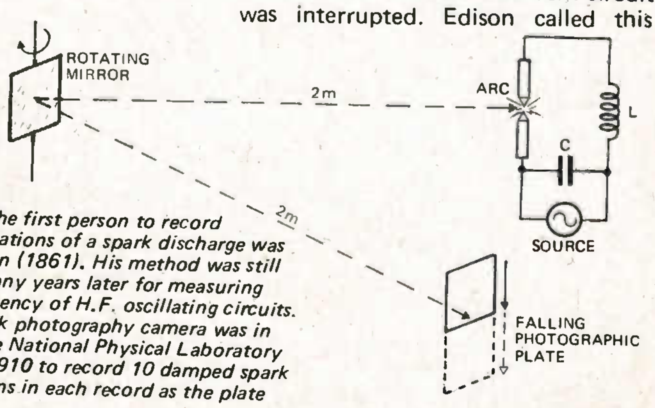


Fig. 3. The first person to record the oscillations of a spark discharge was Fessenden (1861). His method was still in use many years later for measuring the frequency of H.F. oscillating circuits. This spark photography camera was in use at the National Physical Laboratory around 1910 to record 10 damped spark oscillations in each record as the plate fell.

RADIO-the true pioneers

etheric force. Other events at hand turned him onto another track of invention and he apparently failed to realise the full significance of the observation.

Few people took the idea of radiating energy seriously as the following extract shows. It relates to an American dentist (he might have been a meteorologist), Loomis, who decided that the higher atmosphere contained electrical charges in layers that were independent of each other. His scheme proposed to discharge a layer to ground via an electrically connected kite and sense the balance-charge flowing in a second kite circuit flown some distance away. It is said he actually transmitted over a 20 km range in 1876 — there is a published account in La Liberte of 26th April 1876. A story in the 1877 "Journal of Telegraphy" in New York relates to Loomis' concept in a curious way.

"The never ending procession of would-be inventors who from day to day haunt the corridors and offices of the electrician's department at 195 Broadway, bringing with them mysterious packages tied up in newspapers, was varied the other day by the appearance of a veritable lunatic. He announced that his much talked of great discovery of a few years ago, aerial telegraphy, was in actual operation right here in New York. A.M. Palmer, of the Union Square Theatre, together with one of his confederates, alone possessed the secret. They had, unfortunately, chosen to use it for illegitimate purposes, and our visitor, therefore, felt it to be his solemn duty to expose them. By means of a $60,000 battery, he said, they transmitted the subtle fluid through aerial spaces, read people's secret thoughts, knocked them senseless in the street — aye, they could even burn a man to a crisp, miles and miles away, and he no more knew what had hurt him than if he had been struck by a flash of lightning, as indeed he had! The object of our mad friend in dropping in was merely to ascertain how he could protect himself from Palmers illegitimate thunderbolts. Here the legal gentlemen, lifting eyes from "Curtis on Patents" remarked: "Now I'll tell you what you'll do. Bring a suit against Palmer for infringement of Mahlon Loomis' patent. Here it is, "no. 129,971". That'll fix Palmer'. But the madman protested that he was in danger of his life every minute, and casually remarked that it had occurred to him that by appearing in the streets in a robe of pea-green corded silk, gutta-percha boots, and a magenta satin hat with a blue glass skylight in the top of it, he would be effectively protected from injury during his daily perambulations."

The coherer principle evolves

Before we get too far ahead in the sequence of events that eventually saw Hertz prove once and for all that electromagnetic waves did exist (in 1888) thus proving Maxwell's theory in practice, we need to return to yet another train of events that led to the first sensitive EM wave detector — the so-called coherer.

The earliest date at which it was noticed that the electrical resistance of a tube filled with metallic filings reduced when traversed by a discharge current appears to be 1838 and is credited to Munck of Rosenschold. This could well be the first observation of the semiconducting effect! This, however, probably had no influence on the subsequent development of the coherer detector that relied upon this principle as shown in Fig.4. When a high frequency current flows in the coherer it takes on a reduced, permanent value of resistance thereby indicating that a comparatively feeble current has passed with a useful degree of amplification of that fact. The major shortcoming was that the filings had to be disturbed to restore the original higher resistance. With nothing else available the early radio systems and research of the 1895-1905 period managed with this concept but were limited to on-off signalling.

It is also recorded that in 1850 Guitard noticed that electrified air caused dust particles to cohere. Again no obvious use was made of Guitard's efforts even though the implications existed that this could provide a reduced electrical condition. Clearly as high frequency EM waves were at this time, not predicted, no one had any desire to detect them.

In 1856, S.A. Varley, in the course of work on lightning protection arrangements for the booming telegraphic systems, hit on the same idea as had Munck a generation before. (Some confusion of dates exists in the early reviews as 1866 is also quoted as the date of Varley's discovery). We will see later that it was rediscovered yet a third time by Oliver Lodge in 1883 and yet again by Calzecchi-Onesti in 1884.

The quest to generate and detect radio waves

By around 1875 all the ingredients for generating and detecting radio waves existed. The mathematical theory of Maxwell on the waves, the theory of the resonating frequency circuit due to Kelvin, the spark generating induction coil, the coherer and the necessary circuit elements were all available. The coherer, however, did not play a part in the first experimental set-up but was vital in final commercial exploitation.

We have seen how Edison probably observed radiation with a poor carbon contact in 1875. Similarly, in 1878, D.E. Hughes, the inventor of the loose carbon granule microphone, appears to have detected electric waves when investigating the electrical properties of metallic powder — the coherer again. This was yet another case where action was not taken toward a radio path of development. Telephones were the new thing of the day and they promised great riches to those who could invent a method that used the existing cable telegraph lines to send voice, music and even pictures over long distances as well as the dot-dashes of the telegraph. In the following year Hughes demonstrated, rather crudely,

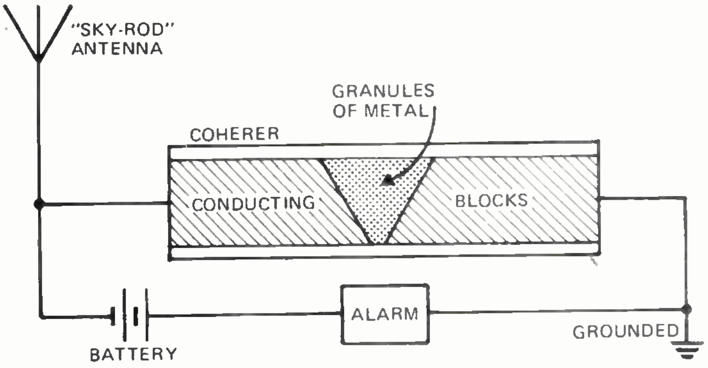


Fig. 4. The resistance of the particle coherer falls from megohms to tens of ohms when a high frequency current flows through the unit. Thus a buzzer can be energised when a signal is received. Once cohered the particles need to be mechanically agitated to restore high resistance ready for reception.

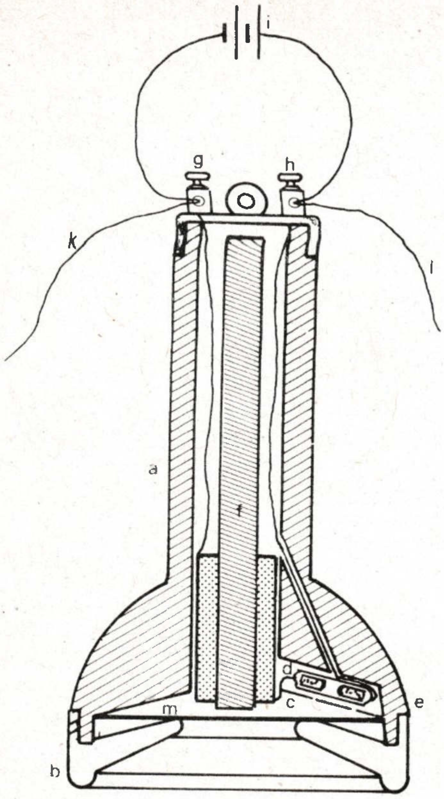


Fig. 5. The Hughes coherer made use of an imperfect contact existing between carbon blocks. It incorporated spontaneous decohering action.

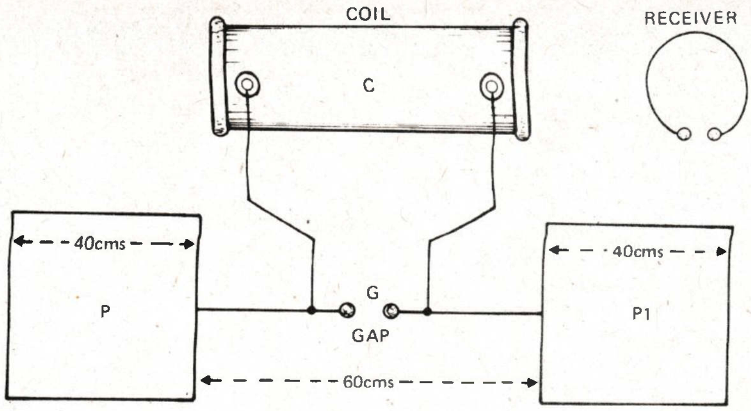


Fig. 6. The Hertz transmitter and receiver.

that a telephone ear-piece, in series with a microphone but with no battery, could detect the working of an induction coil at a range of nearly a kilometre. Feeling that he could do better he did not publish this finding even though he attributed this phenomenon to the transmission of waves. He had devised a self-decohering detector at the same time.

To understand why Hughes did not shout to the world about his discovery we must realise that near-field induction effects between wires, a subject we take up below, was quite common knowledge because of the 'cross talk' existing between telegraph wires commonly in use by this period. Being a telegraph-cum-telephone engineer he may well have felt that he had detected direct induction, not the radiated energy which is capable of far greater range. Hughes later made a coherer along the lines of a telephone ear-piece; a cross section is given in Fig.5.

In that same year, 1879, other developments were finally leading to definite experimental verification of Maxwell's theory. In that year the Berlin Academy of Science offered a prize that was concerned with aspects of Maxwell's electro-magnetic wave theory. At the time Heinrich Rudolf Hertz, was studying at the Academy under Helmholtz. As Hertz had already won a gold medal for an essay on a similar subject, Helmholtz suggested Hertz enter the competition. It was, however, several years before Hertz' ideas materialised into a realisation that he could go better than the prize essay's desires by actually proving Maxwell's ideas with controlled experiments.

Working on the knowledge of resonance gained by Kelvin and Feddersen he designed his own inductance-capacitance circuit so that it would resonate at a much higher frequency (100 MHz, in fact) than previous workers in order that the wavelength (being about 3 m) was short enough to be observed in a reasonably large room.

His spark transmitter — see Fig.6 — consisted simply of two metal plates (the capacitor 'plates') attached to the end of two rods terminated in small balls held apart by 10 mm. These were an inductor formed as the secondary winding of an induction coil that induced high voltage sparks to jump the gap, thereby, radiating high frequency . at the characteristic frequency of the tuned system.

His receiver was simply a loop of wire with a small spark gap in it that exhibited sparks when radiation was received — he did not employ a coherer even though they existed in principle at the time.

In 1888 Hertz made a series of experiments that tested Maxwell's theory as he carefully explored the properties of the radiation — speed of propagation, refraction, polarization. He thus provided the basis of practice needed for realisation of radiation wire-less telegraphy but, even though the potential of his work was pointed out to him Hertz is said to have remarked that he could see little use for it. Hertz died in 1894, not knowing that within a decade radio would become a new powerful force in communcation.

Induction methods of wireless telegraphy

Many popular accounts of the growth of radio give the impression that it all started with Hertz' work. We have seen that this is not so for Hertz was just one player in the performance. Although it can be said he produced the first system using EM radiation in explainable conditions the fact was that many people had already been investigating the use of induction between two 'antennae' for some time previously.

Early in the 1870's the telephone came into general use and this

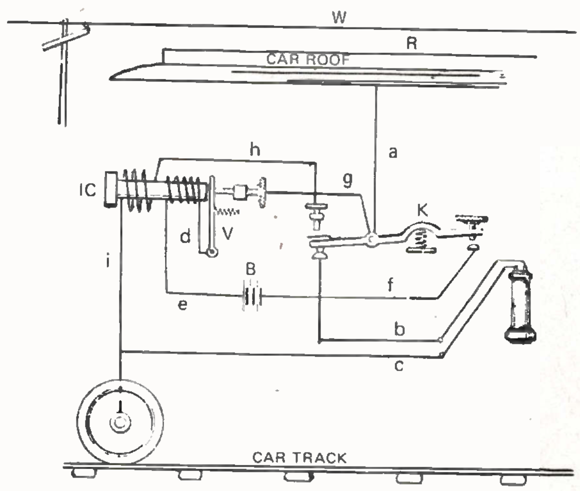


Fig. 7. Basic arrangement of the electrostatic induction system used by Smith and later Edison, to signal to moving trains.

RADIO-the true pioneers

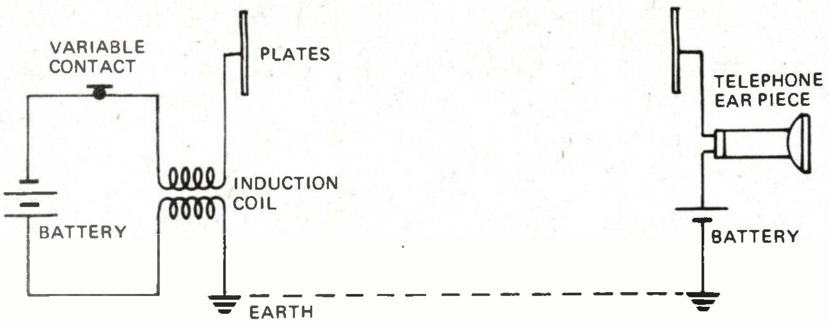


Fig. 8. The Dolbear system of wireless, using induction, is said to have worked to 25 km.

development increased awareness of crosstalk between circuits in a way that did not exist before. Identifiable cross-talk was observed to such an extent that the telgraph engineers were able to make more sensitive and specific studies to quantify the effect whenever wires were run in close proximity. In 1874 new proposals for wireless communication began to talk of making use of induction between wires. A patent of 1879 describes how a ship could communicate with a lighthouse via cables trailing in the sea — acting as an induction system.

One man who made a thorough study of this was John Trowbridge, a Professor at Harvard University. In 1880 he described a similar system to that described above and also managed to send signals over a 2 km distance using a wire at each terminal location, the two being parallel.

Other people put their effort into short distance induction links using either electrostatic or electromagnetic (electrodynamic is the name used in early literature) fields to transfer a signal over a short distance. In 1881 Smith devised the arrangement shown diagrammatically in Fig.7 for signalling to trains in motion. An Edison patent of 1885 was on the same subject. As these were not of long range use we leave them with the brief description that the trains held one plate of the communicating capacitor, the station and track the other in the form of overhead wires. As the trains passed, the two were ac coupled for a period of time decided by the speed and the length of the overhead wires.

A very interesting account of work appeared just before this time. Professor Dolbear, in 1883, actually succeeded in sending signals through space without wires. At first he achieved 1 km but later he personally claimed 25 km. He used, see Fig. 8, a microphone, induction coil, battery and capacitors and sent on-off bursts from the coil into space via a kite supported aerial. In 1889 he exhibited the system at Philadelphia. He thought the *air* carried the signals not radiation waves but nevertheless he does appear to have built a workable radio system. A patent of 1883 also spoke of the use of moist air to replace the cable — the intrenched ideas of conduction wireless died hard.

At this stage in events W.H. Preece, who was Chief Engineer of Telegraphs in the General Post Office in Britain, began systematic work into the induction phenomenon. Using parallel wires, one at each side, he pushed the range of this form of wireless communication up to several kilometre distances between islands in the Bristol Channel. These induction systems used typically 100-400 Hz interruption of a dc current of 0.5 amperes. Reception was detected via a telephone earpiece.

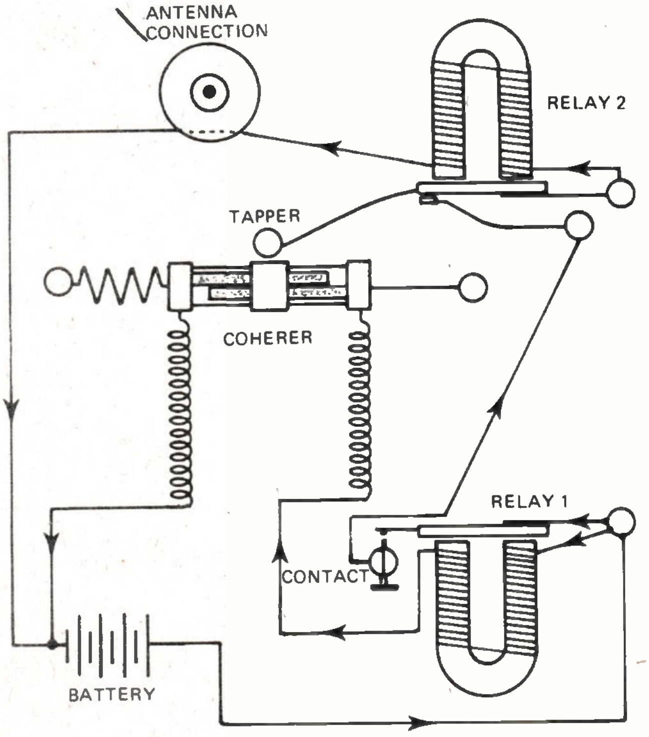


Fig. 9. Around 1895 Popoff used this system to receive radio waves produced by lightning. When the coherer circuit resistance fell it actuated the lower relay which operated the upper relay providing a gentle tap to decohere the circuit. His 'sky rod' was a lightning conductor.

Marconi sums up to commercial advantage

We have seen that by 1890 radio by EM radiation was no longer something to be ridiculed. Reliable radio systems could have been built: it needed someone to sift through the knowledge and parcel it up in an efficient manner as day-to-day long distance communication link. Four years later, in 1894, Marconi started to do just this. In the preceding four years several events of note took place.

In 1892 Crookes, the scientist known best for his work on arc discharges in tubes, predicted the use of focussed waves in the "Fortnightly Review". In 1894 Preece summarized his past ten years work on wireless technique for general release. In the same year Lodge demonstrated the series of Hertz experiments to the Royal Institution and to the British Association. He made use of a Hertzian oscillator and a Branly coherer (the most advanced form of coherer at the time) to go one stage further than Hertz had.

Sir Oliver Lodge must have realised the implications of his work for he had put much time into the demonstrations and into compiling a lengthy report on the system but, due to other interests and in his own words *"a lack of foresight"* of its importance to the world as a new form of communication he did not pursue it. This was clearly to his regret later for he did not acknowledge the credit Marconi received for pioneering radio.

It was in December of 1894 that Marconi subsequently claimed he had sent the first recorded message through space by electromagnetic waves (see the personal claim of Marconi given with this article) but there is no recorded evidence of this, his first written support to claim being in 1896 when he finally found someone to listen to him.

Popoff

This review would be incomplete without mention of the work of the Russian, Popoff. In April of 1895, Popoff communicated in writing that his work at the Torpedo School at Cronstadt in Russia involved the detection of radio waves produced by lightning. His apparatus was described: his receiver — he had no transmitter — used a vertical antenna (a lighting conductor) and a Branly coherer to which Popoff had added a decoherer in the form of an automatic tapper driven by an electromagnet. His set up is given in Fig. 9. Professor Mazzotto, an Italian, who reviewed the state of this art in 1906 says:

"As we know, the Popoff receiver comes in historical sequence before the Marconi receiver which has all its fundamental parts in common."

Marconi invented very little, he himself admits to using other people's inventions which is, of course, the true story of most developments. Other people's work was gradually adopted to further improve radio; the magnetic detector used by Marconi replaced the coherer for a brief period, this was based on a finding by Rutherford in 1895; Braun introduced tuned circuits in 1895; Fessenden sent voice for the first time in 1902; Heuelmeyer patented the first radar in 1904. Valves appeared and so-on.

Marconi's own claim

This account has shown that *numerous* people were the true pioneers of radio for they created the mood and provided the knowledge needed for the each progressive wave of enlightenment. Marconi had a meteoric, hard to justify, rise to fame — he left Italy in 1894 unloved or cared for by his government and returned in 1897 as a guest of the Minister of the Italian Navy where he was presented to the King and Queen!

He is said to have been most courteous and modest but the press, in their ignorance of the events leading to Marconi's work, tended to credit him with inventing everything about wireless telegraphy. He obtained a cool response from many because of this, incorrect publicity especially from Lodge who said in a lecture to the Royal Institution in 1894 on the subject:

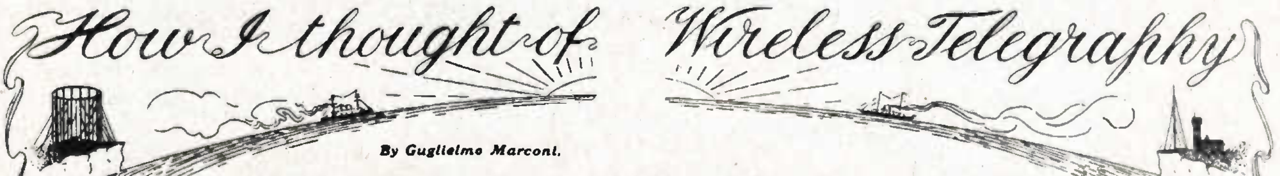
"... with the powerful aid of the Post Office, Signor Marconi proceeded to develop his system of Telegraphy."

In 1898 Preece, who had indeed greatly supported Marconi through the Post Office, gave a lecture to the Royal Institution in which he attacked the critics who said Marconi had done nothing. Preece pointed out that Marconi had done it better than the others, but not uniquely.

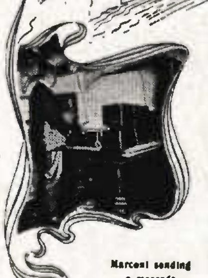
Finally, in 1902, Marconi published a short article in the London magazine. It is repeated here for you to study his claims expressed in his own words.

Clearly no single person invented radio but Marconi, with skill and a lot of luck certainly made men see its full potential. ●

How I thought of Wireless Telegraphy



By Guglielmo Marconi.



Marconi sending a message from the cabin of an Atlantic liner, and—

—An operator receiving the message 1,500 miles away.

THE idea of transmitting messages through space by means of etheric waves, otherwise wireless telegraphy, came to me in the spring of 1894, while reading an account in an Italian electrical journal of the work of Professor Hertz, who had died in January of that year. I had followed Hertz's experiments for several years previous to that, but they had never before awakened in me more than a passing interest. For detecting the waves radiated from the transmitting oscillator Hertz had used a metal hoop having a small gap at one side. Upon bringing this hoop within the influence of the electrical disturbance set up by his oscillator, he discovered that minute sparks passed across the gap. In other words, he showed that electric waves, when radiated into space, could be detected at a distance by means of the metal hoop. It occurred to me that if I could interrupt the wave transmission from the oscillator, breaking it up into long and short periods, similar interruptions would be detected in the spark gap of the metal hoop. Here, in short, was the possibility of signalling across space by means of the Hertzian waves. A short emission of the transmitted waves would signify the dot of the Morse alphabet, a long emission the dash, and thus words might be spelled out in the distant receiver.

The idea seemed so simple and evident to me that at first I had no thought of attempting practical experiments to demonstrate its possibility, because I knew there were many clever men in the world experimenting with etheric waves, and I thought someone would quickly work out the problem. After waiting almost a year without seeing any account of attempted applications of the discoveries of Hertz to the transmission of signals, I began my first experiments in December, 1894, and obtained results which surprised me, and which I at once realised were new.

I may say that for several years previous to the beginning of this work I had been deeply interested in electricity, though purely as an amateur. I had fitted up a rude laboratory or workshop in my father's house near Boulogne, where I had began to work with primary batteries and thermopiles, grappling with the problem which has puzzled so many inventors—a method of transforming heat directly into electricity. I had also experimented with the utilisation of steam in engines, and had likewise been deeply interested in chemistry.

I have seen it stated that Professor Righi, of the University of Boulogne, first suggested to me the idea of communicating messages through space. This, however, is not the truth. I never even attended any of Professor Righi's lectures—I wish now I had—though I did have discussions with him, as beginner with master, on the subjects of chemistry and mechanism. He had repeated very successfully the experiments of Hertz, detecting transmitted waves a short distance across a room—but he evidently had not thought of using the waves for the communication of intelligence, for when I first mentioned the idea to him he said he thought it would not be practicable. I think I am right in saying that previous to my experiments no one had attempted the practical use of the Hertzian waves for telegraphy.

I do not think it occurred to other experimenters that these rays could be so utilised, although Professor Oliver Lodge, who had long been experimenting along the lines suggested by Hertz, gave, in a book which he published in 1894, a number of suggestions as to the uses to which these rays might be put, but never mentioned their application to telegraphy. He suggested that if one should put iron filings in his eye he might see the Hertzian waves; but he did not suggest that these rays could be used for signalling.

One English electrical journal in its issue of September 17th, 1897, said that Dr. Lodge's apparatus for thus utilising the Hertzian waves was shown in Oxford in 1894, but I fear that this statement is not quite correct. Either public interest was very low at that time, or the exhibition was very little noticed, because no written report of such an exhibition was made, and I have the word of Professor Fleming, of University College, London, who was present at the meeting in question, that to his knowledge no suggestion was made to the effect that the Hertzian waves could be used for the purpose of signalling over long distances.

Indeed, when I began to utilise Hertzian waves for telegraphy I did not know that anyone else had ever thought of such a thing. I learned later, however, that many experimenters had been close to the idea, and had even suggested it. One writer in an English electrical journal in April, 1891, said:—

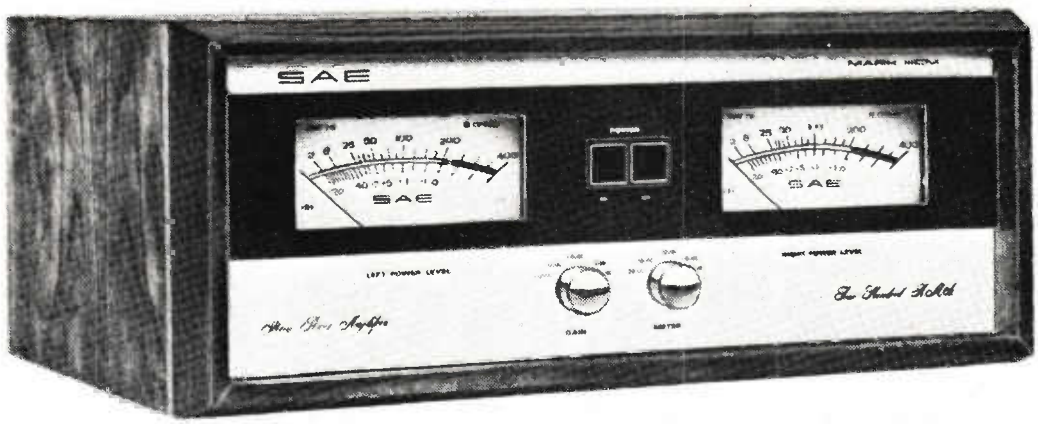
"If we could reduce the frequency about 2,000 times, and produce vibrations of about 200,000 millions per second, we should get waves of about one millimetre long. These radiations would probably pierce not only a fog but a brick wall. *When* we get such vibrations there will be many interesting uses for them. One, at all events, will be the possibility of communicating between lightships and the shore."

The Hertzian wave was experimented with and its identity with light waves was often demonstrated, but no one used it for telegraphic purposes before I began my experiments. I believe I am right also in saying that I sent the first recorded message through space by electro-magnetic waves in 1894, and was the first to telegraph from a ship in motion (Italian Navy, 1897).

In my apparatus I have made use of known ideas. My instruments are improvements of my predecessors', with the introduction of a few developments which from my observation seemed necessary. It is only fair to say that the introduction of these new elements was the basis of my long-distance success. It is the business of science to acquire results with the least possible outlay of work and time, and results are regarded as the standards by which a man's work is judged.

Reproduced from the London Magazine — 1902.

The Bible records the miraculous collapse of the "Walls of Jericho"



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  4 ohms—Less than .2% 20 Hz-20 KHz at full power.
- **I.M.:**
  8 ohms—Less than .05% at full power.
  4 ohms—Less than .1% at full power.
- **Signal to Noise Level:**
  Better than 100 db below 200 watts RMS.
- **Full 5-year parts and labour warranty.**
- The S.A.E. Mark IIICM will **not** oscillate under any load conditions, regardless of phase angle.

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LER 078

HIGH VOLTAGE FOR LOW COST

by Walter Wills, Varo Semiconductor

Simple diode-capacitor networks can be cascaded to deliver any desired voltage.

IF YOU NEED a power supply for a high-voltage low-current application, your best bet is probably the voltage multiplier circuit. It's inexpensive. It's simple. And you can get any voltage you want by cascading multiplier stages. The voltage is limited only by the ratings of the components you use.

A voltage-multiplier circuit contains diodes and capacitors, with the devices connected to develop a dc output that is a multiple of the peak or peak-to-peak input voltage. There are two major variations of the circuit: multipliers that use an even number of diodes and those that use an odd number of diodes.

The basic rectifier circuits in Fig. 1. (equations assume perfect diodes and capacitors, loads are considered light) can be combined to form a complete family of half-wave multipliers. A full-wave multiplier can be made by combining two half-wave multiplier sections, one positive and one negative (Fig. 2), The major disadvantage of a full-wave multiplier is that the secondary side of the transformer nearest the core requires heavy insulation to withstand one-half the output voltage. Therefore inductive coupling is worse and efficiency lower than for a transformer used with the equivalent half-wave type. Thus half-wave multipliers are better for most high-voltage power supplies.

Figure 3 shows the two variations of half-wave multipliers. Each of these circuits consists of identical sections cascaded, except for the first stage in Fig. 3a. The first section of a multiplier with an odd number of diodes is a simple half-wave rectifier. This first section of a multiplier with an even number of diodes is a half-wave doubler. A basic rule of thumb for multiplier designs is: For waveforms that are symmetrical about zero, use an even number of diodes; for asymmetrical waveforms, use an odd number.

CALCULATING THE OUTPUT VOLTAGE

The regulation of a multiplier with a load is a function of the input's source impedance, the values of the capacitors in the multiplier, the forward drop of the diodes and the turn-on and turn-off times of the diodes. The output voltage of a multiplier is approximately

$$V_{out} = N\frac{(V_1 + V_2)}{2} - \frac{N^3}{12Cf} \cdot I_{out}$$

Here N is the number of diodes or capacitors used for circuits like those shown in Fig. 3; V_1 is the positive peak input voltage; V_2 is the negative

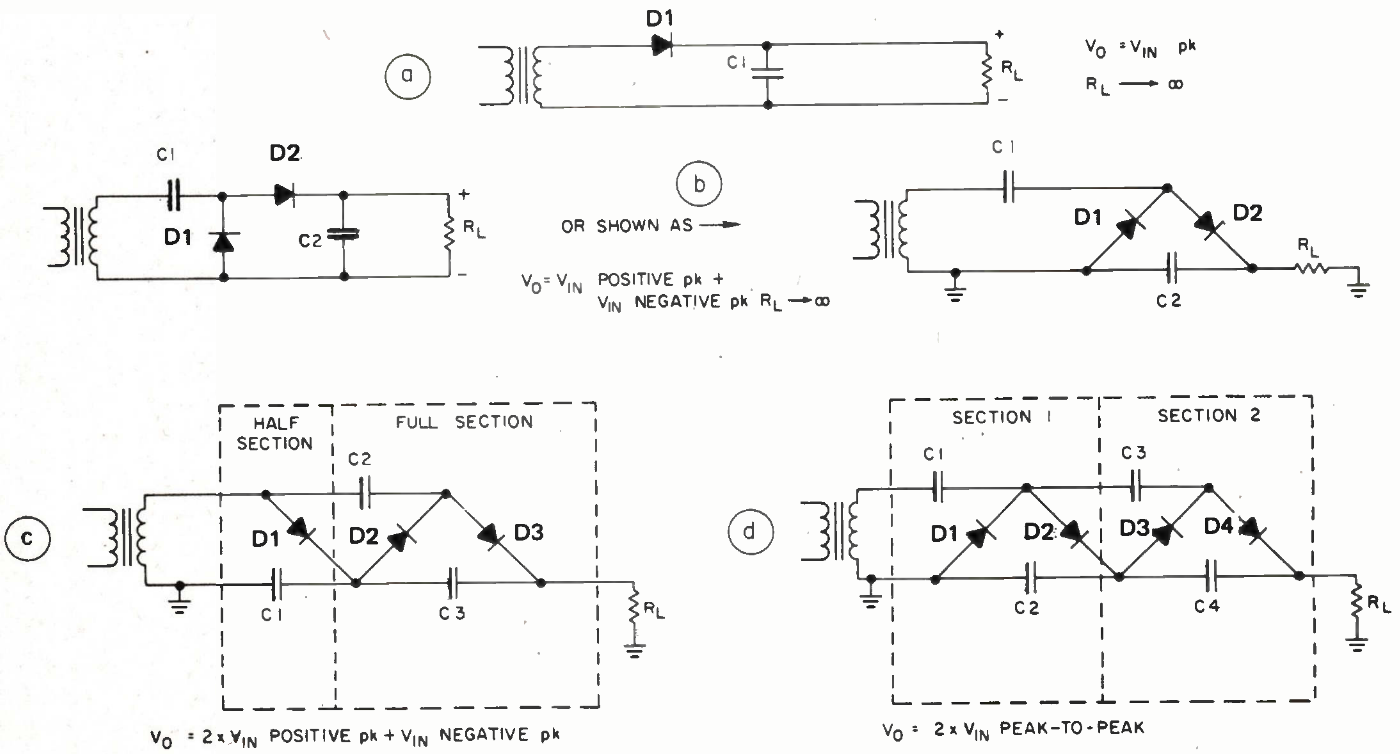


Fig. 1. The basic half-wave rectifier circuit (a), can be modified to become a voltage doubler (b). Various higher output voltages can be obtained by adding further sections (c and d).

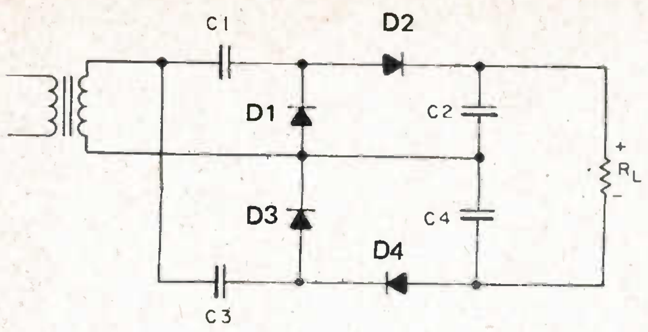


Fig. 2. The full-wave voltage quadrupler circuit requires a transformer with heavy secondary insulation.

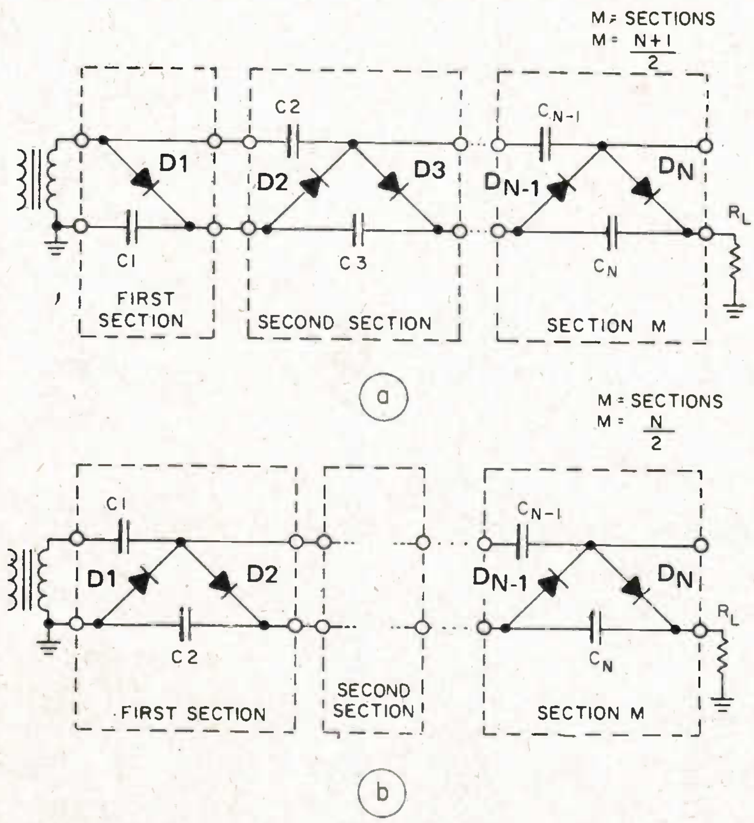


Fig. 3. A multiplier with an odd number of diodes works best for assymetrical waveforms (a). An even number of diodes (b) is best for symmetrical waveforms.

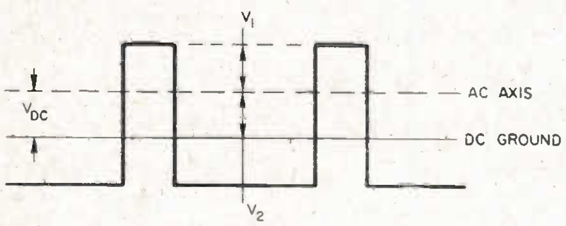


Fig. 4. A recurring waveform with a positive peak V_1 and negative peak V_2 is used as an input for the voltage multiplier circuit described in Fig. 5.

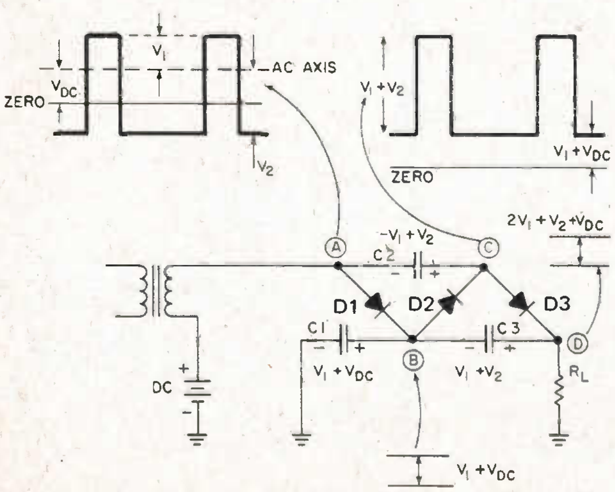


Fig. 5. The voltage waveforms at different points within the multiplier circuit with an odd number of diodes show the transformation of the pulse waveform described in Fig. 4 into a much higher dc voltage.

peak input voltage; C is the capacitance in farads; f is the frequency of the input, and I_{out} is the current in amperes. This equation assumes a sufficiently large load capacitance, equal value capacitors, and ideal diodes. It will produce sufficiently accurate results for all practical purposes.

WATCH DIODE SWITCHING CHARACTERISTICS

The turn-on and turn-off times of the diodes are important if high frequencies are involved. Both turn-on and turn-off must be kept fast, if regulation and efficiency are to be maintained.

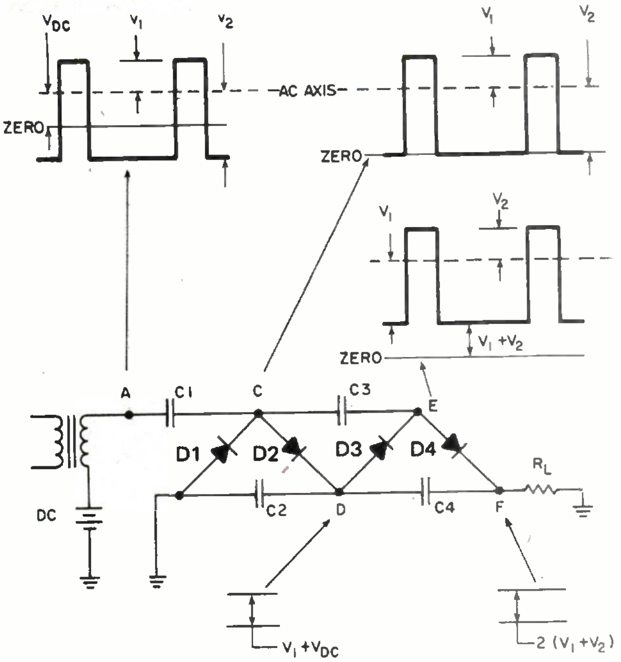
The forward drop of the diodes is usually not a significant factor. For example, a typical multiplier, rated for 25 kV at 2 mA, has six diodes – each with a forward voltage drop of approximately 15 V at 10 mA. Thus this multiplier has less than a 100-V drop when operating.

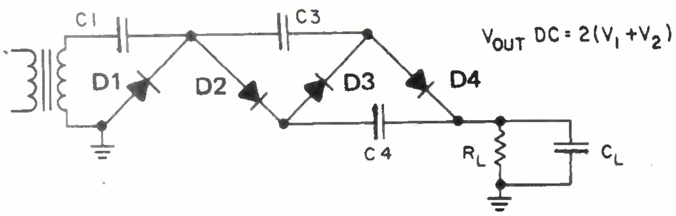
The output regulation of voltage multipliers ranges from 100 V to 5 kV per milliamp of current. Some applications use regulation schemes to control power-supply output. Some common methods are shunt dc load, rectified pulse feedback and a saturable reactor in series with the high-voltage transformer. In other applications, it is desirable to have the output voltage sag with load – with very poor regulation built into the multiplier through selection of the capacitor's value.

The output voltage of a multiplier will always have some ripple in the output. Ripple is a function of load capacitance, input frequency, multiplier impedance and input-to-output coupling.

The load capacitance acts as a filter, and the effective series impedance of the multiplier limits voltage ripple. If regulation is not a consideration or if load current is almost constant, a series resistor can be added to the multiplier output. The series resistor will act with the load capacitance as an RC filter.

The high-frequency components of the input voltage are the most easily coupled into the output. But the higher frequencies are also easier to filter at the multiplier output when necessary. The most unpredictable ripple component, though, is generated by stray capacitive coupling of the input to the output terminal. This coupling is difficult to control. The mechanical layout of the multiplier can reduce it, and if more ripple reduction is required, an electrostatic shield can be used to isolate the output area further from the input.





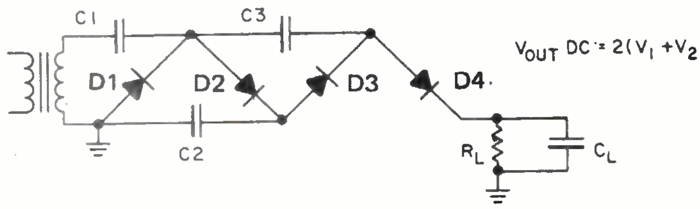


Fig. 7. To reduce component cost and count if the load is capacitive remove one of the doubling capacitors.

Fig. 6. The multiplier circuit with an even number of diodes and the same input as described in Fig. 4 produces an even larger dc output voltage than the circuit of Fig. 5.

HOW MULTIPLIERS WORK

The multiplier circuit can handle any waveform, but the three most common for multiplication are sine, pulse (or square) and trapezoidal wave. The only waveform restrictions are that the rise and fall times of the input signal be slower than the diode switching time.

In the signal in Fig. 4, V_{in} is a recurring waveform composed of the positive peak V_1, the negative peak V_2 and an ac axis that can be displaced from dc zero by voltage V_{dc}.

Figure 5 shows the voltages at each point of a 1.5-section multiplier. The half-wave, 1.5-section multiplier (three diode) operates as follows: During the positive peak of V_{in}, diode D_1 conducts to charge C_1 to a voltage equal to $V_1 + V_{dc}$. Capacitor C_2 acts as a coupling capacitor to couple V_{in} to point C. Diode D_2 conducts on the negative voltage peak at point C when the voltage tries to become more negative than the anode of D_2 (the anode voltage of D_2 is $V_1 + V_{dc}$). Diode D_3 conducts on the positive peak at point C and charges D_3 to $V_1 + V_2$. The output, V_{out}, is the sum of the voltages on C_1 and C_3:

$$V_{out} = V_1 + V_{dc} + V_1 + V_2 = 2V_1 + V_2 + V_{dc}.$$

Only dc voltages are applied to C_1 and C_3; these capacitors are therefore dubbed "dc capacitors." An ac voltage is applied to C_2, which is called an "ac capacitor". If the input voltage is symmetrical about the zero axis, the multiplier output will be three times (either) peak voltage, $V_{out} = 3\ V_1$. This circuit is called a tripler. If, however, the waveform is such that V_2 is much greater than V_2, the output voltage is approximately twice V_1. The circuit could be called a doubler. For clarity, we can use the diode count to define multiplier capability.

The operation of the four-diode multiplier – a two-section, half-wave unit – is similar to that of the three-diode multiplier (Fig. 6). Capacitor C_1 blocks the dc bias from the remainder of the multiplier and acts as a coupling capacitor to couple V_{in} to point C. Diode D_1 conducts when the negative voltage at point C becomes more negative than the anode of D_1 (the anode of D_1 is at 0 V). This causes C_1 to charge to a voltage equal to $V_2 - V_{dc}$ and simultaneously causes the positive peak at point C to reach $V_1 + V_2$.

The positive voltage at point C turns on D_2 and charges C_2 to $V_1 + V_2$. Capacitor C_3 acts as a coupling capacitor to couple the input waveform at point C to point E. Diode D_3 conducts when the cathode voltage becomes more negative than the anode voltage (the voltage at point D). The positive peak will be at a voltage equal to the charge on C_3 plus the peak voltage at point C. This positive voltage will cause D_1 to conduct and charge capacitor C_4 to $V_1 + V_2$. The output, V_{out}, is the sum of the voltage on C_2 and C_4:

$$V_{out} = (V_4 + V_2) + (V_1 + V_2) = 2\ V_1 + 2\ V_2.$$

Both C_2 and C_4 are dc capacitors. Points D and F are "dc points", and C_1 and C_3 are ac capacitors. In both the odd-diode and even-diode circuits, the diode peak-inverse voltage (PIV) ratings should be at least $V_1 + V_2$. In the even-diode multiplier, C_1 should have a voltage rating of at least V_2. In the odd-diode multiplier, C_1 should have a voltage rating of at least $V_1 + V_{dc}$. All the other capacitors should have a voltage rating of at least $V_1 + V_2$. Negative output voltages can be obtained if the diode polarities are reversed.

HIGH VOLTAGE FOR LOW COST

VARIATIONS FOR SPECIAL APPLICATIONS

For applications with a very high load capacitance, any one of the dc capacitors can be omitted in the multiplier and it will still function (Fig. 7).

While this appears to be a good way to reduce component costs and package size, consider what happens when the output terminal is arced to ground: the distribution of voltages on the diodes becomes unequal, which causes more stress on some diodes than others. The uneven distribution can cause a diode's peak inverse rating to be exceeded and a malfunction to occur. For better transient protection, leave all the capacitors in the circuit.

Many applications require a second voltage that is proportional to the output voltage. A tap at any dc point of the multiplier can be used. The ratio of the voltages can be determined if you examine the circuit up to the tap as a complete unit and the total multiplier as another.

Consider carefully the maximum average current. The multiplier current ratings are intended to keep the components cool enough to perform reliably. It will help, of course, if the high-voltage drive source has some maximum-load protection that reduces the input voltage if too much current is demanded.

The multiplier must withstand all arcing, including that between the output lead and ground. and also direct shorts of the output lead to ground. The multiplier must sustain the peak current drawn by the arc or short as the internal capacitors discharge.

A resistor in series with the output lead serves two functions: (1) It reduces the Q of the oscillator circuit that is established during arcing, thus reducing considerably the stress on the diodes, and (2), it limits the peak current to a value that the diodes can handle safely. The value of this resistance must be high enough to do the limiting job but not so high as to promote arcing around or through the resistor body or overheating at maximum current drain when the output arcs to ground.

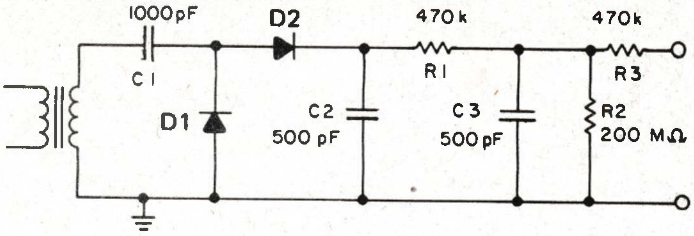


Fig. 8. A voltage doubler can be combined with a filter to provide very low ripple outputs. (The example shown gives a 30 kHz, 10 kV, 50μA output)

CONSIDER THE MECHANICAL LAYOUT

The mechanical design, mounting method and location of the multiplier can all affect current capability.

