

Jansen

JUNE, 1975
75c*

electronics

HI-FI

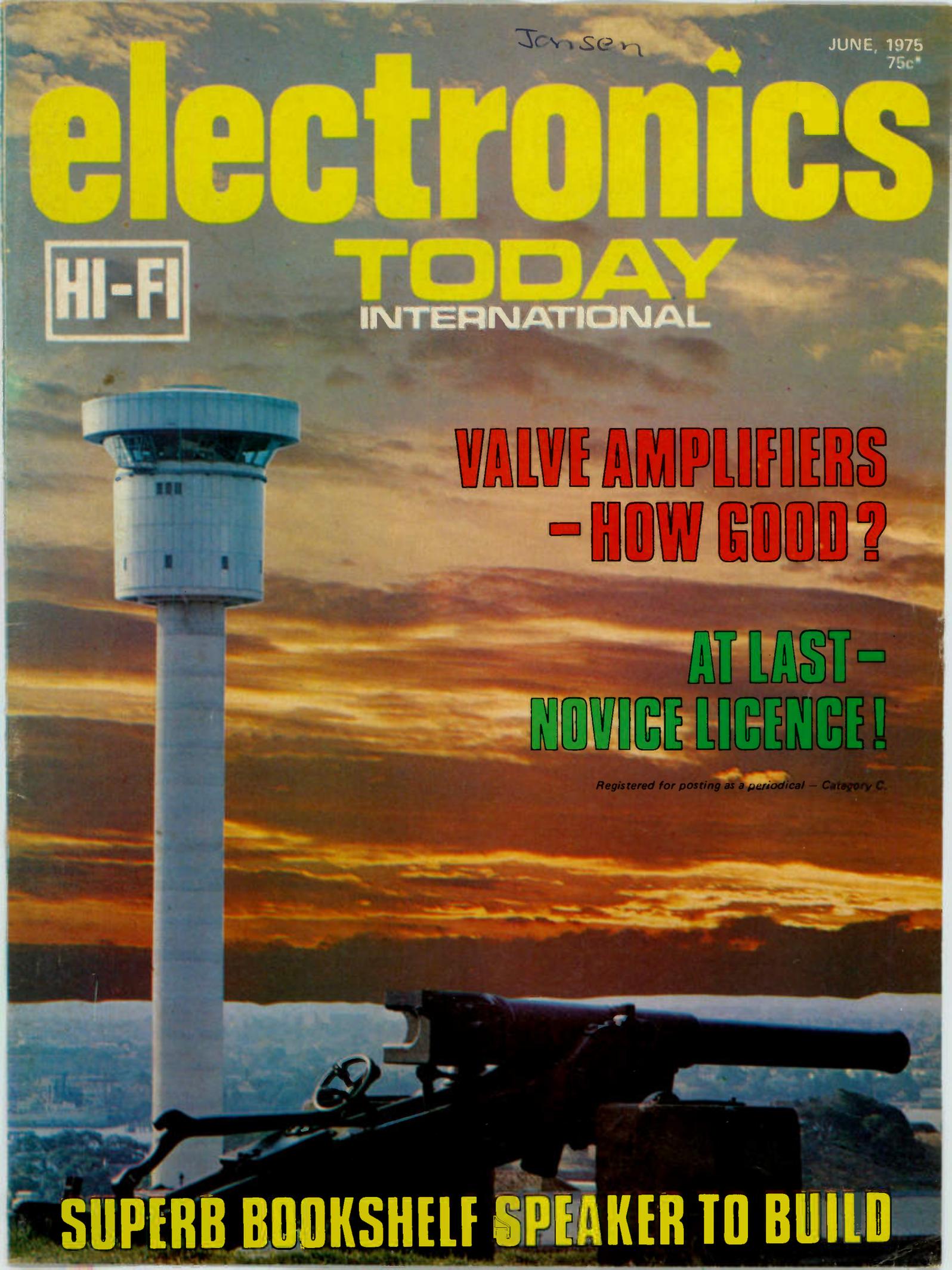
TODAY
INTERNATIONAL

VALVE AMPLIFIERS
- HOW GOOD?

AT LAST -
NOVICE LICENCE!

Registered for posting as a periodical - Category C.

SUPERB BOOKSHELF SPEAKER TO BUILD



KILL THE HISS



keep the music

Until now tape hiss and other irritating noises prevented true high fidelity reproduction, so JVC invented ANRS (automatic noise reduction system) and incorporated this exclusive feature in the 1667U stereo cassette deck.

ANRS (automatic noise reduction system) as the name implies, ensures absence of tape hiss without sacrificing fidelity and musical reproduction and is claimed to be the world's best system by independent authorities.

Additionally the 1667U features the 'cronios heads' developed by JVC, that have a life

ten times longer than ordinary heads. Naturally CrO₂/Normal tape selector switch, electrically governed DC motor, automatic stop mechanism and tape counter are all included.

For maximum recording ease the 1667U features two large VU meters, separate sliding volume controls and convenient push buttons. All this helps the 1667U boast of a frequency response of 30-16000Hz (± 3 dB) and a low wow and flutter of 0.15% RMS.

