SEPTEMBER 1975
75c*

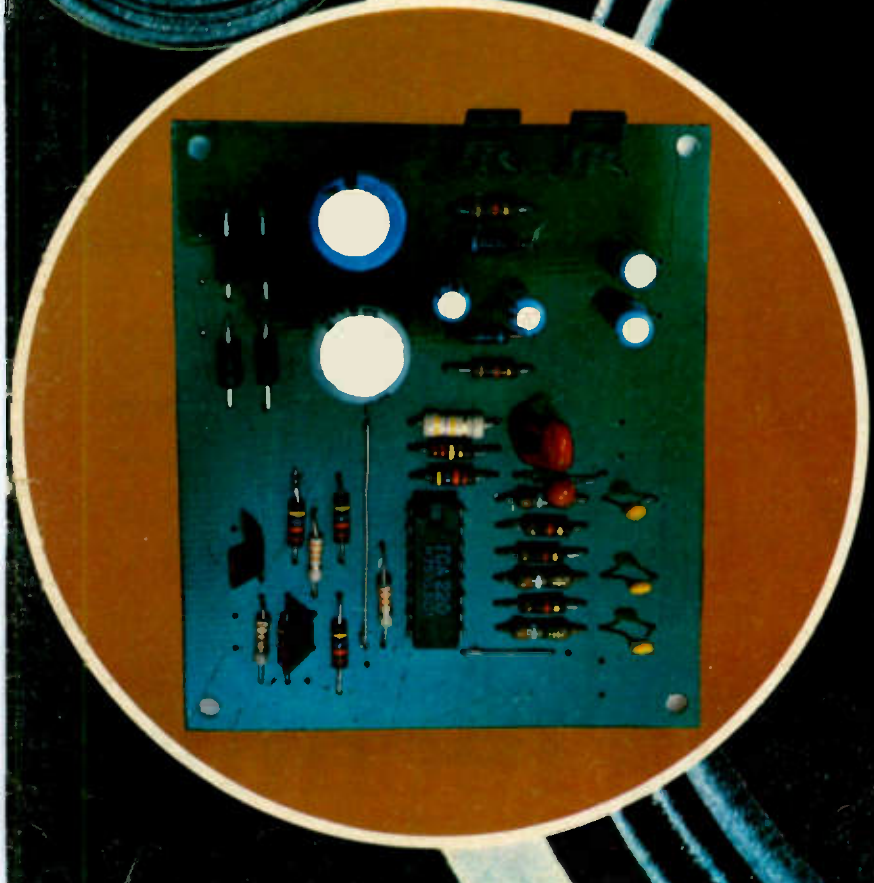
electronics TODAY INTERNATIONAL

Jansen

1 Book 75c

ACTIVE CROSSOVER PROJECT

DYNAMIC NOISE FILTER TO BUILD



Registered for posting as a periodical — Category C.

DIRECT DRIVE

SL 120

SL 120 BASIC

- Add tonearm of your choice.
- Direct-drive brushless DC motor.
- Wow & flutter: less than 0.03% WRMS.
- Rumble: better than −50 dB [DIN A], −70 dB [DIN B].
- Fast build-up time (within ½ rotation at 33⅓ rpm).
- 33 cm aluminium diecast turntable platter, dynamically balanced.
- Stroboscope speed indication on tapered rim for easier checking.
- Variable pitch controls (±5%).
- Aluminium diecast base.
- Audio-insulated legs.
- Removable dust cover

SL 1200

SL 1200 STANDARD

- Direct-drive brushless DC motor.
- Wow & flutter: less than 0.03% WRMS.
- Rumble: better than −50 dB [DIN A], −70 dB [DIN B].
- Fast build-up time (within ½ rotation at 33⅓ rpm).
- 33 cm aluminium diecast turntable platter, dynamically balanced.
- Stroboscope speed indication on tapered rim for easier checking.
- Variable pitch controls (±5%).
- Precision-engineered tonearm with lateral balance and direct read-out of tracking force.
- Anti-skating device.
- Adaptable for discrete 4-channel (CD-4) records.
- Aluminium diecast base.
- Audio-insulated legs.
- Removable dust cover stays open at any angle.

SL 1300

SL 1300 AUTOMATIC

- Automatic start, stop and return.
- Memo-repeat mechanism — plays same record up to 5 times.
- Direct-drive brushless DC motor utilising the platter as part of the motor.
- Wow and flutter less than 0.03% WRMS.
- Rumble: better than −50 dB [DIN A] −70 dB [DIN B].
- Pitch control range 10%.
- 33 cm dynamically balanced platter.
- Stroboscope speed indication on tapered rim for easier checking.
- Precision engineered tonearm with gimbal suspension, "S"-shaped tubular, universal 4 pin connector, direct read out stylus pressure.
- Anti-skating control.
- Adaptable for CD4 records.
- Audio insulated legs.
- Removable dust cover stays open at any angle.

electronics TODAY INTERNATIONAL

SEPTEMBER 1975 Vol. 5 No. 9

projects

main features

reviews

news & information

COVER: Active electronic crossover networks may take over from our present passive compromise systems. Our picture shows the ETI active crossover described in full on pages 39-44 this issue.

NEXT MONTH

SCIENTIFIC CALCULATORS

— which one is for you?

OPERATIONAL AMPLIFIERS

— practical three-part series.

Projects include:

* Active-crossover amplifier.
* Add-on amplifier boosts output of low power amps to 50 watts/channel.
* Simple switching unit provides tape to tape recording.
* Logic IC tester.

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

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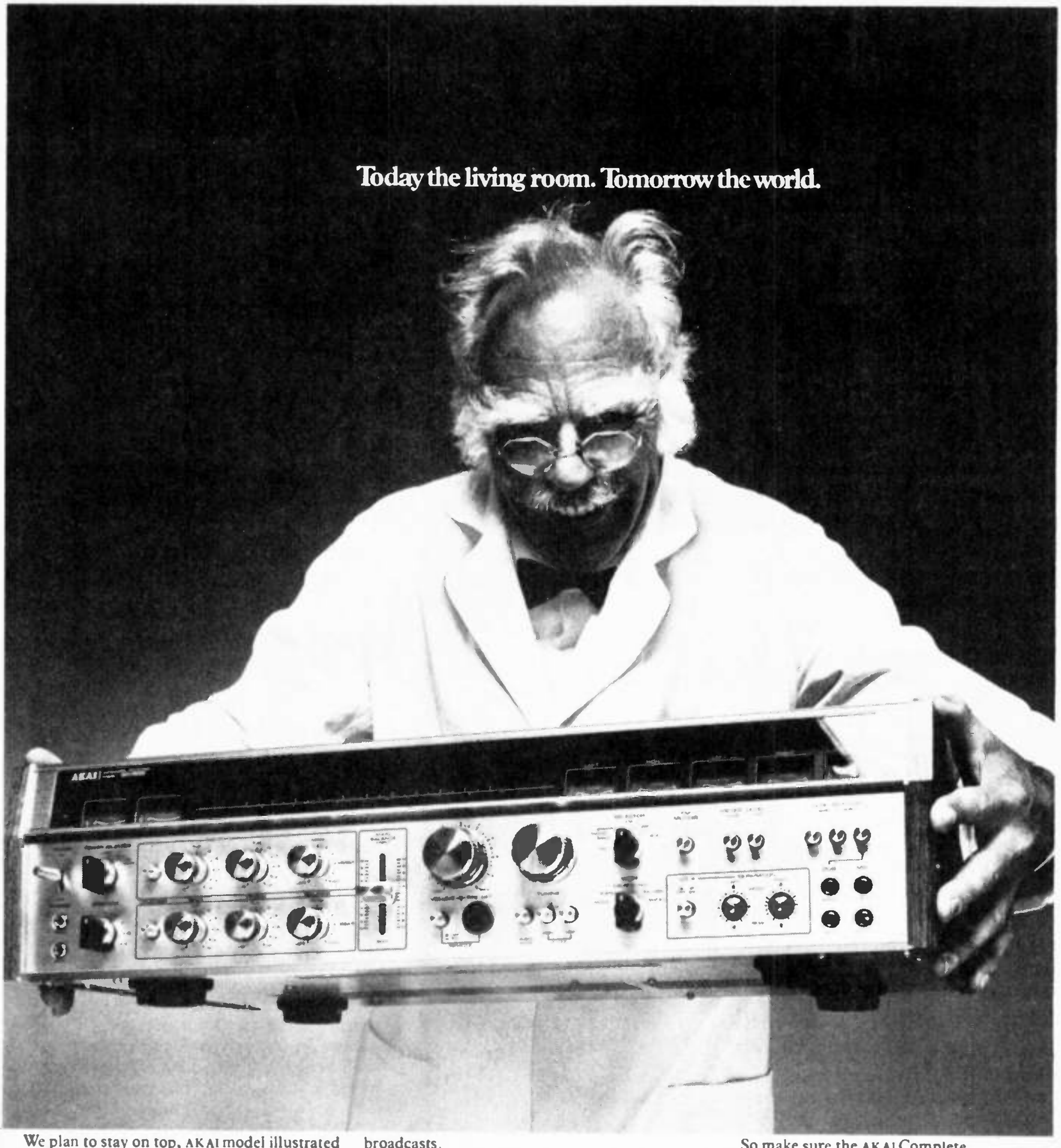

Today the living room. Tomorrow the world.
AKAI

news digest

BELL LABS RECEIVES PATENT FOR NEW SOLID-STATE DEVICES

Two Bell Laboratories scientists have received a U.S. patent for a new class of semiconductor devices that has already stimulated extensive research and development efforts world-wide.

Known as the charge-coupled device (CCD), the invention performs solid-state functions simply and inexpensively for a wide range of applications both within and outside the telecommunications business.

For their 1969 invention of the CCD, Bell Labs researchers Willard S. Boyle and George E. Smith have won wide acclaim in research and development circles, including major awards from the Franklin Institute (the 1973 Stuart Ballantine Medal) and the Institute of Electrical and Electronics Engineers (the 1974 Morris N. Leibmann Award).

Charge-coupled devices are currently being considered for many possible uses ranging from a small colour TV camera for future videotelephone systems, through time-delay and filtering circuits for telephone transmission, to memory devices for use in electronic switching systems.

The basic CCD described in the Bell Labs patent comprises three layers: one layer of metallic electrodes, one layer of silicon crystal, and a layer of silicon dioxide sandwiched between the other two that prohibits electrical flow between them. As the patent notes, however, other materials may be used.

As do many other miniaturized solid-state devices, the CCD employs a phenomenon found in certain crystals: their ability to permit negatively charged electrons (or positively charged "holes") to move about inside the crystal. Most other devices use this phenomenon simply to change the electrical current that flows through them — to amplify or switch it, for example. The CCD, however, uses the phenomenon to store and transfer information in the form of discrete charge packets — collections of electrons, in effect — rather than flowing currents.

To move the packets about in the CCD, the voltages on the electrodes are used to form "potential wells" — regions within the semiconductor into which the charge packets can be placed for temporary storage. The packets are then sequentially passed from one well to another under the influence of voltages placed on the electrodes.

The packets of charge that represent information may be introduced into the potential wells by other electronic devices, directly by light interacting with the silicon crystal, or by other means. Once arranged to store the desired information, the charge packets may be easily and quickly moved within the device, with each packet typically consisting of up to 10 000 electrons and contained in a thin layer about 0.25 mm on a side.

Since the invention of the CCD, Bell Labs researchers have made a number of devices. These include shift registers in which the packets may be stored and moved in precise patterns, in two dimensions, and can be detected and measured at some location. The basic shift register may be used to construct a recirculating memory, say for a telephone switching system, or it can be used to build a variety of filters for transmission systems. In another mode of operation, information can be read in at one rate and read out at another, thereby compressing or expanding the information in time. This feature can be used, for example, to put more than one phone conversation on a single line. Used as a memory, the CCD can replace such magnetic means of storing information as tapes, disks and drums. As a filter, the CCD might replace much more expensive and cumbersome electronic apparatus.

Another use is in imaging devices. One example a solid-state camera — may be made by shining a light image on a surface of the crystal, creating a pattern of electrical charges. The electrical charges representing the optical pattern can then be read out in sequence, transmitted, and displayed on a conventional TV tube. Thus the CCD could be used one day to replace the much larger and more expensive vacuum camera tube.

Already, imaging devices have been constructed which are 10mm on a side and have 56 000 picture elements.

news digest

TEXAS RELEASE DIGITAL WATCH

Texas Instruments has now released its long-awaited digital watch — at the recent Consumer Electronics Show in Chicago.

The watch, which sells for under US$100, was Texas Instrument's timing and control chip. A light emitting diode (LED) display is used — indicating seconds, minutes, tours, days and months.

FACSIMILE TRANSMISSION NOW TOTALLY PORTABLE

Recent approval by the PMG's department for the use of acoustic coupling to facsimile transceivers has opened the way for the marketing of truly portable units.

Plessey Communications Systems have been quick off the mark with the release of the model KD211N facsimile transmitter/receiver. The compact (500 mm x 350 mm x 127 mm) unit weighing only 8.16 kg can be taken anywhere for ready transmission of vital information using a standard telephone instrument.

The portable remote copier can be used with mains electricity, or be completely independent using power from a 12 volt battery.

Detailed information in printed, typed, handwritten or drawn form can be sent over any distance. The same phone call can be used to personally discuss other topics of concern.

Acoustic coupling eliminates the need for any wiring between the equipment and the communication line. The handset of a standard telephone is simply inserted into the acoustic coupler on the unit. It can even be used in a public telephone if necessary.

The KD211N, a development by Plessey of their larger desk mounted KD111 unit, produces dry electrosensitive copies for permanent reference.

The new portable transceiver can transmit a full A4 size with 64 lines / inch in only three minutes or a maximum of six minutes with 96 lines / inch.

The transmission system is an inbuilt line coupler. There is an optional phasing and line verification module to ensure correct reception.

The Plessey model KD211N acoustically coupled portable facsimile transmitter/receiver has already created interest among newspaper publishers with interstate offices and organisations with branch offices where salesmen can send and receive information considered vital in finalising a sale.

SHORT WAVE LISTENING GROUP

A short-wave listening group has been formed in Sydney 'to foster the hobby of DX listening and amateur DX contacts'. The group offers assistance and advise to beginners.

Interested readers should contact the group directly — President is Neil Stollznow, 90 Bandabah Avenue, St. Ives, NSW 2075 — Tel. 44-6030.

IMPLANTING GLUCOSE MONITOR FOR DIABETICS

The Space Sciences Division of the US Whittaker Corporation manufacture and distribute implantable glucose sensor-monitor-alarm systems for use by diabetics.

The glucose sensor system is an implantable bio-electronic device. With this device diabetics will be able to better control their insulin dosage and food intake so as to minimize the adverse consequences of diabetes.

The glucose sensor, invented by scientists and engineers at Whittaker Corporation's Space Sciences Division in Waltham, Massachusetts, is in the final development stage of a joint development programme between the Whittaker Corporation and a diabetes research laboratory who are jointly seeking companies to license and manufacture the device.

The remaining tasks consist of optimizing the various alternative modes of implementation followed by more extensive long-term animal implant tests in preparation for clinical validation tests in humans. It is expected that the final glucose monitor system will be about half the size of a heart pacemaker and will be implanted subscutaneously by a simple surgical procedure. Worn externally by the diabetic will be a miniature receiver plus microcomputer and alarm system to signal when the body sugar (glucose) level is too high or too low. It will indicate which corrective action the diabetic should take.

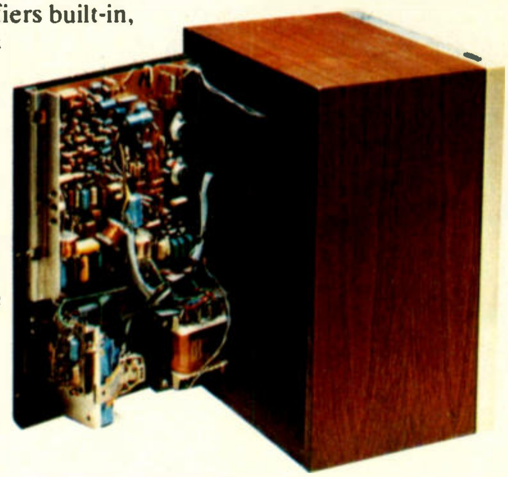
(Continued on page 11)

Philips Motional Feed-back Speaker systems.

The cleanest, purest, most distortion-free sound you'll ever believe possible.

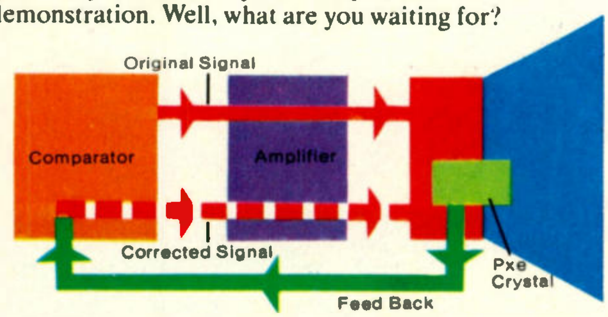
Philips Motional Feedback Speakers (MFBs) are totally unlike any other speakers you've ever experienced. Philips MFBs create their big, powerful sound by having 2 amplifiers built into the back of the enclosure - a 40W unit for the lower frequencies, a 20W unit for the middle and high frequencies, a total output of 60W RMS from each enclosure.

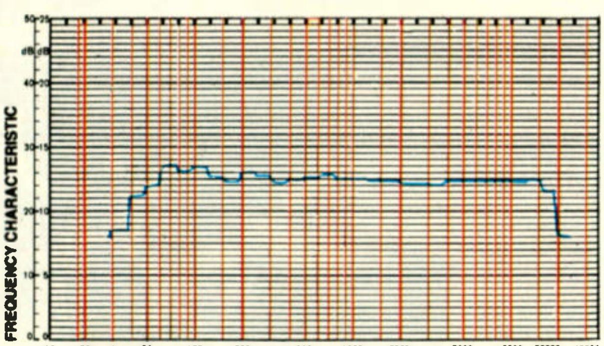
And having their own amplifiers built-in, MFBs can be run off either a power or pre-amplifier.



But the real story is Motional Feedback, the process that totally eliminates distortion. It works like this. A P x E crystal built into the MFB woofer picks up the motion of the cone and converts it into an electrical signal. This signal is fed back into a comparator to be converted to a signal that is complimentary to the original signal. This signal is then fed back through the MFB cone, cancelling any distortion that has developed because of the normal limitations of speaker boxes and speaker cones.

The resulting power and clarity of sound is equal, if not better than the sound you've heard from quality speakers 20 times their size. But the only way you're really going to believe how good they are is to ask your Philips dealer for a demonstration. Well, what are you waiting for?





⅓ octave plotted average room characteristic

TECHNICAL DATA

General: Semiconductors:
25 transistors and 16 diodes
Lamps: 1 pilot lamp
Power Supply:
120/240V AC, 50 Hz
Cabinet:
Timber veneered, with perforated metal front.
Dimensions:
w x h x d = 283 x 378 x 212 mm
Volume:
15 litres, 9 litres acoustic.
Total power of Amplifiers:
60 Watt, cont. sine wave power.
Frequency response:
30-20,000 Hz
Loudspeakers:
AD 8065/W4 MFB woofer 8"
AD 5060/Sq8, 5" squawker
AD 0160/T8, 1" dome tweeter.
Amplifiers:
Amplifier for woofer:
Output power:
40W cont. sine wave power
Harmonic distortion:
D less than 0.1% at 30W
Power bandwidth: 10-3,000 Hz
Frequency range:
5-2,000 Hz (+ 0.5,-3 dB)

Amplifier for squawker and tweeter:
Output power:
20W cont. sine wave power
Harmonic distortion:
D less than 0.1% at 15W
Power bandwidth:
100-50,000 Hz
Frequency range:
500-60,000 Hz (+ 0.5,-3 dB)
Cross-over Frequencies:
Electronic cross-over at 500 Hz
Passive cross-over at 3,500 Hz
Connections:
Sockets for mains in/out
DIN sockets (5-pole, 180°) for signal in/out
Input sensitivity:
1V at 3 kOhm, for connection of pre-amplifiers 3V at 35 Ohm, for connection of low power amplifiers. 7.5V at 25 Ohm, for connection of high power amplifiers.
Electronic On/Off switch:
Relay rise time less than 1 sec. at input signal greater than 1.5mV: fall-off time greater than 2 min.

PHILIPS

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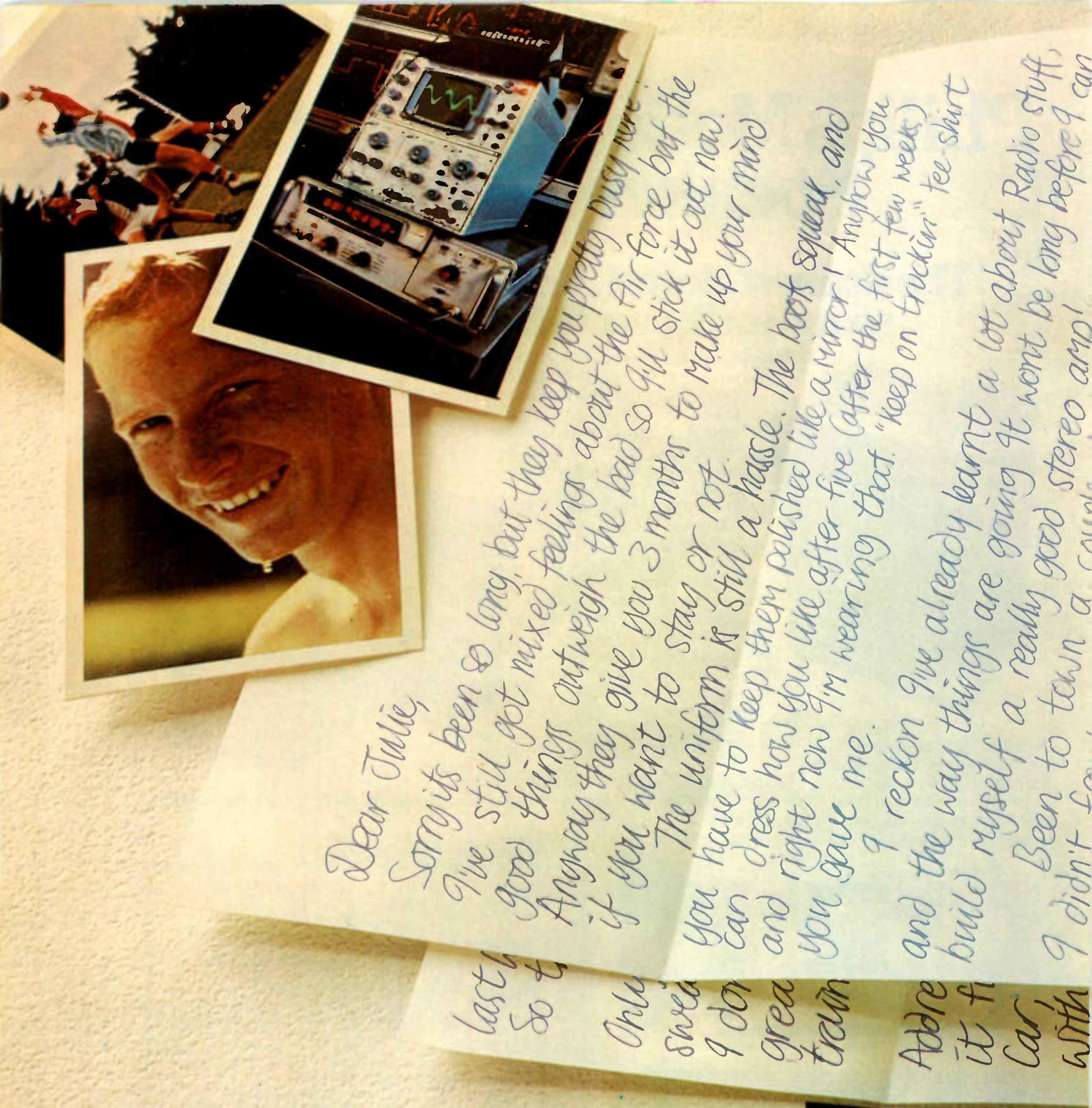


Free! full colour poster & book

An apprenticeship in the Airforce. Is it really something to write home about? Find out for yourself. Send us the coupon and we'll send you a free poster and a book that gives you the lowdown on our trades and our way of life – good and bad.

So, if you've reached the age of 15 and are not over 17 on 1 January, send off the coupon. Or contact your nearest Airforce Careers Officer before 6 October 1975.

Air Force Apprenticeships. Something to write home about.

To: Airforce Careers Officer,
G.P.O. Box XYZ in your nearest State Capital City

Name ________________

Address ________________

____

Postcode ________ Date of Birth ________

...leave. Don't worry
...! Oh that reminds me, I really like
getting your letters, but please stop spraying that perfume
on them. It can be very embarrassing!!
I've put in a few photo's for you Jools. My mate Dronga
took the one of me just after I flipped my canoe last week.
(Dronga's the long, gormless one in the other photo). There's
one of me playing footy, and one of some of the beaut
equipment we've been using.
The training's hard, but better than school – no wonder
blokes with an Airforce training have no worries getting
a job outside.
All the apprentices had a flight in a Hercules C130 →

...forward to seeing you when my holidays
(6 weeks a year, plus plenty of other time off)
...t that? And please, no perfume when you write!
Lots of love,
Peter xxx

Auth. Director-General Recruiting, Dept. Defence & by the Dept. of the Media.
AFAP6.DPS.75

(Continued from page 6)

SIGNAL PROCESSING SEMINARS

Don Munroe and Jon Noonan, senior sales engineers from Princeton Applied Research Corporation of the U.S.A., are to give one-day seminars on "low level signal determination", in Sydney and Melbourne in September. Each seminar will cover, lock-in-amplifiers, photon counting, light measurement techniques and boxcar integrators.

The Sydney seminar will be held on Friday, 12th September at the Travelodge Motel, Camperdown, and the Melbourne seminar will be at the Travelodge Motel, St. Kilda Rd., on Tuesday, September 16th.

Reservations for these should be made through: Tecnico Electronics, Premier St., Marrickville, 2204. NSW. Tecnico Electronics, 2 High St., Northcote, 3070, Vic.

NON-CONTACT DEVICE MEASURES 10 MILLIONTHS OF AN INCH

Radionics of New York have announced their RAD-9000 Series of non-contacting dial indicators. These instruments accurately measure short-range mechanical motion without contacting the surface being monitored. They enable measurements not possible by conventional dial indicators, such as applications in which the work is moving fast or is either too rough or too delicate for common methods of measurement.

Applications include the measurement of shaft alignment, gear reduction alignment, fan-blade vibrations, multiple belt alignment, and lathe work in motion. It is also an excellent sensor for automatic and adaptive equipment used in manufacture of paper, plastics, glass and metal parts.

In principle, the non-contacting dial indicator is a voltage reflection coefficient measurement apparatus especially adapted to physical motion or distance measurement. The various probes essentially constitute non-radiating antennas which have been matched to the characteristic impedance of the coaxial cable by means of a precision impedance matching network. As the probe approaches the work, the antenna detunes, and an impedance mismatch is established on the coaxial cable. This impedance mismatch is proportional to the distance of the probe to the surface being measured. The length of cable to probe is non-critical so that extensions of arbitrary length may be inserted without affecting calibration.

A digital read-out indicates displacement and a BCD computer-compatible output is also provided. For further information, contact Gollin Data Systems, 54 Lexton Road, Box Hill, 3128.

COMPUTER GAMES

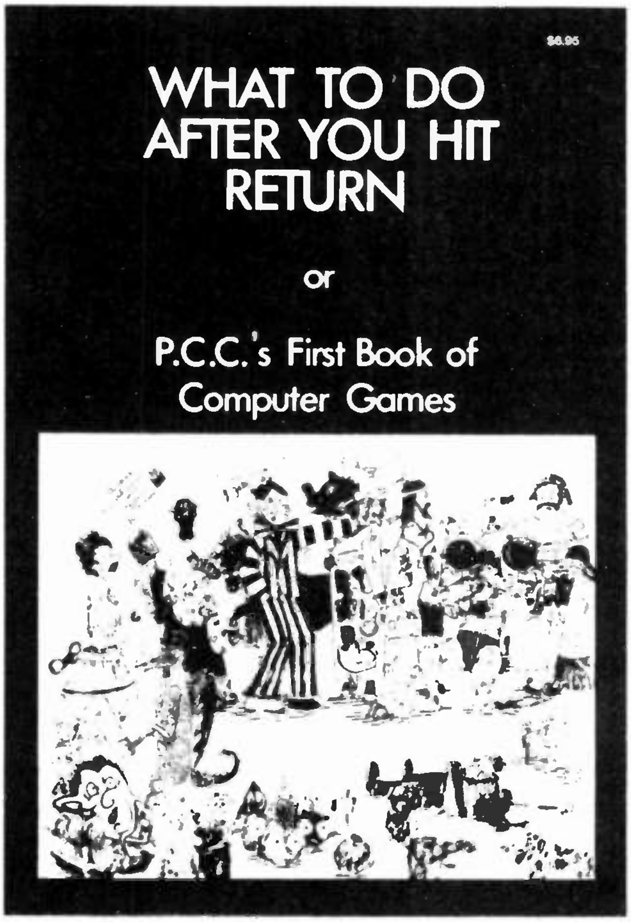
A new and bright computer games book is announced by joint publishers Hewlett-Packard Company and the People's Computer Company. Titled "What To Do After You Hit Return", the book illustrates the educational as well as entertaining value of some 60 BASIC games distributed by the HP Contributed Library.

The games range from simple routines for first graders (number guessing games) to the more sophisticated social science simulations and space travel adventures (civil war simulation, Star Trek and Star Trader).

The book is fresh, light and fun while subtly teaching the user valuable details about Cartesian co-ordinates, logics of game strategy and BASIC programming skills.

All of the games illustrated in the book are written in BASIC and will run on the Hewlett-Packard TSB/2000F Timeshare System, or can easily be converted to run on any BASIC timesharing system.

"What To Do After You Hit Return" (HP 36000-91005) is priced at $6.95. A brochure with further details and ordering information is available without cost from Marcom Department, Hewlett-Packard Australia Pty Ltd, 31-41 Joseph St, Blackburn, Vic. 3130.



news digest

PLANNING FOR NOISE CONFERENCE

The Australian Acoustical Society will hold its 1975 Conference "Planning for Noise" at the Hydro-Majestic Hotel, Medlow Bath on the 19th to 21st September, 1975. The emphasis of the Conference is on planning, not only for today's noise problems, but looking to effective answers for the future.

This Conference is a working conference designed to achieve maximum participation between delegates. The Conference employs an unusual format where each 1½ hour session is organised by a convenor who will lead a panel of experts to present their particular point of view. Each panel will examine solutions to their session in terms of:—

(a) Legislation
(b) Planning
(c) Noise Control
(d) Incentives
(e) The cost implication of these aspects.

The conference will examine noise in industry; transportation noise; noise in and around the home; noise in offices; sports and recreation noise; and the noise of demolition and construction.

These sessions are structured to allow the panel and delegates to put their views forward and emphasis has been placed on participation by experts outside the normal field of acoustics. Information about the Conference can be obtained from the Conference Registrar, Mr. D. Pickwell. 02-428-3009 or P.O. Box 80, Crows Nest 2065.

COMPUTER TELEPHONE SYSTEMS

The Australian Post Office recently issued a tender for a stored programme controlled analogue local switching system — that is computer controlled telephone exchanges.

Already in use in many countries, computer controlled telephone exchanges have many inherent benefits for both the telephone and telecommunication authorities.

The tender issued by the Australian Post Office is one of the most important ever offered to the Australian telecommunications industry and will involve the manufacture, supply and installation of hundreds of millions of dollars worth of equipment over a ten year period.

The APO is calling for a total network solution embodying remote controlled administration and maintenance which will enable the Department to take full advantage of the facilities of computerised systems.

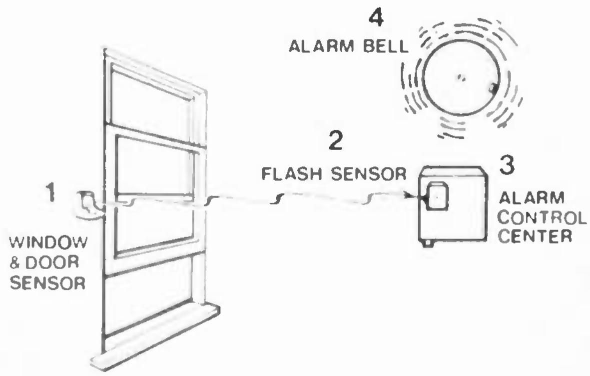
Philips Industries Limited, through its subsidiary company, Philips Telecommunications Manufacturing Company Limited (Philips-TMC) is preparing a tender for the APO to supply its Philips PRX (Processor controlled Reed eXchange) equipment, the bulk of which would be manufactured in Australia. Philips throughout the world has had a great deal of experience in the development and manufacture of computer controlled telephone exchanges and at present is supplying the Indonesian telecommunication authorities with more than $160 million dollars worth of PRXs.

PRX, the new Philips semi-electronic stored-program controlled telephone system is the result of long experience gained in telephone switching and in the application of electronics

LIGHT BURST BURGLAR ALARM

The major cost of most professionally installed burglar alarms is inter-unit wiring.

A new system which overcomes this cost has been developed by a US company called Flashguard. The Flashguard system uses self-powered pyrotechnic flash 'cubes' to guard windows and doors. If an intrusion is attempted, the pyrotechnic sensors trigger and direct an intense flash of light to alarm control sensors.



and computers in communication technology. The system is designed for widely varying applications in public telephone networks — ranging for simple local terminal exchanges to main transit centres.

The introduction of the 'stored-program control' principle is certainly one of the most important milestones in telephone switching development. According to this principle all logical control functions and data are concentrated in the central processor, allowing a flexibility and variety in the switching facilities which could be achieved in electromechanical systems only at great expense — if at all. Having the logic in the software permits easy accessibility and changing of functions and data via both internal and external data channels.

As a result, centralized supervision and maintenance can be realized in an economic way. Functions such as blocking and unblocking subscribers, changing routing patterns, reading out metering data and other even more complicated functions can be initiated simply by commands transmitted over data links.

A national and even international telephone network could be divided into a number of maintenance areas, each equipped with a processor controlling, through data links, the several stored-program exchanges in these areas. In this way it would also be practicable to supervise traffic volume and the grade of service from a central point. This could provide the authorities with valuable data enabling future maintenance and expansion strategies to be planned and scheduled.

The introduction of a well-organized, high-capacity control system such as a computer provides a number of new facilities which enable trunk networks to be used more efficiently. Because of their cost, conventional systems can incorporate only a limited number of these facilities.

The introduction of computer techniques and common-channel type signalling in the PRX system philosophy could give rise to a data communication facility which is not only of interest for data transport associated with the basic telephone functions, but also offers a number of data services of a quite different nature, such as inquiry from central data banks and other man-machine or even machine-to-machine communication.

news digest

NEW MANAGING DIRECTOR FOR TEKTRONIX

Tektronix Australia Pty. Limited have announced the appointment of Mr Graham Williams as Managing Director, effective June 27, 1975. Mr Williams joined Tektronix in 1972 as a Sales Engineer, and has subsequently held positions as Manager of Tektronix Operations in Adelaide and National Sales Manager.

Tektronix Australia's Managing Director for the past three years, Peter Strong, will be returning to the U.S.A. Parent Organisation in a Division General Management position.

INDUSTRIAL COMMUNICATION SYSTEM

Selective communication between individual stations as well as 'ring' communication without a large central amplifier is a feature of a modular industrial loudspeaker communication system which can be installed quickly and altered easily to meet changing conditions. The system has been developed by GEC-Elliot Process Automation (UK).

Direct access to the system — the Clearcall 300 — is by switch instead of dialling. Each station can be fed from the nearest power point so that cabling costs are kept low.

The system is claimed to provide efficient speech communication even in noisy environments.

A basic 'ring' system comprises several speech transmitter/receiver or 'talk back' stations, linked by one pair of signal wires and with the power for each station supplied by a 'ring' main taken from the nearest supply point.

Up to 100 stations may be linked and any one of them can initiate communication by merely calling the required station by name. All other stations on the 'ring' hear the message — a useful feature in continuous-process industries where different operators and departments must know of local (or station) conditions that may affect production flow.

The standard 'talk back' station is a self-contained unit, either wall-mounted or free-standing, with built-in micropnone, small loudspeaker, pushbutton switches for 'speak' and 'call', pre-amplifier and drive amplifier. If required, the unit may be panel-mounted. Additional horn speakers can be provided.

If selector and/or exchange stations are linked into the system, communication between individual 'talk back' stations can be selective. A selector station incorporates the normal transmitting/receiving facilities as well as a selector/switching unit with each switch allocated to one station.

An exchange station is, in effect, a master control providing selection of up to 36 out-stations for selective communication. By choosing the appropriate switches, its operator can create temporary multi-station 'ring' systems without affecting inter-communication facilities between exchange and other out-stations. There is also a facility for hailing all stations simultaneously.

System flexibility is further increased by temporary plug-in 'talk back' stations, hailing stations and facilities for mounting equipment on travelling cranes and other movable in-plant machinery.

Details from GEC Measurement & Control Division, P O Box 170, Artarmon, NSW 2064.

NEW FLUKE DMM FOR PEAKING AND DIPPING MEASUREMENTS

A new version of the Fluke 8000A 3½ digit DMM designed to perform analogue peaking and dipping measurements as well as the regular digital functions of the unit has been introduced by the John Fluke Mfg. Co., Inc., Seattle based manufacturer of precision electronic instruments and systems.

Designated the Model 8000A/MTR, it carries all the features of the standard 8000A plus an analogue panel meter. The panel meter can be used not only for peaking and dipping measurements but also indicates battery status of the optional self-contained rechargeable battery pack.

The Fluke 8000A/MTR measures voltages from 100 microvolts to 1200 volts, ac-dc currents from 100 nanoamps to 20 amps and resistance from 100 milliohms to 20 megohms.

Options include rechargeable battery pack, digital printer output and high current and low ohms measurement capability. Accessories available include RF, HV and ac current probes, rack mount kits, test lead kits, dust covers and carrying cases.

Details from Elmeasco Instruments Pty. Ltd. P.O. Box 334, Brookvale, NSW 2100.

(Continued on page 123)

C&K Switch Selector

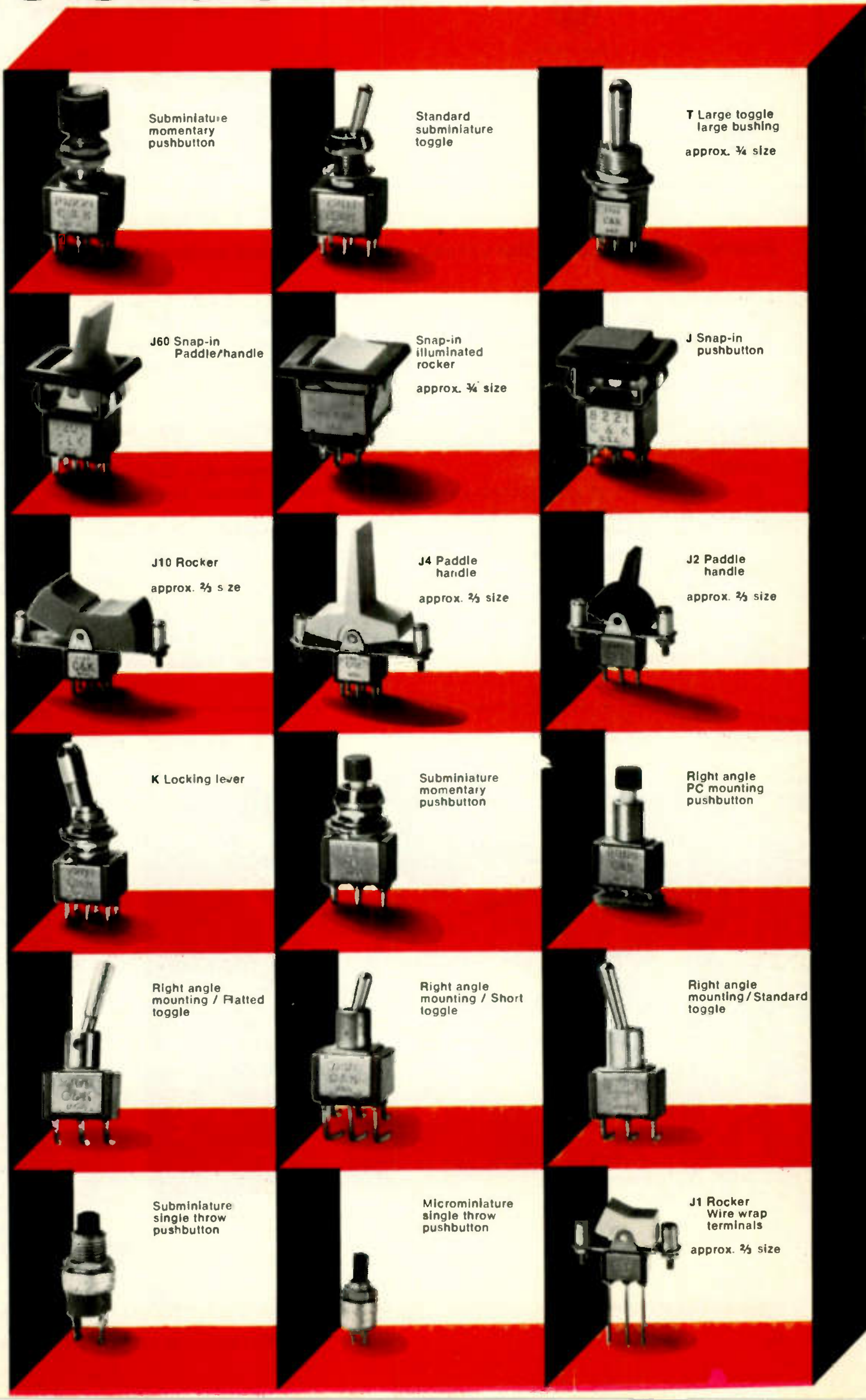
The switch is to C & K because switches from C & K Components, Inc. (USA) are superior in every design aspect through engineering know-how and experience. Quality, craftsmanship and care make each of these switches a precision component.

The types illustrated are simply a basic cross section of the range available. The range embraces the widest possible variety of switch combinations to meet every requirement . . . Toggles, Rockers, Illuminated Rockers, Paddle Handle, Pushbutton.

Miniature, subminiature and microminiature sizes in many circuit/position configurations are available in one, two, three and four pole models. All switches feature rugged construction and simple mounting . . . long-term, trouble free operation is ensured.

Toggle switch contacts are rated 2 amps @ 240 VAC and 5 amps @ 28 VDC resistive load.

A catalogue containing full specifications, options, mounting information, panel layouts, etc., is available on request.

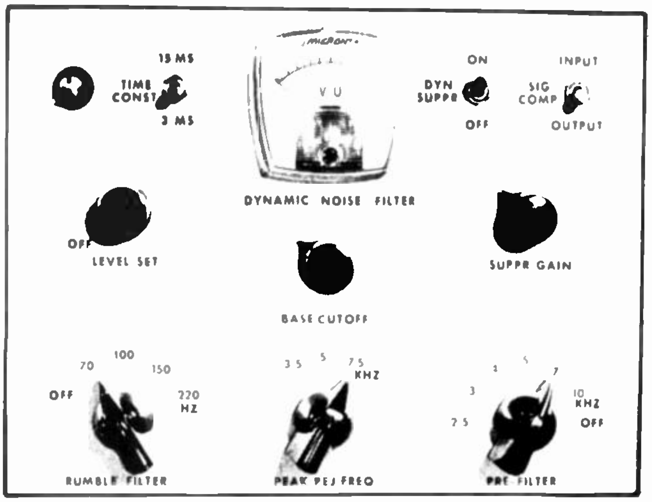


PLESSEY

Plessey Australia Pty Limited
Components Division
Box 2 PO Villawood NSW 2163
Telephone 72 0133 Telex 20384

MELB.: Zephyr Products Pty. Ltd. 56 7231. ADEL.: K. D. Fisher & Co. 223 6294. PERTH: H. J. McQuillan Pty. Ltd. 68 7111. N.Z.: Henderson (N.Z.) 6 4189.

tear out and keep for easy future reference



DYNAMIC NOISE

by M.G. Strange

Flexible low-cost noise filter virtually eliminates record surface noise.

DESPITE denials from many record manufacturers, many present day recordings have excessively loud surface noise – and this cannot be reduced using conventional tone controls without also losing a substantial amount of the programme content.

Serious collectors of older recordings have an even more serious problem. Most of these records are quite noisy – even by today's standards. For example, 78 rpm commercial discs, even though in mint condition, will have a typical signal-to-noise ratio of only 30 to 35 dB due to the abrasive nature of the record material.

Many collectors dub their best records onto tape. This way they may be played as often as desired – and conveniently shared with other collectors – while the often irreplaceable originals are safely preserved. Also, the sound can often be improved considerably during the copying process through equalization and filtering.

This article describes a flexible, low-cost noise filter designed for taping records with a maximum "fidelity-to-noise" ratio. It can be duplicated by the serious electronics hobbyist for about $80, or slightly less if certain features or ranges won't be needed. Although not recommended as a beginner's project, the experimenter with some circuit experience should have no difficulty. Minimum equipment requirements are an oscilloscope, sine wave generator, and multimeter.

The heart of this circuit is a dynamic noise suppressor with frequency characteristics and convenience features which are optimized for its intended use. The concept of dynamic noise suppression has existed for many years. Workable circuits were designed by H.H. Scott in 1946, and their performance was improved by Scott and others in 1947 and 1948. Then with the advent of the vinyl microgroove record and the rapidly increasing use of tape, both of which offered a considerable noise improvement over the 78 rpm system, the dynamic noise suppressor was almost forgotten. Recently, R. Burwen has revived this principle and applied it primarily to tape playback. Taking full advantage of modern integrated circuits, Burwen has designed highly sophisticated and flexible systems with impressive specifications. These, however, are too expensive for many hobbyists and do not have frequency characteristics optimized specifically for old, intrinsically band-limited material.

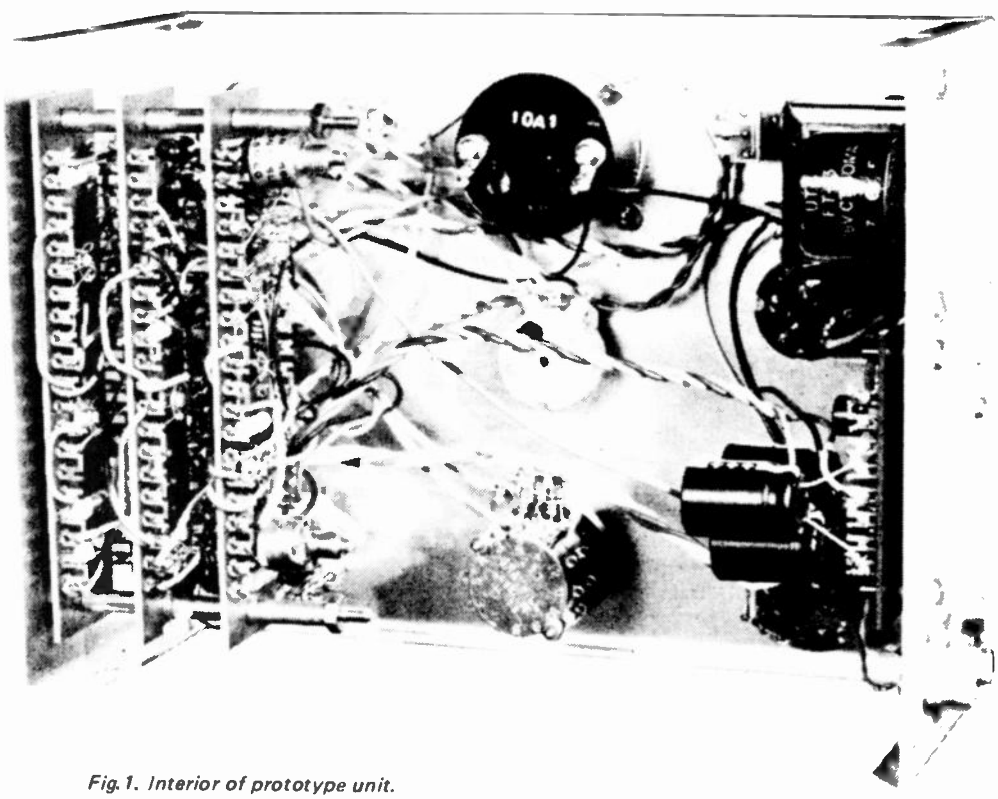


Fig. 1. Interior of prototype unit.

THEORY

Dynamic noise suppression is simple in concept. Record surface noise varies in spectral content, but the higher frequencies (above 1 or 2 kHz) predominate. Low-pass filtering is commonly used to limit noise. But unless used sparingly, this type of filtering band-limits the programme material, making it sound muffled and lifeless. The dynamic filter, however, provides a method by which a signal can be effectively extracted from the noise (at least subjectively) *when signal and noise occupy overlapping frequency ranges.*

Operation of the dynamic noise suppressor depends upon a characteristic of the human auditory apparatus. If two signals occupying well-separated frequency ranges are present simultaneously, they are clearly perceived as individual entities. (This effect is often used to advantage in public address systems for noisy environments. If considerable high-frequency boost is used, voice announcements will seem to cut through ambient noise of predominately lower frequency without having to be excessively loud.) This is the case, at least for a large portion of the time, for a typical recorded signal with attendant surface noise; hence, the annoyance of the noise. However, if two simultaneous signals occupy substantially the *same* frequency ranges, the ear will tend to hear only the louder signal and ignore the weaker one. A level difference of only a few dB is sufficient for one signal to effectively override, or mask, the other. Operation of the dynamic noise suppressor depends upon this masking effect.

The dynamic filter has a fairly steep low-pass characteristic which, in the absence of signal, starts cutting off at about 1 kHz. This very effectively rejects the noise spectrum. When a signal having high-frequency components at sufficient amplitude comes along, the filter is made to "open up"; that is, its cutoff frequency is quickly raised. As the high-frequency programme content drops in frequency and/or amplitude, bandwidth contracts. The idea is that when high-frequency signal components are present, they will tend to mask the accompanying noise. When highs are not present, the wide bandwidth is not needed. Admittedly, the recovered signal is not as faithful as a noise-free original would be. For example, high-frequency content in low-level passages may be lost. Of some help here is the fact that many musical instruments tend to have less harmonic content at low acoustic levels. In spite of this compromise, the processed signal is usually far more pleasing to the ear than the noisy input signal.

The bandwidth control signal is derived by separating the high-frequency programme components from the signal-plus-noise. Unless the signal level is consistently higher than the noise to begin with, this becomes impossible. Thus, there is a minimum signal-to-noise requirement below which no improvement is possible. As the original S/N improves, the dynamic suppressor's performance improves also.

Ideally, the signal frequency range to which bandwidth is most sensitive should correspond to the frequency range of maximum noise. The optimum filter characteristic for separating the bandwidth-control signal from the noisy input thus varies widely with the characteristics of the noise with which we are dealing. Bandwidth control sensitivity (or gain) must be set properly for the incoming signal level and noise properties. Bandwidth should respond rapidly to signal changes to avoid loss of transients and to prevent audible "swishing" sounds which can be produced by delayed bandwidth contraction.