Remember that very high voltages may be involved so pay particular attention to component layout and insulation — also ensure that there are no sharp edges that might otherwise initiate corona discharge. ●

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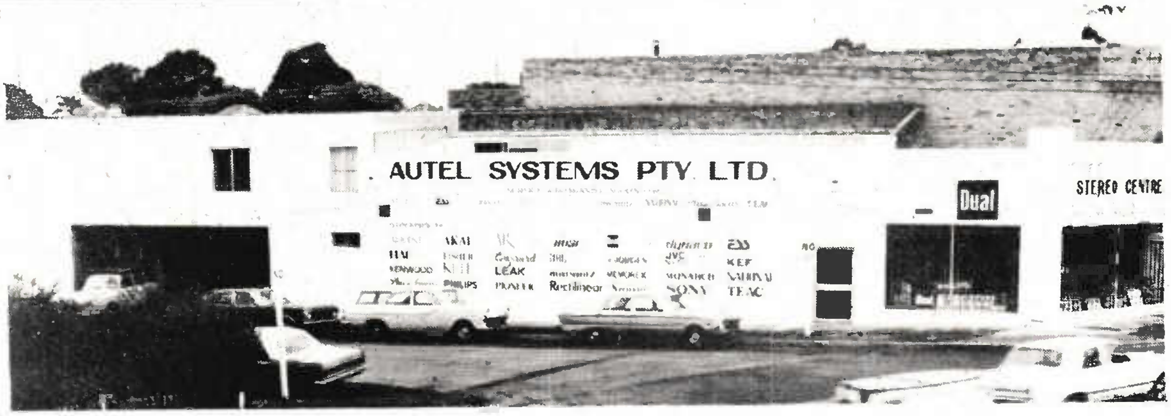

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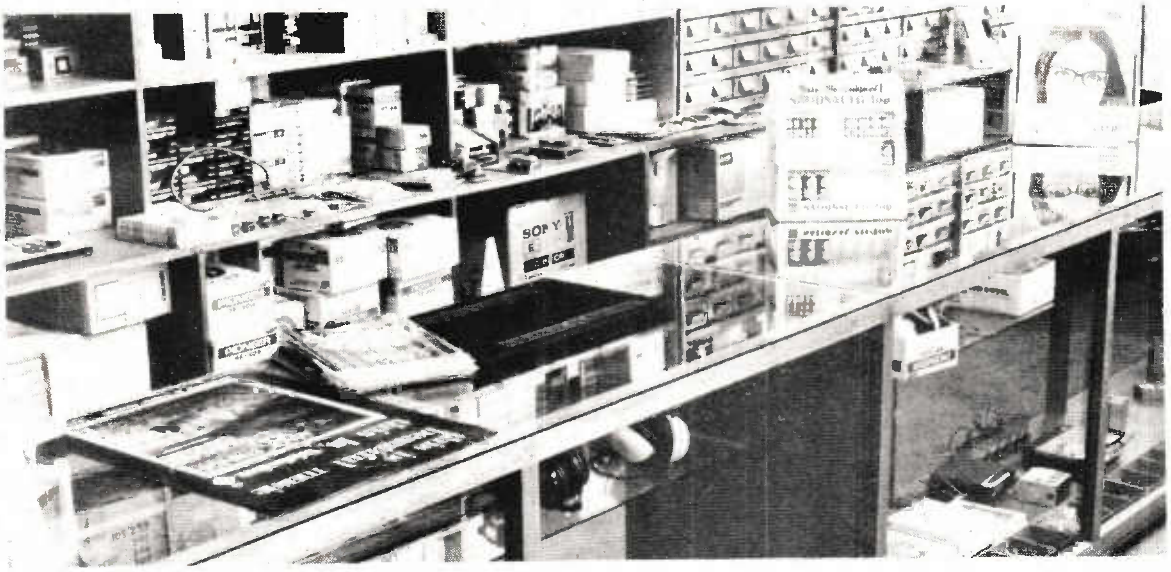

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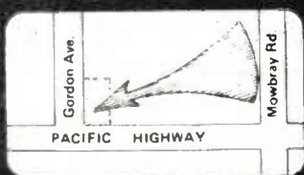
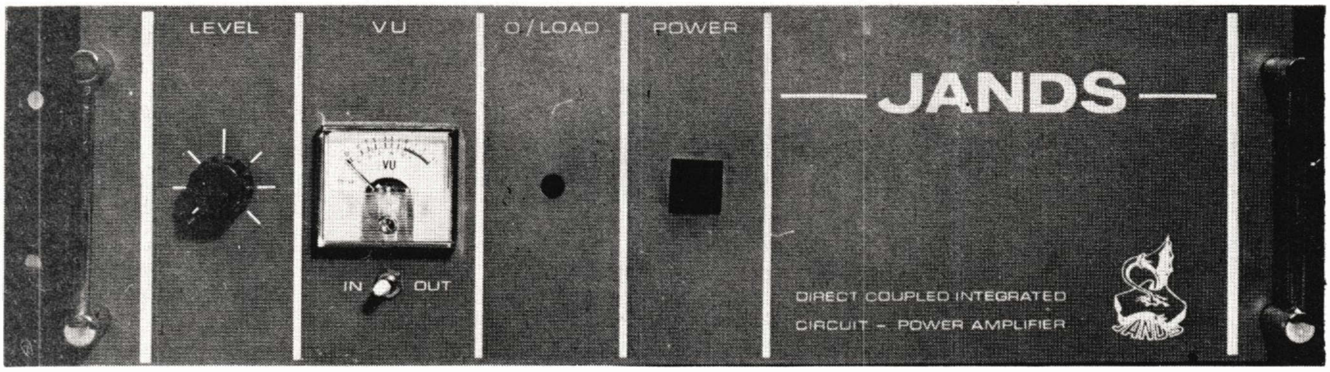


JANDS PS4 Professional Amplifier



Over 100 watts from dc to 20 kHz

Recommended Retail Price $207

JANDS is a name known to virtually everyone in the commercial entertainment field in Australia.

The company manufacturers and installs a wide range of equipment for use in theatres, cinemas, clubs, auditoria etc. In particular, Jands build and supply the extra-ordinarily high-powered sound equipment used in rock festivals and similar events.

This is a very specialised field of electronics for the equipment must combine very high reliability with facilities for flexible control and monitoring. At the same time it must be quickly interchangeable, easily repaired and capable of being installed by non-electronically minded people.

Further to complicate matters, there is a worldwide trend to develop automated control equipment which will allow one person to carry out operations in cinemas and studios that previously required the use of as many as three or four people.

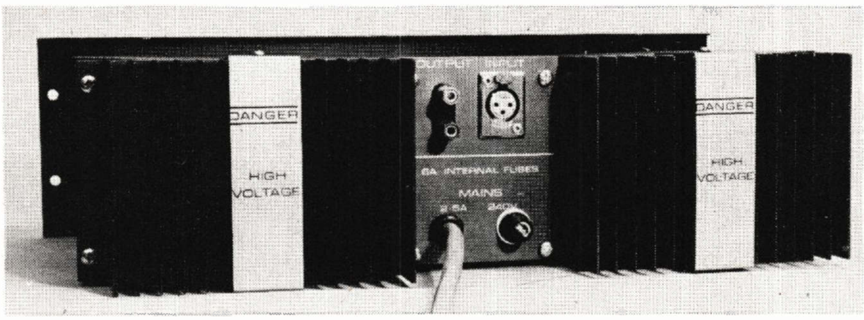
Jands, an Australian company, are amongst the world's leaders in this field, previously dominated by American and European manufacturers.

The Jands PS4 (mono) amplifier is designed for standard 19" rack mounting and is sensibly flanked on either side by two handles to ease installation.

The front panel has a light blue anodised facia over which is screened clear white lettering. From the left hand side the controls provided are a level control whose setting can be clearly seen from all positions, a small VU meter calibrated for peak voltages, below which is a switch for bridging either the amplifier input or output; and to the right of this is an LED which lights up when the amplifier reaches clipping level.

In the very centre of the panel is a large square power switch which contains an indicating light powered by the positive and negative dc supply. This is connected *after* the fuses to indicate power supply problems.

Should the amplifier be subjected to prolonged overload for more than a few minutes, two slow blow dc supply fuses break the power supply. When



PRODUCT TEST

this occurs the pilot light on the main switch will be de-energised as it draws its supply *after* these fuses.

To the right of the power switch is the large Jands logo – an old-fashioned Edison type horn 'growing' out of Central Australia.

Two large heat sinks are mounted at the rear of the unit, the active transistors of which are covered by covers sensibly labelled *Danger High Voltage*. A Cannon type XLR 3-pin connector with unbalanced input, a pair of universal binding post banana terminals for speaker connection, together with 240 volt mains fuse and two metre mains cord are located in the centre of the rear panel.

The chassis of the unit is constructed in heavy gauge steel whilst the top panel is perforated steel with an open area of approximately 50%.

Internally, components are mounted on two printed circuit boards which plug into a 'mother' board mounted horizontally along the major length of the unit.

One board contains the main power amplifier components (except of course the heat-sink mounted transistors) – the other is for the overload LED and associated pulse stretching circuitry.

The power transformer is sensibly mounted on the front panel so that weight distribution is fully compensated for by the strength and support of this panel. The transformer has the primary wound on a completely separate part of the nylon former to preclude any possibility of mains leakage between primary and secondary – a very necessary precaution for this type of unit.

The main amplifier is a fully direct-coupled integrated circuit device featuring a μA 748 integrated circuit front end in a current generating mode. This is followed by two 798 & 797 complimentary driver transistors which are followed by 9148 & 9149 driver transistors. The final output stage consists of four 40411 transistors.

MEASURED PERFORMANCE
JANDS PS4 DC INTEGRATED CIRCUIT
POWER AMPLIFIER, SERIAL NO: 116

Power Output

Measured	104 watts in 4 ohms – dc and 20 kHz	
	55 watts in 8 ohms – dc and 20 kHz	
Rated	100 watts in 4 ohms	
	50 watts in 8 ohms	

Frequency Response

at rated output	dc – 20 kHz	± 0.5 dB
at 10 watts	dc – 20 kHz	± 0.5 dB
at 1 watt	dc – 20 kHz	± 0.5 dB

Hum & Noise with Respect to Rated Power

Gain control at maximum gain	–81 dB (Linear)
	–94 dB (A) Weighted
Gain control at minimum gain	– 82 dB (Linear)

Input Sensitivity for Rated Output
640 mV (input impedance 40 k bridging)

Total Harmonic Distortion (at Rated Output)

0.1% 100 Hz	0.06% at 1 kHz	0.3% at 6.3 kHz

Intermodulation Distortion
Better than 0.05%

Dimensions 482 x 133 x 321 mm

Note – this is a single channel (mono) amplifier.

SHORT-CIRCUIT PROOF

The output is short-circuit proofed by both voltage and current sensing transistors which limit the drive signal.

The emitter resistors for the final output stage are unusual. They are made from solderable resistance wire individually measured to exact value – and are capable of working at red heat if required!

This approach is very sensible, for many conventional 10 watt resistors are liable to fail catastrophically (like fuses) if driven for any protracted time at only 10-20% above their nominal maximum rating.

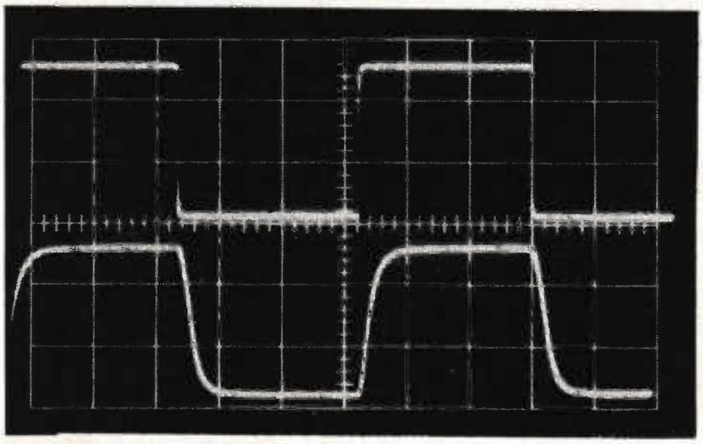
The whole of the amplifier can be stripped down to its basic components in under four minutes flat. Even the heat sinks on the back of the amplifier directly unplug from the mother circuit via gold plated plugs.

SEPARATE VU AMPLIFIER

The inclusion of a special VU amplifier is unusual and is the first of its type we have seen built into a basic amplifier of this type. It consists of a dual IC one half of which is permanently bridged across the input of the amplifier, hence the VU meter is untroubled even by inputs as high as 50kΩ, whilst the second half of the IC is capable of being switched between the output circuit of the power amplifier or the output of the buffer stage. In addition, the VU amplifier has a calibration control so that the VU meter can be re-adjusted from peak reading to continuous average reading should this be desired.

MEASURED PERFORMANCE

Our measurements proved that the amplifier has a continuous rating of 104 watts into four ohms, or 55 watts into eight ohms – but unlike many amplifiers which require transformers to cope with higher load impedances, the PS4 works quite happily into *any* load up to and including an open circuit, or for that matter a short



Square wave response TOP: 10 kHz input. BOTTOM: Output from amplifier (50 watts).

In response to the needs of the recording and broadcasting industries. Stanton creates the new calibration standard

...the 681 TRIPLE-E

A definite need arose.

The recording industry has been cutting discs with higher accuracy to achieve greater definition and sound quality.

Naturally, the engineers turned to Stanton for a cartridge of excellence to serve as a primary calibration standard in recording system check-outs.

The result is a *new* calibration standard, the Stanton 681 TRIPLE-E. Perhaps, with this cartridge, the outer limits of excellence in stereo sound reproduction has been reached.

The Stanton 681 TRIPLE-E offers improved tracking at *all* frequencies. It achieves perfectly flat frequency response to beyond 20 Kc. It features a dramatically reduced tip mass. Actually, its new nude diamond is an ultra miniaturized stone with only 2/3 the mass of its predecessor. And the stylus assembly possesses even greater durability than had been previously thought possible to achieve.

The Stanton 681 TRIPLE-E features a new design of both cartridge and body and stylus; it has been created for those for whom the best is none too good.

Each 681 TRIPLE-E is guaranteed to meet its specifications within exacting limits, and each one boasts the most meaningful warranty possible: an individual calibration test result is packed with each unit.

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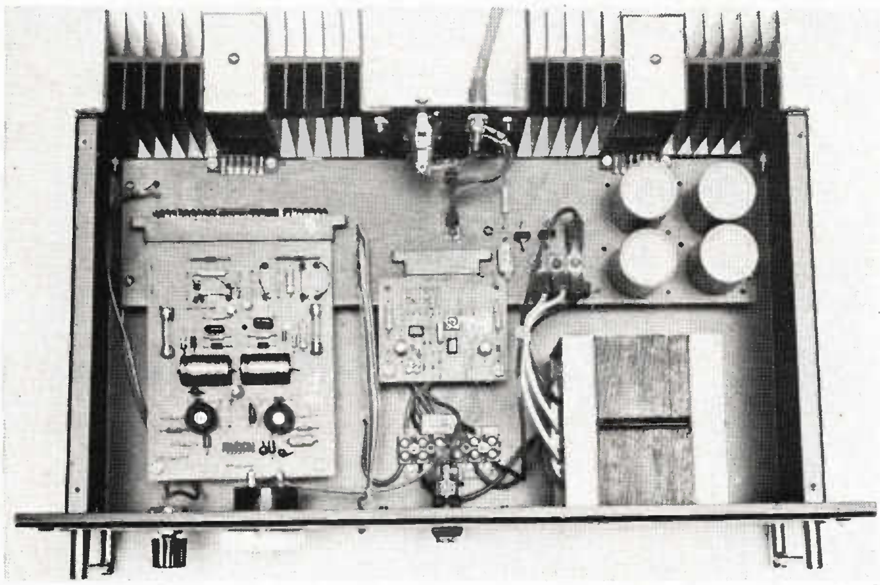
LER063

JANDS PS4 Professional Amplifier



circuit, although if the short stays there for more than a few seconds the main amplifier fuses will blow.

The manufacturers claim that one can safely draw sparks off the output terminals without causing any serious or ill effects. Frankly we doubted the validity of this claim – so we tried it for ourselves – and it's true!

The measured frequency response of the unit is ±0.5 dB from dc to 20 kHz – sensibly drooping at higher frequencies so that any incipient instability (encountered in large installations) is inhibited.

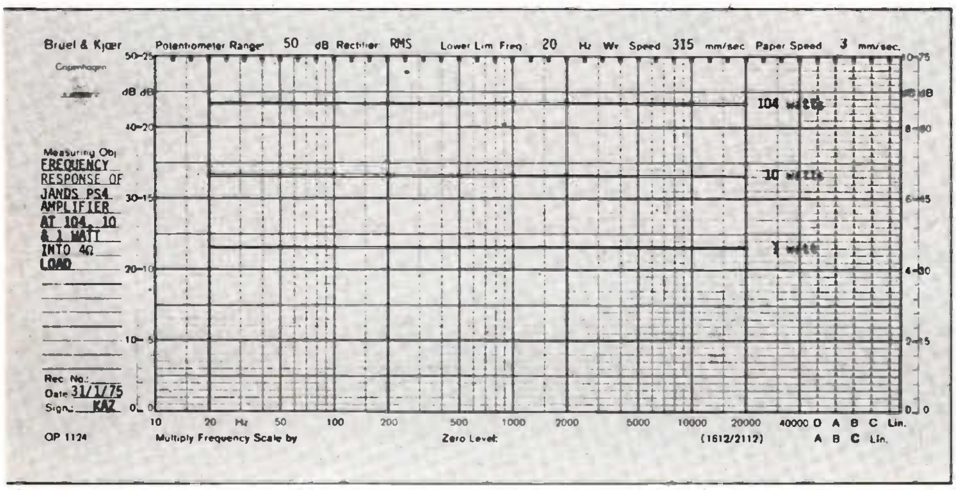
However because the unit amplifier is dc coupled, any pre-amplifier with dc leakage could well cause the PS4 to pass a dc current through the connected speakers – possibly resulting in damage. Where such a possibility exists, a high quality capacitor should be inserted in series with the input.

The total harmonic distortion at maximum output is particularly low, being 0.1% at 100 Hz, 0.06% at 1 kHz, and 0.3% at 6.3 kHz.

Intermodulation distortion measured in accordance with the S.M.P.T.E. method is a very healthy 0.05%, whilst the signal to noise ratio is –94 dB(A) at maximum volume or –81 dB(Linear) at maximum volume and –82 dB(Linear) at minimum volume.

Sensitivity is 640 mV for maximum output.

The Jands PS4 Amplifier is a very high quality unit marketed at a very modest price in a field where Australian manufacturers are fast disappearing. ●



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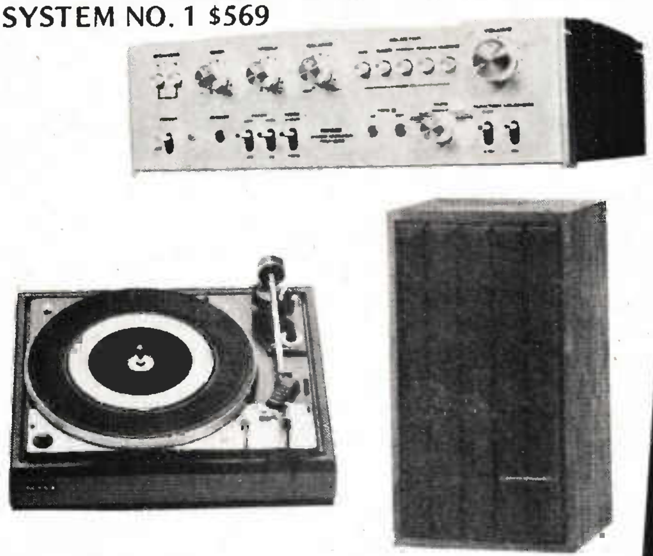

Comprising
Dual 1225 player with Shure M75.6 cartridge, base and cover. Nikko TRM 500 stereo amp. 22 watts per channel. 1 pair Marantz 5G Loudspeakers.

SYSTEM NO. 2 $639

Comprising
Dual 1228 player with Shure M91ED cartridge, base and cover. Nikko TRM 500 stereo amp. 22 watts per channel. 1 pair Marantz 5G loudspeakers.

SYSTEM NO. 3 $849

Comprising
Dual 1228 player with Shure M91ED cartridge, base and cover. Marantz 1060 stereo amp 30 watts per channel. 1 pair KEF Concerto loudspeakers.

SYSTEM NO. 4 $899

Comprising
Dual 1229 player with Shure MGIED cartridge, base and cover. Marantz 1060 stereo amp. 30 watts per channel. 1 pair KEF Concerto loudspeakers.

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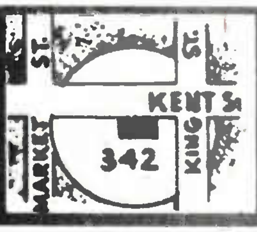

HOW AMBISONICS WORKS

DURING the past year or so Electronics Today, together with several overseas publications have described, as far as we have been able, the so-called Ambisonic surround-sound system.

These articles attracted very considerable interest, but had perforce to be limited to the *philosophy* of the proposed new system as no *specific* details could be obtained.

However a search through the British Patent files resulted in our finding Patent No 1369 813 dated October 1974 'Improvements in or Relating to Reproduction of Sound'. The Patent is in the name of Britain's National Research Development Corporation — and the inventor is named as Peter Berners Fellget.

Working from the information contained within this Patent — and from previously released information — ETI's Technical Editor Brian Chapman has prepared this article setting out for the first time just how Ambisonics actually works.

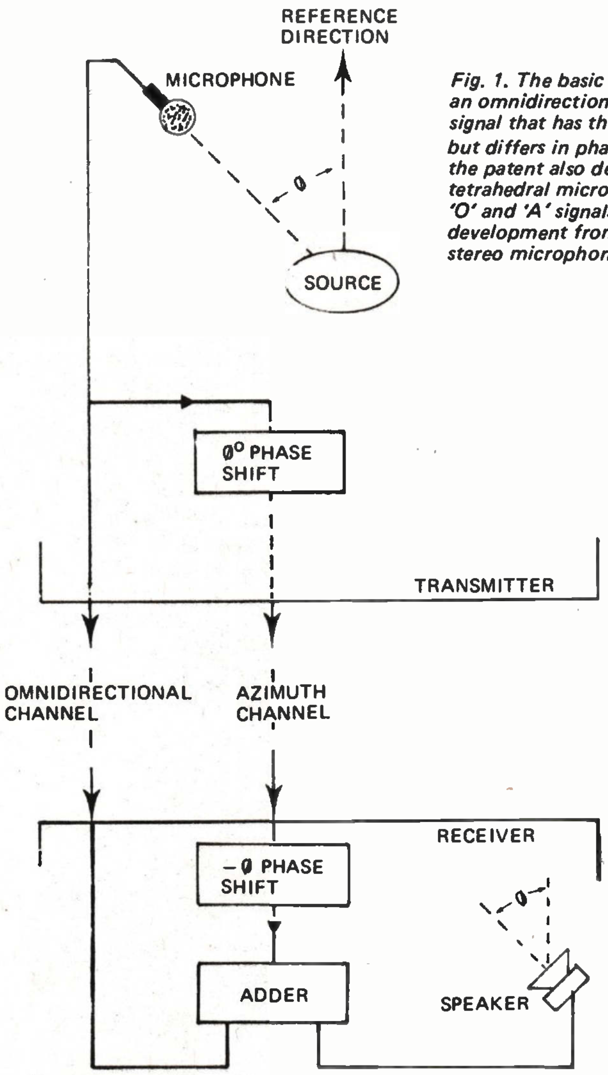

Fig. 1. The basic ambisonic channel produces an omnidirectional signal and an azimuth signal that has the same frequency spectrum but differs in phase by the angle. Note that the patent also describes a special tetrahedral microphone which provides 'O' and 'A' signals. This microphone is a development from the original Blumlein stereo microphone.

IN THE continuing quest to obtain more realistic audio reproduction we have seen stereo replace mono, and various attempts made to extend conventional stereo's two channels to four — the so-called quadraphonic systems.

The sound images created by current systems seem artificial in that they appear to be distributed along the walls of the room. Furthermore the actual source of many sounds appears to shift position at times. This can sometimes be very disconcerting. We know of one record in which a contralto instantaneously moves from the front to the back of the room everytime she sings above C3.

What is required for realism is that the ambience information, normally experienced in a live performance, also be reproduced more realistically than it is at present, and that a listener should be able to determine the direction from which the original sound was produced — and that that direction be stable.

The Ambisonic system attempts to surround the listener with the direct *and* the reverberant sound, from *all* directions, such that the original sound field is reproduced as accurately as possible.

Whilst it is certainly *possible* to encode height as well as full azimuth information with this system, such periphonic systems will probably not be commercially used for some time. This discussion is therefore limited to systems which reproduce the sound field in the horizontal plane only, that is, pantaphonic systems.

To do this a totally different concept of recording is required which nevertheless can be encoded on to two transmission channels in a similar manner to conventional stereo discs and tapes.

The Ambisonic system adopts a completely different approach that does not exhibit the directional ambiguities common to existing systems. When recording, a number of microphones are used each of which provides an omnidirectional, 'O', signal and an 'azimuth' 'A' signal which is phase shifted by the angle between the individual microphone and a reference direction. This process is shown in Fig. 1.

In an actual system, at least three microphone setups must be used in order to obtain full directional coverage. All the omnidirectional signals are simply added into one channel and all the azimuth signals into another. Such a system of four microphones is shown in Fig. 2. Here the left front microphone is taken as the reference direction and hence its signals are passed direct to both transmission channels. The other three microphones are summed directly into the 'O' channel and via appropriate phase-shift networks to the 'A' channel.

It should be noted at this point that the phase-shift networks in an actual system are of the 'all-pass' filter type. Hence the phase of both 'O' and 'A' channels may be shifted together; the apparent phase-shift to the 'A' channel being the difference in phase between the two.

Thus the content of each channel is a continuum of signals rather than a set of discrete signals. That is the two channels of information are representative of the sound-field surrounding the source. This means that although a system such as the transmitter of Fig. 2a, and the receiver of Fig. 3a may be used, a speaker at any azimuth orientation may be added simply by feeding it with appropriately phase shifted signals.

A system in which four microphones at 90° spacing are used, will transmit the signals as shown vectorially in Fig. 2b. To correctly decode this, at the receiver, a decoder, as shown in Fig. 3a, is required. Vector diagrams, adjacent to each speaker, show the signal fed to that particular speaker.

To better understand the decoding process let us trace the decoding to the right-front speaker as detailed in the vector diagrams on Fig. 3b. This shows the azimuth channel being firstly shifted by 90° and then inverted (phase-shift of 180°). When the azimuth and ommidirectional channel are subsequently added we find that the left back signal is completely cancelled, a twice amplitude right front signal is obtained and right back and left front signals of 1.4 times amplitude are also obtained at phase angles of plus and minus 45°.

Thus the diagonal separation is infinite but that between pairs on one side is only 3 dB. (This figure of 3 dB is in conflict with the Patent — there Professor Felgett shows the side channels — vectorially — as having 0.707 amplitude, equivalent to 9 dB down on the main signal. We have asked three suitably qualified people to check our figures — and all agree that the correct result is 3 dB. Thus unless there is some factor not described in the Patent we cannot see how 9 dB separation can be obtained).

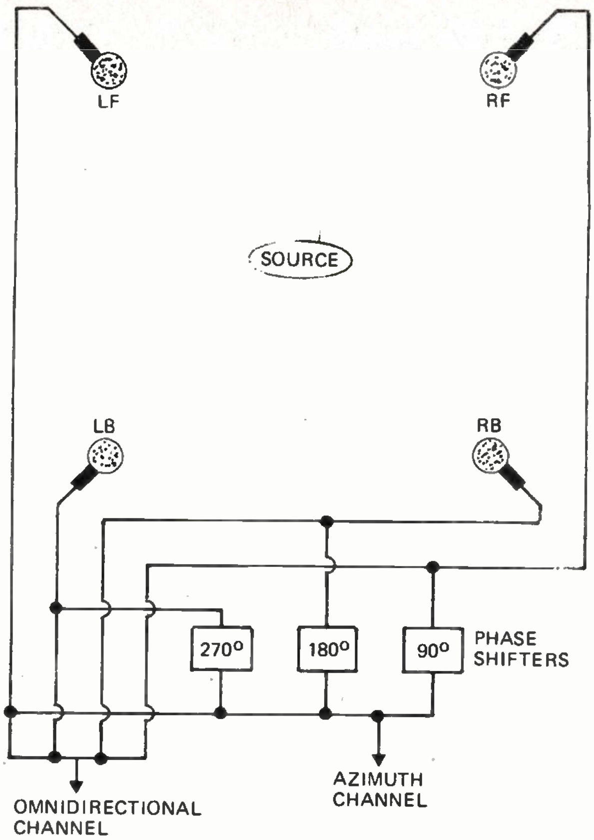

Fig. 2a. An ambisonic system using four microphones with the left front transducer being the reference direction.

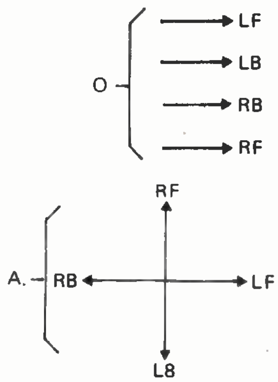

Fig. 2b. The transmitted signal vectors.

However separation does not have the same meaning for ambisonics as it does for conventional four channel. Ambisonics reproduces a field surrounding the listener rather than four separate sound sources.

COMPATABILITY WITH STEREO

The system described in Fig. 2 and 3 is not compatible with existing stereo systems but may readily be processed to be so. To generate right and left signals the 'O' and 'A' channels are added and subtracted respectively at

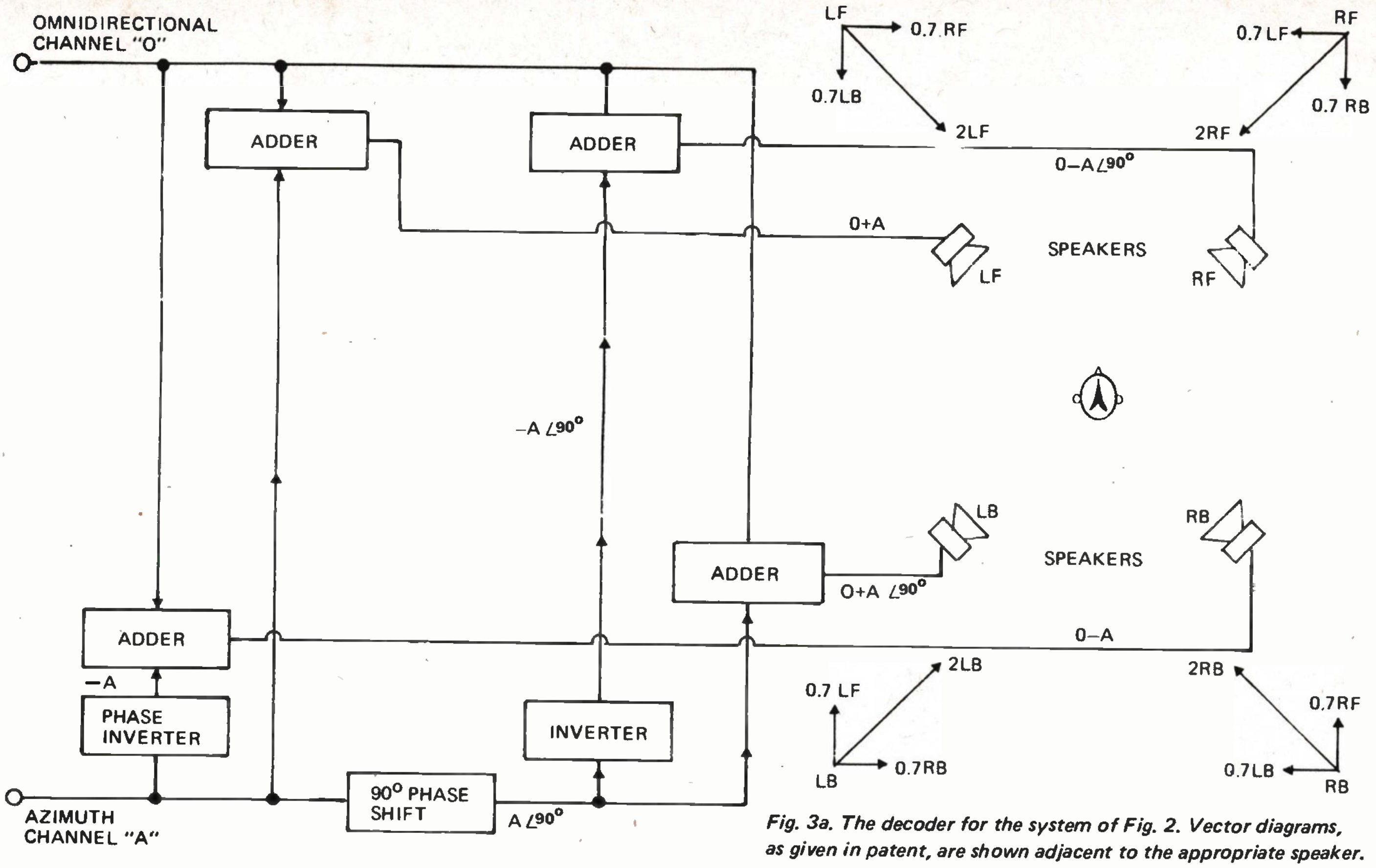

Fig. 3a. The decoder for the system of Fig. 2. Vector diagrams, as given in patent, are shown adjacent to the appropriate speaker.

the transmitter. At the receiver the decoder must be modified as shown in Fig. 5 to recover the 'O' and 'A' signals. The 0.707 multiplier must be incorporated to halve the power in the 'O' channel, which was doubled in the first adder, and thus restore balance between 'O' and 'A' channels.

The Ambisonic system is thus very flexible in the number of speakers which may be used. It gives unambiguous directional information and has infinite separation diagonally and 3 dB (or 9dB!) separation between adjacent speakers. Finally it may readily be made compatible with conventional stereo systems and offers the ultimate capability of height, as well as horizontal transmission. ●

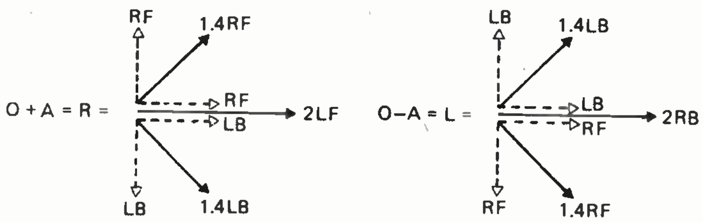

Fig. 4. The Patent says that right and left stereo channels are constructed by adding and subtracting O and A channels respectively. Note however that, using vectorial addition, O+A gives 2LF, and O–A gives 2RB. So the labelling of left and right as in the Patent seems to be reversed, and skewed by 90° relative to the original reference direction.

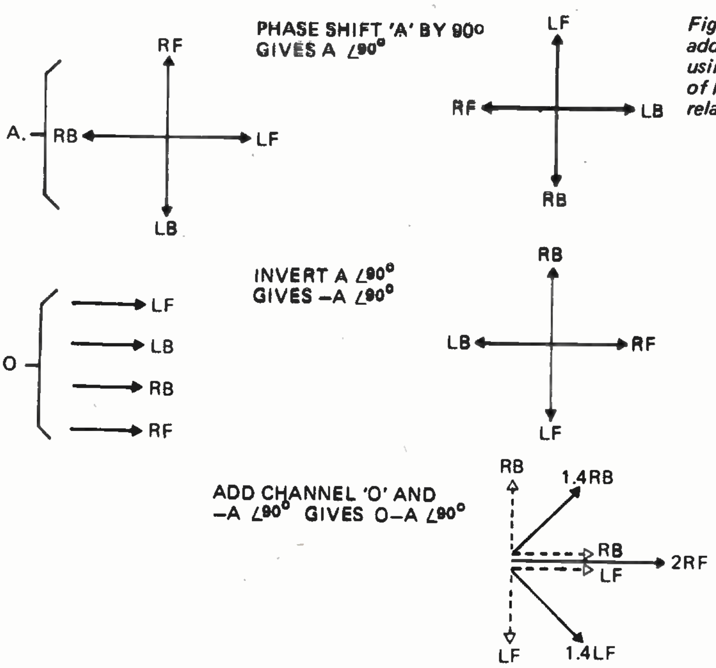

Fig. 3b. The processing of the right-front channel shown vectorially.

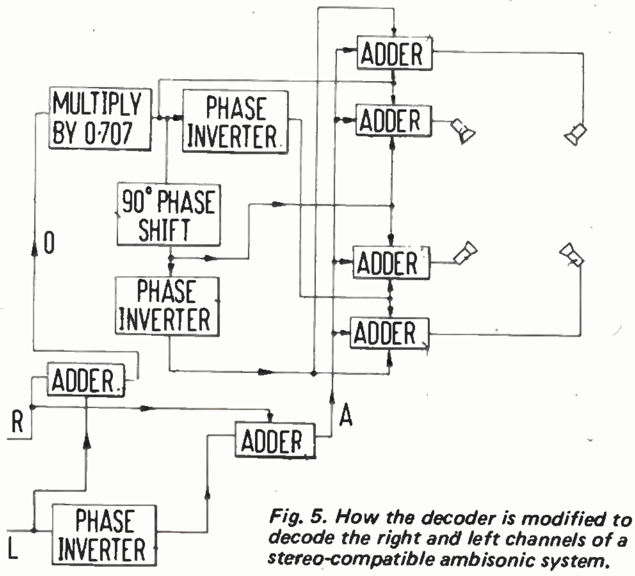

Fig. 5. How the decoder is modified to decode the right and left channels of a stereo-compatible ambisonic system.

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HI-FI LOUDSPEAKERS FROM ENGLAND

10" The model B101/10LR is a 10" loudspeaker with a 2" voice coil working within a 10,000 guass magnet structure, total flux 100,000 maxwells. The free air-resonance of the loudspeaker is 25Hz thus making it suitable for a small sealed cabinet of between 1½ and 2 cu.ft.
Efficiency is higher than might be expected from a sealed cabinet and power handling is 20-25 watts r.m.s. **$34.50**

12" The model B122/10LR is a 12" bass speaker featuring a rubber suspension which allows a fundarmental resonance of 17Hz in free air. This low-resonance, combined with a 2" voice coil working within a carefully selected magnet structure makes the speaker ideal for a sealed cabinet of about 2 cu.ft. capacity. Efficiency of the B122/10LR is surprisingly high for this type of loading and the speaker is ideal for amplifiers with an output of 20-25watts r.m.s. per channel at 8ohms. **$39.50**

12" The model B122/12LR, like the B122/10LR described above, is also suitable for sealed cabinets but because of its more powerful magnet structure a volume of about 3 cu.ft. is required to ensure the speaker gives its optimum performance. **$49.50**

15" The Fane model B152/12LR is a 15" bass driver with a fundamental resonance of 15Hz in free-air. Once again a sealed cabinet provides ideal loading for this unit and the volume can be varied from 3 to 5 cu.ft. The performance in 5 cu.ft. is particularly outstanding as the resonance is kept in the region of 30Hz. This results in firm, non-resonant bass without any of the "boxiness" often associated with conventional speakers. Efficiency is reasonably high and power-handling is up to 30watts r.m.s. at 8ohms. **$59**

5" The Fane 505 x 5" mid-range loudspeaker employs a special cone material which is doped to remove any irregularities in response. Useful frequency range is 400-4.000Hz and sound quality is very neutral. **$24.50**

1" The Fane 1" Dome Tweeter DD1 is a newly developed soft-dome tweeter with a useful frequency response from 4,000Hz to 20,000Hz. Efficiency is medium to high. **$23.50**

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15" CRESCENDO 15/100 BASS. Specially designed for high power, high efficiency bass performance. This magnificent unit is rated at 100 watts r.m.s. and has a resonant frequency of 40Hz. VOICE COIL DIAMETER: 3", FLUX DENSITY: 15,000 Guass, IMPEDANCE: 8 ohms. **$99.00**

920 HORN UNIT. This unit has just been released on the Australian market and features super high efficiency of 109 dB and power handling of 100 Watts r.m.s. above 600 Hz. VOICE COIL DIAMETER: 2", FLUX DENSITY: 20,000 Guass, IMPEDANCE: 8 ohms. **$149.00**

12" POP 50. A general purpose 50 watt r.m.s. loudspeaker of high efficiency, but economically priced. VOICE COIL DIAMETER: 2", FLUX DENSITY: 13,000 Guass, IMPEDANCE: 8 ohms. **$39.50**

18" POP 100 An outstanding 18" bass loudspeaker for musical instruments, the POP 100 handles 100 watts r.m.s. at high efficiency. Resonant frequency is 55 Hz. VOICE COIL DIAMETER: 3", FLUX DENSITY 14,000 Guass, IMPEDANCE: 8 ohms. **$79.00**

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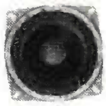
CHALLENGE H-22 DOME TWEETER
The development of dome tweeters has been a major project of most loudspeaker manufacturers of recent years. The H-22 dome is one of the latest designs. The 1" diaphragm is made of carefully selected metallized polyester material which is of very small mass to allow maximum efficiency. **$8.50**



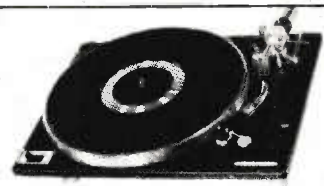
SPECIAL MID-RANGE SPEAKER
An outstanding 5" mid-range loudspeaker developed by one of Germany's leading loudspeaker manufacturers. It employs carefully selected cone material and a special cone termination to ensure flat response and high efficiency. A protective cover is fitted to the rear of the loudspeaker to prevent interference from air pressure developed within the cabinet by the bass speaker. **$15.90**

CHALLENGE 10L-24 WOOFER
This robust 10" unit features a 4 layer wound 1½" voice coil which allows it to handle 30 watt r.m.s. comfortably. The combination of extremely rigid cone and low-fundamental resonance of 35 Hz in free-air ensures deep, positive bass when used in the recommended enclosure sizes. **$16.90**

CHALLENGE HP 1 HIGH-POWER CROSSOVER NETWORK
features 4 inductors including a high-efficiency air-wound 3.55 Mh choke in series with the bass speaker. 3 crossover capacitors are also used. Crossover points are 500 Hz and 4 000 Hz and the rate of roll off is 12dB/oct. **$14.50**

The **CHALLENGE SYSTEM 1** can be purchased as components only as above or completely assembled and tested in 2 cu.ft. walnut veneered cabinets at **$179 pair**

NEW CHALLENGE TURNTABLE SEMI-AUTOMATIC BELT-DRIVE



$99.50

- The automatic arm return is achieved by a very simple and effective mechanism which ensures years of trouble free operation.
- Oil damped cueing lever permits instant selection of any record track without having to reject the tone arm.
- Heavy cast platter, belt-driven by a syncronous motor, reduces rumble, wow and flutter to negligable proportions.
- Tone arm features anti-skate, lateral balance and removeable headshell fitted with magnetic cartridge. Fully adjustable counter balance weight with independent scale allows easy adjustment of stylus pressure.
- All connecting cables and plugs are fitted to the turntable.
- 12 month guarantee.
- Walnut base and tinted perspex cover with hinges available as for $27.50.

CROSSOVER CAPACITORS

Our wide range includes 2.2 mfd mylar film **$1.20** each, 3.3 mfd mylar film **$1.40** each, 5 mfd NP Electrolytics **40c** each, 10 mfd NP Electrolytics **45c** each, 16 mfd NP Electrolytics **50c** each, 30 mfd NP Electrolytics **60c** each and 60 mfd NP Electrolytics **90c** each.

CROSSOVER CHOKES

A comprehensive range is now available of high power, high efficiency inductors in the following values, 0.25 Mh, 0.35 Mh, 0.5 Mh, 0.75 Mh, 2.2 Mh and 3.55 Mh. Prices range from **$1.00** to **$5.00** each.

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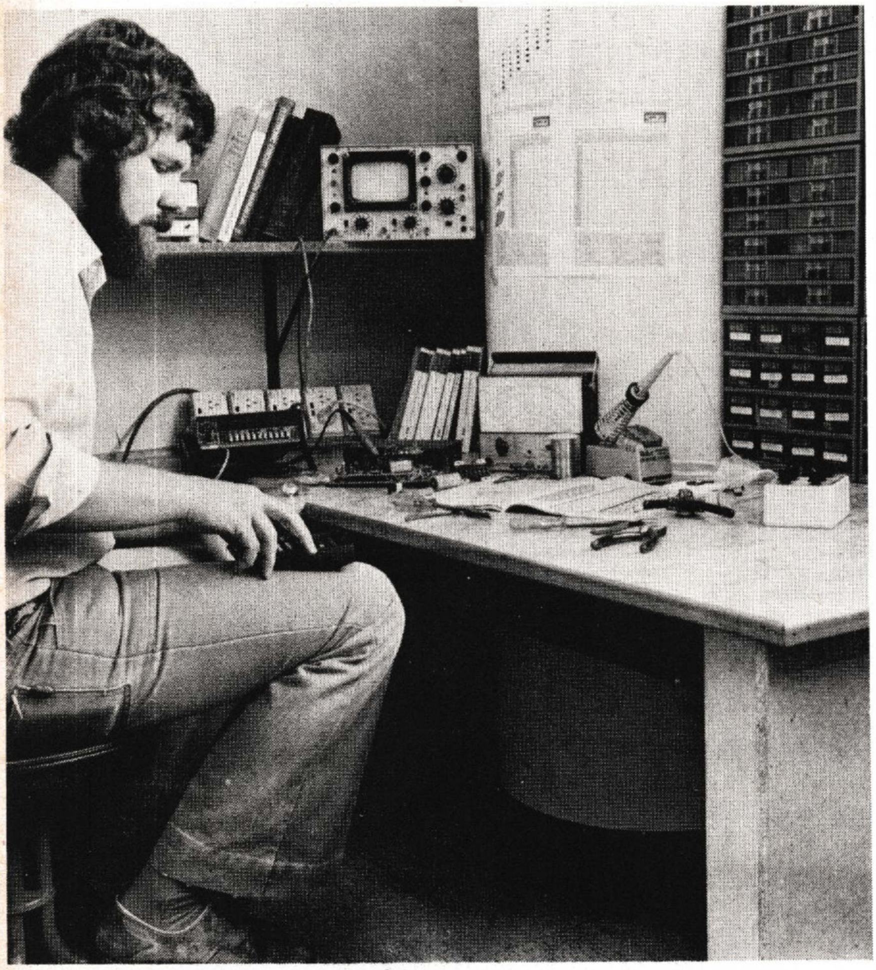
Project Building Guide

THE HOME WORKSHOP

Space, light, power, components, tools — save time and money with ETI's home workshop guide.



Even an awkward corner like this can be utilized effectively. Note particularly the equipment shelf, storage bins, array of power points and linoleum on top of bench.

WORKSHOP KIT

The following list of tools and basic components has been carefully compiled to assist the novice constructor setting up a home workshop from scratch.

Virtually nothing on the list is redundant.

Test gear has not been included as this will form the basis of a further feature article to to be published shortly.

Very roughly, all the items listed above should cost somewhere between $100 and $150 — naturally though prices will vary from supplier to supplier, and to some minor extent with the quality of the tools offered.

Some kitset suppliers have indicated that they will supply all or sections of the items listed as 'package deals'. Watch out for their adverts in this and future issues.

TOOLS

Soldering Iron — approx 19 watt 240 volt
Iron rest & wipe pad
Side cutters
Long nose pliers
Neon indicator screwdriver
Wire strippers
3 x screwdrivers including one medium 'Philips' head

HARDWARE

500 gram pack 18 Swg "Ersin" Multicore 'Savbit' solder
Solder wick
500 grams tinned copper wire 22 Swg
2 x 100 metre reels hook-up wire (one 7/0076 and one 10/010 different colours)
Assorted spaghetti (not plastic)
50 x ½" x 1/8" bolts
50 x 1" x 1/8" bolts

NOT all of us are blessed with space in which to build a workshop and many experimenters must be satisfied with the kitchen table or invade a small corner of the "sewing" room.

For those who can find a suitable space the requirements of a good workshop may be summarized under the headings of location, benches, light, power, storage and tools.

THE LOCATION

As much space as possible is required if one is to undertake electronics as a serious hobby, anything from 2 x 2 metres upwards is needed. Electronic equipment (and the experimenter) is adversely affected by extremes of temperature. The area must also be dry as damp floors or walls will rapidly corrode contacts and cause rapid general deterioration of valuable equipment. A location should therefore be chosen that is clean and dry and not subject to temperature extremes.

BENCHES

The work bench should be strong and rigid as heavy equipment may be used on the bench.

Pine board or similar material makes an excellent bench top but, whether pine board, floor boards or ordinary other materials are used, it is advisable to surface the top with linoleum, tiles or sheet to provide a good stainproof and continuous surface.

A well-braced frame work should be constructed from 75 x 50 mm timber or, alternatively a steel frame may be constructed using Dexion angle or "Speed Frame" box section tube.

An equipment shelf should be provided along the rear of the bench at least 300 mm wide and 300 mm above the bench. Such a shelf allows the working space to be kept free of test equipment.