A 'must' for any serious stereo enthusiast, the 1667U stereo cassette deck, from JVC.

JVC

IF YOU'RE SERIOUS
ABOUT SOUND

ANRS
Automatic Noise Reduction System

electronics

TODAY

INTERNATIONAL

JUNE 1975

Vol. 5, No. 6

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NEXT MONTH

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Round up of types of meter available.

ELECTRONICS IN MEDICINE

ALL ABOUT TAPE BIAS

SIMPLE HI-FI AMPLIFIER

Designed for reasonable power output at lowest possible price.

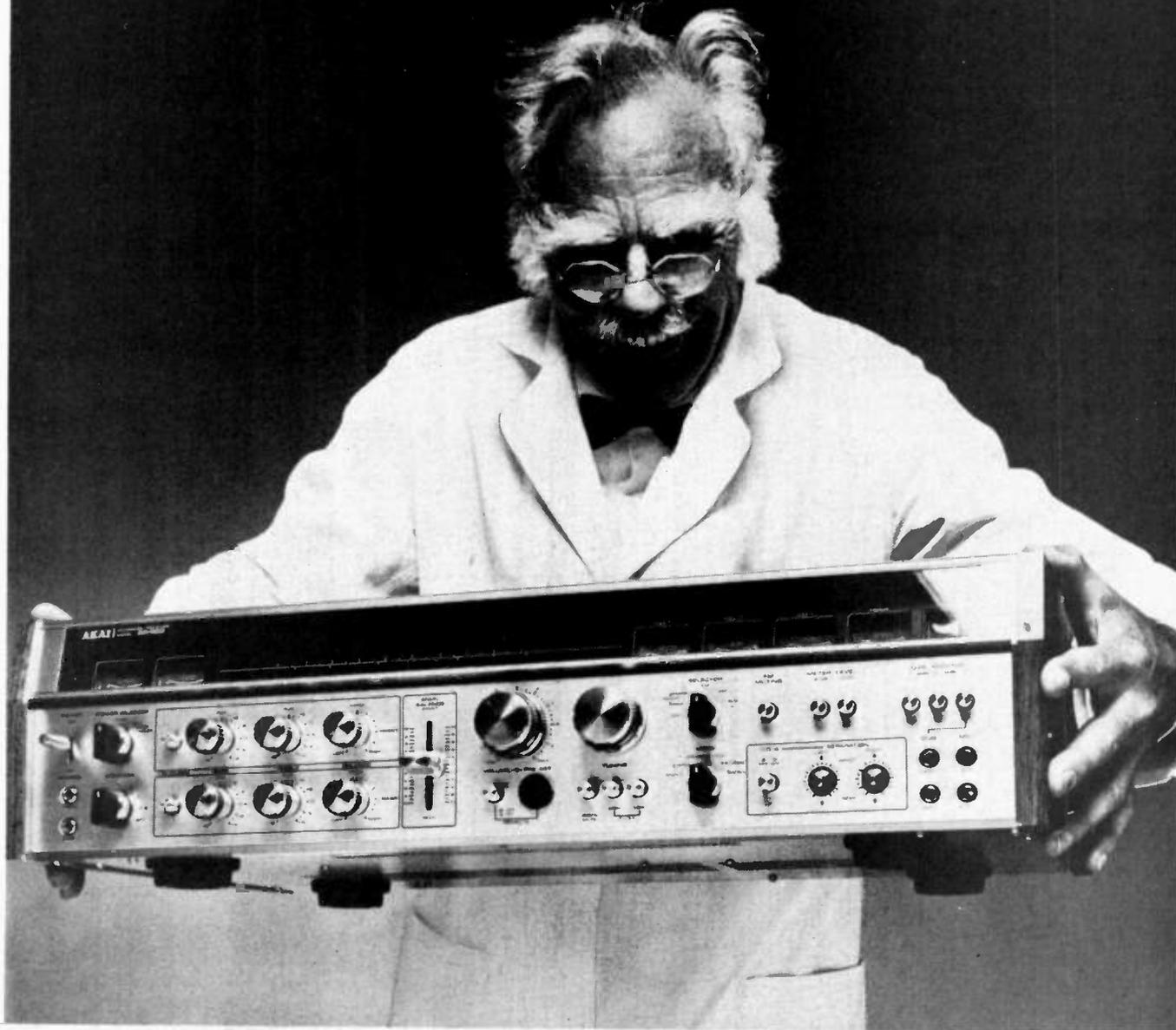
PLUS LOTS MORE!

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

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SONIC SHARK REPELLENTS

Sonic shark barriers may well be used to protect people swimming off Australia's beaches soon.

For the past year a research programme organised and led by Australian marine researcher Theo Brown has been studying the effect of sonic repellents and attractants.

In his latest report to his sponsors, Theo Brown reports that significant advances have been made. Experiments have in fact been reasonably successful over the past 14 years, but in past experiments it was found that fish soon became 'habituated' to the sonic sources and ceased to respond to further similar signals.