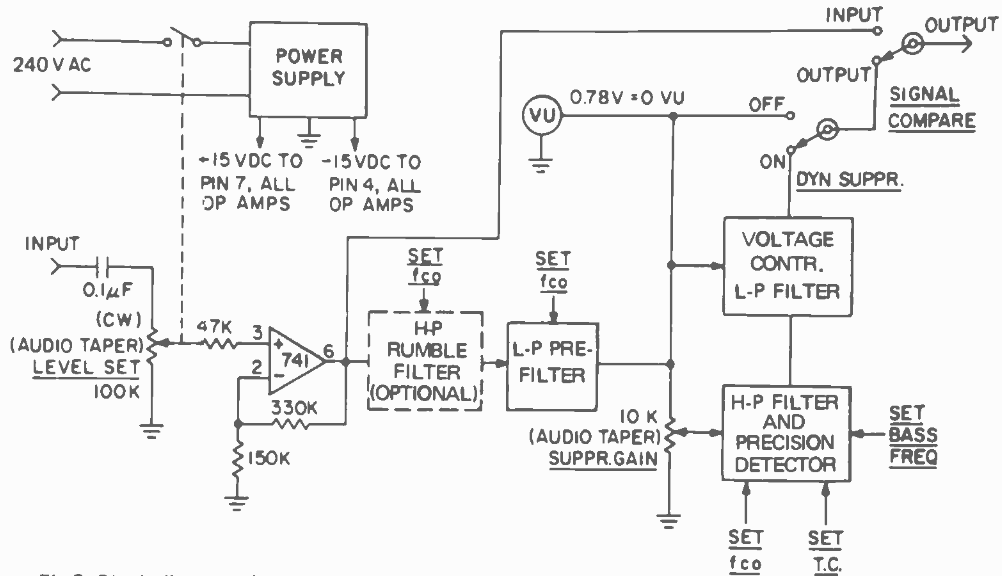


Fig. 2. Block diagram of system.

DESIGN APPROACH

I have tried to implement the basic requirements outlined above as completely as possible in an easy-to-use, low-cost unit. A dynamic high-pass filter stage was considered but later dropped, as high-frequency noise predominates on most older records. Low-frequency noise can usually be handled adequately with a simple manually-set rumble filter.

Figure 2 shows an overall block diagram of the noise filter. Operational amplifier A1 is connected as a non-inverting amplifier with a voltage gain of 3.2 (10 dB), enabling the system to be driven to 0 VU with an input level of 0.25 volt. This amplifier also serves as a buffer, providing an input impedance of 100 kilohms for compatibility with virtually any signal source.

Amplifier A1 drives the *rumble filter*, which could be omitted if one is available in the associated external equipment. Following this is the *pre-filter*, which is simply a low-pass filter with a manually set cutoff. This filter is important for several reasons. First, it removes noise which is above the frequency range of the recorded signal. Many recordings have no signal content above 4 or 5 kHz (even lower for acoustic records), and no programme content is lost by cutting off the upper range. Thus, the total noise voltage is lowered, often appreciably, permitting the use of higher suppression gain settings as will be seen later. Another reason for this filter is that the dynamic filter can do nothing to reduce the annoyance of high-frequency distortion. Furthermore, since a limited-bandwidth signal cannot effectively mask higher-frequency noise, removal of the latter helps to eliminate audible evidence of the continually changing bandwidth.

From the pre-filter output the signal passes to the *voltage-controlled low-pass filter* and, via the *suppression gain* control, to the *high-pass filter/precision detector* whose function is to derive the bandwidth control signal. This point additionally goes to a switch which permits the dynamic filter to be by-passed at will so that its effect with various control settings may be easily judged. Another switch permits the output to be compared with the "raw" input signal.

All of the filters used in this system, including the voltage-controlled filter, are of the 2-pole active type, giving a 12 dB/octave rolloff slope. The damping factor is chosen (with one exception) for a Butterworth response, which produces the steepest possible slope beyond cutoff with no peaking in the passband. (High-pass filters with 3 dB peaking were tried, but these produced a slightly rough, "grainy" sound compared to the flat-passband version.) The design approaches are widely published and need no further discussion here. The rumble filter

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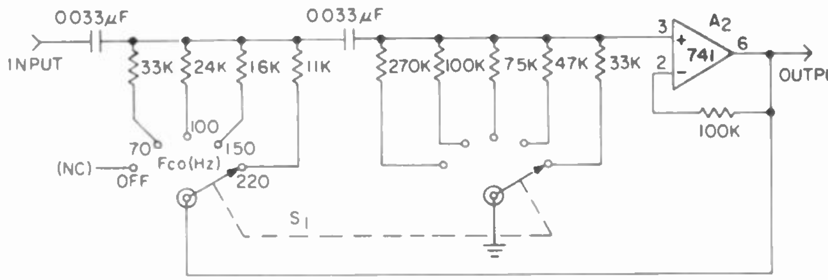

Fig.3. Optional high-pass rumble filter schematic.

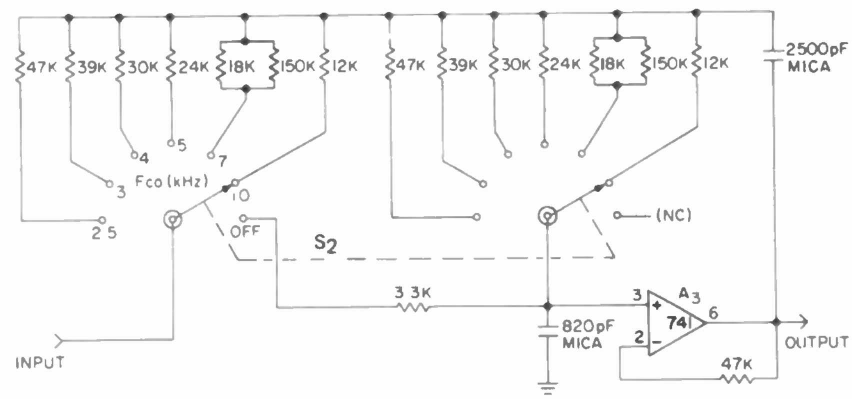

Fig.4. Schematic of the low-pass pre-filter.

(Fig. 3) and the pre-filter (Fig.4) are of this type; their response curves are shown in Fig.5. The rumble filter is not essential to proper suppressor operation, but is convenient in case an effective low-cut filter is not included with the associated preamplifier in the copying setup. The design shown here has rather high settings intended primarily for acoustic records.

The bandwidth control signal is derived with the circuit of Fig. 6, which consists of a high-pass filter followed by a precision detector. The filter damping factor is made low in order to produce a pronounced peak and more rapid low-frequency rolloff (Fig. 7). Three selectable cutoffs produce peaks at 3.5, 5, and 7.5 kHz; these were empirically determined to best accommodate a wide range of noise characteristics and recorded bandwidths.

The knowledgeable enthusiast could readily modify the cut-off points to suit his own particular application.

The filter output is coupled to the detector via a small capacitor to make the low-frequency rolloff even steeper below 1.6 kHz. The precision full-wave detector uses diodes in the feedback circuit of an op-amp to effectively produce ideal rectification characteristics down to the millivolt region. The output amplifier doubles as a post-detection filter. Resistor R determines the gain, and capacitor C makes this stage behave as an operational integrator with time constant RC. A switch is provided for increasing the time constant by paralleling capacitor C1; this is helpful with sources having sharp impulse noise. The output of the detector/filter circuit controls the bandwidth of the dynamic suppression filter according to the curve of Fig. 9.

Early experiments showed that it is undesirable to make the no-signal cutoff lower than absolutely necessary to substantially reduce noise with a particular signal source. When the cutoff is made lower than actually needed, weak signals are unnecessarily band-limited and the dynamic filter produces such a level-dependent bandwidth contrast that its action is much more likely to be audible. Hence a BASE CUTOFF (not "BASS CUTOFF") control was found to be desirable. This control is simply a pot which offsets the detector output at zero signal level by applying a variable reference voltage to the op amp non-inverting inputs. This voltage, variable from about −1 volt to −6 volts, establishes a "starting point" or base cutoff frequency which can be set just low enough to virtually eliminate no-signal noise.

The variable-cutoff filter, Fig. 8, is the very heart of the system. Since there is some part selection and adjustment necessary, it must be checked out separately. The basic configuration is similar to that of the pre-filter, except the latter's switch-selected resistors have been replaced by field-effect transistors (FETs). FET channel resistance R_{DS} changes as a function of gate voltage V_{GS} as shown in Fig. 11, thus varying cutoff frequency. A resistor across each FET establishes a solid lower cutoff limit and smooths the control characteristic as the FETs approach their "off" state. The gate circuit network, consisting of diode D1 and resistors R1 through R5, is used to empirically shape the control curve (Fig. 9) for best audible results. Diode D1 prevents excessive positive gate drive, maintaining isolation between the gate and signal circuits.

An input attenuator (R10 and R11) limits the signal amplitude presented to the FETs to about 0.1 volt p-p at 0 VU to ensure low distortion. Output amplifier A7 makes up exactly for this loss. An op amp having external frequency compensation was used here so that this relatively high-gain stage could be tailored for flat response to 15 kHz (a μa741 could be used, but would roll off slightly above 10 kHz). Resistors R16 and R17 attenuate the output signal by an amount equal to the gain, so that this amplifier doubles as the unity-gain buffer required for filter operation. The highest cutoff frequency is dictated by minimum FET resistance and capacitors C1 and C2. The latter should have values in a ratio of about 3:1 to produce the

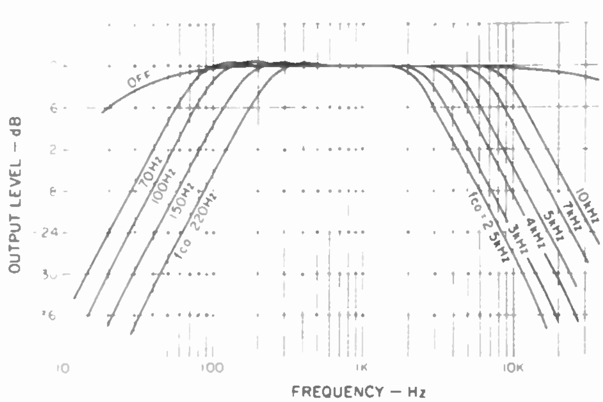

Fig.5. Frequency characteristics of the manually-set rumble filter and pre-filter.

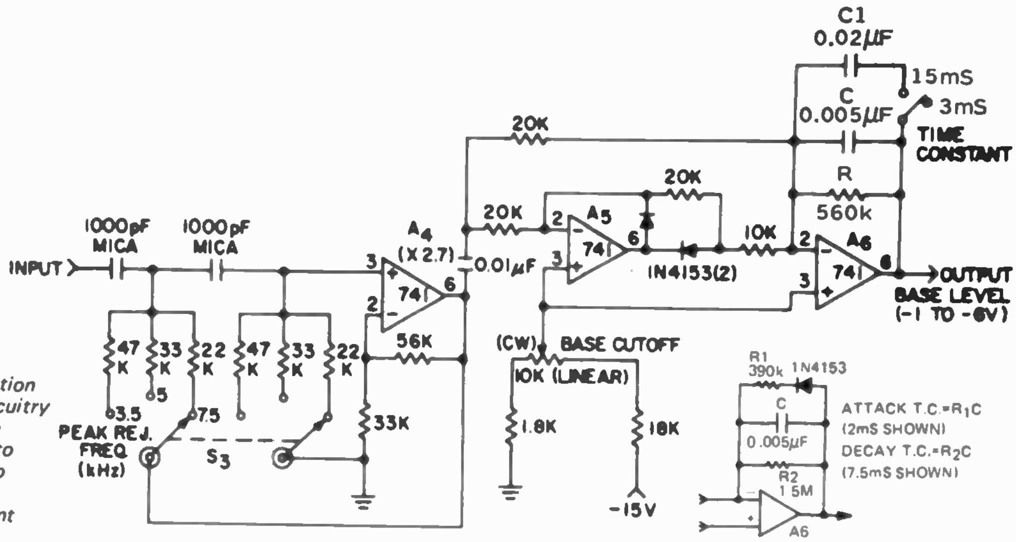

Fig.6. Bandwidth control signal separation filter and precision rectifier. IC A6 circuitry may be modified, as shown in separate detail, for shorter attack with respect to decay time — note that R1 and R2 also affect rectifier gain so time constant changes are not completely independant of 'suppression' gain.

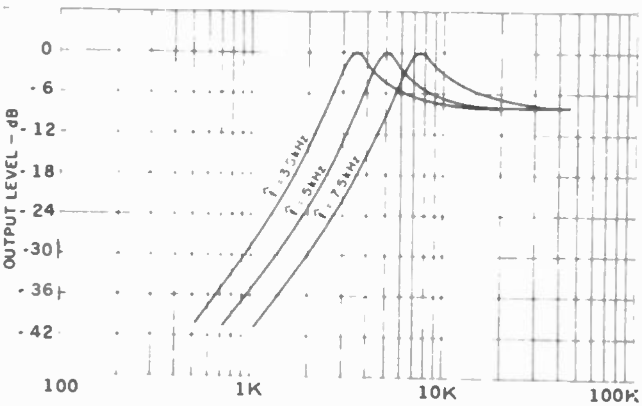

Fig.7. Frequency characteristics of the filter used to derive the bandwidth control signal.

desired Butterworth response. Figure 10 shows the measured response of the complete filter for four values of control voltage.

Unfortunately, FETs vary widely in characteristics, even between units of the same type, so these devices must be selected. The two FETS must be reasonably well matched over at 15:1 R_{DS} range for a 15:1 range in cutoff frequency (15 kHz to 1 kHz). (Dual matched FETs are available, but are more expensive and not necessarily matched for the parameter of interest here.) A transistor curve tracer is most convenient for this purpose and permits selection for best linearity as well as matching. I used N-channel 2N4220s on hand ($1.50 each) and selected the best matched pair out of a group of six units. Figure 11 shows the VI characteristics of one of these. There are many other inexpensive FETs which should work as well, such as the 2N5484, 2N5716, and 2N5717. In fact, any general-purpose, depletion-type FET with fairly low zero-bias current (I_{DSS}) and pinch-off voltage (Vp) should be usable. P-channel units would require reversing diodes D1 and D2 and the polarity of the control voltage.

If a curve tracer is not available, the setup of Fig. 12 can be used. A transistor socket will facilitate changing FETs. A good procedure is to first measure R_{DS} at V_{GS} = 0. Then increase V_{GS} (negatively for N-channel FETs) until R_{DS} is about three times the zero-bias value; this corresponds to a mid-range cutoff frequency where matching is the most critical. With this V_{GS} setting try different FETs until a 10 percent or better match is found. If R_{DS} values seem to cluster higher or lower, try another unit as a reference and try matching to it. When matched units are found, check the match at minimum R_{DS} (V_{GS} = + 0.5V) and at 10 times this value of R_{DS}. A 20 percent mismatch can be tolerated at

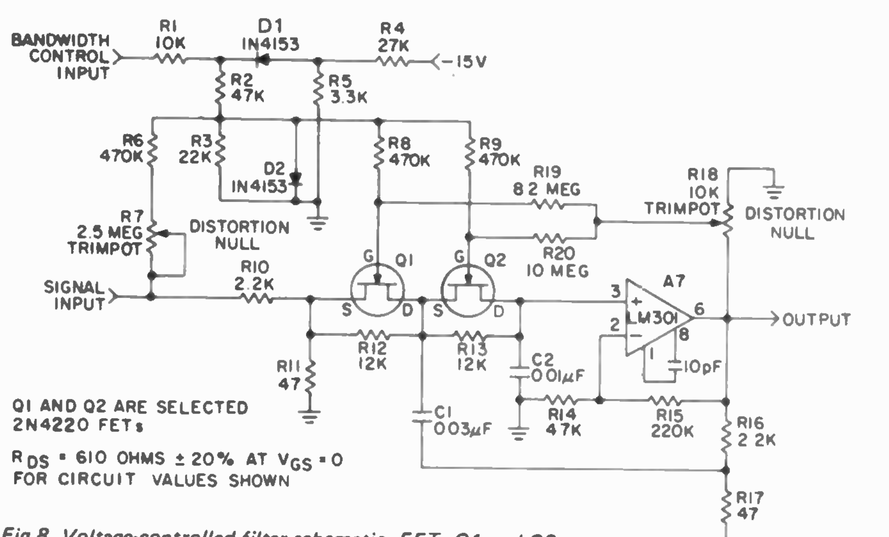

Fig.8. Voltage-controlled filter schematic. FETs Q1 and Q2 are critical and must be selected (see text).

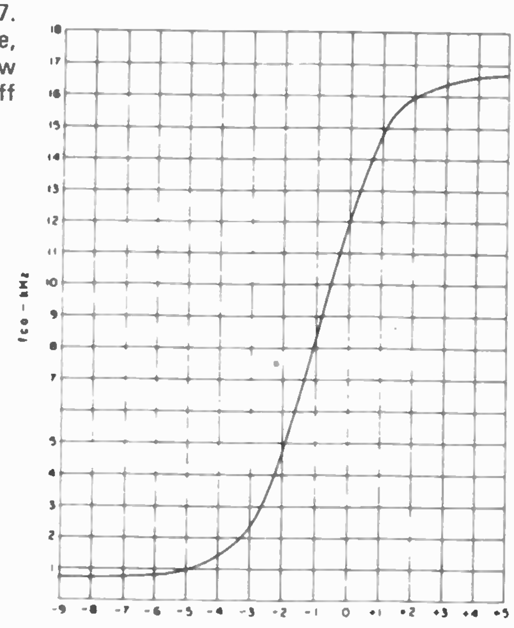

Fig.9. Variable-bandwidth filter cutoff frequency vs. control voltage.

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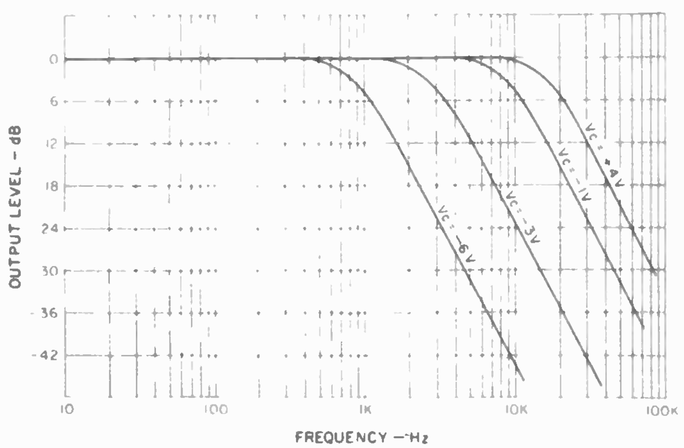

Fig. 10. Variable-bandwidth filter characteristics for several control voltage values.

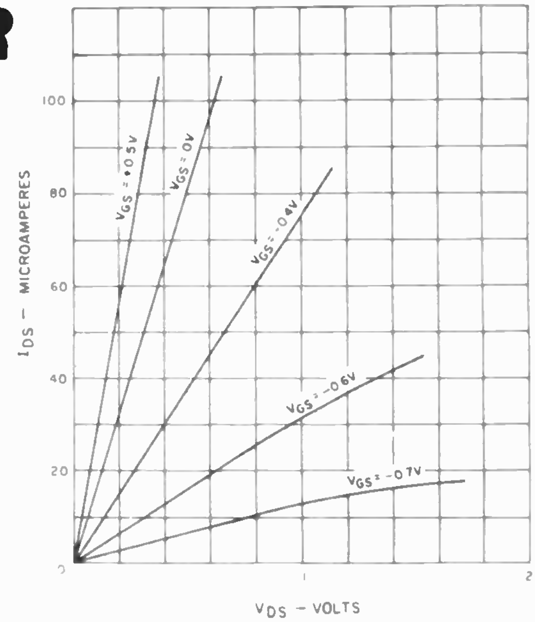

Fig. 11. Variable-resistance characteristics of a junction field-effect transistor with low values of drain-to-source voltage.

these extremes. My 2N4220s measure 610 ohms at zero bias, 360 ohms at V_{GS} = + 0.5V., and about 8 kilohms at V_{GS} = –0.7 V. R11 and R12 are chosen for a cutoff of between 800 Hz and 1 kHz with the control voltage at its maximum negative value of about –6 volts. Circuit cutoff at zero FET bias should be roughly 12 kHz (see Fig. 9). A slight forward bias, limited to about +0.5 volt at the FET gates by diode D2, then boosts the cutoff to at least 15 kHz with maximum positive output from the precision detector.

Resistors R6, R7, R18, R19, and R20 reduce harmonic distortion significantly. R6 and R7 feed some signal to the FET gate circuit so that signal voltage does not appear between source and gate, which would make R_{DS} vary slightly with instantaneous low-frequency signal amplitude and polarity. R18, R19, and R20 feed back some output signal to the gates to further reduce distortion (this is a cancellation effect, not true negative feedback).

Distortion settings are best made in the vicinity of cutoff, where FET linearity is the most critical. Connect a variable-voltage d.c. source (the slider of a 5 k pot temporarily connected between – 15 V and ground will suffice) to the bandwidth control input and set it for a cutoff frequency of 2 kHz. Then, with a 2 kHz sinusoidal input at about 0 VU (2.2 V p-p), set trimpots R7 and R18 for lowest harmonic distortion at the output. It should be possible to sharply null the total harmonic content, which consists primarily of the 2nd and 3rd harmonics, to at least 60 dB below 0 VU. Then vary the cutoff frequency and make sure distortion is low for all settings. Of course, the filter itself will reduce harmonic distortion appreciably at its lower cutoff values. Lacking a distortion meter or wave analyzer, these adjustments can be made quite well by driving the input at 7 volts p-p (10 dB above 0 VU) to accentuate the distortion and setting very carefully for a symmetrical output waveform as monitored by a 'scope. Fixed resistors, determined by two decade boxes (the settings interact somewhat), could replace the pots. These adjustments, once made, are permanent unless the FETs are changed.

Figure 13 shows the distortion of the complete noise filter measured at two fixed values of bandwidth control voltage. At normal levels, distortion is so low that it is largely a measurement of the harmonic distortion of the test oscillator. The large margin above 0 VU passes the highest programme peaks ever likely to be encountered without clipping.

The simple power supply of Fig. 14 easily supplies the power requirement of ± 15 volts at about 10 mA.

CONSTRUCTION

The entire filter can be duplicated for about $80 with new parts. Very few components are critical and substitutes can be used in most cases. Quarter-watt, 5 percent composition resistors are suitable. Layout is not critical, since signal levels are high and impedances are relatively low. I strongly recommend that each of the functional blocks of Fig.2 be built and checked for reasonable conformance with the curves before integration into the system. This makes troubleshooting for errors and occasional bad components much easier, practically ensuring success. My unit (Fig. 1 and lead photo) is a "breadboard in a box." The circuit is still undergoing occasional changes, even though it is a third-generation model. Parts are mounted on terminal boards which were on hand. A neater approach would be to use the

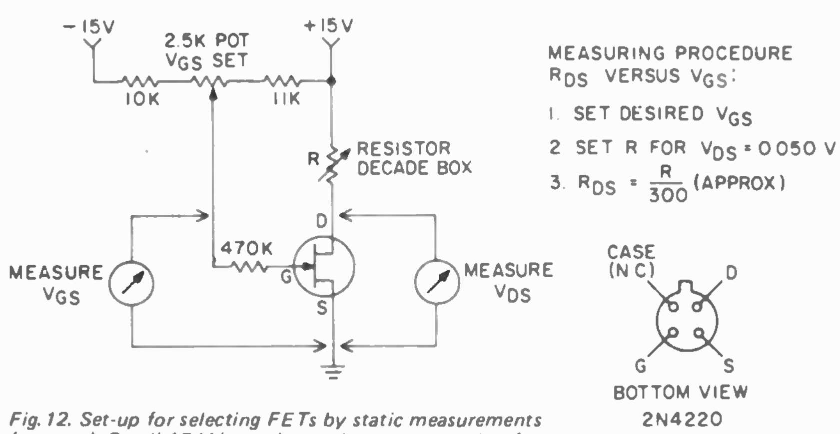

Fig. 12. Set-up for selecting FETs by static measurements (see text). Small 15 V batteries or the power supply of Fig. 13 may be used.

commercially-available matrix-board with snap-in terminals.

OPERATION

After checking the wiring, apply power to the unit and check for proper power supply voltages. Positive and negative supplies should both be between 14 and 16 volts with respect to ground. Much lower values would indicate a short circuit or bad op amp. Current drain should be on the order of 10 mA.

The noise filter can be conveniently connected to your audio system by means of the *Tape In* and *Tape Out* jacks included on most preamplifiers. An advantage to this connection is that the processed signal passes through the pre-amp tone controls, which can be set for the most pleasing final balance. For taping, the recorder input is paralleled with the output which drives the power amplifier.

For intial set-up experience, a record having a good frequency range and moderate, steady surface hiss is desirable. (A slightly noisy FM station can also be used, but results will not be quite as good because of the latter's flatter noise spectrum.) Initial control settings should be:

Pre-Filter: Off
Rumble Filter: Off
Time Const.: Off
Peak Rej. Freq.: 5 kHz
Base Cutoff: CCW
Suppr. Gain: CCW
Dyn. Suppr.: Off
Sig. Compare: Input

The signal should now pass through the unit unaffected, except the *Level Set* control will vary the gain from zero to 3.2 (10 dB). Set the level for 0 VU on signal peaks as you would set a recording level. Whenever the source is changed, the signal level should be reset as necessary.

Now switch the *Sig. Compare* switch to "output". The signal is now passing through the rumble filter (if used) and pre-filter, but bypassing to dynamic filter. Lowering the *Pre-Filter* cutoff setting should progressively cut off the highs. At the lower settings, which are primarily for acoustic records, the signal will sound severely band-limited. The best setting is the lowest cutoff which does not significantly affect the recorded bandwidth. I have found that with vocal music, the unfiltered sibilant sounds provide a means of judging bandwidth. If sibilants are quite strong and natural, a 7 kHz or higher cutoff is indicated. If they are weak or have a slight "whistling" sound, the upper limit is about 5 kHz. If sibilants are lacking, a 4 kHz or lower setting is best. Of course, the presence of high-frequency distortion may dictate a compromise setting a notch or two lower than indicated above. The filtered and unfiltered sounds may be compared at any time by means of the *Sig. Compare* switch.

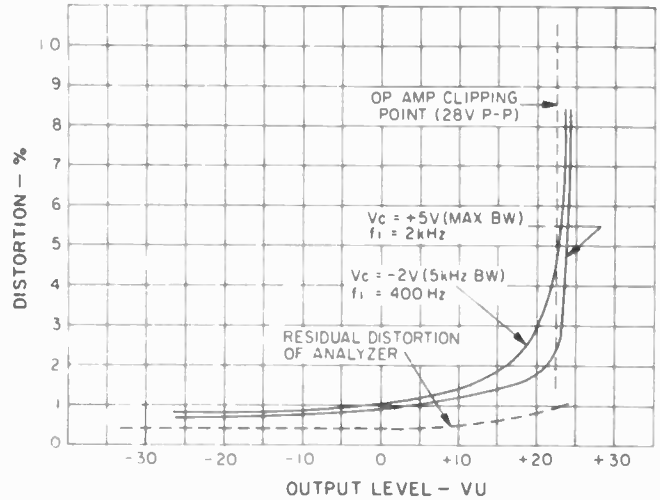

Fig. 13. Overall harmonic distortion of the noise filter for two constant values of bandwidth-control voltage.

The optional rumble filter is used for the occasional records which have warpage or bumps or low-frequency noise in the recording. For *acoustic* records it can be routinely left at 150 Hz, as nothing is recorded below about 200 Hz.

Next flip the *Dyn Suppr* switch to "on", putting the dynamic suppressor in the circuit. The sound should become very dull and lifeless, as the high-frequency cutoff is now 1 kHz or less. Increase the *Base Cutoff* setting until record noise just begins to be audible. The signal will probably still be quite lacking in high-frequency content (if it is not, only the pre-filter may be needed for this particular source). Now turn up the *Suppr Gain* slowly. This should "magically" restore the highs without increasing the noise level. The highest possible setting which does not noticeably increase the noise is normally best.

At this point it is edifying to monitor the bandwidth control input signal to the variable-bandwidth filter with a d.c.-coupled oscilloscope. The instantaneous voltage here is a measure of high-frequency programme amplitude and dynamic filter bandwidth (see Fig. 9). It should follow transients rapidly and may reach saturation (about + 14 volts) on musical passages having high harmonic content and on strong voice sibilants.

The *Peak Rej. Freq.* switch selects the frequency of peak rejection by choosing the appropriate filter curve (Fig. 7) for separating the bandwidth-control voltage from the input signal. The *5 kHz* position is used for most electrical 78 rpm records. For acoustic records or very noisy electrical 78s where the pre-filter is set for 4 kHz or less, the *3.5 kHz* position gives better results. Here the *Time Const.* switch can be set for *15 mS*. The longer time constant also helps to attenuate sharp clicks and pops occuring in quiet passages, as it prevents the bandwidth from increasing rapidly enough to follow their steep wavefronts. The *7.5 kHz* position is used for wideband recordings and tape.

With a little practice, you will be able to set the controls quickly for optimum performance. It is often best to set the *Base Cutoff* for a significant improvement, rather than to try to eliminate the noise completely. This will minimize low-level band limiting, and the suppressor will be less likely to betray its presence with obvious bandwidth changes.

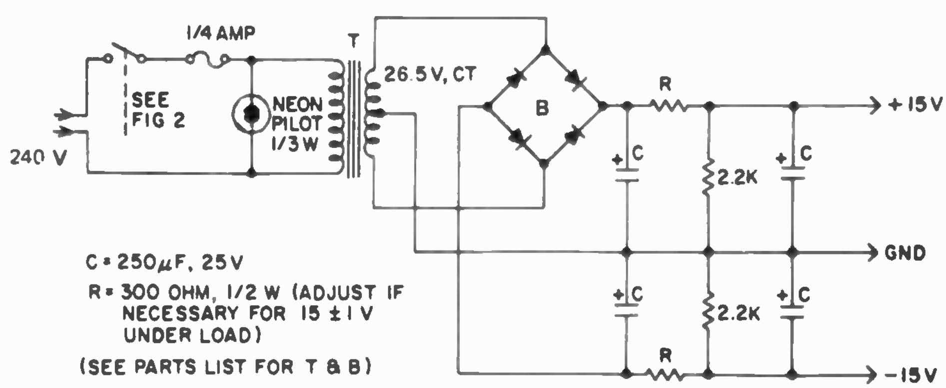

Fig. 14. Power supply. A two-channel suppressor may easily be powered by reducing R slight.y

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PERFORMANCE

Figures 5 and 10 indicate the bandwidth ranges available. The pre-filter and dynamic filter (slope is 24 dB/octave above both cutoffs) can together provide well over 60 dB of noise attenuation at 10 kHz and over 40 dB at 5 kHz. The overall improvement in signal-to-noise ratio is strongly determined by the character and spectrum of the noise, which varies greatly with records. With the steady hiss typical of new electrical recordings on shellac, an average improvement of 8 dB (unweighted) is realized from the dynamic filter alone. Including the effects of the rumble filter and pre-filter on band-limited material, S/N improvement can be more than 12 dB. The apparent improvement is even greater, since the ear heavily weights the higher frequencies where record noise is concentrated.

The effect of the noise filter is surprisingly great on records which were originally thought to be quiet without filtering. It is a little weird at first to hear a familiar old record with realistic strings and brass and clear voice sibilants, but with the background suddenly rendered deadly quiet. I have spent many hours listening to the records and tapes in my collection and enjoying them anew.

The noise filter works very well on tape noise, providing at least 8 dB total S/N improvement. A stereo version built for tape only could be simplified considerably, as only the *Level Set, Base Cutoff, Suppr. Gain, and Sig. Compare* controls would be needed. The power supply as shown can easily handle two channels.

The noise level of the filter itself depends mostly on output amplifier A7. Of several units I tried, the noise level ranged from 62 to 68 dB below 0 VU.

A few tips on the mechanical aspects of copying records are in order here. The importance of good tracking cannot be overemphasized. More can be gained here than with any amount of electronic processing. Groove radius, depth, and angle were not standardized on early discs, and experimentation with tracking force and stylus size, if possible, may yield a considerable improvement in both noise and distortion. The playback stylus should, of course, ride on the sides of the groove. If it is too small it may ride the bottom of the groove and skate from side to side in a partially uncontrolled manner, creating severe distortion. If too large, it will ride high in the groove where it is more sensitive to surface blemishes. Also, larger styli cannot follow high-frequency modulation as well, especially on the inner record grooves. Elliptical styli are helpful on relatively wide-range 78s if the latter have not been damaged by previous playings.

Acoustic records (1925 and earlier) tend to have a larger groove, since with acoustic playback the mechanically-imparted stylus motion had to supply all the sound power. For these, a stylus of 4-mil (.004") radius may produce better results than the standard 3-mil size. Custom-made styli with a "truncated" tip (really a smooth transition from a 2- or 3-mil radius to about a 4-mil radius at the very tip) have been used to track the groove sides of 78s properly while avoiding contact with the bottom. (Truncated and other special styli are available from the International Observatory Instruments, 5401 Wakefield Drive, Nashville, Tenn. 37220). Although not a cure-all, these can give dramatic results on selected discs. A 2.5 mil stylus is best for most post-1946 transcriptions. Obviously, the pickup should have adequate lateral compliance and should produce no output for vertical motion. Incidentally, electrical recordings made before the mid-1940s are mostly recorded flat, that is, they have no high-frequency pre-emphasis, while later records have pre-emphasis of as much as 16 dB at 10 kHz.

Edison cylinders (160 rpm) and discs (80 rpm), some Pathe discs, and some early wax transcriptions are vertically modulated. Here the stylus does ride on the groove bottom, and the pickup should have only vertical response. This can be obtained (as can lateral-only response) from a suitably-phased stereo cartridge. Stylus radii of 4 to 10 mils are typical here; as always, experimentation is in order.

An article, outlining a number of techniques for obtaining good quality sound from early recordings was published in the May 1975 issue of our associated journal 'Hi-Fi Review'. Some back copies are still available from our subscription department for $1.00 each, including postage and packing.

FUTURE DEVELOPMENT

The experimenter may want to try to improve the performance of the circuit described. Of course, additional types of processing can be added, such as more effective click suppression at the filter input or multi-channel equalization at the output. These would be electrically independent of the noise filter, and beyond the scope of this article. However, there are some possibilities for improving the noise filter itself. Many of these, unfortunately, would require an incongruous increase in complexity and cost.

Sharper filter cutoffs give a marginal improvement on very noisy material, but setup adjustments become more critical. Dynamic high-pass (low-cut) filtering using a simple 6 dB/octave slope might be a reasonable addition. Since the noise-rejection frequency band of the low-pass dynamic filter should complement the noise spectrum of the signal, a statistical study of record and tape noise spectra might lead to a better shape for the bandwidth-control-signal separation filter of Fig. 7. The separation filter selector could be ganged with the pre-filter cutoff switch to eliminate one control knob. Perhaps a noticeable improvement could be realized by experimenting with the shape of the bandwidth control characteristic, Fig. 9. The attack time constant could be shortened by using a more elaborate filter at the precision detector output; this would improve the response to occasionally encountered wide-band transients.

An obviously desirable change would be to replace the FET bandwidth-control filter with one of the voltage-controlled state-variable types. This would eliminate the need for FET selection, but would increase the cost severalfold. It therefore appears that the original goal of high performance per dollar has been achieved, yielding a practical design which is within reach of the hobbyist.

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If you have ever spent time auditioning speakers under controlled circumstances, you know that consecutively produced speakers of the same model sometimes can sound very different. The difference can be as great as that found between speakers of diverse price ranges – a situation that challenges the validity of listening to a demonstration speaker and then purchasing another unit of the same model.

This problem resides in the measurements rather than in the speaker construction. It can occur whether the speakers are individually handmade or whether they are run on an assembly line.

In a university research programme started by Dr. Bose in 1956 and in continuing research at BOSE Corporation, it has been found that some of the most commonly made measurements on speakers are not adequately correlated to the perception of sound. Extensive research has been performed to develop a set of measurements that correlate sufficiently to perception to provide a means of precise control of production speakers.

The result was a set of measurements that was not practical to implement with existing instruments. At this point (1970), the BOSE research department launched a program to design a special purpose computer, programmed to test for audible differences and to interpret these differences in a manner that would allow production engineering to detect and correct the assembly problems.

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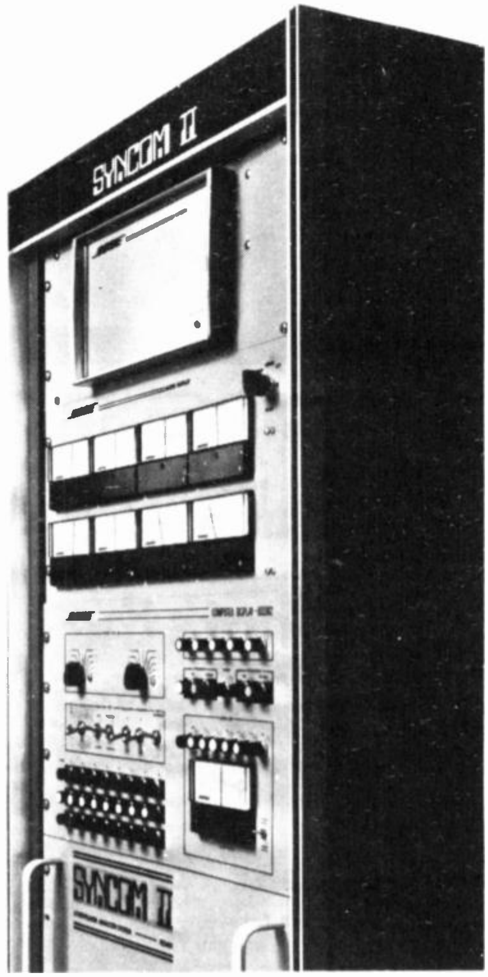

It is now installed and it is controlling all production on the BOSE 901 and 501 speakers. The technical details of this computer are, of course, a closely guarded proprietary secret, as is any technology that enables one company to produce better products in a competitive market. While we cannot share this information with you, we are confident that you will share in the results of the SYNCOM II computer operation through the enjoyment of more natural music reproduction in your home. Only speakers from BOSE passing this computer test bear the SYNCOM trademark.

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PROJECT 413x2

200W BRIDGE AMPLIFIER

An economical way to interconnect two ETI 413 100 watt amplifiers.

NO MATTER how big an amplifier you design – someone always wants a bigger one! We have certainly found this to be true, for hundreds of our ETI 413 Guitar Amplifiers have been built, and the only complaint that some builders have is that they would like even more power – especially into eight ohms.

Whilst a 200 watt amplifier can quite readily be designed, special high-voltage, high-power output transistors and a large and expensive power transformer are required. Fewer people require such power and hence, for commercial amplifiers, this means even higher cost in terms of dollars-per-watt of output power. About the cheapest 200 watt amplifier available commercially costs $1.50 per watt, that is – over $300 dollars per channel!

Here is a way to couple two ETI 413 amplifiers together to obtain 200 watts into 8 ohms for around $150.

The ETI 413 was first described in December of 1972. That issue of ETI is long out of print as is also Project Book 2, where it was subsequently reprinted. However, due to its enormous and continuing popularity it was also included in Audio Projects Volume 1 – which is still available from newsagents, or directly from our subscriptions department.

Normally the ETI 413 provides 100 watts into 4 ohms or 65 watts into 8 ohms. By connecting the two amplifiers in a bridge configuration each amplifier effectively sees an 8 ohm load as 4 ohms. Their combined output will therefore be 200 watts. The only additional components required, apart from the two amplifiers are four resistors and three capacitors.

CONSTRUCTION

Construction of the individual 100 watt amplifiers is detailed in any of the sources given above. If two existing amplifiers are to be interconnected they should be mounted end-to-end on a common base such that the connections between the two printed circuit boards are as short as possible. Of course, if the amplifiers are being specially built for the purpose, it is preferable to mount them in a common box.

For 200 watts into eight ohms two complete power supplies will need to be constructed and their outputs commoned. This is cheaper than buying a larger transformer to supply both amplifiers. A larger transformer will certainly cost more than two individual transformers but, if one is available, it may be used together with a single rectifier bridge. If the amplifier is to be used to supply 100 watts to a speaker load of 16 ohms minimum, one single supply (as for the normal amplifier) will be sufficient.

Before modifying the amplifiers for bridge connection set up and test each of them separately.

To modify the amplifiers add the series 0.1 microfarad and 4.7 ohm network across the output of each amplifier and add the series 0.01 microfarad and 10 ohm network from the base of transistor Q6, in the second amplifier, to ground. Using

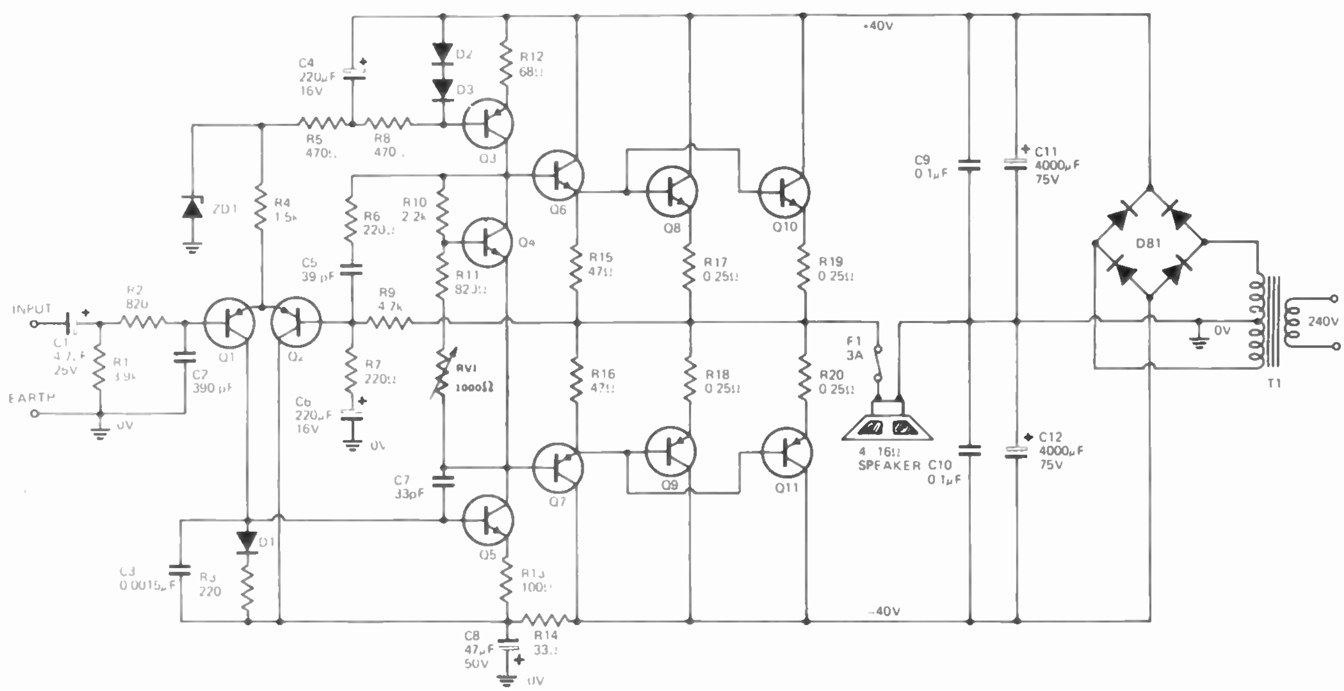


Fig.1. Circuit diagram of the ETI 413 amplifier. Full constructional details of this unit were published in ETI, December 1972 and Top Projects from ETI Vol. 2 – The latter is still to be found in some newsagents. However the full project has subsequently been published in our Audio Projects book – this is still available from most newsagents – or directly from our subscriptions department ($2.50 including postage).

23/0076 wire (or heavier) link each of the +40 V, 0 V and –40 V, of one amplifier, to the corresponding rails of the other amplifier. The 4.7 k ohm resistor may now be installed between the output of the first amplifier and the base of transistor Q2 in the second amplifier. Use insulated wire and spaghetti to extend and insulate the resistor leads. The input of the second amplifier should be shorted out to prevent noise pickup. The speakers may now be connected (with a fuse in series) between the outputs of the two amplifiers.

Note that if it is possible to use two separate amplifiers, each delivering 100 watts into separate four ohm loads, this is preferable to a bridge amplifier supplying 200 watts into an eight ohm load. In a bridge amplifier if one of the amplifiers fails then all output is lost. Thus from a reliability point of view the bridge amplifier should only be used where the eight ohm load cannot be separated. ●

SPECIFICATION

OUTPUT POWER

8 Ohms	200 watts
15 Ohms	120 watts *

Loads less than 8 ohms not recommended.

INPUT IMPEDANCE 3.9 k

INPUT SENSITIVITY 1 volt

*A single transformer may be used for 15 ohm loads in which case the power output will be 100 watts.

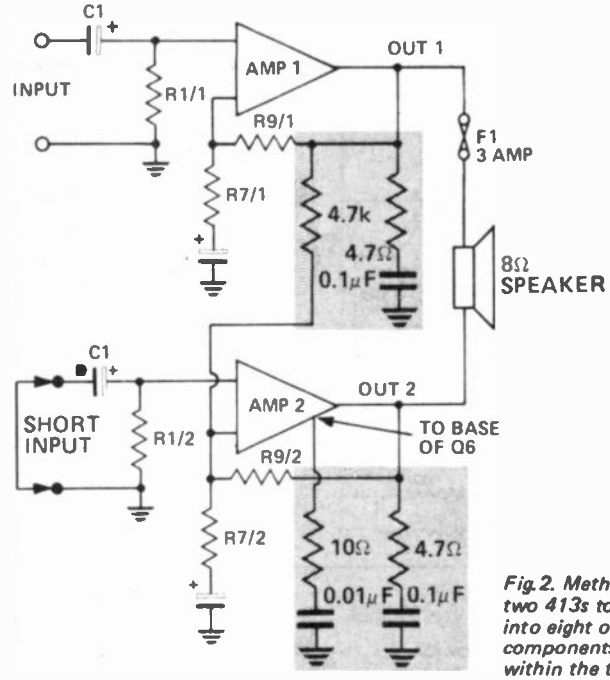


Fig. 2. Method of interconnecting two 413s to obtain 200 watts into eight ohms. Additional components required are shown within the tone blocks.

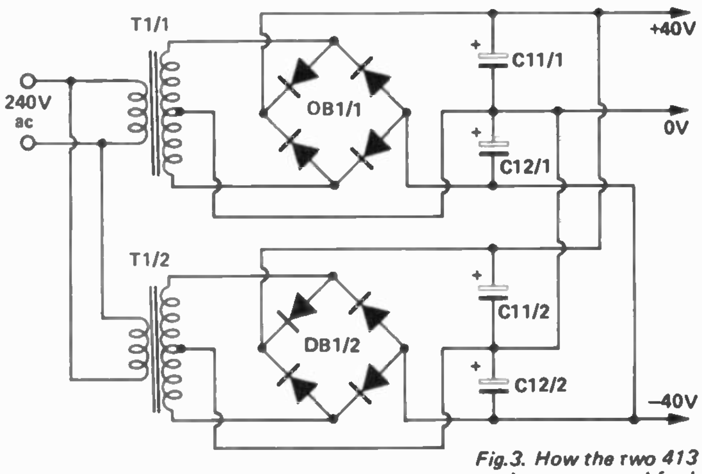


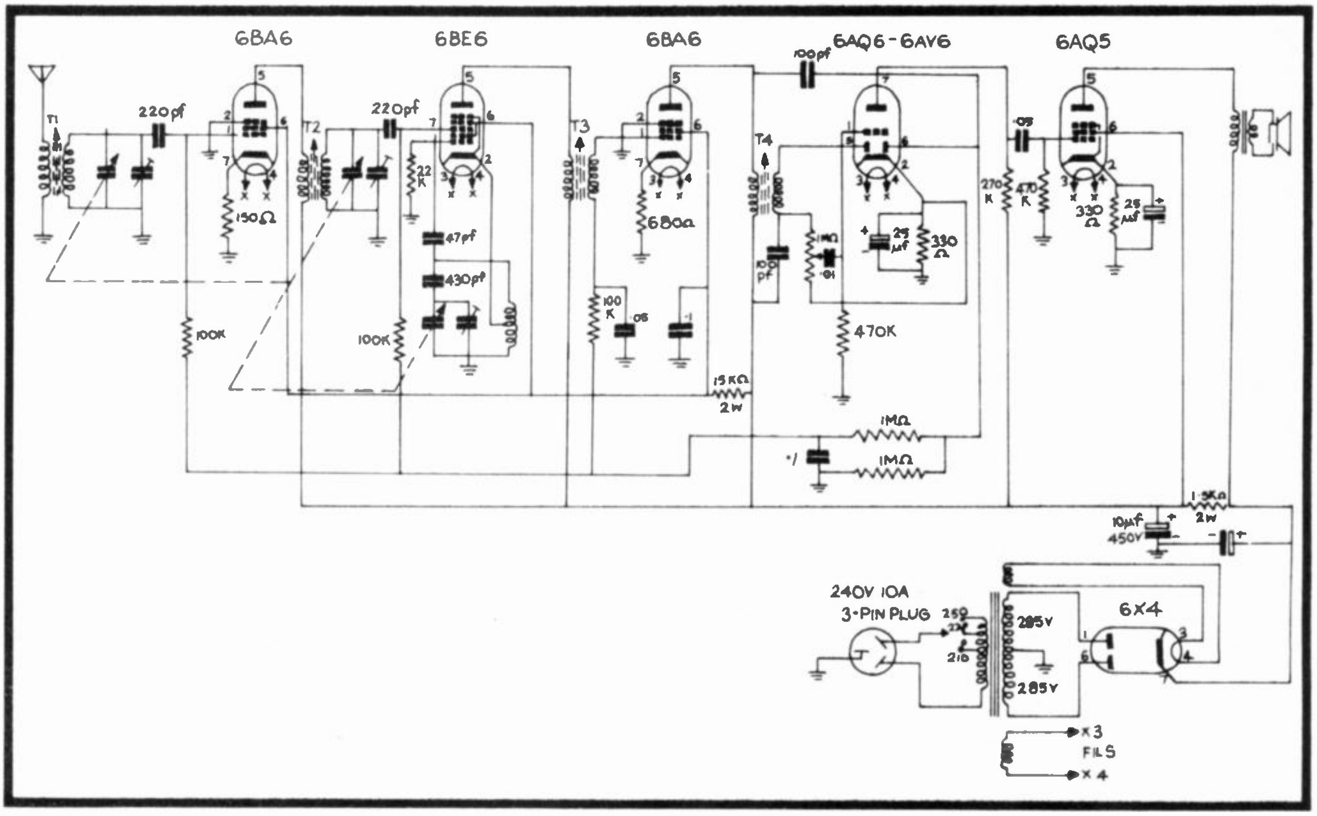
Fig. 3. How the two 413 power supplies are interconnected for bridge amplifier operation.