LIGHT

The rule is as much light as possible. A good general illumination should be provided and, in addition, a desk lamp capable of swivelling to illuminate the interiors of equipment should be provided. If fluorescent general illumination is used purchase a twin lamp fitting that has lead/lag ballasts. Flicker is much reduced with this system and, although a little more expensive, you will save much eyestrain.

POWER

Whilst in general very little mains power is required in an electronics workshop many pieces of equipment must be powered simultaneously and hence a multitude of power points is required.

Here we must emphasise that such power points *must be properly wired* — you seldom get a second chance with mains power. Make sure your

---

100 hex nuts (1/8")
50 x ¼" 'self tappers'
50 x ½" 'self tappers'
50 x 1" 'self tappers'
2 x 6" square 0.2" pitch matrix board
2 x 6" x 9 holes/0.15 pitch matrix board
1 x 3.75" x 3.12" and 1 x 3.75" x 8.12"/0.1 pitch Veroboard
1 x resistor mounting strip (48 lugs per side)
3 x 3 lug tag strips
2 x 5 lug tag strips
1 x 10 lug tag strips
1 x 12 way screw terminal strip
12 x assorted grommets

COMPONENTS

Resistors ½ watt 5% tolerance
5 x all standard values from 10 to 820 ohms
15 x all standard values from 1k to 82k ohms
5 x all standard values from 100k to 8.2 M ohms
plus 20 x 1kΩ, 4.7kΩ, and 10kΩ
(660 resistors)

Capacitors
3 x all standard values from 10pF to 820pF (Miniature Philips or similar)
3 x all standard values from 0.001µF to 0.47µF plus 5 x 0.1µF and 0.01µF (greencaps or similar)
3 x 1µF capacitors (greencaps or similar)
2 x all following electrolytics (25 Vdc) microfarads (1,2.2,3.3,4.7, 10, 16, 25, 47, 100, 200, 330, 470, 640, 1000)

Trimpots
1 x 500Ω, 1kΩ, 2.5kΩ, 5kΩ, 10kΩ, 25kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ' 1MΩ (LIN)

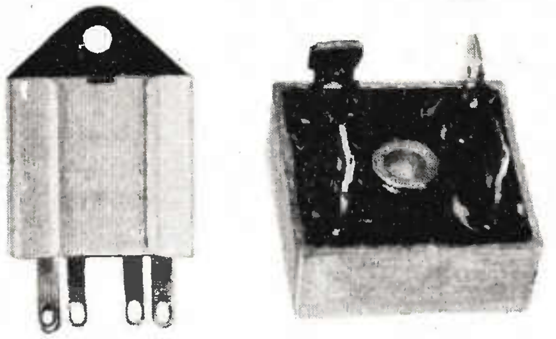
Potentiometers
1 x 2.5kΩ, 10kΩ, 25kΩ, 50kΩ, 100kΩ, 500kΩ (LIN)
1 x 50kΩ (LOG)

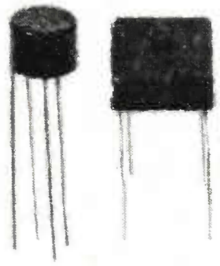
Relays and Switches
1 x 6-17 Volt (200 ohm) relay double pole C/O
2 x DPDT 3A toggle switches
1 x SP miniature push button (push-on)

Semiconductors
6 x BC108 or equivalent transistors
2 x BC178 or equivalent transistors
1 x TT800 transistor
1 x TT801 transistor
1 x 2N3643 transistor
1 x 2N3638 transistor
1 x 2N3055 transistor
1 x 2N2646 UJT
1 x 2N6027 (D13T1) PUT
1 x 2N5459 FET
6 x 1N914 silicon signal diodes or similar
6 x EM404 silicon power diodes or similar
1 x LED
1 x OA90 germanium diode (or similar)
1 x BZY88 C4V7 zener diode
1 x BZX79 C5V6 zener diode
1 x BZX79 C6V8 zener diode
1 x BZX79 C10 zener diode
1 x BZX79 C12 zener diode
1 x BZX79 C15 zener diode
1 x ORP 12 light sensitive resistor

Integrated circuits
1 x NE555 timer IC
1 x µA 741 operational amplifier
2 x LM301 operational amplifier

A Small Segment of the Soanar Range





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Play your cassettes through your 8 track player, with this unit; includes a fast forward switch. **$39.00**

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Sanyo 18" full PAL-D **$675**
Toshiba 18" full PAL-D **$738**
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CASSETTES

	1	12	24
Hitachi C60	1.60	1.47	1.33
Hitachi C90	2.20	2.00	1.80
UDC46	1.90	1.80	1.70
UDC60	2.35	2.14	1.93
UDC90	3.15	2.84	2.56
UDC120	3.95	3.60	3.00
Sony C60	1.60	1.47	1.33
Sony C90	2.55	2.35	2.10
Sony C60 CR02	2.95	2.75	2.55
BASF C90 SM	2.20	2.20	2.00
BASF C90 SM CR02	3.95	3.75	3.50
AGFA C90 CR02	3.95	3.75	3.50
TDK C90 LN	2.25	2.00	1.80

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THE HOME WORKSHOP

power installation is correctly wired and safe — after all it's your life. It is illegal to modify household power distribution yourself but it is legal to wire a bench so that it may be plugged into an existing power point. Although the bench power lead may be plugged into a single 10 amp power outlet such outlets only have a single pole switch. Hence for safety a two-pole switch, which breaks both active and neutral to the bench circuit, together with a neon indicator and fuse should be fitted such that the bench circuits can be completely isolated even though still plugged into the outlet.

To wire the bench use 23/.0076 three-core flex if the current drain does not exceed seven amps and 40/.0076 if the current does not exceed 10 amps. Choose the ratings of fuse and double-pole switch to suit. Make particularly sure that the earth is *solidly* corrected to each power point and wire the power points such that when looked at *from the front* of the outlet, the order will be earth, active and nuetral in a clockwise direction.

Plugs, should be wired to correspond. That is looking at the rear of the plug, the order will be earth, active and neutral in a clockwise direction. This is VERY important as a reversal of active and neutral can be dangerous, for, if a single pole switch is used to switch off equipment and you fail to pull out the plug — there could still be an active present if the plugs etc are incorrectly wired.

It is essential to check that the outlet socket (into which the bench sockets are plugged) also be wired correspondingly. Generally it will be — but not necessarily so because the relevent regulation merely *recommends* that the 'clockwise' order be used — it is not compulsory.

The only way to be sure is to actually measure the AC voltage between the pin that *should* be neutral, and the earth pin (with power switched on of course).

It is quite normal to have the odd volt or two between neutral and earth — but if there's 240 volts or so there (and little between active and earth) then the outlet socket has been 'incorrectly' wired by the installation electricians. Have it corrected by a suitably qualified person.

If you don't have a meter available check by connecting a 240 volt globe between neutral and earth — and active and earth. It should be energized when it is between active and earth.

STORAGE

An electronics workshop needs tons of storage capable of efficiently storing everything from small components through tools to electronic equipment so that they can be located with a minimum of fuss.

For small components the small moulded-plastic drawer cabinets are ideal. For tools and other medium sized gear a set of conventional drawers is required, whilst for storing equipment, tins of lacquer etc, a cupboard with several shelves is ideal. Storage is expensive, but, if properly implemented, it can save many frustrating hours of searching.

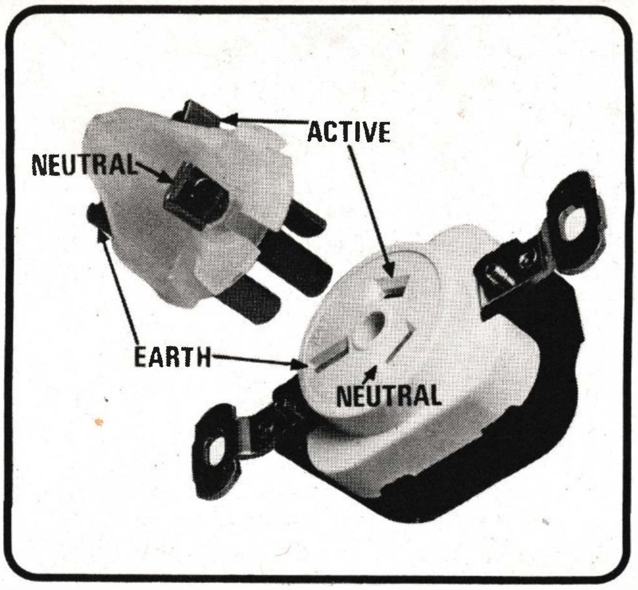
TOOLS

Very few tools are required for basic electronic work — soldering iron, set of screw drivers and side cutting and long nose pliers will do to get started.

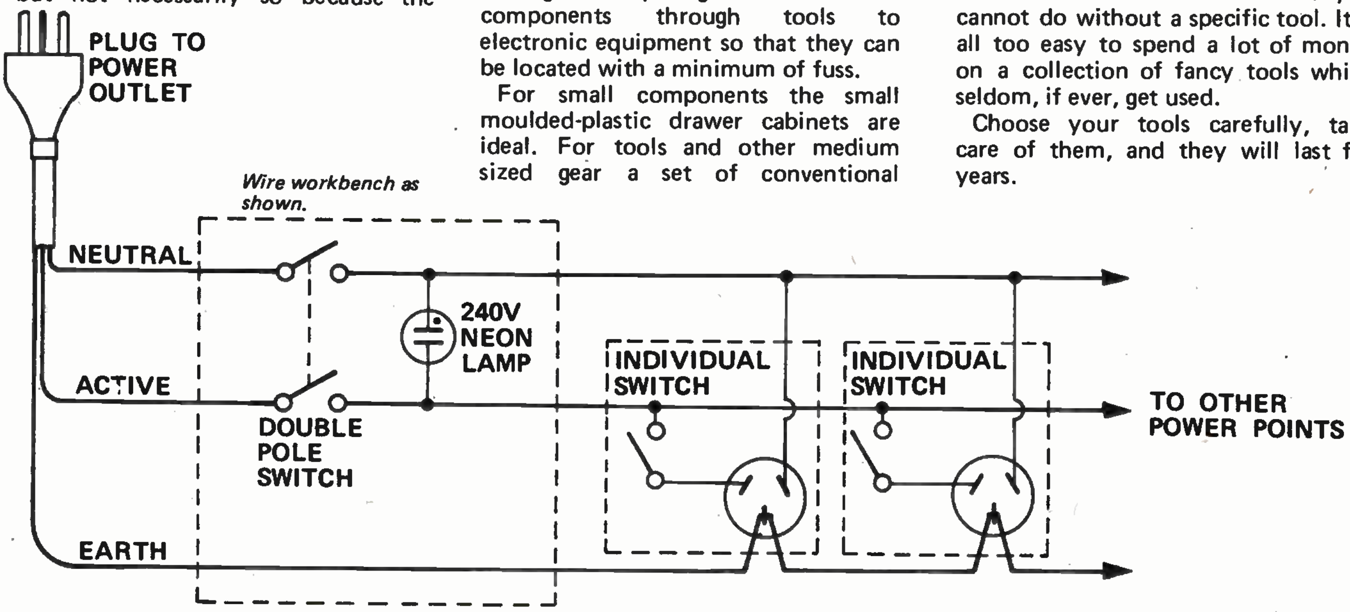
As one progresses other things will become essential. Typical second line purchases will be a set of files, a vice, an electric drill, and set of drill bits, nibbling tool, tin snips, steel rule and scriber.

All tools purchased should always be of the best quality that you can afford, cheap tools are *never* cheap in the long run, they do not perform satisfactorily and they wear out quickly. Purchase *only* those tools that you actually require to do a specific task and only add to your collection when it becomes obvious that you cannot do without a specific tool. It is all too easy to spend a lot of money on a collection of fancy tools which seldom, if ever, get used.

Choose your tools carefully, take care of them, and they will last for years. ●



How plugs and sockets should be wired.



Wire workbench as shown.

How to make sound solder joints

THE ART OF SOLDERING

SOLDERING is an art — an art that is essential to the successful building of fault-free electronic circuits. Suppliers of kitsets tell us that about 90% of all problems with kits are due to faulty solder joints. Hence the beginner (if he wishes to avoid much frustration and, possibly expensive service charges) *must* learn to solder correctly.

In essence, soldering is a method of making joints having low electrical resistance. It is not primarily used to give mechanical strength. If mechanical strength is required the component must be separately supported.

SOLDER

A good solder should have a low melting point, low electrical resistance, should go very quickly from liquid to solid state (and vice-versa) and should be capable of rapidly fusing to the metal surfaces being soldered.

Solder, for electrical connections, is an alloy of tin and lead. Pure tin melts at 327°C and is plastic over the range 183° to 327°C, whilst pure lead melts at 232°C and is plastic over the range 183° to 232°. Either metal, used alone, is unsuitable as any movement whatsoever whilst the soldering metal is in its plastic state will result in a faulty joint. However when lead and tin are mixed it is found that the melting temperature of the mixture is lower than for either metal alone, and the plastic temperature range is decreased. When the composition is 63% tin and 37% lead the mixture has no plastic region and goes from solid to liquid at precisely 183°C. However, in practice it is found that a very small region of plasticity is desirable in a solder for electronics, and the usual proportions are 60 percent tin and 40 percent lead. Other alloys are made for special purposes, but only 60/40 composition should be used for electronic purposes as this provides optimum-strength with lowest-resistance of electrical joints combined with the most desirable plastic range of about 5°C.

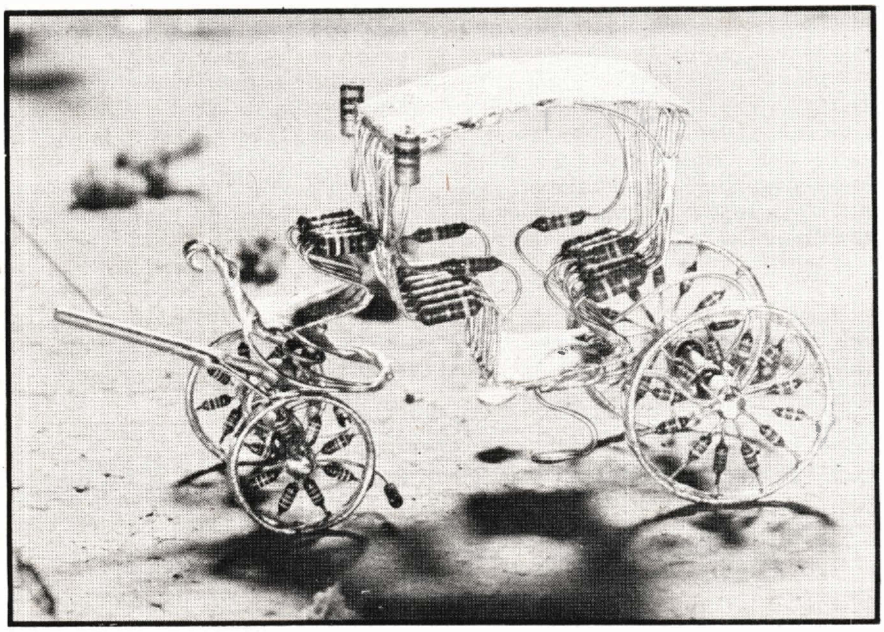
THE NEED FOR FLUX

All metals (even when freshly cleaned) are covered with a non-metallic film of oxide which prevents solder fusing to the metal. The oxide has a surface tension which effectively *isolates* the solder from the metal. For a reliable, low-resistance joint this oxide *must* be removed during the soldering process, and this is performed by the use of a flux.

The flux used for electrical soldering is a high grade of wood or gum resin together, with a small quantity of activator. The molten resin effectively wets both solder and metal, whilst the activator dissolves the oxides on the surface, allowing the solder to flow freely and form a molecular bond with the metal.

In order to dispense automatically the correct amount of flux, modern solders have the flux contained within cores in the solder itself. Five cores are generally used, throughout the entire length of the solder — so no additional flux is needed. Any excess flux hardens on the surface of the joint but it is completely non-corrosive.

Fluxes are also made for non-electronic uses. These are generally acidic and must *never* be used on electronic equipment as component leads and printed circuit board tracks will be corroded. Additionally the use of such a flux will



(photo — courtesy Siemens, West Germany)

completely void any warranty on a kit or electronic equipment on which it is used.

SAVBIT SOLDER

If the soldering iron has a copper bit the copper will gradually be dissolved in the molten solder. Thus the tip wears away quickly and requires constant filing and retinning. To overcome this problem some soldering iron tips have a copper core with an outer skin of iron. Another solution to the problem is to add a small amount of copper to the solder alloy. This prevents the absorption of further copper and greatly extends tip life. Such solder is known by the trade name of 'Savbit' The use of the Savbit solder can extend the life of ordinary copper tips up to ten times.

SOLDERING IRONS

There are many types of soldering iron on the market and those most commonly used in electronics may be grouped into three main categories.

(1) Quick heat irons.
(2) Continuous heat irons.
(3) Temperature controlled irons.

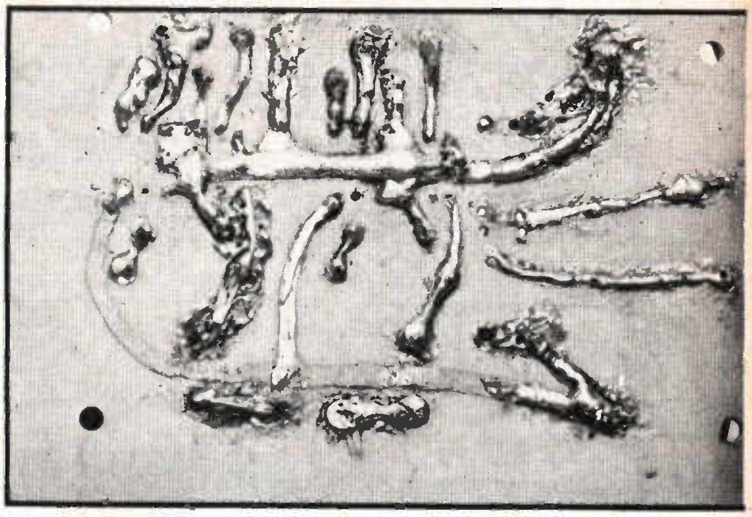
QUICK HEAT IRONS

Irons of this type generally work from a transformer which supplies a low voltage at very high current. The two main types are solder guns and low-voltage irons.

The solder gun passes a current of about 50 amps at 0.5 volts through a short length of copper wire, thus heating it quickly to very high temperatures. These irons usually include a reel of solder which is automatically fed to the tip each time a trigger is pressed.

The low-voltage irons have a copper tip against the rear of which a carbon contact is made. A current of around 30 amps at 3 volts is passed via this contact whenever the sleeve switch is actuated.

Both these types of iron are ideal for intermittent handyman use. However some irons of this type do not have an electrostatic screen on the transformer (which means delicate ICs and transistors could be damaged by leakage currents) and, if used improperly, are prone to overheat components and possibly damage them, and/or, the printed circuit board upon which the components are mounted. Such irons, (i.e. those without electrostatic shields) should therefore only be used for general electrical work for soldering to chassis and other tasks where large reserves of heating power are required. They are not recommended for printed circuit board assembly or general electronic service work. So before buying an iron of this type do make sure it has an electrostatic screen between the primary and secondary windings of the associated transformer.



How not to do it!

So much heat has been applied to this board, that in places the tracks have been damaged. In other places insufficient heat, or improper fluxing, has caused the surfaces to be not wetted properly. So much solder has been applied that one does not know where the tracks really are, or whether the joints are good or not! A kitset supplier would be quite justified in refusing to accept responsibility for a project, built this way and: not working.

CONTINUOUS HEAT IRONS

The most universally used irons are those of the continuous heat type. These irons are heated by an element of resistance wire wound around (but insulated from) the rear end of the copper tip. They are manufactured in wattages from about 6 to 250 watts but, for average electronic work, those most commonly used are rated between 15 and 30 watts.

These irons are slow to heat and hence are usually left running continuously. Such operation, although adequate, causes problems with oxidation of the tip. The tips therefore require constant attention and fairly frequent replacement.

Many workers find that these inexpensive irons are entirely adequate despite the drawbacks of continuous operation. They are light, cheap and well insulated.

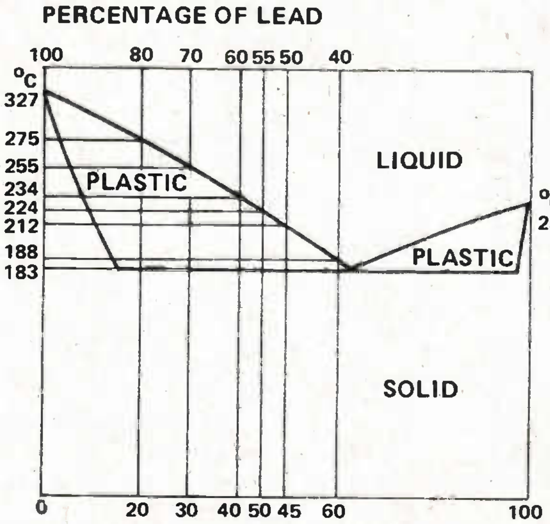


Fig. 1. How melting temperature and plastic range are affected by the relative percentages of lead and tin in a solder alloy.

HEAT CONTROLLED IRONS

For continuous use on a production line or in an electronics laboratory a temperature controlled iron is often used. Those irons are relatively expensive but are unsurpassed, for accurate soldering and for minimizing damage to components and printed circuit boards due to overheating.

A typical temperature controlled iron, (manufactured by Weller), uses a switch operated by a magnet and spring assembly (within the barrel of the iron) to control temperature.

When a ferromagnetic material is heated it is found that at a certain temperature, which depends on the material, all magnetic properties are lost. This temperature is known as the Curie point and is typically 1000°K for iron, 633°K for nickel and 1393°K for cobalt. Thus by alloying these or other ferromagnetic materials the Curie point of a material may be set to any required temperature.

On the Weller iron the tip has a small piece of material at the rear, called the sensor. This is designed to have a specific Curie point. When the tip is cold the sensor attracts the magnet

Project Building Guide

THE ART OF SOLDERING

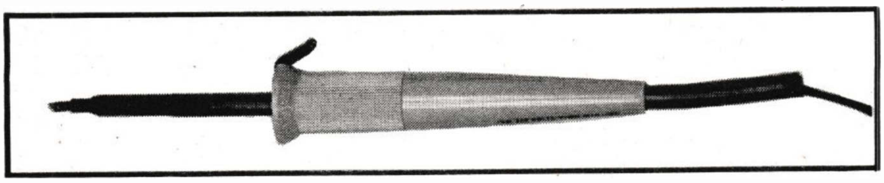


Fig.2. An ideal type of continuous heat iron — this one is from Adcola and is rated at 19 watts.

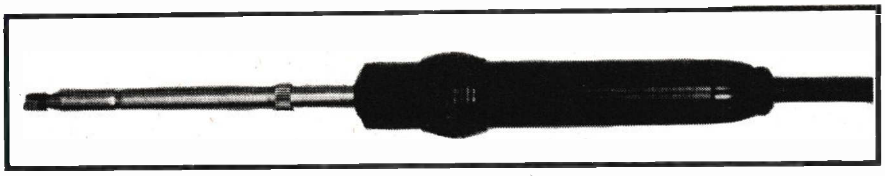


Fig.3. The Scope iron is of the quick heat type, it has enormous heating power. It heats within six seconds and is therefore switched on each time a joint is to be soldered by the sleeve switch on the handle.

and hence the switch closes heating the iron. When the tip reaches the Curie temperature the sensor pad is unable to hold the magnet which is then forced back by the spring. The switch therefore opens, removing power to the iron. It can be seen therefore that the iron will switch on and off automatically to maintain the desired temperature.

These irons operate from a 24 V transformer within the stand and are supplied with a variety of tips of different shape and operating temperature. The temperature is stamped on the base of each tip. Thus, one can pick the operating temperature most suited to the class of work.

Where 60/40 solder is being used for new soldering, a bit temperature of 250°C (500°F) will be adequate. This allows adequate margin over the melting point of 215°C to allow for heat conducted away by the component or terminal etc. Savbit No 1 solder melts at a slightly higher temperature, and for this a temperature of at least 275°C (550°F) is required.

For unsoldering, a higher temperature is needed again. This is because the surface of the solder becomes oxidized and heat flow is impeded. Hence for general service work we recommend a tip temperature of at least 315°C (600°F) and perhaps even 370°C (700°F) for large connections etc.

The tips for temperature controlled irons are all iron plated and should never be filed. The tips are cleaned during use by wiping on the small sponge supplied. This should be kept damp. If really dirty, steel wool or fine emery paper may be used.

If you can afford it this type of iron is by far the best available. The plated tips will last ten times as long as plain copper types, the irons heat in 30 to 40 seconds and have heating power equivalent to a 100 watt continuous type.

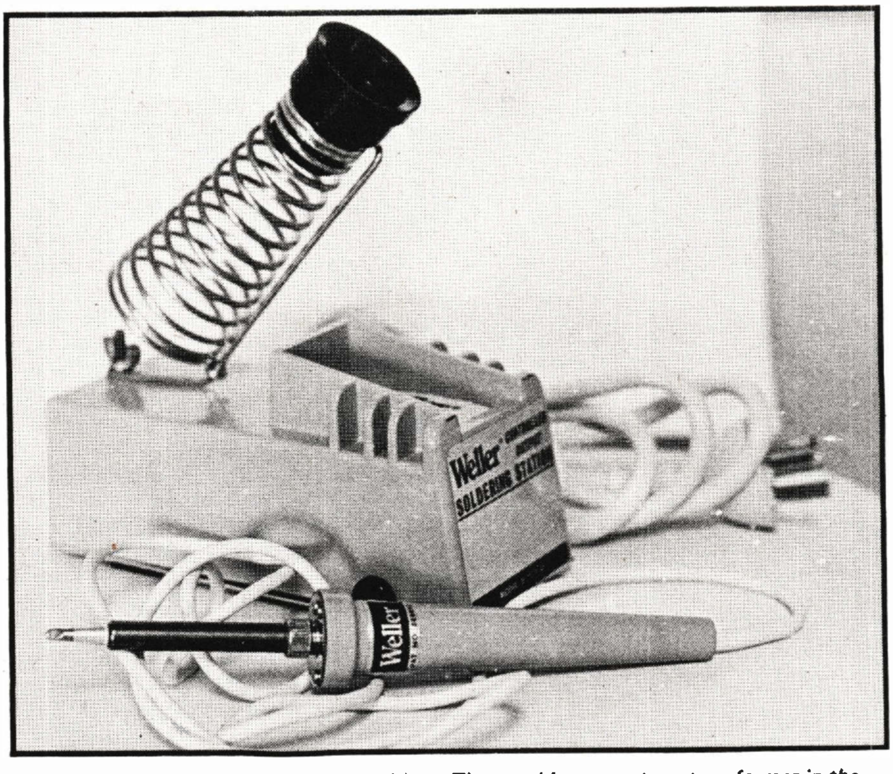


Fig.4. The Weller temperature controlled iron. The stand incorporates a transformer in the base. The operating temperature is selected simply by changing the tip.

TINNING THE IRON

To make sound solder joints it is necessary to keep the tip of the iron clean and well tinned.

Iron-clad tips only need to be cleaned occasionally with fine emery cloth whereas copper tips will need to be dressed with a file and retinned at regular intervals.

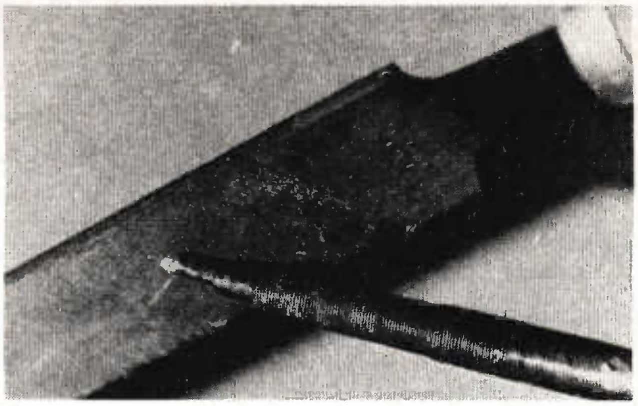
Whenever a plain copper tip becomes pitted, and oxidation scale builds up between the heating element and the tip, the efficiency of the iron will drop considerably. To recondition the tip, clean off the oxide scale and, while the tip is cold, dress it with a file to remove the pitted surface on the end of the tip.

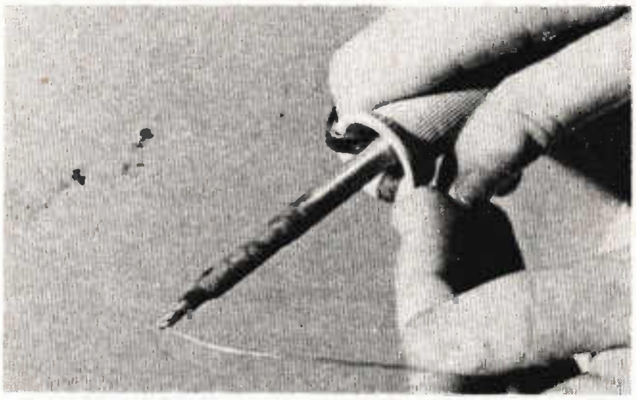
Heat the iron and apply solder at the lowest iron temperature which will melt it. Wipe the iron on a damp cloth or sponge until the whole tip is covered with a bright coating of solder. The iron is now ready for use.

PREPARING COMPONENTS AND LEADS

Most components have plated or pre-tinned leads which will accept solder without any special preparation. However, if the components are old, or the leads tarnished or oxidized, the leads to be soldered should be cleaned and tinned before attempting to solder them in position. To do this apply the iron and the solder to the lead until a uniform coating of solder is obtained. If the lead is unusually dirty, and will not take solder, pull it through a piece of doubled over emery paper.

Stranded hook-up wire should be prepared by stripping away about 7 mm of insulation from each end. The strands should then be twisted





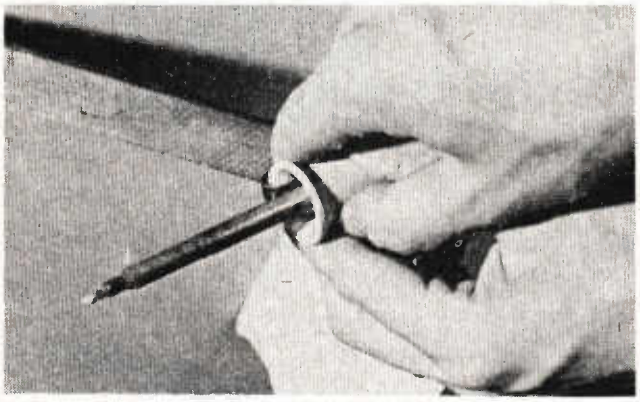


Fig.5. To tin the iron first file the tip so that a clean copper surface is obtained. Any pitting of the tip should be completely removed.

Fig.6. Next apply solder with the iron — just hot enough to melt the solder.

Fig.7. Finally wipe the tip with a damp cloth to obtain a uniform clean and shiny coating of solder over the entire tip.

together and tinned, and as detailed above, before the wire is attached.

MECHANICAL ASSEMBLY

When assembling components to printed circuit boards the component leads should be fitted through the correct holes and spread slightly, as shown in Fig. 8 so that the component is held firmly in position. Always mount the component such that its value, if printed on it, is visible. This facilitates later servicing.

Components are inserted from the non-copper side of the board, as shown in various pictures throughout this article, (this may seem totally obvious to experienced enthusiasts but it's surprising how often we and kitset suppliers come across boards on which the components have been mounted on the copper side!).

When fitting components to terminals or tag strips turn the lead half way around the lug or tag so that the component is mechanically secure. This prevents component movement (and resulting faulty joints) whilst the solder is cooling. Do *not* make a full turn, or more, around the lug as this will make it very difficult to remove the component in later servicing.

SOLDERING

The iron must be fully up to working temperature and the tip clean and coated with 'wet' solder. It should actually look 'wet' and shiny. If it doesn't, touch it briefly with the solder and wipe off surplus onto a damp sponge.

Now press the tip against the terminal (or printed circuit board track) *and* the end of the component lead. Preheat like this for two to three seconds.

Still keeping the iron in position, apply solder to the joint — never to the iron. Continue to apply solder only long enough for the solder to flow evenly over the joint. After removing the iron you must let the joint harden before moving either the component or the PC board. Then snip off any excess lead.

A correctly soldered joint should be bright and smooth. Poor joints look crystalline and grainy or, the solder tends to the in blobs (that is solder has not wetted the surface properly).

Take care not to apply too much solder as it is difficult, then, to see if the joint is a good one. Solder bridges may also be formed.

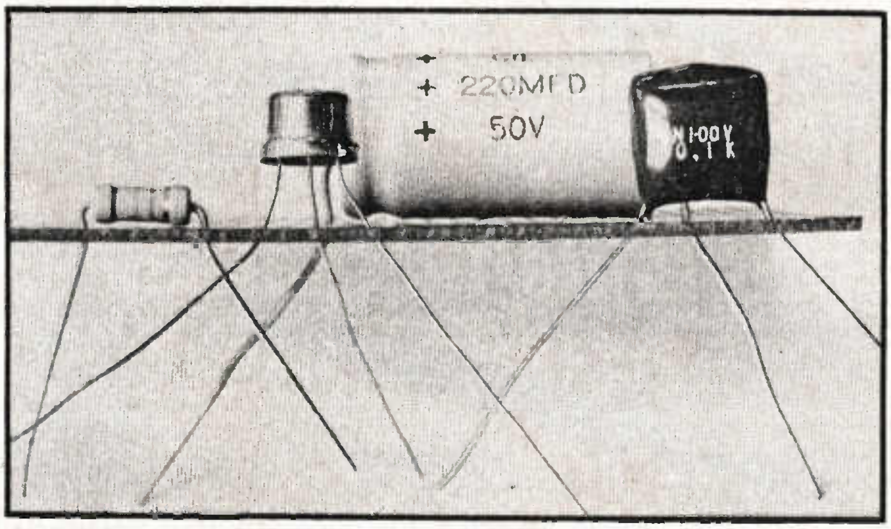


Fig.8. When components are fitted to a board the leads should be splayed, as shown, to keep them in position prior to soldering. Position components so that values and voltage ratings may be seen. This facilitates later servicing.

Project Building Guide

THE ART OF SOLDERING

REMOVING COMPONENTS

If it is necessary to remove a component from a printed circuit board the solder should be removed from the joint by 'wicking'. To do this remove about half an inch of insulation from a piece of stranded hook up wire, dip the prepared end into liquid resin and lay it on top of the solder joint. Then apply the flat tip of the iron above the wire and joint until the solder melts and is sucked up by the wire. Repeat the procedure if necessary to remove all excess solder from the joint. Alternatively a proprietry product such as 'Solderwick' (braid that is pre-fluxed) may be used.

After all excess solder is removed, it is a simple matter to pry the component loose. Removing

(Continued on page 55)

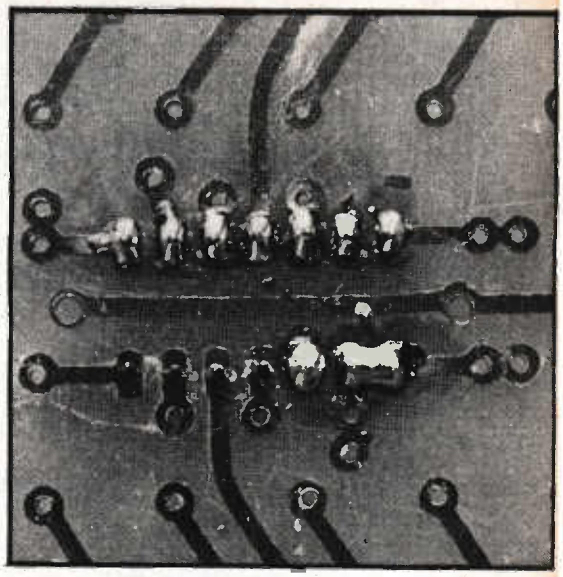


Fig.12. Too much solder may cause solder bridges. The top row of joints to this IC are fine but on the bottom row too much solder has resulted in a solder bridge (bottom right).

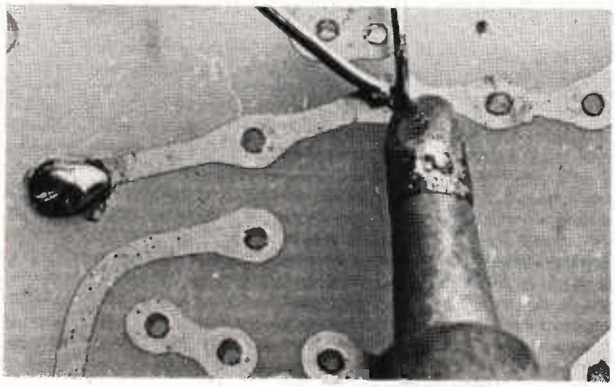


Fig.9. Apply the soldering iron to the joint so that the track and component wire are heated together for about two seconds, then apply the solder to the joint — NOT to the soldering-iron tip.

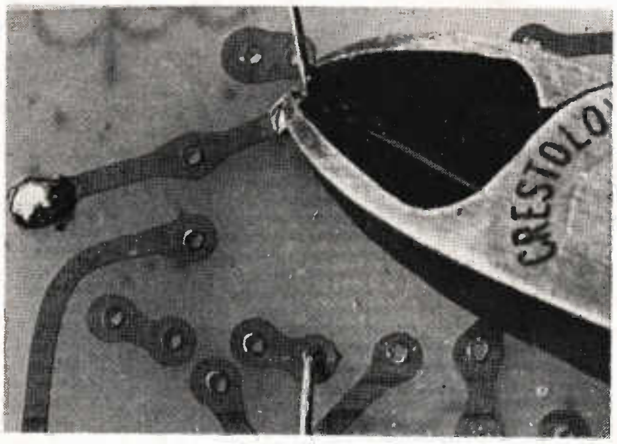


Fig.10. Allow the joint to cool completely undisturbed and then snip off the excess component lead. A joint that has been disturbed during cooling will appear crystalline and will probably be 'dry' (that is it will have a high resistance which will affect circuit operation).

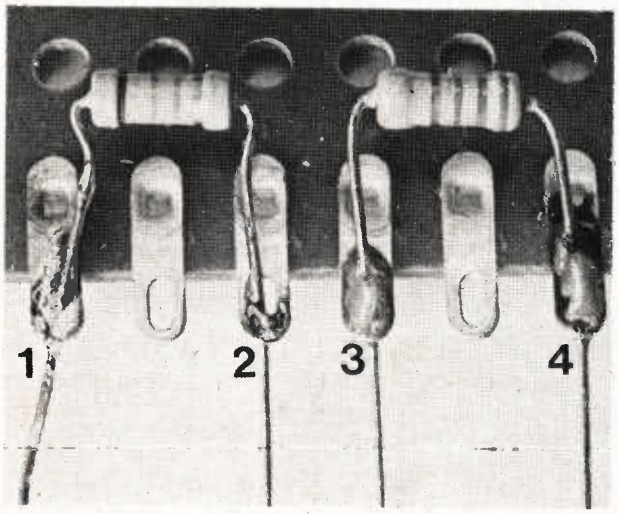


Fig.11. How the joint will appear — from left to right (1) too much heat results in solder leaving the joint. Movement of joint before it cooled results in the crystalline appearance. (2) Insufficient solder and not enough heat — solder has not wetted the tag. (3) A good joint should be smooth and shiny. (4) Solder has not thoroughly wetted the tag — the joint could be dry.

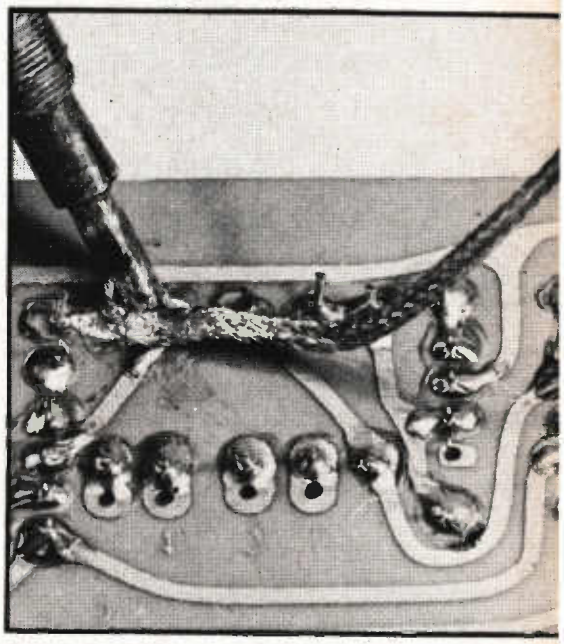


Fig.13. To de-solder using Solderwick apply the braid over the joint and place the iron on top of the braid until the solder is sucked up.

Fig.14. In a 'dry' joint the solder has not properly bonded to either or both metal surfaces, or the joint has been moved during the plastic region of the molten solder. Such joints have a high electrical resistance and low mechanical strength. Here this resistor lead 'dry-jointed' to a potentiometer may be pulled away quite easily.

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THE ART OF SOLDERING

components by means of vacuum solder suckers (although effective) must be done very carefully indeed as there is a tendency for the devices to lift the copper tracks from PC boards. Although, as we have said, the method is very effective we don't really recommend it for amateur use.

Solder bridges, if they occur, should be removed by wicking and resoldering, or by heating the bridged area with the iron and wiping quickly with a soft cloth or with a brush to remove excess solder. Resolder the cleaned joints using less solder.

SOLDERING SEMICONDUCTORS

Most semiconductors will be damaged if subjected to too much heat. Hence transistors and ICs, etc, should be soldered quickly and cleanly. If you doubt your ability to do this — use a heat shunt (eg pair of long nose pliers), between the end of the lead being soldered and the transistor body, to divert heat from the device.

Integrated circuits based on MOS or CMOS technologies are particularly prone to damage during soldering not only due to heat, but also by electrostatic charges or leakage currents. These devices should be left with their pins inserted in the black conductive foam (in which they are usually supplied) until they are to be used. Avoid touching the pins of the IC as even static discharges from the body can possibly cause damage.

MOS and CMOS ICs should be the last components to be fitted to the board. They should be inserted quickly and cleanly, and the power supply pins should be soldered first. This activates the built-in protective circuitry and the remaining pins may then be soldered without fear of damage. Beginners may well find that it is safer to use an IC socket for MOS and CMOS ICs as soldering directly to the IC is not then required. ●

CONSTRUCTIONAL METHODS

Veroboard, matrix board, printed circuits — or tag strips.

ELECTRONIC PROJECTS may be constructed in several different ways. The simplest by far is by using a printed circuit board. Boards, etched and drilled for specific projects are readily available from most of the kitset and component suppliers who advertise in this magazine. Alternatively, pc boards (as they are usually called) can be made at home.

Other methods of construction include matrix board, Veroboard and tag strips. The pros and cons of each method are described in this article.

VEROBOARD

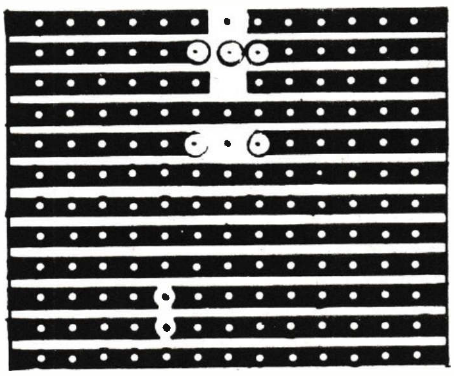
Veroboard is a commercial product specifically made for rapidly assembling prototype equipment, or for building one-off projects etc.

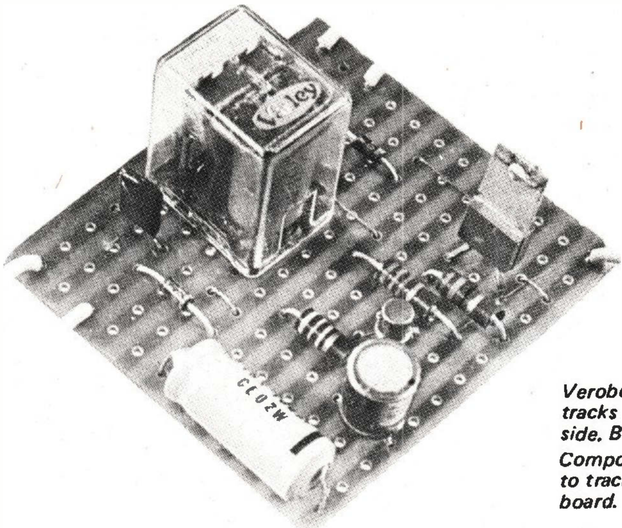
It consists of a high-grade laminated circuit board upon which parallel copper strips are bonded. The board is pierced by a matrix of holes, for inserting component. These holes may be at 0.1, 0.15 or 0.2 inch spacing. For miniature electronic work, incorporating integrated circuits, the 0.1 inch pitch is most commonly used, whilst for general electronics, the 0.15 inch pitch is very popular.

USING THE BOARD

To assemble a circuit using Veroboard, the components are inserted into the board such that they are interconnected by the copper strips in the desired pattern. Where a break in the copper strip is required a sharp drill (as shown in the illustration) or a 'spot face cutter', specifically made for this purpose, is used.

The components for a simple circuit may be placed on Veroboard in the same configuration that they have in the circuit diagram. This makes circuit





Veroboard — board has copper tracks bonded to non-component side. Breaks are cut where necessary

Component leads are soldered to tracks on copper side of board.

checking much easier and any faults are subsequently easier to find.

Most connections may be made directly to the copper strip but, where strong connections are required, or where many wires are to be terminated at the one point, Veroboard pins may be inserted to make secure terminals.

MATRIX BOARD

Whilst Veroboard is very suitable for one-off equipment that is to be used permanently, it's rather difficult to strip and use again.

Matrix board, is more suitable for re-use in mocking up first prototypes but may also be used for equipment of a more permanent nature.

Matrix board is perforated with holes, in the same way as Veroboard, but does not have the copper strips. To use it one inserts the components through an appropriate set of holes and makes connections by routing the component leads at the rear of the board or, by using tinned copper wire to link the components. This sounds pretty messy, but it is surprising how quickly circuits can be built up and — how neatly they can be made.

Where component leads or the tinned hook-up wire cross they should be insulated by a small piece of insulating 'spaghetti'. This does not need to be done as often as one would think and quite complex circuits may be assembled neatly, compactly and speedily.

Matrix board is available in 0.25 inch or 0.1 inch spacings. The latter is preferable for miniature electronic work. Turret pins and eyelets are also available at low cost if required. Thus the matrix board system is ideal for assembling experiments as well as of one-off special equipment.

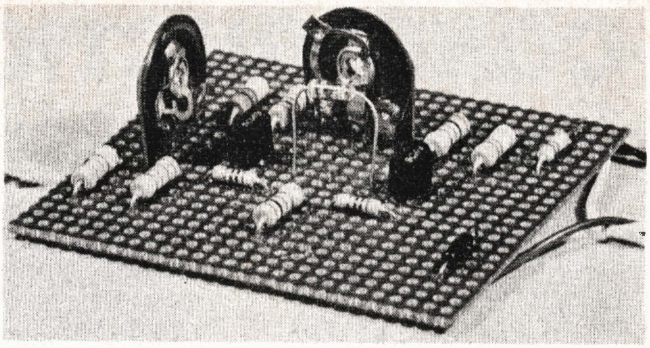
PRINTED CIRCUITS

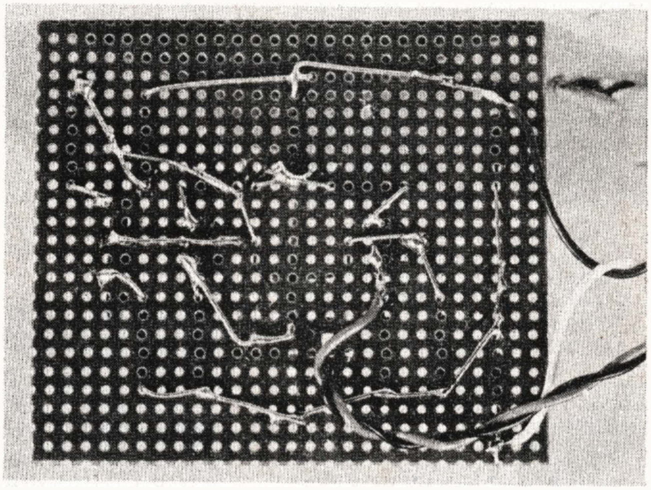
Printed circuit boards simplify electronic circuit building enormously — to the extent that some enthusiasts feel that it is degrading the hobby to that of 'painting by numbers' — but of course you can always make your own circuits, as explained here.

The boards are made of a phenolic resin or glass fibre laminated with a thin copper sheet bonded (generally) to one side.

Intercomponent wiring is formed by etching away the unwanted copper — so that only the required tracks remain. Holes are then drilled for the components which are mounted on the non-component side and their leads soldered directly to the copper tracks.