It now appears however that by suitably modifying the signal patterns, fish can be attracted or repelled (as desired) for substantial periods of time. For example Theo Brown reports that schools of up to 10 000 fish could be controlled for up to three hours.

Shark repellent experiments were even more successful. Here the experiments were conducted in a lagoon known to have resident shark populations. (Rangiroa Lagoon in French Polynesia). Following a prolonged period of underwater transmission with modified repellent signals it was observed that the sharks did not return to the test area when transmission ceased.

Whilst Theo Brown stresses that it is only conjecture at this stage, it would

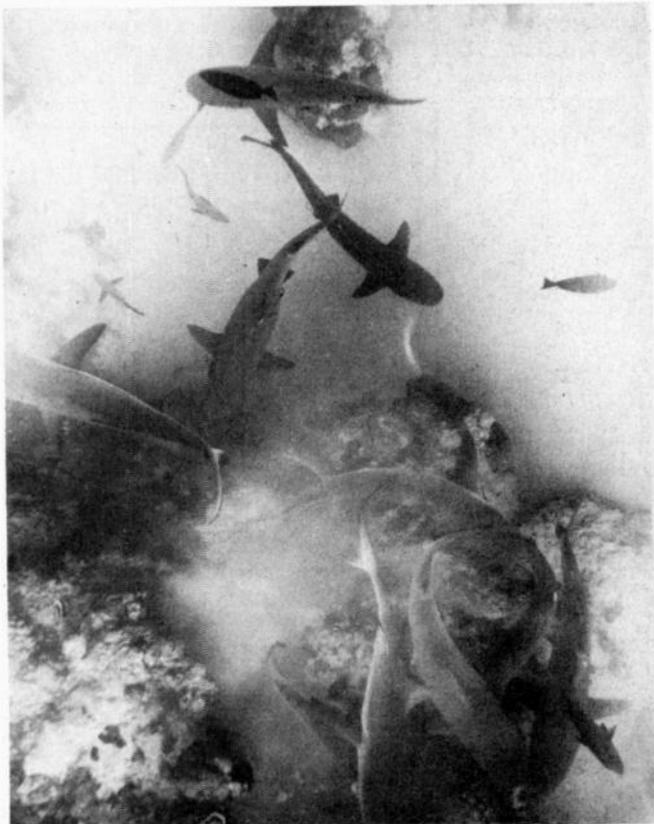
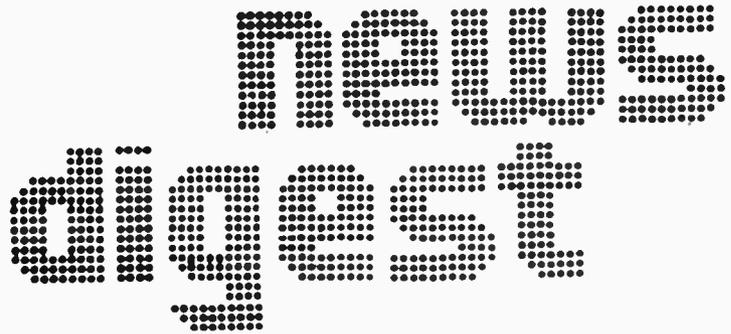
appear that the modified repellent signals were so objectionable or unbearable to the sharks that they tended to avoid the area, even when transmission had ceased.

Theo Brown's work has attracted a considerable amount of interest from various Australian councils and other official bodies. Manly City Council has approved a plan to install a sonic shark repellent barrier in Manly Cove during the 1975/1976 season. The South Australian branch of the Surf Life Saving Association of Australia has asked that experimental work with sonic repellents be undertaken in South Australian waters.

In a slightly different field the Victorian Rivers Commission has asked

for help in their programme to eradicate a species of freshwater carp that is now becoming a serious environmental problem by threatening other forms of aquatic life.

The Shark Research Expedition is being conducted in association with the Medical Oceanographic branch of the Institut de Recherches Medicales, and the Service de la Peche, Papeete, Tahiti. It is financed by donations from a number of Australian companies — particularly Pioneer Electronics (who have supplied amplifiers, cassette decks and the very specialised underwater transducers) and BHP. A number of other companies have donated goods and materials — such for example as TDK tape.



Sharks, excited by sounds from a concealed transducer, fight to reach the signal source. The transducer, weighing 14 kg, is concealed beneath the corals to avoid damage. If accessible, sharks will attack and consume the transducer during the experiment.



VIDEOPLAYER USES STANDARD AUDIO CASSETTES

A video-tape system based on the standard Philips-type audio tape cassette has been developed by Japan's Matsushita Electric Corporation.

The system is currently being demonstrated in Tokyo using apparently standard Memorex cassettes.

At present the system appears to be designed for play-back only, competing with videodisc systems such as Teldec, Philips/MCA and RCA.

No further details of the Matsushita system were available at the time of closing for press.

A further videoplayer development is that BASF are believed to be developing a video version of their Unisette audio cassette. The latest version uses the standard Unisette cassette housing (which accepts 1/4" width chromium dioxide tape).