HOW IT WORKS – ETI 413x2

One of the amplifiers is driven normally such that the output signal is in phase with the input. The second amplifier is driven from the output of the first and is connected as a unity-gain inverting amplifier. The second amplifier is changed to an inverting amplifier by injecting the signal, via a 4.7 k resistor, into the base of transistor Q2. The differential pair, Q1 and Q2, always tries to balance the voltages at the bases of the transistors by means of a change in output voltage. In the unmodified amplifier if the input voltage increases, the output voltage must also increase by the ratio of (R9+R7)/R7 (gain determining components). In the inverting mode the voltage on Q1 is constant and therefore, to keep the voltage at the base of Q2 constant, the current in the new 4.7 k resistor (from the output of amplifier 1) must be balanced by an equal current through R9 in amplifier 2. Therefore the output of amplifier 2 is identical to that of amplifier 1 except that it is out of phase by 180 degrees. The speaker, being connected between the two amplifiers, receives twice the output voltage that could be delivered by one amplifier alone.

Some additional stabilizing networks are needed when working in this mode and these consist of a 4.7 ohm resistor and an 0.1 microfarad capacitor in series across each output. Also required is a 10 ohm resistor and an 0.01 microfarad capacitor in series from the base of Q6 to ground on the second amplifier only. The power rails (+40 V, 0 V and –40 V) should also be linked between the two amplifiers.

One year from now you'll be able to read this circuit as easily as the back of a cornflakes packet.



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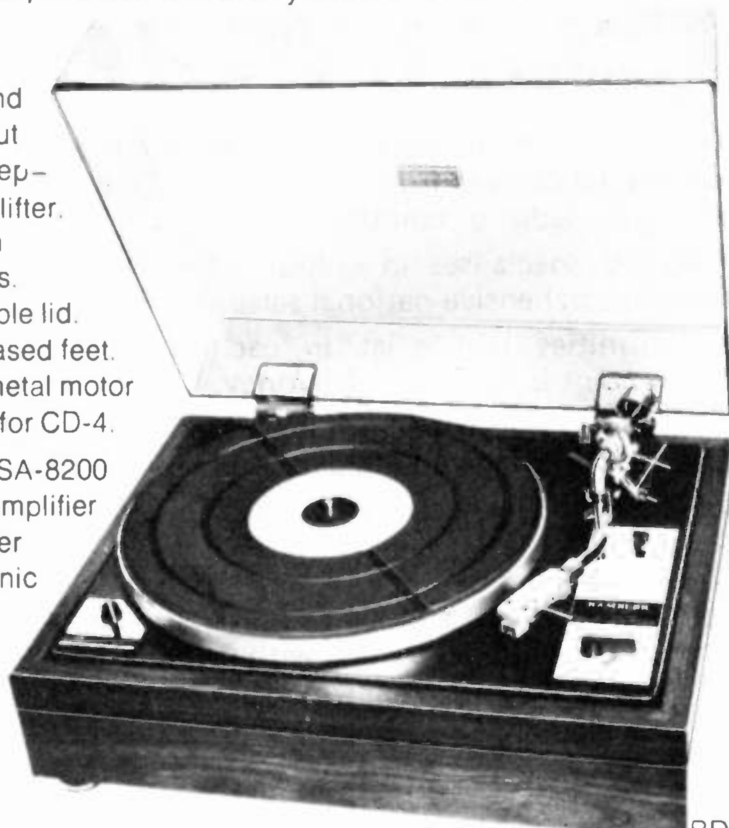
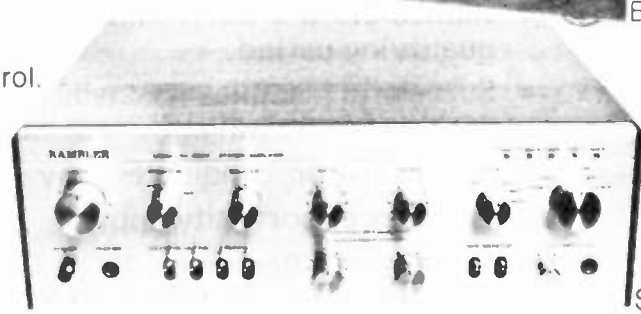
The BDP-100 2-speed turntable is quali-y engineering throughout, featuring a diecast platter, belt driven from a synchronous motor. An "S"-shaped, low tracking error arm with adjustable anti-skate and lateral balance. Auto cut and return arm with indep-endent dampened arm lifter. Magnetic cartridge with diamond elliptical stylus. Spring loaded detachable lid. Shock absorbing felt based feet. Sprung, heavy gauge metal motor board and wired ready for CD-4.

Channel it through our SA-8200 multi-purpose, stereo amplifier with its 55 watts RMS per channel output. Harmonic distortion of less than 0.2% at 45 watts RMS per channel. Inputs:— 2 phono, 2 AUX, 2 tape, tuner and mic. Separate base and treble controls on each channel. High and low filter switches and loudness control. Provision for 2 pairs of speakers. These are just some of the many value packed features in these two superb pieces of Rambler Hi-Fi equipment.



BDP100



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DUAL 701 Direct Drive Turntable

Hall-effect feedback control ensures almost perfect speed accuracy

PRODUCT TEST

THE THREE major factors which characterise a superior record player are: reduced wow and flutter (the speed stability of the turntable); the quality of the tone-arm and, in particular, the minimisation of tone-arm resonance; and the quality of the cartridge which should have the highest possible frequency linearity together with the best possible trackability.

All other factors, whilst very important, tend to be secondary when separating the sheep from the lambs.

Dual — a West German company — have long had a well-earned reputation for producing superior machines — their latest Dual Model 701 is their finest yet. And, like an increasing number of the latest top quality turntables, it has direct drive.

The unit came to us well packed, complete with a very cleverly designed plastic plinth, with a simulated wood finish, and a detachable acrylic top. The plinth is one of the best examples of precision moulding that we have seen and provides an insight into the skills that the German manufacturers have developed in the past few years in using plastics to replace less readily obtainable natural materials.

The turntable is spring-mounted on this plinth and uses a pressed metal base to support the precision diecast motor drive assembly (type EDS 1000) and the heavy diecast turntable (with a mass of 2.9 kg). The turntable is carefully machined and dynamically balanced. It incorporated an integral strobe wheel on the under face. This strobe wheel overlies a mirror system and strobe light, the position of which is adjustable from a simple knurled lens system on the front left-hand side of the base. By rotating the lens, it is possible to focus on either the 33 or 45 rpm strobes and thereby check turntable speed. The strobe wheel is adjustable for 50 Hz and 60 Hz mains frequencies and, unlike the motor drive, has to be set for the operational frequency by resetting the position of the strobe light and mirror system.

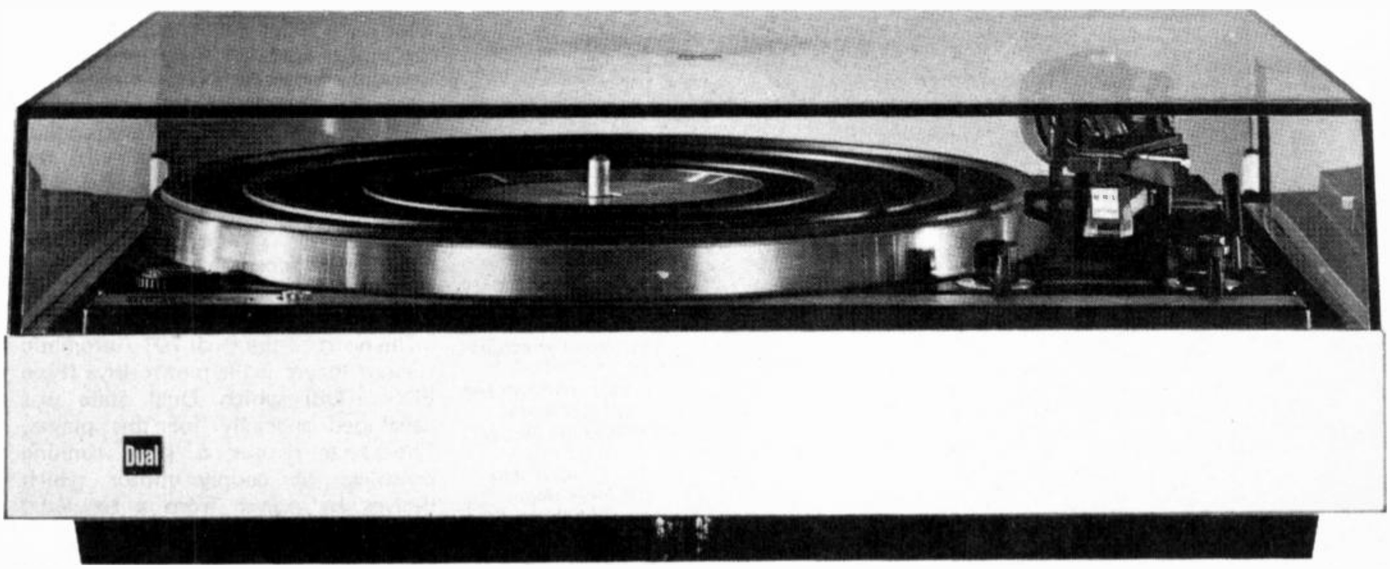
In an ordinary synchronous motor if the frequency of the mains varies, so too does the speed of the turntable. Such variations in frequency are common in an interconnected electrical system, but using a conventional synchronous motor and an integral strobe, such variations would not be readily detected. With the Dual 701, it is possible to detect variations on the strobe wheel even though the motor itself is quite constant in its speed. Under conditions of fluctuating mains frequency a situation could occur where the user could be attempting to adjust the motor speed to compensate for the fluctuations of the external mains. This may however be just a theoretical objection — certainly we experienced no difficulty during our tests.

On the right-hand side of the turntable are two control levers, the left-hand one actuating the start/stop mechanism, whilst the right-hand one selects the turntable speed of 33 or 45 rpm. On the spindles of each of these controls levers are located two vernier knobs which provide fine control for the 45 and 33 1/3 rpm feedback control loops. When used in conjunction with the inbuilt strobe, speed settings can be achieved with an accuracy as high as one part in 10^4.

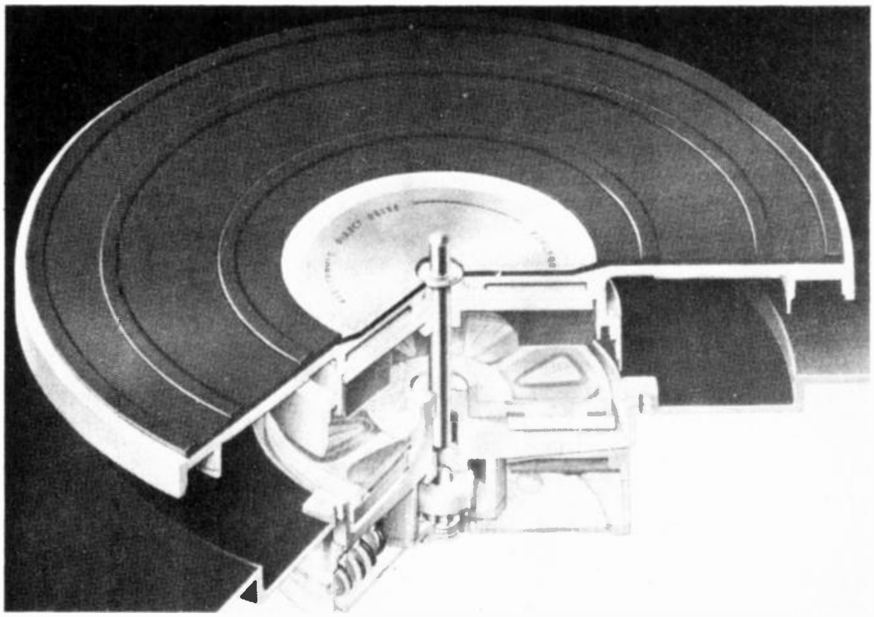
The only other control provided at the front of the turntable is the cueing lever which is hydraulically actuated and extremely smooth in its operation. The cueing lever is not instantaneous in its operation, it has a small time lag which, whilst at first disconcerting, we were soon able to adjust to.

MEASURED PERFORMANCE
DUAL 701 TURNTABLE FITTED WITH SHURE V15-111 CARTRIDGE
SERIAL NO: 061469

Frequency Response:	20 Hz to 20 kHz ±1 dB
Channel Separation at 1 kHz:	29 dB
Trackability at 1 kHz:	300 mm/second peak
Channel Difference:	0.2 dB
Sensitivity re 1 kHz at 50mm/sec:	1.75 mV
Speed Accuracy:	$>3 \times 10^4$
Speed Stability for 10% change in Mains Voltage:	±0.05%
Range of Speed Adjustment:	± 5%
Hum and Rumble:	−70 dB (A)
Wow and Flutter:	0.03% rms
Tone-Arm Resonance:	6.5 Hz
Dimensions:	420 x 147 x 365 mm.



DUAL 701 Direct Drive Turntable



The low-speed brushless dc motor used by Dual in the 701 turntable.

TONE ARM

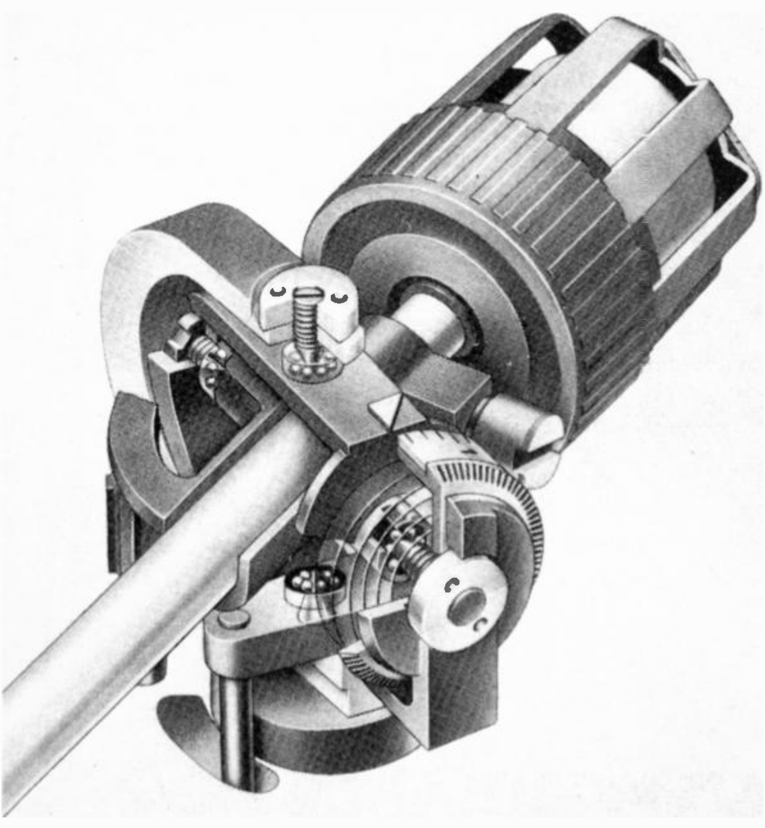
The tone-arm is conventional in appearance, made of tubular bright aluminium with a removable head shell fabricated from black plastic. The designers have protected the tone-arm against dropping onto the base of the record player by extending the tone-arm rest as a cantilevered arm finishing adjacent to the edge of the platter.

At the other end of the tone-arm, Dual have designed a very impressive looking pivoting structure. This incorporates jewelled bearings, a wheel for adjusting the tracking weight, and an unusual balance weight. On the right-hand side of the turntable, adjacent to the tone-arm support, is the anti-skating compensation control which has three separate scales for setting adjustments — for conical 15 micron styli, bi-radial eliptical styli, and Shibata styli for CD4 records. The handbook provides the correct settings for styli with tip diameters in the range 11-19 microns if one is of a mind to use non-standard styli. However, as most people will purchase this record player with the cartridge supplied, much of this information is only of academic interest.

Whilst relatively similar in appearance to previous Dual units, the tone-arm balancing mass utilises a number of novel design features. All manufacturers aim for a maximum rigidity with the minimisation of tone-arm mass, but this is not easy to achieve. When combined with this requirement is the need for minimising bearing friction, the designer has a particularly difficult task. Dual believed that by specially designing the tone-arm counter balance weight, they could increase the trackability within the range of tone-arm resonance and chassis resonance. For this reason, they designed the inner section of the counter balance to be tuned to the tone-arm resonance, to have an anti-resonance effect, whilst the outer part of the counter balance is designed as an anti-resonator at higher frequencies to prevent the transmission of chassis resonances to the tone-arm.

The claims that Dual make for this reduction in tone-arm resonance seem a little excessive. They claim what would appear to be a breakthrough in the control tone-arm resonance. As will be shown below, there *is* a significant reduction in resonance, but the results are not as conclusive as the literature suggests.

The concept of providing resonant or anti-resonant responses in resonant systems is not new and, whilst the claims made here are not supported by our measurements, the system resonance characteristics are nevertheless acceptable.



The tonearm is mounted in a four-point gyroscopic gimbal and pivots in both planes on hardened, precision-polished steel points. The tonearm pivots vertically around the axis of the inner ring. The tonearm and the inner ring pivot horizontally within the outer U-shaped ring.

THE DRIVE MOTOR

The heart of the Dual 701 Automatic Record Player is the motor drive (type EDS 1000) which Dual state was developed specially for this player. The system uses a slow running brushless dc supply motor which derives its power from a regulated supply. In lieu of the mechanical switch commutator common in cheaper dc motors, the EDS 1000 motor utilises two Hall generators for electronic switching. These generators regulate four switching transistors in sequence, to control the four windings of the motor. This cyclical switching of the field windings produces the rotational field to produce the rotational motion of the motor. The rotary field coils in their turn produce a voltage which is measured and compared against a reference voltage. The differential voltage is fed back to regulate the flow of current for the four switching transistors. Dual claim that this system of control reduces speed errors to less than 0.025%.

The motor field coils are non-ferrous and are mounted in the air gaps between the eight-pole ring magnet of the motor. As there are no grooves in the motor and because of the minimisation of hysteresis and eddy currents, there is a minimisation of the disturbing groove frequencies which are a function of cheaper motors. Dual claim that this gives a completely vibration-free and particularly steady drive force for the turntable, and these claims as we will show below are fully substantiated.

We subjected the record player to an extremely thorough check of performance characteristics very thoroughly and in all areas, bar two, the manufacturers' specifications were achieved with typical German precision.

The only faults we could pick with the unit were, firstly, that the tone-arm resonance characteristics did not display the sort of characteristic that the handbook shows. The response was steeper and sharper than indicated by Dual which indicated that the claimed performance of the anti-resonant balance weight was not achieved.

Secondly, trackability was not quite as good as we had expected, at least the Shure V15 MK3 cartridge, supplied with the unit, would not track (at 350 mm/sec peak velocity) as well as we have come to expect from other V15 M3's. Results using our own reference V15 M3 were virtually identical. As we already know the performance of our reference cartridge, we believe that the slight degradation in performance was caused by the tone-arm rather than the cartridge. This, of course, highlights the problem that all purists face when trying to optimise the trackability of their cartridge.

It is important to achieve an acceptable compromise between the anti-friction characteristics of the bearings and their internal damping if maximum trackability is to be extracted from the system. It is apparent to us that the Dual 701

Why Direct Drive?

– the Editor comments

The ideal turntable rotates at absolutely constant speed and is not subject to variations with applied loads or time.

It should not generate any noise of its own (such as rumble) nor should it generate any extraneous electromagnetic field that could be picked up by the phono-cartridge.

In practice turntables fall somewhat short of this theoretical ideal. Most turntables are driven either by a rubber wheel pressing against the inner periphery of the turntable platter – or via a pulley and rubber belt system. Both systems can be made to work very well indeed, but are each prone to individual limitations that, ultimately degrade performance.

Rim drive systems are limited by the difficulty in maintaining totally even drive wheel/turntable contact. An even slightly out-of-balance motor, for example, will cause cyclic variation in contact pressure, and hence cyclic variations in platter speed.

The rubber idler wheel tends to wear unevenly and in some cases to vary in resilience from one part to another – thus introducing further speed variations.

Belt drive machines are possibly less prone to long-term degradation, but unless the belt is very carefully made, variations in elasticity will appear – causing quite horrendous wow and flutter. (From time to time readers complain to us about the cost of replacement belts – and several have suggested that engineering '0' rings make a satisfactory replacement. Don't be so tempted – '0' rings are certainly a fraction of the cost of the correct belts – but generate enormous amounts of wow.)

Rumble is a fault common to both types of drive mechanisms – for rumble is generated partly by the centre bearing holding the revolving platter – and partly by the drive motor – especially if the latter is not adequately isolated from the platter assembly. And that is particularly difficult to do if the drive is to be transmitted to the platter via a rim drive wheel.

But despite their theoretical failings, in practice both belt and rim drive systems, at least when new, perform very well indeed. We have, for instance, recorded wow and flutter as low as 0.07% on the very low-priced Connoisseur BD1. Nevertheless both rim drive and belt drive turntables are a bit like the hi-fi cassette recorder in that they are essentially triumphs of development over design.

Hence the direct drive turntable. In these devices the turntable is coupled directly to the shaft of a necessarily slow-running motor.

Direct drive turntables are *inherently* complex for elaborate speed sensing and correction circuitry must be provided. The Dual 701 machine, for example, uses two Hall generators which regulate four switching transistors which in turn control four motor windings. (A cyclic switching action causes a rotational electric field.) The rotary field coils produce a voltage which is measured and compared against a voltage standard. Any resultant different voltage is then used to regulate the flow of current in the four switching transistors.

Other machines use dc motors within a tacho-generator feedback loop; there are also various oscillator controlled synchronous motor designs.

The performance of most direct drive machines is truly excellent, wow and flutter is generally very low indeed and rumble is virtually imperceptible.

Nevertheless, direct drive turntables are currently very expensive animals indeed and, unless the remainder of your hi-fi system is of really top quality, a conventional turntable will provide adequate performance – that is, it will not be the weak link in the hi-fi chain.

DUAL 701 Direct Drive Turntable

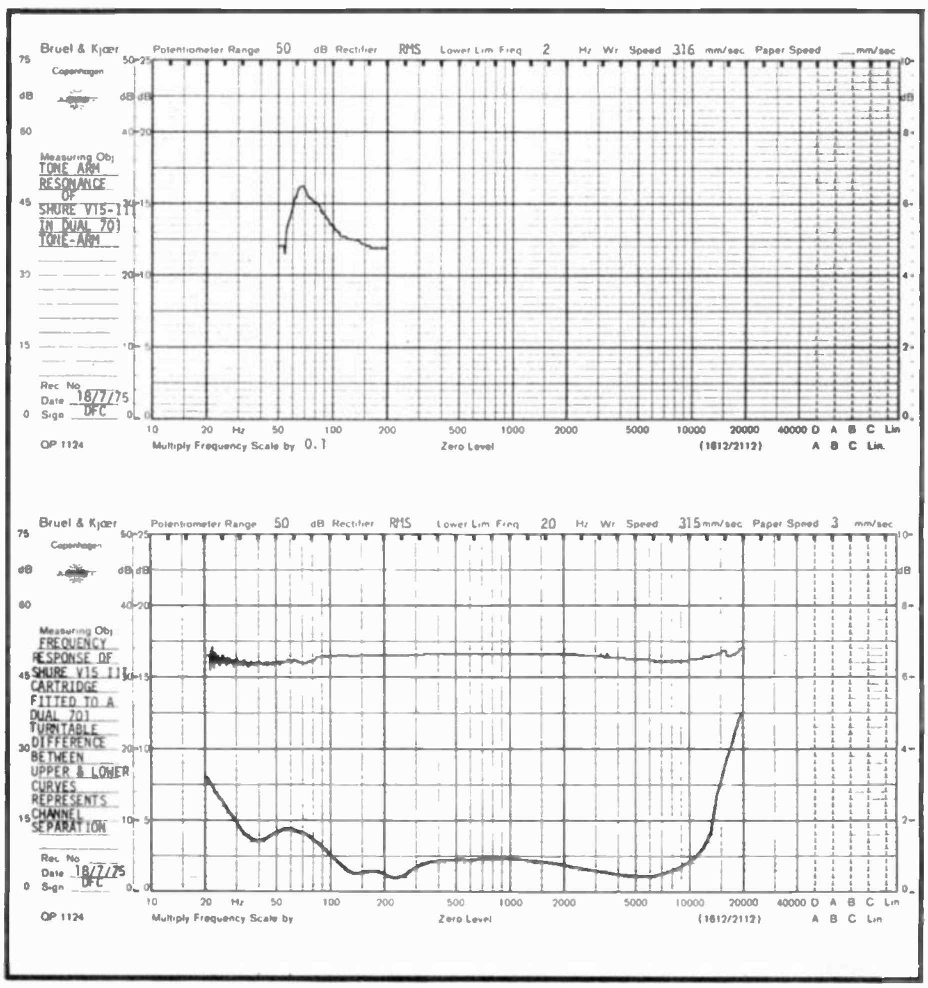
tone-arm, whilst well-designed, is still not perfect in this respect and the result is a slight impairment in cartridge tracking performance at the highest tracking levels experienced in modern records.

The unit comes with a 36-page full colour instruction book in German, English, French and Dutch. The instruction book is, without a doubt, one of the most beautiful and comprehensively produced that we have yet seen. Not only does the handbook give an excellent rundown on the operation and unpacking, electrical connections and normal operation, but it also goes to great lengths to explain how to adjust the record player to optimise its performance.

The performance achieved in the area of speed stability and minimisation of wow and flutter is by all accounts exceptional, for here we found the lowest level of wow and flutter that we have ever measured on any record player, either professional or consumer products orientated. The figures we achieved were so low that at first we disbelieved them ourselves, but very careful checking showed that the manufacturer's claims were fully substantiated and that the level of speed stability and higher order components introduced by the EDS 100 motor drive were absolutely minimal.

We are at a loss to know why the resonant characteristics of the tone arm fall so far short of what should be expected. There may be some factor of which we are not aware but nevertheless the performance characteristics indicated in the handbook could not be obtained on the unit tested.

In summary, the Dual 701 is an unusual unit – the drive mechanism is quite superb – to the point that it is a real technical breakthrough – if the tone arm can be improved to the same relative extent this will be a truly great unit. ●



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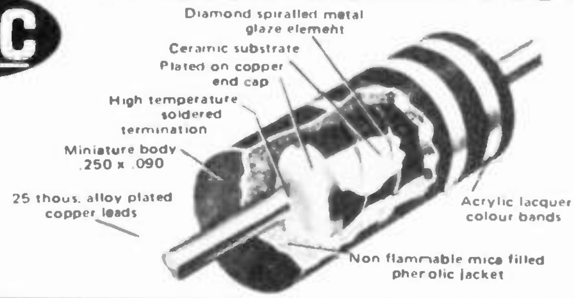

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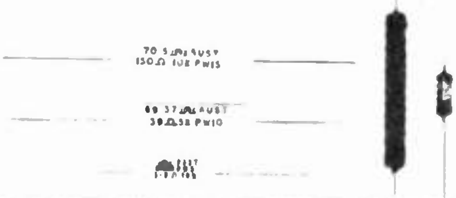

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PROJECTS 433A,433B

ACTIVE CROSSOVER

Optimize your multi-way system with this electronic approach to crossover design.

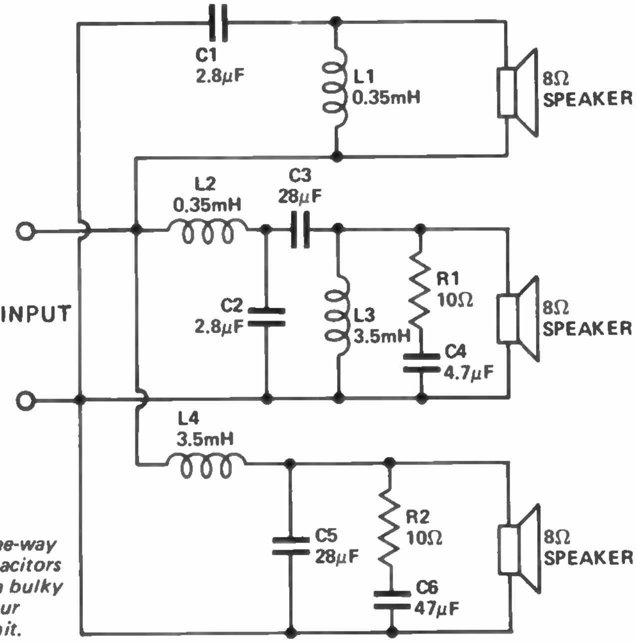


Fig. 1. A conventional three-way crossover system using capacitors and air-cored inductors is a bulky and very expensive unit. Our drawing shows a typical unit.

NO SINGLE loudspeaker can adequately handle the whole range of audio frequencies in high-fidelity reproduction. Thus to obtain the best possible fidelity we must resort to multiple speaker systems where each driver is designed to cover one portion only of the audio spectrum.

This means that some method must be used to divide the audio spectrum, from the amplifier, so that an individual driver only receives the band of frequencies for which it was designed. This is especially important for midrange and tweeter drivers for they are seldom capable of handling frequencies lower than a specified limit without being damaged.

PASSIVE CROSSOVERS

In simple systems a single capacitor may be used to block low frequencies and pass only highs to a tweeter. But unfortunately such a capacitor only provides 6 dB per octave attenuation. With some tweeters this attenuation is not sufficient to suppress the resonant frequency of the tweeter. The driver could thus be damaged when operated at high power levels. Additionally, the presence of frequencies other than those in the desired pass – band leads to high levels of intermodulation distortion and a general 'muddiness' of reproduction.

Hence all good multi-way systems use networks which provide at least 12 dB per octave attenuation, in the stop band, to control the audio band presented to each drive unit. A typical network for a three-way system is given in Fig.1. To keep power losses down in such networks the coils must have dc resistances of less than one ohm. This means that heavy gauge wire must be used, making the coils large and expensive. Additionally the high value of capacitance required would normally call for the use of non-polarized electrolytics, however, there are several disadvantages with these, Firstly, the tolerance on non-polarized electros is plus or minus 50%! This means that a crossover using them could quite easily give a system which had peaks and/or deep holes in the response. Additionally such capacitors have disadvantages such as limited life, fairly low working voltages and problems due to leakage. Thus all good crossovers use polyester capacitors which, again, are rather expensive.

This all leads to the fact that, for a multi-way high-fidelity system, the crossover can and should be quite expensive. In fact it can cost almost as much as the bass driver!

Many people try to save money by trimming crossover cost – they use lighter wire and electros – and then wonder why an otherwise expensive system does not sound right. *The crossover design is one of the most important features of the whole system – it is better to compromise on a less expensive woofer than to compromise on the crossover.*

(Main text continued page 42)

SPECIFICATION

Cutoff Slope	(High pass)	12 dB / octave
	(Low pass)	6 dB / octave
Maximum Output		2 V rms.
Distortion (at 2 V out)		<0.05%
Noise (Below 2 V)		86 dB
Cutoff Frequency		As required
Input Impedance		47 k
Output Impedance (Buffered)		< 10 ohm
Minimum Load (Buffered)		500 Ohm
Frequency Response (Sum of all ouputs) 20 Hz to 20 kHz		± 1 dB

ACTIVE CROSSOVER

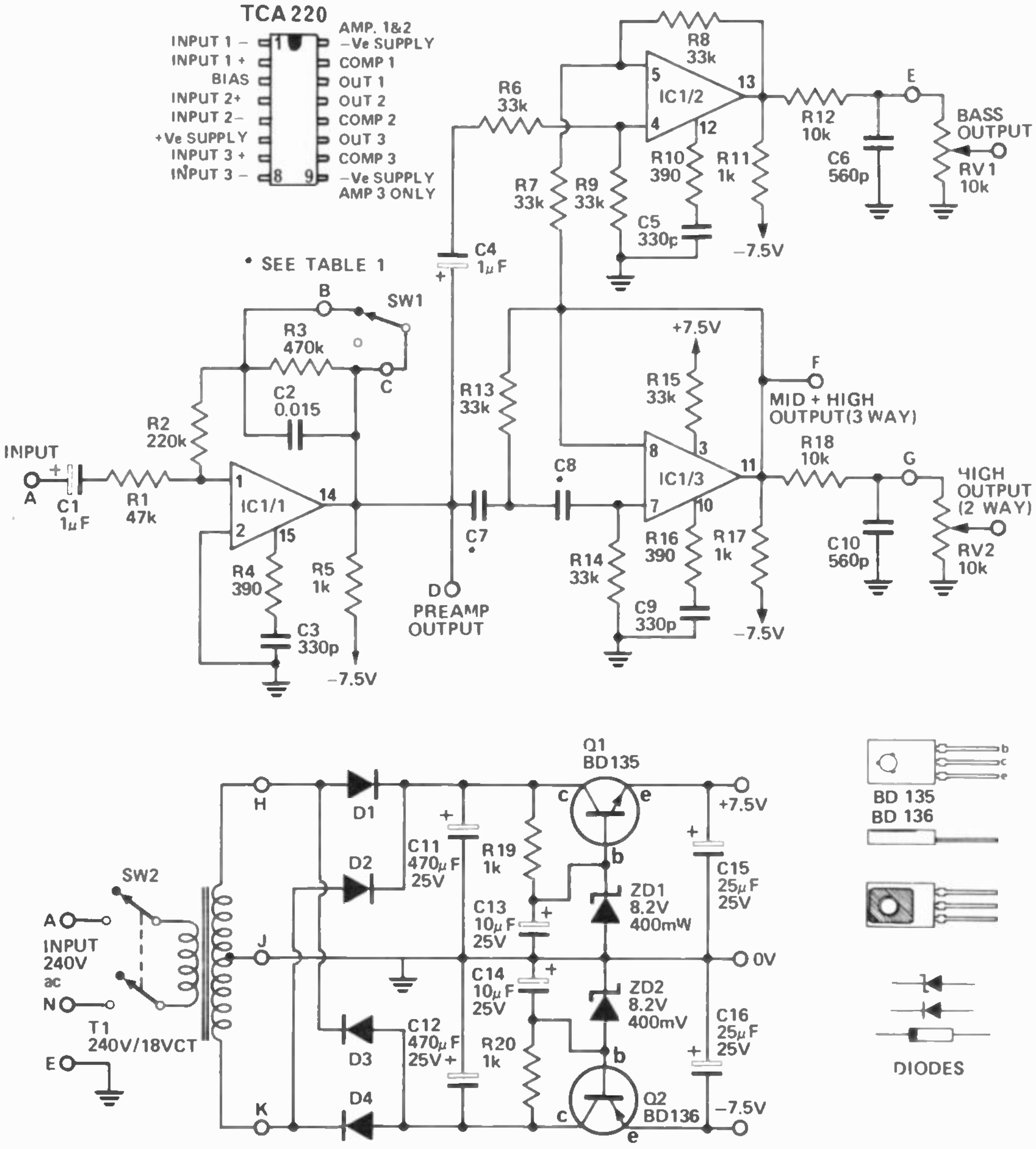


Fig. 2. Circuit diagram of the basic two-way electronic crossover and its power supply.

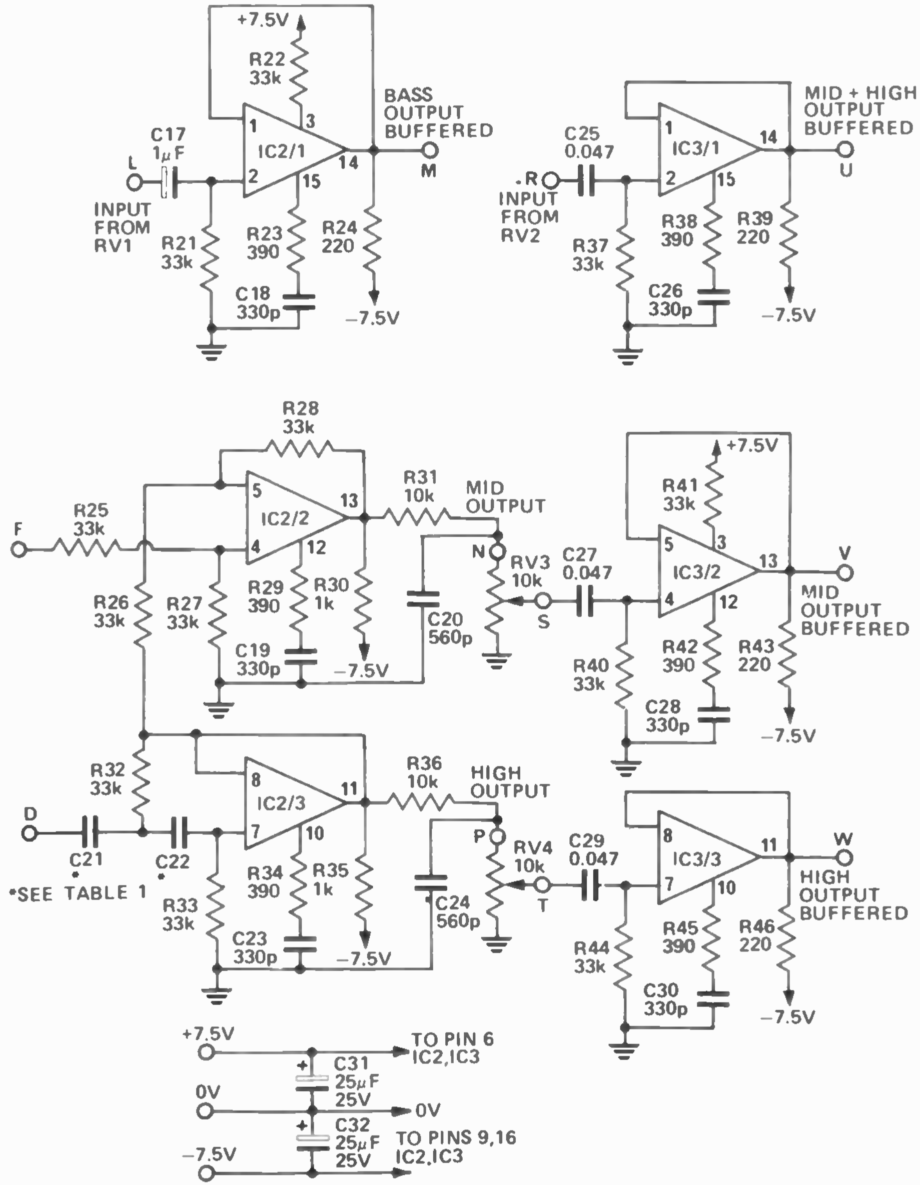


Fig. 3. Circuit diagram of the mid/high crossover board which provides four output buffer amplifiers.

HOW IT WORKS – ETI 433

The input signal is initially amplified by IC1/1. Switch SW1 together with R3 and C2 provide a maximum of 10 dB of boost below 50 Hz at a rate of 6 dB per octave. The frequency at which the boost comes in may be altered by selecting a value of C2 such that its reactance is 220k at the frequency where the woofer is normally 3 dB down. Thus if the turnover frequency is required to be 100 Hz the value of C2 should be halved.

If the boost facility is not required R3, C2 and SW1 should be deleted and a link installed between points B and C. The mid frequency gain is set by R2/R1 to about 13 dB and the input impedance is equal to the value of R1, that is, 47 k.

The first high-pass filter consists of IC1/3 where R13, R14, C7 and C8 set the cut-off frequency. The values of C7 and C8 required may be found from Table 1. This output is the high range in a two way system, or the mid plus high of a three-way system. This signal, when subtracted from the input signal by IC1/2 gives the bass range output. A second high-pass filter, where C21, C22, R32 and R33 form the frequency determining network, gives the output for the tweeter in a three-way system. This when subtracted from the mid-plus-high signal leaves the mid only as required.

Each of these outputs goes to a level set potentiometer and then is buffered by amplifiers IC2/1 and IC3/1,2,3. These outputs are now capable of driving loads in excess of 500 ohms. If the crossover is to be used to drive a constant and known load (that is, it is to be used on only one type of amplifier) the buffer amplifiers may be omitted and the outputs taken directly from the potentiometers.

The full-wave power supply provides plus or minus 13 volts which is regulated down to plus or minus 7.5 volts, by series regulators Q1 and Q2, where zeners ZD1 and ZD2 provide the necessary reference. If the unit is to be powered from the power amplifier C11, 12, and D1 to D4 should be deleted. Resistors R19 and R20 are altered to suit as shown in Table 2. The collector of Q1 now goes to the positive supply rail of the amplifier and the collector of Q2 to the negative supply rail. If the amplifier supply rail is above plus and minus 20 volts, or if both printed circuit board are being used, (that is it is a buffered three way system) a heatsink must be added to Q1 and Q2.

PARTS LIST – ETI 433A

2-WAY SYSTEM

R4,10,16	Resistor	390	¼W	5%
R5,11,17	"	1k	¼W	5%
R19,20	"	1k	¼W	5%
R12,18	"	10k	¼W	5%
R6,7,8,9	"	33k*	¼W	2%
R13,14,15	"	33k	¼W	5%
R1	"	47k	¼W	5%
R2	"	220k	¼W	5%
R3	"	470k	¼W	5%

*These may be any value between 15k and 82k provided they are all the same value and preferably 2%.

RV1,2 Potentiometer 10k lin.

C3,5,9	Capacitor	330 pF ceramic
C6,10	"	560 pF ceramic
C2	"	0.015 μF polyester
C1,4	"	1 μF Tag tantalum
C13,14	"	10 μF 25V Electro
C15,16	"	25 μF 25V Electro
C11,12	Capacitor	470 μF 25V Electro
C7,8	"	See Table 1.

D1-D4 Diode EM401, IN4005 or similar
ZD1,2 Zener Diode 8.2 volt 400 mW

Q1 Transistor BC135 or similar
Q2 Transistor BC136 or similar

IC1 Integrated Circuit TCA220

T1 Transformer 240V/18V CT 150 mA
SW1 toggle or slide switch SPDT
SW2 Toggle switch DPDT 240V rated
PC Board ETI 433A

PARTS LIST – ETI 433B

3-WAY WITHOUT BUFFERS
All 2-way system PLUS

R29,34	Resistor	390	¼W	5%
R30,35	"	1k	¼W	5%
R31,36	"	10k	¼W	5%
R25,26,27,28	Resistor	33k*	¼W	2%
R22,32,33	"	33k	¼W	5%

* These may be any value between 15k and 82 k provided all are the same value and preferably of 2% tolerance

RV3,4 Potentiometer 10k Lin

C19,23	Capacitor	330 pF ceramic
C20,24	"	560 pF ceramic

C21,22 See Table 1.

IC2 Integrated Circuit TCA220

PC board ETI 433B

3-WAY SYSTEM WITH BUFFERS ADD

R24,39,43,46	Resistor	220	¼W	5%
R23.38,42,45	"	390	¼W	5%
R21,37	"	33k	¼W	5%
R40,41,44	"	33k	¼W	5%

C18,26,28,30	Capacitor	330 pF ceramic
C25,27,29	"	0.047 μF polyester
C17	"	1 μF TAG Tantalum
C31,32	"	25 μF 25V electro

IC3 Integrated Circuit TCA220

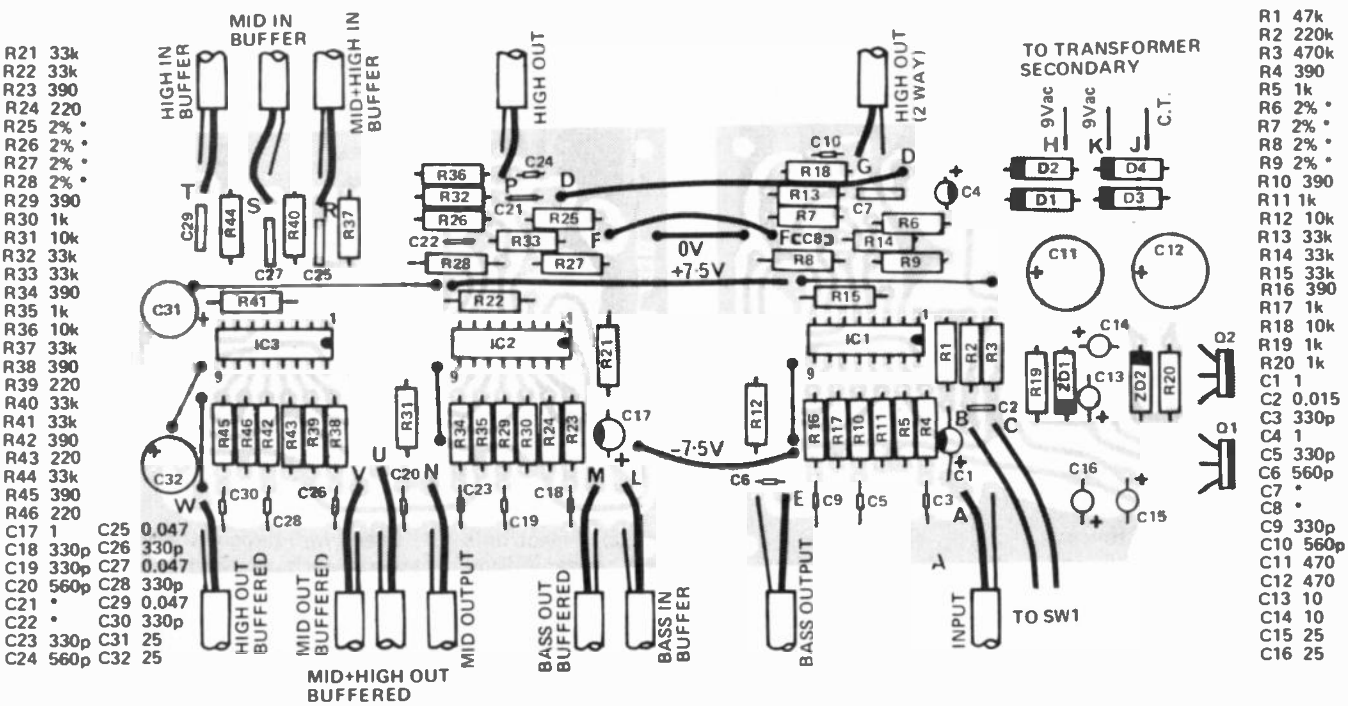
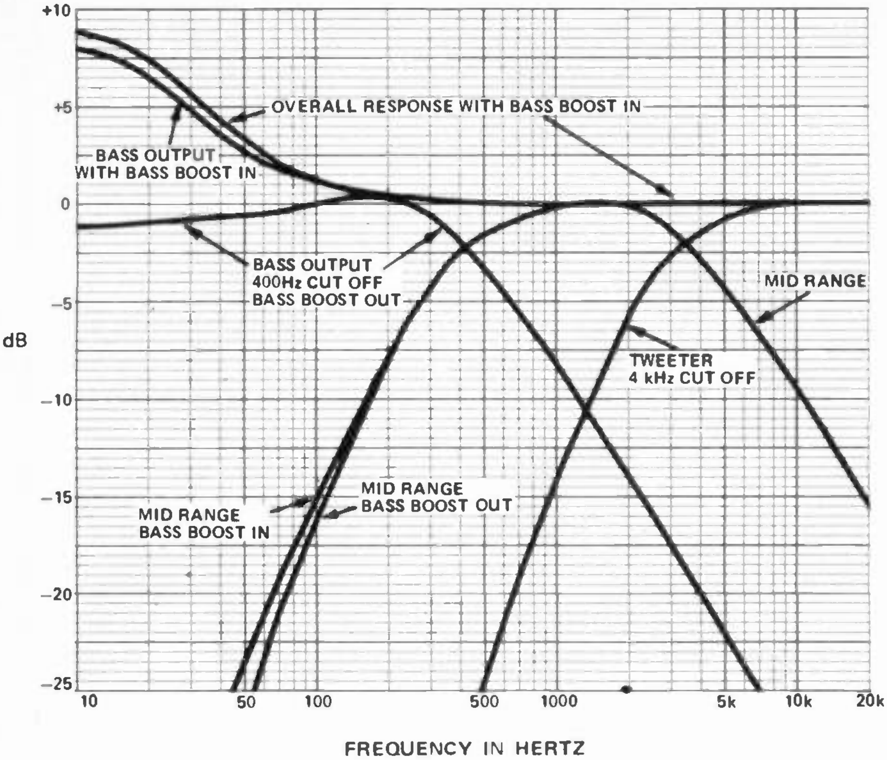


Fig.4. Component overlay for complete three-way system capacitance values are in microfarads except where otherwise noted.



Response curves of the active filters.

TABLE 1	
CROSS OVER FREQUENCY IN HERTZ	VALUE OF C7,8 or C21, 22 in μF
100	0.082
130	0.068
150	0.056
200	0.047
230	0.039
270	0.033
330	0.027
400	0.022
500	0.018
600	0.015
750	0.012
900	0.0082
1300	0.0068
1500	0.0056
2000	0.0047
2300	0.0039
2700	0.0033
3300	0.0027
4000	0.0022
5000	0.0018
6000	0.0015
7500	0.0012
9000	0.001

ACTIVE CROSSOVER

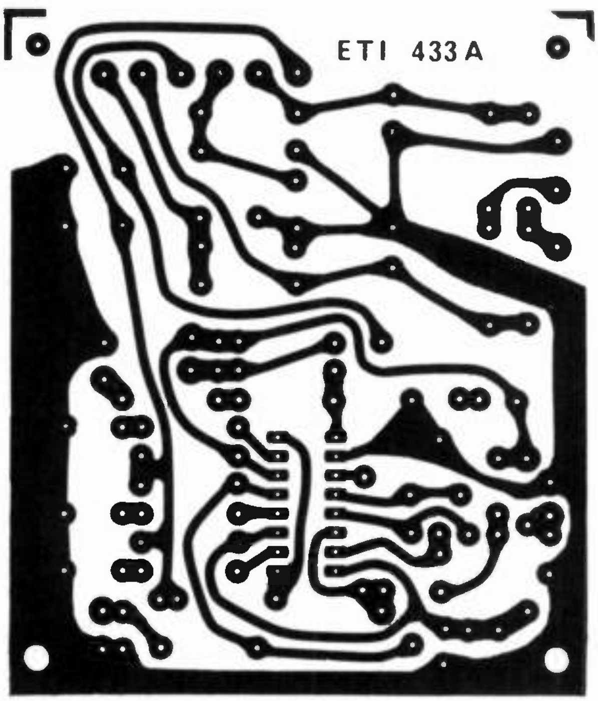


Fig. 5. Printed-circuit layout for the two-way board. Full size 77 x 90 mm.