Most component and kit set suppliers stock printed circuit boards already drilled and etched for most popular projects. They also stock printed





MATRIX BOARD — Components are inserted through holes and leads soldered on non-component side. Novices find matrix board easy to use as components and wiring can be positioned exactly as on the circuit diagram.

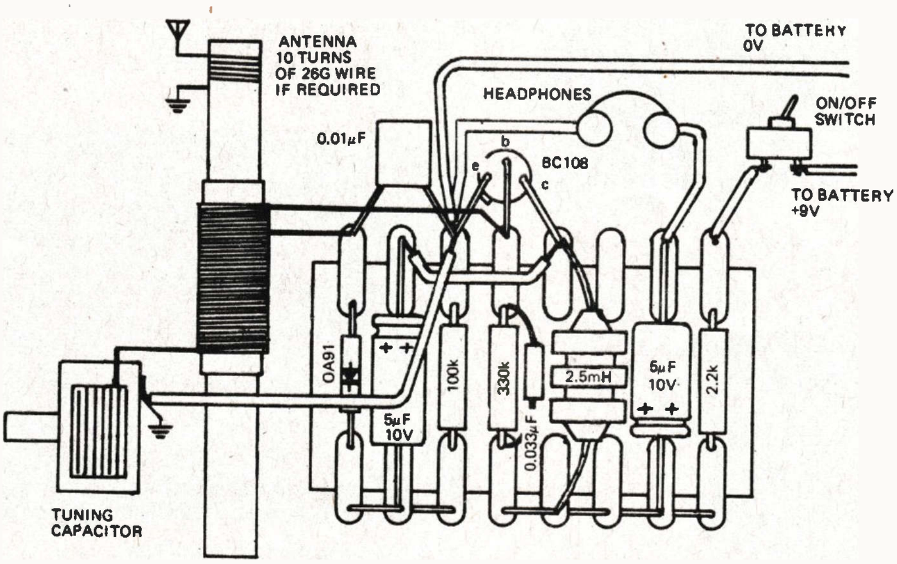
circuit board material for those who like to make their own boards.

There are very many different ways of etching printed circuit boards. The method described here is virtually identical to that used by our own projects laboratory at ETI. We use this method as in our experience it is the simplest, least messy way of making professional looking boards.

Although printed-circuit boards can be prepared for etching by painting the design on the board with bituminous or other etch-resistant paint or ink, one of the so called photo-resist methods is preferable by far.

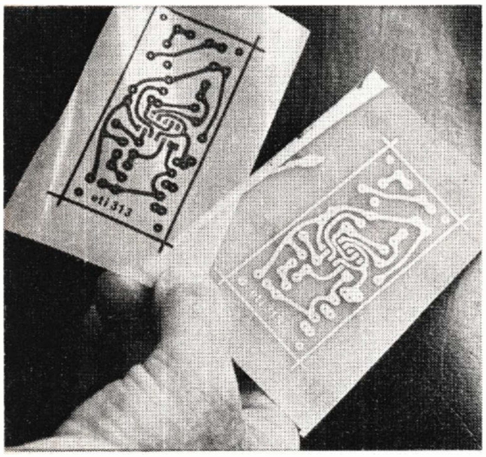
Two methods are used — **negative resist** and **positive resist.**

The negative resist method is very effective, it is commonly used commercially but requires a photographic negative of the printed-circuit layout, whereas the positive resist process does not. Hence, using positive resist, a step which may



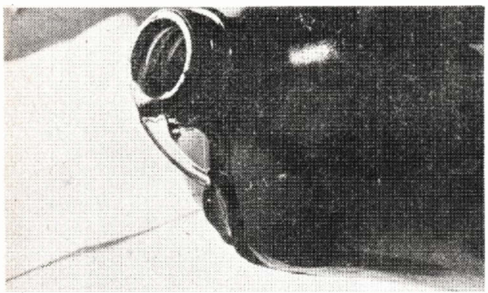
Tag Strips — construction is quick, cheap and simple. However the method is only really suitable for small scale projects as inter-tag wiring will otherwise be extensive and tedious. The method also wastes space. (Circuit shown is of a single transistor reflex receiver first published in our December 1971 issue).

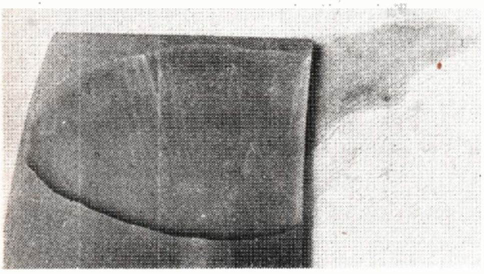
CONSTRUCTIONAL METHODS



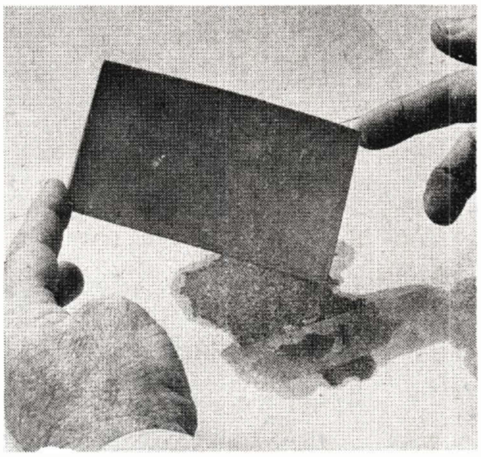
The artwork is prepared (full size) on a piece of transparent film using opaque PC board tape and pads. An original master is shown here together with an etched but untrimmed or drilled board.

The laminate should be thoroughly cleaned with paper towel and abrasive cleanser powder until the surface is uniformly bright, and wets uniformly.

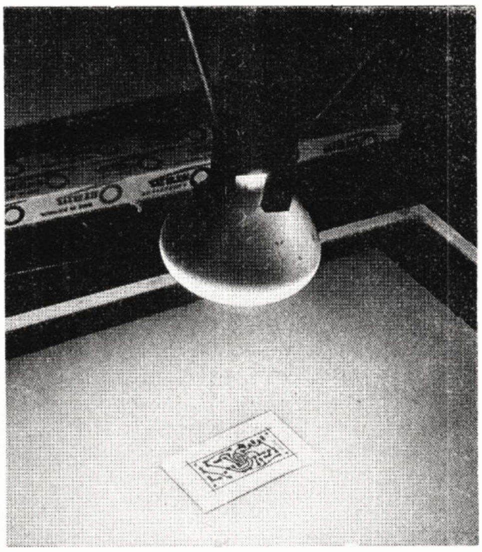




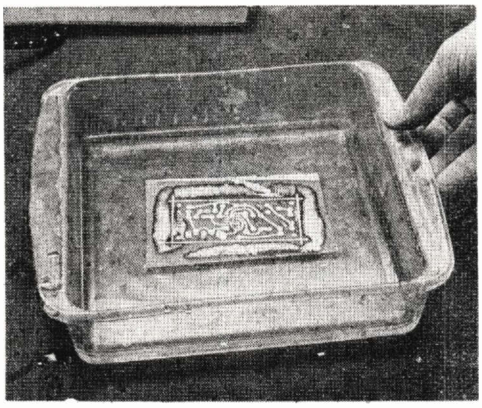
The prepared laminate is coated with a thin film of 'resist' and allowed to dry.



Excess resist should be drained off and the board dried in a dark and dust free place.



The artwork is placed on top of the copper side of the board and sandwiched between a piece of foam and a sheet of glass. The board should then be exposed to light with a high ultra violet content for a time as detailed in the text.



After exposure the resist is developed (see text) the board allowed to dry and then etched in ammonium persulphate or ferric chloride solution. The board here is seen when partly etched.

be difficult for some experimenters is eliminated.

The process described here is based on the CCPR12 positive resist and associated developer marketed by Bishop Graphics. This is available in NSW from Circuit Components or from suppliers of printed-circuit board materials in other states.

HOW IT WORKS

The copper surface of the board is coated with resist and then exposed to light through a piece of translucent film upon which the desired circuit pattern has been layed out with opaque artwork tape and/or ink. When subsequently developed the resist that has been exposed washes away leaving an etch-resistant pattern of the required circuit. The exposed copper may be etched away with ferric chloride or ammonium persulphate.

THE ARTWORK

Materials are available from suppliers for making the so-called 'artwork'. This is the required pattern laid-out full size, with opaque tape onto nylon film. Tapes of various widths are available together with stick-on transistor and IC pads. Such materials, although relatively expensive, greatly facilitate making artwork.

1. LAMINATE PREPARATION

(a) Allow an 8 mm border beyond the finished board perimeter to simplify handling.

(b) Scrub laminate thoroughly with a powdered abrasive cleaner using a new Scotchbrite pad or clean paper towelling and water. (Do not use sponge type kitchen pads or steel wool, due to their susceptibility to grease retention).

(c) Hold scrubbed laminate under running water and check that the copper surface 'wets' evenly all over. If a break appears, rescrub and retest.

(d) Dry with a clean piece of paper towelling, being particularly careful not to touch the prepared surface of the laminate with the fingers. (Skin oils will contaminate the surface and nullify the preparation). Then brush the surface with a 'soft', clean brush to remove lint, dust etc.

2. COATING THE LAMINATE

(a) Pour a small pool of resist in the centre of the prepared laminate and thinly smooth over the surface with a ½" to 1" paint brush. (Use a new brush and keep for use with CCPR 12 Resist only. Wash brush in methylated spirits, then in soap and water). A "streaky" appearance when wet usually settles evenly during the drying process.

(b) Place coated laminate in a preheated oven at 80 to 90°C (176 to 194°F) for 10 minutes. This will dry the resist sufficiently for exposure.
It is recommended that ovens using exposed or infra red elements not be used as the red light may prevent the photo-sensitivity from functioning. Where these and gas ovens are employed, bring the oven up to temperature and switch off, then place the prepared laminate in the upper section of the oven for 15 to 20 minutes.

EXPOSING

Now place the artwork in intimate contact with the prepared board by sandwiching the board and artwork between a sheet of polythene foam and a piece of thoroughly clean glass.

The sandwich must now be exposed to light. This can be done in several ways — two of which are described below.

(a) Direct sunlight may be used — the exposure time should be four to five minutes.

(b) Using 2 x 20 watt Sylvania type F20T12-BL fluorescent tubes (or Philips Actinic Blue Fluorescent tubes, both makes being 3900 angstroms) mounted on a twin batten unit, at a distance of 25 mm, a master made on single matte film, typically requires an exposure time of four minutes. The time will vary depending on the film used (clear, single matte or double matte) and the distance between the tubes and the work. Clear film typically halves the exposure.

DEVELOPING

(a) To 1 litre of water add 40 grams of CCPD16 developer crystals. Place the solution in a glass or plastic tray. (Do not use aluminium containers as this solution is alkaline and will be contaminated by the aluminium).

(b) Immerse the exposed laminate in the developer and rock gently, avoiding splash. Another very satisfactory method is to lightly brush over the surface, while fully immersed, with a clean paint brush.
The exposed areas should dissolve completely within two minutes. This developer is not flammable, but should be treated with care. Always wash hands and other exposed skin areas as soon as possible.

(c) Rinse the developed laminate under running water and dry off with a soft cloth, then allow to stand in free air to stabilise for approximately 30 minutes.

(d) Where a very hard finish is needed, post baking at 100°C (212°F) for five to 10 minutes is recommended. Allow laminate to fully cool before etching.

ETCHING

Two suitable etchants are:

(a) **Ferric Chloride:** Yellow lump (hydrated). Mix 1 kilogram with each litre of water. To speed dissolving, heat the water to between 75 and 85°C (167° – 185°F).
Ferric Chloride: Anhydrous. Mix 500 grams with each litre of cold water. Important, add the powder to the water slowly stirring continuously, as this process generates extreme heat.
An ideal etching method for one or two small boards is to use a plastic paint roller tray and plastic handled nylon bristle hand broom. Place the board on the draining board, and the *cold* ferric chloride in the reservoir, then sweep the ferric chloride up and brush over the surface of the resist. This should be done at approximately one stroke per second. This should give an etch time of four minutes with a fresh solution of etchant.

(b) **Ammonium Persulphate:** Dissolve 200 grams in half litre of water. This solution should be heated to 40°C (100°F) but not above 50°C (125°F) for etching. Form a "basket" of plastic tubing and use a continuous "dunking" action until fully etched. Constant agitation is essential and a fresh solution should etch in five to seven minutes. This is a particularly clean etchant, but does not etch as much area as the same volume of ferric chloride. Note that this particular etchant is extremely slow when used cold.

Warning: Avoid spillages. If spilt or splashed, wash from affected areas immediately otherwise damage will occur.
When etching is completed, wash off in running water, then strip the resist off with methylated spirits or lacquer thinners. However if required this resist may be left on the finished board as it does not greatly impede soldering.
The resist is not a flux, therefore an electrical grade cored solder should be used in final assembly.

Warning: Exercise caution when using all chemicals, do not smoke, do not use the resist, thinners or methylated spirits near naked flame, and on no account use any utensil which has been used with chemicals for food or drinking purposes. Good housekeeping is essential for good results — keep all utensils clean and dust free. ●

SOLVING PC BOARD PROBLEMS

	PROBLEM	PROBABLE CAUSE
(a)	Resist will not "take" in spots (breaking surface tension).	Laminate not cleaned properly.
(b)	Resist will not wash off exposed areas during development.	(1) resist under-exposed (11) developer too weak (111) oven temperature too high
(c)	Resist washes away during development.	(1) board baked at too low a temperature (11) baking time too short (111) developer too strong (1V) board overexposed or has been exposed to ultra-violet light prior to development.

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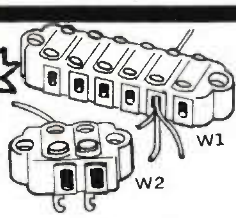

PAINTON 'CAM-BLOCK' terminal block . . . providing a fast, positive method of effecting terminations which completely eliminates the danger of severed wires, the necessity for tinning, and the disadvantage of loose parts. The 'CAMBLOCK' comes in medium miniature and sub-miniature size. The heavy duty medium is rated at 30amps, the miniature at 20amps and the sub-miniature at 10amps.

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Pt. No:	No. of Ways	Type.	Price each.
0205	5	Medium	65c
0208	8	Medium	95c
0242	2	Miniature	40c
0310	10	Sub-min	$1.00
0320	20	Sub-min	$1.25
0330	30	Sub-min	$1.50

WIRE-IN/SOLDER SPILL-OUT TYPE. (W2)

0223	3	Medium	55c
0263	3	Miniature	35c
0264	4	"	40c
0269	9	"	60c
0271	11	"	65c
0333	3	Sub-min	60c
0334	4	"	65c
0336	6	"	75c
0337	7	"	90c
0340	10	"	$1.00
0341	11	"	$1.25
0350	20	"	$1.50

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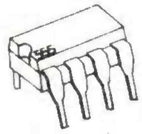
Type TW single Turn 5 watts. In the following values: 2.5KΩ – 5KΩ – 10KΩ – 20KΩ – 25KΩ – 50KΩ & 100 KΩ $2.50 ea. P&P 30c.

Type MW Single Turn 1 Watt. In the following values: 10 & 50Ω, 10-30 & 40kΩ. Body dia. 91". Standard ¼" x 5/8" spindle. Non-sealed. All values $1.00 each P & P 20c.

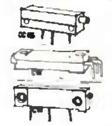
Type MWT. Single Turn 1 Watt. In the following values: 500Ω Spindle ¼" x 5/8" same dimensions as Type MW but sealed. $1.25 P & P 20c.

PRICE CRASH 3



SIGNETICS LINEAR IC. TIMERS
NE555 TIMER. As recommended in the ELECTRONICS TODAY project features, in the November issue. Owing to an enormous purchase of these very versatile linear I.C.'s we can now offer them at the very low price of **$1.25 each or 10 for $11.00.** FEATURES: Timing from Microseconds through Hours; Operates in both Astable and Monostable modes; Adjustable Duty cycle; High current Output can source or sink 200 mA; Output can drive T.T.L.; Temperature stability of 0.005% per °C Normally ON & OFF output. Also special offer of **Signetics NE556 Timer** (Replace 2 NE555 Timers). Same features as above but in a 14pin D.I.L. package $2.15 each or 10 for $20.00. NE553 4 Timers in one 14pin D.I.L. package . . . Only $3.35 each.

NEW



RELIANCE CONTROLS MULTI-TURN WIRE-WOUND TRIMPOTS.
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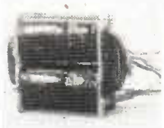

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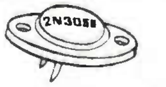

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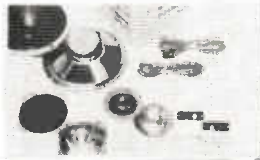
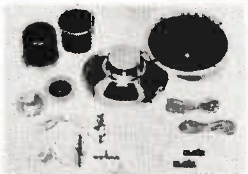
Features (8SA-1)

Type of cabinet	Closed type
Type of speaker	3-way 3-speaker
Input impedance	8 Ohms
Crossover frequency	4,000 : 9,000 Hz
Frequency response	70 ~ 20,000 Hz
Sensitivity	93 dB
Capacity	35 W



$30 PAIR



Price $50 PAIR

10" CORAL SPEAKER SYSTEM KIT 10SA-1
50W, 3-way, 3-speaker system in kit form includes all speakers, crossovers, terminals, wire, screws, coral emblem for front of box.
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Features (10SA-1)

Type of cabinet	Closed type
Type of speaker	3-way 3-speaker
Input impedance	8 Ohms
Crossover frequency	2,000 : 6,000 Hz
Frequency response	40 ~ 20,000 Hz
Sensitivity	93 dB
Capacity	50 W

12" CORAL SP. SYSTEM KIT 12SA-1
60W, 3-way, 4-speaker system in kit form includes all speakers, crossovers, terminals, wire, screws, coral emblem for front of box.
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Features (12SA-1)

Type of cabinet	Closed type
Type of speaker	3-way 4-speaker
Input impedance	8 Ohms
Crossover frequency	1,000 : 10.000 Hz
Frequency response	30 ~ 20.000 Hz
Sensitivity	95 dB
Capacity	60 W

Price $70 PAIR

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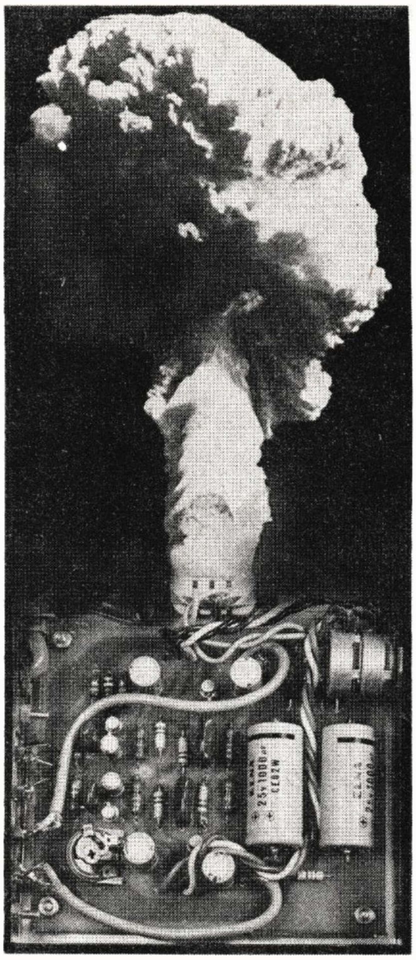

Project Building Guide

WHY DOESN'T IT WORK?

Don't call us — just read this!

OCCASIONALLY we and kitset suppliers receive phone calls (some abusive and some plaintive) from project builders who have been unable to get a project to work. Almost invariably when such complaints are investigated it is found that the problem is due to one of several common mistakes made by beginners.

The most common single cause of trouble is poor soldering. Good soldering technique is *absolutely essential*. A beginner would be amply rewarded by studying the "How to Solder" article in this issue. For example a digital clock kit built by one reader exhibited all kinds of queer faults but after reworking *all* the solder joints — the clock worked perfectly.

A further example involved one of our special IC offers. A young reader complained that both the ICs he received were faulty. We replaced these free of charge but were subsequently told that these too were faulty.

As only a tiny proportion of new ICs are faulty (<1% typically) the chances of a reader receiving two bad ones is remote — to receive four is improbable in the extreme.

On further investigation we found that very poor soldering had not only destroyed the ICs — it had ruined the pc board as well. A photograph of the board is included on page 49 not deliberately to embarrass our reader, but to illustrate just how soldering should *not* be done. Note the multitude of imperfect joints (despite the weight of solder used) and that some tracks have disappeared completely from the board.

CONNECTIONS

In every constructional article constructors are warned to check orientation of components yet, in many cases where complaints are investigated ICs, transistors, diodes and capacitors are found to be inserted the wrong way round. Double check orientation (or even triple check) before soldering in components. Give the whole board another check before switching on the power.

Note particularly that different brands of transistor having the same part number (eg BC548, BC558 series) may have *different* pin connections. Other transistors that are electrically similar to each other may have different pin connections again. (The correct pin connections are generally shown in ETI projects — if in doubt, refer to manufacturers' data sheets).

On several occasions we have seen components located on the copper side of PC boards rather than the non-copper side! This requires considerable mental dexterity to reverse correctly the component lead configurations given in component overlays. It *can* be done but it invariably leads to foul-ups!

Power transistors must be fitted to the correct specified heat sinks. Where specified they *must* be correctly insulated from the heatsink.

Fit components snug against the board and keep wiring as short as possible Untidy assembly inevitably leads to wiring errors.

To return to soldering again, use only enough solder to make a good joint. Using too much solder can result in bridges between tracks or IC pins that are sometimes difficult to detect visually.

Where a setting up procedure is given make sure that the procedure is followed *exactly*. For example power transistors may be destroyed if the bias control is set at the wrong end when a power amplifier is first switched on.

SUBSTITUTION

Don't substitute components for those specified unless you know *exactly* what you are doing. Time and time again we waste hours trying to advise a reader how to fix a project that won't work — only to find that despite denials — a completely unsuitable component has been substituted for that specified. In one example a reader completely 'redesigned' our allegedly faulty power supply because he didn't appreciate that a transformer has a much higher output voltage off-load to on-load — then he wondered why his resultant supply produced too low a voltage to drive the rest of the project.

There are one or two minor exceptions to the above — for example some (generally overseas) projects specify 50 k or 500 k potentiometers. However most manufacturers now produce potentiometers in preferred ratings only — i.e. 4 k7, 47 k, 470 k etc. These may be substituted directly.

Resistors are made in various tolerances — 1%, 5%, 10% and 20% for example. Most projects specify 10% or 20% resistors — in other words the value is not critical within ± 10% or 20%. Therefore it is often perfectly satisfactory to replace a nominal 470 k resistor with say a 430 k resistor if the latter's value is reasonably accurately known, for the 430 k is well within the 10% tolerance of the nominal value.

Even greater liberties may often be taken with electrolytic capacitors where tolerances of 50% (or even 100%) of capacity are quite normal.

Generally though it is best to assume that the circuit's designer knows more about the project than you do. So stick to the components specified! ●

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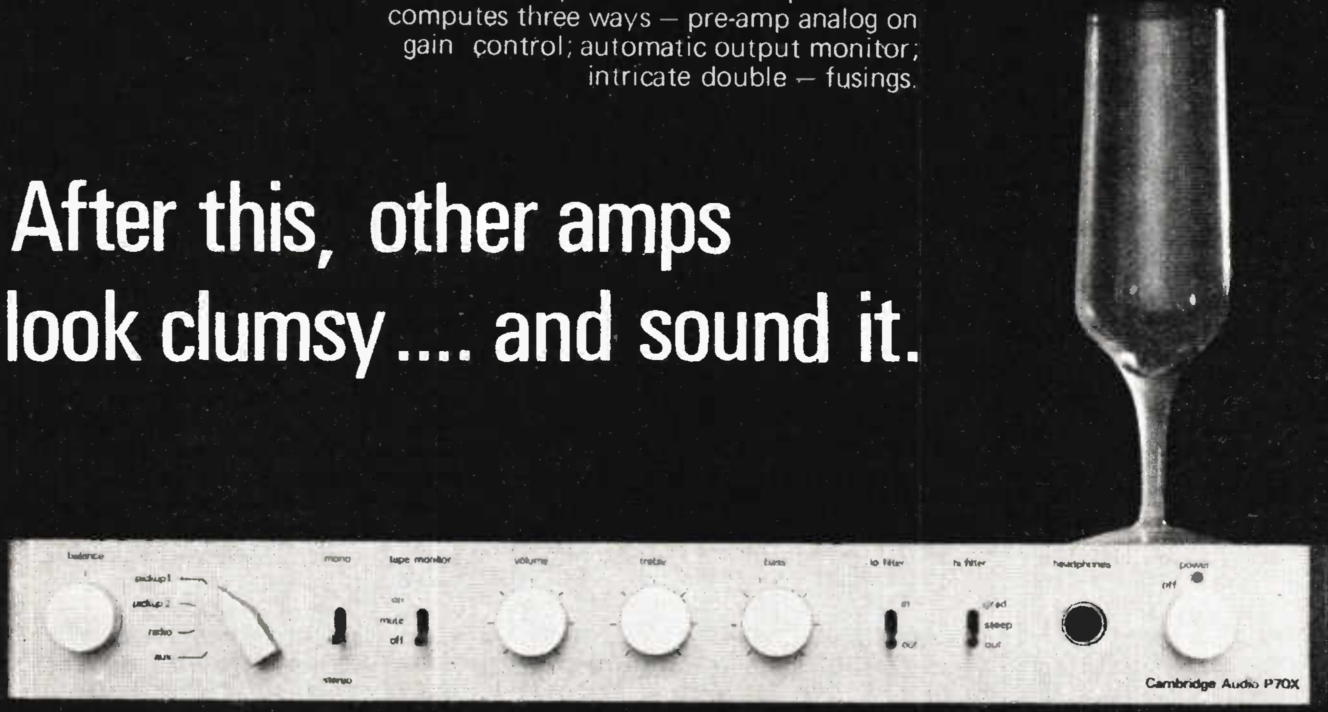

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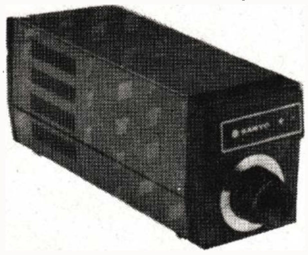

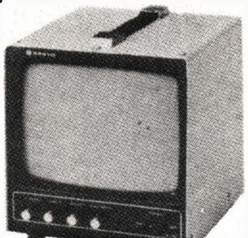

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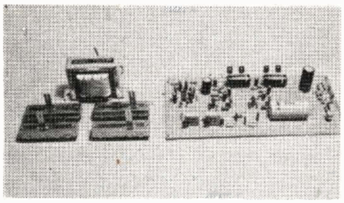

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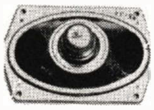

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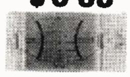

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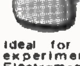

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(See E.A. April '75)

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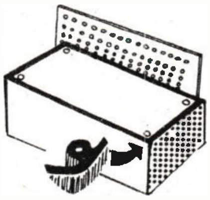

Here's the boxes for project builders who want a real professional look to their projects. These boxes are moulded in ABS, so they are tough yet easy to drill. The finish is a posh black with ingenious posts in each corner to take self tapping screws and hold a printed circuit board. They are supplied with a flush fitting aluminium panel which fits all ways round (such is the precision of these boxes). Special panels are also available made of bakelite at **50c** and matrix board at **60c** (large size only).

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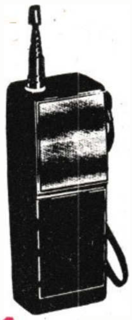

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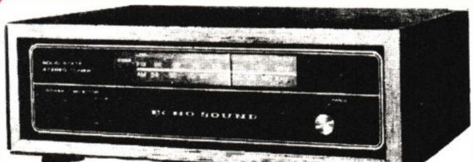

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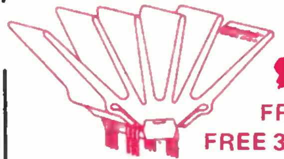

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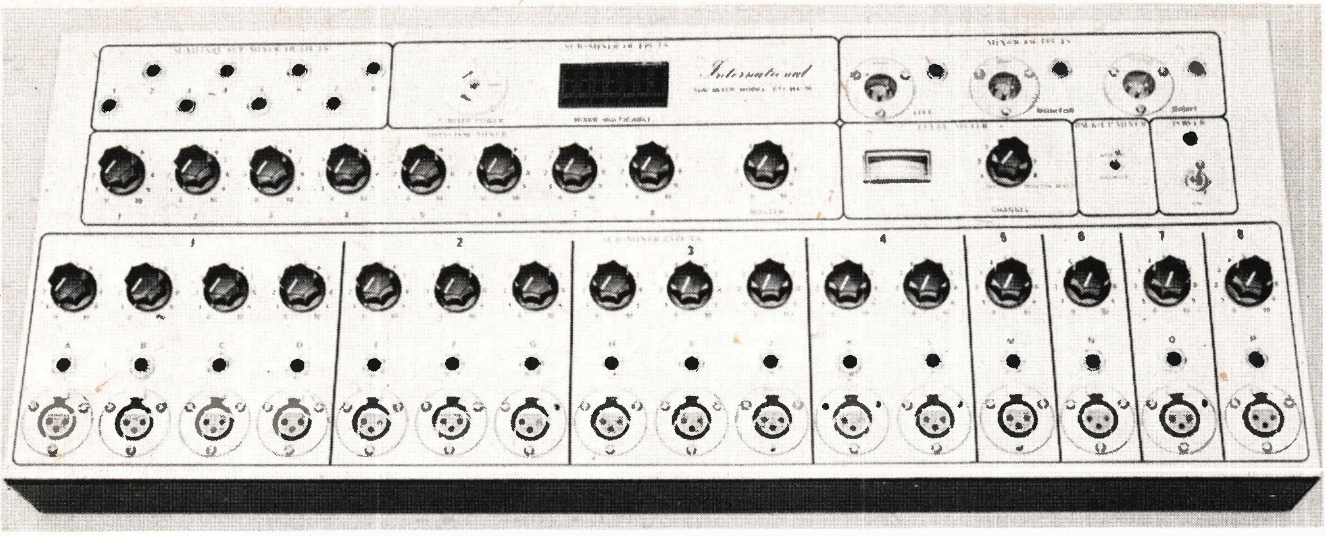


eti PROJECT 414 STAGE MIXER

Constructional details.

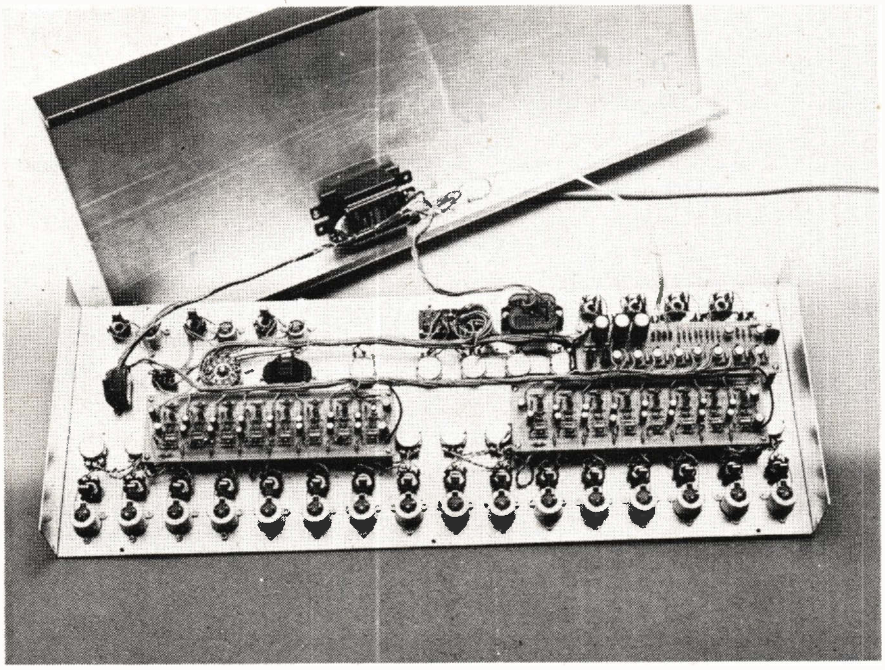
LAST MONTH we introduced the principle of our Stage Mixer and gave constructional details of the preamplifier boards. We continue now with details of the mixer board and interconnection wiring.

CONSTRUCTION

The mixer board (ETI 414E) should be assembled with the aid of the circuit diagram, Fig. 5, and the component overlay, Fig. 7. The parts list for this board was given in last month's issue. It is advisable to use terminal posts or pins for the eight input lines, the O V line and the +19.6 volt line. This makes later interconnection considerably easier.

Our prototype was constructed in a simple pan shaped chassis and cover. We suggest that the sides of the front panel be bent up (rather than the ends as shown in the photographs). This will strengthen the front panel and allow the transformer to be mounted on it rather than in the case as shown in our prototype unit.

Mount the spacers for the printed circuit boards, the multi-cable socket, VU meter and power outlet socket to the front panel with countersunk screws. It is suggested that the wires to the three-pin socket be attached before mounting – it is difficult later. All other front-panel components can now be mounted along with the escutcheon.



Internal view of the completed mixer.

HOW IT WORKS – ETI 414 MIXER/POWER SUPPLY

The signals from any number of line amplifiers may be summed by one of the sub mixers (eight per board IC1-IC8) the output from each mixer is taken directly via the output socket to the master mixer, and via a 22 k level control to the monitor mixer, IC9.

The output of the monitor mixer is taken to the master-monitor level control on the master mixer and then returned to a buffer amplifier in the stage mixer, IC10.

In an emergency (main mixer faulty) SW2 disconnects the outputs from the master mixer and connects the output of the monitor amplifier to the PA channels.

Power for the stage mixer is provided by a conventional supply which provides plus and minus 15 volts for the mixer amplifiers and plus 19.6 volts for the line amplifiers.

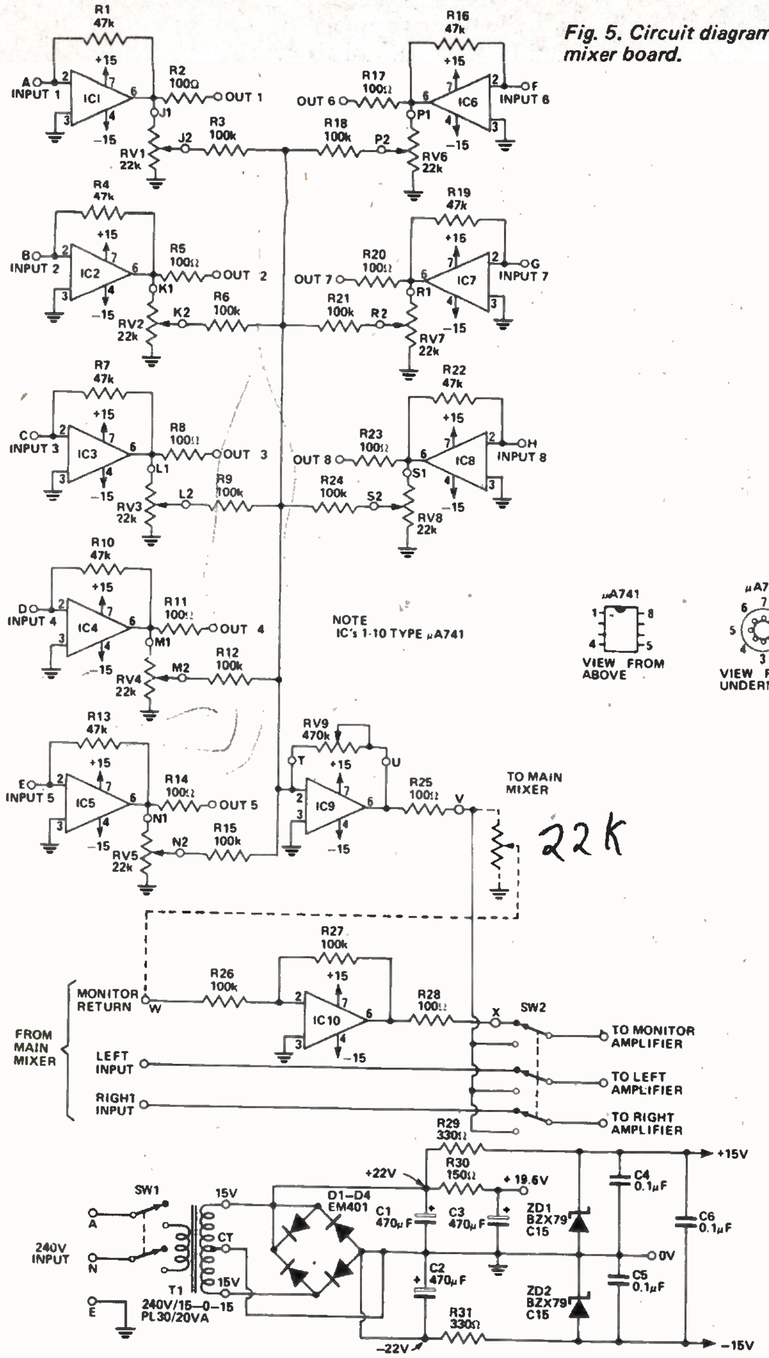


Fig. 5. Circuit diagram of the mixer board.

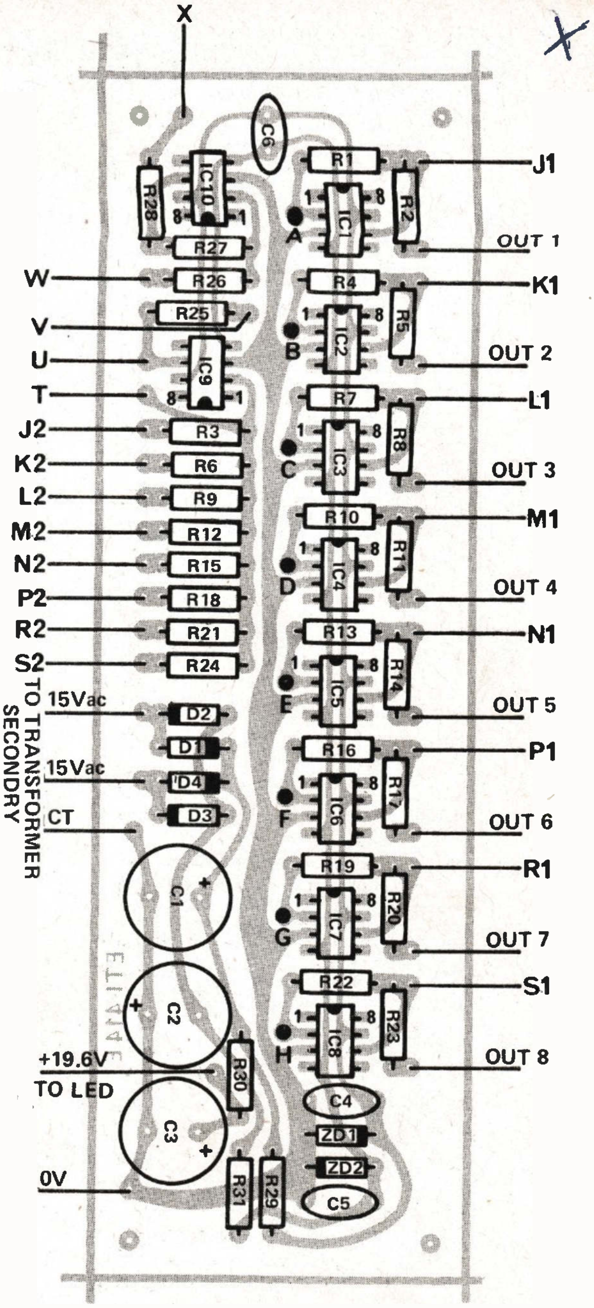


Fig. 7. Component overlay for the mixer/power-supply board.

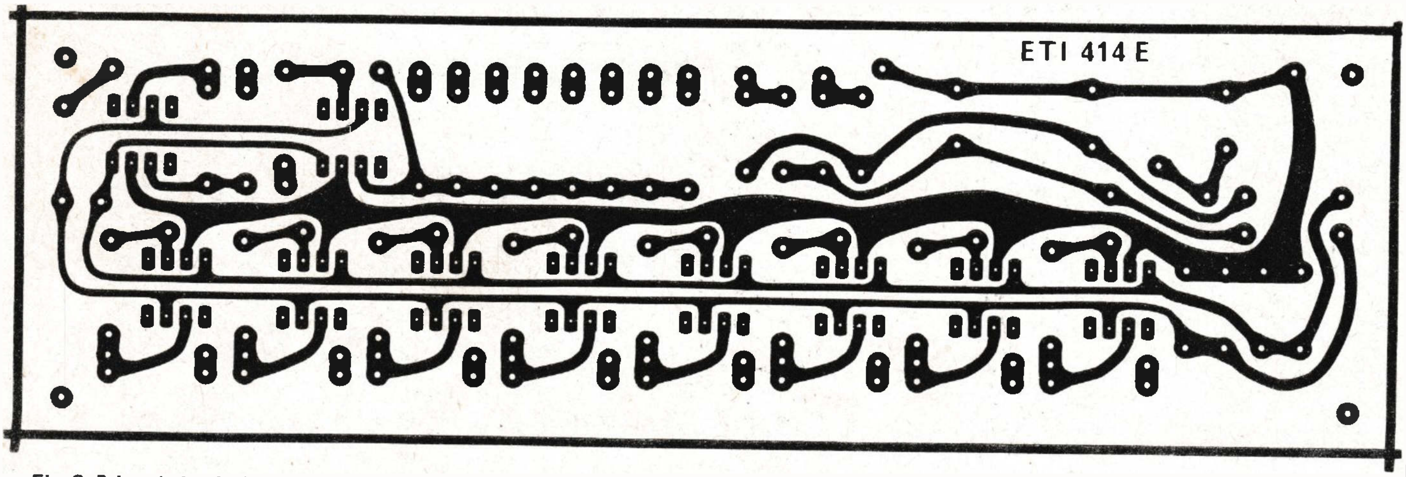
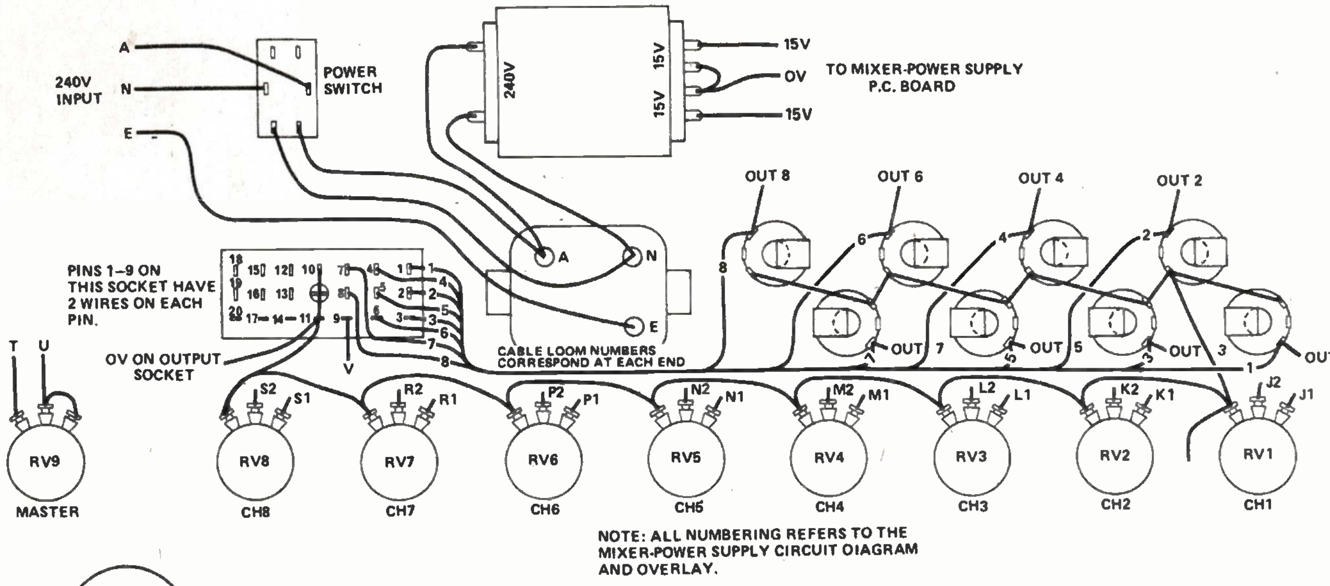


Fig. 6. Printed circuit layout for the mixer/power-supply board. Full size 182 x 57 mm.

STAGE MIXER

Fig. 9. Connection diagram for the mixer/ power-supply board.



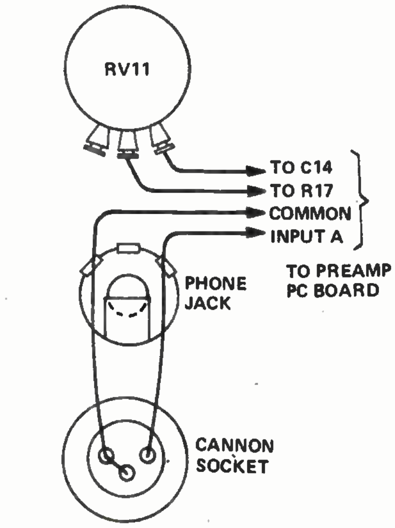


Fig. 8. Wiring to input sockets.

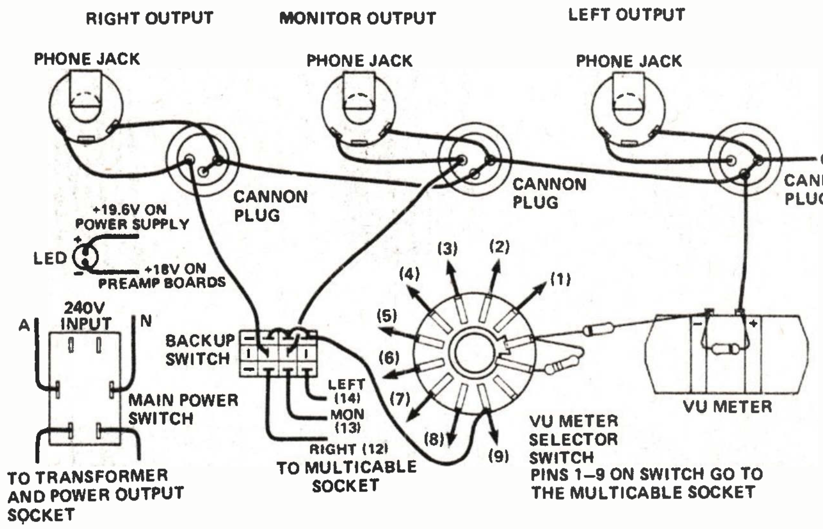


Fig. 10. Interconnection of output sockets VU meter and switch and backup switch.

Since the mixer may be subject to rough handling it is recommended that all screws be sealed in position with LOCTITE or similar compound.

Commence interconnection wiring by connecting the input sockets and potentiometers as shown in Fig. 8. This diagram shows connections to channel 1 of the preamplifiers — all other channels being similar. For neatness, we terminated these wires by soldering to the appropriate places on the underside of the board. Attach wires to the preamplifier outputs, on both boards, long enough to reach the appropriate mixer inputs. Similarly attach wires for the O volt and +18 volt supply lines.

The +18 volt supply comes from the negative side of the LED, the positive side being fed from the 19.6 volts of the power supply (1.6 volts drop across LED). When all these leads are attached, both boards may be

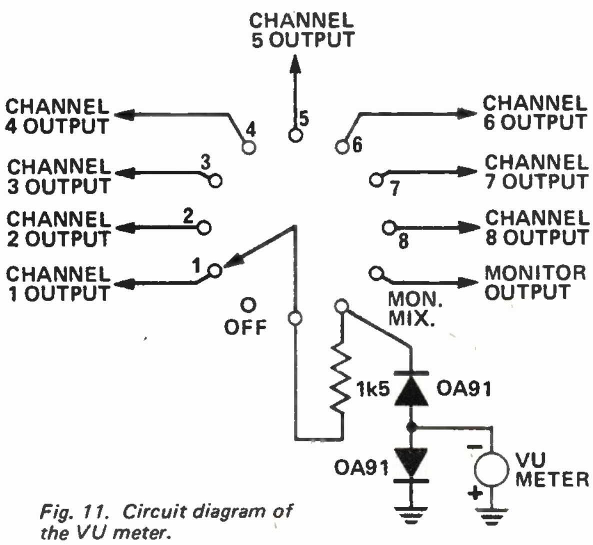


Fig. 11. Circuit diagram of the VU meter.