NEW CONTROL SYSTEM FOR SINGLE LENS REFLEX CAMERAS

Electronic shutter speed and exposure controls can now be built into single lens reflex cameras without mechanically modifying the camera bodies or lenses.

A new control system, developed by Matsushita Electrical Industrial Corporation, measures the light at a preset aperture (in less than two milliseconds) and then sets exposure time accordingly. Control range varies

from 0.0005 seconds to four seconds — dependent upon lens aperture and film speed.

Prior to the Matsushita development, it was necessary to have a light measuring device accommodated behind the main lens — calculating light intensity with the lens held wide open.

TV TRANSMITTER FIRED FROM GUN

A TV camera and transmitter have been successfully fired out of an eight inch (203 mm) gun by the US Navy's Surface Weapons Centre (Dahlgren VA). Once at maximum trajectory a parachute is deployed and the TV assembly transmits pictures of the terrain below to an associated receiver complex.

TEMPORARY RADIO AUSTRALIA STATION AT CARNARVON (WA)

The Postmaster-General, Senator Reg. Bishop has announced that a temporary Radio Australia Transmitting Station will be established at the former NASA Tracking Station site at Carnarvon in Western Australia.

He said that the new station, approved by cabinet on 11 March, 1975 was designed to improve Radio Australia's Voice in the Asian region, which had deteriorated with the loss of the Cox Peninsular/Radio Australia Station in the Darwin Cyclone Disaster. Since the Darwin Disaster all Radio Australia transmissions have had to be derived from the older, lower-powered transmitting station at Shepparton.

Several sites in Western Australia have been investigated for the establishment of the temporary station but, all things considered, the Carnarvon site is the most suitable, the Minister said.

The new station, which would receive its programmes from the ABC Radio Australia studios in Melbourne over existing relay links, is expected to be operational by the end of 1975.

The Minister said that his Department had already placed orders for the necessary equipment.

RAAF AIRFIELD COMMUNICATIONS CONTRACT

ACI Electronics, a member of the Australian Consolidated Industries Limited group, has been awarded a major communications network contract involving the design, manufacture and testing of base and mobile UHF transceivers.

The equipment, comprising some 500 hand-held and 300 vehicle mobile and base units will be supplied complete with power sources, remote control accessories, retransmission bays and full documentation.

The system which is unique to the Australian Armed Services will be designed in accordance with RAAF technical and performance specifications. Systems are to be installed at both RAAF and RAN air stations for ground crew operations which will include fire services, tarmac control, airport supply and the broad range of communication requirements extending to message retransmission to other ground and air networks. The contract is in excess of \$1 million.

DIGITAL WATCH PRICES TUMBLE

Digital watches may soon be selling for less than \$50 — and could be as low as \$20 in two years time.

This forecast was made by Victor Kiam of Benrus Corporation during a digital watch seminar held in New York earlier this month. As if to illustrate Kiam's point, Litronix (Cupertino, California) announced a range of five LED readout watches costing from \$US59.95 — US\$49.95.

Not all manufacturers are aiming for ultra-low prices however. Intersil for example are about to introduce an LED readout wristwatch range (called Cronus) selling for around US\$200 — US\$350; and there is also a new HWM Pulsar unit retailing for about \$2000! But that one has a 14 ct gold case and strap.



"So! This is the spot of decorating you were hoping to do while I was staying with mother."

Continued on Page 11

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2000 AXT



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SPECIFICATIONS

Frequency Response:
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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:
27 1/4" 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.