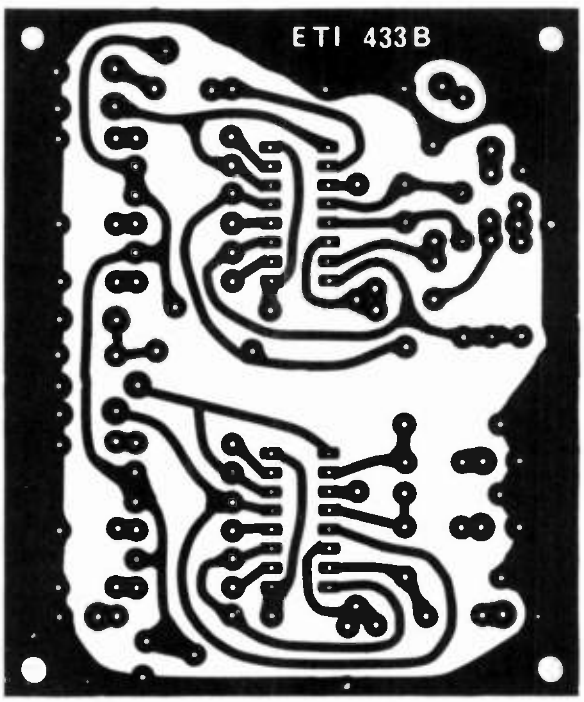
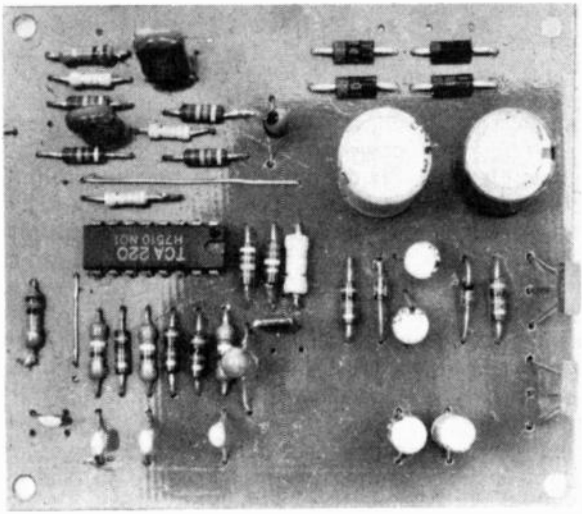


Fig. 6. Printed-circuit layout for the add-on three-way board. Full size 77 x 90 mm.

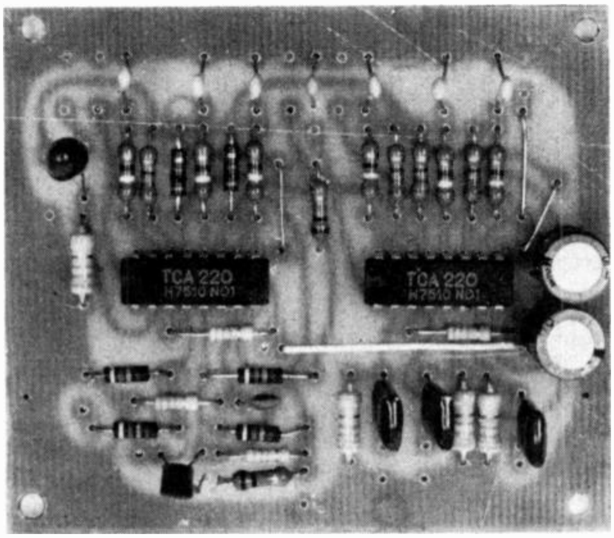
ACTIVE APPROACH

Having now established that effective conventional crossovers cost money, we may now wonder if that money could be spent in a better way by using a completely different approach. There is a better way, but until recently it has been much too expensive to be generally used. The method is to use an electronic crossover, after the preamplifier, followed by separate power amplifiers for each driver. This is feasible because a power amplifier can now be built at a cost which is about the same as that of the passive crossover. Indeed quite a few manufacturers are bringing out systems based on this principle.

Even well-designed crossovers have several serious disadvantages. As we have already said they are expensive, they waste power, they reduce damping factor (in the crossover region damping factor may drop to less than unity) and they only perform correctly into their designed load impedance. Practical drivers exhibit



The basic two-way electronic crossover.



This board provides three-way crossover plus output buffers if required.

their nominal impedance only over a very small portion of their passband, and impedance may well increase to several times the nominal value at the high end of the range. It is possible to compensate for this, to some extent, by using extra networks across the driver (the series RC networks in Fig. 1) — but this adds even more expense. Further, it is very difficult to alter the crossover frequency and also difficult to trim the crossover for best results.

However, if we were to use an electronic crossover incorporating active filters, we overcome most of the problems mentioned in a single stroke. The bulky and expensive inductors and the large and expensive capacitors are eliminated. Damping factor is restored (due to seperate amplifiers being used to drive each speaker directly) and it is quite easy to change or trim the crossover frequency as desired.

Further, as electronic crossovers may have gain, it is quite a simple matter to match the various drivers of the system for sensitivity. This can be only achieved, in passive designs, by attenuating the more sensitive units down to the level of the least sensitive unit. A process which can be quite wasteful of amplifier power.

Of course with active crossovers, as with anything, there are disadvantages. In active filters we generally use operational amplifiers to implement the filters and therefore, bandwidth and noise become considerations. Further, as said before, a separate amplifier is required for each driver or group of drivers — and this can be expensive.

Nevertheless the technique is now quite feasible and is certainly worthwhile. Consequently we have developed a minimum — expense method of building a very fine system based on active filter techniques. This month we describe a basic two or three way active filter system which may be incorporated into existing amplifiers. To follow next month will be an active filter/amplifier combination based on the 422 amplifier and later still we will be describing how a complete system, including a three-way speaker system, may be built.

For those interested in the design of active filters a full article on this subject will also be published in the near future.

DESIGN FEATURES

There are several different approaches which may be used in the design of active filters. The first and most commonly used method, is to use separate filters for the bass, mid and high range speakers. This method is capable of compensating for amplitude, if the components are chosen correctly, but not for phase. In fact there has to be a phase change of 180° between filters to eliminate the hole that would otherwise occur at the crossover point. This is the reason for the tweeter being reversed in phase when a conventional crossover is used in a two-way system.

Another design approach, and the one that we have elected to use, is to use an active high-pass filter to generate the signal for the tweeter, and to subtract this signal from the input signal in a differential amplifier in order to generate the bass output. This substraction process generates the required crossover characteristic with both amplitude and phase taken in to account.

Initially we were worried because the bass output had a slight peak before the cutoff point but the peak is necessary to maintain that response when phase is taken into account. When the output of all channels are summed the combined response is within plus or minus one quarter of a dB of being flat over the whole range.

With this type of active filter the initial slope can be varied by adjusting the feedback resistor (R13, R32) to give a slow rolloff (Bessel filter) or to give a slight peak and fast cutoff (Chebishev). The sharper the initial cutoff the greater the apparent peak in the bass response.

As several operational amplifiers are required to implement this design we elected to use the TCA 220 triple operational amplifier. This IC, as well as containing three op-amps in the same package, is cheaper than using three separate op-amps of the 741 type or similar. Unlike the 741 type of op-amp, the TCA 220 requires a pull-down resistor on each output and a compensation network. An additional resistor is required to bias each complete IC. The use of the TCA 220 simplifies and cheapens the construction of the filter system considerably.

With active filter crossovers it is a relatively simple matter to alter the gain-versus-frequency characteristic of the filter, within its pass-band, in order to compensate for non-linearities in the associated driver. An example of this kind of compensation is our inclusion of low frequency equalisation for the woofer. Most woofers begin to drop off in the 50 to 100 hertz region. This may be corrected to some extent by adding boost below this turnover frequency. In our design we have provided 6 dB of boost which may be switched in when desired and which is limited to a maximum of 10 dB. The 10 dB limit is necessary to prevent the amplifier being over driven at low frequencies even at fairly low average listening levels.

The turnover frequency may be

selected by means of a simple component change to suit the driver in use. This equalisation technique can effectively extend the low frequency response by another octave, eg, from 50 hertz down to 25 hertz.

CONSTRUCTION

The configuration of the electronic crossover used will depend very much on the system into which it is to be built. The prospective builder should therefore carefully determine his individual requirements before commencing to build a system.

If a fixed load is to be driven (ie, numbers of amplifiers) as would be the normal case, the buffer amplifiers are not required, and the output may be taken directly from the potentiometers.

It must also be decided whether you want a two-way or a three-way system. Rather than use three separate amplifiers to drive the woofer, mid and tweeter drivers separately, it may be better to use a conventional crossover for the mid/high crossover and a two-way electronic crossover for the bass/mid.

Mono or stereo? If a stereo unit is to be built only one power supply is required and the bass-boost switch and the level potentiometers can all be dual units.

If the amplifier has a dual power supply with voltages exceeding ± 10 volts it may be used to power the crossover. This course of action will save one transformer, four power diodes and the filter capacitors.

Mechanical layout is not given as the unit will most probably best be mounted within the amplifier case. Keep it well clear of the power transformer and mount it using insulated spacers. This is necessary to avoid the possibility of earth loops which will cause a high hum level.

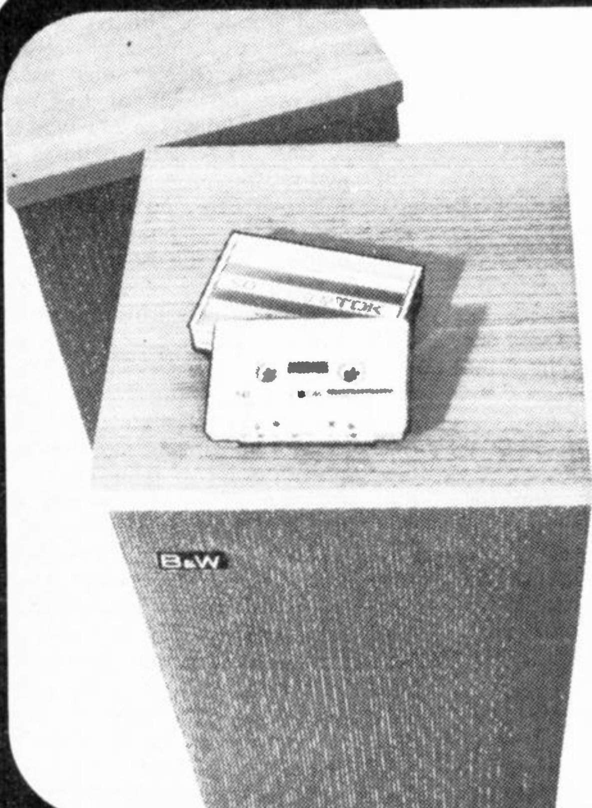
Full component overlays are given for all alternatives but only the circuitry required should be assembled. In a three-way system without buffers one section of IC2 is not used. In this case just leave out the components associated with the unused section in order to reduce power consumption.

If the unit is being powered from the main amplifier, or a three-way system with buffers is being used, a heatsink is required. The heatsink recommended is a piece of aluminium 60 x 85 mm bent into a 'U' shape and mounted vertically on the end of the board. The transistors should be insulated from the heatsink.

For a stereo system delete the power supply components on one of the boards (up to C15 and C16) and just link the two boards together. ●

TABLE 2

MAIN AMPLIFIER SUPPLY VOLTAGE	VALUE OF R19,R20
± 10-15 V	1 k
± 15-20 V	1.8 k
± 20-25 V	2.7 k
± 25-30 V	3.9 k
± 30-40 V	5.6 k
± 40-50 V	8.2 k



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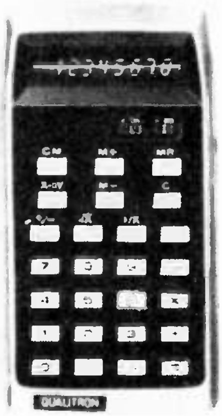

● Algebraic operation.
● Six Functions: Add, subtract, multiply, divide, percentage key and constant key.
● Fully automatic plus or minus percentage functions, add-on and discount operation.
● Eight digits with negative indication.
● Constant and chain operation.
● Floating decimal point, overflow, easy to read display.
● Refer to keyboard for full functional capabilities.

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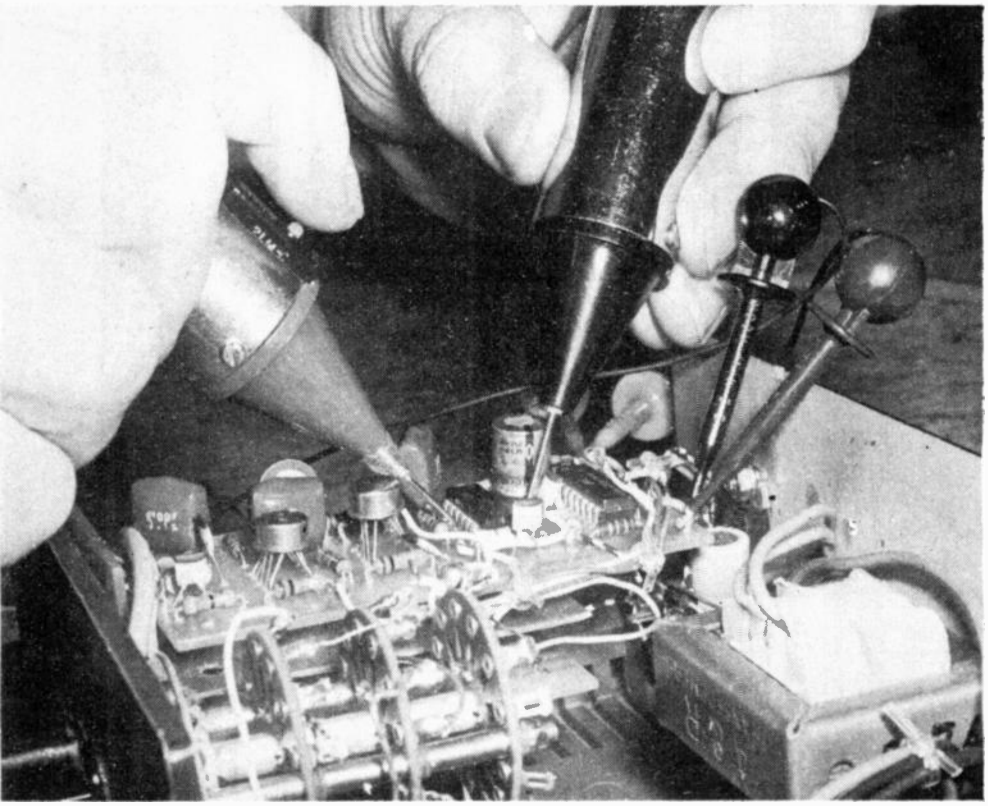


PROJECT 120

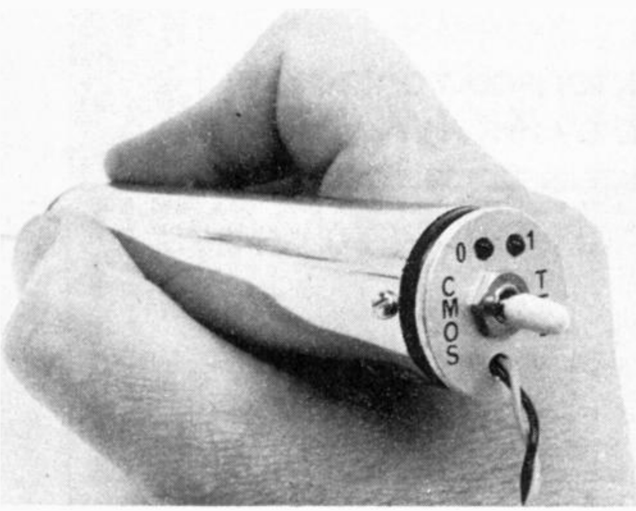
LOGIC PROBE

A basic tool for digital servicing.

THE SERVICING of digital equipment is greatly simplified by the use of a logic pulser and logic probe, for these two instruments enable one to follow circuit operation stage by stage.

THE PROBE

The probe must be capable of detecting pulses as short as 50 nanoseconds (for TTL operation) and make them visible. It was found that readily available linear ICs were not suitable as they are too slow and required dual supply voltages. Neither could CMOS be used as it also is too slow, for testing TTL gates, and its threshold voltages are not consistent. Further, TTL could not be used as it cannot withstand the voltages used with CMOS logic. This virtually means that the only devices that are suitable are discrete transistors.



The logic probe seen from the rear.

HOW IT WORKS

The probe consists of two independent voltage level detectors which, via pulse stretching monostables, drive light-emitting diodes to give a visual indication of the logic state being monitored. Transistors Q1 and Q4 form the low level or '0' detector, transistors Q5 and Q6 the high level or '1' detector whilst the remaining components form the pulse stretching monostables and visual indicators.

The high level detector works as follows. If the input level is below about 2.5 volts (1.3 volts above the level set on R17 by transistor Q5) transistor Q6 will be cut-off. When the input level rises above 2.5 volts, transistor Q6 will turn on, as will Q7, causing LED 2 to light – indicating a '1'. The transition at the collector of Q7 will, at the same time, be passed to Q8 turning it off. The current which was flowing through Q8 will now flow via R22 in to the base of Q7 holding it on even though Q6 may by now have stopped conducting. After fifty milliseconds the charge on C2 will leak away via R19, 20 allowing Q8 to conduct. When Q8 conducts it robs the current from the base of Q7 turning it and the LED off. However should the voltage at the tip of the probe still be present Q6 will still be turned on holding on in turn Q7 and the LED.

Resistors R11, 12, 13 and 14 set the operating conditions of Q5 such that the threshold voltage is optimized for either TTL or CMOS. As CMOS logic works on supply voltages ranging from five to fifteen volts, transistor Q5 has been arranged to track the supply so that the correct threshold is maintained at all times.

The low level detector works in exactly the same fashion except that it is inverted in order to detect pulses which approach within 0.45 volts of the negative line (TTL only). Each PNP transistor and each NPN transistor have been replaced with their complements. In this case Q4 sets the thresholds and the circuit operates exactly as stated for the high detector. Note that the diodes have also been reversed.

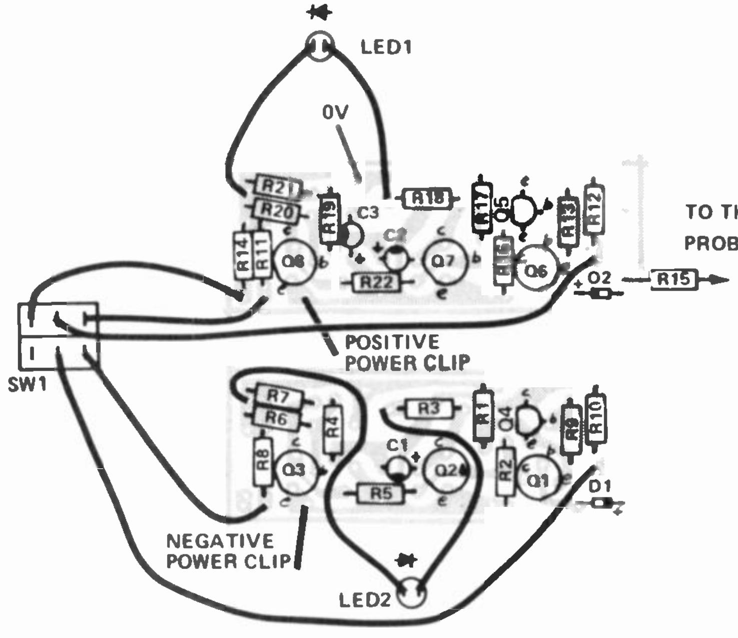


Fig. 3. Component overlays for the two comparators showing interconnection wiring.

PARTS LIST – ETI 120

R3,18	Resistor	680	¼ W	5%
R4,15,19	"	1 k	"	"
R10,13	"	1 k8	"	"
R1,9,12,17	"	2 k7	"	"
R5,14,22	"	3 k3	"	"
R2,16	"	8 k2	"	"
R7,21	"	10 k	"	"
R8,11	"	27 k	"	"
R6,20	"	100 k	"	"
C1,2	Capacitor	0.47 μF	25 V tantalum	
C3	"	10.0 μF	25 V "	
D1,2	Diode	IN914 or similar		
Q1,7,8	Transistor	2N3638, 2N3638A		
Q2,3,6	"	2N3643		
Q4	"	BC179, BC559		
Q5	"	BC109, BC549		
SW1	Switch	Two pole, two position miniature toggle		

PC boards 2 off ETI 120
Probe case (see text)
LED 1, 2 Light emitting diodes 5082 — 4484 or similar
2 Alligator clips or Ezy-hooks

CHARACTERISTICS

PULSER – ETI 121

- Will source, or sink, up to 500 mA.
- Operates on supply voltages from 5 to 15.
- Suitable for both TTL and CMOS.
- Power supply drain less than 15 mA under worst case conditions.
- Press for '1' release for '0'. High impedance at other times (>1 M).
- Will drive capacitive loads up to 1000 pF.
- Protected against accidental reversal of supply leads.
- Duration of pulse 500 nanoseconds.

PROBE – ETI 120

- Pulses as narrow as 50 nanoseconds will be detected.
- Stretches narrow pulses to 50 milliseconds for ease of detection.
- Operates on supply of 5 to 15 volts.
- Suitable for TTL or CMOS.
- True '1' and '0' level detectors. Neither LED is alight if the circuit is faulty or the probe is not making contact.
- Current drawn from the circuit is less than 20 microamps.
- Current drawn from power supply (one LED alight) 12 mA on 5 volts, 35 mA on 15 volts.

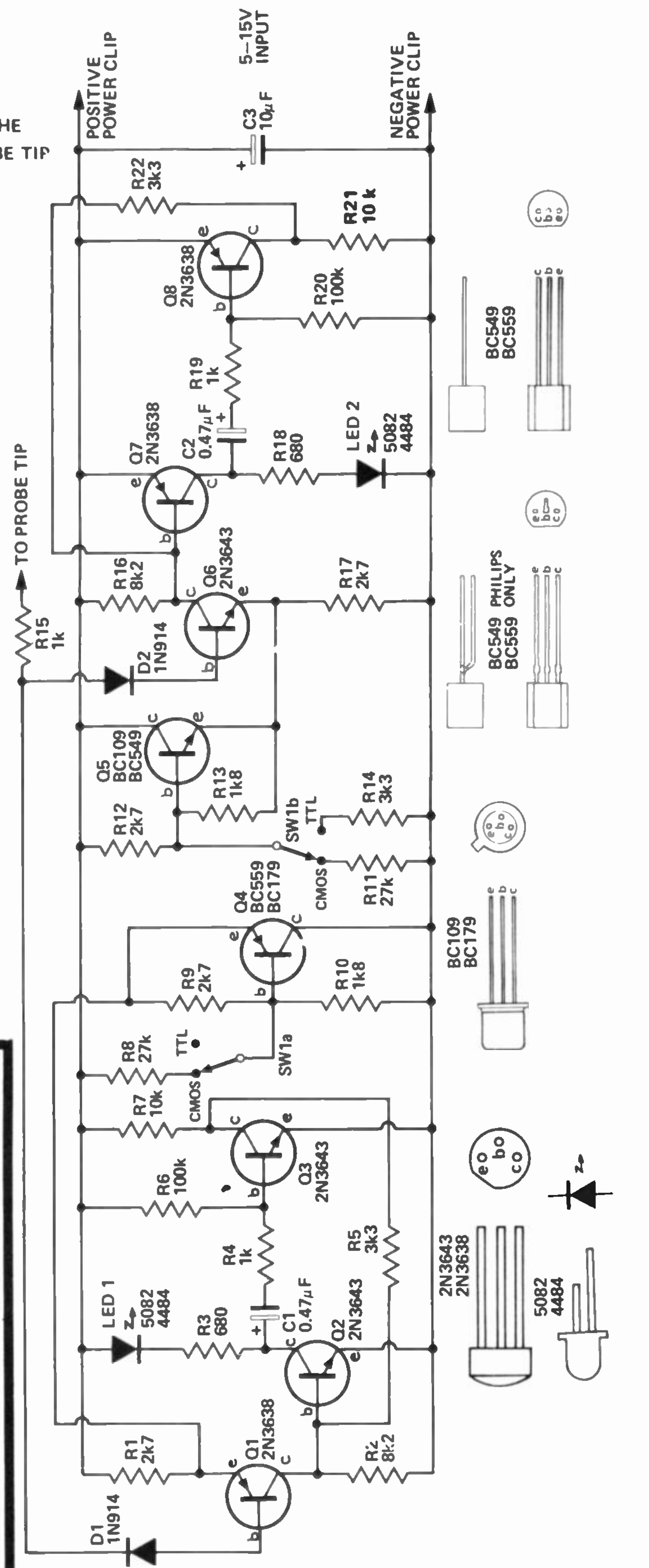


Fig. 1. Circuit diagram of the logic probe

LOGIC PROBE

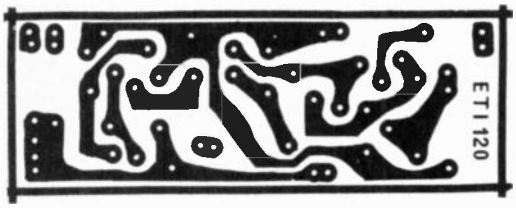


Fig. 2. Printed circuit board for the logic probe (2 required). Full size 23 x 66 mm.

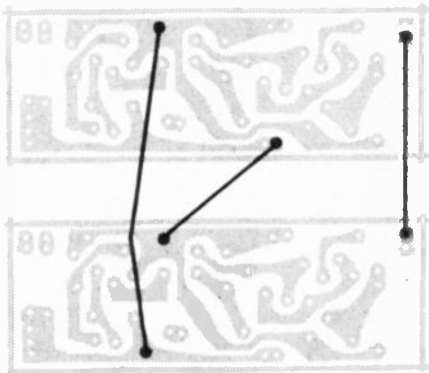


Fig. 4. Linking required between the two boards.

As both high and low logic states must be detected, a discrete transistor voltage-comparator circuit was designed to detect each state separately. These comparators must not load the circuit under test as CMOS is sensitive to current and capacitive loading. In our prototype the current drawn was a maximum of 19.7 microamps for a high, and 10 microamps for a low.

In both comparators the transistors associated with the pulse detector are turned on by an input level that exceeds the comparator threshold.

As transistor turn-on time is much faster than turn-off time, using the transistors in this way ensures the highest possible speed of operation for the particular types of transistors used. Additionally, the delay in turning off assists by lengthening the pulse, thus ensuring more reliable triggering of the monostable on very short pulses.

The input transistors Q1 and Q6 are protected against breakdown, due to excessive base-emitter voltage, by diodes D1 and D2. The diodes are also required to ensure that Q1 and Q6 remain conducting even when the probe tip is taken to the supply voltage.

Transistors Q3 and Q8 are also protected against reverse base-emitter voltages by R4 and R19 respectively.

In operation the probe will light LED 1 if a low level is detected, LED 2 for a high, neither LED if the point being monitored is at ground potential or a poor contact is made with the tip, and both LEDs will light if there is a pulse train present.

A single pulse input will be lengthened, by the monostables, to 50 milliseconds with the pulse polarity being indicated by the LED which is illuminated. Thus even single pulses as short as 50 nanoseconds may readily be detected.

CONSTRUCTION

We built our probe onto two small printed circuit boards and assembled it into a small, commercially-available probe case. The two printed-circuit boards are identical and care should be taken to use the correct overlay for each board as different transistors are used and some components are reversed on the two boards. Note particularly diodes D1 and D2 and capacitors C1 and C2. Also note how the two boards are linked together and that the supply rails are reversed. No difficulty should be experienced if the printed-circuit boards and the component overlay as specified are used.

The probe case used in our prototype was one manufactured by Jabel. The case has a length of 102 mm and an internal diameter of 23 mm. The probe tip, as fitted, is rather large and awkward. We therefore replaced the tip, with a darning needle, as shown in Fig. 6. The fine point of this tip is much easier to use on micro circuitry and, as it is very sharp, it will penetrate varnish etc to make reliable contact. A needle is a little brittle and for this reason it is recommended that a maximum unsupported length of 12 mm be left protruding. Resistor R15 is mounted within the tip and soldered directly to the needle. The other end of the probe is fitted with a plastic stopper which is used to support SW1 and both LEDs. SW1 is also used to hold a small name-plate in position as shown in Fig. 6. Two LEDs are mounted into the end plate, together with SW1, and after soldering leads to the LEDs they should be passed through the holes in the plate, and the plastic end-piece, and secured in position with a drop of epoxy cement. Another hole is drilled in the stopper through which is passed the two supply-voltage leads.

Connect the leads from the stopper assembly to the previously assembled boards. Position the boards together, copper side to copper side, with a piece of insulating material between them. Make sure that the board assembly will fit in to the tube without fouling the sides. Cut a piece of cardboard or plastic 75 x 85 mm, roll it into a tube and fit in the probe body. Now fit the board assembly into the tube – it may be necessary to dress the sides of the boards with a file to obtain a neat fit.

The tip may now be connected and both ends screwed into position. Finally, alligator or, better still, Ezy-hooks clips should be fitted to the supply leads.

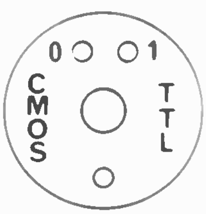


Fig. 5. Artwork for the nameplate on the probe.

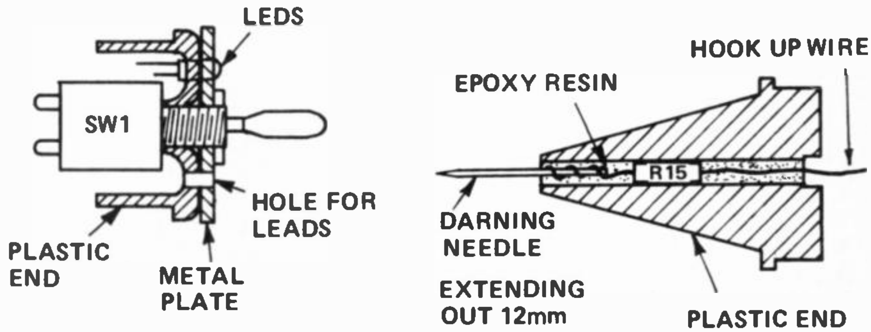


Fig. 6. How the probe ends are constructed.

PROJECT 121

LOGIC PULSER

Companion instrument to the logic probe.

ALTHOUGH the logic probe used alone is a very valuable piece of digital test equipment, it is limited by the fact that it can only observe the logic states that occur naturally within the piece of digital equipment under test.

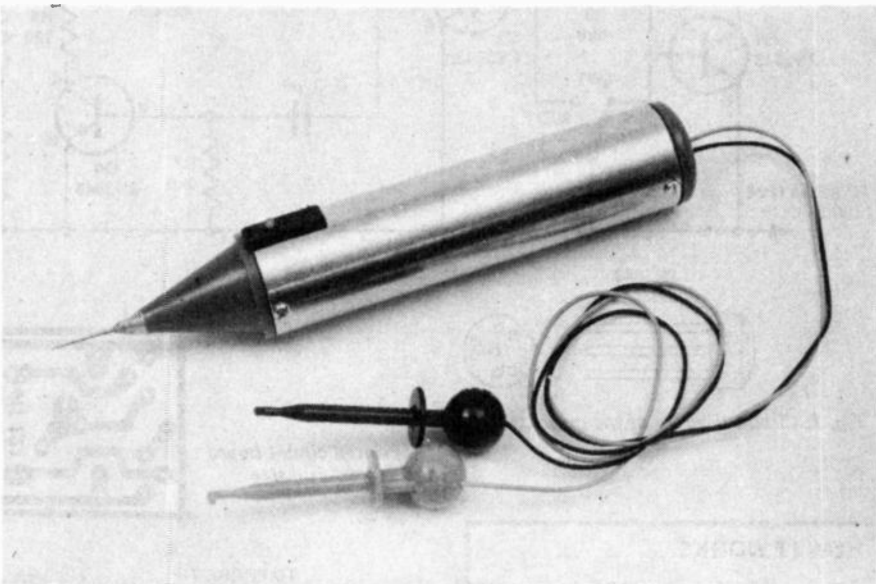
The logic pulser is a further valuable tool that is used in conjunction with the logic probe. It's function is to override the naturally occurring state at the particular circuit node under test. That is, if the circuit node is normally at the '1' state, the pulser will drive that node to a '0' for a very short period when the microswitch is pressed. If the circuit node is normally at a '0', the probe will drive it to a '1' for a very short period when the microswitch is released. Thus it puts a short pulse into the circuit node regardless of it's normal state when SW1 is pressed and released.

A fairly powerful pulse is required to override the normal logic state of a circuit node and care must be taken to ensure that the devices either driving, or being driven from that node are not damaged. This is achieved by making the pulse of very short duration. In our probe the pulse width is 500 nanoseconds. Thus although the pulse is of high current the energy released is insufficient to damage normal logic devices.

The probe must be suitable for driving either TTL or CMOS that is, it must operate from a supply ranging from 5 to 15 volts, it must be capable of operating into loads having a capacitance as high as 1000 picofarads and must supply a current pulse of around half an amp. All these conditions are fulfilled in the ETI 121 Pulser and the prototype has been tested by causing it to generate several hundred thousand half amp pulses without any problems. The probe is quite capable of pulling two (in parallel) high-power TTL 'zeros' to a '1' level and this is the most severe condition it has to meet.

At the same time as providing high level pulses, the pulser should not draw too much supply current as some CMOS supplies may not have much additional capability. Under worst-case conditions the ETI Pulser drew a maximum of 10 mA.

The probe is capable of overriding a normal logic state but is not capable of overriding a point that is connected to ground or to a supply rail. Thus by pulsing a node and at the same time looking at that point with the logic probe it is possible to tell if that point is shorted to either rail.



A basic tool for digital servicing.

The logic pulser combined with the logic probe is thus capable of performing stimulus — and — response testing of both TTL and CMOS logic and of determining the exact nature of a fault at a particular circuit node.

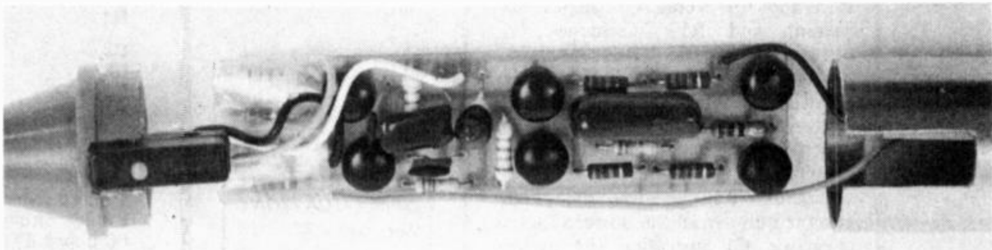
CONSTRUCTION

Construction is greatly simplified if the printed circuit board of Fig. 2, is used. This should have the components assembled to it in accordance with the component overlay. Note particularly the polarity of C1, and the connections of the microswitch such that the normally-closed terminal of the switch is connected to the base of transistor Q1. Also make sure that a red lead is connected to the positive rail of the board, and a black lead to the negative rail, to facilitate later connection.

We used the same probe case for the pulser as for the logic probe. The probe tip is again replaced by a darning needle and the microswitch SW1 is mounted into the plastic-section of the tip as follows. First check the switch to determine what the contact arrangement is. Attach colour coded wires to the switch, to aid later identification, and tape the microswitch into position. Epoxy cement may then be used to fix the switch into place permanently. Now cut a slot into the probe case so that the switch and plastic tip assembly can be inserted into the casing.

Connect the probe tip and microswitch leads to the board and, after insulating the inside of the case with cardboard or plastic as previously described, insert the board into the case. Pass the supply leads through the plastic end piece and then fit both end pieces and secure them in position. Lastly attach Ezy-hooks or alligator clips to the supply leads.

Keep the supply leads as short as is reasonably possible as excessively long leads will degrade the performance of the pulser.



Internal construction of the pulser.

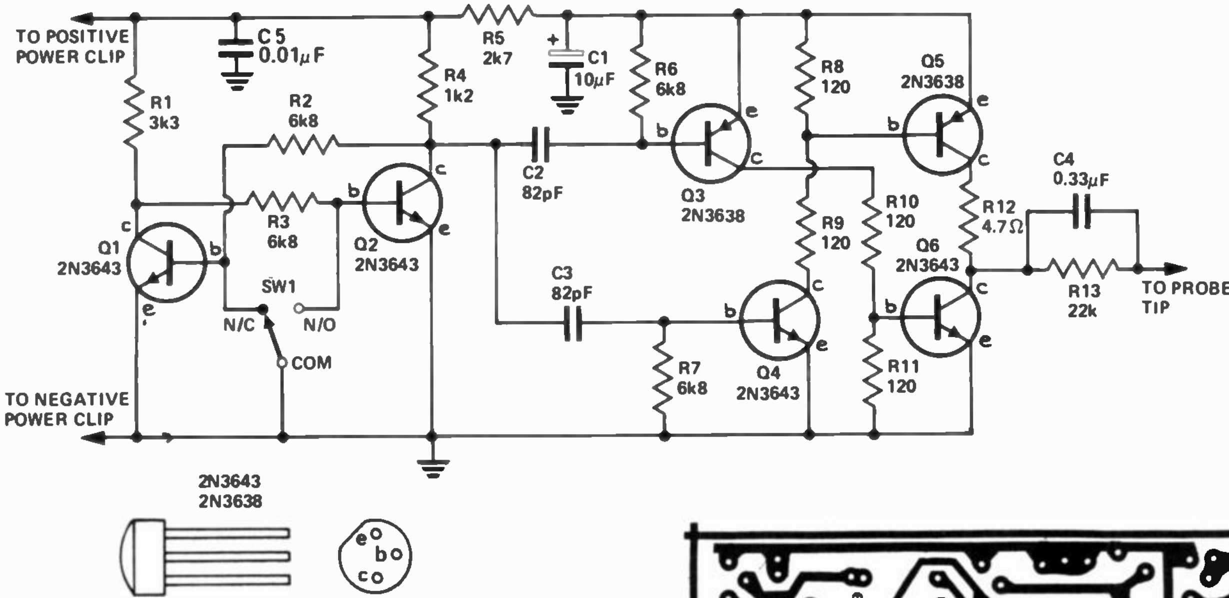
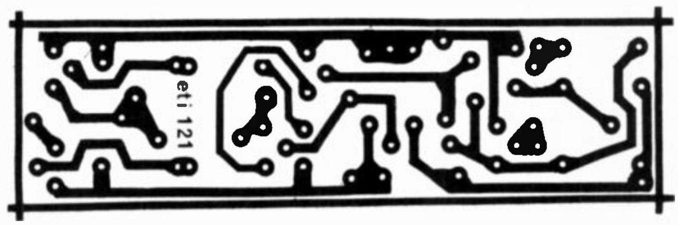


Fig. 1. Circuit diagram of the pulser.

Fig. 2. Printed circuit board for the pulser. Full size 23 x 65 mm.



HOW IT WORKS

The pulser is activated whenever microswitch SW1 is pressed. This switch controls the state of a flip-flop formed by transistors Q1 and Q2. The flip-flop is necessary to prevent contact bounce of the microswitch from having effect.

The output transistors of the probe, Q5 and Q6, which in turn are controlled by Q3 and Q4 are both normally off. However when the microswitch is pressed Q2 turns off and the rising coltage on its collector is coupled, via C3, to the base of Q4 turning it on. This in turn, turns on Q5 pulling the output to the positive rail. This generates a '1' pulse if the point under test was at a '0' level. Resistor R12 provides a current limit of around 500 milliamps. Due to the small value of C3 the pulse output is only about 500 nanoseconds long, short enough so that there is insufficient energy to damage the device under test.

When the switch is released Q2 turns on and the negative-going edge is coupled to Q3 by C2 turning it on. This turns on Q6 causing the output to be pulled to the negative rail. This gives a '0' pulse which, like the '1' pulse, is only 500 nanoseconds long.

The output from the probe is taken via the paralleled combination of R13 and C4 where C4 carries the current and R13 discharges C4 between pulses. This network protects the probe against the condition where the probe is inadvertantly connected to a voltage which is above or below the logic supply rails.

Resistor R5 isolates the high current pulse from the power supply, capacitor C1 providing the actual current needed.

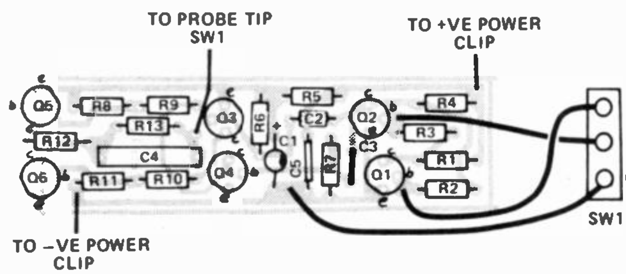
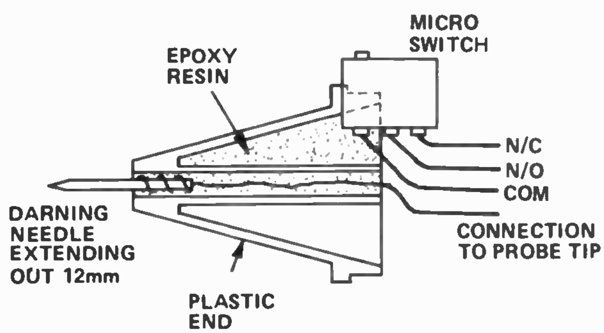


Fig. 3. Component overlay for the pulser.

Fig. 4. Construction of the tip for the pulser probe.



SPECIFICATION
See page 47.

PARTS LIST

R12	Resistor	4.7 ohm	¼W	5%
R,8,9,10,11	"	120 ohm	¼W	5%
R4	"	1k2	¼W	5%
R5	"	2k7	¼W	5%
R1	"	3k3	¼W	5%
R2,3,6,7	"	6k8	¼W	5%
R13	"	22 k	¼W	5%
C2,3	Capacitor	82 pF	ceramic	
C5	"	0.01 μF	polyester	
C4	"	0.33 μF	polyester	
C1	"	10 μF	25 V tantalum	
Q1,2,4,6	Transistor	2N3643 or similar		
Q3,5	"	2N3638, 2N3638A or similar		

1 micro switch miniature McMurdo type 2LM
2 alligator clips or Ezy-hooks
PC board ETI 121
probe case (see text).

The Dual 701 automatic single-play turntable with electronic direct-drive system

The Dual 701 is in every respect the finest turntable ever made. Its full measure of superiority can be appreciated best by the most serious of discerning listeners who impose the highest possible standards on their high fidelity equipment.
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Further evidence of the 701's advanced technology can be seen in the tonearm counterbalance, where two mechanical, anti-resonance filters absorb the resonant energy that would otherwise transfer spurious signals to the stylus.

The 701's many technical features set new standards for high fidelity record playback equipment, and form the nucleus of the highest quality component systems.

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MODEL NO: SYCO-1. Displacement CFM at 1725 rpm 2.7 35lbs. Single stage. ¼ H.P. motor. PRICE $105.00.

MODEL NO: SYCO10-1. Displacement CFM at 1725 rpm 1.9 175lbs two stage unit. 1/3 H.P. motor. PRICE $140.00.

MODEL NO: SYCO11-1. Displacement CFM at 1725 rpm 2.7 175lbs two stage unit. ½ H.P. motor. PRICE $165.00.

MODEL NO: SYCO12-1. Displacement CFM at 1725 rpm 3.29. 175lbs two stage unit. ¾ H.P. motor. PRICE $194.00.

MODEL NO: BLC Displacement CFM at 1725 rpm 1.43 single stage. Operating pressure to 90 PSIG to 110 PSIG intermittent. 1/6th H.P. motor. PRICE $69.00.

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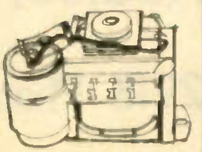

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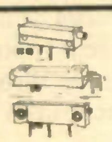

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International Electronics Convention '75

At the UNIVERSITY OF NEW SOUTH WALES, Kensington, Sydney, Australia.

FROM:
Monday, 25th August to Friday, 29th August, 1975

The theme: "ELECTRONICS AND THE FUTURE"

SCIENTISTS and engineers from at least 10 overseas countries will participate in the "International Electronics Convention '75" organised by the Institution of Radio and Electronics Engineers Australia in Sydney from August 25 to 29.

The Convention, to be held at the University of New South Wales, is expected to attract 1500 delegates and 20 000 visitors.

In addition to a number of Australian speakers, addresses will be given by scientists and engineers from the U.K., U.S.A., Finland, Japan, India, New Zealand, Germany, Israel, Czechoslovakia and Singapore.

Contributed by top ranking electronics authorities from overseas and in Australia more than 250 technical papers will be presented. Each day six of the University's lecture theatres will be occupied by speakers delivering these papers. (An Internaticnal Symposium on loudspeakers has been arranged for Aug 20-22 — see our Audio News pages for details.)

A comprehensive display of equipment will cover 30 000 sq. ft of space. Major Australian manufacturers and suppliers and a number of British companies will be represented.

A list of exhibitors is included within this IREE Convention supplement, together with a floor plan of the two main exhibition halls.

The convention will be officially opened by Myles Wright, Chairman of the Broadcasting Control Board on August 25th at 7.30 pm.

Keynote address will be given by Mr. David R. Israel, Deputy Associate Administrator for Engineering and Development for the Federal Aviation Administration, Washington, U.S.A. Mr. Israel is coming to Australia at the invitation of IREE President, Mr. F.R. Lackey.

Currently, Mr. Israel is responsible for directing the Administration's research and development programme for air traffic control systems. He will address delegates on "Electronics in the future of air traffic control". ●

"ELECTRONICS AND THE FUTURE"

IREE Conventions are the recognised regular forums for management executives, scientists, engineers and technical officers engaged in every field of electronics, both in Australia and overseas. Traditionally, they bring together the most significant contemporary knowledge on research, design, development, and manufacturing and offer widespread benefits to those taking part. They provide unparalleled opportunities for formal and informal discussions, for the exchange of information and ideas, and for viewing and examining the latest equipment and components.

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The objects and purposes for which the institution is constituted are "... to promote the science and practice of electronics engineering in all its branches and the usefulness and efficiency of persons engaged therein and to facilitate the exchange of information and ideas in relation thereto."

If you have a university degree, professional diploma, technical certificate or similar qualification you may be eligible for membership — full details of the various grades of membership can be obtained from the IREE, 157 Gloucester St. Sydney 2000.

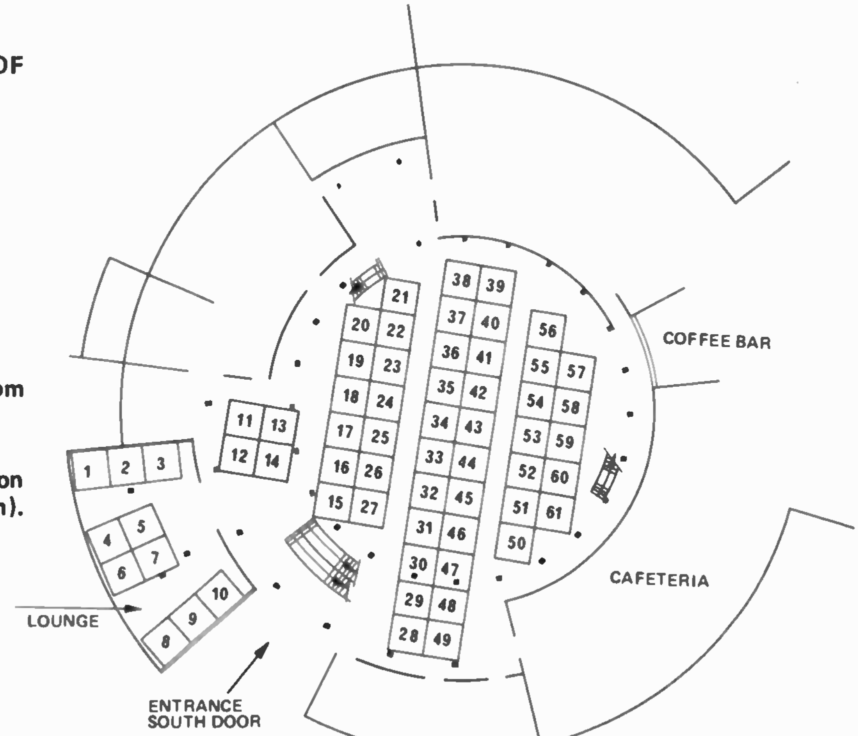
Organised by: The Institution of Radio and Electronics Engineers Australia, Science House, 157 Gloucester Street, Sydney, N.S.W. 2000, telephone 27-1039.

International Electronics Convention '75

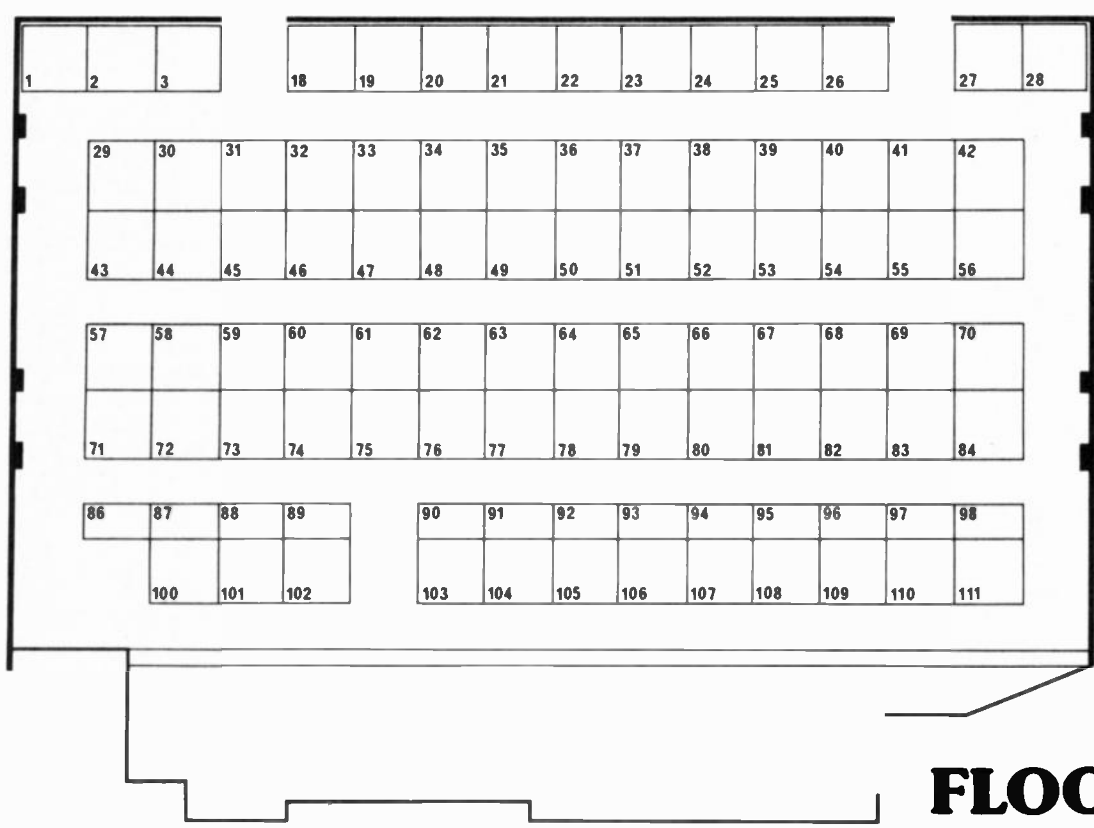
MAIN EXHIBITION AREAS UNIVERSITY OF NSW, KENSINGTON.

1. UNISEARCH HOUSE
2. NEW COLLEGE – Common Room (RCA)
3. ROUNDHOUSE
4. GOLDSTEIN COLLEGE –Wheen Room (Siemens & Philips) Undercraft Room.
5. CENTRAL LECTURE BLOCK (Convention control centre, registration, and information).

Electronics Today will be there too – call in and see us on Stand 61 Unisearch House.



ROUNDHOUSE–GROUND FLOOR PLAN



UNISEARCH HOUSE

FLOOR PLAN

ACI ELECTRONICS — Stand 73/74 Unisearch House.