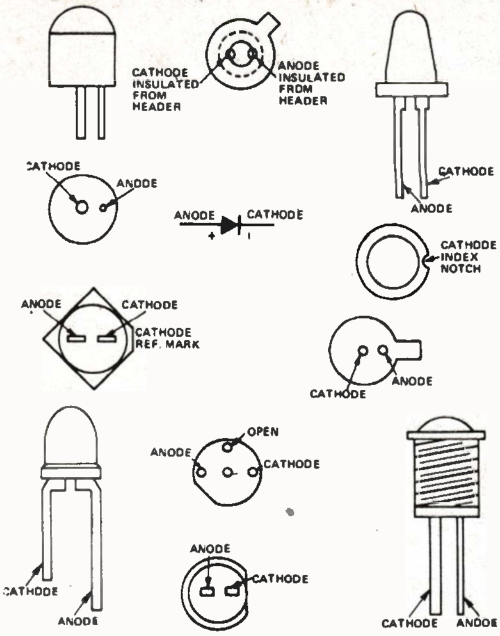
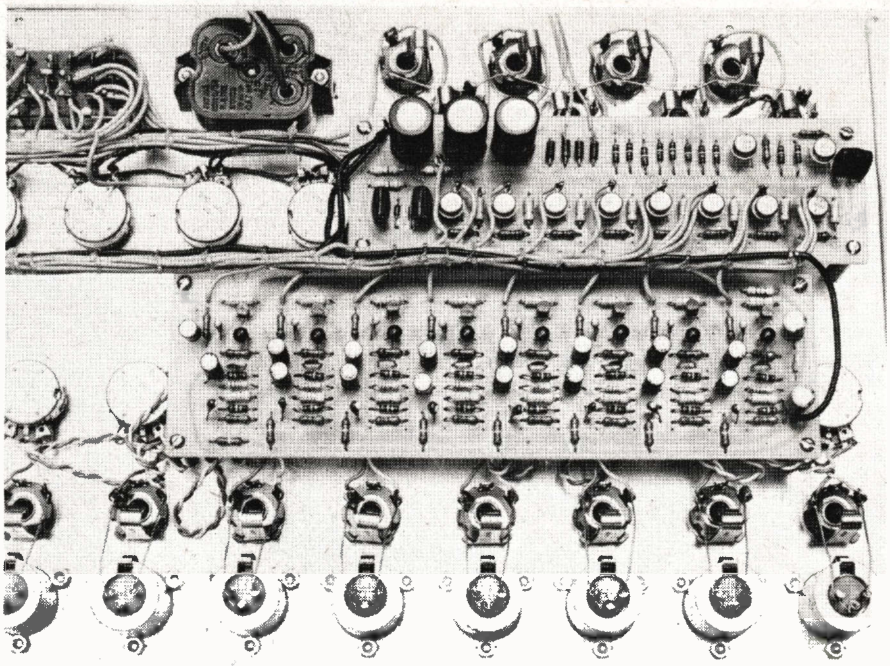


Fig. 1. Common lead connections for LED indicator lamps.

Fig. 12. Common lead connections for LED indicator lamps.



This picture shows the power supply/mixer board at top and one of the pre-amplifier boards (bottom) in position in the chassis.

mounted in position on the chassis.

The mixer/power-supply board may now be interconnected with the aid of Fig. 9. Figure 10 shows the wiring to output sockets and VU meter.

The selector switch and VU meter wiring is as shown in Fig.10 and 11. Note that pins 1 to 9 of the multi-cable socket will have 2 sets of leads, one set from the mixer outputs and one set from the VU meter selector switch. ●

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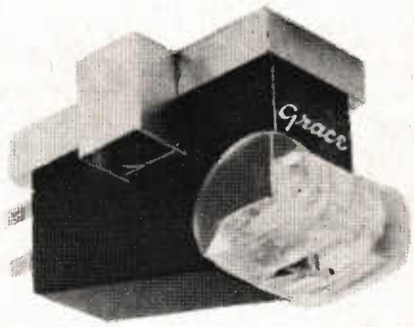

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INTERDYN

International Dynamics (Agencies) Pty. Ltd., P O Box 205, Cheltenham, Vic.

INTERNATIONAL 3600

Constructional details.

UNLIKE our larger 4600 unit, the modules in the 3600 are not designed to be removable as a single unit. Additional components (such as input and output switching for the oscillators) are mounted directly on the front panel (rather than on a sub-panel) and some printed circuit boards, such as the keyboard controller, are mounted in the box and connected to the potentiometers and switches on the front panel by means of leads.

OSCILLATORS

These are the same as the larger unit except that only three (instead of four) are used. The oscillators, as described, are configured for use with F to F keyboards. If C to B keyboards are used resistors R11 and R12 should be changed to 47 k. In using the larger

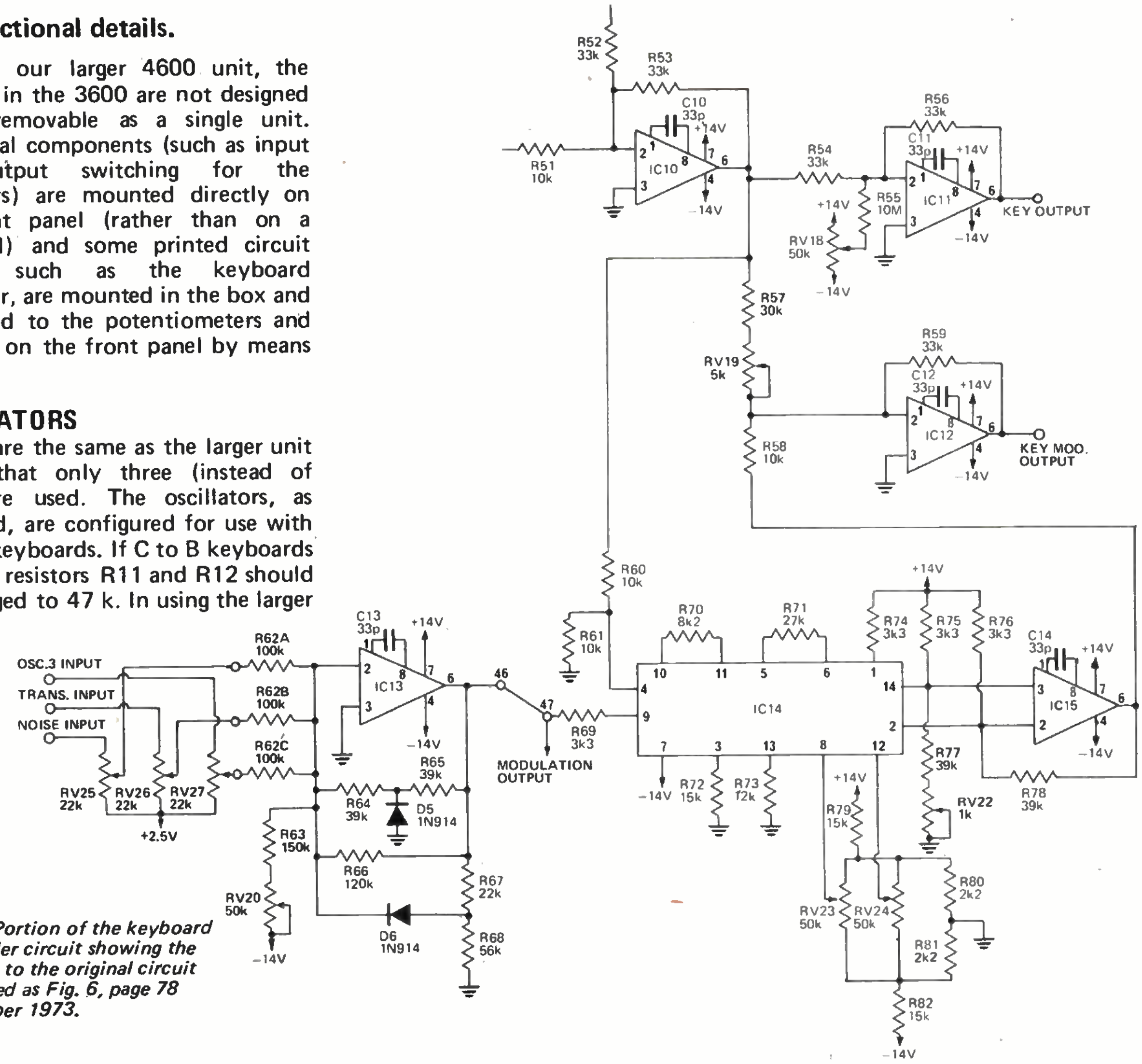
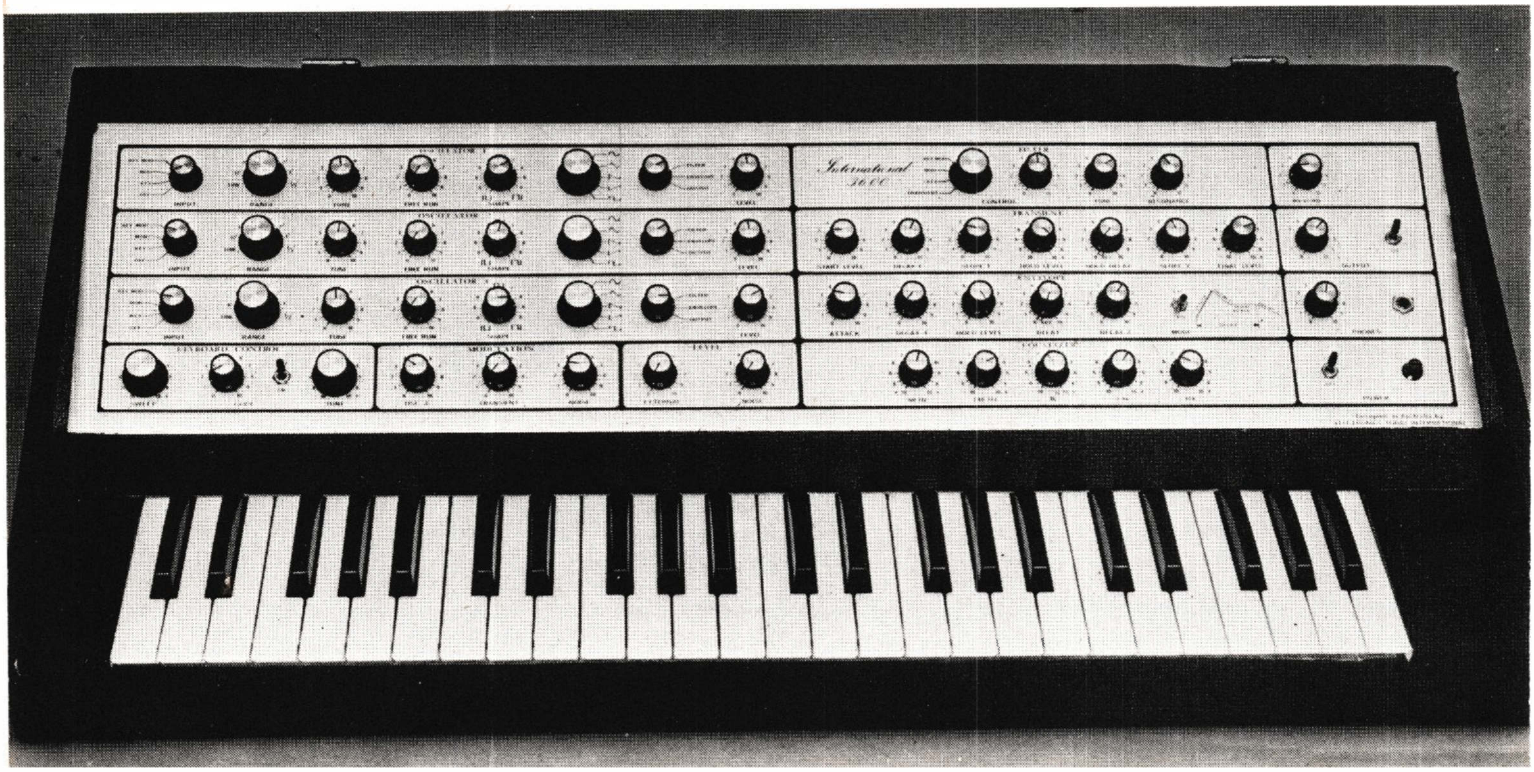
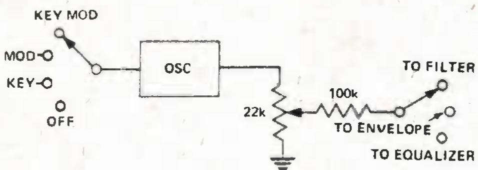


Fig. 1. Portion of the keyboard controller circuit showing the changes to the original circuit published as Fig. 6, page 78 November 1973.



SYNTHESIZER



4600 unit it was determined that the low range of the oscillator is lower than really necessary. It is therefore suggested that the value of C4 be reduced to 1μF. Additional front-panel controls required for the oscillator are a four position rotary switch to select input, a level control potentiometer and resistor, and a three position rotary switch on the output (see diagram left).

KEYBOARD CONTROLLER

The keyboard controller is substantially as published in November 1973 and the subsequent modification published in June 1974. Some parts are deleted and others added (see parts list) to make minor improvements and to adapt the unit to the 3600 format.

A minor modification, which improves accuracy in setting up the keyboard modulation output, is performed by changing R57 to 30 k, RV19 to 5 k, R77 to 39 k and RV22 to 1 k (see Fig. 1).

To set up the controls the following procedure should be used. Connect two oscillators to the 'key output', select '4-foot' range and check that the oscillators track over the entire keyboard range. After setting up RV23 and RV24 as described for the 4600 Unit, connect one oscillator to 'KEY OUTPUT' and the other to 'KEY MOD OUTPUT'.

Disconnect the link between 46 and 47, (if connected) connect 47 to zero volts and adjust RV22 to 'beat' the oscillators on the lowest note. Then adjust RV19 at the top end. These two controls interact and it will be necessary to repeat the procedure several times to get both ends right. The range of RV22 has been made small so that adjustment is less sensitive. However this means that component tolerances may cause the correct setting to be outside the range of RV22. If the correct setting is below the minimum setting of RV22 parallel R77 with 1.5 megohm. If still not correct use 820 k. If the correct setting is above the maximum setting of RV22 parallel R78 with 1.5 megohm or 820 k as required.

On the 3600 the modulation potentiometer, RV21 as fitted to the 4600, is not used and 46 and 47 are therefore linked. An output is taken from this point, being the modulation output. To prevent confusion the output of IC12 is relabled 'KEY MOD OUTPUT'.

The input to the exponential converter, IC13, is modified to accept the three inputs required. The bias network R63-RV20, has also been changed.

The original R62 (47 k) is replaced by three resistors, labled R62A, B and C, each of 100 k. To save making a different printed circuit board the two additional resistors are glued onto the top surface of the board with epoxy cement.

Potentiometer RV20 is adjusted to give zero volts at point 46 when all modulationcontrols are at zero. Zero volts can be checked by switching one of the oscillators to ½-foot range and

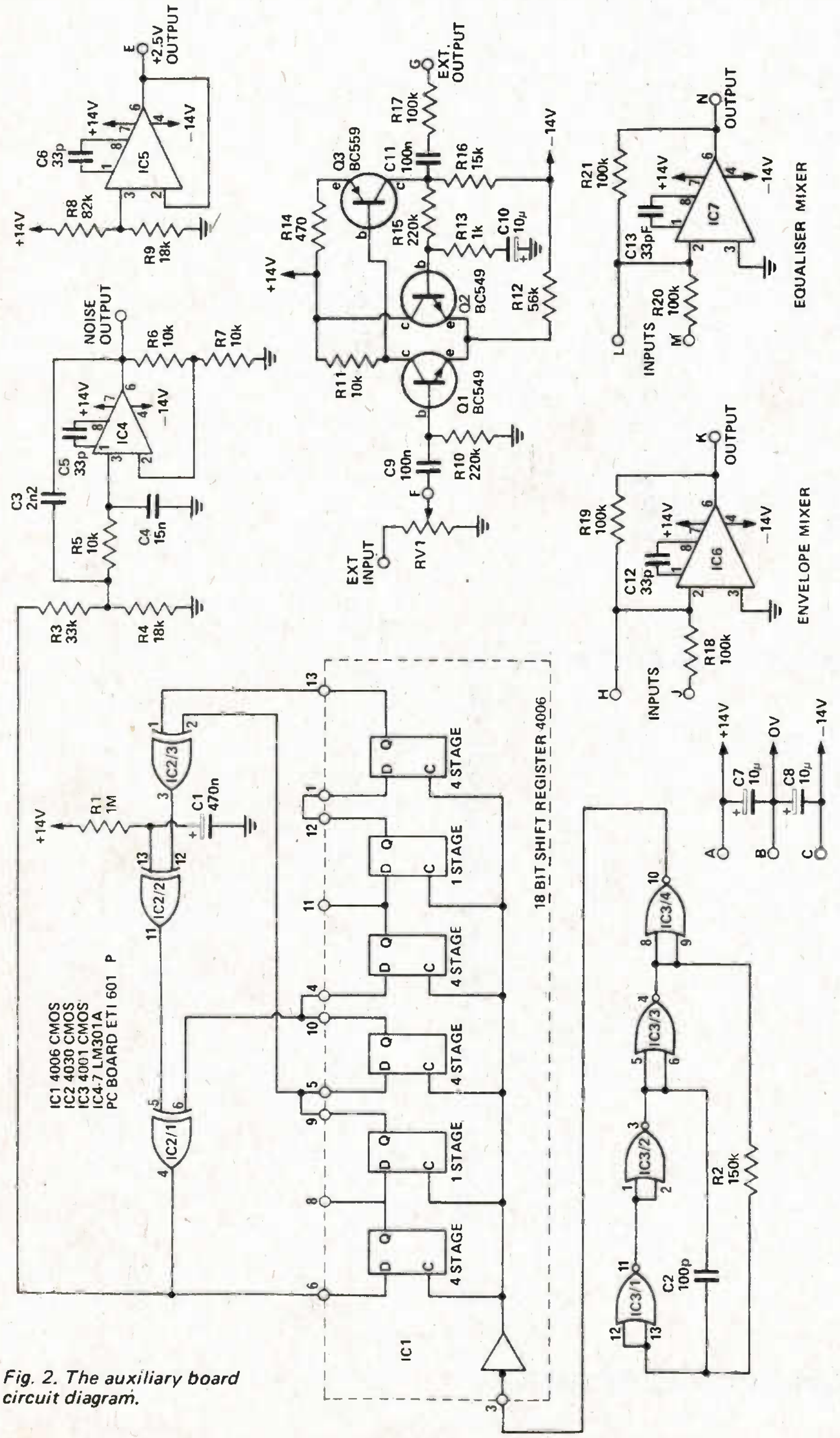


Fig. 2. The auxiliary board circuit diagram.

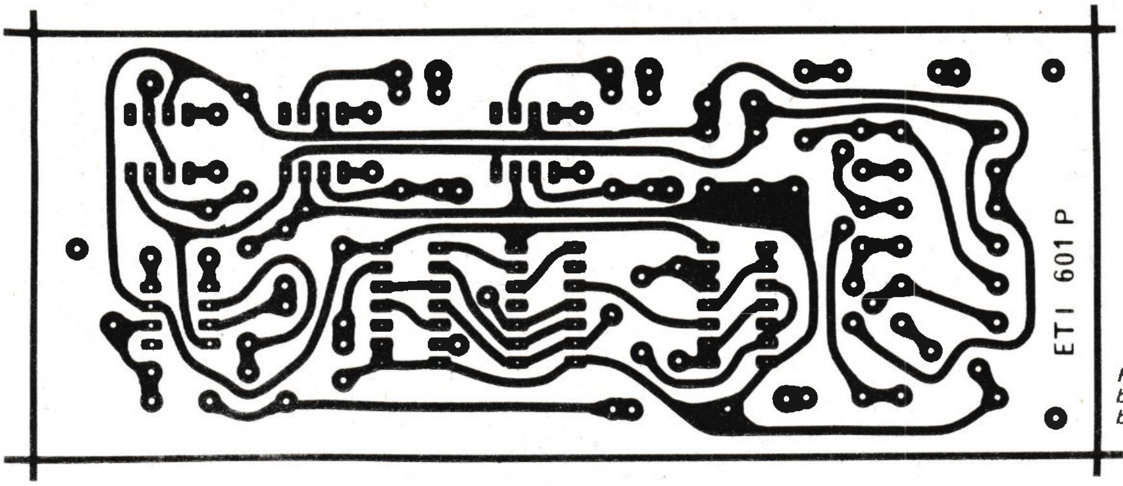


Fig. 3. Printed circuit board layout for the auxiliary board. Full size 142 x 57 mm.

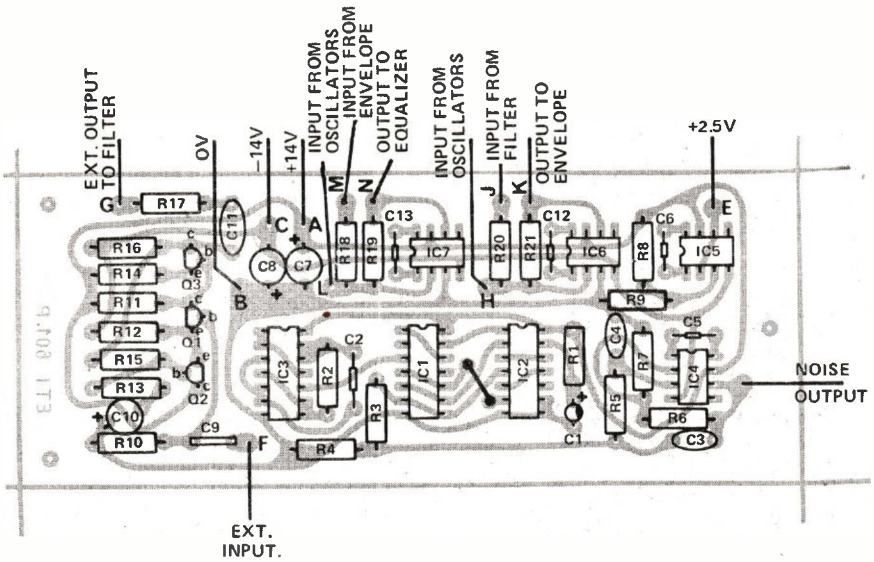


Fig. 4. Component overlay for the auxiliary board.

zero volts can be checked by switching one of the oscillators to the ½ foot range and the input selector to off. Adjust the oscillator to the lowest frequency possible. Now select the modulation input and adjust RV20 to give the same frequency.

AUXILIARY BOARD

The auxiliary board contains the odd circuitry necessary to interface the various sections of the 3600 synthesizer. It contains two mixers, one for the envelope inputs and one for the equalizer inputs. A circuit is incorporated to derive a 2.5 volt supply for the modulation potentiometers. Additionally the board contains a noise generator, similar to that described in the December '73 edition, with the exception that it is permanently connected to produce 'pink' noise. Reference should be made to that issue for the principle of operation of this circuit.

The two mixers are simply LM301 operational amplifiers which have two inputs. One input is via a 100 k resistor and the other is direct to pin 2 of the IC. The later input is used for the oscillator which has a 100 k output impedance.

A 2.5 volt supply is derived from the +14 volt supply by divider R8 and R9. This voltage is buffered by IC5 which is connected as a unity gain non-inverting amplifier.

The external input amplifier uses a differential pair, Q1 and Q2, followed by an additional gain stage, Q3. The feedback components R15, R13 and C10 provide a gain of approximately 40 dB. The output of this amplifier, goes to the filter input.

to be continued next month . . .

PARTS LISTS

PARTS LIST — OSCILLATORS
(Three required)

1	oscillator as described in ETI November 1973
1	switch single pole 4-position rotary (or 2 pole 4-position)
1	switch single pole 3-position rotary (or 3 pole 3-position)
1	potentiometer 22 k lin rotary
1	resistor 100 k ¼ watt 5%

KEYBOARD CONTROLLER

1	keyboard controller as published November 1973.
1	keyboard controller mod as published June 1974 plus
1	1 k trimpot
1	5 k trimpot
1	50 k trimpot
3	22 k potentiometers rotary lin
3	100 k resistors ¼ watt 5%
1	150 k resistors ¼ watt 5%
1	30 k resistors ¼ watt 5%
1	39 k resistors ¼ watt 5%

The following parts are not used — delete from list.

2	10 k trim potentiometers
1	10 k rotary potentiometer
1	100 k trim potentiometer
1	27 k resistor ¼ watt 5%
1	33 k resistor ¼ watt 5%
1	47 k resistors ¼ watt 5%
1	220 k resistor ¼ watt 5%

PARTS LIST — AUXILLIARY BOARD

R14	resistor	470	¼ W	5%
R13	"	1k	¼ W	5%
R5,6,7,11	"	10 k	¼ W	5%
R16	"	15 k	¼ W	5%
R4,9	"	18 k	¼ W	5%
R3	"	33 k	¼ W	5%
R12	"	56 k	¼ W	5%
R8	"	82 k	¼ W	5%
R17,18,19	"	100 k	¼ W	5%
R20,21	"	100 k	¼ W	5%
R2	"	150 k	¼ W	5%
R10,15	"	220 k	¼ W	5%
R1	"	1M	¼ W	5%

RV1 potentiometer 47 k log rotary

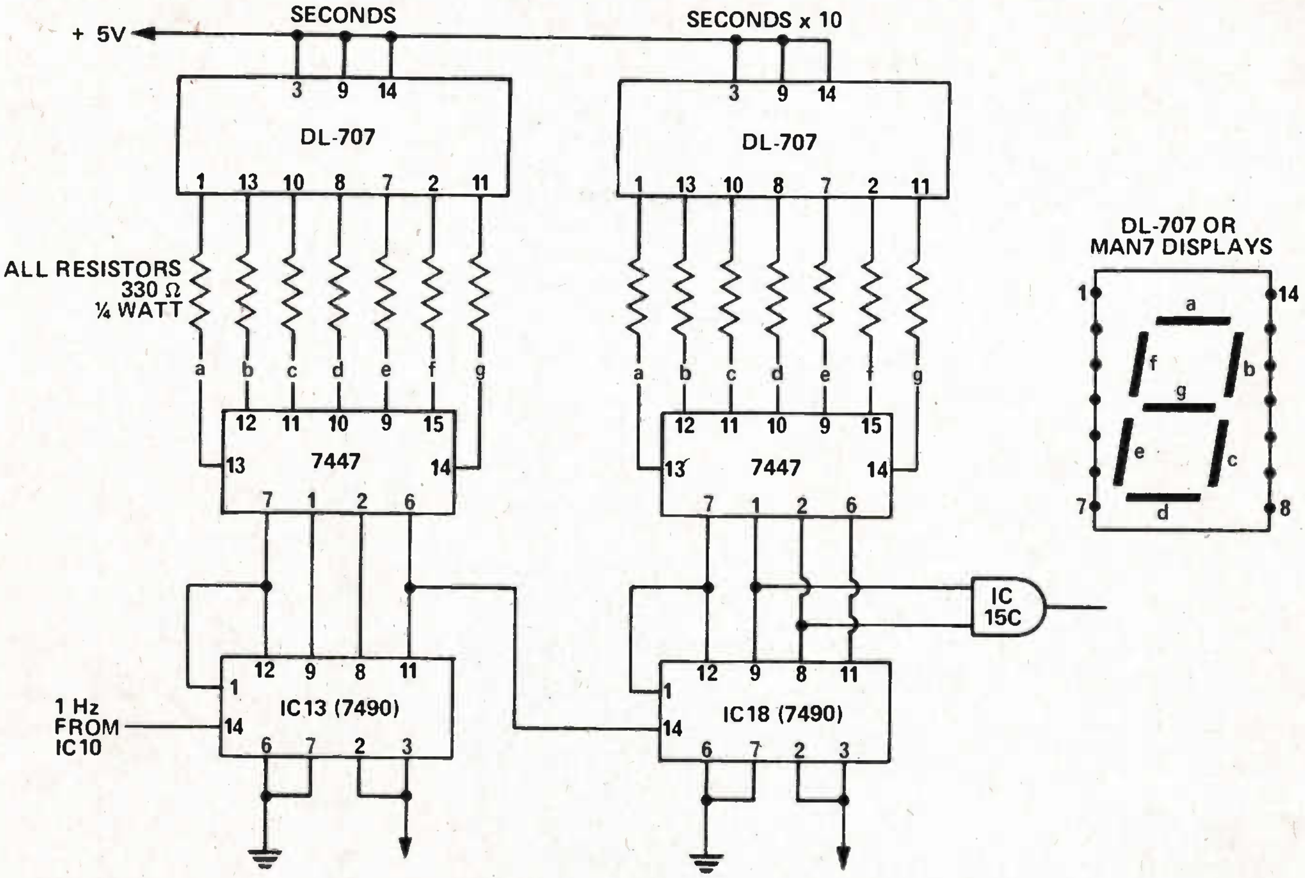
C6,12,13	capacitor	33 pF ceramic
C2	"	100 pF ceramic
C3	"	0.0022 µF polyester
C4	"	0.015 µF polyester
C9,11	"	0.1 µF polyester
C1	"	0.47 µF Tag Tantalum
C7,8,10	"	10 µF 16V electrolytic

Q1,2	transistor	BC549 or similar
Q3	"	BC559 or similar

IC1	integrated circuit	4006 (CMOS)
IC2	" "	4030 (CMOS)
IC3	" "	4001 (CMOS)
IC4,5,6,7	" "	LM301A

PC board ETI 601P

SECONDS DISPLAY for ETI 521 Clock



NOTE THAT CONNECTIONS TO IC13 MUST BE CHANGED (FROM THOSE USED IN ETI-521) TO GENERATE A BCD OUTPUT

MANY READERS have asked us how to add a 'seconds' display to the ETI 521 digital clock.

This may be done by taking the BCD outputs from ICs 13 and 18 (part of existing clock) decoding these outputs with 7447 IC's to drive MAN 7 type displays.

Note that IC 13, as wired in the project, does not provide a BCD output. This may be corrected by feeding the input to pin 14 instead of pin 1, linking pin 1 to pin 12 and by taking the output from pin 11.

The current drawn by this circuit may be 200 mA or more, so check that the load on the five volt regulator is less than 800 mA before performing this modification. (Load will vary, depending on other facilities fitted, eg alarm etc).

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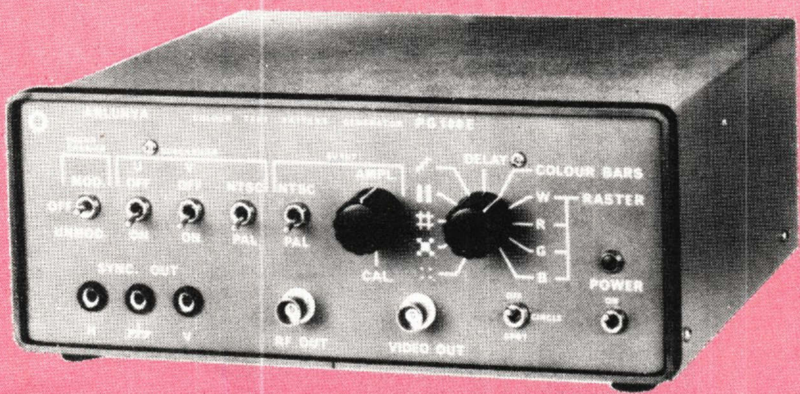

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PROJECT 431 FM ANTENNA

Here are two simple-to-make antennas.

SYDNEY'S stereo FM station, 2MBS-FM has been in full operation for nearly two months and an ETI survey has shown that a good signal can be received in most parts of the metropolitan area.

Soon, Melbourne will have a similar 'fine music' station — in fact broadcasting may have started by the time this issue of ETI is published.

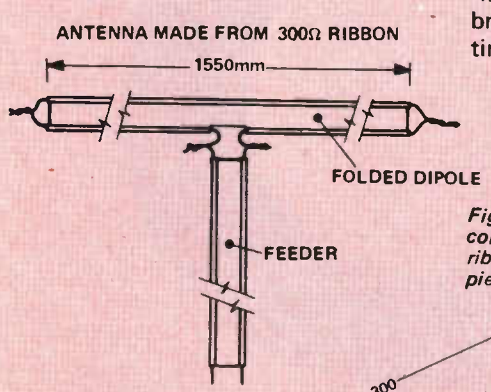

Fig. 1. This simple folded dipole may be constructed from a short length of 300 ohm ribbon tied in position or tacked to suitable pieces of wood or hardboard.

If one lives fairly close to the transmitter, a simple folded dipole like that shown in Fig. 1 may be adequate. However for those who live in the outer suburbs, or in localities where the direct signal is obstructed by building or local topography, a more elaborate antenna will be required.

Figure 2 shows a simple way of building a three-element Yagi array. This antenna gives at least 6 dB more gain than does a simple folded dipole.

The antenna may be constructed exactly as shown — or modified to suit available materials. It is fairly important to retain all dimensions as shown (designed for mid-point of the Australian FM band). The two halves of the main (centre) dipole must be insulated from each other.

Locate the antenna as high up as possible. At present 2MBS-FM's transmitting antenna is vertically polarised — so for best reception the receiving antenna also should be in the vertical plane (as shown in Fig. 4). However 2MBS-FM expect to change to horizontal polarisation within a few months so make provision for horizontal mounting as well.

If motor vehicle ignition noise is a problem, locate the antenna at the rear of the house so that the house itself shields the antenna from RFI.

The antenna's impedance is 75 ohms and, if the FM tuner can be located fairly close to it by far the best way of connecting the two together is to use 75 ohm co-axial cable. But co-ax is quite expensive (about $1.50 a metre) so if you have a longish run it is cheaper to use an impedance matching 'balun' (about $2.50 from most TV parts suppliers) and 300 ohm ribbon. If you do use ribbon, keep it at least 100 mm from any nearby metal and twist it twice per 330 mm to prevent multipath interference due to signal pickup on the ribbon itself.

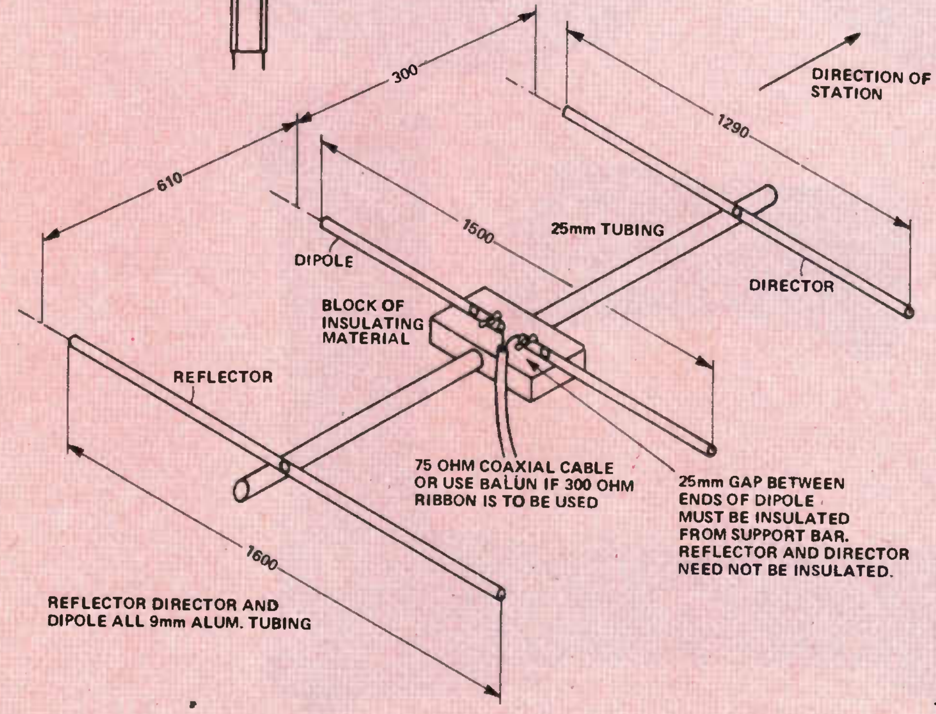

Fig.2. Main details of three element antenna — constructional methods may be altered but dimensions should be kept as shown.

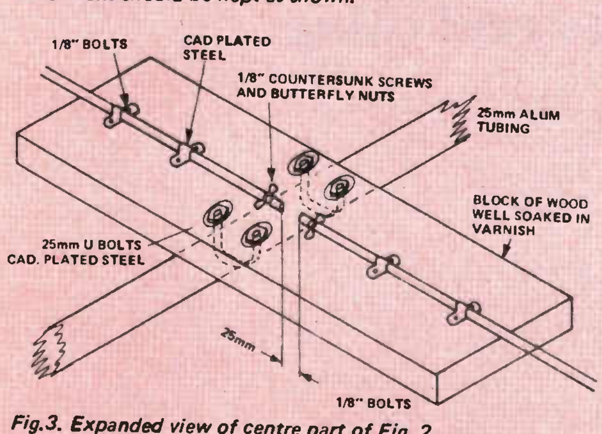

Fig.3. Expanded view of centre part of Fig. 2.

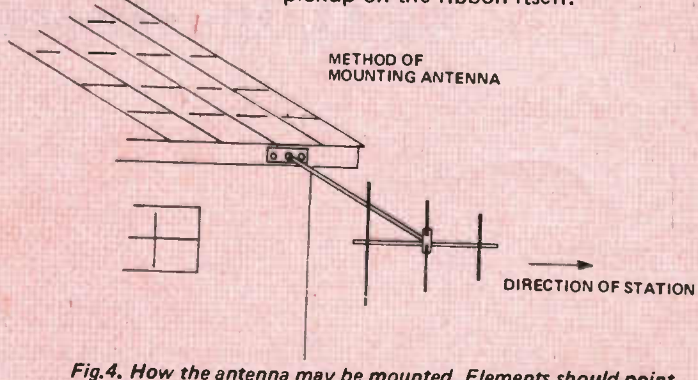

Fig.4. How the antenna may be mounted. Elements should point in main direction of station — final position should be determined by moving around until maximum signal strength is obtained.

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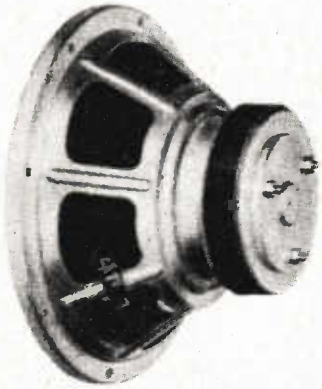

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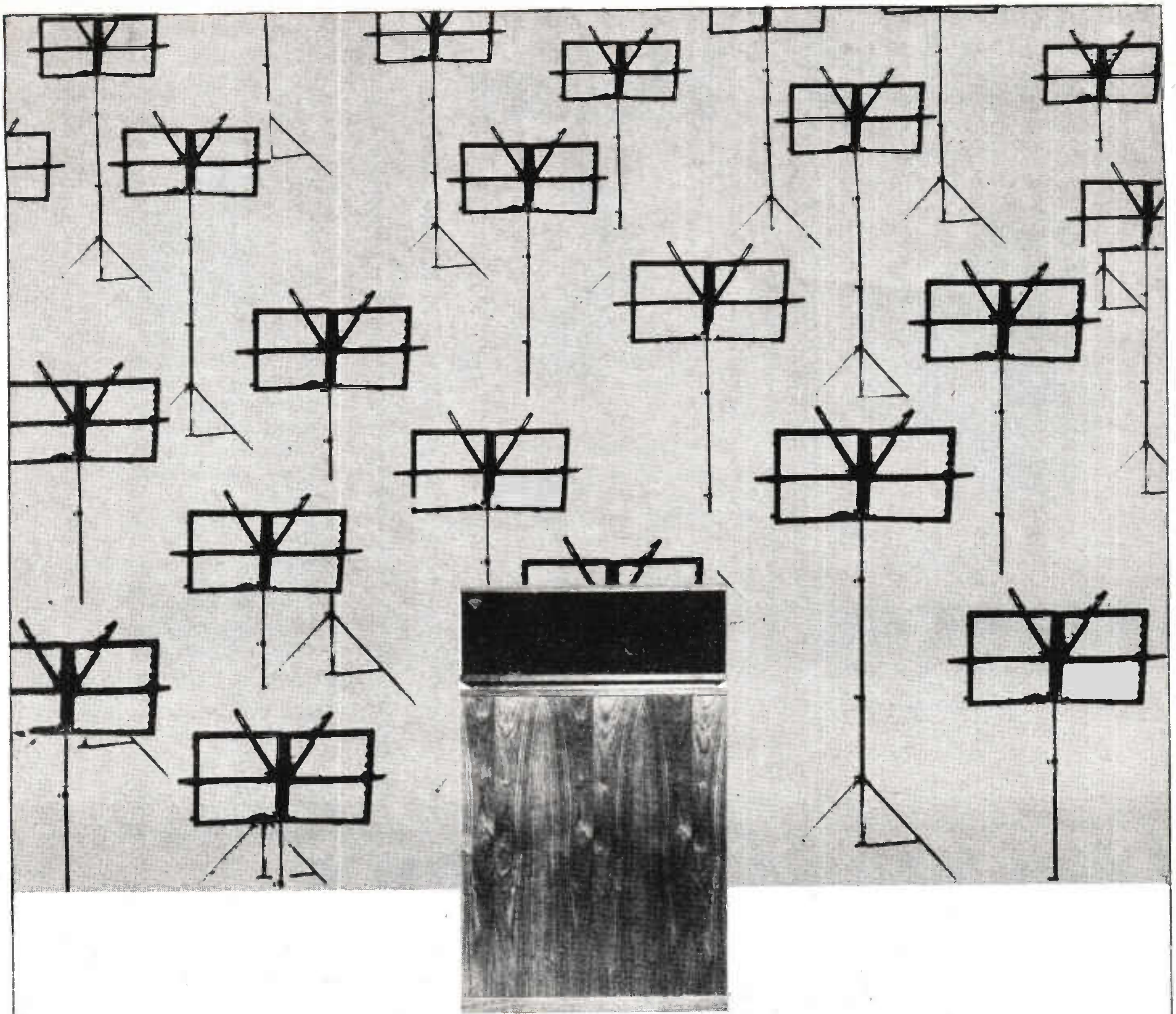

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The Signal Circuits

THE EARLIEST colour receivers (for NTSC system in USA) used a staggering number of valves but before long transistors were in use in the low-power signal circuits. Further progress with high power transistors eventually made possible the first all-transistor colour set, with no thermionic device except the display tube itself. This was introduced by the British Radio Corporation in the sixties. Current progress involves compacting as much circuitry as possible into special purpose integrated circuits. All but the higher power stages can now be contained in a handful of ICs. Good manufacturing economy but often introducing servicing headaches!

A television receiver is a harsh environment for semiconductors because of the surge currents caused by sparking inside the display tube or by reservoir capacitor charging at switch-on. Unless controlled by careful design, these surges can destroy transistors instantly. As a result many European manufacturers prefer to build 'hybrid' receivers which use both semiconductors and valves, using the valves for their tolerance of transients in high power sections.

In spite of their constructional variations virtually all PAL colour receivers conform to the block diagram in Fig. 30.

TUNER

This is a compact preassembled box containing two or three transistors with the functions of tuned rf amplifier and mixer/oscillator. The modern type uses varicap diodes in the tuned stages to allow remote dc channel selection by a pushbutton/potentiometer assembly on the front of the receiver. This gives far easier and more accurately repeatable tuning than mechanical capacitor drives. Automatic frequency control can also be applied to the dc tuning input to further improve tuning stability.

The tuner mixer converts the incoming sound and vision signals at VHF (or UHF where used) to a standard intermediate frequency which is 39.5 MHz for the vision carrier. Since it is impractical to achieve much selectivity in the tuner the frequency response of the following IF strip must be carefully tailored for optimum amplification of each component of the television signal — see Fig. 31a.

IF STRIP

Figure 31a shows in idealized form the components of the television signal after frequency changing to IF. The vision carrier is amplitude modulated by the luminance signal whose frequency range extends to about 5 MHz. Sideband energy is therefore generated up to 5 MHz either side of this carrier but the lower sideband is almost completely suppressed at the transmitter in order to use frequency space more efficiently. Since some low frequencies in the lower sideband (which appears *above* the vision carrier after inversion in the mixer) are allowed to remain this is known as vestigial sideband transmission.

A colour transmission also contains chroma sidebands which centre on a frequency 4.43 MHz below (at IF) the vision carrier. Frequency interleaving is used to enable luminance and chroma to share the same frequency space as was described last month.

The sound is frequency modulated on a separate carrier above the vision carrier. Due to frequency inversion in the mixer it appears below the carrier at IF.

Figure 31b shows the actual IF response shape of a high quality

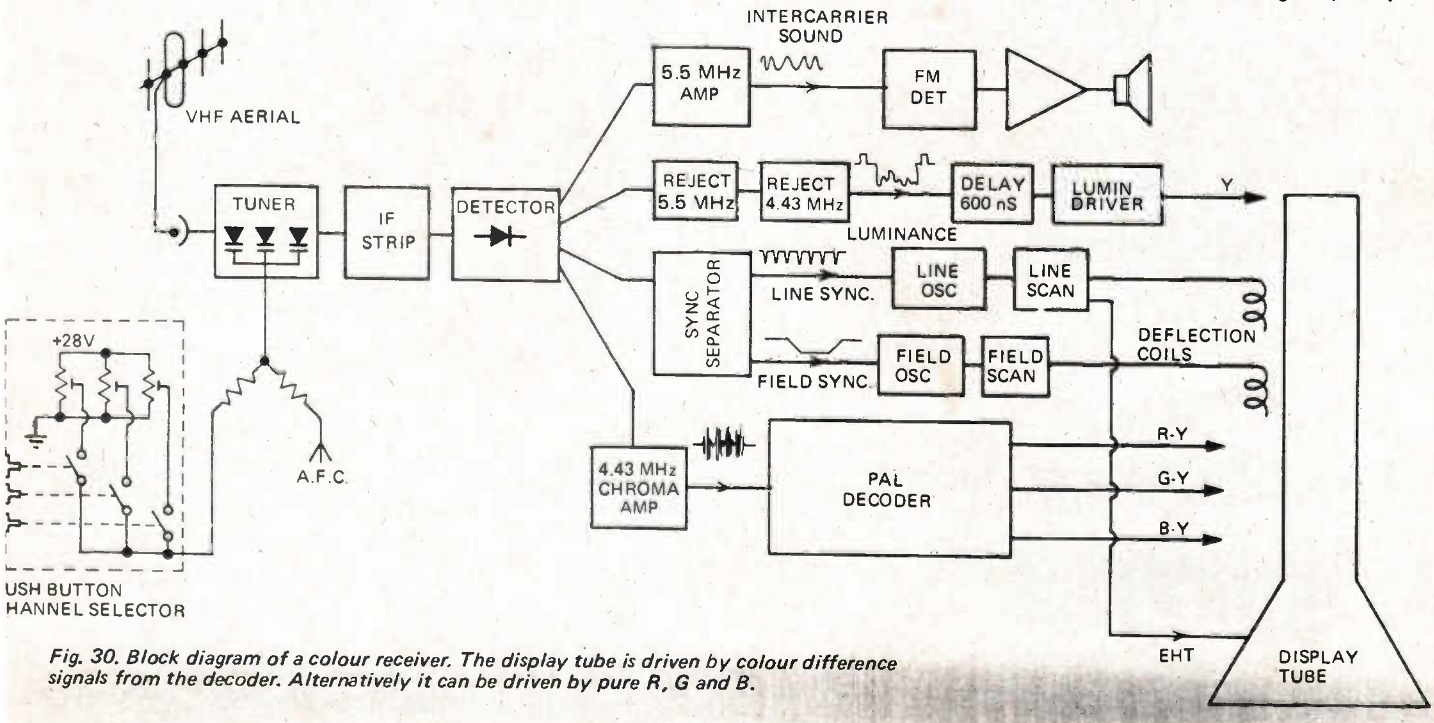


Fig. 30. Block diagram of a colour receiver. The display tube is driven by colour difference signals from the decoder. Alternatively it can be driven by pure R, G and B.

receiver. Relative gain is plotted on a logarithmic (decibel) scale since on a linear scale the lower details would be too compressed into the base line to see properly. Such a response shape is only obtained after careful alignment of as many as a dozen tuned circuits and reflects a number of engineering compromises.

The first requirement is a high quality luminance signal. For this the response shape would ideally have a flat top and steeply falling edges to match the transmitted luminance spectrum. However there are limits to what can be achieved with conventional tuned circuits. A flat top requires a number of low-Q tuned circuits stagger-tuned and there are economical limits to this. Steep sides require the use of high-Q tuned circuits and these introduce large phase changes in the region of their resonance. Such distortion of the luminance signal appears as ringing or vertical striations after (i.e. to the right of) major picture details. Since the edges of the luminance response cannot be steep it is usual to place the vision carrier about 6 dB down on the high-frequency fall-off. A correctly shaped fall-off in this region prevents attenuation of low frequency luminance components by allowing some vestigal sideband energy to supplement the main sideband.

At the high frequency end of the luminance spectrum a compromise is made between the desire for maximum picture resolution and the inevitable slight interference by chroma on luminance i.e. fine patterning in areas of saturated colour. Therefore the response will be 'rolling off' somewhat before the 5 MHz luminance limit.