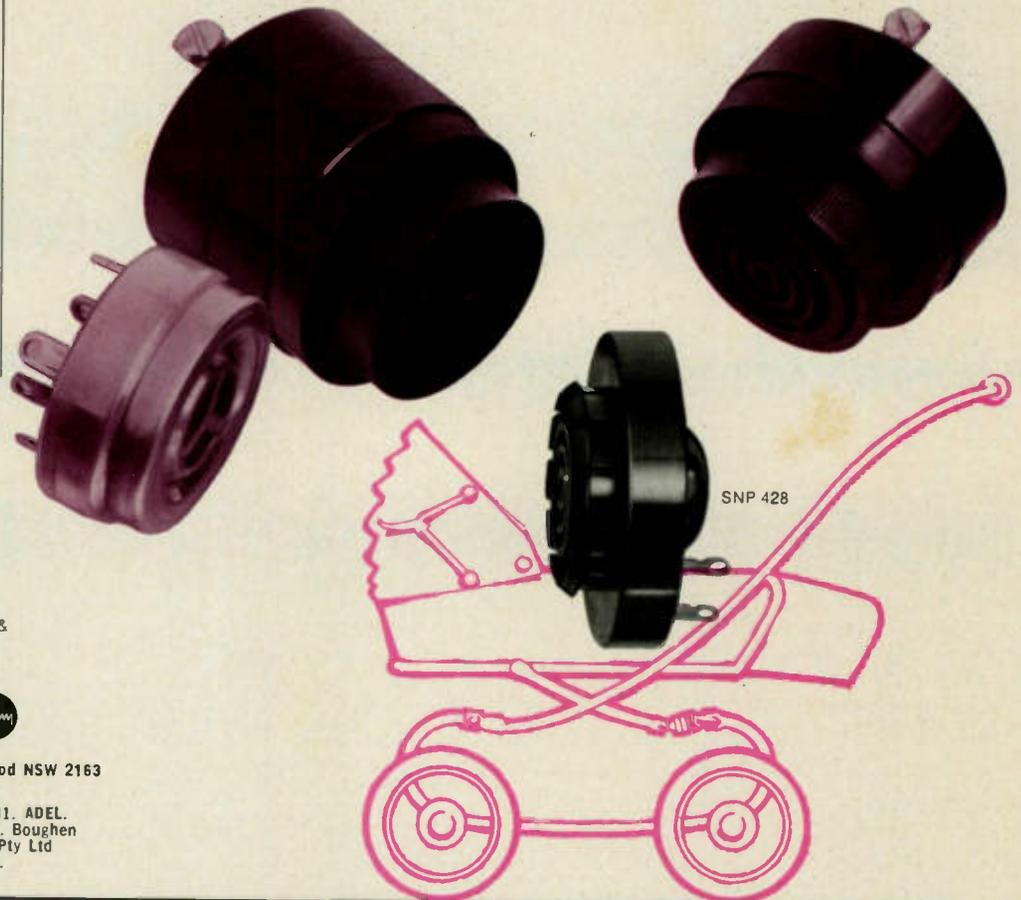


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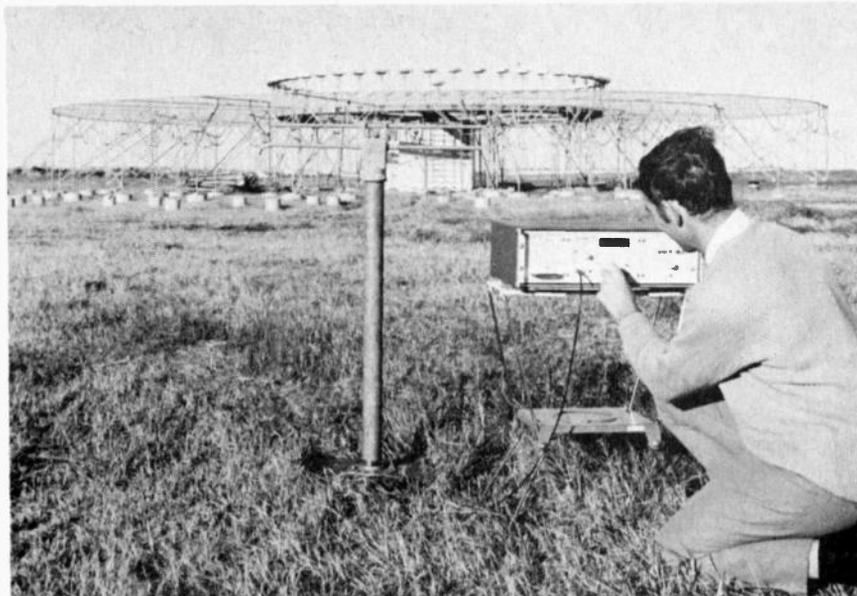
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AWA EXPORTS TO PEKING

As a result of participating in last year's Australia Exhibition at Peking, AWA has exported to China test instruments designed and made at its North Ryde works.

The instruments, used for calibration and maintenance of VOR ground beacons and associated airborne equipment, have been supplied to the China National Machinery Import and Export Corporation, Peking.

The AWA VOR Signal Generator can be used for calibration and testing of VOR receivers, beacon monitors and phasemeters. The Digital Phasemeter is for field measurement of VOR and Doppler VOR radiated signals,



AWA Digital Phase Meter

calibration of VOR signals generators and remote monitoring of one or more VOR stations.

One of the Company's subscriber

radio telephone systems, designed to serve areas beyond the economic reach of wire lines, was sold in Peking during the exhibition.

CHRYSLER'S ALL-ELECTRONIC IGNITION — FURTHER DETAILS

As briefly reported in our News Digest pages last month, Chrysler may go over to an all-electronic ignition system next year.

The main aim of the additional ignition timing electronics is to reduce exhaust emissions. Although full details are not yet available we understand that input signals are taken from throttle position, rate of throttle change, engine temperature, basic ignition timing, engine speed and engine load (the latter presumably from manifold vacuum).

All inputs are fed into a basic analogue computer made from quad amplifiers, quad comparators, and a complementary — MOS counter. The output then controls the rate of advance and retard over a wide range.

Although the system is expensive — primarily due to the cost of the pressure sensors — it is still very much cheaper than the exhaust-gas recirculators and catalytic convertors that the system is hoped to replace. In addition performance is claimed to be increased by 10% and fuel consumption reduced six to seven per cent.

The system is working satisfactorily in prototype form and three vehicles are currently undergoing the Federal Environmental Protection Agency's 50 000 mile obligatory durability trial.