DYNAPAR CORP — production control and monitoring, linear and rotary transducers, counters, indicators, alarms, data loggers and special digital systems.

EMERSON INDUSTRIAL CONTROL — solid-state high power Accupower uninterruptible power systems, 'Accuspede' adjustable speed ac drives.

ICS — low power solid-state standby power systems, inverters, process controls and medical instruments.

B & R SYSTEMS — electronic weighing systems for large bulk-weight, electronic readouts weighbridges and process peripherals.

TELEDYNE ISOTOPES — hydrogen/oxygen gas generators for turbine applications and related requirements.

FRIESEKE & HOEPFNER — dust emission measuring and monitoring.

ACI — control and supervisory systems, communications equipment, military and government systems.

ACME ENGINEERING Stand 27/28. Unisearch House

ACME coaxial connectors, audio and telephone type connectors, Acme-designed BNC push-on patching system now widely used in TV industry, comprehensive range of RF coaxial connectors, coaxial cables, patching and switching systems etc. from oversees manufacturers represented by Acme.

AIR PROGRAMS INTERNATIONAL, Stands 28—31 Round House.

RECORTEC — video tape evaluator.

Q-TV — video prompter system.

PORTA-PATTERN — television test charts, test slides and transparencies.

MTE — audio wow and flutter meter.

WRIGHT AUDIO — precision MF/AM broadcast monitor receiver, crossed ferrite "anti fading" MF/HF broadcast monitor receiver.

CMC — video discs and quadruplex video head refurbishing.

AMALGAMATED WIRELESS (AUSTRALASIA), Stands 16—19 Round House.

DIAL ADJUSTMENT SET — modern version of conventional speed-ratio tester for telephone dial adjustment.

DIALSCAN — telephone dial individual pulse duration measurment.

SPECTRUM ANALYSER — features flicker free display, dual image storage, integral counter, tracking signal generator, adjustable electronic graticule, electronic cursor and wide dynamic range.

DISTORTION AND NOISE METER — IREE Convention first release features fully automatic frequency nulling, time taken for distortion measurement, to −90 dB is cut to seconds.

AMPLITUDE MODULATION MONITOR — solid-state instrument covering the MF band.

QUARTZ CRYSTALS — discrete frequency-determining crystals and monolithic crystal filters.

SURFACE ACOUSTIC WAVE DEVICES — frequency filters, oscillators, delay lines and matched filters, surface wave devices on display.

MICROELECTRONICS — design and manufacture, standard and custom built applications, IC cardiac pacemaker, digital telephone, digital compass, test instruments, fire protection, military equipment.

AKG — microphones, pick-up cartridges, headphones and reverberation units.

REVOX — tape recorders and amplifiers.

AWA — automated broadcast equipment.

PSI — computerised system for billing, trafficking, and accounting for radio and TV stations.

CONRAC — and Electrohome video monitors.

ANDREW ANTENNAS Stand 54 Unisearch House.

GRIDPAK — collapsible grid parabolic antenna.

ANDREW HELIAX — solid copper corrugated outer conductor co-axial cable for laboratory or high power TV or sound broadcasting use.

RADIAX — slotted coaxial cable, radiates controlled amount of signal along entire length — acting as a distributed antenna.

ANDREW HYBRID — directivity reference instrument for precise measurement of waveguide components.

AUDIO BROADCASTING SERVICES, Stand 51/52 Round House.

SCHAFER — automated broadcasting station model 903.

AUSTRALIAN VIDEO ENGINEERING, Stand 11/14 Round House.

GRASS VALLEY GROUP — GVG 1600 series vision switching systems.

INTERNATIONAL VIDEO CORPORATION — electronic news gathering system, IVC 7000 cameras including portable hand-held camera, IVC digital timebase error corrector operating from IVC range of 1" Helical Scan recorders, IVC EA51 editing system for news off-line or on-line. IVC 201 1" helical scan cartridge recorder.

BELL & HOWELL, Stand 23 Round House.

BELL & HOWELL — 5-144, seven channel recording oscillograph, 4-800 thin film pressure transducer, CR 3000 portable battery-operated direct and FM recorder reproducer, standard Philips cassettes to record and reproduce four channels FM and direct information, twelve and 18 channel recording oscillographs, CPR 4010 portable 14 channel I.R.I.G. tape recorder, working demonstration of Bell & Howell Astro Science recorder designed for military and hostile environments.

BELL & HOWELL'S GERMAN SUBSIDARY — a PCM (digital) translation system for use with analogue tape recorders, and computer interfaces to allow Bell & Howell instrumentation tape recorders to be computer controlled.

BRITISH AIRCRAFT CORPORATION (AUSTRALIA) Stands 57/58 Unisearch House.

SYSTEM & ENGINEERING DESIGN — optical tracking equipment for calibrating ILS and MLS systems equipment embraces TV optics, digital shaft encoders, precision gears and telemetry of digital data.

STRAIN RANGE PAIR COUNTER — flight load monitor for fatigue assessment, is airborne unit which processes outputs from strain gauges and records as running total of "Range Pairs" with associated mean values.

PROGRAMMED I.F. ATTENUATOR — for reducing clutter and angel effects in radars.

BRITISH AIRCRAFT CORPORATION (U.K.) — products of the Corporation's Precision Product Group, including gyroscopes and gyro-based products, special equipments based on the BAC electrical remote reading spirit-level.

BRITISH CONSULATE GENERAL, Stands 20/23, 34/37 Unisearch House.

Six British companies' exhibits mutually arranged by Britain's Electronic Engineering Association and the Overseas Trade Board of the Dept of Trade.

ADDENDA

The following organisations are also exhibiting — however at the time of closing for press no exhibition details could be obtained.

UNISEARCH HOUSE

Consolidated Electronics, Stand 45/46

EMI (Aust), Stand 75

Depts of Army, Navy, Airforce, Transport (Air Group, Stands 47-50

Sydney City Council, Stand 33

McMurdo (Aust), Stand 18/9

Tektronix Aust, Stand 24-26

Studio Electronics, Stand 29.

Thompson Publications, Stand 86

ROUND HOUSE

Ampex Australia, Stand 25-27

Kanematsu Gosho, Stand 20-22

Magnatectronics, Stand 44/45

NEC Aust, Stands 46-49

Transmission Products, Stands 37/38

Albert Einstein had a hair problem. And a lot of mathematical problems.

The hair he could have fixed with a good brush. And with a lot of his other problems, 'Eveready' Gold Alkaline batteries could have helped out.

Just think what a man like Einstein could have done with a battery that out-performs all others in high drain electronic equipment.

A battery that delivers full and consistent power, even after being left idle for long periods.

A battery that isn't bothered by extreme changes in temperature.

Albert, we only wish we'd been there to help.

EVEREADY BATTERIES Products of UNION CARBIDE

'Eveready' & 'Union Carbide' are registered Trade Marks.

International Electronics Convention'75

GEC — products from this and associate companies including semiconductor components from AEI; relays from Londex and Associated Automation; metrosyl resistors from Micanite Insulators; instruments and components from Salford Electric; Sunvic relays and energy regulators from Satchwell Controls — and the GEC-Clearcall two-way communications system from GEC.

IMHOF-BEDCO — small instrument cases.

LCR COMPONENTS — standard and specialized capacitors up to 20 kV.

MEDELEC — recording instruments for industry and research — including fibre-optic techniques.

MICAPLY — glass epoxy laminates to Nema and military specifications.

MULTICORE SOLDERS — solders, solderability tester, soldering chemicals and fluxes.

BWD ELECTRONICS, Stand 60 Unisearch House.

BWD — oscilloscopes and function generators including model 170 'Wavemaker', BWD 'mini-lab', stabilized dc power supplies.

CLOSED CIRCUIT TELEVISION, Stand 65 Unisearch House.

MICHAEL COX ELECTRONICS — 6 x 4 ABC and P/V vision mixers, with 10-wipe SFX with chroma key facility, Downstream Keyer, Coxbox colour synthesiser updated to include camera shading controls, Type MCE 208 caption colouriser, takes video plus BCD code to provide word by word colouring with five different colours.

ASTON ELECTRONIC DEVELOPMENTS — video character generator and external multipage message store MMS2. Facilities include line protect function, crawl facilities and slow readout, full range of system video products including PAL Signal Generator, also range of waveform and vector monitoring instruments.

GRAFIKON ENGINEERS — the optical comparator.

R.H. CUNNINGHAM, Stand 55 Round House.

WATKINS JOHNSON — communications receiver systems.

DATA GENERAL, Stand 55/56 Unisearch House.

DATA GENERAL ECLIPSE — general-purpose computer system.

DATAMATIC, Stand 66 Unisearch House.

CALCOMP — disc storage systems, floppy disc drive, disc formatter.

VERSATEC — electrostatic printers and plotters using matrix electrostatic writing technique.

DATUM — model 4000 terminal adapter.

DICK SMITH ELECTRONICS, Stand 89 Unisearch House.

DICK SMITH SHOWBAG — containing wide selection of components and data sheets, bags, which contain many dollars worth of parts, will be sold for a nominal sum and profit donated to charity, also showing a wide selection of semiconductors and imported transformers.

LENK — cordless soldering iron.

SINCLAIR — digital multimeter.

DIGITAL ELECTRONICS, Stand 53 Unisearch House.

DIGITAL ELECTRONICS — wide range of locally manufactured and imported data acquisition systems, modular conversion products, data transmission devices and electronic training aids.

ELMEASCO INSTRUMENTS, Stand 102 Unisearch House.

JOHN FLUKE — digital voltmeters, multimeters, frequency counters, thermometers, printers, signal generators, frequency synthesizers and calibration equipment.

FLUKE TRENDAR — digital logic test instruments and digital board testers.

BIOMATION INTERNATIONAL — analogue transient recorders, digital logic recorders and wide band AD/DA converters, for video digitising.

NEWPORT LABORATORIES — digital panel meters and printers.

TELEDYNE PHILBRICK — modular operational amplifiers, power supplies, AD/DA converters and VF/FV converters.

ELECTRO-NAVIGATION — broadband RF power amplifiers.

LINEAR INSTRUMENTS — chart recorders.

ITHACO INCORPORATED — lock in amplifiers, filters and signal conditioning equipment.

KEPCO INCORPORATED — bipolar, general purpose and operational power supplies.

L. M. ERICSSON, Stand 67/58 Unisearch House.

L.M. ERICSSON — constant potential battery chargers.

TRIMAX — programme line amplifier, ionisation tester, extended range volume indicator, telephone line isolating transformers and transformers to 20 kV breakdown.

NERA — precision VSB TV demodulator.

ELMI — pulse train generator.

ELMI — event recorder.

ELECTRONIC — voice switched intercom system using T.D.M. (Time Division Multiplex) technology.

ERICALL "CONTACTOR" — staff locator solid state receiver utilising digital coding.

AEE CAPACITORS — metallized paper, polyester, polystyrene or polypropelene dielectrics, high grade electrolytic capacitors with long life characteristics specialised C.R. and R.C. units for contact arc suppression and radio frequency interference suppressors.

FILMTRONICS, Stand 30/31 Unisearch House.

BERKEY COLORTRAN — studio lighting equipment and ancillaries, portable lighting kits for film and television.

MITCHELL WILCAM — 16mm single and double system sound camera.

MEOPTA — 16mm sound projector.

DELNOCTA — lens set, for unique three-stage image intensifier system for recording of events at low light levels without artificial lighting or infra red radiation.

SHOWCHRON — expandable editing console.

STELLAVOX — portable tape recorder.

GENERAL ELECTRONIC SERVICES, Stand 69/70 Unisearch House.

E & L INSTRUMENTS — circuit design systems.

ANCOM — modules for analogue applications.

AVANTEK — 4 to 8 GHz GAs FET amplifiers, light weight YIG tuned oscillators, arsenic emitter wave guide amplifiers, and MIC varactor tuned oscillators.

FREQUENCY WEST — microwave phase-lock oscillators, synthesizers, amplifiers and pre-selectors, satellite ground station equipment, microwave landing systems and retrofitting of solid state communication equipment, phase-locked microwave oscillators, 680 MHz to 14.3 GHz.

CAMBRIDGE THERMIONIC — high density wirewrap Cambi-Cards, card files, power planes, and interface systems, interface cards, logic cards, memory cards and experimental breadboards, patch cord kits, interfacing hardware, Euro-Cards (metric), wirewrap pins, universal panels and integrated socket high density packaging, terminals, coil forms, chokes, connectors and thermo-electric components.

ROBINSON NUGENT — dual-in-line IC sockets both solder and wirewrap, strip sockets, test sockets, low insertion force sockets, TO pattern sockets for transistors and TO IC's flatpack test sockets, terminals, breadboards, socket board systems, Allochiral socket board systems.

EZ HOOK — micro hook, 86-1 heavy duty nail clip, scope meter probes.

GENERAL LASER (AUST.), Stand 59 Unisearch House.

GENERAL LASER — Helium-Neon lasers for process monitoring and control, metrology, holographic testing, education, alignment, data processing, communications, and environmental studies.

GOLLIN, Stands 1/2/3 Unisearch House.

COMTERM — locally designed micro computer based visual display communications terminal.

EDITSET — graphic arts production management system exhibited as a typical configuration. has hardware with Gollin-produced visual display units, software and systems integration.

TELEPERF — "off-line" paper tape preparation machine for telex or telegraphic transmission.

VIDISCREEN 33 — "Glass Teletype".

BARRY RESEARCH — time diversity modem for character error reduction.

ELOGRAPHICS — digitiser for conversion of graphic information to digital data.

GNT AUTOMATIC A/S — dataprinter data terminal operational speeds up to 30 characters per second, reader punches.

KURZ KASCH — logic probes Kurz Kasch.

DI/AN CONTROLS — diversified printers for tickets, tags, labels and airline tickets, fast teleprinters, strip printers and column printers.

SINGER INSTRUMENTATION — quality communications test and measuring apparatus, communications service monitor, noise and field intensity meters.

TABOR ELECTRONICS — digital frequency counters, 3½ digit digital multimeter, frequency counters.

HARMAN AUSTRALIA, Stand 24, Round House.

HARMAN KARDON — Citation series power amplifier Citation 16.

RABCO — ST7 straight-line tracking turntable.

JBL — studio monitor loudspeakers, some with bi-amplification.

HEWLETT PACKARD AUSTRALIA Stands 90/98 inclusive, Unisearch House.

COMPUTATION and measurement instruments.

Nine booths, each booth dedicated to specific product groups, including

computers, measuring instruments and systems, components, calculators and a display showing capabilities in service and calibration of products.

I.R.T. ELECTRONICS, Stand 42/43 Round House.

TELEVISION AUTOMATION SYSTEM – film cue detectors and video tape cue systems, video pulse and audio distribution amplifiers, microphone, compression and talkback amplifiers, 8 x 1 vertical interval video switchers with vertical split features, vertical interval cue encoders and decoders, real time blocks with slaves, and elapsed time clocks, outside broadcast amplifier with inbuilt cue receiver, equipment racks and associated hardware.

JACOBY MITCHELL, Stands 103/107 Unisearch House.

ROHDE & SCHWARZ – working and passive examples of Rohde & Schwarz V.H.F. FM transmitters.

VITS AUTOMAT – automatically measures distortions which can be indicated by the standard CC1 R lines 17, 18, 330 and 331, raises alarm when parameters exceed nominal tolerances. The new sound automat is incorporated in the 2MBSFM broadcast chain and can be seen operating on the stand as a part of the radio relay equipment. Television demodulator A.M.F., with test modulator, test signal sources, evaluation instruments, and field strength measuring equipment for broadcasting use.

VISICORDERS – instrumentation package incorporating signal conditioning amplifiers for variety of different types of signal. Fibre-optic CRT line scan recorder working with 5600C tape recorder to demonstrate infra-red mapping, analyzer readout and thermography. Standard galvanometer oscillographs.

TAPE RECORDERS – portable 14 channel tape recorder with direct write, FM and digital electronics, twenty eight channel laboratory recorder with push button selectable speeds and 16 inch diameter reels.

SIGNAL ANALYSISERS – correlators, Fourier transform analysers and real time spectrum analysers.
MAGNASYNC/MOVIOLA – logging tape recording systems and digital clocks, also time display and an Insta-call cassette recorder.

KLARION ENTERPRISES, Stand 51/52 Unisearch House.

OTARI – multi-track and professional tape recorders, tape and cassette duplication systems.

M.C.I. – multi-track and professional tape recorders, mixing desk consoles and modules.

INOVONICS – audio limiters and compressors.

PANDORA – audio limiters and compressors.

ALSO displaying loudspeakers, microphones, recording tape, and allied instruments from Australian, American, Japanese, UK and German manufacturers.

KODAK A/SIA, Stand 35/36 Round House.

KODAK – Ektachrome EF film (tungsten) 7242 in silent and magnetic stripe sound super 8 cartridge.

JOHN BARRY GROUP inc. BIRNS & SAWYER, Stand 64 Unisearch House.

LEMO – precision self-latching connectors.
IANIRO – H.M.L. studio lighting.
ACMADE – Pic-sync motorized film editor.
CINEMA PRODUCTS – CP sound camera.

LEROYA INDUSTRIES, Stand 32/33 Unisearch House.

FERROGRAPH – professional tape recording equipment etc.

NATRONICS, Stands 71/72 Unisearch House.

IRC – metal glaze resistors, wire wound resistors, carbon potentiometers and presets, wire wound rheostats, precision trimmers (single turn wire-wound, metal glaze, round and rectalinear) – multi-turn wirewound potentiometers.

MURATA – filters and tuning forks, ceramic disc capacitors.

TOWA – polyester capacitors.

HITACHI – tantalum and electrolytic capacitors, toggle, push button, see-saw, miniature, rotary, sub-miniature, lamp lighted, modular push button and indicator styles, Schadow, NKK, Mulon, Tschudin and Heid. Scope soldering irons and etching tools.

HAMLIN – reed switches (micro miniature to heavy duty styles), temperature sensing reed switches, coils, reed relays.

MAGNETIC DEVICES – complete range of relays and solenoids.

OMP – fluorescent, neon and incandescent indicators.

SHINKO – electronic temperature controllers, indicators and recorders.

N.I.C. INSTRUMENT COMPANY, Stand 50 Round House.

ATLANTIC RESEARCH – data communications, test equipment, data/audio quality control monitors, communications test boards, remote alarm acquisition equipment, communications network management, interface devices and compact mobile data terminal.

BEMCO – bench type temperature and temperature/humidity models environmental cabinets, floor standing temperature/humidity/altitude, sand and dust, salt spray etc.

CARL ZEISS – precision measuring instruments and microscopes for production and quality control in the electronic industry, precision co-ordinatograph for large areas.

CUSHMAN – VHF/UHF, AM and FM mobile radio monitors and telephone transmission test equipment.

DAYTRONIC – modular instrument system for the measurement and control of electro-mechanical phenomena.

LAFAYETTE RADIO ELECTRONICS – transceivers in 27 MHz band for use by surveyors, walking and yachting clubs and use within limited areas.

LEBOW ASSOCIATES – torque sensors, load cells, multi-component transducers, slip rings and motor testing dynamometers.

NIPPON ELECTRONIC COMPANY, Stand 46/47/48/49 Round House.

WIRED COMMUNICATION DEVICES – electronic switching exchanges, assorted telephones, video telephones, conference telephones, carrier transmission equipment (FDM and PCM), submarine cable transmission equipment, data modems.

CATV – crossbar switching exchanges, PBX and PAX equipment, facsimile equipment.

RADIO – microwave communications equipment (FCM and PCM), satellite communications equipment, mobile and portable radio equipment including paging system, communications supervisory and control equipment, millimeter-wave communications equipment, laser communications equipment, radio navigation equipment, television and radio broadcasting equipment, VTR and studio equipment, postal mechanization equipment, medical electronic equipment, numerical control equipment, educational electronic equipment, industrial telemetering equipment, pollution monitoring equipment.

INFORMATION PROCESSING AND INDUSTRIAL SYSTEMS – general-purpose and control computers, data communications equipment, computer input – output peripherals and terminals.

ELECTRON DEVICES – IC, LSI, transistors, diodes, electron tubes, microwave tubes, electron beam equipment, laser application devices, rectifiers, colour picture tubes, wire memory, printed circuit tubes, condenser, capacitors.

DOMESTIC APPLIANCES – TV receivers, TR radio, refrigerators, audio equipment, lighting tubes, heating and cooling equipment.

OPTRO, Stand 60/61 Round House.

OPTRO – professional sound mixing consoles, multitrack recorders, graphic equalisers, reverberation unit, studio processor.

IGM – automated radio system.

MAGNATE – video and audio tape cleaners, evaluation systems.

ADVENT – videobeam colour TV projector.

JBL – professional sound reproducers.

TABE – bulk tape erasers.

WARDBECK – mixing consoles.

PARAMETERS, Stands 43/44 Unisearch House.

MEGURO DEMPA – test equipment primarily for the broadcasting industry, stereo signal generator, F.M. output with monophonic or stereo modulation, general purpose bridge for LCR measurements, mini-current ohmmeter measures very low resistances at very low currents for checking relay and switch contacts, low distortion oscillator 100 to 10 000 Hz distortion, wide band CR oscillator with sine and square wave output, phase meter 10 Hz to 2 MHz phase range from 0 to ±180°.

TRIO – oscilloscopes, stereo signal generator.

PATON ELECTRICAL, Stand 32&34 Round House.

PATON – electrical transducers, for measurement of ac current and voltage, watts, vars, frequency, and power factor fully designed and manufactured by Paton in Australia.

VAISALA – fast reading humidity meter.

LAB-VOLT – electro-mechanical system, and practical electronics demonstration kit for technical education demonstrations.

HALMAR – equipment for high-accuracy measurement of current from 0 to 200 kA including portable units.

TSUDA – fault indication and protection for dc supply and bus system.

KUWANO – analogue and digital instrumentation and test equipment, digital voltmeters and ohmeters, signal generators, etc.

FUSO – high accuracy laboratory bench meters for dc and ac current and voltage measurment.

WHITTAKER – electro-medical equipment for pulse and blood pressure measurement.

METRAWATT – galvanometric and potentiometric chart recorders, portable test equipment and temperature measuring instruments.

ENTRELEG – mosaic tile display and control systems, switches, annunciators, and associated hardware. Also rail-mounted terminals.

KNICK – portable and laboratory pH measuring instruments.

HONEYWELL – temperature measurement and control instruments.

ELTEX – measurement, monitoring, exploitation bi-metals and thermal control elements.

MENTOR – metal and plastic knobs.

PENNY & GILES – precision potentiometers, rectilinear potentiometers, faders, pressure transducers, specialised transducers for aviation.

JEMCO – high quality multitesters.

H.H. PEASTON, Stand 59 Round House.

HARNESS – assemblies for quantity production of domestic and professional equipment, fabricated short lengths of multi core cables, insulated wire, cut to length, solder dipped or terminated, power cords, moulded plugs, moulded plug cord sets for domestic appliances, ancillary harnesses for cars, battery cables, booster kits, HT kits, battery terminals.

SMALL POWER MACHINES – injection moulding equipment.

HEXCELL – neoprene moulding equipment.

CAROL CABLE – all types of cable.

PYLE NATIONAL – explosion proof connectors and lighting.

CAMLOK – heavy duty connectors.

PHILIPS INDUSTRIES, Separate buildings

ELCOMA (ELECTRONIC COMPONENTS & MATERIALS) – numerous examples of custom designed devices include 41XQ image intensifier/plumbicon LLLTV camera tube, XQ1410 30mm light bias and XQ1423 2/3 inch plumbicon camera tubes, 20AX self converging colour TV picture tubes and deflection yokes, Doppler radar cavities and MRX25 doppler radar units, 250SA/SR A4 high speed, low noise mosaic printers, BPX47 solar cell array, Colour TV integrated circuits, diode split line output transformer, E-cores for switched mode power supplies, one inch silicon vidicon camera tube, high quantum efficiency photomultiplier, transmitting tubes, cavities and circulators, CATV transistors, Hybrid wideband amplifiers, 100W SSB transmitting transistor, reed switches, ferrite and ticonal magnets, barricade flasher and radiosonde custom ICs, stretched 7-segment led displays, photocouplers, numerical display units, connectors and mounting chassis, stepper motors and drive modules, mains filter, illuminated thumbwheel switches.

PHILIPS TELECOMMUNICATIONS TELEPHONE DIVISION – 12/24 channel multiplex equipment displayed in conjunction with Radio Division L300 microwave bearer equipment, V.F.T. speech plus telegraph system equipment, SpheriCall repertory push-button dialler, 300 bit per second and 1200 bps leased-line version data modems, "Dialite" indicator switches, professional quality custom printed circuit boards.

PHILIPS TELECOMMUNICATIONS (RADIO DIVISION) – VHF mobile local or remote control equipment, UHF mobile local or remote control, solid state 50 watt base station, selective calling console, selective calling decoder, mobile remote control consoles, low capacity 1.5 GHz bearer equipment, range of VHF and UHF portable radio units.

PHILIPS ELECTRONIC SYSTEMS – new grouping of five closely associated Philips Divisions resulting from rapid expansion of professional equipment range. The exhibition is the debut of Philips Electronic Systems, members of the group demonstrate extensive variety of new products.

PHILIPS VISION & SOUND – products for the professional broadcast industry and for educational or industrial application, LDK-5 studio colour camera with image intensifier accessory. Two working broadcast colour recorders with 1" helical scan controlled by an EDS 200 tape editing system, production model of LDK-15 hand held broadcast colour camera. Australian-made colour and monochrome TV monitors and precision TV receivers. Australian-made low-cost high-quality audio mixing consoles in stereo and mono versions, for broadcast stations, imported audio mixing consoles incorporating ultra-thin control modules, variety of professional audio amplifiers and speaker boxes, LDH20, LDK2 and LDk2A colour TV cameras. Five versions of N1500/1520 video cassette recorder and the new N1460 playback-only VCR. LDH 8310 ministudio 2 cameras, 2 monitors, audio and visual mixing etc.

PHILIPS SCIENTIFIC & INDUSTRIAL EQUIPMENT – oscilloscopes include true dual-beam storage oscilloscope, dual-trace dual-timebase multiplier oscilloscope. Pulse generators covering 1 Hz – 250 MHz with large output amplitude, high frequency and dual outputs.

PLESSEY PACIFIC, Stands 81/84 Unisearch House.

PLESSEY – private automatic branch exchange, telegraph and data testing equipment, including telegraph distortion measuring set, telegraph signal generator and data and telegraph test set.

PLESSEY – Computermatic timber grading machine control unit, shift register controls and a pulse generator used in Plessey mail handling systems and suitable for a wide variety of other sorting and materials handling applications, Portable data capture unit, capable of entering 12,000 individual orders on signal cassette for direct computer input. A light pen system for recording movement of various items such as classified document registries and library circulation systems.

TWO-WAY RADIO EQUIPMENT – UHF mobile radio and hand held portable two-way radios, MTR 40 series mobile plus associated selective-calling encoding and decoding units.

COMPONENTS DIVISION – lithium and nickel-cadmium batteries, switches, lamps and indicators, potentiometers, connectors, dry reed inserts and relays, optoelectronic and microelectronic devices, audible electronic signalling devices, capacitors and resistors etc. The division will also display Garrard turntables, the products and facilities of Plessey Semi-conductors (UK) and latest development in local thick film hybrid production.

PLESSEY COMMUNICATION SYSTEMS – Remotecopier KD III facsimile transceiver and the Plessey Electrowriter.

PRINTED ELECTRONIC COMPONENTS, Stand 87 Unisearch House.

COLVERN – potentiometers including cermet trimming, sealed tropical, miniature, helical and precision cam-corrected potentiometers.

KYORITSU ELECTRONICAL INSTRUMENT WORKS – panel, edgewise and educational meters.

OXLEY DEVELOPMENTS – range of printed circuit board accessories, trimmer capacitors and solid state indicator lamps.

SILICONIX – FET, MOS, FET, technology, FET high frequency amplifiers, low gate current devices, photosensitive circuits and analogue switching.

THE SUPERIOR ELECTRIC COMPANY – AC synchronous/DC stepping motors with associated controls, variable transformers and voltage regulators.

RACAL ELECTRONICS, Stands 76/79 Unisearch House.

RADIO COMMUNICATIONS PRODUCTS – marine and land mobile radio-telephone equipment including synthesised, but free-tuned, receiver for ISB, AFC, FSK and dual diversity operation, wide range communication and ancillary equipment for use by industry and the Services.

INSTRUMENTS & COMPONENTS – test and measuring instruments, includes digital frequency meters up to 3 GHz, universal counter/timers and specialised communications test equipment for calibration and measurement of MF/VHF/UHF transmitters and receivers, digital multimeters and panel meter components intended for use in the telecommunications field.

RANK INDUSTRIES AUSTRALIA, Stands 1/10 Round House.

CONTROL DESIGN CORPORATION – automated radio broadcasting systems, type CD28AS is 80-event sequential system, CD28APM system with memory ranging from 2000 to 8000 events and hire function codes. Both systems have keyboard entry, silent sensor alarm and switch selected audio fade.

RCA, Common Room, New College.

QUADRUPLEX VIDEO TAPE RECORDER – includes computer wiring techniques, computer component insertion and final computer testing, visitors welcome to operate it, also portable quadruplex video tape recorder.

PORTABLE COLOUR CAMERA – features the incorporation Mini-Pack CGU and Mini-Max Adaptor to adapt to regular large studio type zoom lenses.

TELECINE EQUIPMENT – TK-28 Telecine Island incorporates two cameras, one with PbO tubes and other with vidicon tubes. One camera will be fully operational, has A.S.C.E.T. automatic system which inclues automatic differential gamma correction for mid-tone colour errors. Visitors are invited to bring along clips of poor film with any colour cast for demonstration of system's ability.

SCALAR INDUSTRIES, Stands 110/111, Unisearch House.

SCALAR INDUSTRIES – VHF-UHF omnidirectional base station, VHF-UHF mobile, VHF-UHF directional, H.F. antennas – land & marine, citizen band and paging antennas, installation hardware and accessories, radio frequency interference suppression.

HATFIELD INSTRUMENTS – attenutators, baluns and instrumentation.

GRANGER ASSOCIATES – baluns, transformers, multicouplers and complete capability of H.F. antenna systems.

CLARK MASTS – Nato codified air operated telescopic masts.

ALLTRONICS – secure communication and signal-line filters, filter discharge units, RF filter and shielded circuit breaker panelboards, power line filters.

PRODELIN – microwave antennas and transmission line systems.

DECIBEL PRODUCTS – bandpass and band-reject filters, bandpass cavities, mobile duplexers.

FILTRON – secure communication and signal line filters, power line filters, etc.

METEX – EMI shielding material, gaskets and components.

KNITMESH – R.F.I. shields.

CARPENTER – wire stripping equipment.

SCIENTIFIC DEVICES AUSTRALIA, Stand 41/42 Unisearch House.

SYSTRON-DONNER – microwave frequency counter measures to 18 GHz with high FM tolerance to 3500 MHz.

NATIONAL – dual channel inkless recorder capable of printing in two different colours.

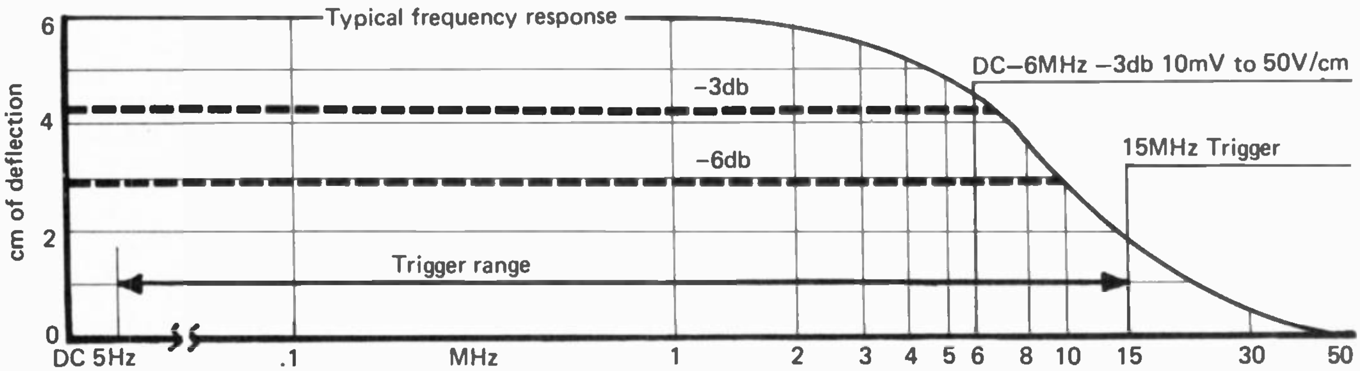
BOONTON – phase locked 520 MHz signal generator.

RFL – crystal impedance meter.

ELECTRO SCIENTIFIC INDS digital IC tester linear IC tester.

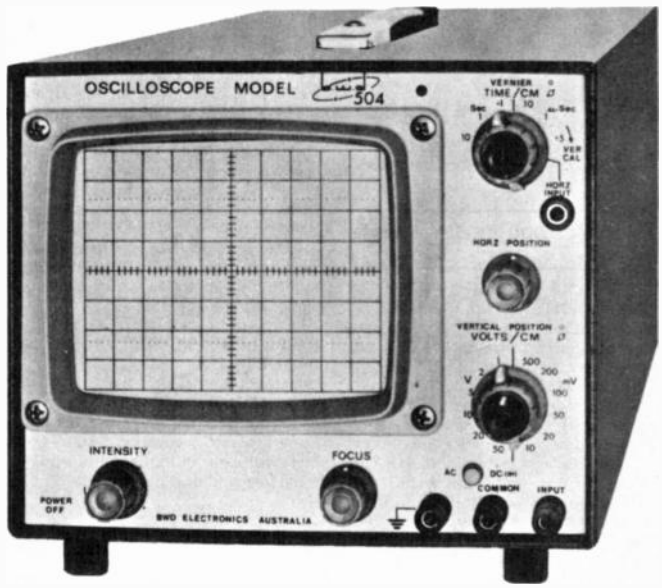
A DC to 6MHz, CALIBRATED, TRIGGERED, OSCILLOSCOPE

FOR UNDER $200 including Tax!



bwd 504

4.5kg of high performance with 12 months warranty.



JUST LOOK AT THIS SPEC

DC to 6MHz–3db	bandwidth
10mV to 50V/cm	sensitivity
5Hz to 15MHz	triggering
0.5μSec to 1sec/cm	time base
DC to 1MHz–3db	X–Y operation
8 x 10cm	CRT screen
1.6KV	EHT
±400V DC isolation	input ground

PLUS

5% calibration including effects of a 10% line change.

Completely automatic triggering of almost any waveform to 15MHz

Phase corrected X–Y operation to <3° from DC to 50kHz.

Usable frequency response to beyond 25MHz.

$178 plus tax if applicable

Price includes x1 signal and ground probes plus moulded protective pack.
Ex distributor, Aust. Capital City.

AND LOOK INSIDE . . .
there's an all silicon solid state circuit, an astatically wound 'C' core transformer, a completely balanced vertical amplifier with excellent pulse response, a fully protected FET input stage to ±400V and a compensated 12 step attenuator accurate to 2% at each step. Built in reliability with conservatively rated high stability components throughout.

bwd 504 an AUSTRALIAN instrument for the INTERNATIONAL market.

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SELECTRONIC COMPONENTS, Stand 88 Unisearch House.

SELECTRONIC – aerial and oscillator coils, IF transformers, chokes, RF and TV, chokes, audio equalising and filter, crossover networks, mains filter suppressors, transformers, custom wound components.

CHANNELLOCK – comprehensive range of tools designed specifically for the electronics industry.

SIEMENS INDUSTRIES, Display Stand, Wheen Room, Goldstein College.

SIEMENS INDUSTRIES – broad spectrum of products, automated electronic traffic signal controller.

SIEMENS CROSSPOINT PABS SYSTEM – with ESK relays, topset executive secretary telephone system.

ELECTRONIC COMPONENTS – comprehensive range of TV wound components for transistor and thyristor deflection circuits, components for use in colour TV receivers, semiconductors, liquid crystal displays, red, green, yellow and orange discrete LED's, 7-segment LED displays, LD241 high power infra-red LED, photo diode suitable for infra-red transmission of audio signals, stacked foil polycarbonate capacitors, ceramic capacitors, motor capacitors, large value electrolytics, RF interference suppression components and filters, gaseous arrestors, connectors and cable relays.

LONG RANGE TRANSMISSION SYSTEMS – carrier multiplex equipment featuring channel, group and supergroup modems and a 12 MHz underground repeater. High capacity long haul 4 GHz radio relay equipment plus medium capacity 300 MHz equipment and associated multiplex.

MEASURING INSTRUMENTS – white noise measuring setup, level measurement and automated setups for programme lines etc.

SYNTEC, Stands 38/40 Unisearch House.

POUL KIRK ELECTRONICS – "ON AIR" console.

ORB/PARASOUND – parametric equaliser.

MICMIX – reverberation chamber.

ECONCO – transmitter tube re work service.

ARISTOCART – magnetic tape cartridges.

SPARTA CENTURY – cartridge machines, professional studio turntables.

DESIGN TWO THOUSAND – limiting amplifier.

TEAC – logging (low speed) recorder professional reel/reel recorder.

PKE – pickup equalisers.

SHURE – magnetic pickup cartridges.

BURWEN – dynamic noise filter

KEF – monitoring loudspeaker systems.

WRIGHT – audio amplifiers/phase shifter and mod monitor.

SONY KEMPTRON, Stand 56, Round House.

SONY – cassette recorders with electronic editing facilities, portable colour recorder and camera in PAL version (N.T.S.C. also available), colour studio camera. Subject to arrangements being made, Sony Projection TV system will be shown in audio visual caravan adjacent to Round House, equipment to facilitate multiple cameras and the assembly and editing of programmes. TV monitors for black-white and colour.

TECNICO, Stands 39/41 Round House.

B & K CORPORATION – colour TV test equipment including signal generators, tube checkers, sweep and marker generators, also low cost 3-digit digital multimeter.

DAWE INSTRUMENTS – general purpose and precision sound level meters, also sound and vibration kit, octave band sound level meters and acoustic calibrators, stroboscopes including unit capable of measuring up to 600 000 rpm.

LABGEAR LIMITED – colour bar and pattern generators, TV distribution and masthead amplifiers, indoor and outdoor splitters, and solderless co-axial connectors.

RUSTRAK AND GULTRON RECORDERS – galvanometric and potentiometric types measure power, temperature, pressure, strain, events, etc, Gulton portable multichannel recorders with plug-in signal conditioners and variable chart speeds.

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BACH SIMPSON – analogue and digital multimeters, panel meters and temperature testers.

BELLING & LEE LIMITED – components for circuit protection and indication, RF connectors, terminals and terminal blocks and low frequency connectors.

BOURNS TRIMPOT PRODUCTS AND INSTRUMENTATION DIVISION – adjustment potentiometers, control/variable resistors, precision potentiometers and resistor networks. Basic elements include wirewound, conductive plastic, carbon and a Hybritron which is conductive plastic on wirewound. Special potentiometers, industrial and aerospace transducers including linear, gauge, altitude, airspeed and absolute pressure devices.

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SIGNETICS CORPORATION – TTL/MSI, Bipoles, Memory, Linear, MOS/CMOS and a large range of interface element devices, devices for FM reception including gain blocks, stereo decoders and complete receiver subsystems. D-MOS series monolithic arrays of silicon insulated gate field effect transistors using the N-Channel enhancement mode process.

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3M COMPANY ELECTRICAL PRODUCTS DIVISION – Scotchflex cable interconnecting systems.

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6 DIGIT CLOCK KIT

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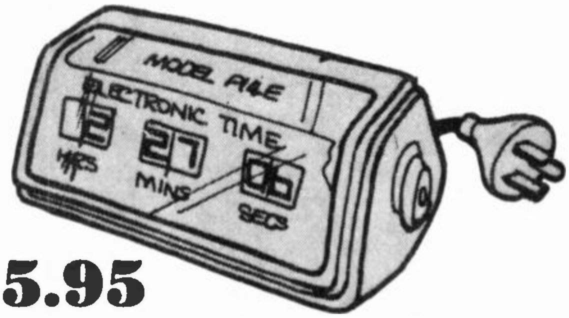

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"Space-Age" techniques permit the simple construction of a modern electronic clock in an attractive, compact case — AT VERY LOW COST.

Six large, bright green numerals indicate highly accurate time in 12 or 24 hour format. The kit includes P.C. board, IC and socket, transformer, case, etc. — AN IDEAL BEGINNERS PROJECT. $35.95. P&P $2.

6 DIGIT CALENDAR CLOCK KIT WITH ALARM

Similar in appearance to the one above, this de-luxe version indicates AM or PM as well as the date, which automatically appears (briefly) approximately every 10 seconds and features a built-in electronic audible alarm with "snooze" facility — i.e. the alarm will operate every 10 minutes until switched off. The kit is complete, as above, for only $47.95. P&P $2.

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HUGE PRICE REDUCTION!
Popular Expo model TC-601,
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- Fast forward lever.
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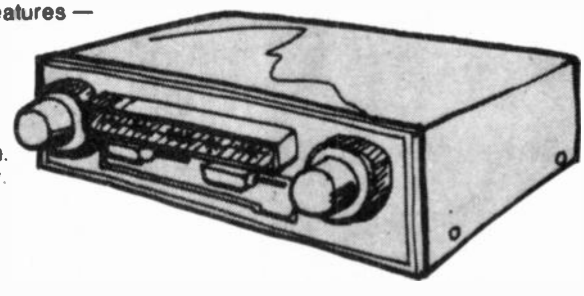

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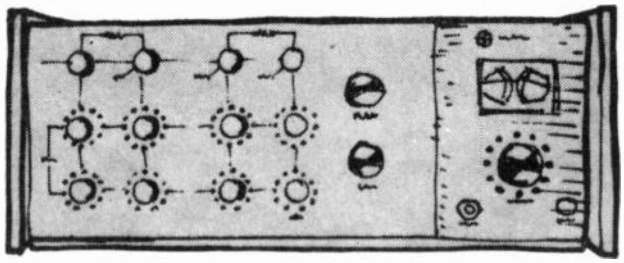
8 INPUT STEREO/MONO MIXER



Ideal for hobbyist or professional use. $135.00. P&P $5.

This new multi-input mixer offers automatic muting, base/treble controls, headphone monitoring, signal metering and plug-in pre-amps for a wide variety of signal sources, e.g., mics, phono, tape deck, etc.

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ETI 440 25 WATT/CHANNEL

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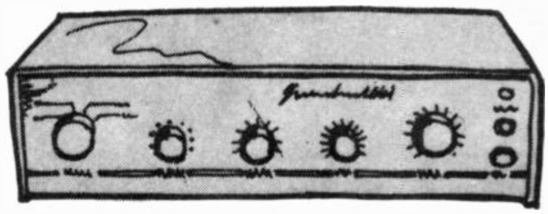

Big performance at a low price. $95.00. P&P $3.

Check the impressive performance figures on page 70, July ETI, and see for yourself. Simplicity of construction makes this great new kit a practical beginner's project, with 9 pages of instructions, etc., to make it easy for you.

$95.00

1 HOUR TIMER

$4.95. P&P 75c.

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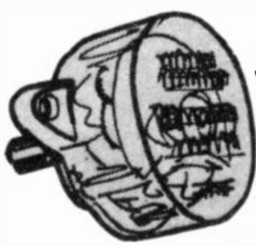

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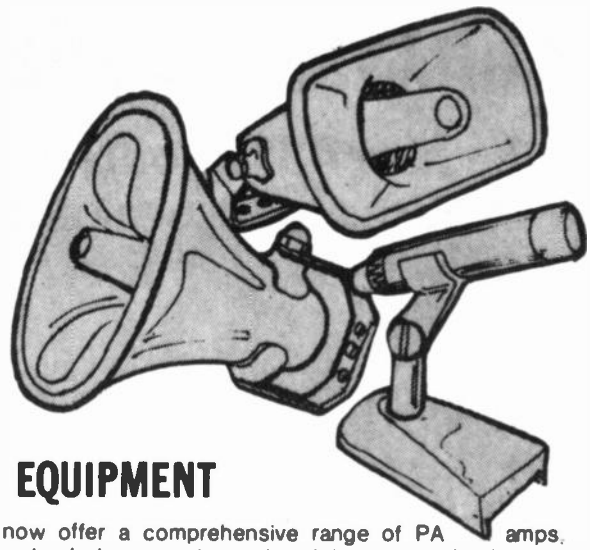

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$29.00

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NOW AVAILABLE $1.35. P&P 20c.

LM 3909 FLASHING LED INDICATOR IC

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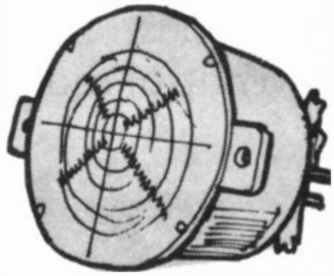

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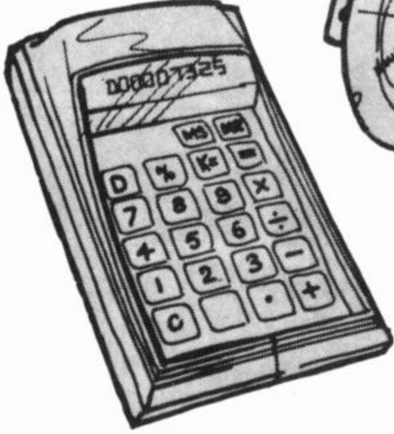

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Code: F—floating. K—constant. BS—battery save feature. MS—Memory storage. MC—accumulating memory.

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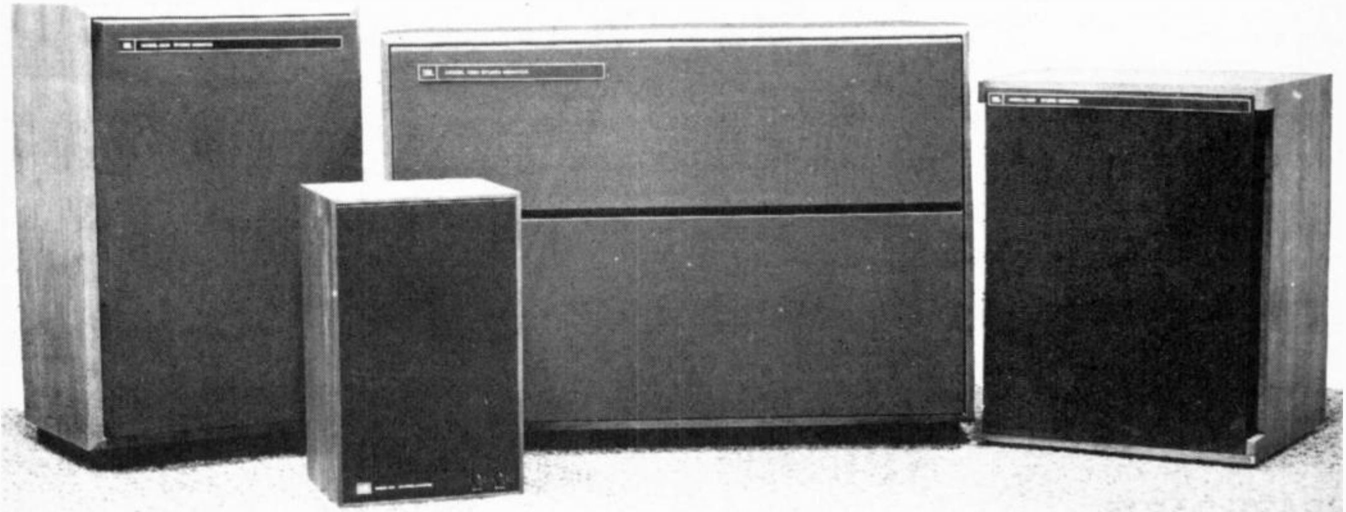

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eti PROJECT 118

SIMPLE FREQUENCY COUNTER

Inexpensive unit works to 1 MHz.

WE CONTINUE our series of simple units, based on the ETI 533 Display Module, by describing a simple frequency meter. The unit is easy to construct and quite inexpensive.

DESIGN FEATURES

We originally considered that this project would only take a short time to develop — but were we ever wrong! Just about everything that could have gone wrong did so, and we became convinced that Murphy, was not only alive and well but, was living in Rushcutters Bay.

The first problem was to choose suitable timebase circuitry. As the project had to remain fairly economical to build, the use of a crystal timebase was ruled out. We eliminated a mains referenced timebase because it was considered that the possibility of battery powered operation was a definite advantage. Especially as control tones on the mains can cause problems.

An NE555 timer was tried for the 10 second timebase but it soon became apparent that the device just was not stable enough even when the power supply was regulated. The change in frequency due to supply changes was about 1.5%/volt. And even with a regulator the stability was not good enough to allow more than four digit readings. The error occurs because the NE555 output stage does not go exactly to the supply rails but only 0.6 V away from them. The same applies to the discharge transistor which has a fixed saturation voltage.

We considered many oscillator designs in an effort to find one with a stability of better than one part in 10 000 and ultimately chose the one shown in the circuit diagram. This type of oscillator is well known but is not normally considered to have good accuracy and stability. This is because in a conventional op-amp IC there is normally a base-emitter junction at the output, as in the 555. However in the new CA 3130 device this problem has been eliminated as the output stage is CMOS and appears as a resistance (about 500 ohms) and not as a voltage drop. A further advantage of this IC is the extremely high input impedance which eliminates any inaccuracies due to loading effects. On the prototype the frequency change was less than one part in 10 000 with a supply voltage change of from 8 to 16 volts. The main source of error is now due to the temperature coefficient of R10. The expected error, using good quality metal-film resistors would be around 0.01% per degree C.

The CA3130 IC is also ideal for the input stage, because of its high input impedance, and also because it allows a 0 V reference to be used thus eliminating the centre-tap point normally required for conventional operational amplifier circuits.

(Main text continued page 75)

SPECIFICATION

INPUT IMPEDANCE	470 k // 47 pF
INPUT SENSITIVITY 10 Hz to 10 kHz	< 50 mV rising to 1 V at 1 MHz
RANGES	99.9 Hz to 999 kHz
DISPLAY	3 digits (no overload indication)
ACCURACY	as calibrated.
STABILITY	0.01% can be expected but depends on resistor stability.
OVERLOAD PROTECTION	
up to 100 kHz	50 Vac.
100 kHz to 1 MHz	dropping from 50 Vac to 10 Vac 50 Vdc.
POWER	240 Vac or 12 Vdc at 100 mA.