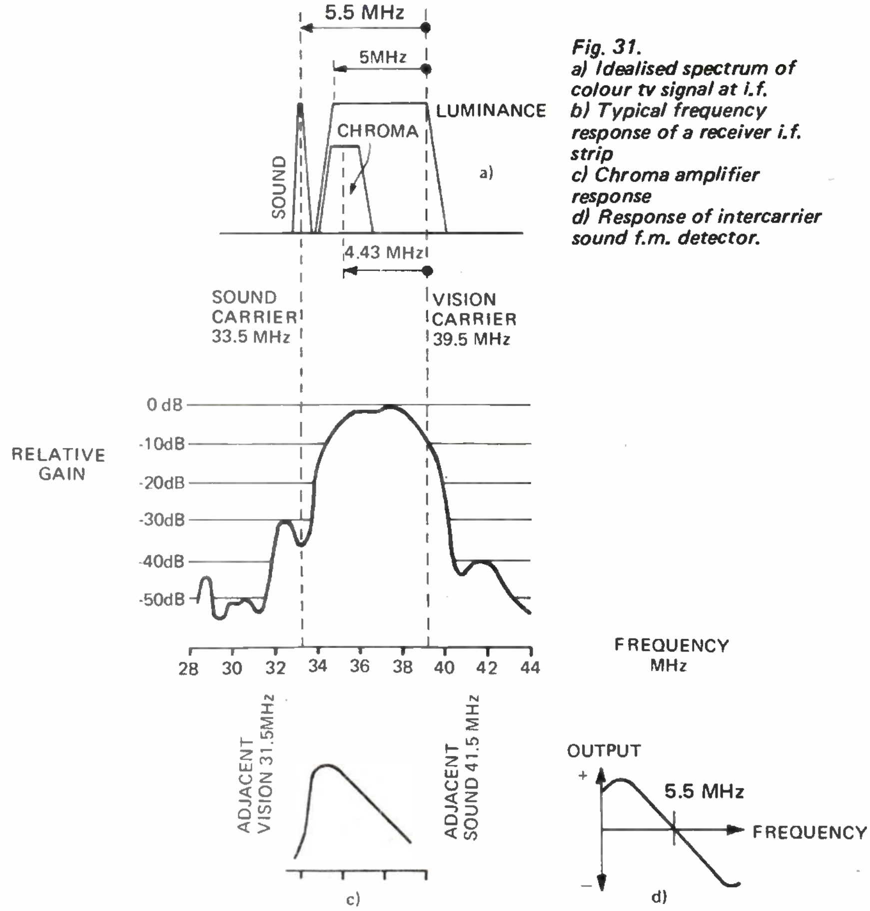
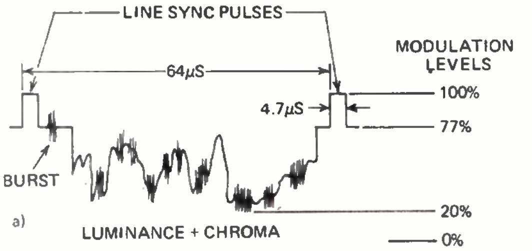


Fig. 31.
a) Idealised spectrum of colour tv signal at i.f.
b) Typical frequency response of a receiver i.f. strip
c) Chroma amplifier response
d) Response of intercarrier sound f.m. detector.



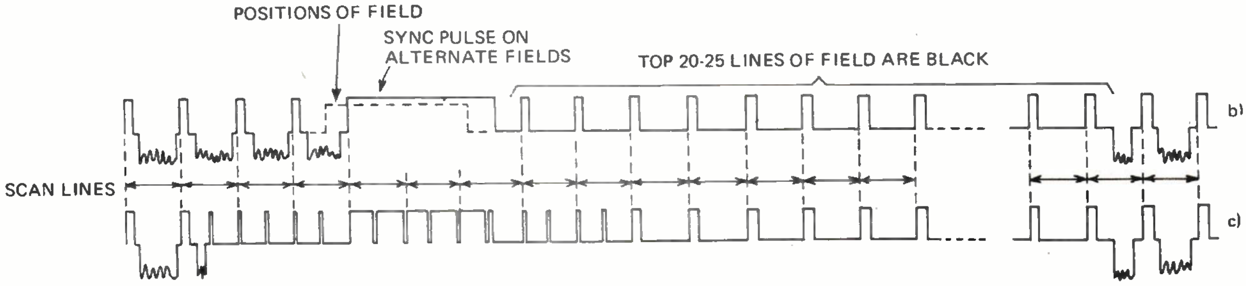


Fig. 32. a) Line sync pulse
b) Basic form of field sync. pulse
c) Actual form of field sync. pulse

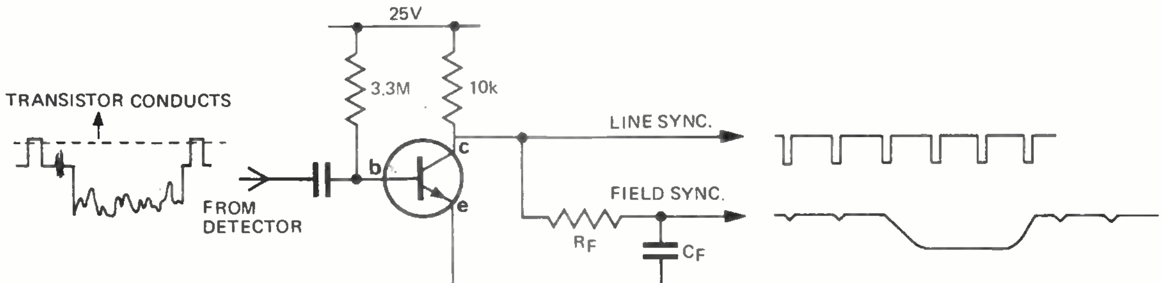


Fig. 33 Simple sync. separator

The sound carrier passes through the i.f. strip at considerably lower level than luminance or chroma for reasons which will become clear. Two other features of the IF response are the strong rejections at 41.5 MHz and 31.5 MHz which prevent interference from the sound or vision carriers of transmissions on adjacent channels.

The IF response shape of a colour receiver is far too critical to set up without the proper equipment – a sweep frequency generator and synchronised oscilloscope. Fortunately it usually only has to be done at the factory.

DETECTOR

Sometimes a single diode envelope detector, as in an am radio, is used after the IF strip. However the diode non-linearity encourages the generation of beat products between sound and chroma (5.5 – 4.43 = 1.07 MHz) which can cause an unpleasant coarse 'herringbone' patterning in coloured areas. Therefore many sets use two or more detectors. In the future synchronous detection may be used in this stage. After the detector the various components of the television signal are separated as follows.

SOUND

The fm sound signal is extracted by an amplifier tuned to the *difference* (5.5 MHz) between the sound and vision carriers, known as the 'intercarrier' frequency. This frequency is produced when the two carriers beat together in the detector and has the sound frequency modulation. The reason for presenting the amplitude modulated vision carrier to the detector at much higher level than the sound carrier is now clear: it is to ensure that the intercarrier product does not disappear on picture whites where the vision carrier is at minimum amplitude. A single 5.5 MHz tuned stage gives sufficient gain to drive the fm detector (which has the response in Fig. 31d). This stage must be accurately tuned to reject any vision amplitude modulation present on the intercarrier signal. This causes a buzz on the sound channel, primarily at field frequency (50 Hz). Intercarrier buzz is easily recognised because it changes pitch as the picture content changes and is worst on pictures containing peak whites e.g. captions.

LUMINANCE

The strongest signal from the detector is the luminance signal. Intercarrier sound (5.5 MHz) and chroma (4.43 MHz region) are filtered out to prevent fine patterning, the latter rejection being a compromise with resolution. Luminance is fed through a small delay line (½ micro-second approx.) to the driver stage which controls the red, green and blue beams of the display tube equally to give shades of grey and white. The luminance delay, not to be confused with the much longer PAL-D delay in the decoder, compensates for the time taken by signals to pass through the decoder and ensures that the colour signals are registered in time with luminance when they reach the display tube.

CHROMA

The chroma signal is extracted from the detector by a tuned (±1 MHz about 4.43 MHz) amplifier. This often has a non-symmetrical response as in Fig. 31c) to compensate for the falling IF response to the upper chroma sideband. The reference burst also passes through this amplifier to the PAL decoder.

SYNCHRONIZATION

The vision signal carries two sets of pulses for the purpose of synchronizing the line (horizontal) and field (vertical) picture scan rates in the receiver to the studio camera. They are pulses of peak carrier strength i.e. 'blacker' than black video level, and therefore appear as peak positive excursions from the detector. Their shapes are shown in Fig. 32. The sync. separator is a simple peak detecting stage such as a transistor with small forward base bias and no emitter resistor as in Fig. 33. This serves to strip all but sync. pulses from the signal.

The field sync. pulse is distinguished from the line sync. pulse by being much wider – as crudely shown in Fig. 32b). It can therefore be separated from the line pulses by a simple integrator R_F/C_F in the sync. separator, and then used to trigger the start of each field scan. Note that in each field half of the 625 lines (= 312½) are scanned. This means that the field pulse must trigger the field scan at the start of a line or half way through a line on successive fields. This starting difference must be established accurately or the fields will not interlace properly, with unpleasant effects. Therefore the waveform (in Fig. 32b) is improved in a number of ways before transmission.

Firstly by providing uninterrupted line sync. during the field pulse the line scan is given no opportunity to drift off frequency. In Fig. 32c there is a positive-going synchronizing edge at the start of every line.

Secondly the video information is blacked out on 2½ lines before the field pulse. The line sync. pulse for each of these lines is 'split' into two half-width pulses known as equalizing pulses. Their purpose is not to make the line scan suddenly run at double speed; instead it is a way of ensuring that the level on the field sync. integrating capacitor C_F in Fig. 33 is exactly the same before every field pulse, whether it happens to start on a whole line or half a line. Therefore the time taken to charge C_F to the field scan trigger level is constant so interlace is correct.

The original reason for blanking so many lines after the field pulse was to allow enough time for receiver line and field scans to stabilise. Modern sets do not need anything like as much time as this and most of these lines could now be included in the picture proper with a slight gain in vertical resolution. However there is no sign of this being done because these non-picture lines (as many an 50 out of 625) have other uses. The viewer is unaware of anything transmitted on these lines because they are 'off the top' of his picture. They often carry test signals for studio and network monitoring and a recent exciting proposal is to put alpha-numeric information on them in digital code – the British CEEFAX/ORACLE system now under trial.

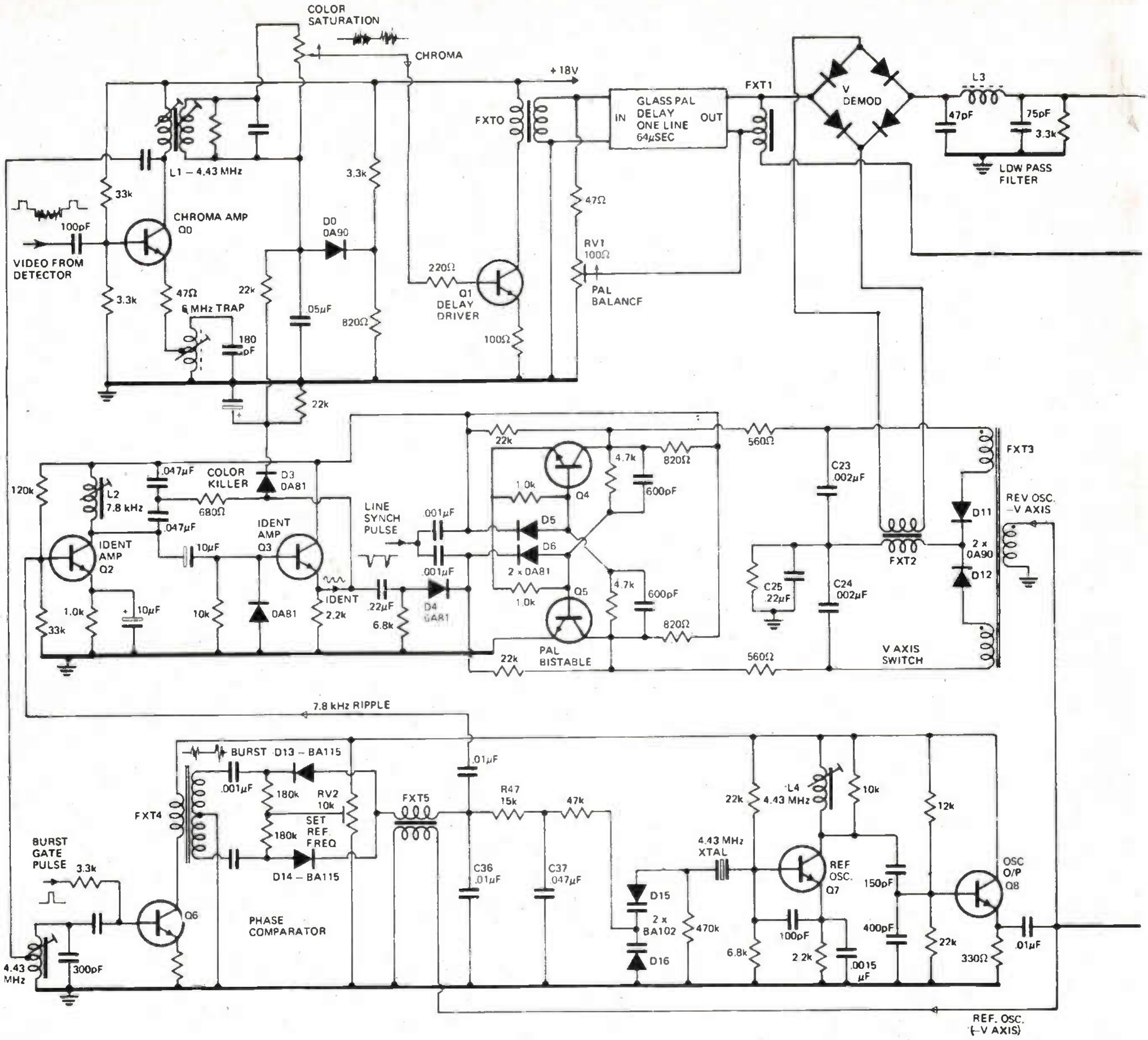
PAL DECODER

The function of a colour decoder is to recover the two colour difference signals from the chroma (modulated subcarrier) signal and thereby control the proportions of red, green and blue light produced by the display tube to create correct colour impressions by additive mixing. A commercial decoder circuit and its block diagram are shown in Fig. 34. A hybrid circuit is chosen because the stages are most readily identifiable.

The chroma amplifier is a simple tuned stage Q0. The 5.5 MHz sound intercarrier is blocked by a tuned trap in Q0 emitter. Amplified chroma passes via a viewer control to the PAL delay line driver Q0. The control VRO varies the overall gain of the chroma stages. Although this could be fixed by the designer virtually all PAL receivers have this control which enables the picture colours to be set under-saturated, correctly saturated or over-saturated to taste. It does not affect the colour hues which are never adjustable on PAL receivers.

Note that Q1 obtains its base bias through the 'colour killer' D3. Excessive forward bias is prevented by DO. For the moment note only that the colour killer has the power to shut off this chroma stage, as its name suggests.

Transistor Q1 drives the PAL delay line via a transformer FXTO. The delayed chroma passes to an autotransformer FXT1. Suppose VR1



is anticlockwise so the centre tap is earthed. Then delayed chroma appears at the bottom of FXT1 and inverted delayed chroma appears at the top. Now by advancing VR1 some *undelayed* chroma can be added to both these. If the undelayed chroma strength is set exactly equal to the delayed signals (after delay loss) the upper and lower autotransformer outputs become:

(undelayed – delayed)
and (undelayed + delayed).

As explained last article, this separates the V and U components of chroma respectively and achieves electronic cancellation of phase errors. These components are fed to two synchronous demodulators which also receive suitably phased subcarrier frequency from the crystal oscillator Q7. This is controlled by the burst in a phase-lock loop similar to the one described last month.

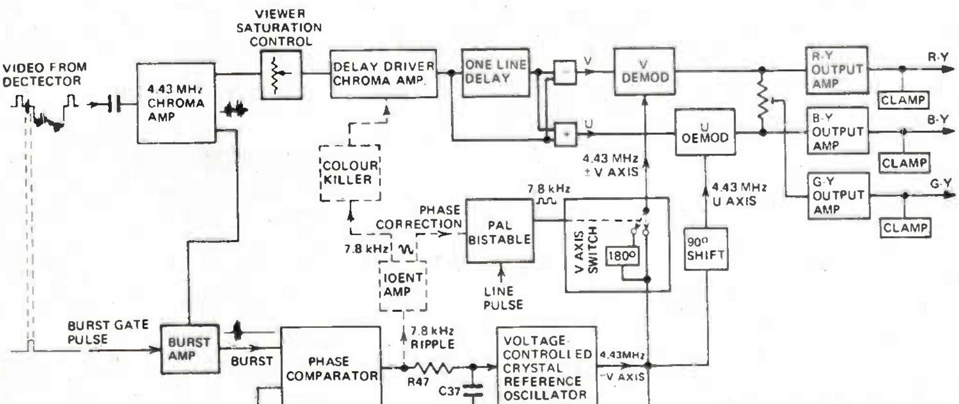


Fig. 34b This is a block schematic of Fig. 34a. The dotted stages are not essential for decoding.

PHASE LOCK LOOP

The chroma at Q0 collector is also picked off by C4 and fed via a 4.43 MHz tuned circuit to the *burst amplifier* Q6. This transistor receives forward bias only during the 4.43 MHz reference burst (Fig. 32a) i.e. during the back porch period just before the picture information on each line. This is achieved by a *burst gate pulse* which is derived elsewhere in the receiver by delaying line sync. pulses to turn on Q6 at exactly the right times. It is essential that no picture chroma information should get past Q6 to the phase comparator.

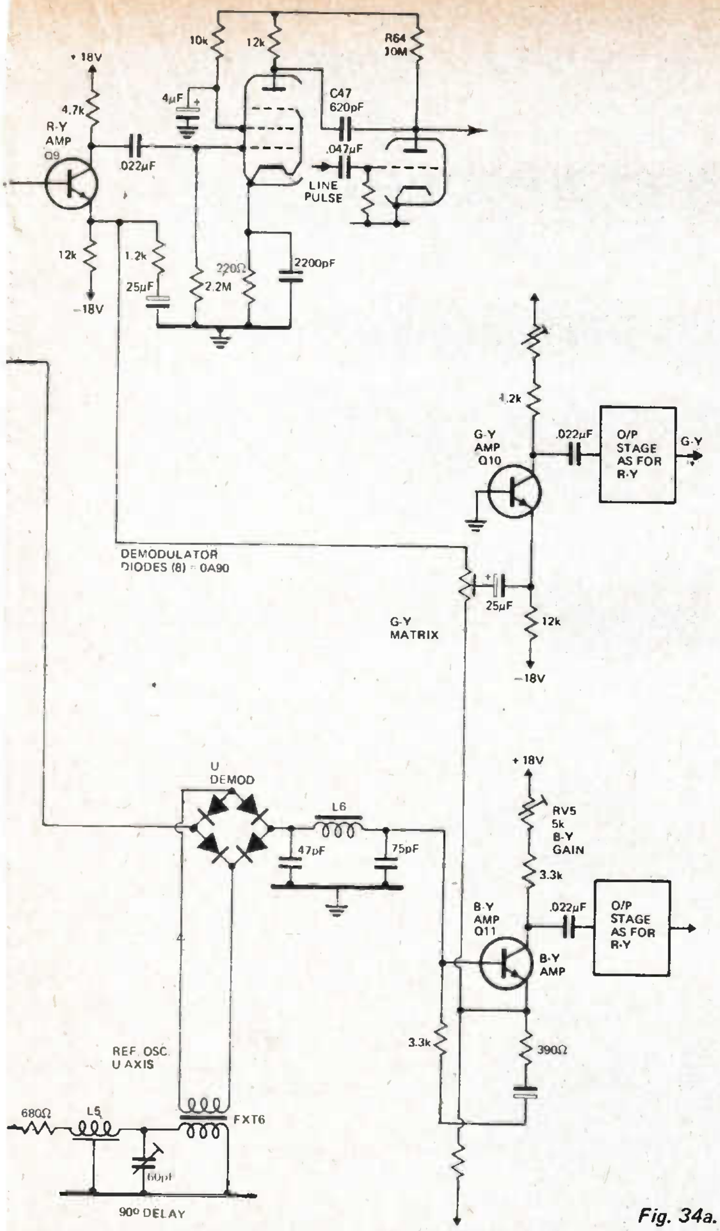


Fig. 34a. Typical PAL decoder.

The frequency of the reference oscillator Q7 is accurately held at 4.43 MHz by the quartz crystal. Its output is buffered by emitter follower Q8 and fed back to the phase comparator.

The action of the phase comparator is to produce an output voltage on C36 which is proportional to the phase difference between the burst and reference oscillation. On the half cycles of burst when the lower end of FXT4 secondary is positive and the upper end is negative, D13 and D14 conduct. This effectively connects VR2 slider to C36, via the 180k Ω resistors and FXT5 secondary. Since the latter is a source of reference oscillation the voltage left on C36 after the burst has passed is equal to VR2 slider voltage *plus or minus* the average level of the reference oscillation during D13 and D14 conduction. This depends on the phase relation between burst and reference – see Fig. 35.

If burst lags reference by 90° the mean level is zero and nothing is added to or subtracted from VR2 slider voltage. In practice this phase relation never occurs because a feature of the PAL signal is that the burst phase jumps forwards and backwards through 90° on successive lines. This causes alternate positive and negative swings on C36 – see Fig. 35 (b) and (c). This waveform is smoothed by R47/C37 to obtain its mean dc level which is applied as a control voltage to the two varicap diodes in the reference oscillator. Increased positive voltage causes these diodes to lose capacity causing the oscillator to gain in phase (slightly increased frequency);

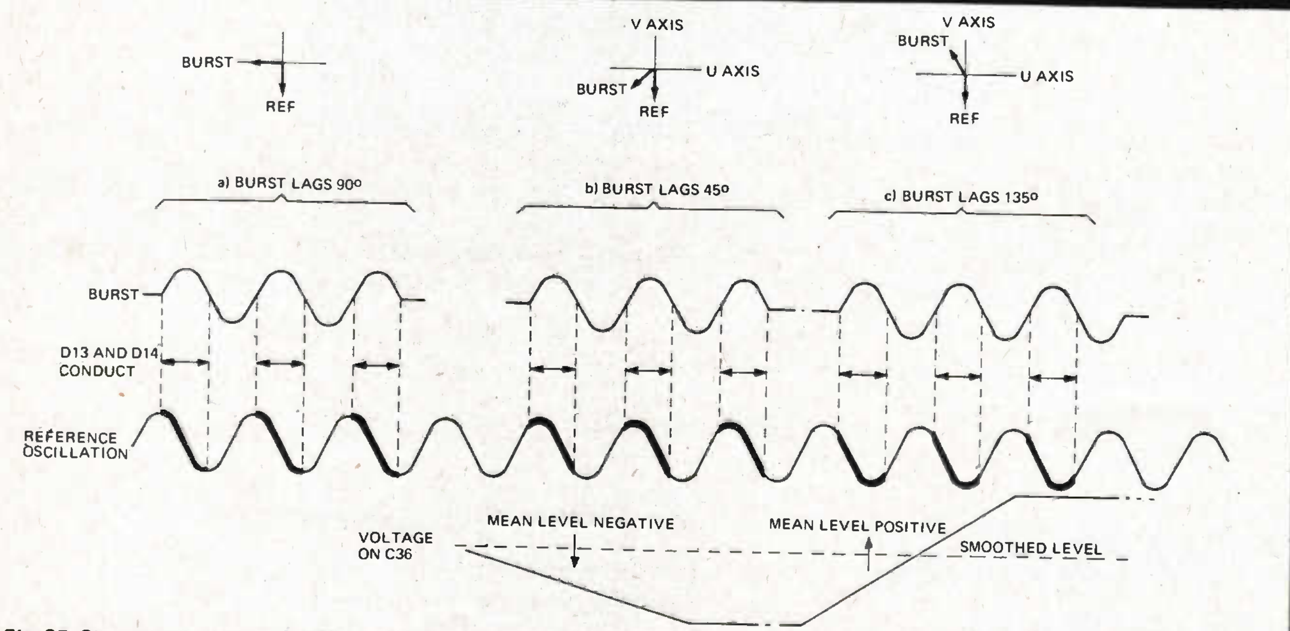


Fig. 35. Phase comparator acton. The bursts actually consist of ten cycles of subcarrier frequency only three of which are shown here. The burst swings between case (a) and case (b) on successive lines causing an a.c. waveform on C36.

decreased voltage causes the oscillator to lag. If VR2 is set for exactly correct reference the smoothed phase comparator output stabilises the oscillator phase on the –V axis (see Fig. 35) since here alternate bursts cause equal swings of the C36 waveform about its mean level.

SYNCHRONOUS DEMODULATION

The U and V demodulators each consist of a four-diode switch. Half cycles of reference oscillation cause all four to conduct, alternate half cycles cause them to block. The output of each demodulator is the algebraic product of the two inputs; high frequency harmonics are also produced because the cycle of conduction of the diodes is rather more abrupt than a true sine law. All harmonics are removed by the low pass filters following the demodulators. From these are obtained demodulated U and V.

The U axis reference oscillation feed for the U demodulator is simply obtained by delaying the reference oscillator output by ¼ cycle (90°) in an LC delay L5/C46. However the V demodulator needs a reference feed which differs 180° on successive lines to follow the PAL reversals of the V signal. The reference oscillator is already at the –V phase. The phase switching is performed by D11 and D12. One or the other of these diodes is always conducting depending on the state of the 'PAL bistable' Q4/Q5. Therefore either the upper or the lower secondary winding of FXT3 is connected to the V demodulator via FXT2. (C23/C24/C25 have low impedance at 4.43 MHz.) Since FXT3 secondaries are oppositely phased with respect to earth, the V demodulation phase is reversible simply by changing or 'toggling' the PAL bistable. This is done at the start of every line by a line sync. pulse which is 'steered'. by D5/D6 to whichever of Q4 or Q5 happens to be on. It turns off this transistor causing the bistable to adopt a new state until the next pulse.

IDENT

The problem of ensuring PAL switching operates in correct phase has been mentioned. It is solved by the ident amplifier Q2/Q3. This is tuned to magnify the 7.8 kHz ripple produced on C36 by the swinging bursts. The ripple is amplified to a beefy sinewave, the 'ident' at Q3 emitter. Note that 7.8 kHz (half line-frequency) is also the operating frequency of the PAL bistable. The ident however carries the *correct* PAL phase information. Diode D4 allows the ident to overule the toggle pulse steering to correct the bistable phase if necessary.

In theory the ident could be amplified sufficiently to drive the V phase switch directly but only one manufacturer is known to have chosen this approach. The scheme described is used by the majority of PAL receivers for its simplicity.

THE COLOUR KILLER

During a colour programme D3 receives the 7.8 kHz ident signal and half wave rectifies it to produce several volts positive on reservoir capacitor C7. This voltage is the source of forward bias for the chroma amplifier Q1.

Like any amplifier, the chroma stages generate some electrical noise. It happens that a small amount of chroma noise which would be unnoticed in a colour picture can cause a very unpleasant effect on a monochrome picture, appearing as a kind of 'coloured confetti'. The purpose of the colour killer is to switch off the chroma stage(s) to prevent this.

Monochrome transmissions do not (or should not) carry any subcarrier burst in the line back porch period. No swinging bursts means no 7.8 kHz ripple from the phase comparator thus there is no ident and hence no bias supply from D3 for Q1. Therefore Q1 draws no collector current and no chroma noise is fed into the PAL delay line.

WEAK SIGNALS

Because of the colour killer, a PAL colour receiver gives only a monochrome picture if tuned to a distant colour transmitter. The subcarrier bursts in this case are too weak to bring the decoder's phase-lock loop into control so no (or weak) ident is produced. This is satisfactory because a weak television signal may give an annoying confetti-ridden colour picture but only a slightly degraded monochrome picture.

In receiver repair the colour killer is rather a nuisance because a wide variety of component failures can cause it to shut off the chroma leaving no colour information on the screen to interpret. Therefore servicemen often deliberately over-ride (disable) the colour killer circuit by some simple means. For example in Fig.34 an appropriate method is to solder a resistor of 10 kilohms or so from h.t. to Q1 base to provide uninterrupted forward bias. For other circuits the manufacturer's service information, if available, usually gives a method. But don't forget you've done it. One is liable to forget to 'unkill' the killer when 'shutting up' the set after servicing!

Many receivers employ a sophistication of the colour killer which improves picture resolution on monochrome. We recall that the luminance signal chain includes a 4.43 MHz trap circuit to remove chroma. The principle is to fit a diode in series with this trap and use the 'colour killer voltage' on C7 to keep the diode forward biassed so the trap action is unaffected. However the absence of voltage on monochrome causes the diode to block. This disables the trap to restore full bandwidth luminance drive to the tube.

DECODER OUTPUTS

It will be shown later that the outputs of a decoder can be either E_R, E_G, E_B or E_R-E_Y, E_G-E_Y, E_B-E_Y depending on how the display tube is connected. The latter set of signals is produced by the decoder in Fig. 34.

Since V = 0.877 (E_R-E_Y)
and U = 0.493 (E_B-E_Y)
the signals in brackets are simply obtained by passing the outputs of the U and V demodulators through stages of suitable gains. In Fig.34, VR0 sets the overall colour gain and VR5 sets the gain for E_B-E_Y relative to E_R-E_Y.

The third signal E_G-E_Y is obtained by adding together suitable proportions of the other two — see Part 2. The proportions are set by VR3 and VR4 in Fig.34.

The display tube requires large voltage swings from the decoder which are provided in this hybrid design by the three identical pentode amplifiers V0a, V1a and V2a. Since each colour difference signal may swing positively or negatively from its 'no colour' (black, grey or white) level, it is important to fix this level. This is achieved by coupling each colour difference signal to the tube via a capacitor (C47, etc.) and a *driven clamp* consisting of the triode section of each output valve. Normally this valve is off. Between scanning lines where there is no chroma signal, the clamp triodes are briefly turned on by a line sync. pulse fed to their grids. This adjusts the charge on C47 so that the no-colour output level is the voltage at the triode cathodes, which is fixed by a resistor divider. A long time-constant is formed by R64 and C47 which prevents the no-colour level drifting during the scanning line. The decoder, which is the most formidable part of any colour receiver circuit, has now been fully described.

To be continued . . .

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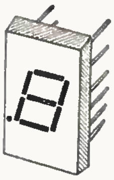

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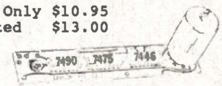
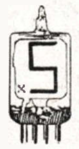


RCA DR2010 NUMITRON



RCA DR2010 Numitron digital display tube. This incandescent five-volt seven-segment device provides a .6" high numeral which can be seen at a distance of 30 feet. The tube has a standard nine-pin base (solderable) and a left-hand decimal point. Each $4.00
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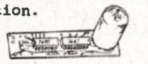

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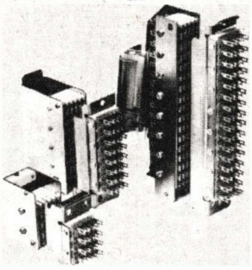

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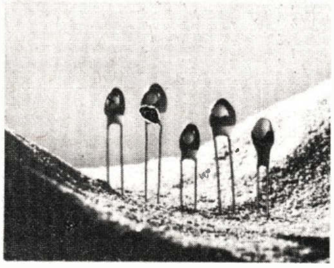
Internationally recognised "RACINE" hydraulic pumps and valves are sold and serviced throughout Australia by Plessey Australia, Telecommunications Division, Meadowbank, NSW.



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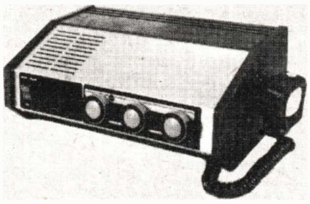

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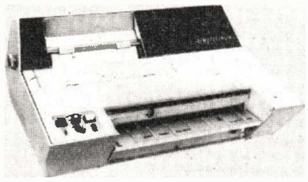
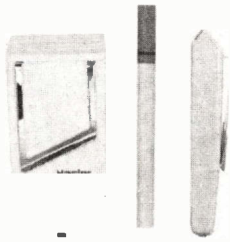
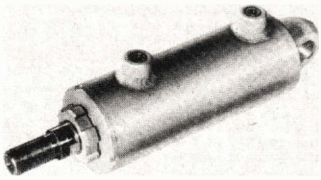


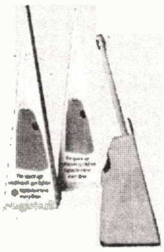
Marketed by Plessey Communication Systems, the Facsimile Remote Copier is a desk-top copier capable of transmitting and receiving over public or private telephone lines, printed, written or graphic material within minutes.



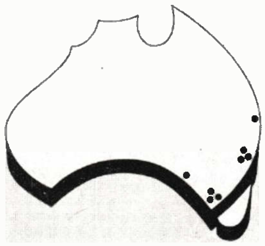
This cigarette pack size radio paging receiver uses the most advanced electronic equipment to maximise efficiency in the location of staff. This inductive loop system is available from Plessey Communication Systems.



Designed and manufactured locally, Plessey hydraulic cylinders and presses are available for a variety of industrial and mobile applications. The cylinder illustrated is just one of the wide range available from Plessey Australia, Telecommunications Division, Meadowbank, NSW.



Marketed by Plessey Australia, Components Division the 'Magispark' is a compact electronic gas lighter providing a continuous spark suitable for use in kitchens, on boats, caravans and for outdoor stoves and gas barbecues.



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APP70

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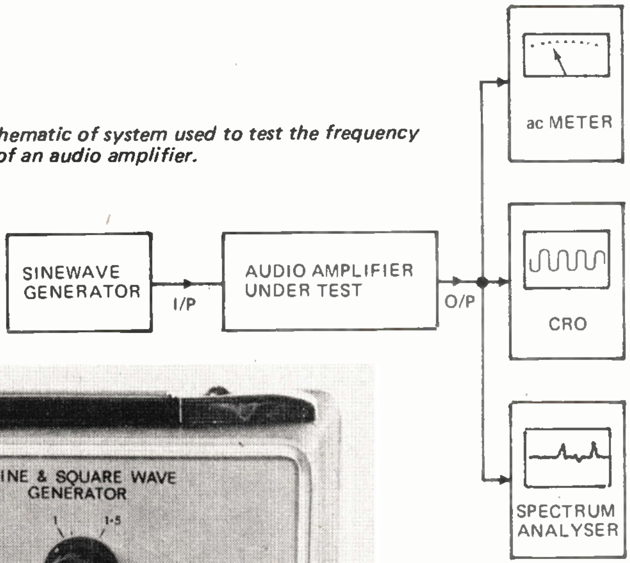


Fig. 1. Schematic of system used to test the frequency response of an audio amplifier.

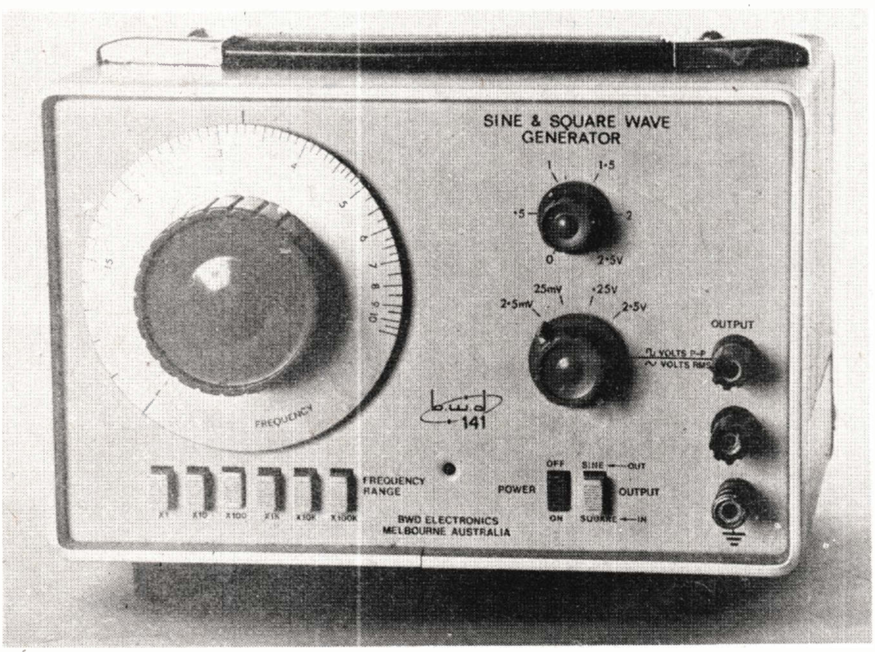


Fig. 2. This audio frequency generator, from BWD, is a medium cost unit that provides adjustable amplitude sine and square waves at frequencies from 1 Hz to 1 MHz.

THROUGHOUT electronic systems, repetitive waveforms of specific shape are commonly processed in order to achieve the desired function. Typically used are — sine waves, square waves, triangular and sawtooth waveforms as well as many types of pulse train.

For instance one may need a sinewave signal generator to determine the response at various frequencies of an audio amplifier. This is done by feeding a sinewave into the input (as shown in Fig. 1) whilst monitoring the amplitude and wave shape of the output. By such means it is possible to establish an amplifier's gain and distortion over its working frequency range. A suitable signal source for this task, such as that shown in Fig. 2, would need adjustable frequency range over the audio band (10 Hz — 20 kHz), adjustable amplitude, and above all an adequately pure sinusoidal wave shape. Any distortion in the test sine-wave would of course affect measurements.

Similarly radio and television receivers are tested by injecting known sine-wave frequencies, only here, the frequencies used are much higher.

In the construction of a radio transmitter, or a multiplexed signal system, a basic carrier is required upon which the modulation is impressed. This technique was described in Part 5 of this series. Here however, the requirement is for fixed frequencies; there may not be the same need for waveform purity as in the testing of a superior audio amplifier.

An excellent example of the need for signal generation is in electronic musical instruments such as the electronic organ or music synthesizer. Both types of instruments require numerous waveforms to be generated over a wide range of frequencies. These waveforms are then mixed and modified in amplitude and time to create an enormously wide variety of sounds. Virtually any sound can be created — from surf breaking on the rocks to conventional musical instruments.

In instrumentation a measuring bridge similar to that shown in Fig. 4 is often used. This particular configuration, known as a Wheatstone bridge works as follows.

If, when an excitation voltage is applied to the bridge, R1 equals R2

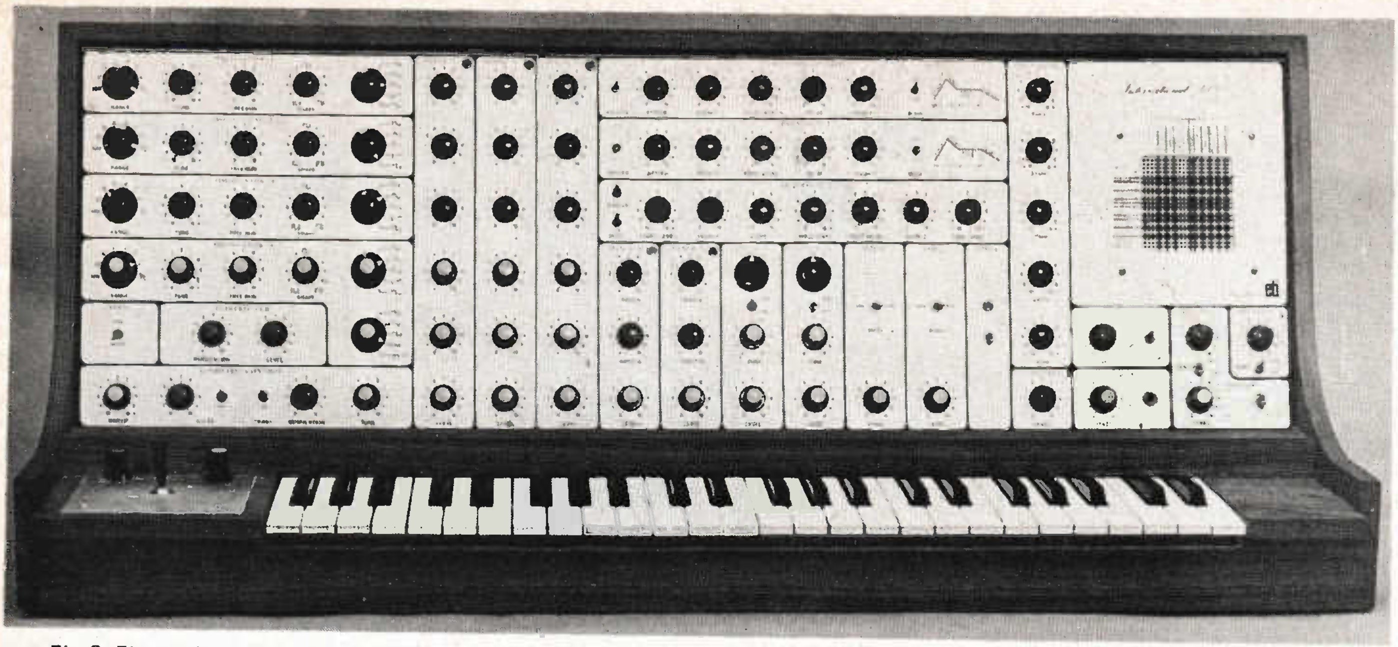


Fig. 3. Electronic music synthesizers, such as the ETI 4600 shown here, create musical sounds from signal generators and waveform shaping modules — not from musical instruments.

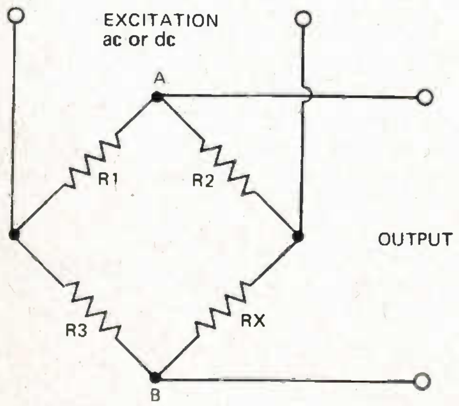


Fig. 4. The Wheatstone bridge is commonly used in instrumentation for measurements with various types of sensor. The bridge is usually excited by an ac source so that the output may be more readily amplified.

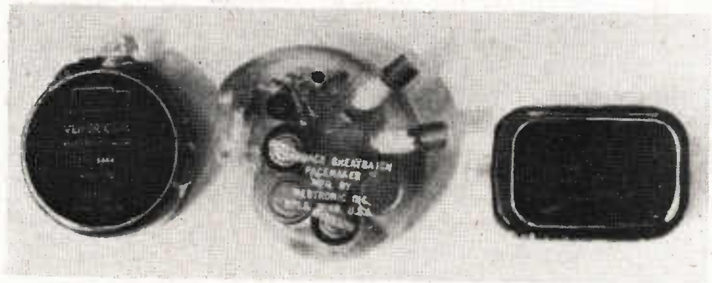


Fig. 5. Three common, fixed-rate implantable pacemakers.

and R3 equals RX there will be equal voltages at points A and B, and hence, there will be no output.

Resistor RX is usually a sensor, such as an LDR, thermistor etc which changes its resistance proportionately to the quantity (light, temperature pressure etc) being measured. As RX changes in value the bridge will become unbalanced and an output will be obtained, which is proportional to the change in light level etc.

The excitation used is most often ac because then the output will also be an ac voltage. An ac voltage is more easily amplified and more easily extracted from noise than a dc voltage.

Some instrument applications require a steady sine-wave to excite resonance in a mechanical component, this, in turn, is used to maintain the signal at a constant value. Many accurate clocks work on this principle.

The pacemaker, used to strobe the failing human heart into regular pumping action, puts out a steady train of stimulating pulses. In this application the design demands are for long-life, utmost reliability and, in the case of implanted units, small size, as is depicted by the units shown in Fig.5.

The time-base generator as used in the cathode-ray-oscilloscope, or in the television camera and monitor, provides a signal that steadily increases in amplitude in order progressively to deflect the electron-beam of a cathode-ray tube across the imaging surface. Once the end of the trace is reached it may retrace back again at the same rate or fly back at a much higher speed to start again. The generation of sawtooth and triangular signals that fulfil timing operations — the sweep action of a flat-bed plotting table is another example — is an often met need.

Digital calculators and computers (really one and the same thing in many cases, see Fig.6), require a steady source of timing pulses — a square or rectangular wave train — that pulses the digital — computational circuits along pulse by pulse. This is called the system clock. In many systems, clock rates may be as high as several million pulses per second.

In some applications a short burst of waveform only is required — not a continuous train. In this case the unit must generate the signal needed and then stop, waiting for the next demand. Ultrasonic and radar distance measuring devices are examples of this need: a single pulse is fed to the transducer or antenna, the time taken to go the target, bounce off and return, is then measured against a time base. The cycle is then repeated for the next measurement.

Although noise is usually regarded as having only nuisance value in electronic systems, the occasional need arises where noise must be generated. The obvious way to test the performance of a system under noisy conditions is to feed it with signal and noise mixed together. By adjusting the signal-to-noise ratio the performance of the system on noisy signals may be measured.

One last example is the provision of tremulant (amplitude modulation) in electric guitars. This is simply the amplitude modulation of the artist's created musical sounds with a constant low-frequency signal. Once the string vibration has been transduced into an electrical equivalent signal form this is modulated by the low frequency signal.

These are but a few of the vast number of applications. The range of performance specifications vary so widely that we must employ many different generating methods to cover all needs. What is good for audio frequency is of no value at UHF frequencies. It is, therefore, necessary to study many alternatives if a really useful knowledge of electronic systems is to be gained.

SIGNAL TYPES

In Part 4 we saw how all wave forms are composed of numerous sine-waves of different frequency and amplitude. In theory we need only generate sine-waves and mix them together as needed to obtain any desired waveform. In practice, however, this is rarely the way that wave shapes are created. There are many much simpler ways. For example, consider the generation of a low frequency square wave. All we need is a mechanical switch that repetitively opens and closes a dc circuit. To provide a ramp we need only use the voltage building up across a capacitor as it is fed from a dc source.

This is not to say that the Fourier-analysis method is of no value. Indeed, by recognising that waveforms *can* be built up from sine-waves we can improve wave shape by following design procedures that observe this rule. A perfectly-adequate, pure sine-wave can be generated by filtering the higher harmonics out of a square wave signal; a much used technique.

A variety of wave forms is shown in Fig. 7. They are photographs taken of signal generator outputs applied singly and in various combinations to the

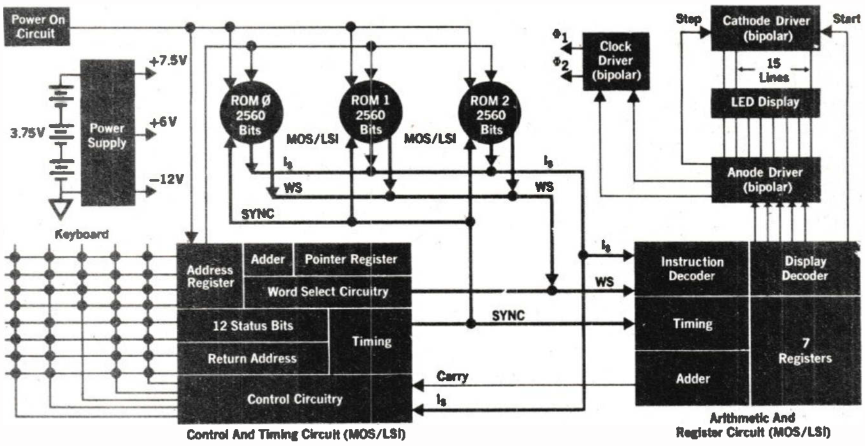
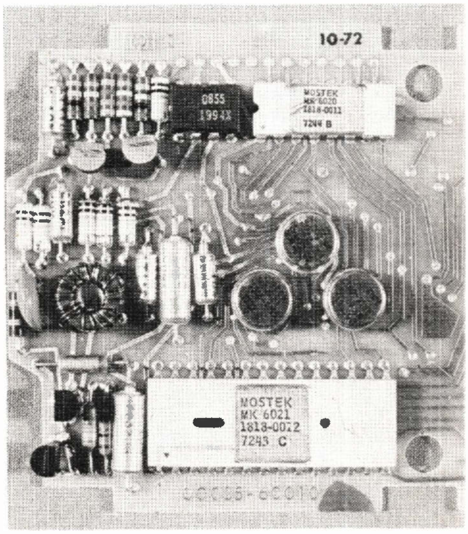


Fig. 6. Calculators work by processing pulses under the control of a train of clock pulses and instructions stored within a digital memory. Shown here is the schematic and logic card of the Hewlett Packard HP35 scientific calculator.