Electronics is also being applied to carburetor control. Britain's Zenith Carburetor company has pro-

duced a carburetor in which the fuel metering orifice is controlled via a feedback loop using signals derived from a zirconium dioxide sensor which monitors the percentage of oxygen in the vehicle's exhaust gases.

store, at 125 York St, carries a full range of components, test gear and hi-fi equipment. It is situated less than 100 metres from Town Hall station in the centre of the City. Mail order business continues to be handled exclusively at the Gore Hill headquarters. The new store is managed by Bob Johnston.

DICK SMITH OPENS THIRD SYDNEY STORE

Dick Smith recently opened his third 'Electronics Centre' in Sydney. The new

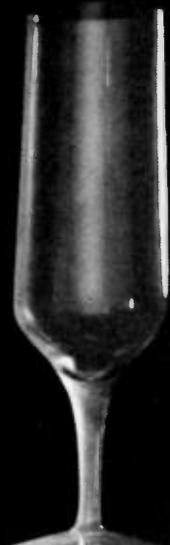
Continued on Page 13



Sleek, sheer soundpower. Cambridge Audio Integrated Amplifier. No fat, no frills. Just 5½ cms deep — but inside a massive toroidal mains transformer. Rated 35W it exceeds 45W effortlessly. All virtually distortion-free. In fact less than 0.05% at 1 KHz at all powers to full power — and crossover distortion almost non-existent. The sound? Incredible low frequency response at high levels. Hugely forgiving for boisterous speakers. Separate outlet uniquely sensitive for tape volume.

Computer-safe Overload is impossible. Fail safe protection computes three ways — pre-amp analog on gain control; automatic output monitor; intricate double — fusings.

After this, other amps look clumsy and sound it.



International experts hail Cambridge Audio equipment as a triumph of intelligent design, and quality without compromise . . . "in the highest rank". For instance the matching Transmission Line Speakers are unique in their use of a long hair lambswool damped tapered labyrinth. The result is so rich and natural it has to be experienced to be believed. This is truly ultimate sound — by specialists, for enthusiasts. But the most remarkable thing is the cost: literally about half what your ear hears.

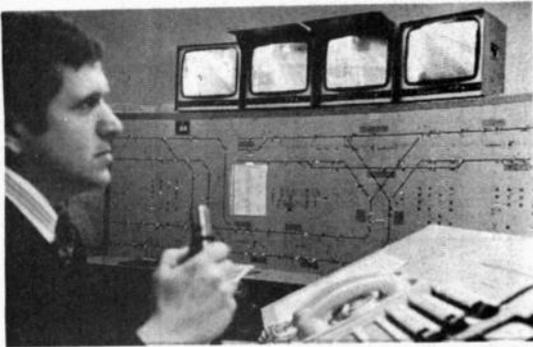
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COMPUTER CONTROLLED TRAIN

The world's first computer-controlled train guidance system for a rapid-transit network was recently placed in service in W. Germany for the Cologne Public Transport Dept. (KVB).

The system, planned and supplied by Siemens AG, is built around two Type 320 process-control computers and controls all underground railway operations in the area covered by the

Ebertplatz interlocking — an area extending to seven stations.

With its four radially converging lines, the Ebertplatz underground station is a particularly important junction: up to 120 trains per hour have to pass through it. For a traffic volume of this magnitude, conventional means of automation such as relay storages would be too large and their performance unsatisfactory, especially as regards the necessary flexibility to handle unusual traffic situations.

TINY NEW CALCULATORS

A 'calculator in a compact' has just been released by the Sharp Corporation. The device is a mere 71 mm by 79 mm by 19 mm when folded opening up to 9.5 mm by 79 mm by 142 mm when opened. Weight is about 120 grammes.

The unit is a four-function eight digit machine in which all components, wiring, keyboard contacts and display contacts are formed on a single flexible printed circuit board. This flexible board is bent double when the

'compact' is closed but life tests have shown that it can be folded and unfolded at least 10 000 times without failing.

A 'pocket diary' version of the 'compact' unit is also being produced. This uses a rigid printed circuit board in a case only 9 mm thick (other dimensions are 76 mm by 129 mm).

Both units will go on sale in Japan, Europe and the USA later this month. At the time of closing for press we have not been able to establish whether the units will be sold here in Australia.



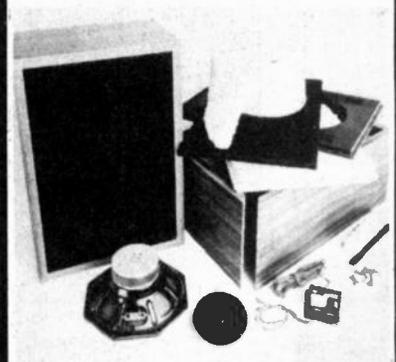
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MUSIC SYNTHESIZER ETI 3600
April 1975

The photo of the 3600 synthesizer shows the prototype at an early stage of development. The filter switch shown in this picture does not correspond to the switch wiring diagram. The wiring diagram is correct.