SIMPLE FREQUENCY COUNTER

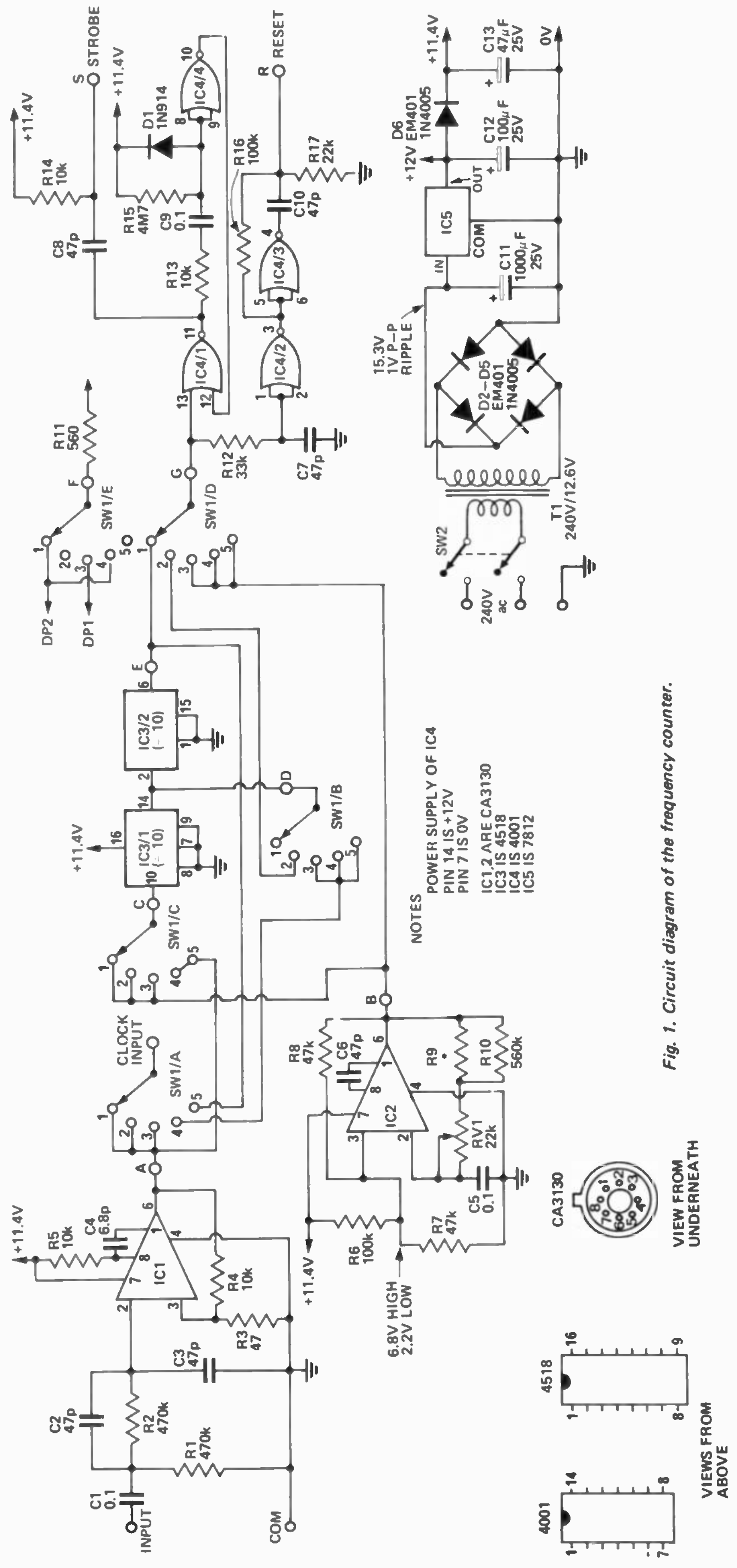


Fig. 1. Circuit diagram of the frequency counter.

PARTS LIST

R3	Resistor	47 ohm	¼W	5%
R11	"	560	¼W	5%
R4,5,13,14	"	10 k	¼W	5%
R17	"	22 k	¼W	5%
R12	"	33 k	¼W	5%
R7,8	"	47 k	¼W	5%
R6,16	"	100 k	¼W	5%
R1,2	"	470 k	¼W	5%
R10	"	560 k	¼W	2%
R15	"	4M7	¼W	5%

R9 (See table 1)

C4	Capacitor	6.8 pF ceramic
C2,3,6	"	47 pF ceramic
C7,8,10	"	47 pf ceramic
C1,5,9	"	0.1 µF 100v polyester
C13	"	47 µF 25 V electro
C12	"	100 µF 25 V electro
C11	"	1000 µF 25 V electro

D1 Diode IN914 or similar
D2-D6 " EM401, IN4005 or similar

IC1,2 Integrated Circuit CA3130 (AWV)
IC3 " " ·4518 (CMOS)
IC4 " " 4001 (CMOS)
IC5 " " 7812 (plastic pack).

SW1 Rotary switch 6 pole 5 position
SW2 toggle switch DPDT (miniature)
T1 transformer 240 V/12.6 V 150 mA

PC Board ETI 118
Case type PC1 (A&R Soanar) or similar

Shield as per Fig. 7.
Front panel as per Fig. 5.
3 plain spacers 6.4 mm long insulated
3 plain spacers 19 mm long
3 1/8 whit. spacers 25 mm long
One 8 way tag strip
3 core flex plug, grommet and clamp pc board pins
3 25 mm long 1/8 whit. screws
9 12 mm long 1/8 whit. screws
6 1/8 nuts.
Two input terminals (red-black)

PARTS AVAILABILITY

The CMOS ICs used in this project are distributed by CEMA and TOTAL.

We have been informed that the CMOS counter type 14553 is at present out of stock but will be readily available by the end of August.

HOW IT WORKS – ETI 118

The frequency counter may be divided into several basic sections.

a. Input amplifier – Schmitt trigger.
b. 10 Hz oscillator.
c. Two divide by 10 networks.
d. Strobe and reset circuitry.
e. Power supply.
f. Display module (ETI 533).

The input amplifier is a CA3130 connected as a Schmitt trigger. Resistors R3 and R4 provide positive feedback whilst resistor R2 provides protection for the input of the IC. The resistor R5 is used to increase the negative slew rate of the amplifier thus increasing the range of operation to one megahertz.

The 10 Hz oscillator is another CA3130 where positive feedback is applied by R8 and negative feedback by R10. When the output is high the voltage at pin 6 is about 6.8 volts. The capacitor C5 charges via R10, and when it reaches 6.8 volts the output goes low. The voltage now set at pin three is 2.2 volts and the output remains low until C5 has discharged to this point at which the output goes high again. Preset RV1 varies the oscillator frequency by

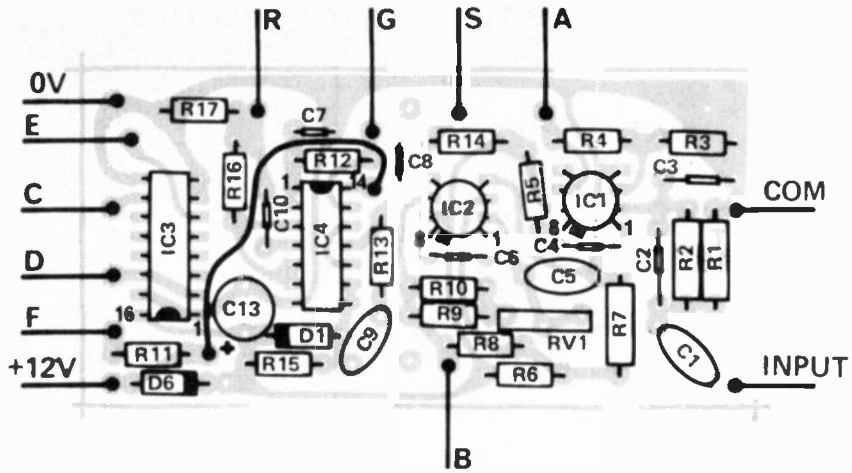


Fig. 2. Component overlay.

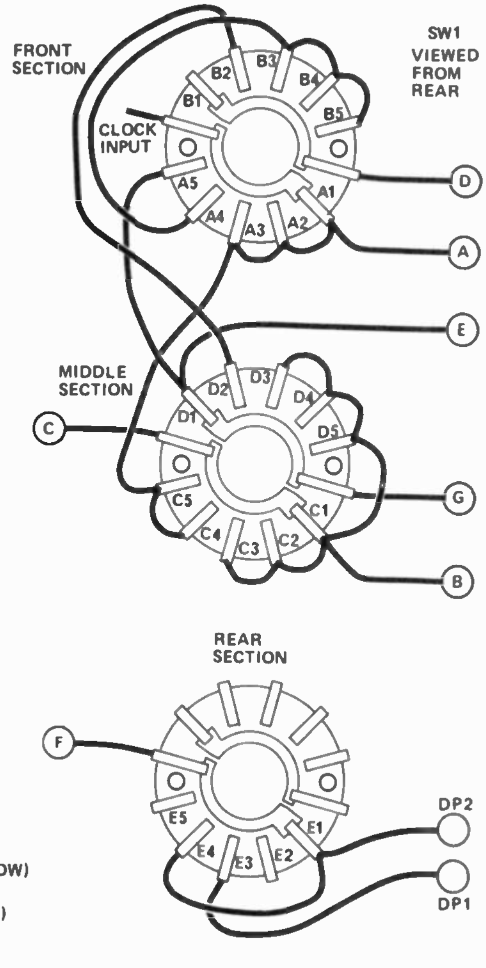


Fig. 3. Wiring of the range switch.

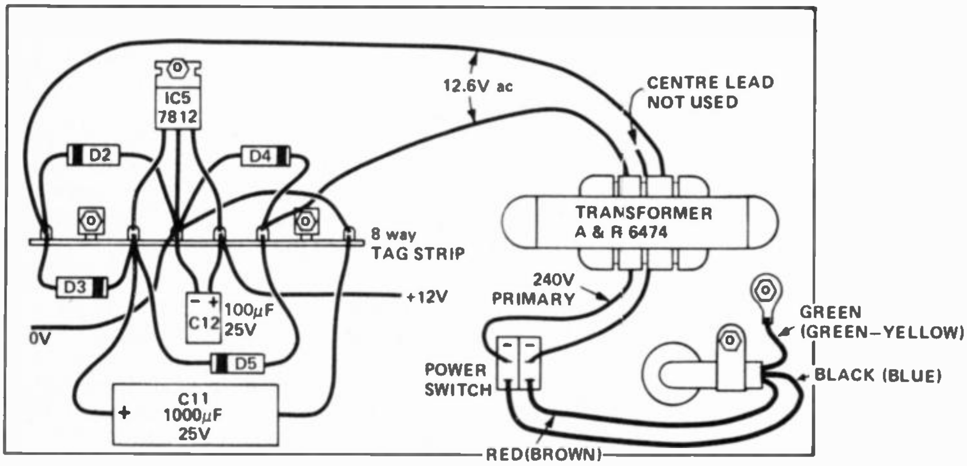


Fig. 4. How the power supply is mounted on the back panel and interconnected.

about 4% and a parallel resistor, R9, is required to set it within the required adjustment range. A higher value preset could be used but it becomes difficult to adjust with accuracy.

The divide by ten circuitry is simply a 14518 IC which contains two decade counters. It can be switched to divide the input frequency (100 k, 1 M ranges) or the timebase (100 Hz, 1 kHz ranges) by means of the range switch SW1.

The timebase, be it ten seconds, one second or 0.1 seconds, is coupled by SW1/d to IC4/1 pin 13. When this voltage goes high the output of IC4/1 goes low and C1 couples a short negative going pulse into the strobe terminal of the display module. After a short time, due to R12 and C7, the output of IC4/3 goes high and C10 couples a short positive pulse into the reset terminal of the display module. When the output of IC4/1 goes low the output of IC4/4 goes high and the output of IC4/1 remains low irrespective of what now occurs at pin 13. After about 350 milliseconds C9 recharges via R15 releasing IC4/1 to the control of the timebase. This procedure removes three out of every four strobe pulses when using the 10 Hz timebase, making the display easier to read.

The resistor R16 is used to raise the steady-state voltage at the reset terminal to about 1.8 volts, thus ensuring that the reset pulse goes high enough to give reliable triggering. The voltage at the strobe terminal sits at about 10.4 volts due to the 100 k input impedance of the display module.

The power supply is a full-wave rectifier and capacitor filter supply which is regulated down to 12 volts by a 7812 regulator IC. The control circuitry is isolated by a diode D6 and capacitor C13 to prevent any ripple appearing on the 12 volts due to the current drawn by the display module.

The display module contains a three decade counter-store-decoder and display as published in the July 75 issue of ETI.

To measure frequency all that is needed is to count the number of pulses occurring over a given period of time. If we count the number of input pulses over a one second period we can measure to the nearest one cycle, or one hertz. If a three digit display is used then the maximum reading will be 999 Hz. However if the frequency happens to be, say, 156254 Hz the display will read 254 and ignore the 156. To measure a higher frequency, either a shorter timebase must be used, or, the input frequency must be divided down. For the 10 kHz range we simply use an 0.1 second timebase giving 10 Hz resolution. For the 100 kHz we divide the input by 10 and use an 0.1 second timebase, whilst for the one megahertz range the input is divided by one hundred. For the 100 Hz range a ten second timebase and no division is used.

If we use the one megahertz range to measure our 156254 Hz, we display 156. Switching to 100 kHz we get 563, on 10 kHz we get 625 and finally 254 on the 1000 Hz range, thus the frequency can be read to the nearest hertz but the accuracy depends on the accuracy of the initial setting up and the fact that temperature variations cause an error of one part in 10 000 per degree C.

SIMPLE FREQUENCY COUNTER

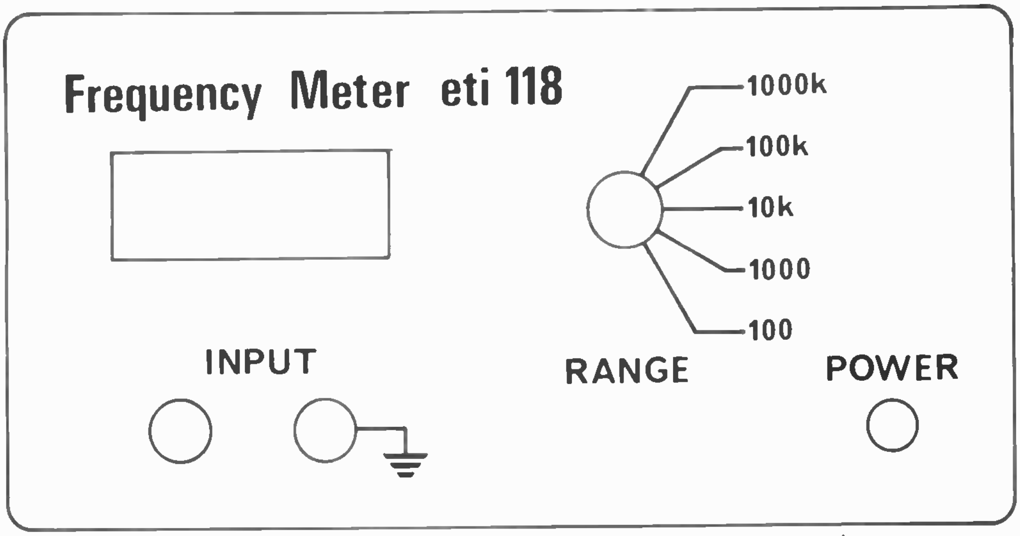


Fig. 5. Front panel of the frequency meter.

Initially the maximum frequency of operation was limited to 200 kHz due to the slow, negative slew-rate of the IC. Looking at the internal circuit of the IC it was decided to increase the bias current in the second stage by adding a resistor between the positive supply and pin 8. This allows the frequency response to be extended to beyond one megahertz. A small compensating capacitor was found to be necessary to eliminate the effects of a small amount of coupling from the 10 Hz oscillator. The resistor to pin 8 also alters the offset voltage but this does not affect the operation of this circuit.

Another problem that occurred was in the strobe and reset pulse network. Using an 0.1 second timebase the display changes too rapidly for ease of reading. Therefore IC4/4, which is connected as a 350 millisecond monostable, is used to eliminate three out of every four strobe pulses thus making the display more readable. However it was discovered that, when using this delay, the timebase changed frequency by about four parts in 10 000. Since the power supply to the control circuitry was isolated from the display module, the circuitry is mainly CMOS, and the oscillator rejects supply rail change, none of these factors could be suspected as a cause of the trouble. The problem was due to the fact that IC4/4 works in the linear mode and can draw 10 to 20 mA. This modulates the power supply by up to 20 millivolts. The cure is to power IC4 directly from the 12 volts. This explains the use of the link of the board.

Some coupling between the display board oscillator and the input stage occurred and was cured by adding an aluminium shield between the two boards.

To obtain all five ranges with only two divide-by-ten sections necessitates a more complex switch. This was considered to be justifiable as the alternative was to use a switch with one less wafer but add one more 14518 IC.

CONSTRUCTION

The display module should be constructed as described in the July issue of ETI. The value of resistors R5 to R11 should be 560 ohms for operation of the 12 volt supply.

The control board should be assembled with the aid of the component overlay Fig. 2. Use printed circuit board pins for all outputs and for R9 as an aid to later assembly. Make sure that the link between +12 volts and pin 14 of IC4 is installed.

Wire switch SW1, in accordance with Fig. 3, and leave the leads long enough to reach the printed circuit board. Assemble the power supply onto the tag strip and the back panel of the box as detailed in Fig. 4. There is no need to insulate the tag of the regulator from the rear panel as it is the common terminal which should be earthed. The rear panel itself is earthed via the mains cable.

The front panel has to be cut and drilled as shown in Fig. 5. It can be either silk screened with the required

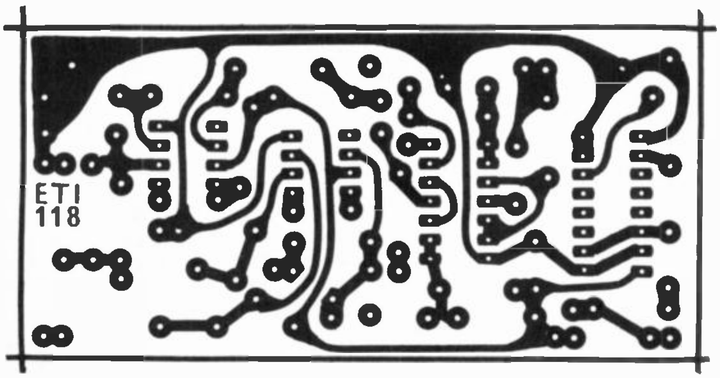


Fig. 6. Printed circuit board for the counter. Full size 90 x 45 mm.

TABLE 1

Frequency with RV1 at minimum 50 Hz input	Value of R9 to allow RV1 to calibrate
48.1 – 50	–
49.8 – 51.8	15 Meg
51.3 – 53.4	8.2 Meg
52.7 – 55.0	5.6 Meg
54.7 – 57.1	3.9 Meg
56.7 – 59.3	3.0 Meg
58.8 – 61.7	2.4 Meg

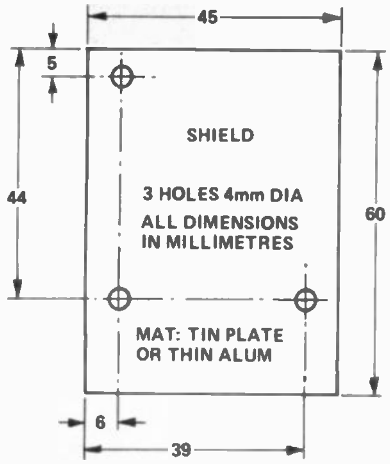


Fig. 7. Drilling details of the shield plate.

range markings etc, or a Scotchcal panel can be used as in our prototype. Scotchcal panels for this project can be obtained for $2.00 (plus SAE) directly from Electronics Today. A piece of polarized or red plastic can be used to protect the displays. If the A&R box, as specified, is used mounting holes will have to be drilled in the base of the box. These can be marked by temporarily installing the front panel, by fitting the three 25 mm spacers to the control module (the left front mounting hole on the module is not used) and sitting the control module in position. It will be found that the right front spacer interferes with a rib in the base of the box. Cut this rib away with a chisel or similar tool such that the spacer can sit flush with the base. Mark the hole positions, remove the module and drill the holes.

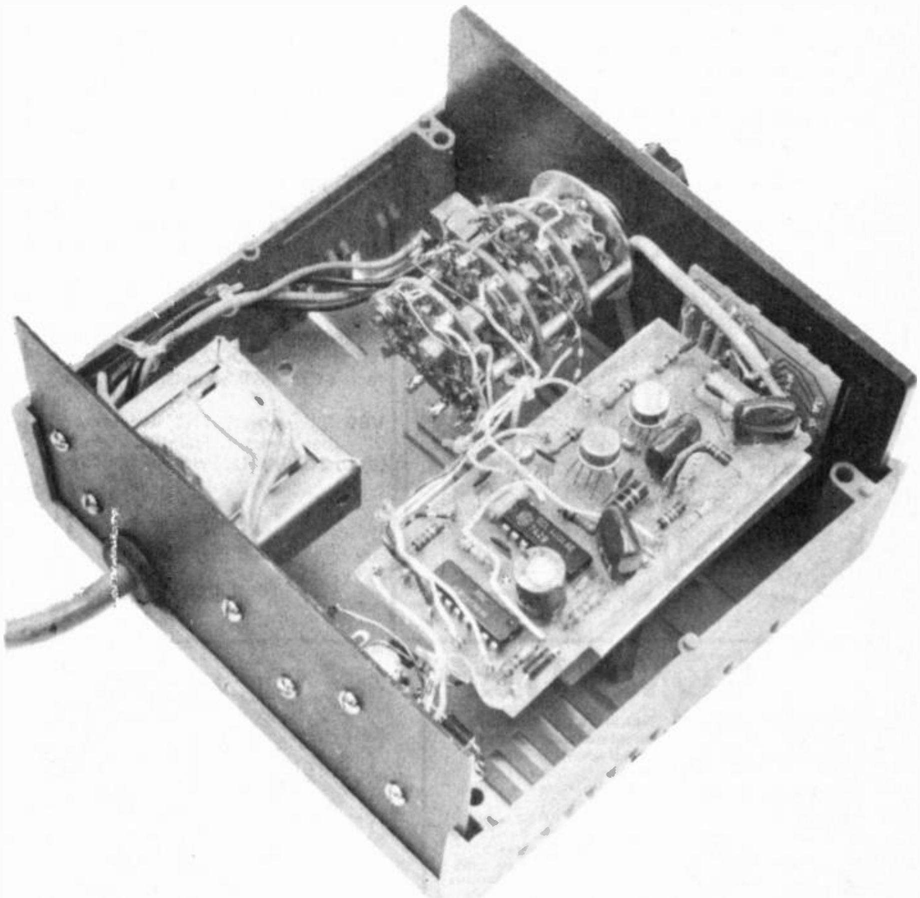
Fit the rear panel in to the box and then mount the input terminals to the front panel (the rear of the screws of the terminals may have to be shortened to clear the display module mounting spacers). The rotary and toggle switches should also now be mounted to the front panel. Connect a short length of coaxial cable to the input terminals (about 150 mm) for later connection to the control board. Connect leads to the positive volt, zero volt, strobe, reset and input clock inputs on the display module and assemble the display board, shield and control board as shown in Fig. 8. Make sure that the spacers do not touch the copper tracks on any of the boards, (except for the front spacer on the control board). If any of the spacers are too close to the tracks add a piece of insulation material under the spacer. The whole assembly can now be mounted in to the box.

On the display module the power rails are taken direct to the power supply whilst the 'reset' and 'strobe' go to the control board and the 'control' to the rotary switch. On the control board the power rails also go direct to the power supply whilst all other leads, with the exception of the coaxial cable, go to the rotary switch.

Finally connect the power switch and insulate it with plastic tape to prevent accidental personal contact.

CALIBRATION

Apply about 6 volts ac at 50 Hz, from the secondary of a power transformer to the input of the counter. Select the 100 Hz range and set the trimpot, RV1, to its minimum resistance position. Wait for the reading to settle (there is about ten seconds between readings) and using this reading look up the corresponding value of R9 from Table 1. Instal this resistor and again check the reading, it should now be just under 50 Hz. The trimpot RV1 can now be adjusted to give a reading of exactly 50.0 Hz. If a more accurate frequency source than the mains is available it can be used instead of the 50 Hz for final calibration. Due to the effect of soldering upon the value of resistors final calibration should be left until several hours after R9 is soldered into position so that the resistor may stabilize. ●



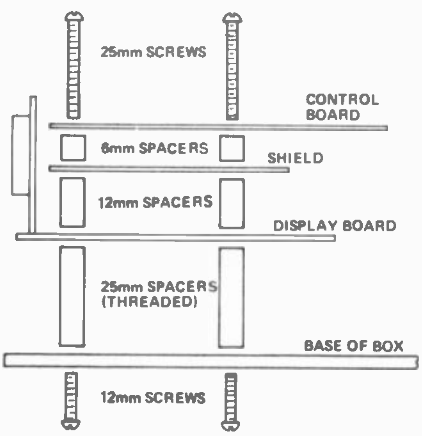


Fig. 8. Assembly of the counter display boards.

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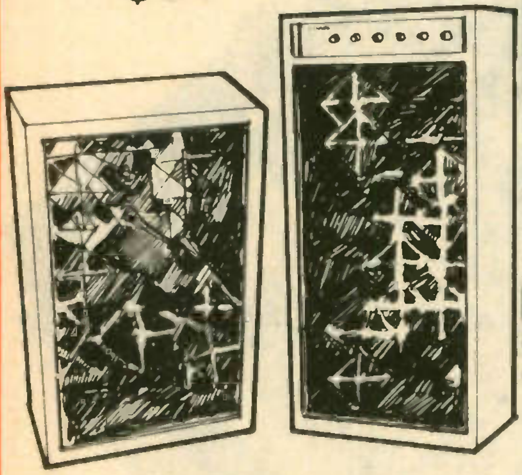

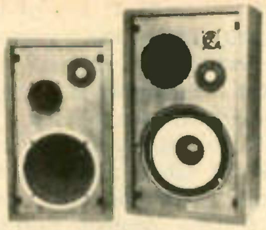

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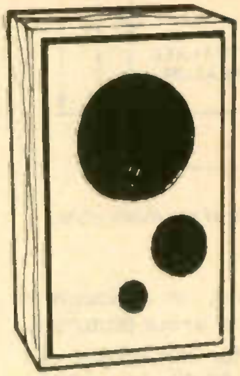

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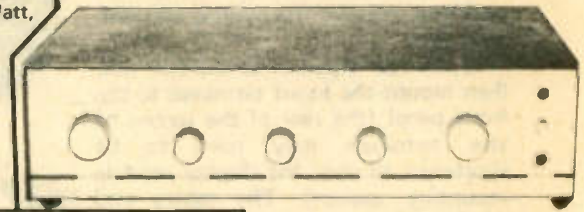

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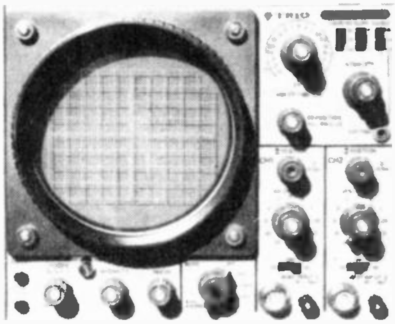

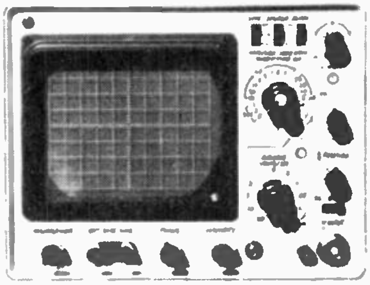

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Sensitivity	250mV cm	250mV/cm	500mV/cm
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Method	Trigger sweep, Automatic sweep	Triggered or self excited sweep	
Time Base	0 5 microsecond/cm to 0 5 second/cm in 19 calibrated steps with continuously variable control for TV–H, TV–V, and EXT	0 5 µ sec/cm – 0 5 sec/cm in 19 ranges, plus TV–V and TV–H, with fine control of each range, or EXT	10 Hz – 100 kHz in 4 range
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Synchronization:			
Triggering	Internal, CH1, external or line, either + or – on all modes	Internal or external (+) or ( ) in each mode.	Internal (–) only
Range	CH1 More than 10 Vpp Internal More than 10mm on screen External More than 1 Vpp	Internal 20Hz – 10MHz for 10mm on screen External 20Hz – 10MHz at 1Vpp	**Intensity Modulation:** 25 Vpp
Frequency	AC 30Hz to 10MHz LF 5Hz to 10kHz DC DC to 10kHz		
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Output Waveform	1 kHz sqaure wave	0 5V pp 1kHz square wave	
Output Voltage	10 Vpp, 1 Vpp		
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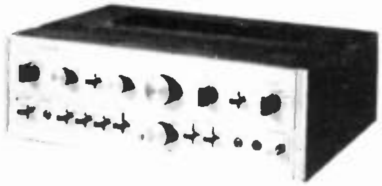

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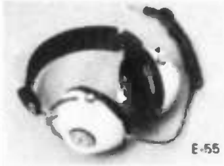

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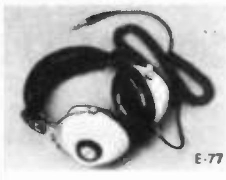

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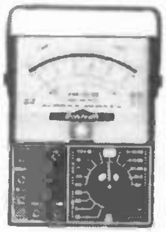

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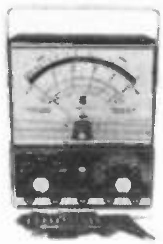

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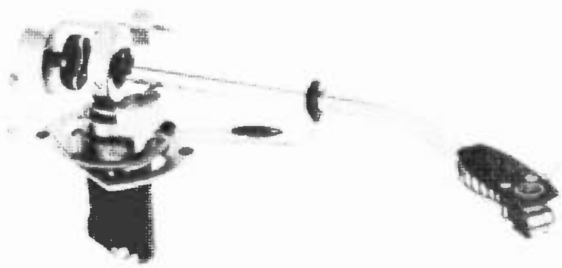

Technico SL120 ...
the turntable with a heart

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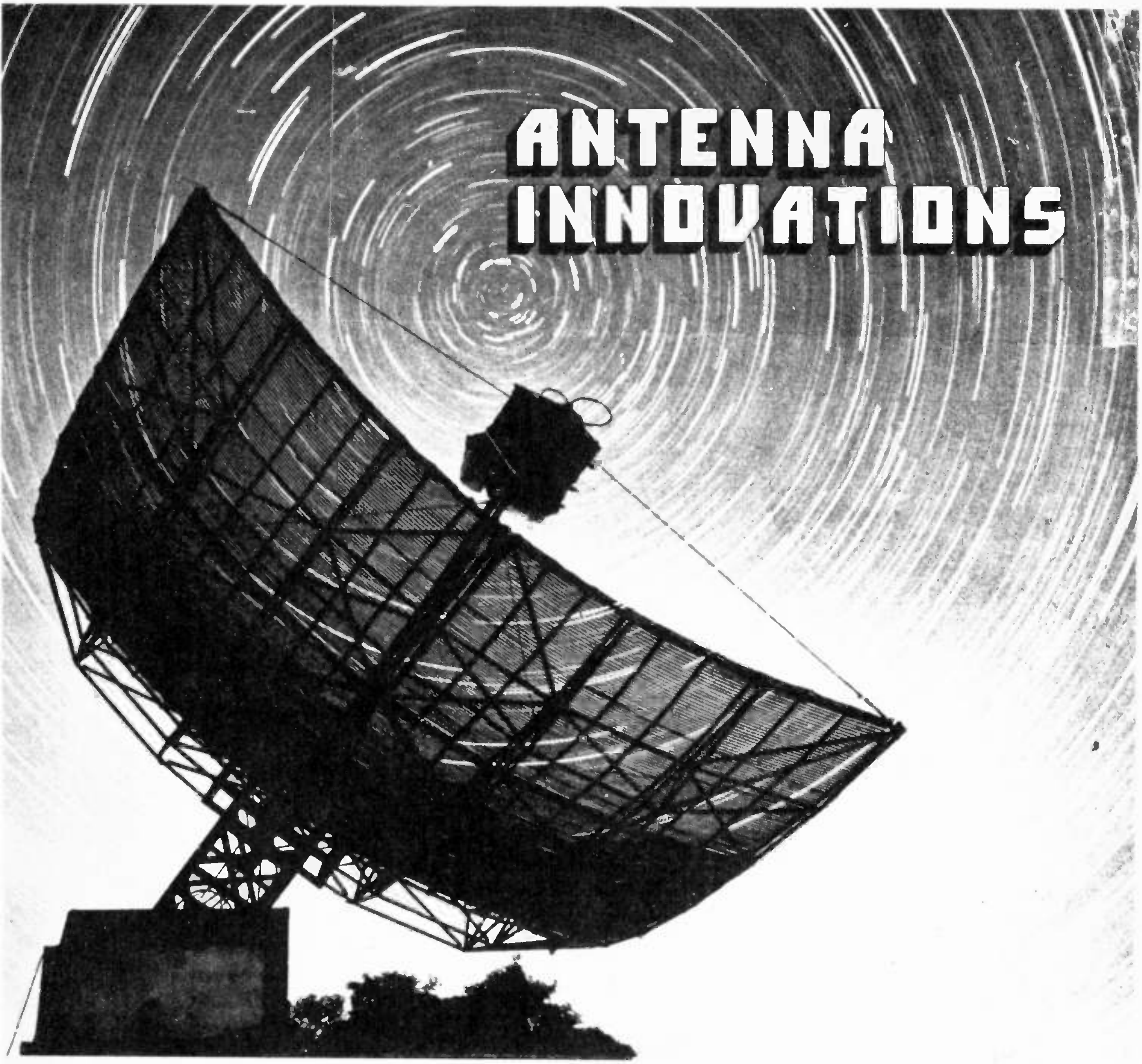
STATE OF THE ART

By Roger Harrison — VK2ZTB

ANTENNA INNOVATIONS



FOR A NUMBER of years now, various workers have demonstrated that yagi arrays of loop elements* have distinct advantages, in size and gain, over the conventional yagi array of parasitic dipoles. For example, see the article by Ian Berwick VK3ALZ (references 1 and 2). An article by John Lindsay WØHTH in WST, May 1968 (3) is also very instructive. (This article has been precised in the ARRL 'Antenna Handbook').

Typically, the gain advantages of loop yagis over conventional yagis, of the same length, is about 2 dB. Not much when you look at it. But, for arrays longer than about a wavelength, a conventional yagi would have to be nearly twice as long as a quad of equivalent gain!

In their classic article on yagi antenna design, Ehrenspeck and Poehler in 1959 (4) stated that the phase velocity of a surface wave travelling along the directors of the yagi array can be used as the design criterion for maximum gain, which seems to indicate that the shape of the elements should have little influence. A short paper by J. Appel-Hansen, in 1972 (5), reported the results of an experiment confirming this; admittedly under limited circumstances. The paper described gain comparisons between antennae having identical numbers of elements, with identical spacings, but with different element shapes (ie: rods and circular loops of flate plate and wire).

Over the years since Ehrenspeck and Poehler's original article, many improvements have been made in their

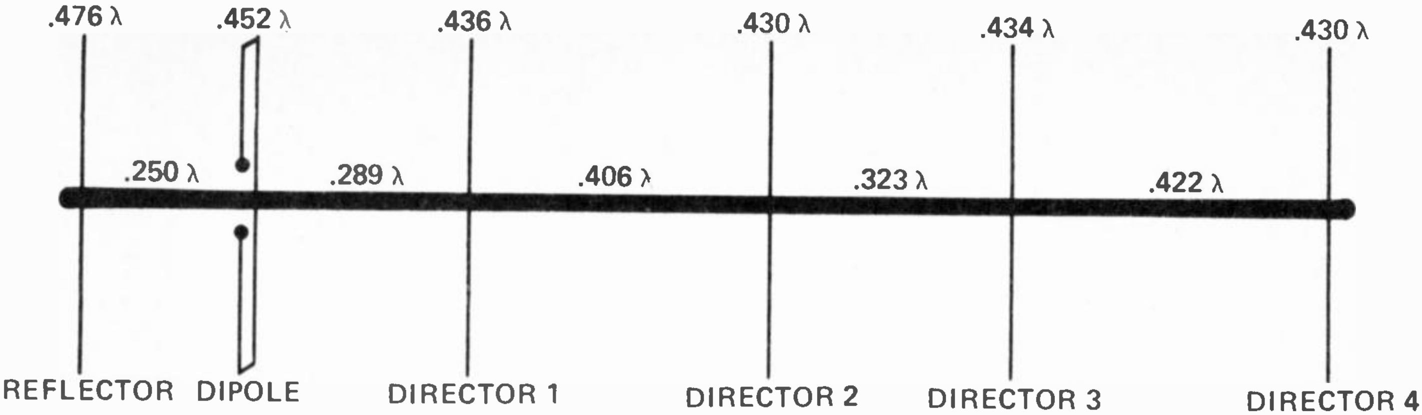


Fig. 1. Yagi after Chen and Cheng (6).

design method and with practical techniques. However, in particular terms, loop yagis still take the lead.

So, if Ehrenspeck and Poehler are correct (and nobody has really proved they aren't), why the observed difference between yagis and loop yagis?

The answer probably lies in practical difficulties. It seems easier to fulfil the required conditions for optimum gain when using loop elements (see references 1 and 2). The controversy of loop yagis (usually the popular 'quad') versus conventional yagis has raged for many years as the advantages and disadvantages of each are almost legion. Usually, something very pragmatic such as mechanical convenience, aesthetic appearance (spouse/neighbour appeal) or filthy lucre is the decisive influence in an individual's choice. At the risk of feeding the controversy, I draw to your attention two recent papers that detail design methods for optimum gain arrays, one for yagis of conventional design and one for loop yagis.

The first is entitled "Optimum Element Lengths for Yagi-Uda Arrays" (by C. A. Chen and D. K. Cheng) and appeared in the January 1975 issue of the IEEE (USA) journal 'Transactions on Antennas and Propagation) (6). An analytical method is described which achieves maximum gain by shuffling the element lengths and spacings several times until the desired result is achieved (length-spacing perturbation!). The mathematics of the method is too complex to go into here (not that I understand it!) but is amenable to solution using a computer program. I recommend the exercise to those of this perverse bent who have lots of midnight oil to burn and free access to a computer – you could do the amateur radio fraternity a service. May I please have a printout of representative designs? The whole thing is akin to better mousetrap design. Twisting the adage – "build a better yagi and the world will beat a path to your door".

Chen and Cheng computed the parameters for an optimum array starting from a simple six-element yagi consisting of the common combination of a driven dipole, a 4% longer reflector spaced a quarter-wave behind the dipole, and four, uniformly-spaced directors (0.31 wavelength spacing) of equal length (0.43 wavelength). Gain of this initial array is 8.8 dB (gain in dB referred to a dipole), a typical sort of figure. Chen and Cheng then adjusted the parameters of this array for maximum gain, using their perturbation procedures, ending with an array having a gain of 11.25 dBd. In the process, the length increases from 1.49 to 1.69 wavelengths. The gain increase is nearly 2.5 dB, which puts the array in the same ballpark as loop yagis of similar length, judging by references 1, 2 and 3.

This six element yagi, and the element lengths and spacings, is illustrated in Figure 1. Dimensions of element lengths and spacings for

TABLE 1 ELEMENT DIMENSIONS

ELEMENT	LENGTH IN λ	FREQUENCIES (MHz) 28.5	52.1	144.1	146.0	432.1	435	2 MBS-Fm 92.1
REFLECTOR	.476	4.852 m	2.654 m	960	947	320	318	1.502 m
DIPOLE	.452	4.607 m	2.520 m	911	899	304	302	1.426 m
DIRECTOR 1	.436	4.444 m	2.431 m	879	868	293	291	1.375 m
DIRECTOR 2	.430	4.383 m	2.398 m	867	856	289	287	1.356 m
DIRECTOR 3	.434	4.424 m	2.420 m	875	864	292	290	1.369 m
DIRECTOR 4	.430	4.383 m	2.398 m	867	856	289	287	1.356 m
ELEMENT DIAMETERS		69	38	14	14	5	5	22

ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED

Element diameter is 0.006738 wavelengths

TABLE 2 ELEMENT SPACINGS

	SPACING IN λ	FREQUENCIES (MHz) 28.5	52.1	144.1	146.0	432.1	435	2 MBS 92.1
Ref. – dipole	.250	2.548 m	1.394 m	504	498	168	167	789
Dipole – D1	.289	2.946 m	1.611 m	583	575	194	193	912
D1 – D2	.406	4.138 m	2.264 m	819	808	273	272	1281
D2 – D3	.323	3.292 m	1.801 m	651	643	217	216	1019
D3 – D4	.432	4.302 m	2.353 m	851	840	284	283	1331
Array Length		17.23 m	9.43 m	3.41 m	3.4 m	1.14 m	1.14	5.33 m

* Footnote: The elements of a yagi can be of a variety of shapes. The most common shapes used to date are rods (i.e.: as in the conventional yagi) or square, circular or triangular (delta) loops. The popular 'quad' or 'quad-yagi' having square elements about one wavelength in circumference is the most familiar. More recently, circular loops and delta loops have come into prominence. I will refer to those antennas having loop elements, of whatever shape, as 'loop-yagis'.

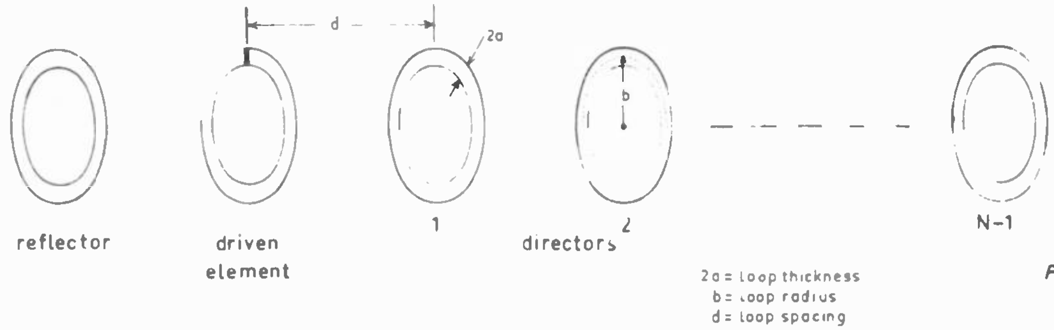


Fig. 2. Loop Yagi Antennas.

various frequencies are given in Tables I and II. Dimensions for 28.5 MHz are included for the rich or ambitious! Note also dimensions for the Sydney FM station 2MBS-FM on 92.1 MHz for troglodytes and inhabitants of Gosford, Wollongong, Blue Mountains, FM-DX freaks etc.

The second article of interest is by L. C. Shen and G. W. Raffoul and is titled "Optimum Design of Yagi Array of Loops" (7). They describe quite a simple design procedure which, in essence, proceeds as follows.

The general form of the array is shown in Figure 2. The first parameter chosen is usually gain or array size. The graph in Figure 3, after that given by Shen and Raffoul, gives bandwidth versus array size and gain (in dBd). From this you can select an appropriate d/b ratio or an appropriate bandwidth, for the array length decided on. Table III (again, after that given by Shen and Raffoul) gives the b/λ ratio for the d/b ratio just selected. Knowing the wavelength, one can then find b, followed by 2a (loop thickness) and thus the distance between the loops – d. The number of elements (including the reflector) can be found by dividing the approximate boom length by d.

Note that bandwidth decreases with array size, (as one would expect) but even with a large array, the bandwidth is substantial.

Just to get the hang of things, here is a worked example.

Wavelength is calculated from :–

$\frac{2\ 90\ 500}{f \text{ (in MHz)}}$ in millimetres

let f = 433 MHz, thus λ = 671 mm

From Figure 3, choosing an array length of 3 λ the bandwidth is 13% (56 MHz!) and the gain 15 dB.

For a d/b ratio of 1.0, and d/b of 0.01 (fixed parameter).

From Table III b/λ = 0.142.

thus, radius of loop

= 0.142 x 671 = 95mm.

circumference

= 2 π x radius = 600 mm.

loop thickness

= 2a = 0.02 x 95 = 2mm.

loop spacing = 95 mm (as d/b = 1).

Number of elements

= $N = \frac{\text{array length}}{d} \triangleq 21$

thus, actual boom length = 202 mm.

In summary:–

Number of elements	–	21
Array length	–	202 mm
Loop diameter	–	190 mm
Loop circumference	–	600 mm
Loop thickness	–	2 mm
Loop spacing	–	95 mm
Bandwidth	–	56 MHz
Gain	–	15 dBd
Frequency	–	433 MHz

Elements could be made from sheet metal, rod or tubing, just provided that the loop thickness is correct. Horizontal polarization results if the driven element is fed at the top or bottom. Making the reflector 5% longer could improve the front-to-back ratio. Vertical polarization is obtained by feeding the driven element on one side. The method of feed is not stated in the article.

The elements can be supported by a metallic boom through the centre of the loops and using insulated arms. Alternatively, they can be supported at voltage nodes (current maxima) (ie: at the feedpoint or directly opposite) on each loop. An insulating boom of ABS or PVC conduit is a very good method and can attach to the loops at a convenient point, but preferably not a voltage maxima. This sort of boom allows the elements to be glued on. Etching the loops on fibreglass printed circuit board would be an ingenious method. However, the effect on resonant frequency and impedance would have to be determined. If sufficient area of fibreglass is left around the outside of the loop, each element could be fitted into appropriate slots on a boom! As all the elements are the same, except the driven element and perhaps the reflector, and as spacings are all the same as well, one could make a portable antenna with plug-in elements that could be put together quite

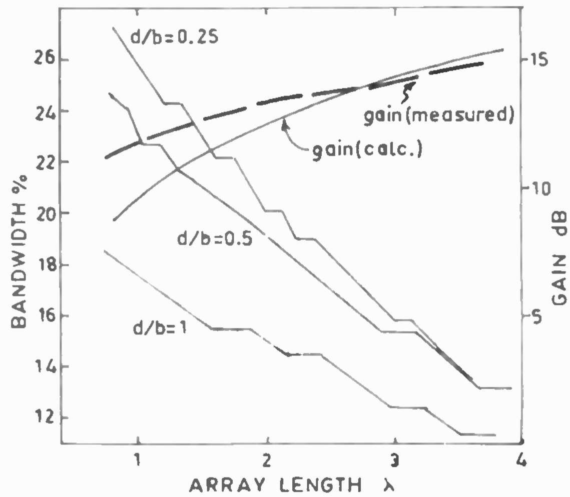


Fig. 3. Bandwidth versus array size and gain (in dBd) for optimum Loop-Yagi design procedure of Shen and Raffoul.

TABLE III LOOP YAGI DESIGN PARAMETERS

(a/b = 0.01) L = array length

d/b = 1.0		d/b = 0.5		d/b = 0.25	
L/λ	b/λ	L/λ	b/λ	L/λ	b/λ
0.73 – 0.87	0.146	0.78 – 0.98	0.142	0.81 – 1.00	0.140
0.88 – 1.44	0.145	0.99 – 1.45	0.140	1.01 – 1.40	0.138
1.45 – 2.55	0.143	1.41 – 1.99	0.138	1.41 – 1.80	0.137
2.56 – 3.36	0.142	2.00 – 2.51	0.137	1.81 – 2.18	0.135
3.37 – 4.03	0.140	2.52 – 3.28	0.135	2.19 – 2.55	0.135
		3.29 – 3.92	0.134	2.56 – 3.17	0.132
				3.18 – 3.65	0.131
				3.66 – 3.84	0.129

TABLE IV Some Loop Yagi Dimensions

Dimension	20 metres	6 metres		2 metres		70 centimetres	
Loop radius	3 m	795	797	288	279	96	95
Loop circumference	18.8 m	5 m	5.008 m	7.810 m	1.79 m	604	600
Loop thickness	60	16	16	6	6	2	2
Element spacing	3 m	795 mm	797	288	279	96	95
Number of elements	6	7	12	12	29	12	21
Bandwidth	2.7 MHz	9 MHz	7.8 MHz	22 MHz	16 MHz	65 MHz	56 MHz
Gain	> 9 dBd	> 10 dBd	> 11 dBd	> 11 dBd	15 dBd	> 11 dBd	14 dBd
Array length	0.8 λ	7 λ	1.7 λ	1.7 λ	4 λ	1.7 λ	3 λ
Physical length	15 m	5.565 m	8.8 m	3.2 m	7.8 m	1056 mm	2013 mm

All dimensions in millimetres except where noted

rapidly! Just the thing for fox hunts, field days etc.

Taking a look at Figure 3, a loop yagi 1.7 wavelengths long has a gain of around 11-12 dBd which compares with the six element yagi by Chen and Cheng just described. But, note that the measured gain is higher than the calculated gain by about 1 dB. Perhaps loop yagis still have the edge? A loop yagi of this size designed using Shen and Raffoul's method, has 12 elements. The obvious disadvantage here is more hardware, but the wide bandwidth is an advantage and construction tolerances are relaxed.

Now all we need is someone to adapt the length-spacing perturbation techniques of Chen and Cheng to the loop-yagi designs of Shen and Raffoul. It may not improve the gain, but the exercise would be interesting.

A representative series of loop-yagi dimensions appears in Table IV for a variety of amateur bands.

For further reading on loop yagis, see references 8 and 9.

MICROSTRIP ANTENNAS

These antennas have barely rated a mention in the amateur literature, although microstrip transmission lines and resonators have received quite some attention over the past few years, their use in UHF equipment now becoming widespread in both amateur homebrew and commercial equipment.

Microstrip antennas are an extension of the microstripline concept and consist of a planar resonant element, or elements, parallel to a ground plane, and separated from it by a thin dielectric substrate. They exhibit unique characteristics which have definitive advantages in some situations, particularly in VHF/UHF work.

(a) They are very thin (low profile) and, as a consequence, are naturally rugged.

(b) Either linear or circular polarization can be obtained from a single element.

(c) Dual frequency antennas can be readily constructed.

(d) Economical to build.

(e) They are easily mounted on existing metallic structures. Just think, stick-on antennas!

(f) They have obvious applications in 'active' antennas.

Design information is readily obtained from a very clear short paper published in the January 1975 issue of the IEEE 'Transactions on Antennas and Propagation' entitled "Microstrip Antennas" by John Q. Howell (10).

Figure 4 shows three simple forms and the appropriate design formulae (after Howell). If the value of C (velocity of electromagnetic

FUNDAMENTAL MODE

$$d = \frac{c'}{2f\sqrt{\epsilon_r}}$$

HIGHER ORDER MODE

$$d = \frac{nC'}{2f_n\sqrt{\epsilon_r}} \qquad n = 1,2,3\ldots$$

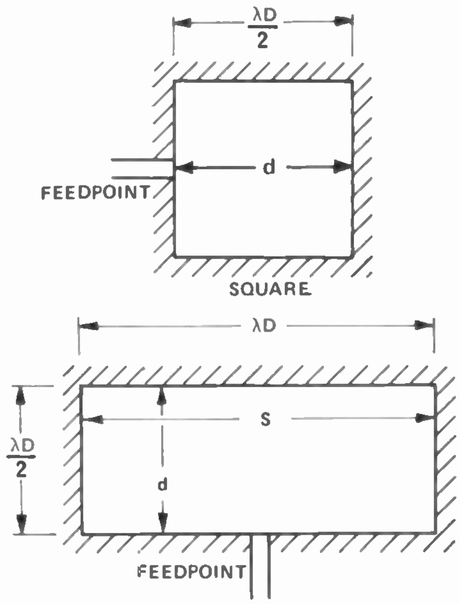
C' = 290500

f = MHz

d will be in mm

ϵ_r = dielectric constant

λ_D = electrical wavelength taking dielectric into consideration.