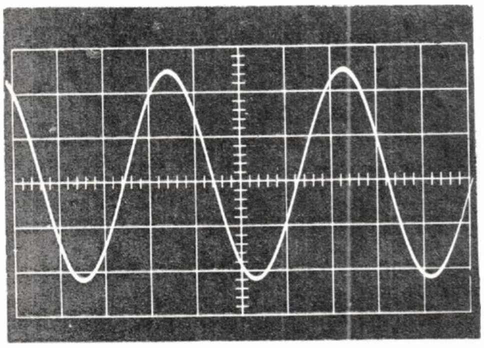
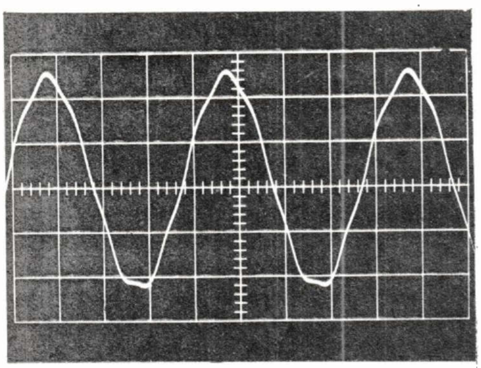
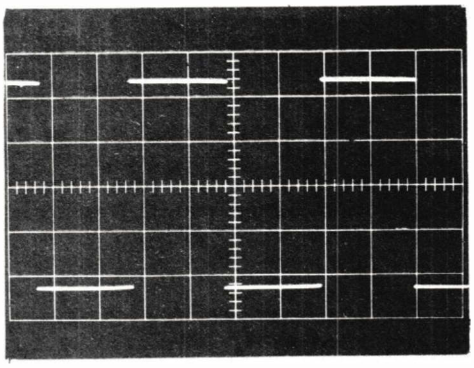
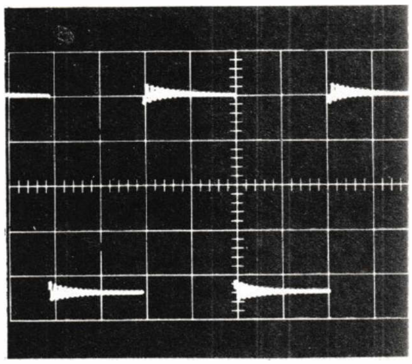


Fig. 7. Various waveforms as photographed on an oscilloscope screen.
(a) Sinewave
(b) Sinewave with harmonic distortion
(c) Square wave
(d) Square wave with ringing.
(e) Sawtooth or ramp.
(f) Triangular (g) White noise







vertical "Y" amplifier input of a cathode ray oscilloscope. The CRO trace is swept across the screen by its own in-built time-base generator. With practice it is possible visually to assess the quality of a wave shape to within a few per cent by studying its geometric shape. A mask, cut out in the shape of the required function, if placed over the CRO graticule, is a useful aid in wave-form distortion studies. Serious work, however, requires the use of expensive frequency analysers which record the amplitude (and possibly phase) of the frequencies present. A pure sine-wave will have no energy at any other than the frequency desired. Thus, in practice, distortion shows up as energy at other higher frequencies.

The square wave should be perfectly sharp and square-cornered — deviations from perfection show up as an obviously rounded rise and fall or as decaying ringing oscillations at the step transitions. Signal analysers are again ideal for studying the imperfections but are not always available due to their high cost.

Most general-purpose signal generators will provide both sine and square waves — this is because the square wave is easily derived from a sine-wave by amplification and clipping of both half cycles. More expensive generators will provide ramps, and triangular waveforms as well, and perhaps single shot pulses of any waveform type, the pulses being manually initiated or triggered by an external signal.

More expensive, instrumentation signal-generators generally fall into two groups; precision sine-wave (and other shapes) generators with two outputs that can be varied in phase with respect to each other, at the other extreme is the pulse generator which provides digital forms of signal.

For practical reasons, generators cover a specific range of frequencies. There are low frequency generators that provide signals of various waveforms with repetition rates of cycles per hours to several kilohertz. (What is low is highly subjective — the earth scientist regards frequencies of hundreds of years as definite ac signals; the electronic engineer would treat these as pure dc, ac signals being to him those from one cycle per second upward. The optical engineer works with frequencies of terahertz! It is all a matter of relativity.

The audio range is covered with generators providing from around 10 Hz to 20-100 kHz, there being little need for higher or lower frequencies in audio studies.

Radio frequency, (RF) generators provide frequencies needed in radio work, for example, 500 kHz to 1.5 MHz for the broadcast band. Yet higher, are systems for testing and driving radar networks (in the GHz range).

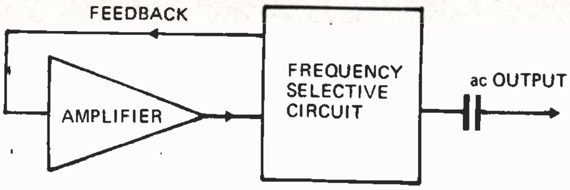
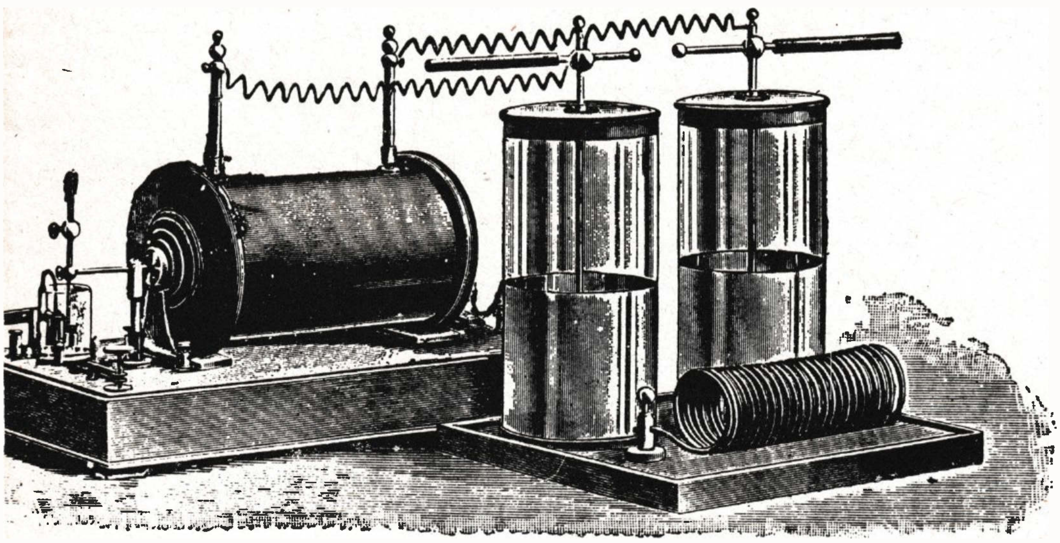


Fig. 8. Basic block diagram of a feedback oscillator.



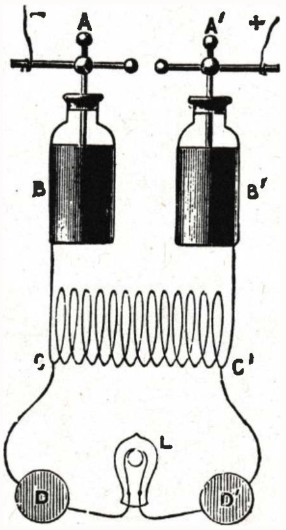
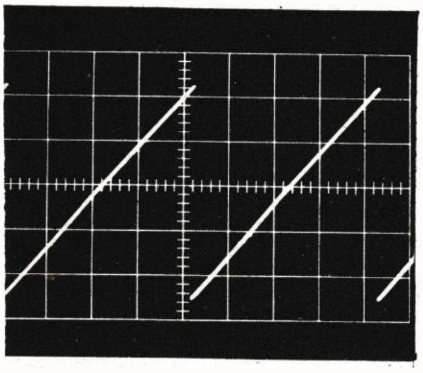
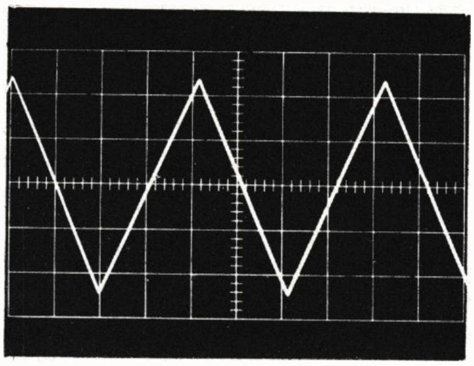
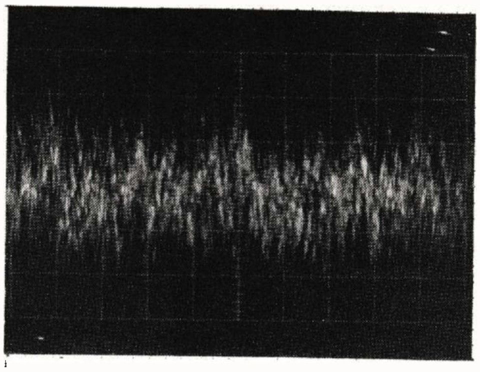


Fig. 9. High frequency generation using a spark discharge from a tuned LC network. The D'Arsonval high frequency apparatus employed two Leyden jars where the outer coatings were joined by a helix, and the inner coatings fed by an induction coil.







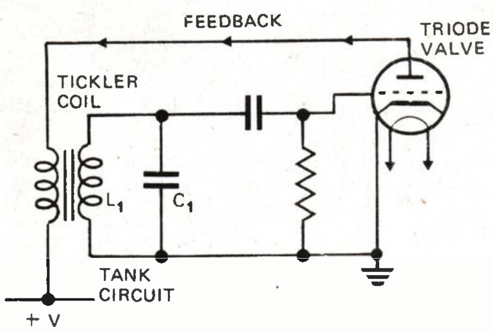


Fig. 10. Schematic of Armstrong's oscillator — the first practical unit to apply positive feedback to the thermonic valve. Developed in 1914.

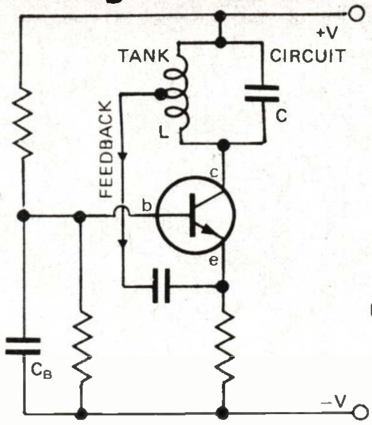


Fig. 11. The circuit of one of the basic forms of feedback oscillator. This type (feedback from tap on tank coil) is known as a Hartley oscillator.

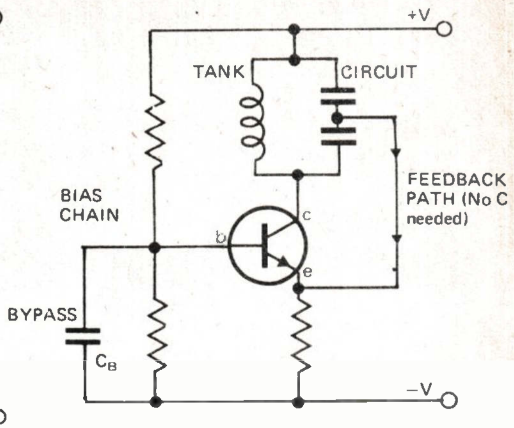


Fig. 12. An alternative arrangement of feedback taps the capacitor rather than the coil. This circuit is called a Colpitts oscillator.

Noise generators provide basically white noise (white noise is defined as having constant power at all frequencies) within the range of interest. There is no sense in building the generator to provide megahertz frequencies when the unit is intended for 1 Hz system testing. By appropriate filtering noise generators may also provide 'pink noise' (noise which falls off uniformly as the frequency rises) or one of many forms of 'grey noise' (non-ideal white noise where the power at various frequencies follows no set law).

Some generators can provide bursts of signal waveform at preset intervals between them. These are useful in radar and sonic distance gauging, in telegraphy and in electronic-music synthesizers.

You might by now feel that the variety of needs implies an overwhelming number of techniques to comprehend. Fortunately the techniques used are far fewer than the possible applications, and many techniques are common to a number of frequency ranges.

BASICS OF GENERATION

Open loop — The desired waveform may be created by using an appropriately shaped mechanical device. A time-varying waveform can be produced by rotating the mechanical part at the speed required. For example, the experiment described in Part 5 used a rotating blade to alter the light level on a light-dependent resistor. The photo-optical method of generation is economic where very low-frequency waveforms of great complexity are needed. One commercial unit uses a circular transparent disk that can be masked as needed. One unusual application of such a device was to simulate the electro-cardiogram signal of a snake. This allowed the data processing equipment, used in research on snakes, to be tested without a live snake, (snakes vary their heart rate randomly from minutes to hours between beats).

Rotary mechanical generators generally produce signals in 'open-loop' — no use is made of the signal produced to modify itself. Tone wheels for electronic organs and strobing lines on turntables also operate this way. In general, however, most signal generators used in electronics make use of feedback, or closed-loop systems.

Closed-loop — on several previous occasions we have seen how negative feedback (that is, the sign of the feedback voltage is opposite to the signal input) helps to stabilise circuits. Examples are, the use of an emitter resistor to improve thermal stability in the basic ac transistor — amplifier stage, and in the operational amplifier networks where a desired gain is obtained from a much higher gain amplifier; the advantage of negative feedback being greater precision and stability.

The converse also applies: positive feedback leads to enhanced instability. By arranging for the output of the active device to feed back into its input with like sign (similar phase) any small change in input leads to rapid build up of output — up to an amplitude governed by the circuit. If the circuit can then be so arranged

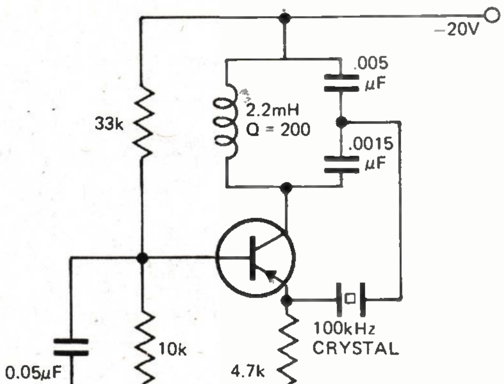


Fig. 13. Oscillator using feedback via a crystal in series-mode.

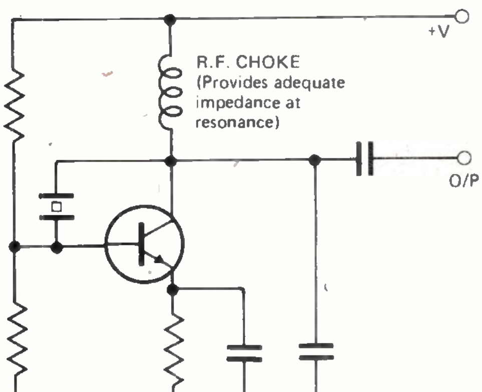


Fig. 14. The Pierce oscillator uses the quartz crystal in its parallel mode of vibration.

that once this limit is reached the source of energy is disconnected the output will fall to zero again. In the meantime the source becomes energised again and the device output again rises. The process repeats providing a steady cyclic signal of wave form decided by the mechanism used. Some oscillators, as such generators are called, produce square-waves, some sinusoids, others ramps.

In general, feedback oscillators can be shown as a system, with a block diagram as in Fig. 8. An amplifier feeds a wave-shaping circuit that controls the time-behaviour of the all-important positive feedback. This diagram should also help to explain why high-gain circuits often oscillate, for any in-phase feedback will turn what is intended to be a stable circuit into an oscillator — the higher the open-loop gain the less in-phase signal needed to cause oscillation.

The natural frequency of oscillation of a feedback system depends upon component values and can be estimated with reasonable accuracy in most designs. There are three basic criteria that must be satisfied if a feedback circuit is to oscillate. Firstly, the phase shift through the amplifier and forming circuit must be zero, or close to zero at the frequency of oscillation required. Any shift toward 180° provides increasingly greater stabilising action. Secondly, the voltage gain of the amplifier and forming circuit must be greater than unity at the frequency needed. Thirdly, the voltage gain must drop to unity once oscillation has begun. If it did not do this, the amplitude would keep on building up with time.

These rules will become more evident as we now look at several design alternatives.

BEFORE ELECTRONICS

Before thermionic valves were invented the generation of high-frequency signals was particularly difficult. One way was to use the oscillatory discharging action of a magnetic-induction coil coupled to Leyden jars. The two formed a tuned circuit which, when the jars were fully charged from the dc source, discharged across a spark gap. A typical layout is shown in Fig. 9 along with contemporary equipment used in medical-electricity treatment around 1900. These produced a train of bursts of decaying oscillation.

Also commonly known at the beginning of this century were the Faradic coil generators. These were based on the electric-bell principle. A magnetic coil was fed with current. As the magnetism built up it pulled in a small armature that opened a contact thus disconnecting the coil. This then allowed the armature to return closing the contact again. The system, therefore, oscillates at a characteristic frequency. High voltage pulses were produced from this chopped primary current by induction in a secondary winding having a large number of turns.

These two devices were commonly known when the first triode active element was invented in 1907. They probably led to the creation of the first useful thermionic valve oscillator built by Armstrong in 1914.

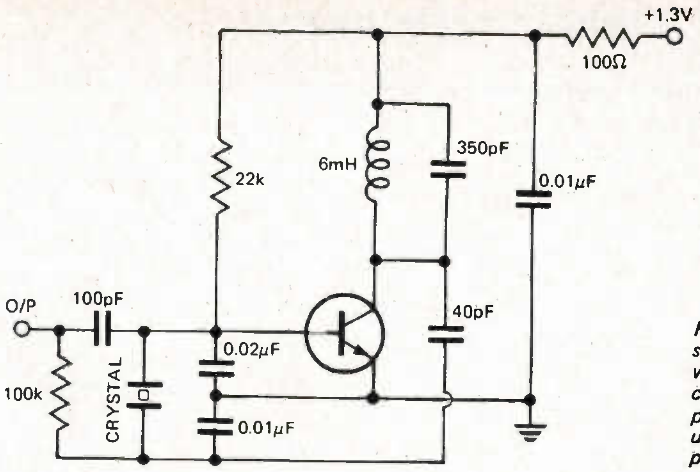


Fig. 15. This very stable oscillator, with a temperature coefficient of one part in 10⁸, is used for calibration purposes.

ARMSTRONG OSCILLATOR

Armstrong's arrangement is shown in diagramatic form in Fig. 10. The resonant circuit L_1 C_1, if initially charged, will oscillate at its natural frequency, decaying to zero in a few cycles as the energy is dissipated in resistive losses in the coil. When combined with an amplifier, the valve senses the periodic changes in the tuned circuit and feeds a signal back (via the tickler coil), into the tuned circuit, which reinforces the resonance, making up for the losses. Provided the phase is correct the oscillation builds up to a level limited only by non-linearity of the amplifier stage. It is like pushing a child on a swing. In this case the resonant circuit provides the frequency control for it will not resonate at any but its natural frequency. Away from resonance the system responds too weakly and oscillation dies away.

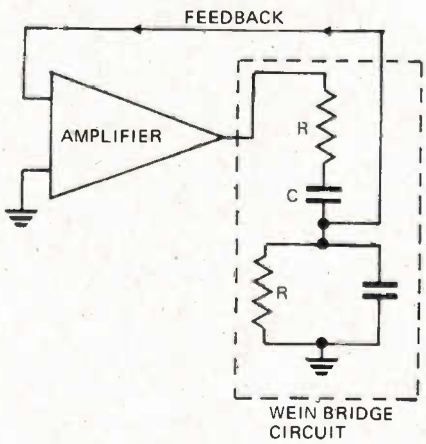


Fig. 16. The Wien bridge network (in the dotted box) provides feedback which is a maximum at one particular frequency. If an amplifier, having sufficient gain, has positive feedback via such a network it will oscillate.

HARTLEY OSCILLATOR

If the inductor of the resonant circuit (called the tank) is tapped, the signal produced at that point can be used to provide the correct amount of positive feedback as shown in Fig. 11. In this case the base of the transistor is effectively earthed through the low impedance of C_b. Thus variations in the tank circuit provide positive feedback to the active element. (Feeding the signal to the base is negative feedback, to the emitter is positive feedback.)

COLPITTS OSCILLATOR

The same effect can be obtained by splitting the capacitor instead of the inductor of the tank circuit. Figure 12 shows the so called Colpitt's arrangement. The output may be taken from the collector, the emitter or from the tank inductor by transformer action.

In each of the above resonant-circuit forms of oscillator the amplifier acts to inject a pulse of current, rather than a smooth change, into the tank circuit. When the amplifier operates this way it is called Class C mode of amplification. The tank circuit provides the quality of waveform. Think of the swing again. This oscillates sinusoidally yet is pulsed to keep it going. In Class -C operation the

ELECTRONICS -it's easy!

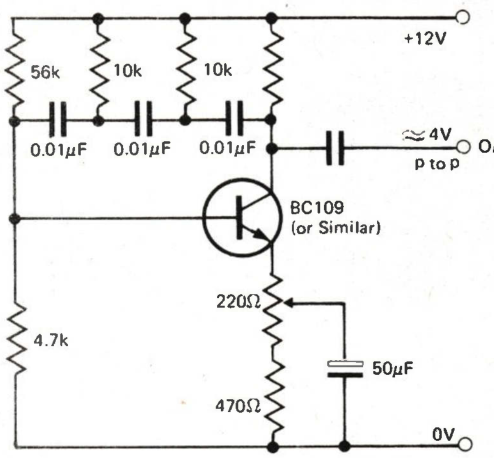


Fig. 17. Inexpensive sine wave generator uses a ladder network to phase shift the output signal 180° at the required frequency of operation.

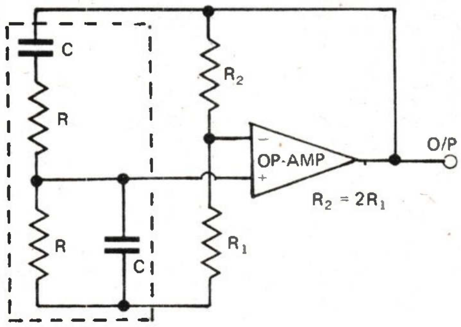


Fig. 18. Wien bridge oscillator using standard, linear op-amp IC (LM301, μA741 etc). The frequency of oscillation fo = 1/2πCR. Thus if fo = 1000 Hz suitable values for R and C would be 160 k and 0.1 microfarads respectively.

active element does not need to respond in the linear region of its characteristic curves. The practical advantage is that it can handle considerably greater power levels in this mode. The actual signal in the active element is, however, a highly distorted version of the output.

QUARTZ CRYSTAL OSCILLATOR

In some designs the frequency generated must be extremely stable. The degree of stability is related to the quality of the resonant circuit in the resonant-type of oscillator. Normal LC tank circuits will achieve quality factors (Q, that is the ratio of reactance of the coil to its resistance) of about 100 but not better because in passive electrical tuned circuits the Q is limited by resistive losses in the inductance.

Mechanical tuned circuits, especially those based on the resonance of quartz crystals, have Q's of 10^5 — they will resonate with about 1000 times greater stability than LC tank circuits.

Quartz is particularly useful for it also possesses sizeable piezo-electric effect. Voltages applied to deposited contact areas will cause the thin slice of quartz to change dimensions. Upon removal of the voltage the crystal resumes its shape generating a voltage whilst doing so. Thus we have an electro-mechanical transducer which is compatible with the electric circuit and which can be used as the equivalent of a superior electrical tank circuit.

A series mode quartz-crystal oscillator is shown in Fig. 13. The crystal "tank" couples the Colpitt's connection back to the active element. The collector tank circuit, which can vary a little due to its low Q, will become synchronised to the natural frequency of the quartz crystal.

Quartz crystal oscillators are useful for frequencies well above audio — in the region of 100 kHz to 100 MHz — but find little application at low frequencies due to the natural limitation of quartz resonance within practical crystals. Where precision low frequencies are needed a quartz oscillator output is divided down to obtain reduced cycle periods. The quartz crystal can also be used in its parallel mode of resonance (decided by the way it is cut and connected). The Pierce crystal oscillator, shown in Fig. 14, uses the parallel mode.

Quartz crystal clocks and watches operate on this principle. A highly stable signal frequency is counted giving time from the known period of the waveform. A highly stable circuit is given in Fig. 15. The tank circuit is tuned to nominally 100 kHz and maintains its value to within one part in 100 000 0C0 per degree celsius change or per 10% change in supply voltage.

PHASE SHIFT OSCILLATORS – WIEN BRIDGE

Another method of obtaining sinusoidal oscillation is to provide the feedback by a network that only provides zero phase shift at one very specific frequency. The stability of frequency then depends upon the network configuration and the stability of the component values.

The Wien-Bridge oscillator is the most commonly encountered phase-shift arrangement. Referring to Fig. 16 it can be shown mathematically that the right-hand network (taken from a Wien bridge arrangement) feeds back a signal which is sharply maximized for one particular frequency and which has zero phase shift. Provided the amplifier has adequate gain the system will oscillate.

The main advantage of phase-shift circuits is that, for low frequencies in

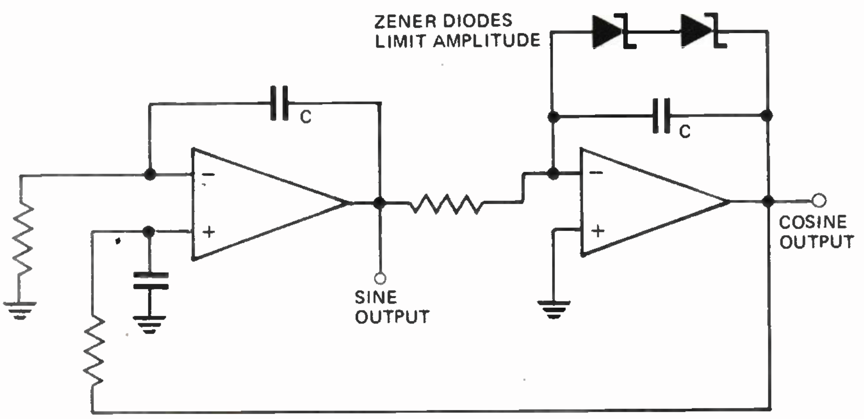


Fig. 19. Generation of sine and cosine waves by implementation of a second-order, differential equation by means of two IC stages. Both stages are essential even if only one output is required.

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7409	.25	7472	.36	74163	1.59
7410	.19	7473	.43	74164	1.89
7411	.29	7474	.43	74165	1.89
7413	.79	7475	.75	74166	1.65
7415	.39	7476	.47	74173	1.65
7416	.39	7483	1.11	74175	1.89
7417	.39	7485	1.39	74176	1.65
7420	.19	7486	.44	74177	.99
7422	.29	7489	2.75	74180	1.09
7423	.35	7490	.76	74181	3.65
7425	.39	7491	1.29	74182	.89
7426	.29	7492	.79	74184	2.69
7427	.35	7493	.79	74185	2.19
7430	.22	7494	.89	74190	1.59
7432	.29	7495	.89	74191	1.59
7437	.45	7496	.89	74192	1.49
7438	.39	74100	1.65	74193	1.39
7440	.19	74105	.49	74194	1.39
7441	1.09	74107	.49	74195	.99
7442	.99	74121	.57	74196	1.85
7443	.99	74122	.53	74197	.99
7444	1.10	74123	.99	74198	2.19
7445	1.10	74125	.69	74199	2.19
7446	1.15	74126	.79	74200	7.95

LOW POWER TTL

74L00	.33	74L51	.33	74L90	1.69
74L02	.33	74L55	.33	74L91	1.45
74L03	.33	74L71	.33	74L93	1.69
74L04	.33	74L72	.49	74L95	1.69
74L06	.33	74L73	.69	74L98	2.79
74L10	.33	74L74	.69	74L164	2.79
74L20	.33	74L78	.79	74L165	2.79
74L30	.33	74L85	1.25		
74L42	1.69	74L86	.69		

HIGH SPEED TTL

74H00	.33	74H21	.33	74H55	.39
74H01	.33	74H22	.33	74H60	.39
74H04	.33	74H30	.33	74H61	.39
74H08	.33	74H40	.33	74H62	.39
74H10	.33	74H50	.33	74H72	.49
74H11	.33	74H52	.33	74H74	.59
74H20	.33	74H53	.39	74H76	.59

8000 SERIES TTL

8091	.59	8214	1.69	8811	.69
8092	.59	8220	1.69	8812	1.10
8095	1.39	8230	2.59	8822	2.59
8121	.89	8520	1.29	8830	2.59
8123	1.59	8551	1.65	8831	2.59
8130	2.19	8552	2.49	8836	.49
8200	2.59	8554	2.49	8880	1.33
8210	3.49	8810	.79		

9000 SERIES TTL

9002	.39	9309	.89	9601	.99
9301	1.14	9312	.89	9602	.89

Data sheets supplied on request
Add $.50 ea. for items less than $1.00

CMOS

74C00	.39	74C74	1.15	74C162	3.25
74C02	.55	74C76	1.70	74C163	3.25
74C04	.75	74C107	1.50	74C164	3.50
74C08	.75	74C151	2.90	74C173	2.90
74C10	.65	74C154	3.50	74C195	3.00
74C20	.65	74C157	2.19	80C95	1.50
74C42	2.15	74C160	3.25	80C97	1.50
74C73	1.55	74C161	3.25		

APRIL SPECIALS

5001	12 DIG 4 funct fix dec	$2.95
5002	Same as 5001 exc btry pwr	4.95
5005	12 DIG 4 funct w/mem	6.95
5725	8 DIG 4 funct chain & dec	2.25
5736	18 pin 6 DIG 4 funct	4.45
5738	8 DIG 5 funct K & Mem	4.95
5739	9 DIG 4 funct (btry sur)	4.95
5311	28 pin BCD 6 dig mux	4.95
5312	24 pin 1 pps BCD 4 dig mux	4.95
5313	28 pin 1 pps BCD 6 dig mux	4.95
5314	24 pin 6 dig mux	4.95
5316	40 pin alarm 4 dig	5.95
8008	8 bit CPU prime quality	64.50

1103	256 bit RAM MOS	$2.95
5260	1024 bit RAM	2.95
5261	1024 bit RAM	2.95
5262	2048 bit RAM	7.95
2102	1024 bit static RAM	6.95
5203	UV Eras.	19.85
HP50827414	4 digit common cathode Fits 14 pin DIP – .11 bubble lens	2.75
MAN 7	Red 7 seg .270"	.99
MAN 66	Red .6" spaced seg	3.50
MAN 6	Red .6" solid seg	3.95
MAN 1	Red 7 seg. .27"	1.50
MAN 2	Red alpha num. .32"	3.39

74C00	$ .29	$25/100	74L00	$ .25	$20/100	7454	$ .25	$20/100
74C02	.49	40/100	74L02	.25	20/100	7460	.15	10/100
74C04	.59	50/100	74L03	.25	20/100	7490	.59	50/100
74C10	.59	50/100	74L04	.25	20/100	7493	.59	50/100
74C20	.59	50/100	74L06	.25	20/100	8836	.19	15/100
74C73	1.15	100/100	74L10	.25	20/100	380	1.19	100/100
74C107	1.25	110/100	74L51	.25	20/100	565	1.95	150/100
74C160	2.75	250/100	74L72	.35	30/100	2N3933	TO-72	1.29
74C164	2.95	260/100	74L73	.49	40/100	40636	TO-3	1.55
80C97	1.25	110/100	74L74	.39	30/100			

MEMORIES w/data

1101	256 bit RAM MOS	$1.75
1103	1024 bit RAM MOS	4.95
5203	2048 bit eras. PROM	24.95
5260	1024 bit RAM low power	3.95
7489	64 bit RAM TTL	2.75
8223	Programmable ROM	3.95

CALCULATOR & CLOCK CHIPS w/data

5001	12 DIG 4 funct fix dec	3.95
5002	Same as 5001 exc btry pwr	7.95
5005	12 DIG 4 funct w/mem	8.45
MM5725	8 DIG 4 funct chain & dec	2.79
MM5736	18 pin 6 DIG 4 funct	4.95
MM5738	8 DIG 5 funct K & Mem	7.95
MM5739	9 DIG 4 funct (btry sur)	6.95
MM 5311	28 pin BCD 6 dig mux	6.95
MM 5312	24 pin 1 pps BCD 4 dig mux	6.95
MM 5313	28 pin 1 pps BCD 6 dig mux	7.95
MM 5314	24 pin 6 dig mux	8.95
MM 5316	40 pin alarm 4 dig	8.95

LED & OPTO ISOLATORS

MV10B	Red TO 18	$ .25 ea.
MV50	Axial leads	.20
MV5020	Jumbo Vis. Red (Red Dome)	.25
	Jumbo Vis. Red (Clear Dome)	.25
ME4	Infra red diff. dome	.60
MAN1	Red 7 seg. .270"	2.50
MAN2	Red alpha num .32"	4.95
MAN4	Red 7 seg. .190"	2.15
MAN5	Green 7 seg. .270"	2.95
MAN6	.6" high solid seg	4.95
MAN7	Red 7 seg. .270"	1.35
MAN8	Yellow 7 seg. .270"	3.95
MAN64	.4" high solid seg	3.50
MAN66	.6" high spaced seg	4.65
DL707	Red 7 seg. .3"	2.15
MCD2	Opto-iso diodes	1.09
MCT2	Opto-iso transistor	.69

DTL

930	$ .17	937	$ .17	949	$ .17
932	.17	944	.17	962	.17
936	.17	946	.17	963	.17

4000 SERIES – RCA EQUIVALENT

CD4001	.55	CD4013	1.20	CD4023	.55
CD4009	.85	CD4016	1.25	CD4025	.55
CD4010	.85	CD4017	2.95	CD4027	1.35
CD4011	.55	CD4019	1.35	CD4030	.95
CD4012	.55	CD4022	2.75	CD4035	2.85

LINEAR CIRCUITS

300	Pos V Reg (super 723)	TO-5	$ .79
301	Hi Perf Op Amp	mDIP TO-5	.32
302	Volt follower	TO-5	.59
304	Neg V Reg	TO-5	.89
305	Pos V Reg	TO-5	.79
307	Op AMP (super 741)	mDIP TO-5	.29
308	Micro Pwr Op Amp	mDIP TO-5	.99
309K	5V 1A regulator	TO-3	1.50
310	V Follower Op Amp	TO-5 mDIP	1.19
311	Hi perf V Comp	mDIP TO-5	1.05
319	Hi Speed Dual Comp	DIP	1.29
320	Neg Reg 5.2, 12, 15	TO-3	1.25
322	Precision Timer	DIP	1.15
324	Quad Op Amp	DIP	1.89
339	Quad Comparator	DIP	1.69
340T	Pos Volt Reg (5V-6V-8V-12V-15V-18V-24V)	TO-220	1.75
370	AGC/Squelch AMPL	TO-5 or DIP	1.15
372	AF-IF Strip detector	DIP	.79
373	AM/FM/SSB Strip	DIP	3.25
376	Pos. V Reg	mDIP	.59
377	2w Stereo amp	DIP	2.69
380	2w Audio Amp	DIP	1.29
380-8	.6w Audio amp	mDIP	1.25
381	Lo Noise Dual preamp	DIP	1.69
382	Lo Noise Dual preamp	DIP	1.69
550	Prec V Reg	DIP	.79
555	Timer	mDIP	.99
560	Phase Locked Loop	DIP	2.75
562	Phase Locked Loop	DIP	2.75
565	Phase Locked Loop	DIP TO-5	2.65
566	Function Gen	mDIP TO-5	2.50
567	Tone Decoder	mDIP	2.95
709	Operational AMPL	TO-5 or DIP	.29
710	Hi Speed Volt Comp	DIP	.39
711	Dual Difference Compar	DIP	.29
723	V Reg	DIP	.69
739	Dual Hi Perf Op Amp	DIP	1.19
741	Comp Op AMP	mDIP TO-5	.35
747	Dual 741 Op Amp	DIP or TO-5	.79
748	Freq Adj 741	mDIP	.39
1304	FM Mulpx Stereo Demod	DIP	1.19
1307	FM Mulpx Stereo Demod	DIP	.82
1458	Dual Comp Op Amp	mDIP	.69
1800	Stereo multiplexer	DIP	2.75
LH2111	Dual LM 211 V Comp	DIP	1.89
3065	TV-FM Sound System	DIP	.69
3075	FM Det-LMTR & Audio preamp	DIP	.79
3900	Quad Amplifier	DIP	.39
7524	Core Mem Sense AMPL	DIP	.79
7534	Core Mem Sense Amp	DIP	.79
8864	9 DIG Led Cath Drvr	DIP	2.50
75451	Dual Perepheral Driver	mDIP	.39
75452	Dual Peripheral Driver	mDIP	.39
75453	(351) Dual Periph. Driver	mDIP	.39
75491	Quad Seg Driver for LED	DIP	.79
75492	Hex Digit Driver	DIP	.89

SHIFT REGISTERS

MM 5013	1024 bit accum. dynamic	mDIP	$1.95
MM 5016	500/512 bit dynamic	mDIP	1.75
MM 5058	1024 bit static	DIP	3.95
SL-5-4025	Dual 64 bit static	DIP	1.50

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the audio region, large and expensive inductors are avoided.

LADDER NETWORK PHASE-SHIFT OSCILLATOR

The appropriate phase shift can be obtained if the output of the amplifier is fed back to the input by a chain of RC filter stages. A typical circuit, set to generate 800 Hz, is given in Fig. 17. Note that it is a conventional ac amplifier stage (refer to part 10) with the ladder network added between the collector and the base to provide the selective positive feedback.

USING IC's

Although many designs of oscillator are based on a single transistor amplifier it should be clear that any amplifier can be wired up with feedback to provide oscillation. Thus, the now inexpensive integrated-circuit operational amplifier is capable of providing better performance with lower output impedance than designs built with discrete components.

Application notes include numerous designs — we show one, that of a Wien bridge oscillator in Fig. 18. For this the bridge circuit, added to the op-amp, is balanced at $f_o = 1/2\pi CR$. The greater the gain the closer the system holds to this value — hence the improvement obtained by using an op-amp opposed to a single transistor (gains 100 000 and 100 respectively).

In our earlier discussion of operational amplifiers (part 12) it was stated that capacitance feedback around a single stage provides an integration action. The solution of a second-order differential equation (those that describe the behaviour of the spring-mass system, L-C resonant circuit and pendulum movement) is a sinusoidal signal. If there is no effective damping the system resonates continuously. We can therefore, using two op-amp integrators, set up such an equation and set it going to produce sinewave and cosinewave signals. Figure 19 shows how this is done. The Zener diodes clamp the output to a set maximum value; without them the output would increase to uncertain limits.

In the next part we will continue with other classes of oscillators — those that produce non-sinusoidal waveforms, those that provide a signal frequency that is electronically adjustable, those that provide digital signals and those that must be used to generate signals at very high frequencies where techniques of amplification are quite different to those based on transistors.

FURTHER READING

Most books on transistor circuit design explain the principle and theory of oscillators. Few devote much space to the subject however the following will be found helpful.

"Electronics for the Physicist" — C. F. G. Delaney, Penguin, 1969.

"Transistor Manual" — General Electric, 1969.

"Electronic Instrumentation Fundamentals" — A. P. Malvino, McGraw-Hill, 1967.

Books and articles on electronic music hardware cover many circuit ideas.

"Electronics in Music" — F. C. Judd, Neville Spearman, 1972.

For operational amplifier designs consult manufacturers' application notes and books on the subject such as —

"Operational Amplifiers — G. B. Clayton, Butterworths, 1971.

"Modern Operational Circuit Design" — J. I. Smith, Wiley, 1971.

"Operational Amplifiers — Design and Application" — J. G. Graeme and G. E. Tobey, McGraw-Hill, 1971. ●

ELECTRONICS – IN PRACTICE

THE BEST WAY to become familiar with oscillators is to build a few basic circuits such as those given here. Figure 20 shows the circuit for another form of phase-shift oscillator that uses a twin-T (a form of frequency selective bridge) feedback arrangement. Its frequency output is stable to within a few parts in 10 000 for 10% supply variations. To obtain best temperature stability (0.2% change for a temperature change of — 20°C to 80°C) use stable capacitors such as polycarbonate types.

The advantage of this circuit is that it will operate at low frequencies. If $C_1 = C_2 = C_4/2$ and $R_3 = R_4 = 2R_5$ then the resonant frequency will be at $f_o = 0.159/R_3C_1$. (f_o in hertz, R_3 in ohms, and C_1 in farads). With the values shown the circuit operates at 60 Hz.

BIRD SOUND GENERATOR

As an example of synthetic sound generation the circuit given in Fig. 21 produces a chirping sound similar to that of a bird. The adjustable resistor alters the tone of the chirp.

If a light dependent resistor (ORP12 for instance) is inserted in series with the adjustable base-bias resistor, the chirp will only occur when the ambient light level is high — the bird goes to sleep at night. An amusing trick is to mount the entire circuit inside a small box — with the lid is opened the bird chirps.

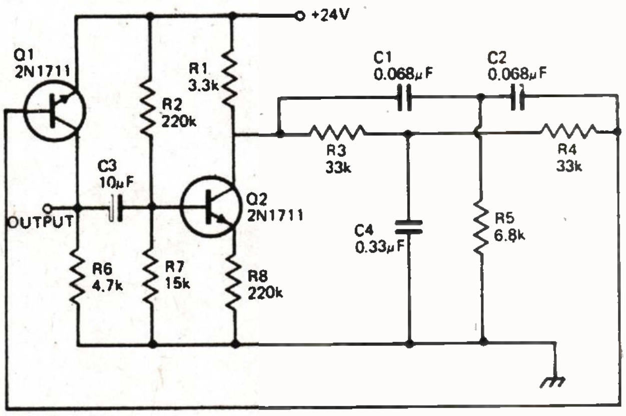


Fig. 20. Phase shift oscillator based on a twin-T, frequency selective network.

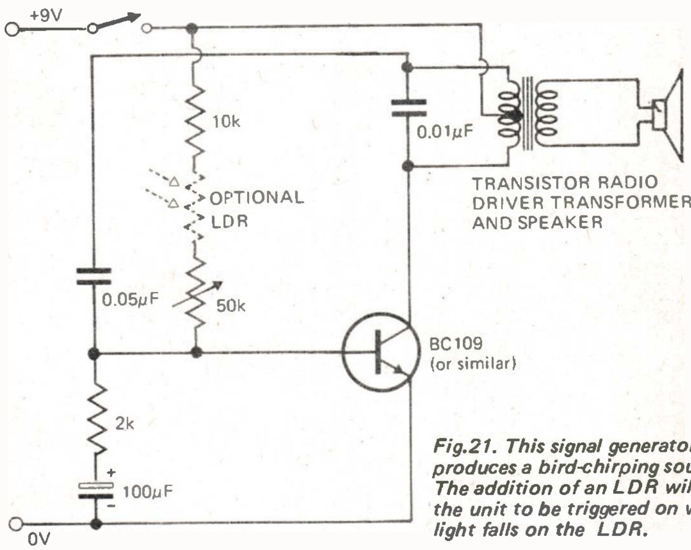


Fig.21. This signal generator produces a bird-chirping sounc The addition of an LDR will a the unit to be triggered on wh light falls on the LDR.

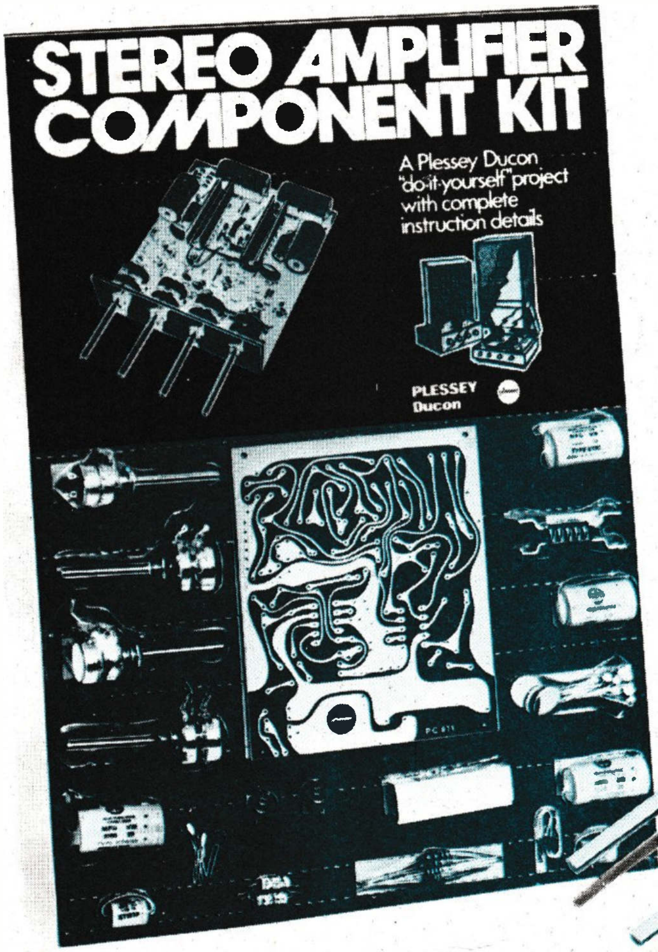
Enjoy top class stereo reproduction with this simple amplifier kit

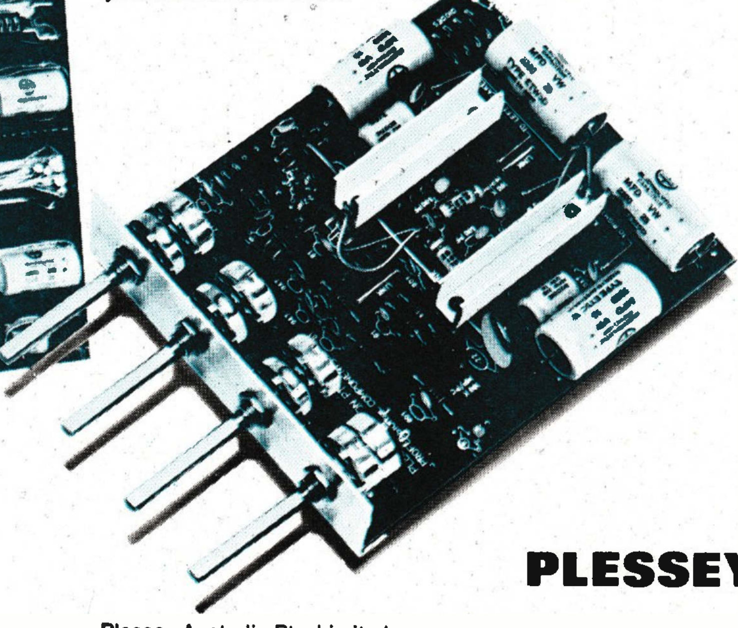
Here at last is the "do-it-yourself" stereo amplifier kit from Plessey Ducon. This is a simple and easy to assemble kit, capable of producing truly first class reproduction from a 3-3 watt RMS integrated circuit amplifier at a cost far below that of equivalent powered units.

This kit comes complete with clearly defined assembly and testing instructions together with construction details for speaker housings, alternative input wiring for tape and radio and advice on how to choose your turntable, speakers and power transformer.

This kit has been thoroughly tested and proved and contains only the best of local and imported professional quality components.

Assemble and create your own means of music pleasure from a quality sound system that you alone have built.





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component news

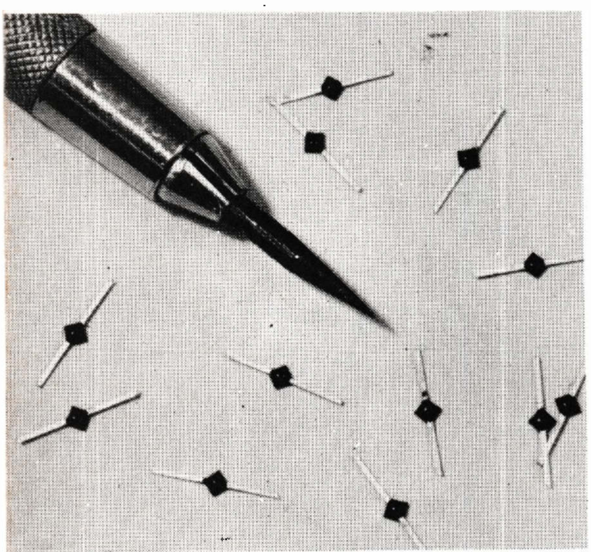
STRIPLINE SCHOTTKY DIODES FOR MIXERS TO 18 GHZ

Effects of package parasitics have been reduced by using a 1.27 mm (0.05in) square package (C-2) for H-P's new Schottky mixer diodes. These small packages are intended for use in microwave integrated circuits, microstrip or stripline in broadband or narrow band mixer assemblies in the 1 to 18 GHz range.

Designated Models 5082-2207 through 5082-2210, the diodes are passivated silicon Schottky barrier with beam lead construction. Beam lead diode construction with brazed package leads results in high mechanical reliability.