ERRATA & ADDENDA

CAR ALARM ETI 313
November 1974

Some readers have experienced incorrect ON/OFF timing relay latching.

This may be caused by diode D2 in that, in some cases, it does not adequately limit the reverse voltage generated across the relay. This reverse voltage may retrigger the IC. This can be cured in one of two ways.

1. Replace diode D2 with an EM401 or similar. Break the track between resistor R6 and diode D2 and place a second EM401 diode across this break such that its cathode and the cathode of diode D2 are together.
2. Add a 220 ohm 1 watt resistor between the + 12 volt line and the output (pin 9) of the IC.

DOPPLER RADAR ETI 702
May 1975

The following letter has been received from Philips.

"The Post Office Radio Branch has allocated the frequency band 10.500 to 10.550 GHz for low power intruder detectors. Although we have in the past referred rather loosely to our series of Doppler Modules as CL8960, this particular code number in fact specifies the frequency 10.687 GHz which is the frequency allocated in the United Kingdom.

As a result we apologise for any inconvenience that may result but ask that you advise your readers that the correct device for use within Australia is CL8963.

The CL8960 module is not withdrawn and of course remains available to any customer who may wish to export

units to the U.K. The complete series is as follows:

- CL8960 10.687 GHz (U.K.)
- CL8962 9.47 GHz (Germany)
- CL8963 10.525 GHz (USA, Canada, Australia)
- CL8964 9.9 GHz (France)

It may be useful to point out from our recent discussions with the Radio Branch of the APO that where X-band transmitters are used in Australia for intruder detectors the following conditions apply.

1. They must not produce any emissions outside the allocated band even allowing for effects of temperatures and supply voltage variation.
 2. They must operate in the CW mode with a power output as measurable into a load of less than 50 mW.
 3. The area controlled by the device is limited to the owners premises.
- If these conditions are fulfilled then Doppler Alarms may be operated without a permit.*

The CL8963 as delivered meets these requirements over the specified temperature range when used with recommended power supply circuits but it becomes important to emphasise that users must not tamper with the tuning screw on our units which is factory preset to ensure compliance with the regulations in force in the various countries for which they are intended.

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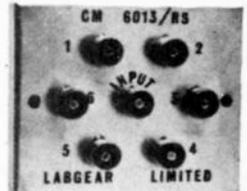
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AMPLIFIER TECHNOLOGY

Were valve amplifiers really that good — how do present-day solid-state units compare?

by John Linsley Hood

IT IS SAID that sailing ships reached their highest state of efficiency and technical development at the time at which they were replaced by steam.

By analogy, the same could be said of the valve audio amplifier, in that by the late 1950s the normal circuit design for a high quality instrument had reached the form shown typically in Fig. 1, using output beam-tetrodes in class-A push-pull, in the split-load or 'ultra-linear' connection. This gave a higher output power for a given output valve plate dissipation, at a virtually identical harmonic content, than the earlier (Williamson) triode connected configuration.

With a single pair of output valves, operated from a 450 V ht line, typical performance figures for this type of circuit are shown in the data panel of Fig. 1.

However, as is often the case no matter how full the specification, it is always the things which are *not* specified which one needs to know, and which can make the difference between excellence and mediocrity.

In the valve amplifier, the unspecified things included a relatively favourable harmonic content of the distortion components — mainly third, with little content of harmonics higher than the fifth, especially at higher frequencies, and a graceful overload characteristic, in which the onset of clipping was gradual and allowed short-term power outputs of 20-30% beyond the nominal rating without dramatic worsening of the harmonic content. In addition, higher powers could be obtained when needed without substantial revision of the circuit design by incorporating additional output valves in parallel. The only limitation was imposed by the physical size of the output transformer and the power demand from the dc power supply. Moreover, this type of design was very nearly short-circuit proof, had a good intrinsic overload protection characteristic, was relatively unaffected by load reactance, and the harmonic distortion, such as it was, was of an audibly acceptable kind.

What then were the snags?