FUNDAMENTAL MODE

$$a = \frac{1.841C'}{2\pi f\sqrt{\epsilon_r}}$$

HIGHER ORDER MODE

$$a = \frac{C'X'_{mn}}{2\pi f_{mn}\sqrt{\epsilon_r}}$$

The lowest order mode is where

X'_{11} = 1.841 (i.e.: fundamental)

The next best mode is f_{31}

where X'_{31} = 4.215

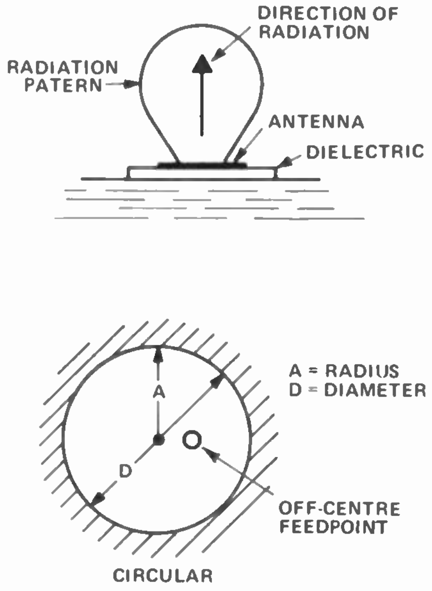


Fig. 4. Microstrip Antennas.

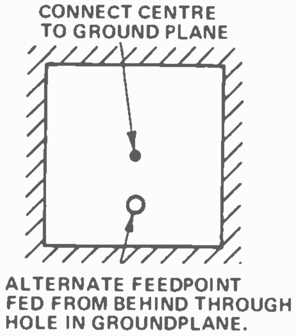


Fig. 5. Method of feed for square section microstrip antenna.

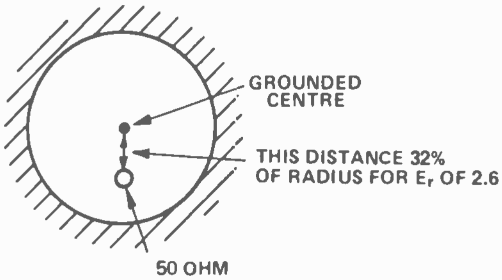


Fig. 6. Method of matching feedpoint for circular microstrip antenna.

propagation) in free space is used, the actual resonant frequencies are low by a few percent. I have given the value of C′ to be used (290500), which takes this effect into account and gives quite acceptable results.

Bandwidth, which depends mainly on the thickness of the dielectric and to some extent on the dielectric constant, is in the order of about 1% to 4% of the design frequency.

The direction of radiation is perpendicular to the plane of the element when operating in the fundamental mode.

Square antenna elements exhibit a high impedance at the edge, and when the feedpoint is located on the edge an impedance transformation is necessary to match to the usual 50 ohm or 75 ohm feedlines. However, if the centre is grounded, the square can be fed from behind, through a hole in the ground plane, the feedpoint being located some distance towards the edge from the centre. Howell recommends that this be found by trial and error. This alternate feedpoint is illustrated in Figure 5.

The rectangular antenna element presents a good match to 50 ohms when fed from the centre of the long side. The rectangular element also exhibits a greater bandwidth than the square element when constructed under the same circumstances. Howell notes that this shape element is being used in phased arrays. Combined with microstrip transmission line feeders over a common ground plane, a multi-element phased array constructed using double-sided printed circuit board is an interesting possibility. Howell makes a further note that, when fed from adjacent sides, the rectangular element can be used as a dual frequency antenna.

The impedance at the centre of the circular element is zero. At the outer edge it is hundreds of ohms. This antenna is probably best fed from behind, through a hole in the ground plane. The feedpoint is located towards the edge of the disc, some way out from the centre. Howell found that, for a dielectric constant around 2.6, the feedpoint is located at a distance of about 32% of the disc radius from the centre. This is a convenient value as the dielectric of Perspex and polyethylene is 2.7, while that of Teflon loaded fibreglass is 2.5. One could construct a circular antenna using any of these dielectrics, place the feedpoint 32% from the centre, and be reasonably confident of obtaining a good match to 50 ohms. This also applies to square elements and an illustration is given in Figure 6.

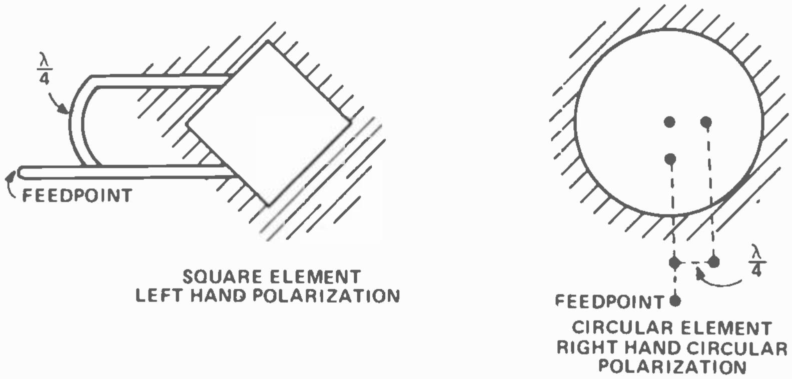


Fig. 7. Methods of obtaining circular polarization with microstrip antennas.

The gain of these antennas in the fundamental mode is about 4·7 dB over an isotropic radiator (2·5 dB over a dipole). When excited in a higher order mode, the antenna radiation pattern divides several lobes, the polarization usually changing as well.

CIRCULARLY POLARIZED MICROSTRIP ANTENNAS

Microstrip antennas with one feedpoint are linearly polarized, the plane of polarization being perpendicular to the line joining the feedpoint and the centre of the antenna. In Figure 4, for example, the square antenna would be vertically polarized and the rectangular antenna horizontally polarized, if we regard the bottom of the page as being parallel to the horizon. The circular antenna, likewise, would be vertically polarized.

Circular polarization is obtained by feeding two feedpoints, located at right angles to one another, 90° out of phase. The direction of polarization is determined by which feedpoint leads in phase. This is illustrated in Figure 7.

APPLICATIONS

The microstrip antenna has obvious applications for satellite antennas, both terrestrial and satellite mounted. An antenna of this type would be particularly useful for mobile satellite communications, mounted on the roof or any upper surface of a vehicle.

Note that, the square element has the smallest overall dimensions. Assuming same frequency and dielectric, comparing the design equations for square and circular elements, we get :–

$$\frac{C'}{2d\sqrt{\epsilon_r}} = \frac{1.841\,C'}{2\pi a\sqrt{\epsilon_r}}$$

Now, 2a is the diameter (D) of the circle, its large dimension.

$$\text{Thus, } \frac{C'}{2d\sqrt{\epsilon_r}} = \frac{1.841C'}{\pi D\sqrt{\epsilon_r}}$$

$$\text{Therefore, } d = \frac{\pi D}{2 \times 1.841}$$

And thus, d = 0.85 D.

However, the circular element appears to have more gain, but this need not necessarily be a drawback.

In the higher order modes, as mentioned before, the radiation pattern splits into several lobes and changes polarization. By choosing the third mode, the radiation pattern, and polarization, produced by a square or circular antenna, oriented parallel to the ground, resembles that of a quarter-wave ground plane. Note that it is longer than the fundamental antenna. The lowest frequency that a third mode antenna is practicable for vehicle mounting is 144 MHz, being

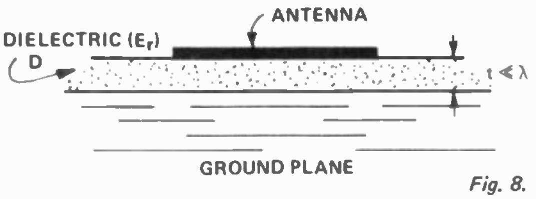


Fig. 8. The format of a microstrip antenna.

nearly 1.5 m across, using a fibreglass substrate. If one could obtain some alumina substrate, which has a dielectric constant of about 10, the situation is somewhat improved. Naturally, it costs more. Somehow, I don't think it's going to catch on as a mobile antenna.

Representative dimensions are given in Table V.

CONSTRUCTION

The shape of the substrate, and the ground plane, need not be similar. The substrate should extend beyond the element edges but Howell gives no figures as to how far. Going by some of his examples, 20% seems a seasonable minimum. The ground plane, too, should be at least this size. Radiation patterns are better if it is larger.

The element can be glued or bolted to the substrate and likewise the substrate to the ground plane, whichever is practical for your situation. Remember, the greater the substrate thickness, the greater the bandwidth. Printed circuit board seems perfectly suited, particularly fibreglass as the dielectric constant is quite high. However, this factor is a variable as some batches have a greater or lesser ϵ_r than the 4.4 quoted. It can be as low as 4.2 or as high as 4.8. If possible, check with the manufacturer, or measure the antenna resonant frequency. Make a test dummy if possible. Another method would be to make a capacitor from a sample of printed circuit board and carefully measure its value. Knowing the dimensions, the dielectric constant can be calculated. Here is the formula:—

$$\epsilon_r = \frac{1.131dC}{A}$$

Where A = area of one plate (assuming two equal parts)
where C = capacitance in pF
where d = thickness of dielectric
† all dimensions in mm

The dielectric constant for polyethylene is quoted differently by various sources, usually in the range 2.2 to 2.6. Similar comments apply to Teflon loaded fibreglass. A table of dielectric constants for suitable substrate materials is given in Table VI.

TABLE V
MICROSTRIP ANTENNA DIMENSIONS

SUBSTRATE DIELECTRIC	ϵ_r	F (MHz)	SQ. side d	CIRCLE radius a	CIRCLE diam. D	RECTANGLE width d	RECTANGLE length s	
FIBREGLASS	4.4	146	475	278	556	475	950	FUNDAMENTAL MODE
PERSPEX or POLYETHYLENE	2.7	146	605	355	710	605	1210	
Teflon loaded FIBREGLASS	2.5	146	629	369	738	629	1258	
TEFLON sheet	2.1	146	704	412	824	704	1408	
FIBREGLASS	4.4	432	160	94	188	160	320	
PERSPEX or POLYETHYLENE	2.7	432	205	120	240	205	410	
Teflon loaded FIBREGLASS	2.5	432	213	125	250	213	426	
TEFLON sheet	2.1	432	238	139	278	238	476	
FIBREGLASS	4.4	438	158	93	186	158	316	
PERSPEX or POLYETHYLENE	2.7	438	202	118	236	202	404	
Teflon loaded FIBREGLASS	2.5	438	210	123	246	210	420	
TEFLON sheet	2.1	438	235	137	274	235	470	
FIBREGLASS	4.4	146	1425	834	1668	–	–	3RD MODE †
FIBREGLASS	4.4	438	475	278	556	475	950	

* All dimensions in mm

† NOTE — Same as fundamental mode 146 MHz element

TABLE VI

MATERIAL	ϵ_r
FIBREGLASS LAMINATE	4.2–4.8
FORMICA LAMINATE	4.6–4.9
PERSPEX	2.6
POLYETHYLENE	2.2–2.6
PLATE GLASS	6.8–9
PORCELAIN (RF ceramic)	5.1–5.9
TEFLON	2.1
TEFLON LOADED FIBRE-GLASS	2.4–3

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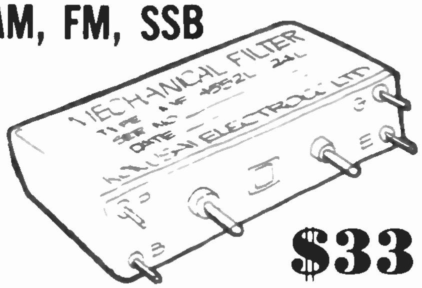

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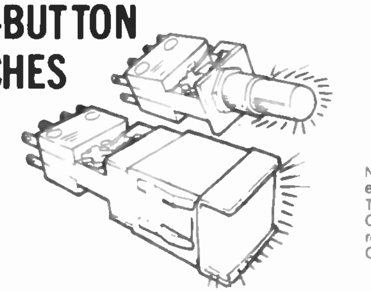

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100+	55c ea

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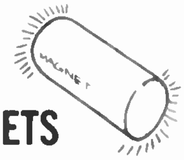
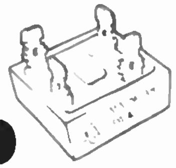


Extra-powerful Mini-Magnets Size only 3 8 diam X 3 4 long Intended primarily for burglar alarm installations since only a 3 8' diam hole need be drilled in door window these extra-powerful magnets will find a host of useful applications for the hobbyist 'experimenter

QTY	PRICE
1 9	25c
10-24	20c
25-99	18c
100+	16c

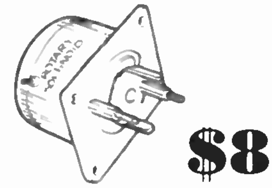
PA40 400V 8 AMP BRIDGE RECTIFIERS



$5.50

The popular EDI PA40 Minibridge is easy to use and features single hole mounting to chassis, etc Normal selling price is around $6-$7 Our special price (while stocks last) is $5 50 ea for 1 to 4, or $5 ea for 5 or more

ROTARY SOLENOID

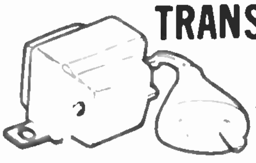


$8.90

New 12 volt Rotary Solenoid Switch Motor by Plessey $8 90 ea

This electro-mechanical rotary actuating mechanism will suit all OAK type F switches up to 12 positions Small in size they are robust easy-to-mount and made to professional standards Only 50 available so be early

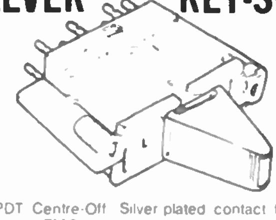
MINIATURE 6V 200mA TRANSFORMERS



$3.50

As used in AC DC cassette recorders and radios these shielded transformers have 240V primary and 6V 0-6V secondary at approx 200 m A Size 38 x 38 x 33 mm with mtg centres at 48 mm Complete with 2 core flex and plug $3 50 ea 10 for $30

LEVER KEY-SWITCHES



DPDT Centre-Off Silver plated contact for long life These modern PMG type miniature keyswitches (as used in latest telephone switchboards) feature positive action long life operation and easy mounting

QTY	PRICE
1-9	95c
10 24	85c
25 99	80c
100+	75c

P.C.B. EDGE CONNECTORS

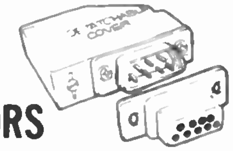
NOW! Custom build your own P.C.B Edge Connectors Featuring gold plated contacts and designed for single-sided boards these top quality 12 long connectors hold 78 contacts at 0 156 pitch Simply cut the length required and fit mounting clips (2 included extras 5c ea) $1 20 ea or 10 for $10

EDGE CONNECTORS

85c

46 way double sided Edge Connector with gold-plated contacts Can be used as 23 way single sided connector 0 156 pitch with mounting holes at 4 centres At these prices you can add that professional touch to all home brew projects 85c ea 10 for $7 50

MULTI-PIN CONNECTORS

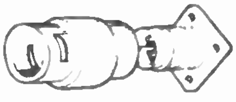


At BARGAIN PRICES A scoop purchase of these top grade connectors enables us to sell below manufacturer's cost prices Suitable for panel mounting or in line applications these miniature connectors have low contact resistance and long life

Gold-Plated Polarised Connectors

	PLUG	SOCKET	COVER
9 pin	50c	50c	30c
15 pin	70c	70c	50c
50 pin	$1	$1	70c

MICRO-MINIATURE CONNECTORS



When space is at a premium and quality and low cost is important, try these amazing **Micro-Miniature Plessey Connectors.** Socket suits panel mounting plug mates firmly with socket due to screw down action of plug and the cable is secured by a clamp Each set includes 1 plug 1 socket 1 cable clamp

TYPE	QTY 1-4	QTY 5-24	QTY 25+
3 pin	85c	75c	65c
7 pin	95c	85c	75c
14 pin	$1 20	$1 10	$1 00
19 pin	$1 50	$1 35	$1 20
37 pin	$1 80	$1 60	$1 40

BONANZA JACKPOT!

$25 value for only $5

For experimenters and constructors a large assortment of new, highest quality electronic components — samples specials end-of-line components including semiconductors, etc This is real anti-inflationary VALUE FOR YOUR MONEY!

ELECTRONICS —it's easy! PART 22

The algebra of logic.

MATHEMATICS is a kind of shorthand language which enables us to present a physical process, on paper, with symbols which may be manipulated in order to gain a better understanding of the process. It is thus a tool which aids understanding.

The familiar kind of algebra which relates two variables, x and y, in combinations such as x+y, x−y, x.y, x/y, x^y and others is a linear process because the two variables can hold any value. It is this kind of algebra that is performed by analogue operational amplifiers.

However, if x and y can only have two possible states, such as a voltage which is there or not there, we can ignore the actual value of the voltage (or whatever) and regard the variables as behaving according to a two-state or binary number system. Just what the two states are is of no importance whatsoever — they can be high or low, positive or negative, there or not there and even true or false.

A mathematical algebra has been developed to cope with such binary systems. It is known as Boolean algebra — the algebra of logic, and it's rules are somewhat different to those of linear algebra. Before delving into the operation of Boolean algebra, it is worth tracing it's historical development.

HISTORY OF SWITCHING MATHEMATICS

Philosophers, those people who apply special skills to resolving paradoxes by the use of logic, have existed since the earliest civilisations. The Ancient Greeks were so impressed with logic that they wrote plays around Aristotle's formally arranged rules of logical deduction. The rules for this process of reasoning were handed down, largely by word of mouth, through the Dark Ages, with little, if any, recognition of their value for logic in computation. It was not until the early 19th century that the use of logical rules in calculation was established. This work was very much the result of George Boole's 1954 work (see Fig. 1) entitled "An Investigation of the Laws of Thought on which are Founded the Mathematical Theories of Logic and Probabilities", Augustus de Morgan, a contemporary, also contributed to the first systematic arrangement of Aristotle's logic.

Boole took the concepts further than the Ancients by substituting mathematical symbols in place of the basic logical situations. This symbolic logic became known as Boolean algebra.

Little was achieved with Boole's work for the next few decades. The first machine to utilize his algebra to solve logic problems, faster than by hand, was William Jevons' logical piano of 1869. Boole's contribution, however, had to wait until the early 20th Century to find extensive application. One by one, logicians advanced the techniques of logical algebra: Pierce, Venn, Dodgson, Marquand, Pastore, Bollee. The "Principia Mathematica" of Whitehead and Russell (1910-1913) and the Hilbert and Ackermann work "Mathematical Logic" (1928) were further milestones in digital computer realisation.

Fig.1. In 1854 George Boole, an English logician, showed how ordinary algebra could be applied to logic situations.

Shannon's 1938 paper "A Symbolic Analysis of Relay and Switching Circuits" was a paper of very practical relevance for it described how to put Boole's rather abstract logical albegra to work in engineering and computer design. But this was not the first recorded use of electrical logic circuits. In a letter Charles S. Peirce wrote to his former student, Marquand, around 1890 he expressed, in the words and circuit diagrams shown in Fig. 2, that logical algebra could be performed with three switches in parallel or in series, also stating that he felt electricity to be one of the best ways to implement logical equipment.

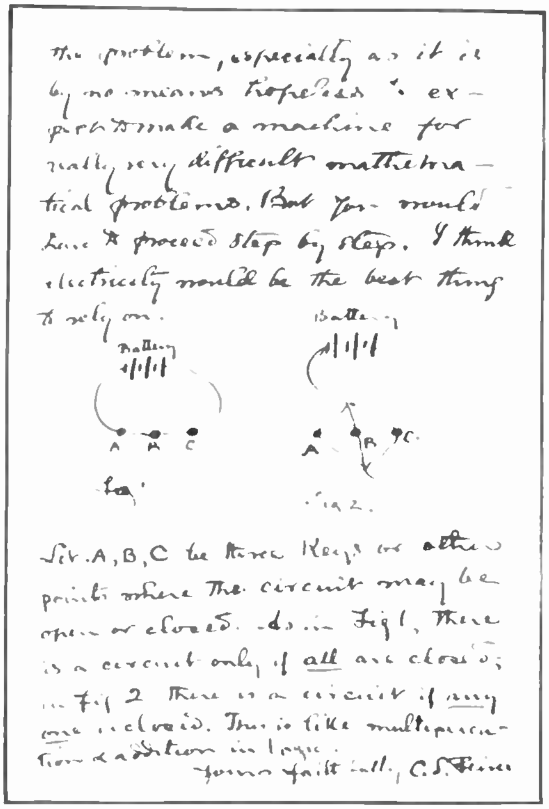
Later theoretical studies concentrated on ways to ensure that switching networks contained no more switch contacts than were absolutely necessary. Unnecessary contacts can easily be unwittingly designed into complex switching networks — the "spares" are called redundant switches. Shannon, in his M.Sc. thesis (Fig. 3) prepared at the famous Massachusetts Institute of Technology, realised ways to systematically set about analysing a given switching networth in order to reduce the contact requirements to a minimum. Thus it was realized in the early 1940's that really powerful digital computers could be built using entirely electronic components.

Later in the course we will be dealing specifically with computer systems. They are, however, but a part of the total use of digital electronic methods — digital electronics finds use in an ever increasing number of instruments and devices.

BASIC LOGIC GATES

A quite satisfactory way to begin to comprehend basic switching algebra is to think in terms of mechanical switch contacts arranged in various different configurations. That we draw them and consider them as mechanical contacts that are either open or closed, does not imply that the contacts necessarily need to be mechanical — they are, today, more often than not the solid-state switches we discussed in the last part.

Groups of switches combining


the problem, especially as it is by no means hopeless to expect to make a machine for really very difficult mathematical problems. But you would have to proceed step by step. I think electricity would be the best thing to rely on.

Let A, B, C be three keys or other points where the circuit may be open or closed. As in Fig 1, there is a circuit only if all are closed; in Fig 2 there is a circuit if any one is closed. This is like multiplication & addition in logic.

Yours faithfully, C.S. Peirce

Fig.2. The first known description of electrical switching carrying out logic is in this letter of C.S. Peirce written around 1880.

Fig.3. Claude Shannon published details of "modern" digital computing design in 1937.

digital signal levels are known as gates. We begin by considering the simplest possibilities where there are just two contacts to build with.

They can be placed in series or in parallel, as shown in Fig.4. In each case different conditions exist between the transmission made through them for the two positions of each of the switches. We denote the switch inputs as A and as B (and C,D, etc., if more are involved) and the transmission as Z, thus using mathematical symbols to represent a physical situation. Imagine that the switches are wired in series with a lamp: when a circuit is made the lamp lights.

In the series case we need switch A and switch B to be made to obtain a transmission function Z. In the parallel case either switch A or switch B will provide transmission.

The AND and OR are basic logical functions. They need not necessarily be used only to describe electrical circuitry. They did, in fact, as we have seen, arise originally from philosophical study of truths and falsities.

Note that switch contacts are always shown in their non-actuated condition and this brings us to another basic gate function which can be realised using only one switch. If, as shown in Fig. 5, the switch A is actuated, Z is NOT enabled. If A is not actuated Z is enabled. A single switch, therefore, can provide a NOT function if its contacts are closed in the non-actuated state.

Attempts to explain switching circuit action in words, as above, only applies for the simplest of situations. The descriptive method becomes prohibitive when, say, we have two switches in series, in series with two switches in parallel, as shown in Fig. 6. Describing the action of all possible switch combinations on the lamp Z using words, is an inadequate way with which to communicate the idea. And few digital systems are that easy: many contain literally thousands of AND, OR and NOT gates.

We designate an OR function by means of the '+' symbol. This does *not* mean the same as our normal understanding of addition. When applied to decimal numbers it means addition as we normally understand it. With binary numbers, however, it has a different meaning and still another meaning when designating an OR function. For example:-

In decimal addition	1+1=2
binary addition	1+1=10
OR addition	1+1=1

In Boolean algebra the OR meaning of addition is the one that applies. Thus A+B=Z means that A OR B switch closed will produce a transmission Z.

We designate an AND function with a dot. The dot means logical multiplication and is not to be confused with normal multiplication. However the truth tables for AND multiplication and normal multiplication are the same. Thus when we give the Boolean equation A.B=Z we mean that if switch A and switch B are both closed there will be a transmission Z.

The NOT function is designated as a line over the switches algebraic symbol giving $Z = \overline{A}$ to mean Z is NOT transmitted when A is actuated.

Each of these functions have a

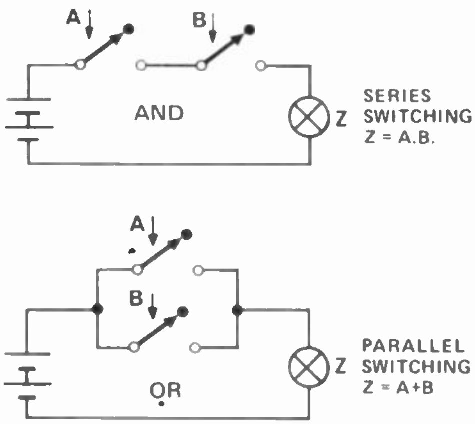


Fig.4. Two contacts wired in series or in parallel provide the basic logic functions of AND and OR.

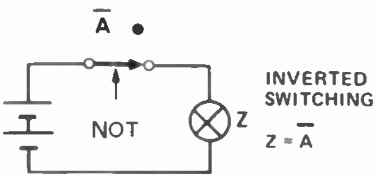
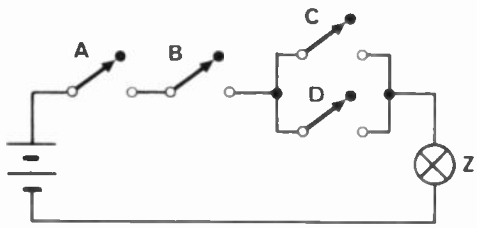


Fig.5. The NOT function is obtained by reversing the state of the switch operation.



Z = A.B. (C+D)

Fig.6. More complex switching functions are best described in terms of logic algebra than by words.

ELECTRONICS -it's easy!

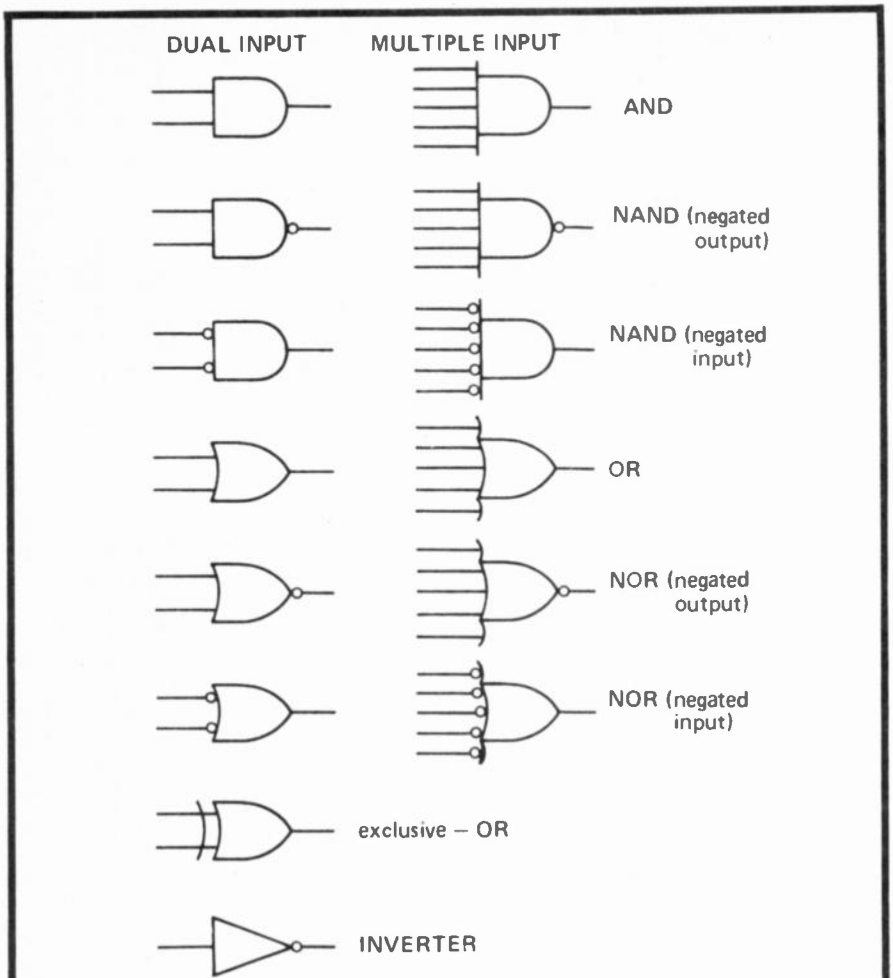


Fig. 7. Two-state logic gate symbols used in this course.

symbolic representation as black-boxes with inputs that act in certain ways to give the output. The shape of the box (or the designation within a square box) tells the viewer the function of the box.

Unfortunately there still exists more than one conventional way to draw these symbols. For this course we will use those given in Fig. 7, which are also those used in projects in Electronics Today.

The NOT function bar can be applied to any function to signify that it is negated. For instance, an OR such as A+B=Z becomes $\overline{A+B}$ which is called a NOR function. Similarly so $\overline{A.B}$ is a NAND function.

The OR, AND, NOR and NAND functions can each have more than two inputs, for example, A+B+C+D=Z. When a function is negated its graphical symbol is also altered in some way to signify this. The convention used is the convention of the addition of a small round circle. If the circle is at the output the output is negated; if at the input the inputs are negated. The inverter (that provides negation) is basically an amplifier providing 180^{o} phase shift so its symbol is that of an amplifier with the circle added.

TRUTH TABLES

Before we discuss more complex gate networks by studying their inter-connection, we need to understand the concept of a truth table. This is a simply drawn table that lists the output state for the various combinations of input states.

Rather than write on and off, or high and low, true or false, it is simpler to express the two states merely as '0' and '1'. The *positive* logic convention considers a high-voltage level as a '1' and the low level as a '0'. Fortunately, today, just about all logic circuits used are now in integrated circuit form and they nearly all work between just two levels – which are the same for any devices from a particular logic family. This provides a compatible arrangement whereby gates and other logic system boxes (that are yet to be introduced) can each be intercoupled without having to worry about matching voltage and impedance levels. However, when transferring logic signals between devices from different logic families translator circuits will be needed to make voltage levels compatible.

Occasionally, but not commonly, it is more convenient to reverse the levels calling a 1 the lower voltage and an 0 the higher. This is denoted *negative* logic. Such a system is however seldom used in modern integrated-circuit logic families.

Consider then the series contacts of Fig. 4. Assuming we use the positive logic convention where 0 represents an open contact and 1 a closed contact; it is easy to draw up columns as given in Fig. 8.

When A and B are both 0 then so also is Z, for no contacts are made. Similarly, if either A or B are open. When both A and B are closed, that is a 1 each, then Z is made. This is called a truth table.

Fig. 9 is the truth table for the parallel contacts of Fig. 4. In this case Z is 1 when A or B are 1.

An interesting property of the AND and OR functions is their dual nature when negated. For example, if we negate the inputs of the OR gate the truth table becomes that of Fig. 10,

INPUTS		OUTPUTS
A	B	Z
0	0	0
0	1	0
1	0	0
1	1	1

AND
Z = A.B

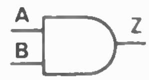


Fig.8. Truth table for A.B.=Z, the AND function.

A	B	Z
0	0	0
0	1	1
1	0	1
1	1	1

OR
Z = A + B

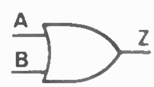


Fig.9. Truth table for A+B=Z, the OR function.

POSITIVE LOGIC		NEGATIVE LOGIC		NAND	AND (IN POSITIVE LOGIC)
A	B	$\overline{A}$	$\overline{B}$	Z	$\overline{Z}$
0	0	1	1	1	0
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	0	1

Fig.10. Truth table showing that negative logic (or negated positive logic) input to an OR gate provides NAND output.

the output of which is the NAND function. Hence a negated input OR gate is a NAND gate. Also, by similar reasoning, a negated input AND is a NOR. Put another way, in negative logic an OR becomes an AND and vice versa.

UNIVERSAL GATES

Using the basic gates, AND, OR and NOT, we can build a logic circuit for any given Boolean expression. Where there is a plus sign (+) we use an OR gate, where there is a dot we use an AND gate and we use an NOT gate for those functions that are negated.

However it is interesting that the NAND gate can be used to obtain any desired function. It can be used to build AND, OR or NOT gates. In other words it is a universal building block, as is the NOR gate also.

Thus the majority of gates used in modern logic systems are NAND gates with the occasional use being made of NOR gates and inverters (NOT) to minimize complexity. The use of one major form of gate simplifies manufacture and reduces costs.

FAN OUT

There exists a finite number of circuits that can be safely connected to the input, or the output, of logic elements. This number is called the fan-in and fan-out respectively, and gives the number of standard loads that can be accommodated. Fanouts of 10 and 30 are typical load factors.

EXCLUSIVE OR

One other important gate is a special class of the OR — the exclusive OR. The logic action of this gate is seen by studying its truth table which

A	B	Z
0	0	0
0	1	1
1	0	1
1	1	0

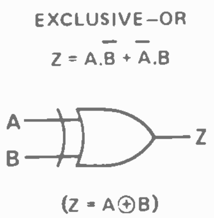


Fig.11. Truth table for two input exclusive – OR gate.

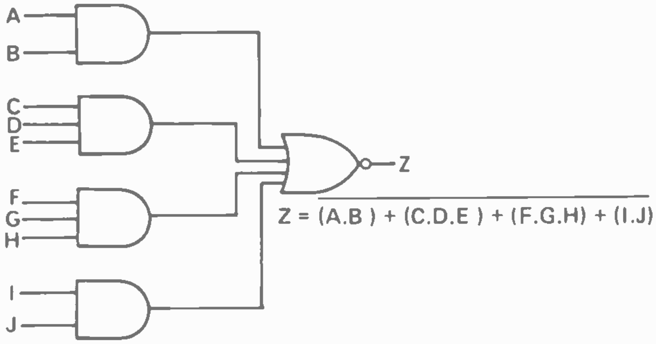


Fig.13. (a) Logic network for function Z=(A.B) + (C.D.E.) + (F.G.H.) + (I.J.) (b) same logic packaged in IC flatpack.

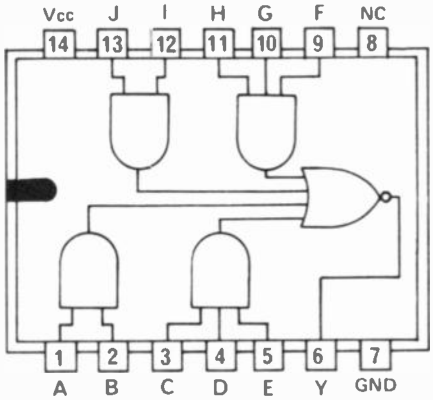


Fig. 13(b).

is given in Fig. 11. In this variation of the basic OF gate the output is 1 for either A or B but not when both are 1 simultaneously. Written in Boolean algebra symbols this gate performs $A.\overline{B}+\overline{A}.B=Z$. (Symbols written as AB imply that a dot exists between them; it is common practice to omit the AND dot).

MORE COMPLEX LOGIC

The exclusive OR gate is more complex than the other gates discussed above because it contains more than one basic gate — it is a small logic system in itself. Fig. 12 shows how two inverters, two AND gates and one OR gate can be interconnected to achieve the exclusive OR requirement.

A second example is given by considering a function

$$Z=\overline{(A.B)+(C.D.E)+(F.G.H.)+(I.J.)}$$

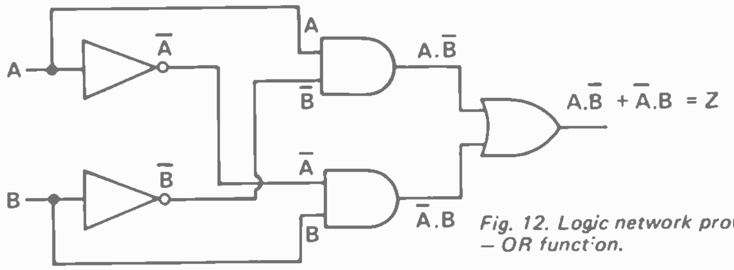


Fig. 12. Logic network providing exclusive – OR function.

The problem might be to realise a logic network that performs this logical task — imagine trying to describe it in words! Brackets are used to ensure that sub-connections are made in the correct way; as in linear algebra operations in brackets are dealt with first as individual units.

The first step in realising the network is to form the dot AND functions of Z. We need two two-input AND gates and two three-input AND gates. (It matters not if a gate has more inputs than needed — the unused terminal is ignored). The outputs of these four AND gates are then fed into the inputs of a four input OR gate so that the function under the negation bar is achieved. At this point we could select an OR gate followed by an INVERTER or make use of a NOR gate direct.

When drawn as a system of interconnected schematic blocks it appears as in Fig. 13a. Also given in Fig. 13b is how a 14 pin dual-in line IC would appear that performs this function.

As a third example the exercise is to devise a logic network that will add (in binary system) two binary inputs producing the binary sum output plus a carry output. This function, called the half-adder, forms the basis of digital computation with binary numbers.

Back in Part 5 the concept of the binary number system was introduced showing that the counting base is 2 instead of the more commonly encountered 10 of the decimal system. At any digit position in the binary number, the value can be only 0 or 1 so addition of two binary numbers gives a value at each digit position that alternates as 0 1 0 1, etc., as counting progresses. When 0 and 0 are added we obtain 0; when 0 and 1 are added we get 1. When 1 and 1 are added we cannot have 2 in a binary system so it returns to 0 with a carry of 1 going to the next higher digit position. Fig. 14 illustrates this idea — try adding the two numbers! A half-adder does this operation for one digit position. The truth table for the half-adder is, therefore, as given in Fig. 15a.

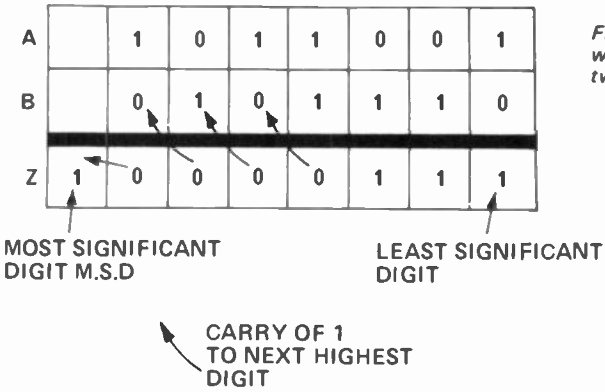
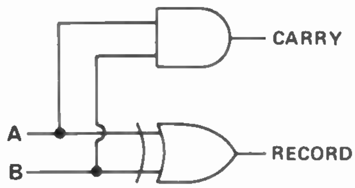


Fig.14. Addition of two binary numbers proceeds with a carry as for decimal arithmetic but with only two states 0, 1 in each digit.



(b) IMPLEMENTATION OF HALF-ADDER

Fig. 15 (b). One form of half-adder logic network.

INPUTS		OUTPUTS	
A	B	CARRY	RECORD
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

(a) TRUTH TABLE OF HALF-ADDER

AND CONDITION EXCLUSIVE-OR-CONDITION

Fig.15. (a) Truth table for half-adder logic.

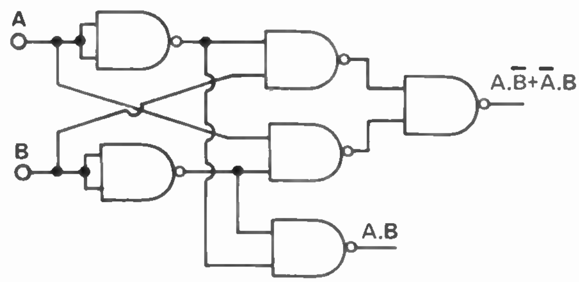


Fig.15 (c). The half adder using NAND gates only.

The sum column shows we need an exclusive -OR to provide the sum value — hence its importance in computer design. A carry is to occur when both A and B appear so an AND gate is needed. From these we can develop one form of the half-adder system — given in Fig. 15b. Note how the complexity is growing. Such a circuit requires around 30 or more passive and active components and hundreds of such circuits are needed in a digital computing circuit. A version of the same circuit only constructed using NAND gates is given in Fig. 15c. Note that NAND gates 1 and 2 have both inputs tied together, they therefore perform the NOT function. Try your Boolean on this as follows — .

SOME LAWS OF BOOLEAN ALGEBRA

When devising systems of logic the situation soon arises which calls for knowledge of the rules for manipulating Boolean expressions. Possible reasons for this may be that a limited range of logic functions are available, so conversion of an expression is needed, or that a large expression may not be in its simplest state. Reduction to its non-redundant state means use of less elements.

A number of axioms (truths based on experience) exist for relationships between Boolean statements. There is little point in dwelling on their individual proofs and historical development — for that see the reading list. The following relationships are summarized to assist when needed:

de Morgan's rule 1 : A + B = A.B

de Morgan's rule 2 : A.B.=A+B

Commutative laws : A + B = B + A
A.B = B.A

Associative laws : A.(B.C) = (A.B).C = A.B.C
A + (B + C) = (A + B) + C = A + B + C

Distributive laws : A.(B + C) = A.B + A.C
A.C + A.D + B.C + B.D – (A + B) . (D + D)

This is as for linear algebra but with extra cases:—

A + B.C = (A + B) . (A + C)
and (A + B) . (A + C) . (A + D) = A + B.C.D

Absorption laws : A + (A.B) = A
A. (A + B) = A

Double negation : not Ā = A

Universe class laws : A + 1 = 1
A.1 = A

Null class laws : A + O = A
A.O = O

Complementation laws : A + A = 1
A.A=O

Tautology laws : A + A = A
A. A = A

Expansion laws : (A + B) . (A + B) = A
(A.B) + (A.B) = A

MINIMIZATION

To save components the network first realised by inspection from a valid truth table may well not be in its simplest or so-called minimal form. In simpler cases, application of the above Boolean algebra laws by a well-practiced person can often come up with simplifications.

Beware, however, of applying linear algebra rules of factoring. It is quite wrong to cancel or subtract equal terms in both sides of a Boolean equation.

Unfortunately, no direct way is known with which to arrive at a minimal network by a routinely declared simple procedure. The nearest we can get to this is by means of a Karnaugh mapping procedure which we do not discuss in this course as few readers will be required to be expert in this facet of digital electronics.

An example will show how a simple system can be minimized by inspection. Consider the expression Z = (A + B) . (A + C) . (A + D). This is readily seen to be the logic network given in Fig. 16a. From the distributive laws given above this can be rewritten as Z = A + B.C.D which represents the logic configuration of Fig. 16b. This minimal form requires two less gates (provided a three input AND gate is available).

THE VENN DIAGRAM

In the early days of logical algebra development, John Venn developed a system of overlapping circle diagrams as an alternative way with which to express the concepts contained in the truth table. Venn's diagrams consist of overlapping circles contained in a rectangular box. Each circle represents one of the required number of independent input variables — A, B, C, etc. If the output variable Z is a 1 (assuming that is the convention

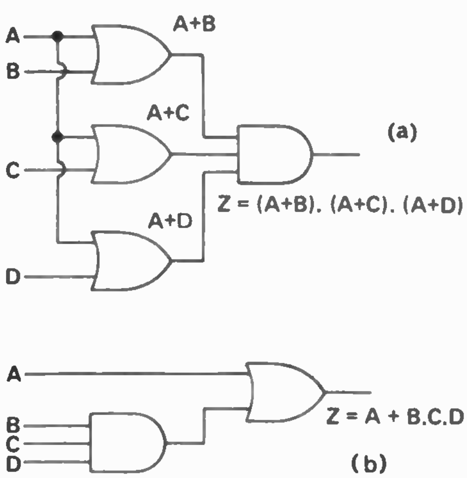


Fig.16. Logic network realising Z = (A + B). (A + C). (A + D)
(b) Simplified network.

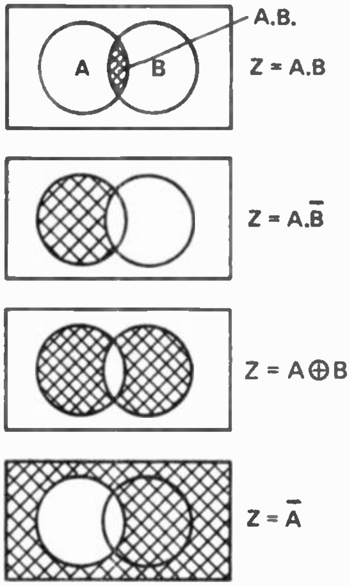


Fig.17. Venn diagrams represent logic states in topological form. Some people find these easier to use than truth-tables.

chosen) the appropriate area of the circles is shaded. The rules are that inside a complete circle its variable is not negated, outside it is negated. Overlapping area of common circles represents their AND combination. The examples given in Fig. 17 illustrate the use of Venn diagrams in various simple logic situations. The concept extends to as many circles, that is, inputs as are needed.

LIMITS OF BOOLEAN

There are a number of limits to the use of Boolean algebra. In the logic combination we have considered so far, there has been no mention of time or of any feedback around the circuit. In practical systems, time delays always occur and, further, other elements such as counters, multivibrators and memory devices are generally present whose state depends, not only on the logical inputs at any given time but, on what has happened previously! Boolean algebra is unable to deal with such situations.

In addition, if a function is minimized by means of Boolean it does not follow that the derived circuit is the cheapest possible. The minimized circuit may call for 3-input AND gates, say, but it could well be cheaper to use the more readily available NAND gates — even if more gates are required to achieve the same function.

Thus it can be seen that Boolean algebra is far from an infallible means of arriving at the cheapest possible solution. In fact it may not give any solution at all! Engineering skill and ingenuity are still the most important factors in efficient logic design. It is of value however, and does give a good insight into the function of straightforward gate circuits.

In the next part we will look at practical circuitry of logic gates and introduce several other basic digital circuit building blocks. We will then be ready to discuss digital systems in some degree of depth. ●

FURTHER READING

Most books on digital computer design include a chapter on Boolean algebra and binary arithmetic.

"Electronic Computers — Made Simple", H. Jacobowitz and L. Basford, W.H. Allen, London, 1967.

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

"Numbers" R. Froom, Electronics Today International, July 1973, p. 84-89

For the historical development of computers and other data processing equipment see

"A Computer Perspective" C and R Eames, Harvard University Press, Massachusetts, 1973.

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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**

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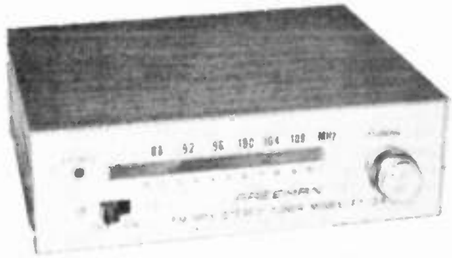
FREEMAN FT-3A STEREO TUNER



The Freeman FM Stereo tuner features 2 IC'S, 1 FET, 2 transistors and 4 diodes. Stereo reception is automatic and indicated by light emitting diode visible on the front panel. The FT-3A measures 165mm (w) x 140mm (D) x 60mm (H). Specifications are as follows:
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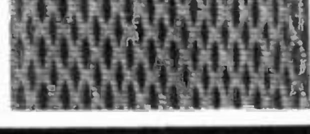

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UNDERSTANDING COLOUR TV

In this final part, Caleb Bradley describes grey scale and decoder adjustments.

AT THE START of this series we showed that natural reproduction of each colour depends on three primary colours being combined in exactly correct ratio of strengths. Unfortunately the shadowmask tube cannot be guaranteed to be equally efficient for each primary colour; the efficiencies of the screen phosphors are unequal (red is usually much less efficient than the other two) and the situation is made more unpredictable by manufacturing tolerances in the electron guns which cause variations of gain and cut-off voltage. The relative performance of each gun of a particular tube might be as sketched in Fig. 56a.

GREY SCALE

The 'grey scale' adjustments are concerned with matching the three gun responses. Only when this is done can colours be correctly reproduced, in particular the *fully desaturated* 'colours', i.e. shades of grey or white, will be reproduced as perfectly neutral shades without any colour bias caused by relative excess or shortage of a primary.

To assess the grey scale quality of a colour receiver look at a monochrome programme and compare the picture colour with a neutral white source such as a typical overcast sky – *not* a tungsten lamp (too yellow) or a white object whose actual colour depends of course on its illumination. The cause of any overall tint can be found from Fig. 56b.

To confuse this, some receivers feature a rather spurious 'Tint' control which enables the viewer to upset the grey scale slightly to give a 'warm' or 'cold' picture impression – leave this control at mid position. Another point to watch is that a few sets have a special circuit associated with the decoder colour killer to give a deliberate blue tint to monochrome pictures. This is to resemble the appearance of normal monochrome sets since a monochrome picture displayed on a colour set in truly netural grey seems somewhat 'warm' by comparison.

Besides relating any grey scale error to Fig. 56b one must decide whether it affects the dark greys, the light greys (whites) or both.

BACKGROUND AND HIGHLIGHT CONTROLS

In Fig. 56a it is necessary to match the three gun characteristics for both cutoff voltage and slope (gain). The grey scale controls for this are simplest on a receiver using colour-difference drive – Fig. 57.

When grey is being displayed the colour-difference voltages on the tube grids are equal; this was ensured by clamps in the decoder. To obtain neutral dark grey the cutoff voltages of the guns are equalized by the first anode (A1) voltage controls which are often called the background controls. If the grey scale is already approximately right it should only be necessary to trim one of these controls with reference to Fig. 56b, seeking neutrality exclusively in the *dark* greys and ignoring white. This is best done in a darkened room.

With correctly neutral background setting, the highlights may need balancing. In the circuit in Fig. 57a this is achieved by two potentiometers which allow the luminance drive from the valve output to the blue and green cathodes to be varied so that the differing slopes in Fig. 56a can be matched. The red gun permanently receives full drive since this usually has lowest overall gain due to the phosphor characteristic.

The lower end of each potentiometer is returned to a dc level which is approximately equal to the luminance black level, conveniently in this circuit the decoupled screen grid supply. This is to minimise the effect of highlight adjustments on the background settings.