The 5082-2207, with a maximum specified noise figure of 6 dB at 9 GHz and a VSWR of 1.5:1, is for applications where noise figure is critical; the 5082-2208 is a matched pair. The 5082-2209 has a slightly higher noise figure (6.5 dB) and a VSWR of 2:1; the 5082-2210 is a matched pair.

Hewlett-Packard Australia Pty Ltd 31-41 Joseph St, Blackburn Vic. 3130.



Hewlett-Packard 5082-2207 through 2210 stripline Schottky mixer diodes.

MEASURING ANGULAR POSITION

A new dc/dc transducer, Type 19900, announced by Jackson Brothers (London) Ltd, (Croydon CR9 4DG England) enables the angular position of a shaft to be very accurately mounted.

Like other Jackson positional transducers, the new device employs a 'contactless' principle based on variation of capacitance and gives a stepless dc output voltage which can be applied directly to an indicator, recorder or controller. Its sensitivity is 10 mV per degree of shaft rotation. The linear range has been increased – the output voltage increases linearly over 330° of shaft rotation, compared with 180° before – and the new transducer requires only a two-wire input: a single stabilised dc supply of between +9 V and +18 V.

A shock-resistant casing suitable for virtually any industrial environment has been provided. This is a standard size 20 synchro housing, mounted either by clamps or through four tapped holes in the front face. All necessary input and output electronics are built in. The complete sensor-head weighs 170 g is 57 mm long by 51 mm diameter. Electrical connections are made via three flying heads whose length may be specified. Operating temperature range is from –40°C to +70°C.

The drive-shaft is balanced and available in various lengths and diameters to suit different coupling arrangements. It requires a drive torque of only 5 g-cm and can rotate continuously through 360°.

The principle of the transducer is that rotating the drive-shaft turns a movable vane lying between two fixed parallel plates. This changes the capacitance between the plates. A radio-frequency signal generated by a built-in oscillator is applied to one of the plates, and the signal received at the other varies with the position of the vane.

This capacitive technique has several advantages over methods employing wire-wound potentiometers. There are no mechanical wiper-contacts, so wear and electrical noise are eliminated and the element's life is practically unlimited. The only mechanical friction lies in the shaft bearings. Furthermore the output voltage varies continuously, rather than in small steps, so that any degree of resolution can be obtained.

British Merchandising Pty Ltd, Shaw House, 49/51 York Street, Sydney, NSW 2000.

LOW COST INFRARED SOURCE/ SENSOR PAIR COMBINES HIGH EFFICIENCY AND HIGH SENSITIVITY

A new low cost infrared source (OP 160) and sensor (OP 500) pair featuring high efficiency emission with high sensitivity was introduced by NS Electronics Pty. Limited on behalf of principal Optron Inc, Texas.

The OP 160 LED features a typical output of 1.5 mW at 20 mA in a concentrated beam at a high efficiency emission wavelength of 940 nanometers. The OP 500 N-P-N planar phototransistor has a high spectral sensitivty designed to match that of the OP 160. Typical output of the OP 500 is 10 mA at 20 mW/cm^2 tungsten lamp irradiance.

When operated as a pair, the OP 160/OP 500 provides a typical output of 6.3 mm 1.0 mA with an input of 20 mA at a lens-to-lens spacing of 6.3 mm. The identical input at a spacing of 254 mm generates an output of 0.5 mA.

Both the OP 160 and OP 500 phototransistor are available in a plastic mini-axial package. They are ideally suited for mounting in high density arrays for such applications as shaft encoders, position sensing, key boards and limit switch replacement.

NS Electronics Pty Ltd., cnr. Stud Road & Mountain Highway, Bayswater, Vic. 3153.

UP TO 24 MILLICANDELAS FROM HIGH-EFFICIENCY RED, YELLOW AND GREEN LEDS

This new series of high-intensity, IC compatible, solid-state 'illuminators' have a luminous intensity up to 10 times greater than currently available LED lamps. For example, the new red LED's produce 24 millicandelas at 10 milliamperes.

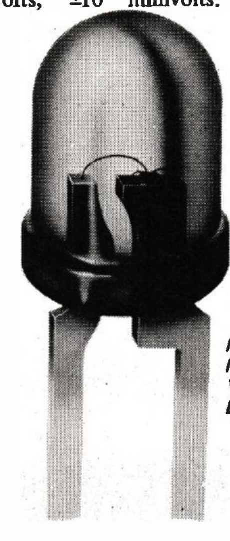
Packaged in the T-1 3/4 outline, the lamps come in both wide beam and narrow beam types. Wide beam lamps used a diffused lens; narrow beam lamps use a clear lens.

Four lamps of each colour are introduced. Two intensities of wide beam, and two intensities of narrow beam are available. High intensity is obtained using a new HP LED technology employing a transparent gallium phosphide substrate and adding a reflector in the LED package. These lamps are ideal for use in high ambient light conditions where a high on-off contrast ratio is needed. Narrow beam, high output models are used as pushbutton switch illuminators and annunciators.

Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn, Vic. 3130.

VOLTAGE SENSING LAMP HAS VERY SHARP TRANSITION

Intended as a built-in battery voltage tester for cameras, radios, test instruments, appliances and other portable, battery-operated devices, this new solid state lamp snaps on sharply at a nominal 2.5 volts, ±10 millivolts. The very high



Hewlett-Packard Model 5082-4732 Voltage Sensing LED.

sensitivity to the threshold voltage makes the Hewlett-Packard Model 5082-4732 VSLED also ideal for applications where precise voltage level indication is required, such as logic level indicators, V-U meters, and other voltage indicating arrays. With the use of an external diode, zener or resistor, the threshold voltage can be increased as desired.

This voltage sensing LED combines an integrated circuit and a red gallium arsenide phosphide LED to provide a voltage sensing function in a standard T-1 package. The lamp is temperature compensated and has a typical temperature coefficient of −1 millivolt per degree C.

Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn Vic. 3130.

MINI-TELATEMP RECORDS TEMPERATURES FROM 100°F to 350°F

Telatemp Model 310, a three-increment temperature recorder smaller than a postage stamp, measures temperatures between 100°F and 350°F within ±1% accuracy.

Model 310 is only 9 mm x 18 mm wide and is ideal for use in space restricted locations where surface temperatures must be measured and recorded.

After removal of a protective backing the Model 310 easily adheres to any clean dry surface. Its three sensing increments cover a range of 20°F and these silver-coloured windows turn irreversibly black as each is exposed to its pre-calibrated value. Each window is accurate to within ± 1%. Response time is one second and readout is permanent, yet the unit may be removed for additional study or filing.

Twelve standard configurations are offered. (example): Standard Configuration No 1A is calibrated for 100° and 120°F. Special variations are available.

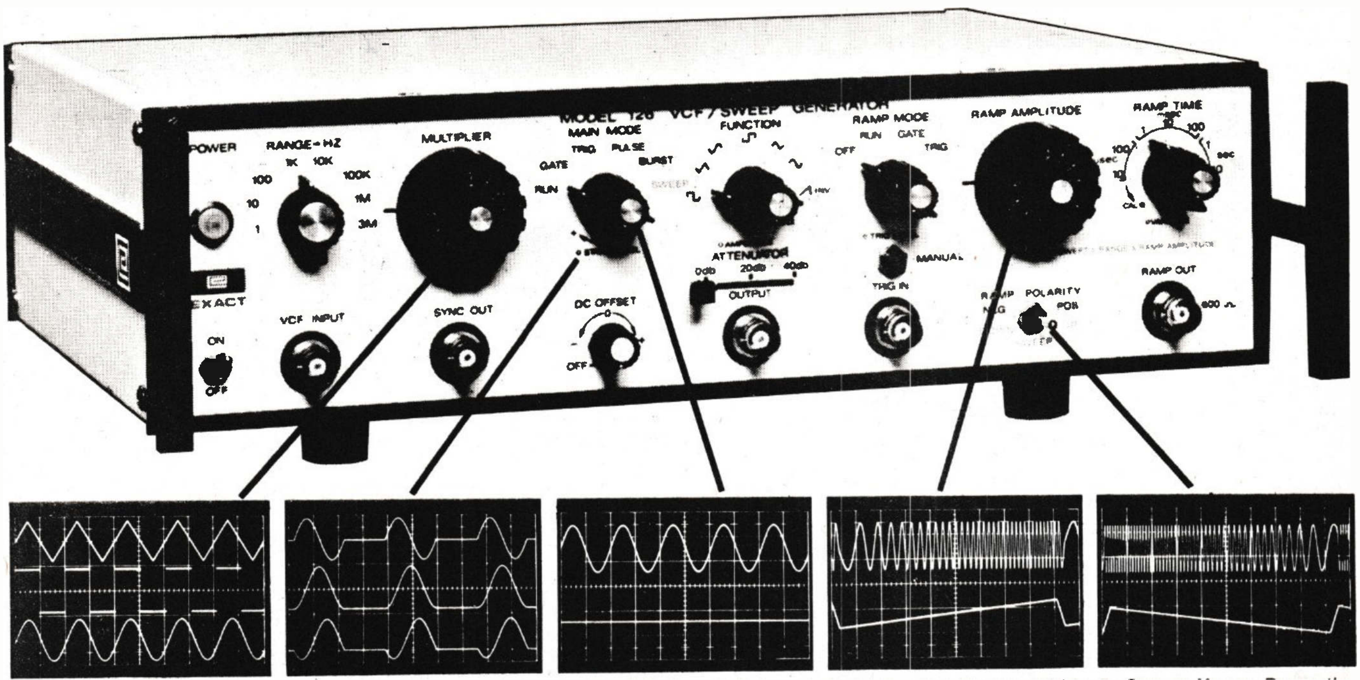
Typical uses include thermal analysis associated with testing, processing and manufacturing operations. Telatemp model 310 is also ideal for warranty protection in electronic products which are susceptible to failure when exposed to elevated temperatures.

NS Electronics, cnr. Stud Road & Mountain Highway, Bayswater, Vic. 3153.

METRIC UNITS

Would companies sending in material for this and our Equipment News sections please remind their appropriate staff that, except in rare and obvious exceptions *metric* units should be used.

how to get your money's worth in a $652 function generator



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COMPACT. Only 3½" high, 12½" wide, 10½" deep. Weighs only 9 lbs. Simple maintenance because all components values, test points and calibration adjustments are printed on the P.C. card, identified and easily accessible.

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JM/132-73

EQUIPMENT NEWS

LOW DISTORTION OSCILLATOR

A new audio oscillator from Sound Technology has a claimed level of total harmonic distortion below 0.002% over the range from 10 Hz to 20 kHz.

Often, low-distortion oscillators require long settling times before their output level stabilizes following each new frequency setting. This can hinder the engineer bent on rapid distortion tests at a number of discrete points. However, the 1400A settles to each new frequency in a maximum of six seconds.

Flipping the slide switch on the front panel changes the output from a grounded to a floating signal source, valuable because it enables the user to avoid ground loops, which often introduce 50 Hz components and impair the accuracy of distortion measurements. Push-button frequency selection provides the user with 3-digit resolution over the range of 10 Hz to 110 kHz. A frequency vernier knob shifts the output plus or minus three least significant digits.

The Model 1400A is 1500 mm high by 240 mm wide by 240 mm deep and weighs 9½ lbs.

Further details: Arlunya Pty Ltd., P.O. Box 113, Balwyn, Vic. 3103.

NEW COLOUR TEST PATTERN GENERATOR FROM ARLUNYA

The Arlunya PG.31 is a solid state test pattern generator designed for alignment and fault-finding in both PAL-colour and black/white TV receivers.

Designed and manufactured in Australia its rugged and compact construction, say the manufacturers, makes it ideal for field/customer house call service and complex workshop alignment and test.

In addition to the nine basic patterns i.e. colour bars, red, white, crosshatch, dots, staircase, circle, spot, and porthole, continuous control of burst and chrominance signal levels, for checking colour killer and automatic chrominance gain control, the unit can also switch the U and V components of the colour signal.

Both video and RF outputs are available with line and frame sync output for externally triggering an oscilloscope. The RF output is tunable from 35 MHz to 220 MHz with the level adjustable with an internal attenuator from approximately 2 mV to 20 µV. This facility is particularly useful for field technicians as they can simulate, amongst other things, the effects of poor aerial performance in the customer's home and thus lay further credibility to their advice for new aerial installations.

The PG.31 will also output all signals at the Australian IF frequency enabling service and alignment to be performed with the tuner removed from the TV receiver.

The electronically generated circle and spot may be superimposed on any of the colour and geometry alignment patterns, and are respectively useful when carrying out receiver scan linearity adjustments and checking EHT regulation on screen.

Arlunya Pty Ltd, PO Box 113, Balwyn, Vic. 3103.

CAR BATTERY CONVERTER

A&R Soanar Electronics Group have introduced a small converter unit designed to power battery operated recorders, radio receivers etc, when used in a car.

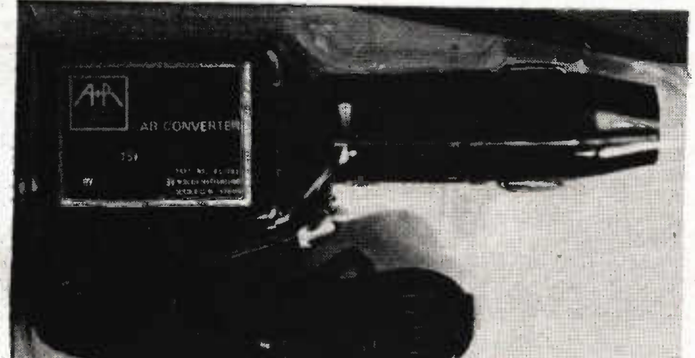
The unit, known as the PS293, is designed to plug into the cigarette lighter socket on the dash board of most modern cars, including the latest Ford models with long reach sockets.

The PS293 may be switched to replace the four dry cells (6 V), five dry cells (7.5 V), or six dry cells (9 V) at present used in a tape recorder or portable radio receiver.

A total drain of 300 mA is allowable which would be more than adequate for most portable equipment.

Output of the unit is via a cord and by a plug which is suitable for the dc input socket fitted to most tape recorders and transistor radios.

A&R – Soanar Electronics Group, 30 Lexton Rd, Box Hill, Victoria, 3128.



EQUIPMENT NEWS

H-P PROGRAMS

Two new handbooks containing programs for the recently introduced HP-55 programmable scientific pocket calculator are now available from Hewlett-Packard.

The two books, "HP-55 Mathematics Programs" and "HP-55 Statistics Programs," contain general descriptions of the programs, formulas used in each program solution, numerical examples, user instructions, program listings and register allocations. The part numbers are: "HP-55 Mathematics Programs" (00055-66001) and "HP-55 Statistics Programs" (00055-66002). Each book cost $10.00 Sales Tax exempt, or $11.50 Sales Tax paid.

"HP-55 Mathematics Programs" contains 74 common programs from the areas of complex variables, business, linear algebra, integration, interpolation, number theory, algebra, trigonometry and analytical geometry.

"HP-55 Statistics Programs" contains 53 programs from the areas of probability, general statistics, distribution functions, curve fitting and test statistics.

Both books are designed to give the HP-55 owner the most efficient program solutions to commonly encountered problems in mathematics and statistics. The user merely has to key the appropriate steps from one of the books into the program memory of the HP-55 and then enter the variables to solve each problem. The books free the user of the need to write his or her own programs to solve these problems.

The HP-55 programmable scientific pocket calculator has 86 keyboard functions, operations and conversions, twenty addressable memories and a digital timer with 100-hour capacity. It is programmable, like a computer, for the solution of repetitive or iterative problems, and has 49 steps of program memory, plus branching, testing and editing capability.

The books may be ordered by cheque or money order only, directly from Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn, Vic. 3130.

GOLLIN DATA SYSTEMS TO DISTRIBUTE SINGER

Gollin Data Systems has been appointed the exclusive Australian distributor for Singer Instrumentation's products. Singer has developed a reputation as a world leader in the manufacture of radio frequency interference products and communications systems servicing equipment.

Gollin Data Systems is the recently re-organised and re-named electronics manufacturing and computer operation of Gollin Holdings Ltd.

The range of products manufactured by Singer include a broad selection of radio frequency interference meters and field strength meters operating over the frequency spectrum 20 Hz to 26 GHz. It also includes communication service monitors to fulfill, in a single compact instrument, the maintenance requirements for alignment of microwave systems up to 40 GHz in frequency, spectrum analysers, synchro and resolver test equipment, and radio transformers.

Gollin Data Systems, 40-50 Clarence St, Sydney 2000.

100 AMP AT 5 V SWITCHING SUPPLY IN LIGHTWEIGHT, HALF-RACK PACKAGE

A new 500-watt switching-regulated modular power supply from Hewlett-Packard (Model 62605M) substantially reduces heat-sink requirements and permits greater freedom in mounting orientation. Integral forced-air cooling in many cases eliminates the need for other in-cabinet cooling. This, combined with the inherent efficiency (≈70%) of a 20 kHz switching regulator, makes for a small light and cool operating power supply well suited for OEM applications.

Model 62605M is regulated to 0.1% with ripple and noise of 20 mV rms, 40 mV p-p (20 Hz to 20 MHz). It will supply 100 amps at 5 V continuous output from 0 to 40°C, with linear derating to 60 amps at 70°C. AC power requirements are 104 – 127 V, 48-63 Hz, single phase with 187 – 250 V option available at no cost.

Although the initial price of this supply is some 10 to 15 percent higher than an equivalent series-regulated supply, long-term costs are claimed to be less due to the supply's higher efficiency. Additional savings may be realised from the reduction in needed cooling equipment and the power it uses.

Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn, Vic. 3130.

BASF announce a very special discount deal on their world renowned

'Chrome' (CrO_2) SM Cassettes

Special Mechanics

There are plenty of sound-gear bargains around — if you're not particular about quality. Here's something rather special, a great discount offer for the man who doesn't usually count the cost of quality. 20% off the world's finest cassettes, plus the unique Modul-Lock storage module.

2 C60 Chromium Dioxide SM cassettes **complete with** the unique interlocking Modul-Lock cassette storage module (holds up to 4 cassettes) all for **$5.99** (usual recommended retail price $9.30)

OVER **20%** DISCOUNT ON THE USUAL RECOMMENDED RETAIL PRICE

C90 CrO_2 cassette **$4.49** (usually recommended at $5.60)

C120 CrO_2 cassette **$5.70** (usually recommended at $7.30)

The ideal time to test the quality of BASF CrO_2, try a C60 CrO_2 cassette at only **$3.20** (usually recommended at $4.00)

'Chrome' puts the polish on cassette sound

BASF perfected Chromium Dioxide (CrO_2) coating for cassette tape. BASF 'Chrome' cassettes give a polished performance every time. With Special Mechanics to smooth away wow and flutter, and the fine surface finish to minimise headwear.

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It's a unique new storage system that grows with your cassette collection. Each precision-moulded polystyrol module holds four cassettes in individual slots. As you get more cassettes you simply lock in extra modules. Any way you like — precisely, rigidly and easily without cutting or glueing. And you can change them again just as easily.

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This unprecedented offer is available from good sound shops and department stores

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BA4402

KITSETS

KIT'S KOLUMN

Well, it's happened. Expense-Account has finally flipped his lid. You never saw such megalomania. I got the usual summons to grace the inner sanctum. There was this wild gleam in his eyes, and Monopoly money all over the desk.
On which he was standing.
"Today—Australia!" he screeched, "tomorrow—the **world**!"
"That's nice," I replied. "How's your Kitsch collection?"
"I don't pay you to be facetious to me!" he snorted, stomping his left gumboot into his new calculator which expired with a sparkling shower of LED's. "Now, lissen to this, my little chicken . . . . . "
An hour later I still couldn't believe what I'd heard. And in the coming months it should stagger you, too.
BIG things are happening at Kitsets. And I think that maybe Expense-Account could be right about the world bit . . .

Just to get the ball rolling, we're lopping up to Thirty per cent off all component parts for personal shoppers during April. Offer lasts as long as stocks do. Even Alfred E. is welcome. (Where **did** he get that haircut?)

Elsewhere in this extravaganza you'll find the first of our monthly specials for personal shoppers. Only a few at each store, so be quick. NOBODY can get within cooee of our cut-throat price on these.

Last month in our top secret report on the operations of Mom we promised to tell you how to convert a 5 cell flashlight into a 2-cell. That'll be in next month's Kolumn. Meantime, keep your letters coming. Just address them to me (Kit) at our Dee Why Box number, and . . . . . .

Keep your iron hot,

COMPLETE HI-FI SYSTEM: A BEAUTY FOR ONLY $299

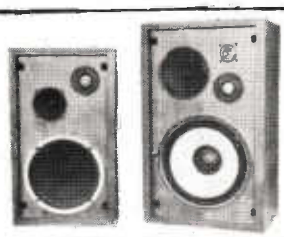
Not a kit, nothing to build. Just hook all units up, plug in, and you're in business. System consists of the Phodis C6000 amp which puts out 20W per channel RMS, has twin VU meters, 6 input jacks, 2 output jacks, and more features than we can list here, PLUS the BSR P128 turntable which has diecast platter and is fitted with a Shure M75 cartridge. Your choice of speakers—our 8"- -way ready-made system or our kit with 12" twin cone and 1" dome speaker in each enclosure, which are both pre-assembled and veneered.
P&P $7

BD1 BELT DRIVE MANUAL TURNTABLE COMPLETE AT $129

This is the famous "Connoisseur" unit as used by professionals. Unique flexible belt drive virtually eliminates vibration. (Rumble -60dB; hum -80dB; wow & flutter less than 0.1%). Comes complete as shown fitted in base with hinged acrylic cover. Also supplied: "Connoisseur" SAU2 precision pick-up arm, PLUS the superb VF3200/6 "Micro" variable flux stereo cartridge. All internal mounting hardware and cords supplied together with illustrated instructions. P&P $3.50.

DON'T WARBLE-DAUBLE: KIT

9-tone door "chime" guaranteed to confuse the Avon lady. J. Pittar's 2nd prizewinner in the Kitsets-Electronics Australia competition. Peals a pre-set number of times then switches off at end of sequence. Be first in your street with one. P&P $1.50.
$22



STEINTRON AGAIN!

Our direct import—back again at las[t]. Beautiful timber cabinets with louvred fronts. Absolutely superb performance.
V120: 12" woofer; 6½" middie; 1½" dome tweeter; 2" super tweeter. Crossover rolloff 12dB per octave; handles 45W RMS; 20-22000Hz. Ha[s] tone control. 25½" x 15" x 11½". P&P each $5. Price each $112.
V100: 10" woofer; 5" middie; 1½" dome tweeter. Handles 35W RMS, 20-20,000Hz. 22½" x 13" x 11½". P&P each $5. Price each $89.

APRIL SPECIAL!

As mentioned in Kit's Kolumn. Soldering irons, 240V 25W Weller SP25D, 1 1/3 oz, 8½" long, 1/8" screw-in replaceable tip nev[er] needs filing. Stainless-steel barrel. Plug fitted. Suggeste[d] retail $12.50. Our whacky April price . . . $7.95 Smal[l] quantity each store, person[al] shoppers only.

THE ULTIMATE ELECTRONIC ALARM CLOCK KIT: $82

Not one of those half-baked thirty buck jobs. This is the superb EA design (Dec. '74) with 24-hour indication, integral snooze facility, sleep facility for turning off a radio or similar, and automatic variable intensity display. When we say "nothing missing" we mean it — our kit includes everything to build the finished product. Full instructions, with diagrams. Not recommended for rank beginners. We rate this as one of the most exciting projects we've yet seen. P&P is $2.

SYDNEY: 400 Kent St. Sydney, 29 1005. 657 Pittwater Rd., Dee Why. 982 9790. **ADELAIDE:** 12 Peel St. Adelaide, 87 5505. **BRISBANE:** 293 St. Paul's Tce. Fortitude Valley, 52 8391. **MELBOURNE:** 271 Bridge Rd. Richmond (Gallery Level, Church St. entrance) 42 4651. **PERTH:** 557 Wellington St. Perth (Opp. new bus terminal), 21 3047.

$3.38 OFF VALVE SET
Check our catalogue. To buy the three most popular valves (IS2/6AL3/6CM5) would normally cost you $6.88. Well, for orders postmarked April (or for personal shoppers) we've zapped the price for the set of 3 down to $3.50! P&P is 60c. Only 1 set per customer. Hurry before our accountant finds out

SEE WHAT COLOUR YOUR MUSIC IS

NOT a kit. These are the spectacular SECO colour organs. Connect to any speaker and the colour lamps flicker and glow with varying brightness in relation to volume, pitch, and rhythm. Why put up with colour TV? Works even with small transistor radios. Leaves fibre-optic lamps for dead. V3050: Domestic unit. 30 lamps, 3 channels, 5 colours. Diamond pattern. 18½" x 11½" x 7 3/8". 3.5kg. P&P $2. **$49·50**

4050X: Professional monster. 32 lamps, 4 channels, 4 colours, individual colour mixing controls and a host of other features. Ideal groups. About 30½" x 15½" x 9 1/8". P&P $3. **$84**

WANNA BE FAMOUS?

You too, can be the adored idol of thousands of Kitsets customers and project freaks. OK then, maybe not exactly famous, but at the very least you'll have your name in our ads . . . and money in your pocket. We're working on a beaut plan that revolves around your own project ideas. More details next month.

$8·50

GLIDE-TONE GENERATOR

Rod Torkington's 3rd prizewinner in the Kitsets-Electronics Australia competition. Simple to build. Checks loudspeaker response by logarithmic sweep down musical scale. P&P $1.

12V negative earth

ELECTRONIC TACHO. IGNITION, & REV LIMITER KIT

vercomes serious failings of sser types, gives same benefits ke extra long point and plug e, plus handy protection ainst over-rev blow-ups. Kit omplete with instructions and agrams, the critical recomm-nded capacitors (no makeshift bstitutes) all screws, nuts, ugs, sockets and so on as well the required eter for cho operation.

$53·50
P&P $2.50.

NEW SQ DECODER KIT

Build this new 3 IC SQ decoder—incorporating both full logic and wave-matching. Connected between the tape out and tape in on your existing amplifier, and connected to a rear channel stereo amplifier it provides you with a fully decoded SQ sound. Our kit comes complete with all parts, including power supply, and a case about 8" x 2½" x 5½" plus sleek blackface front panel. P&P $2.50

$59·50

5 STAGE LOGIC PROBE

This is the 1st prizewinner in the Kitsets-Electronics Australia competition. Designed by Ian Robertson, it's an elegant unit, and easy to build, has 7-segment readout. If you're working with logic circuits, it's one kit you should build. P&P $1. **$13.**

$65 COMPUTER

Not just an arithmetical calculator but a professional scientific tool:
You will be asked to pay $100 and more for similar instruments.
The Hornet SR30 is an algebraic-mode, 8-digit unit with the normal +, −, X and ÷ functions plus Memory with 4 operations (M+, MR, X−M, CM) and 6 command functions (+/−, F, DR, X−Y, rad/deg, CL).
12 scientific functions
These are 1/X, ex, ln, log. sin-1, cos-1, tan-1, sin, cos, tan √x, and xy. Trig and log functions are calculated to 6 dec. places.
The unit comes complete with batteries (4 penlight cells) and handbook. A socket is fitted for external DC power.
Supply is limited, and orders will be filled in strict rotation. Price includes registered post and packing cost.
Note: This unit has a blue fluorescent display.

Use this coupon for mail order. Please don't send cash. Remit by Postal Order or crossed cheque, made payable to Kitsets (Aust) Pty Ltd. Send to P.O. Box 176 Dee Why 2099. For PMG/COD delivery, call 982 7500 (Area code 02) anytime (24 hour service) and tell us what you want. Orders are despatched within 24 hours. Please fill out form carefully and PRINT all details NEATLY. If your order comes in looking like a second-hand pakapoo ficket, we have to hang on to it until you send us a furious letter. And that doesn't do either of us any good.

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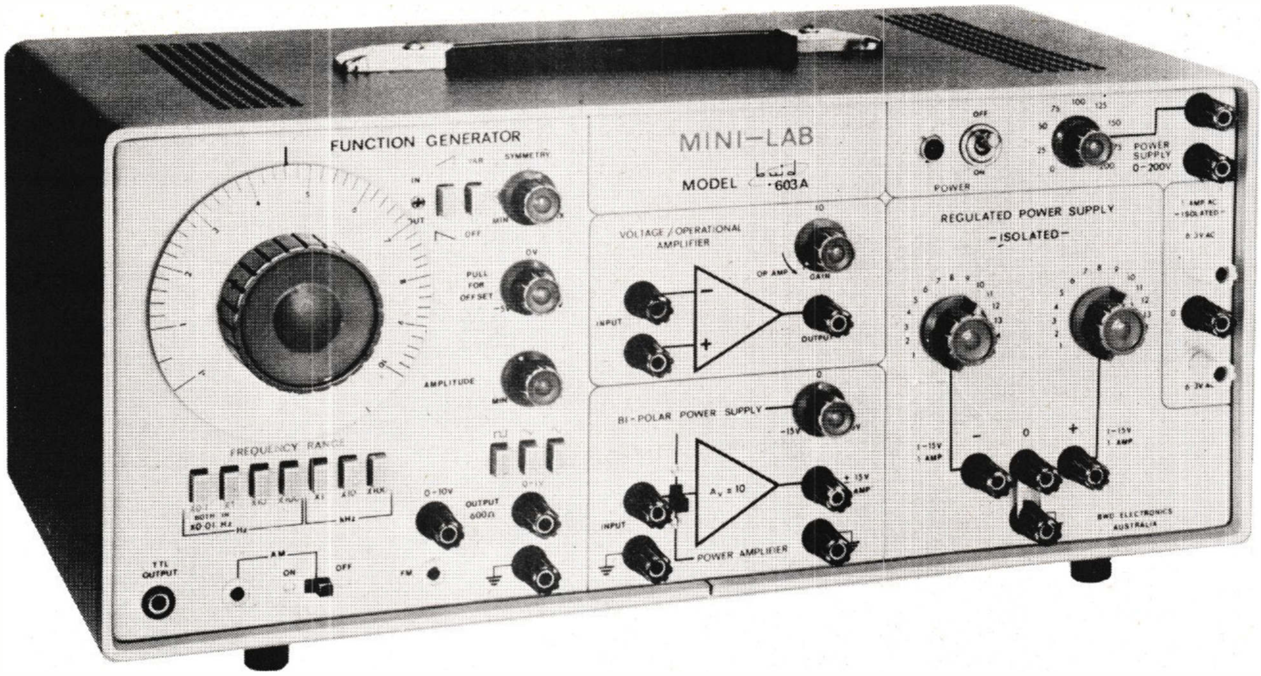
JM2164 DPS

Multi Facility Waveform Generator
BWD 603A Mini-Lab



IF YOU NEED:– Symmetrical, Modulated, Offset, Asymmetrical, Swept, High Power, Clipped, Push Pull, TTL compatible waveforms or any combination a BWD 603A WILL SUPPLY THEM FROM 0.001Hz to 1MHz.

- SINE, TRIANGLE SQUARE, RAMP AND PULSE FUNCTION GENERATOR
- NINE DECADE FREQUENCY RANGE 0.001Hz TO 1MHz
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- DC COUPLED AM AND FM MODULATION
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- TTL COMPATIBLE OUTPUT

PLUS DC to 80kHz power amplifier, output ± 15V at 1 amp into 15Ω; DC to 80kHz operational amplifier; +15 to –15V 1 amp B1 polar power supply; two 1 to 15V 1 amp power supplies; 0 to +200 30mA power supply 6.3–0–6.3V 1 amp AC isolated supply.

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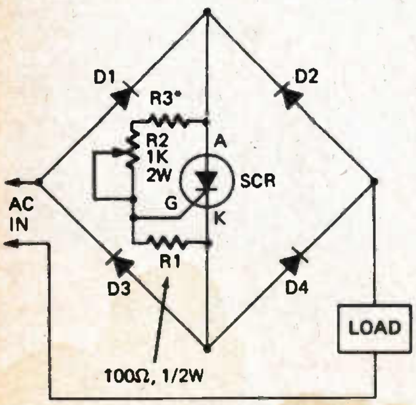
IDEAS FOR EXPERIMENTERS

FULL-WAVE SCR CONTROL



This circuit enables a single SCR to provide fullwave control of resistive loads.

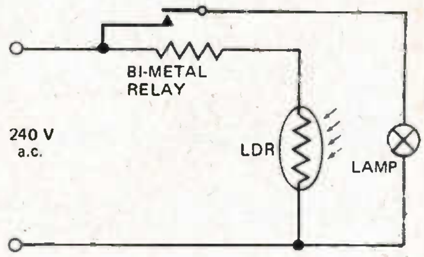
Resistor R3 should be chosen so that when potentiometer R2 is at its minimum setting, the current in the load is at the required minimum level. Diodes should have same current and voltage rating as the SCR.

AUTOMATIC TWILIGHT SWITCH

Here is a circuit which will automatically light your porch light or activate any other device when the ambient light drops below a certain level.

A light dependent resistor is used in series with a relay.

The resistor has a value in excess of 1 megohm when illuminated, this drops to below 110 ohms when dark.



It is important that the LDR be positioned in such a place as not to receive any spurious illumination as this will cause the relay to drop out intermittently.

A bimetallic strip type relay will give sufficient delay to ensure that incident light flashes have no influence.

MULTIPLIER/OP AMP CIRCUIT DETECTS TRUE RMS

To get an RMS value when you can't afford the time it takes to heat an element, try this technique. It may not be feasible for a multimeter but how about a sampling voltmeter good up to 600 kHz?

Mathematically, the RMS value of a function is obtained by squaring the function, averaging it over a time period T and then taking the square root:

$$V_{RMS} = \sqrt{\frac{1}{T}\int_0^t V^2 dt}$$

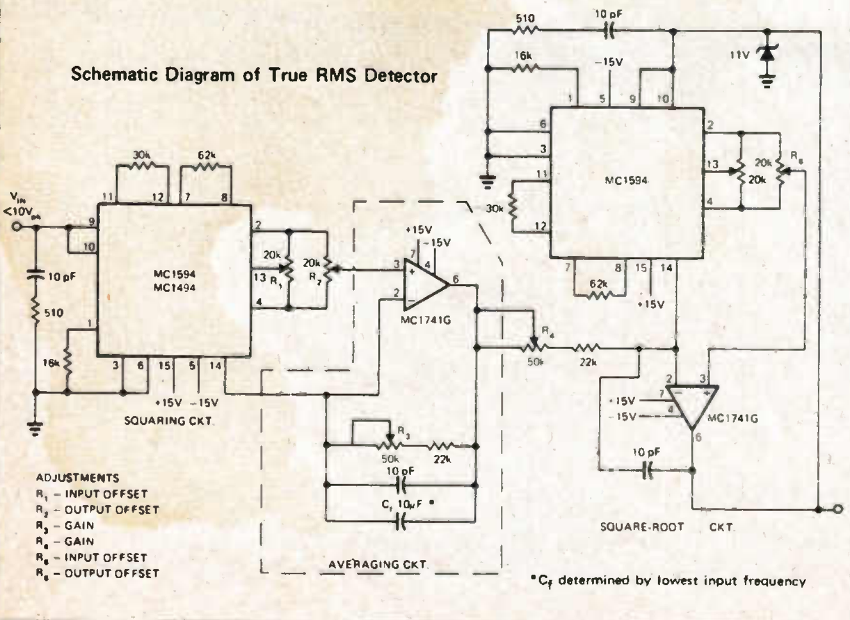
In a practical sense this same technique can also be used to find the RMS value of a waveform. Using two multipliers and a pair of op amps, an RMS detector can be constructed. The first multiplier is used to square the input waveform. Since the output of the multiplier is a current, an op amp is customarily used to convert this output to a voltage. The same op amp may also be used to perform the averaging function by placing a capacitor in the feedback path. The second op amp is used with a multiplier as the feedback element to produce the square root configuration.

This method eliminates the thermal-response time that is prevalent in most RMS measuring circuits.

The input-voltage range for this circuit is from 2 to 10 Vpk. For other ranges, input scaling can be used. Since the input is dc coupled, the output voltage includes the dc components of the input waveform.

Huehne & Aldridge,
Motorola

Schematic Diagram of True RMS Detector



> As the name of this section implies, these pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory.
>
> Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we provide constructional details.
>
> Electronics Today is always seeking material for these pages. All published material is paid for – generally at a rate of $5 to $7 per item.

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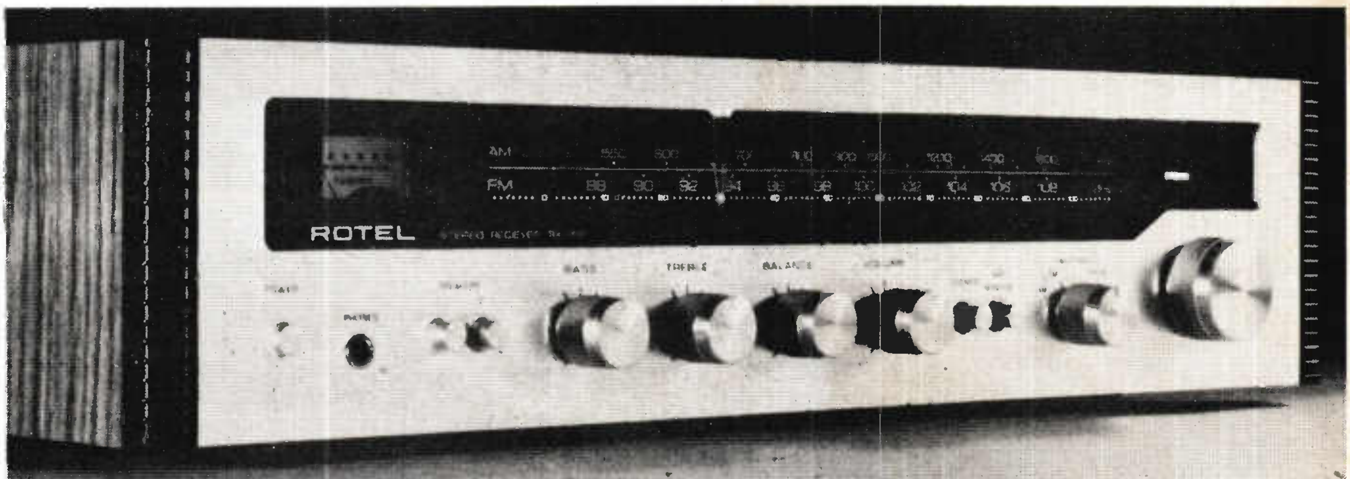
INTERDYN

Sparkling, superb performance... reasonable cost... the 'new concept' range of ROTEL® tuner-amplifiers

What better name than Rotel to show the way to superb FM/AM reception? The Rotel range of tuner-amplifiers herewith will give you the best of both worlds—superb AM-FM radio reception, and magnificent reproduction of your favorite records, at a price that is true value for money. Check the features and specifications—then hear Rotel at any of the addresses below!



RX 152 (Shown): Big, easy-to-see dial makes tuning easy. FM tuner frequency range 88 to 108 MHz, sensitivity 4 micro-volts, harmonic distortion 0.2%. AM tuner frequency 525 to 1650 KHz, sensitivity 20 microvolts.
Amplifier section. Music power IHF 50 watts (4 ohms). Continuous power output 14/14 watts RMS at 8 ohms each channel driven. Frequency response 20-60,000 Hz ± 3dB. Harmonic distortion less than 0.2%.
Low noise silicon transistors advanced semi-complementary SEPP circuitry. Full complement of connection facilities. Extruded aluminium front panel. Walnut finish cabinet.

Also Available:
RX 202, RX 402,
RX 254 four-channel.

BUY NOW—
They'll never be better priced!

Available from:

N.S.W. M & G Hoskins Pty Ltd, 37 Castle St, Blakehurst 2221
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Telephone: 223 3599

TAS. Audio Services, 44 Wilson St, Burnie 7320
Telephone: 31 2390

VIC. Encel Electronics Pty Ltd, 431 Bridge Rd, Richmond 3121
Telephone: 42 3762

W.A. Albert TV & Hi-Fi, 282 Hay St, Perth 6000
Telephone: 21 5004

A.C.T. Duratone Hi-Fi, Cnr Botany St & Altree Crt, Phillip 2606
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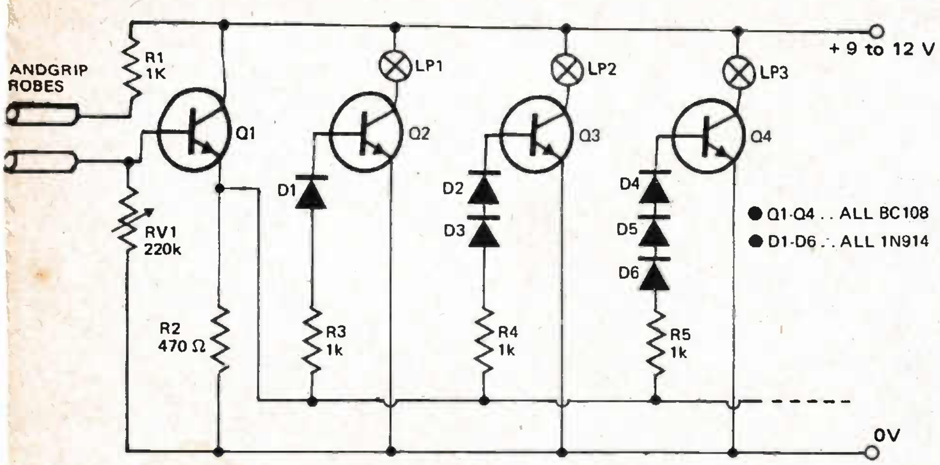
KSV600

IDEAS FOR EXPERIMENTERS

STRENGTH TESTER



Here is a circuit that will quickly tell you and your friends whether it is safe to go onto the beach with no chance of someone kicking sand into your face or conversely that a session with the Charles Atlas academy is advisable!

The idea is to grip the two handgrips which are made out of 25 mm wood dowling (broom handle) covered with aluminium foil.

The stronger the grip, the better the electrical contact made and depending on the strength of grip one two or more lamps will light up.

The circuit operates on the principle that skin contact resistance can be determined to some extent by the amount of pressure applied between the palms and the probes.

The greater the pressure, the lower the resistance and hence the higher the voltage output of the emitter of Q1.

Bases Q2, Q3 . . . are connected to the emitter follower via progressively more series diodes (D1, D2 . . . D6 . . .). Each lamp in the collector circuit will require a progressively higher voltage output from Q1 emitter to ignite. (i.e. a stronger grip).

The number of lamps can be increased as much as one likes, with each stage input having a larger number of series diodes. In the further stages it is not necessary to stack all those diodes since a single Zener will do just as well. For more than four stages reduce the value of R2 to 220 ohms.

RV1 adjusts the sensitivity: Reducing its value lowers the sensitivity.

BATTERY TRAP

When soldering leads to AA size cells (the size used in pen torches) it is most important to remove the metal disc at the bottom of the cell, and solder directly on to the zinc case. These cells are designed to be used under compression, by the spring in a torch, and they depend on the compression to ensure good contact between the metal disc and the cell itself. Without the pressure — such as when a cell is soldered into circuit, it's easy to get a very poor contact or an actual open circuit

A.J. Lowe

ADVERTISER'S INDEX

IDEAS FOR EXPERIMENTERS

METRIC WIRE SIZES

Metric sizes are now used for wire — here's how they relate to earlier specifications. Where possible use the sizes shown in column '1st Pref'.

METRIC DIAM (mm) 1st PREF	2nd PREF	SWG	BS	EQUIV (mm)	INCH
			40	.080	0.0032
		44		.081	0.0032
			39	.090	0.0035
		43		.091	0.0036
0.100				0.100	0.0039
			38	.101	0.0040
		42		0.102	0.0040
	0.112	41		0.112	0.0044
			37	0.113	0.0045
		40		0.122	0.0048
0.125					0.0049
			36	0.127	0.0050
		39		0.132	0.0052
	0.140				0.0055
			35	0.143	0.0056
		38		0.152	0.0060
0.160			34	0.160	0.0063
		37		0.173	0.0068
	0.180		33	0.180	0.0071
		36		0.193	0.0076
0.200				0.200	0.0079
			32	0.202	0.0080
		35		0.213	0.0084
	0.224			0.224	0.0088
			31	0.226	0.0089
		34		0.234	0.0092
0.250				0.250	0.0098
		33		0.254	0.0100
			30	0.262	0.0103
		32		0.274	0.0108
	0.280			0.280	0.0110
			29	0.287	0.0113
		31		0.295	0.0116
0.315		30		0.315	0.0124
			28	0.320	0.0126
		29		0.345	0.0136
	0.355			0.355	0.0140
			27	0.361	0.0142
		28		0.376	0.0148
0.400				0.400	0.0157
			26	0.404	0.0159
		27		0.417	0.0164
	0.450			0.450	0.0177
			25	0.455	0.0179
		26		0.457	0.0180
0.500				0.500	0.0197
		25		0.508	0.0200
			24	0.511	0.0201
		24		0.559	0.0220
	0.560			0.560	0.0220
			23	0.574	0.0226
		23		0.610	0.0240
0.630				0.630	0.0248
			22	0.645	0.0254
	0.710			0.710	0.0279
		22		0.711	0.0280
			21	0.724	0.0285
0.800				0.800	0.0315
		21	20	0.813	0.0320
	0.900			0.900	0.0354
			19	0.912	0.0359
		20		0.914	0.0360
1.000				1.000	0.0394
		19		1.016	0.0400
			18	1.092	0.0403
	1.12			1.120	0.0441
			17	1.151	0.0453
		18		1.219	0.0480
1.25				1.250	0.0492
			16	1.290	0.0508
	1.40			1.400	0.0551
		17		1.420	0.0560
			15	1.422	0.0571
1.60				1.600	0.0630
		16		1.626	0.0640
			14	1.628	0.0641
	1.80			1.800	0.0709
		15	13	1.830	0.0720
2.00				2.000	0.0787
		14		2.032	0.0800
			12	2.052	0.0808
	2.24			2.240	0.0882
			11	2.304	0.0907
		13		2.362	0.0920
2.50				2.500	0.0984
			10	2.588	0.1019
		12		2.642	0.1040
	2.80			2.800	0.1102
			9	2.906	0.1144
		11		2.946	0.1160
3.15				3.150	0.1240
		10		3.251	0.1280

The compliment we like best about the new Monarch Series 8:

"It's no surprise!"

When people already think of one name as the best value for money, they naturally expect every new model to maintain the same high standards — or improve on them. So, Monarch's brilliant new Series 8 amplifiers will come as no great surprise.

No surprise — even though we've created a superb new amplifier, top-of-the-range Monarch 8000 to bring you continuous RMS power of 55 watts per channel at 8 ohms, with distortion of less than 0.1%; even though we've included tape dubbing and turnover controls; even though we've produced a frequency response of 10 Hz to 60,000 Hz; even though we're presenting three other new Monarch amplifiers — the 80, 88 and 800, which feature dramatic improvements in power and efficiency. It's no great surprise — because you *expect* Monarch to be the best . . . And it is, so all Monarch amplifiers remain "kings" on a power-to-performance-to-cost rating.

Try any of them. The prices are as undistorted as the sounds. All with the same beauty of design you expect of top performers. And all have the Monarch two-year guarantee on parts and labour. You know you're getting Monarch quality. Without paying more.

Monarch 8000	—	110 watts RMS
Monarch 800	—	80 watts RMS
Monarch 88	—	48 watts RMS
Monarch 80	—	24 watts RMS

MONARCH

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AVAILABLE FROM REPUTABLE DEALERS EVERYWHERE

Announcing the new JH Phase II Trio

... so quiet — no known amplifier can provide nearly enough bass boost to bring the rumble content to the audible level of the recorded music.

NOW A JH MODEL TO SUIT ALL REQUIREMENTS.

Phase II E – complete with arm and cartridge,
Phase II F – fitted with formula IV tone arm,
Phase II O – without tone arm or cartridge.

The JH lightweight turntable utilizes all of the long sought-for advantages of lightness and eliminates the disadvantages of weight and mass. It is a dramatically new product, offering a performance which transcends all previous designs irrespective of price; it is all new . . . new ideas, new features, a completely new and fresh approach to turntable design!

Constructed of aluminium and suspended on the quietest and most friction-free teflon bearing yet devised, the platter requires so little torque, that an extremely small 12-pole hysteresis synchronous motor, which is locked to the mains frequency, drives it at constant speed, regardless of line and load variation. YET, the mass of this platter plus its rubber mat and the mass of the record are perfectly proportioned to the mass of the armature of the motor, to wipe out all speed variation and still permit acceleration to synchronous speed in less than three-quarters of a revolution!

SPECIFICATIONS

Power Requirements: 200 to 250 volts AC, 50 cps, 5 Watts.
Speeds: 33⅓ and 45 RPM.
Method of propulsion: Belt drive.
Rumble: Unmeasurably small.
Wow and Flutter: Better than 0.04%.
Hum Radiation: Negligible.
Diameter of platter: 12 ins.

EXCLUSIVE TO INSTROL HI-FI

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