The procedure is to look for any pastel tinting of picture whites and from Fig. 56a decide which highlight control to trim to remove it. As a tube ages, the gun efficiencies change and at some stage it may prove necessary to back off the drive to the red gun; if so it is easy to swap two cathode connections to put the full luminance

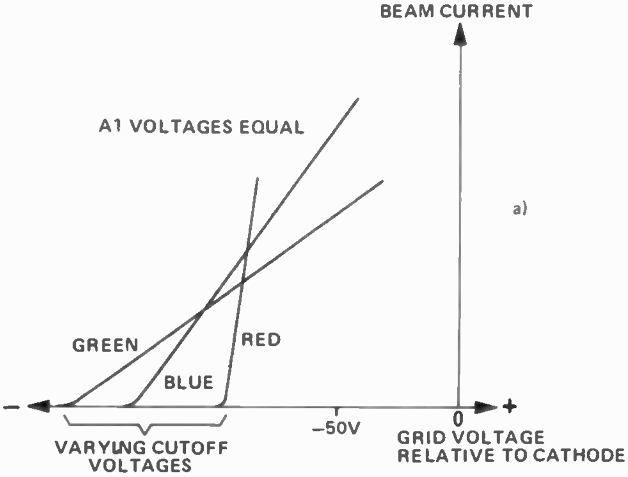
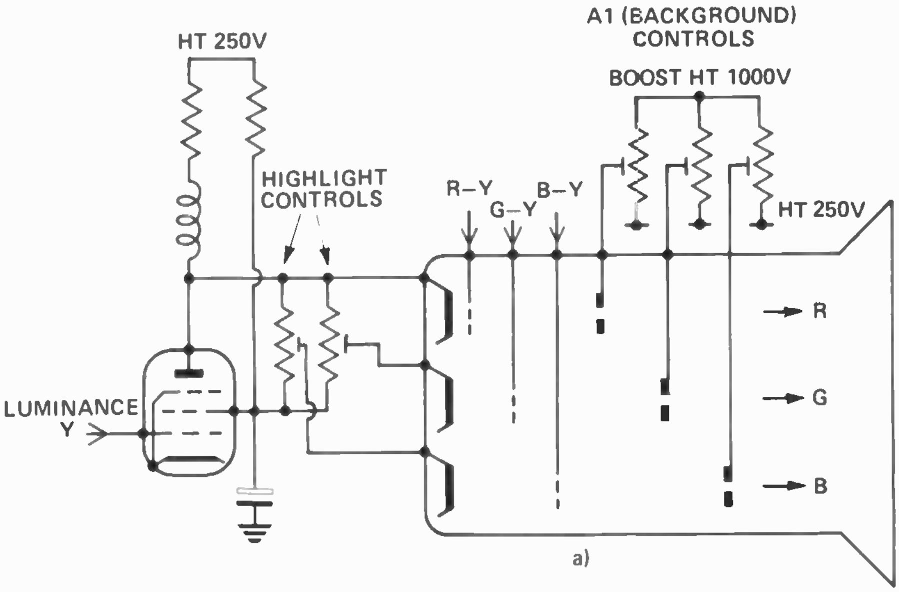


Fig. 56 (b)

GUN RESPONSE: / GUN	TOO STRONG	CORRECT	TOO WEAK
RED	red-brown tint	NEUTRAL GREY OR WHITE	blue-green tint
GREEN	green tint		purple tint
BLUE	blue tint		yellow tint

Fig. 56 (a) Unequal responses of the primary colour guns need compensating by means of the grey scale controls for correct monochrome and colour pictures. (b) This diagram shows the effects on a desaturated (grey) picture area (e.g. any part of a monochrome picture) of incorrect gun response.



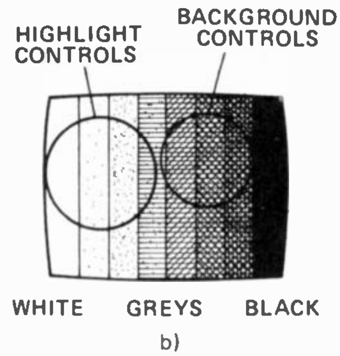


Fig. 57 (a) Greyscale controls associated with tube in a set using colour-difference drive i.e.: luminance (Y) fed to all three cathodes and colour-difference signals fed to grids. (b) Parts of grey scale affected by controls. This monochrome pattern is simply the common colour bars test transmission with the colour turned off.

drive to another gun. Avoid excessively bright (defocussed) whites where the least efficient gun, particularly of an old tube, may be driven into forward grid current which ruins the whole grey scale.

BEAM LIMITING

Besides ruining the picture, over-advancing the brightness control can in extreme cases cause damage by overheating the shadowmask so it distorts, or overloads an eht multiplier. To avoid this possibility most receivers incorporate some form of beam limiting device. Three representative circuits are shown in Fig. 58. Circuit a is common on early sets which use the bulky but efficient valve rectifier plus stabiliser circuit for eht. As beam current through the overwind and VR increases, the stabiliser grid is driven negative. Beam limiting is accomplished by diode D which conducts if it becomes excessive and pulls down the brightness control voltage. A similar circuit but with the diode connected to the contrast control has also been used.

Circuit b uses a low-value resistor to sense the emitter or cathode current in the line output stage — which increases with increasing beam current due to the internal stabilisation feedback. If the current becomes excessive the transistor turns on and again pulls down the brightness control voltage to keep the beam current in hand. The 'beam current' control should be set so this happens at a beam current of about 1 mA. The capacitors in this kind of circuit are important because they restrict the bandwidth of the control loop; they sometimes fail which causes symptoms of oscillating brightness and picture size.

Circuit c is much simpler and is connected in series with the tube cathodes (shown for one cathode only). Normally the diode is forward biased and provides a low impedance path for the luminance signal. However if the luminance drive goes too negative the diode blocks and the peak beam current is limited by VR. The capacitor prevents hf loss in the diode impedance.

DECODER

With correct grey scale established, the final step is to assess the decoder performance. As a colour transmission is tuned in, the picture should initially be monochrome and the colour suddenly pop in at the correct tuning point. This indicates correct action of the colour killer which enables the decoder only when adequate chroma is received. Distant (grainy) colour programmes will therefore be received in monochrome only.

Complete failure to receive colour calls for servicing action which we can only describe in a general way. The first step is to disable the colour killer so that demodulated chroma should be fed to the tube regardless of whether the reference oscillator is in lock. If doing this produces a perfect colour picture there is a simple fault in the killer stage itself. Another possibility is

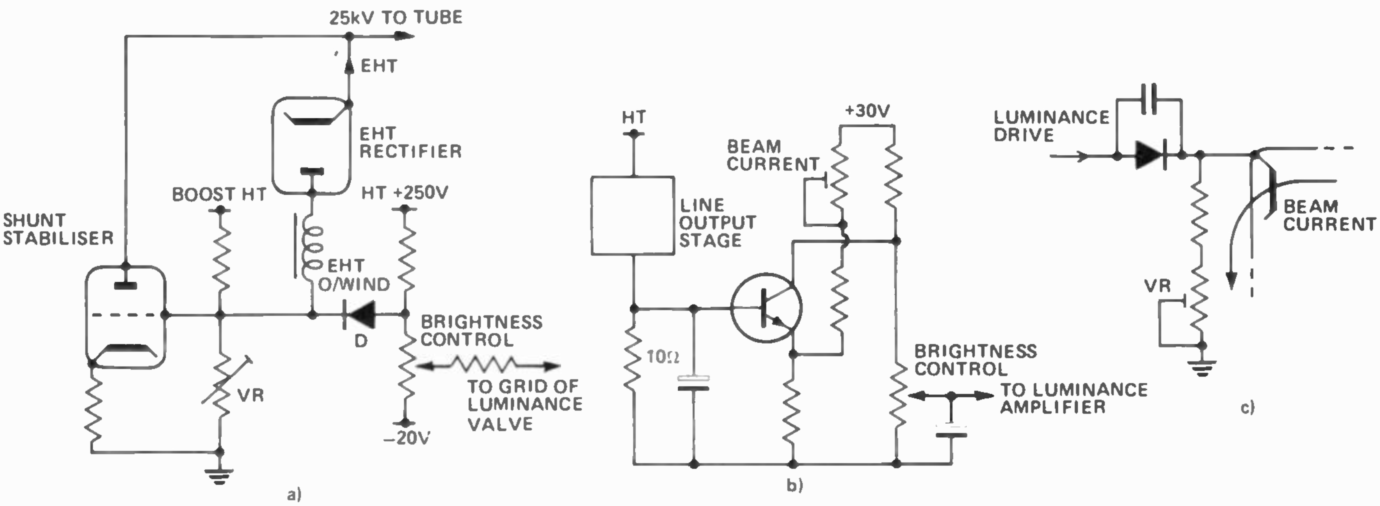


Fig. 58. Various arrangements for beam limiting.

UNDERSTANDING COLOUR TV

that alternate picture lines will show different colours (like Hanover blinds but with more extreme differences). This means the PAL bistable has stopped working and should be easy to cure.

A common fault is the reference oscillator failing to lock to the burst. An unlocked oscillator produces a cyclic variation of colours from top to bottom of the screen, caused by it passing in and out of correct phase, with a large number of cycles if its frequency is far removed from the burst. The cure may be found by adjusting the oscillator frequency control to bring it into lock. Set it to the centre of the lock-in range which is best found by monitoring the varicap diode bias voltage. If lock cannot be obtained or is unstable the next thing to check is the timing of the pulse which gates the burst into the phase discriminator; usually this is determined by an adjustable coil. At this stage an oscilloscope becomes necessary for fault finding.

With a functioning PAL decoder it is child's play to assess the colour performance if a colour bar transmission is available. Switch on the red gun alone. Set contrast and colour saturation so the red bars of the pattern are equally bright. Then change to the blue gun alone which should also be producing equally bright bars. Likewise the green gun. The correct positions of the bars are shown in Fig. 59. Incorrect ident phase has the effect of reversing the red bars. If necessary trim the colour channel gains in the decoder to achieve equally bright bars across the screen from all three guns.

Check the colours for freedom from Hanover blinds (chroma delay amplitude and phase adjustments) and your PAL receiver is ready for action. ●

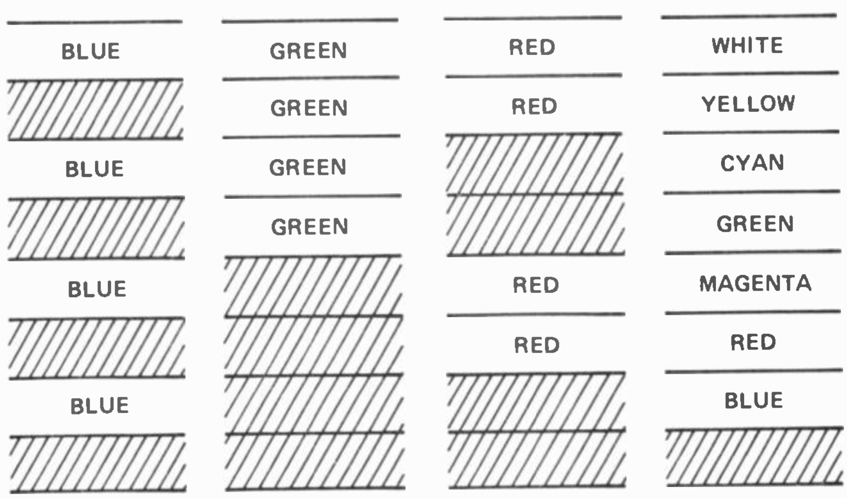


Fig. 59. Correct appearance of standard colour bars test pattern.

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7404	.35	7474	.90
7405	.35	7475	1.00
7408	.35	7475	.80
7409	.35	7480	1.70
7410	.35	7482	1.80
7413	.85	7483	1.40
7420	.35	7486	.60
7430	.35	7490	.80
7437	.60	7491	1.20
7440	.35	7492	.80
7441	1.20	74121	.60
7442	1.00	74123	.85
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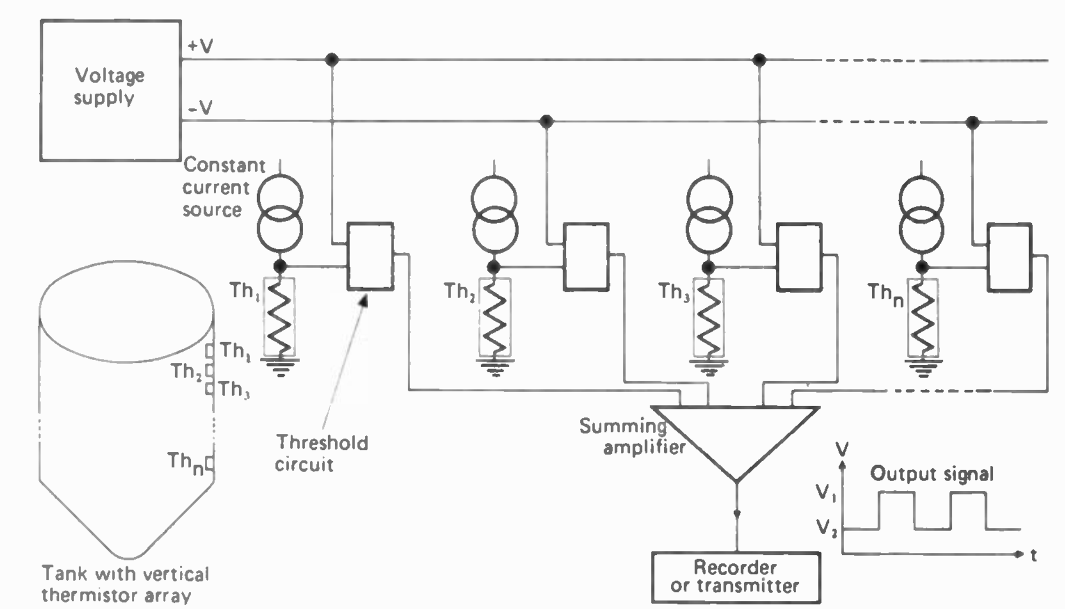


This level measurement system utilizes a vertical array of thermistors. The system was developed by the Royal Aircraft Establishment, Farnborough.

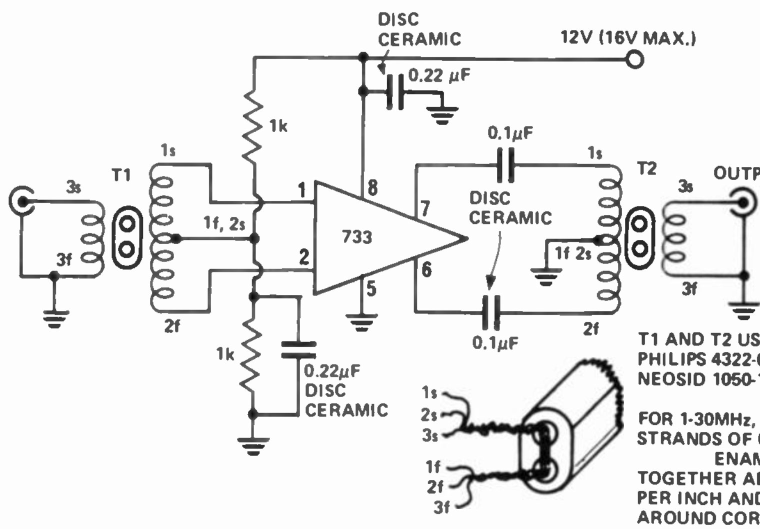
Thermistors are used to monitor liquid levels in tanks in this sensing circuit developed by the Royal Aircraft Establishment in Farnborough (UK).

The thermistors are arranged vertically at the required spacing inside the tank. Each thermistor is energised by a constant current source so adjusted that the thermistors are operating at the lower end of their temperature/resistance characteristics.

When liquid covers a thermistor, the thermistor's temperature decreases (due to the greater thermal conductivity of liquids compared to air), thus the thermistor resistance rises.

Thermistor resistance is monitored by a series of voltage threshold circuits, the outputs from which are added so as to produce a voltage proportional to liquid level.

USEFUL WIDEBAND AMPLIFIER



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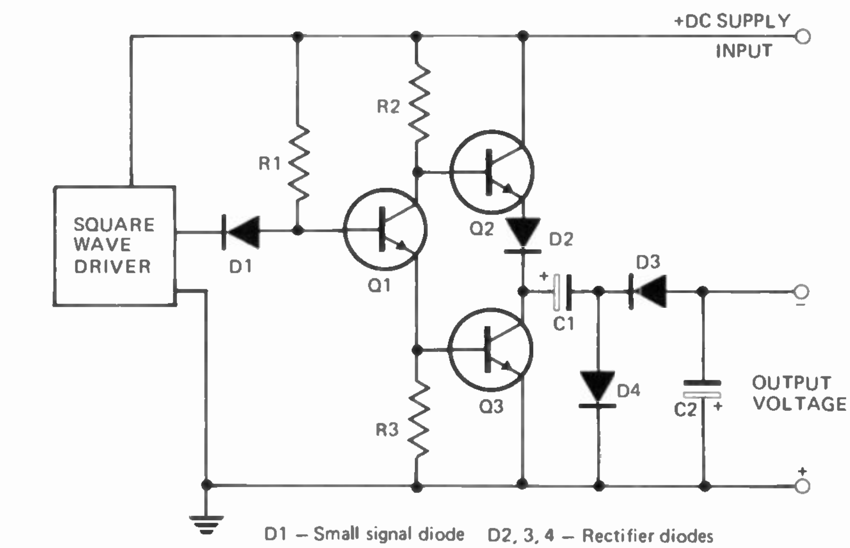
FOR 3-8MHz AS ABOVE BUT ONLY TWO TURNS

A wideband amplifier has many uses when working with RF. This amplifier will cover the HF range and the low VHF range, depending on the balun construction. The IC is an LM733, a wideband differential video amplifier. Switched-gain levels are available, see manufacturers' applications literature.

Although a single polarity supply is shown, a dual polarity supply can be used, simplifying things a little.

TRANSFORMERLESS INVERTER



D1 – Small signal diode D2, 3, 4 – Rectifier diodes
Q1 – Small signal N.P.N. Q2, Q3 – Output transistors

This transformerless inverter chops the dc supply voltage then rectifies the resulting square wave using a conventional voltage doubling circuit.

The square wave source can be a simple IC multivibrator which is used to drive phase splitter Q1 through coupling diode D1. Base bias is established through R1 and the collector and emitter load resistors are R2 and R3 respectively.

The output power transistors Q2 and Q3 in conjunction, with diode D2, serve as a simple high level switch developing a square wave whose peak to peak amplitude is near that of the dc supply voltage.

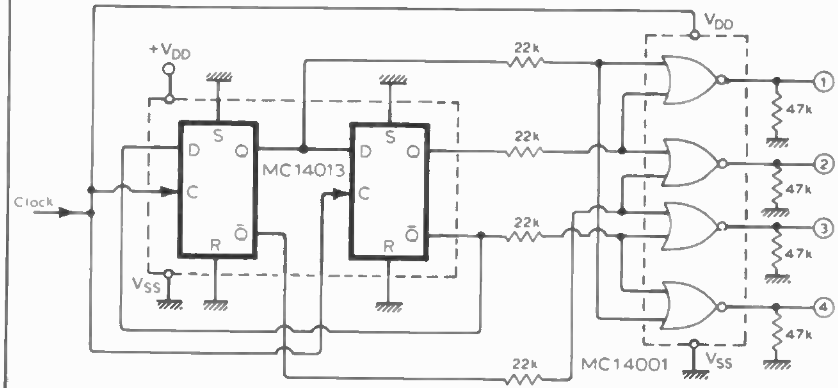
The output square-wave is coupled via C1 (which must be a suitably chosen high-value electrolytic) and fed into a voltage doubler circuit thus producing a dc output of reverse polarity.

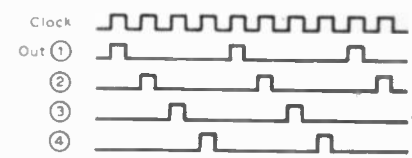
Capacitor C2 is the output ripple filter.

Resistor values are dependent on the original supply voltage – the drive frequency is not critical but signals in the kilohertz region are preferred (2-6 kHz).

IDEAS FOR EXPERIMENTERS

MULTIPHASE CLOCK GENERATOR

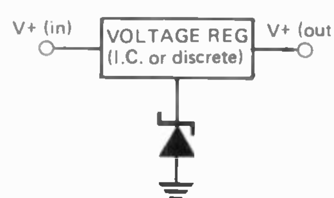


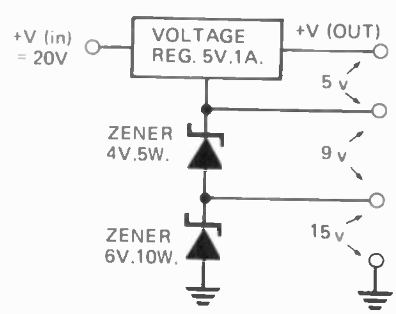


Whenever sequential logic operations are to be performed, a multiphase clock generator is often required. The circuit shown, which uses only two CMOS ICs, was designed by Michel Burri of Motorola's Geneva applications laboratories. It will produce a pulse on each of the four output lines in turn. These pulses do not overlap one another.

Operation of the circuit is self-evident from an examination of the schematic; however, it is interesting to note that the power supply of the MC14001 is derived from the clock input. The maximum operating speed of this circuit is about 1 MHz.

ZENER BOOSTS OUTPUT VOLTAGE OF REGULATOR





In this circuit the zener diode raises all voltages — with respect to earth — by the zener voltage, i.e.

Vin (max) ≏ voltage regulator Vin (max) + zener voltage

Vin (working min) ≏ voltage regulator Vin (min) + zener voltage

Vout = voltage regulator Vout + zener voltage

As the voltage regulator dissipates all excess power while the zener merely clamps the output voltage above its own voltage, a low wattage zener (250 mW) should be adequate — unless lower voltage taps are used, as in the second example in which the total output is one amp.

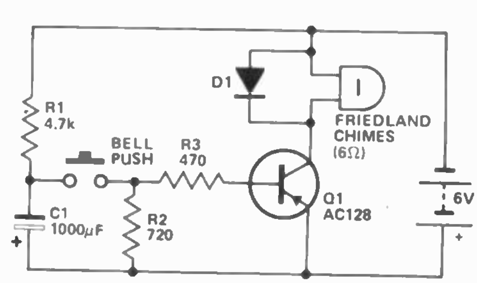
For other value zeners, wattages can be worked out by the formula W = zener voltage X current.

Andrew Hicks, Wootton, NSW

OOORCHIMES DELAY

Ever get tired of people who repeatedly press your doorbell?

With values shown, this simple circuit will permit one operation every 10 seconds or so. Capacitor C1 charges through R1 when the button is released. Making R1 larger will increase the delay.



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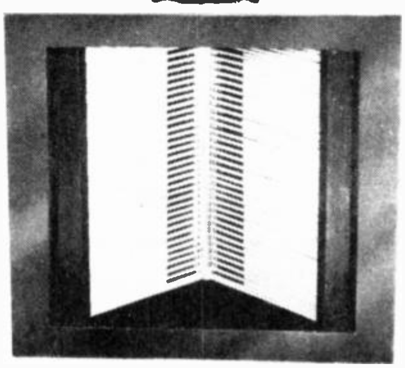
AUDIO FACTS

HEIL DRIVE UNIT NOW AVAILABLE AS SEPARATE UNIT



Heil are now producing their very successful drive unit in separate form.

The unit – known in this form as the 'Elite' can be added to almost any existing speaker system. Switch-selectable crossover frequencies at 1 kHz and 5 kHz cater for two way or three way systems (respectively). A very wide range level control enables the level of the Heil driver to be matched correctly.

Recommended retail price is $399 pair – agent is Megasound 220 West Street, Crows Nest NSW. Tel 922-3423.

LUX MAKE 600 WATT AMP

The hi-fi version of a Ferrari Boxer is now available from Lux. The plus $3000 amplifier (Luxman M-6000) produces

no less than 300 watts per channel continuous power with both channels driven – at which level total harmonic distortion is claimed to be less than 0.05%.

That Lux really are serious is shown by the mains transformer which is rated at 1 kW! Power consumption at full load is 1.3 kVA.

Agent is International Dynamics in Melbourne, a demonstration unit may also be seen at Gordon Hoskins new showroom at 400 Kent Street, Sydney.

MODIFIED 8-30 SPEAKERS – WARNING

A couple of years ago we published details of a revised version of our very successful Magnavox 8-30 speaker project.

The basic modification was the replacement of the earlier-specified Magnavox tweeters by a single Philips tweeter and the incorporation of a sophisticated crossover unit.

Subsequently we received several complaints from readers who made the change – only to burn out the Philips tweeter shortly after. Upon checking we invariably found that the enclosures concerned had been built from kits of parts, sold to the purchasers as being to ETI's specifications, but in which the LC crossover network specified had been replaced by a single series capacitor.

As specified in our project the modified Magnavox enclosure will provide excellent sound at moderate cost. However, much of the performance is due to the crossover network which we designed and specified.

If that crossover has been omitted – and if you have been sold that kit as being to ETI's specifications – you have been cheated. Worse than that in fact. We would like to make it absolutely clear that part of the function of the crossover network specified is to reduce the power input to the Philips tweeter. Without it, that tweeter is drastically overloaded and will inevitably burn out at inputs exceeding seven watts.

HIGH POWER AUDIO AMPLIFIER

A 100 watt audio amplifier – TF010 – aimed at the high power audio market such as disco equipment, and entertainments kit manufacturers, has been introduced by a British company. (Redac Software, Newtown, Tewkesbury, Gloucestershire, UK). It is a hybrid thick film module containing most of the components of a high quality audio power amplifier.

For use with high gain monolithic power transistors, mounted on a suitable heat sink, the unit combines high power output with good linearity and extremely small physical size. Dimensions are approximately 55 mm by 30 mm by 9 mm.

Selection of the power supply voltage range of plus or minus 10 V to 50 V can provide outputs up to 100 W rms (root mean square) with distortion at less than 0.2 per cent.

Australian Agent is Racal Electronics P/L, 47 Talavera Road, North Ryde, NSW 2113.

LOUDSPEAKER SYMPOSIUM AND AUDIO LECTURES

An international symposium on Loudspeakers has been arranged by the Audio Group of the IREE for 20-22 August 1975 at the School of Electrical Engineering, University of Sydney.

The symposium is intended primarily for engineers with a professional or academic interest in loudspeaker system theory, design and measurement. It will feature local authorities in the field as well as interstate and overseas experts who are in Sydney for the IREE International Electronics Convention '75.

Special guests of the symposium include Prof J Robert Ashley of the University of Colorado and Paul W Klipsch,

Big amplifiers seem to be becoming the norm. Latest model RA 1412 from Rotel delivers 110 watts per channel (min. continuous power with both channels driven) into 8 ohms from 20-20 000 Hz with not more than 0.1% distortion.

the designer of the world-famous Klipschorn. Both will take part in the symposium, and both will also present special evening lectures which will be open to the public. These lectures, which are also Audio Group meetings, are scheduled for 8 pm on Thursday and Friday, 21 and 22 August. Both will be held at the University of Sydney in Lecture Theatre 1, Merewether Building, corner of City Road and Codrington Street, Darlington. Admission to the evening lectures is free — there is a charge however for delegates to the main symposium.

Further details on the Loudspeaker symposium may be obtained from the Symposium Comittee Chairman, Dr J Ernest Benson, 4 Beaumont Ave, Denistone, NSW, 2114; Telephone (02) 85-2126.

ELECTRONIC SYNTHESIZERS

Several major feature articles covering the place of the electronic music synthesizer in music are published in the August issue of our companion magazine Hi-Fi Review.

Included within the section is a most interesting article by modern composer David Ahern and a very comprehensive discography — so if electronic music synthesizers are your thing — don't miss out.

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7406	.35	7470	.30	74161	1.25
7407	.35	7472	.30	74162	1.49
7408	.18	7473	.35	74163	1.39
7409	.19	7474	.35	74164	1.59
7410	.16	7475	.57	74165	1.59
7411	.25	7476	.39	74166	1.49
7413	.55	7483	.79	74170	2.30
7416	.35	7485	1.10	74173	1.49
7417	.35	7486	.40	74174	1.62
7420	.16	7489	2.48	74175	1.39
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739	Dual Hi Perf Op Amp	DIP	1.07
741	Comp Op AMP	mDIP TO-5	.32
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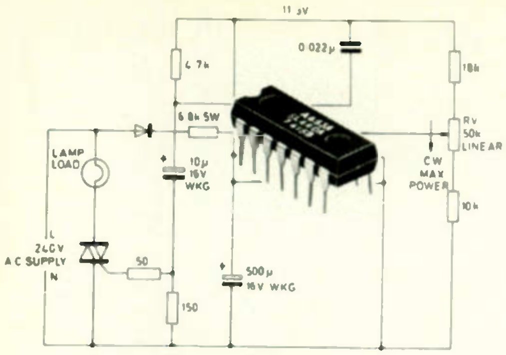
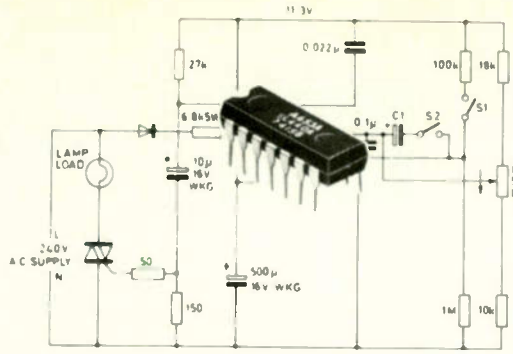
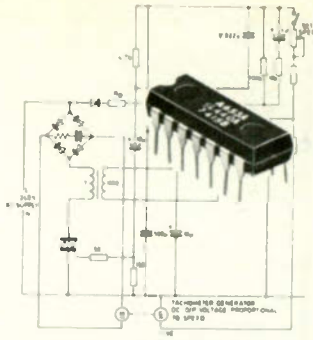


Lamp dimmer



Automatic lamp fading



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It may be applied to a manually controlled lamp dimmer, an automatic lamp fading circuit, for use in a motor speed control or symmetrical timing applications. The SL 440 is encapsulated in a 14 lead plastic D.I.L. package.

Comprehensive technical literature is available on request to the Professional Components Division.

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SO TECHNICALLY ADVANCED IT SHOULD HAVE BEEN INVENTED TOMORROW

SPECIFICATIONS

Frequency Response:
30 to 21 KHz 3.5 db

Crossover Frequency:
500 Hz, 5000 Hz

Nominal Impedance:
8 ohms

Maximum Amplifier Power:
200 watts/channel program

Minimum Amplifier Power:
20 watts. RMS/channel

Dimensions:
27¾" high, 20" wide, 14" deep

The reviewers of Hi Fi Newsletter had this to say about the Infinity 2000A:

> *". . . The Infinity people have demonstrated with the 2000A that they know their way in the problematic and highly controversial speaker world. Their representative, then, deserves our highest rating, and until something better comes along it remains our standard in its price category."*

Infinity is proud to announce that something better has come along — the 2000AXT. It is better because it is smoother in frequency response, has much better dispersion and has about 5 db added efficiency.

It is smoother in frequency response because we use three new drivers, each developed for its smoothness of frequency response and low distortion. It has better dispersion principally due to our patented wave transmission line tweeter. Finally, it has higher efficiency due to the application of our original research into the physics of transducers as applied to speaker systems.

The Infinity 2000AXT has the advantage of being used with various medium priced receivers as well as the super-power amplifiers of today.

THE TWEETER SECTION

The wave transmission line tweeter is probably Infinity's most stunning achievement. It's neither a cone nor a piston drive, not an electrostatic, not a ribbon and not an ionic device. In fact, it really doesn't appear in any textbooks on acoustics.

This Walsh tweeter, acting as a vertical, pulsating cylinder, is a purely coherent source of sound radiation — directly analogous to the light emitted by a laser beam. Therefore, it is transient perfect — a feat which no other speaker has achieved.

The drive mechanism of the tweeter is a voice coil in a very intense magnetic field. This drive mechanism was selected for its simplicity and inherent reliability, although any drive system could be used inasmuch as the cone is only plucked at the base.

Sound velocities much higher than the speed of sound in air are propagated up the metallic cone. Sound is emitted on various parts of the cone corresponding to the temporal and spatial scheme of Figure 1. Thus, each bit of audio information fed into the device is emitted intact at the same instant of time. This is true around the entire device so that 360° coherent radiation is a reality.

THE MIDRANGE SECTION

The midrange speaker is a very high efficiency 4.5" cone utilizing a large Alnico V magnet, the cone of which is treated for five times the stiffness to mass ratio of conventional speakers. The sound quality of this device is big and open with excellent transient response due to its low time delay distortion.

THE BASS SECTION

The bass driver is a 12" woofer with a full *one inch* movement capability. Its cone is treated twice — once to increase the stiffness to mass ratio by a factor of three, while the second treatment ensures proper cone damping to complement the added stiffness. The woofer is loaded into the "Infinity transmission line" enclosure for superb bass transients. It accurately reproduces the very lowest fundamental bass frequencies with excellent transient response and very low harmonic distortion.

The infinity fine family of speakers available from

INSTROL — CNR PITT & KING STREETS, SYDNEY; 91a YORK STREET, SYDNEY; 375 LONSDALE STREET, MELBOURNE • **MIRANDA HI-FI** — SHOP 67 MIRANDA FAIR, 525-7800 • **QUANTUM ELECTRONICS** — HOBART • **TRUSCOTTS** — ADELAIDE

(Continued from page 14)

news digest

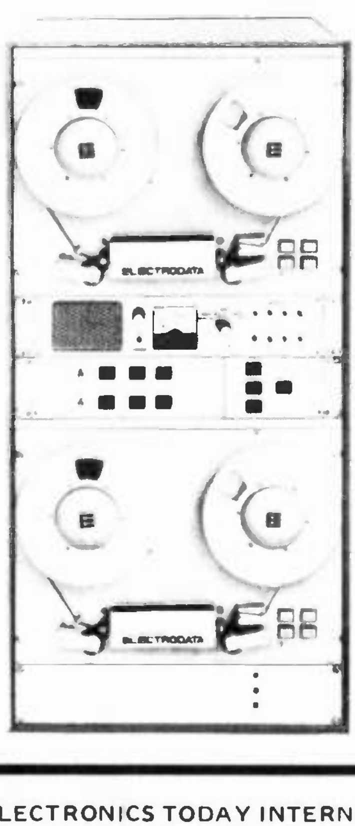
LOGGING TAPE RECORDERS

Electrodata Associates Pty Ltd, 18 Coward Street, Mascot, NSW, Australia, is pleased to announce a new range of communications tape recorders — System 8400 — for logging voice communication channels over extended periods of time.

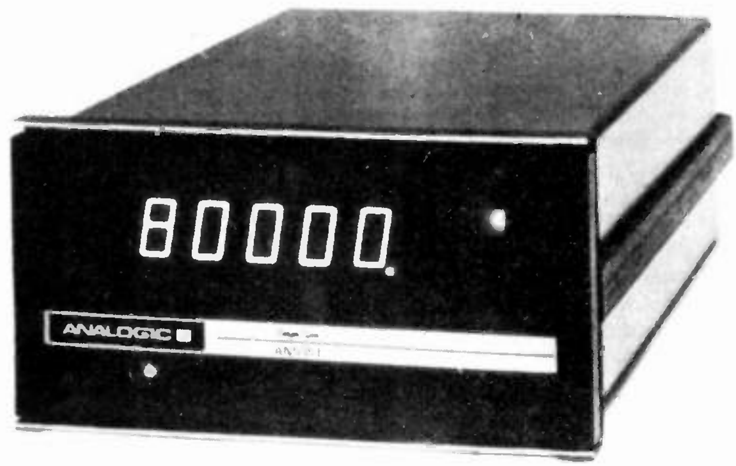
Designed and built in Australia the System 8400 range comprises three basic dual deck models for recording 8, 16 and 32 channels on ¼, ½ and 1 inch tape respectively. In addition a range of lower priced, single deck recorders are available for applications where some interruption to recording every 24 hours may be tolerated in order to change tapes.

The System 8400 recorders are designed for a wide range of applications from single channel recording at television and radio studios to multichannel recording at air, land and marine traffic control centres. The recorders are also ideally suited to improving efficiency in organisations using radio telephone communications.

A wide range of optional facilities, coupled with modular construction, enables System 8400 recorders to be assembled to suit virtually any customer requirement. Australian design and factory support ensures an after sales service standard previously unavailable with this type of equipment.



A/D — D/A CONVERTORS



Anderson Digital Electronics has recently taken over the representation of Analogic products throughout Australia.

Analogic is a company entirely involved with the supply of analog to digital and digital to analog conversion equipment. Typical of this are the digital panel meters, adc's, dac's computer data aquisition systems and the latest industrial digitizing systems, similar to the AN 5351 pictured.

For further information contact: Anderson Digital Electronics, P.O. Box 322, Mt Waverley Vic. 3149.

BATTERY CHARGERS

A&R-Soanar Electronics Group have just added three new battery chargers to their comprehensive range of equipment.

Known as the Formula series these new units are designed to charge six volt and 12 volt lead-acid batteries individually or in banks and are particularly suited to industry, fleet owners, farmers and the automotive trades.

Each charger in the series, is fitted with a large-scale ammeter and incorporates a fully automatic circuit breaker to protect the unit from damage in the event of an overload, short circuit, or reversed polarity when connections are made to a battery or bank of batteries.

A high charge circuit delivers full output current from the charger and is used to boost charge single batteries or fast-charge a group of batteries connected in parallel. A low charge circuit provides 50% of the charger's maximum output current and is particularly useful when charging a bank of batteries as it facilitates achievement of the optimum or trickle charging rates.

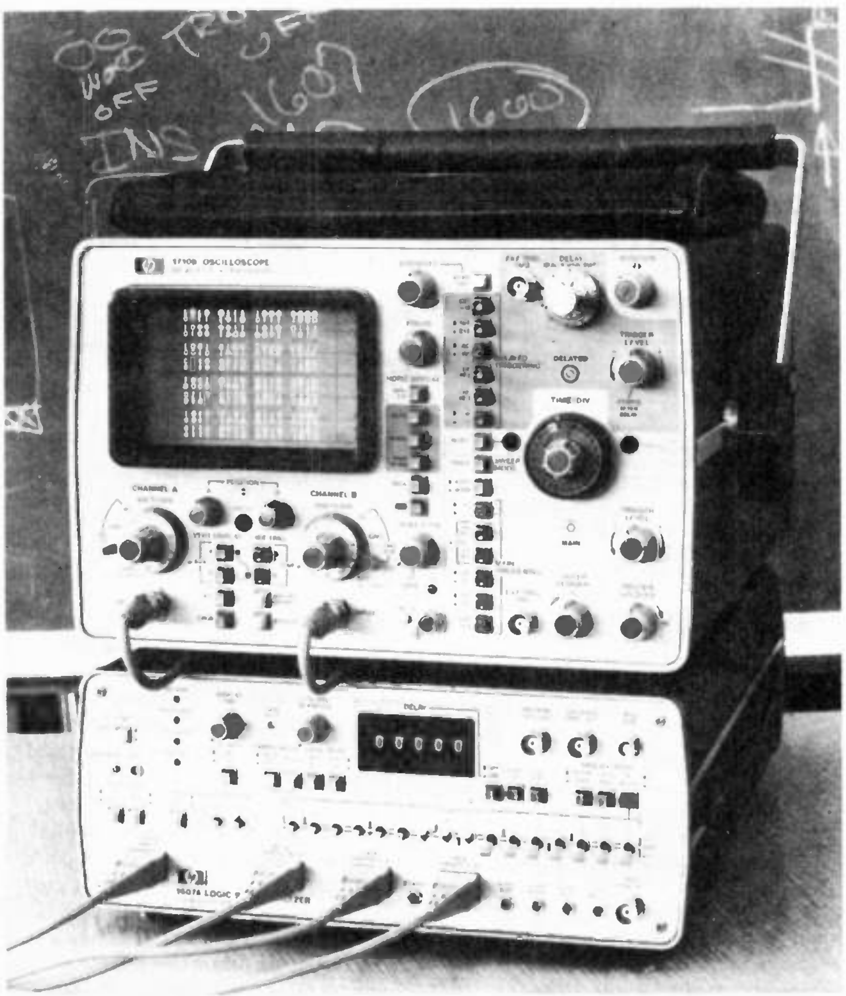
ANALYSERS REVEAL FUNCTIONAL RELATIONS IN AS MANY AS 32 PARALLEL DATA CHANNELS WITH WORD-FORMAT DISPLAY

Today, designers of microprocessor-based or microprogrammed equipment, as well as designers of more traditional computer, data communications, and numeric control logic circuitry must measure much more than the electrical dimensions of data signals. They must analyse the functional relations among the bits. To work thus in 'the data domain,' test equipment should present a functional picture in word format, triggered and indexed on digital words. Many users require 16 channels; 32 would not be a luxury. A way to 'map the territory' in the data domain would also help. Such equipment now exists.

Two new Logic State Analysers from Hewlett-Packard, working together, can present in words formatted in 1's and 0's, the sequential flow of data in 32 parallel channels. Model 1607A alone will produce a 16-channel word-format display on the screen of any modern lab oscilloscope. On its own CRT, Model 1600A can show a 16-channel sequence, or 32 channels when working with the 1607A.

The 1600A introduces a new technique, 'mapping' of logic operations, making characteristic performance instantly recognisable by taking advantage of the ease with which humans can detect patterns and pattern changes. Mapping can contribute importantly to development of efficient programmes. Both analysers work at clock speeds up to 20 MHz and trigger on preset data words.

Triggering is the key to the instrument's ability to find out what goes on in a logic machine. To find out what sequence follows a unique word (established by trigger-word switches), the analyser is set to start display on that word, for example to confirm a turn-on sequence or to check response to a key-stroke. End display triggering makes it possible to capture 'negative time', for example to find the sequence that preceded a 'crash'. If desired, the trigger word can be placed anywhere in the 16-word 'window' to reveal what occurred both before and after the trigger word. The 'window' can be moved beyond the trigger word by any exact number of clock-pulses up to 99 999. That would be useful, for example, to get past loops or to measure the exact length of subroutines. With trigger Off the analyser runs freely; one use would be to discover why a machine may be stuck in a loop – capture a 16-word sequence arbitrarily anywhere in the loop, then use Word and Delay modes to page through until the cause is seen. The Bus trigger makes it possible to bus a 1600A and a 1607A together to form a trigger word up to 32 bits long.



Model 1600A can show 16 successive 32-channel sequences. If a 1607A is also used, the display may be of two independent but simultaneous 16-bit sequences side by side. In programme analysis, data words each as long as 16 bits could be shown alongside corresponding 16-bit addresses.

The 1600A can 'memorise' sequences of 16-bit words, and show them on the right of the screen if desired; to speed comparisons with new sequences called up on the left, the right table can be set to display Exclusive-Or comparisons, showing any bit that differs as an intensified 1. To help catch intermittents, the 1600A can be set to run freely until the two displays fail to match, then to halt automatically and store the anomalous sequence.

The 1600A produces 'maps' of logic-machine operation which graphically show each address or state as a dot on the screen; its brightness reveals its relative frequency of occurrence; lines between dots indicate the direction of state flow. The display is an arrangement of 2^{16} dots, each representing one possible combination of the 16-bit parallel input lines, so every possible input word has a corresponding dot location. Such a map forms an instantly-recognisable pattern for each operation; departures are detected much faster than by comparing tabular presentations. Any dot of interest on the map can be identified with a cursor; spot it over the dot in map-expand mode, return to tabular display with a pushbutton, and the word at the cursor's position will be in the trigger position on the screen.

Model 1607A can convert an oscilloscope into a word-format logic state analyser. Rear panel X, Y, and Z outputs will drive oscilloscopes with dc-coupled inputs on all three channels, with frequency-response 500 kHz or more, and deflection factor 1 v/div or better. Both the 1600A and 1607A have trigger outputs for oscilloscopes, delivering a trigger pulse everytime the preset trigger word occurs, to synchronise the word-format display with oscilloscope measurement of the digital signal's electrical characteristics.

UNIVERSAL COUNTER FEATURES MODULAR DESIGN

Modular design and choice of options give the user of Hewlett-Packard's Model 5328A Universal Counter the ability to fit the counter to his unique needs. The simplest version, with no options, makes frequency measurements to 100 MHz, and single-shot time interval measurements to 100 nanoseconds resolution. Time interval averaging increases resolution to 10 picoseconds for repetitive events. It also measures period, period average and frequency ratio, and will totalise and scale inputs. Frequency measurement sensitivity is 25 millivolts rms to 40 MHz and 50 millivolts rms to 100 MHz.

Arming capability, previously available only in higher-priced instruments, gives precise control over the start of a measurement. When the counter is switched to the armed mode, an input on one channel determines when the counter starts a measurement on a second channel. Such control is essential for frequency profile measurements on swept signals. Arming also enables time interval measurements starting on a selected pulse in a bit stream.

Six options are currently available to expand the capabilities of the Model 5328A. A high performance universal module, option 040, expands time interval capabilities and adds switchable input impedance of 1 megohm or 50 ohms.

Frequency range can be increased from 100 MHz to 512 MHz with an optional Channel C input (Option 030). Sensitivity at 512 MHz is 15 millivolts rms. The ratio of an input frequency on Channel C to that on normal Channel A input can be measured. Also the events occurring on Channel C can be totalled between the time of occurrence of pulses on Channels A and B. The display is nine digits for all Channel C functions.

Two DVM options are available which measure external dc as well as internal trigger level settings. Option

020 is single ended; Option 021 has a floating input with resolution to 10 microvolts, autoranging and an input filter that can be switched in to suppress normal-mode noise.

Hewlett-Packard Interface Bus (HP-IB) Option 011 allows remote programming and digital output through a single I/O connector for systems applications.

A high-stability time base, Option 010, has an oven oscillator with an aging rate of less than 5×10^{-10} per day.

For further information contact Hewlett-Packard Australia Pty Ltd., 31-41 Joseph St. Blackburn, Vic. 3130.

DUAL FUNCTION 'SCOPE PROBE

A locking push-button switch provides instantaneous change from X10 to X1 modes with the passive probe kit now available from B.W.D. Electronics Pty. Ltd.

Designated the DuoProbe P32, the single head, dual function probe is supplied in a protective wallet complete with 1.2m ultra-flexible lead, BNC input connector, detachable sprung hook and insulating sleeve. A trimming tool is also provided for input capacity trimming, and is readily accessible at the probe head.

The push-button, incorporated within the head, provides instant transfer to the X1 mode when, for example, recalling a lost trace on the oscilloscope; with the option of locking-on for continuous use by turning the button through 90°.

Specifications include bandwidths of dc to 80 MHz (X10 mode) and dc to 20 MHz (X1 mode). Rise time is less than 4nSec, and input resistance in the X10 mode is 10M ohms when used with oscilloscopes having 1M ohms input.

Further details from: B.W.D. Electronics Pty. Ltd., P.O. Box 123 Glen Iris, Vic. 3146.

OPTO COUPLERS FROM NATIONAL

National Semiconductor announces the addition of four JEDEC-registered opto-couplers to its line of optoelectronics products. The 4N25, 4N26 and 4N28 — each consisting of a gallium arsenide LED optically coupled to a silicon phototransistor — find wide use in applications such as phase control, feedback controls, telephone line receivers, line to digital-logic isolation circuitry, solid state relays and so forth.

All of the new opto couplers feature high electrical isolation, high current-transfer ratios, small size and low cost.

ADVERTISERS INDEX

news digest

THREE TERMINAL VOLTAGE REGULATORS

Three new series of easy-to-use voltage regulators have been developed by National Semiconductor Called the LM341, LM342, and the LM78L, all of the new regulators are three terminal (in, out, and ground) devices available in several output voltages making them useful in a wide range of applications.

The LM341 series is available in the popular plastic TO-202 tab package in voltages that include 5, 6, 8, 12, 15, 18, and 24 volts. Output current for the LM341 series is a hefty 500 milliamps with adequate heat sinking.

The LM342 series also comes in the TO-202 package and is available in 5, 6, 8, 10, 12, 15, 18, and 24 volt versions with a current rating of 200 milliamps.

The LM78L series is available in either a three-lead TO-5 can or a TO-92 plastic package. It has output voltage ratings of 5, 8, 12, 15, 18, and 24 volts and has a current rating of 100 milliamps.

All of the new regulators may be employed for on-card regulation, eliminating the distribution problems associated with single point regulation. And because of the wide range of available voltages, the devices may be used in logic systems, instrumentation, hi-fi, TV, and other solid state over, electronic equipment. Although designed primarily as fixed voltage regulators, all of the new circuits can be used with external components to obtain adjustable voltage and current operation. In addition, the LM78L series regulators may be used as a zener diode/resistor combination replacement in simple pass transistor regulators resulting in a significant improvement in output impedance and a lower quiescent current. The LM341 and LM342 may also be used in this configuration where higher currents are required.

Current limiting in all of the new regulators is included on-chip to limit the peak output current to a safe level. If internal power dissipation becomes too high for the heat sinking provided, an internal thermal shutdown circuit takes preventing the IC from overheating.

HYBRID CRYSTAL OSCILLATORS

Sprague Electric Company has announced a range of hybrid quartz crystal oscillators.

These completely self-contained units comprise the quartz crystal plus the necessary amplifying circuitry made by thick film techniques, all mounted in a hermetically sealed metal case.

The frequency range of the units is from 300 kHz to 20 MHz. Outputs are TTL compatible and are available in normal, reverse or divided frequency modes.

Frequency accuracy of the units is claimed to be plus/minus 0.003% and frequency stability over 0°C to + 70°C plus/minus 0.008%.

For further detail contact Namco Electronics, 239 Bay Street, North Brighton Victoria 3186.

PAL RECEIVER CRYSTAL

A low cost, quality quartz crystal resonating at 4433.619 kHz is offered for use in PAL Colour TV Receivers.

This crystal is produced by a leading U.S. manufacturer, who has set-up special facilities for volume production and is a major exporter.

The crystal is similar to the HC-33/U outline, adjusted to ±0.002% for 20 pF load capacitance (25°C). Pulling sensitivity is better than -370 Hz to +525 Hz for ±5 pF. Stability over temperature range 0°C to 60°C is better than ±0.002%.

Inquiries to Crystal Department, Amalgamated Wireless (Australasia) Limited, 422 Lane Cove Road, North Ryde, 2113.

ERRATA & ADDENDA

25 WATT AMPLIFIER, ETI 440
JULY 1975
Page 72, Fig. 10

The dimensions marked 42 and 122 for the position of the transistor mounting holes should be 47 and 127 resp.

DIGITAL VOLTMETER, ETI 117

AUGUST 1975
Page 30, parts list.

C5 should be 68 pF. PC board should be ETI 117B not ETI 1178 as published.


MUSICALITY.
The key to the Success of SANSUI's New AU Series Stereo Amplifiers.
As Japan's leading audio-only manufacturer, Sansui has always provided the vanguard in amplifier technology, design and development.
Three new models — the AU-5500, AU-6600 and the AU-7700 — combine the latest developments in design with electronic circuitry which produces an audio transparency — musicality — impossible to write into technical specifications. This abstract quality must be heard.
Power output of the three models range from 70 to 110 watts RMS into 8 ohm speaker systems. Total harmonic distortion is less than 0.15% — the figure for the AU-7700 being less than 0.1%. Frequency response figures are equally outstanding.
Your hi-fi specialist will gladly tell you of all the technical innovations in the new Sansui AU range. Listen critically to these new Sansui amplifiers. Please be quite analytical. We believe you will confidently select Sansui.
Here are abridged technical specifications:
SANSUI — AU-5500.
Output: 35 watts RMS per channel into 8 ohm speaker systems. THD: Less than 0.15%. Frequency response: 10-35,000 Hz +0.5, −1 dB. Sensitivity suits magnetic cartridges, tuners, tape decks, etc. Recommended list price: $419.
SANSUI — AU-6600.
Output: 45 watts RMS per channel into 8 ohm speaker systems. THD: Less than 0.15%. Frequency response: 10-40,000 Hz +0.5, −1 dB. Sensitivity suits magnetic cartridges, tuners, tape decks, etc. Recommended list price: $469.
SANSUI — AU-7700.
Output: 55 watts RMS per channel into 8 ohm speaker systems. THD: Less than 0.1%. Frequency response: 10-50,000 Hz +0.5, −1 dB. Sensitivity suits magnetic cartridges, tuners, tape decks, etc. Recommended list price: $549.
TWO YEAR WARRANTY. All Sansui amplifiers carry a full 2 year warranty. Effective service facilities are available throughout Australia.
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