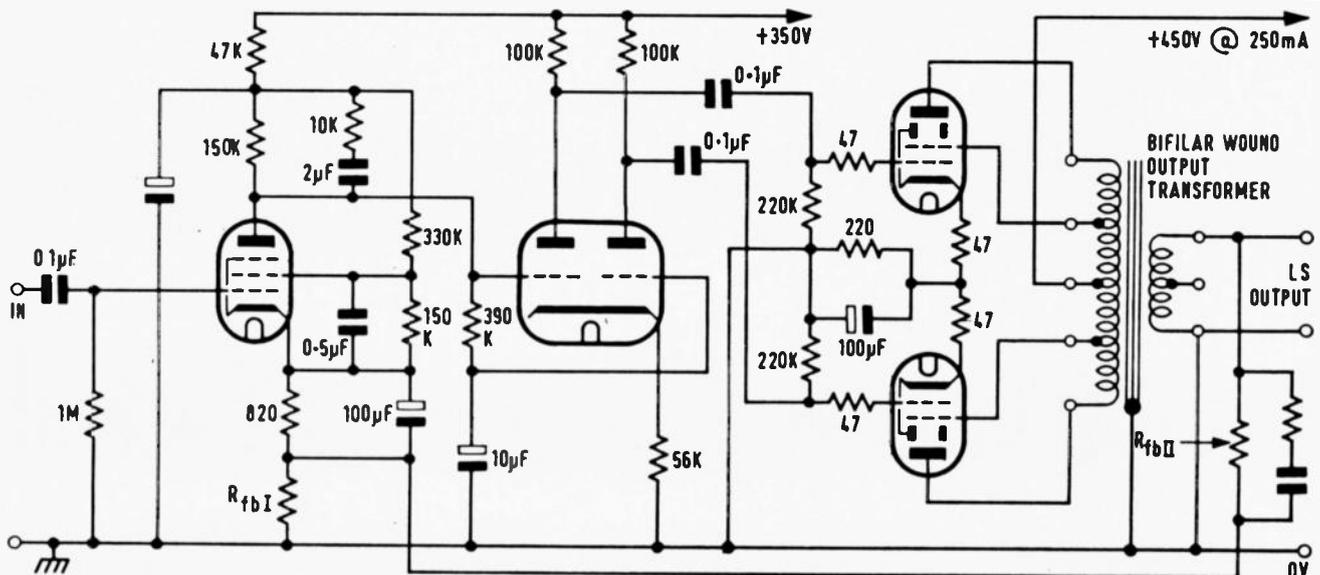
The output transformer was a large and costly item, and the quality of this almost completely dictated the performance which could be obtained from the amplifier. This, therefore, entailed careful construction, to provide good matching between primary halves, a large incremental inductance and a very low order of leakage reactance. The heat generated was considerable, and the total harmonic distortion, mainly generated within the transformer, worsened fairly rapidly with increasing frequency due to the limitations of the feedback network, particularly at higher output powers, and price bracket, having inevitably a lesser distribution. The step-function performance was very poor by presently-accepted standards. Also, if anyone should then have been interested in the phenomenon, the transient intermodulation distortion, as defined by Otala,¹ was poor. Finally, if the amplifier were operated, even at moderate output levels, into an open-circuit load, either the output valves or the output transformer might flash-over because of the very high primary voltages which could be generated, even though, in principle, this should not happen.

Nevertheless, within the limitations imposed by its power-to-weight ratio, cost and heat output, the valve power amplifier did, and does, a good job.

By comparison, the early transformerless transistor-operated 'quasi-complementary' power amplifiers, derived from the ingenious original design proposed by Lin,² and

Fig. 1. This high-quality power amplifier (circa 1955) used output beam-tetrodes in class-A push-pull configuration. Specifications are shown below.

Output power: 25-30 W.
 Small signal frequency response: 3 Hz-200 kHz.
 Phase linearity (small signal): $\pm 45^\circ$ from 3 Hz-150 kHz.
 Signal/noise ratio: Referred to maximum output. Band-width 20 Hz-20 kHz — 80 dB.
 Harmonic distortion: 0.1% maximum rated output, at 1 kHz decreasing as output power is reduced.
 IM distortion: 70 Hz/5 kHz 4:1, max output — 3 dB. Less than 0.25%.



shown in Figs. 2a and 2b, were relatively low quality systems, of which the fundamental shortcomings were only slowly realised, and even more tardily remedied. Of these shortcomings, the most important was the necessary adoption of class-B or class-AB, working in the interests of limiting the thermal dissipation of the power devices. The implication, not realised at the time, was that the harmonic distortion at full power was not necessarily or even probably the same as the distortion at lesser powers; also that the distortion level at 1 kHz was unlikely to be the same as that at 10 kHz, or that the performance with a resistive load, on the bench, was unrepresentative of that which might be expected from a more reactive load when the equipment was in use.

Since the bulk of the 'medium-fi' audio amplifiers imported into this country from the Orient have adhered to the Lin design with few, if any, refinements, it is hardly surprising that the sound quality associated with many domestic installations is unattractive. If this is the yardstick by which transistor-operated design is judged, then there can be little dispute that valves 'sounded better'. However, in informed technical appraisal it is important to compare like with like, and it is probable that only in the last six or seven years have designs emerged which could compete with valves on an equal footing, and these have only emerged in commercial hardware within the last two or three years, and again mainly in the higher price bracket, having inevitably a lesser distribution.

It is fair to say, however, that one form of transistor-operated amplifier (that employing transformer drive with transformerless output, of style adopted in the UK by Rogers and Radford) was capable, given good transformer design, of a very satisfactory performance even with early transistor types. This was subject only to the inevitable limitations imposed by the transformer and the cost and quality considerations it

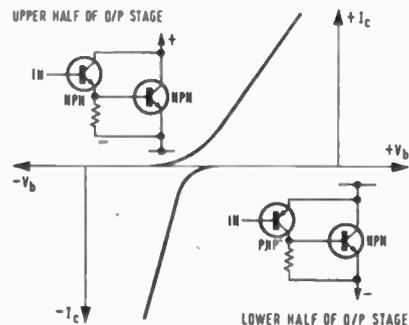
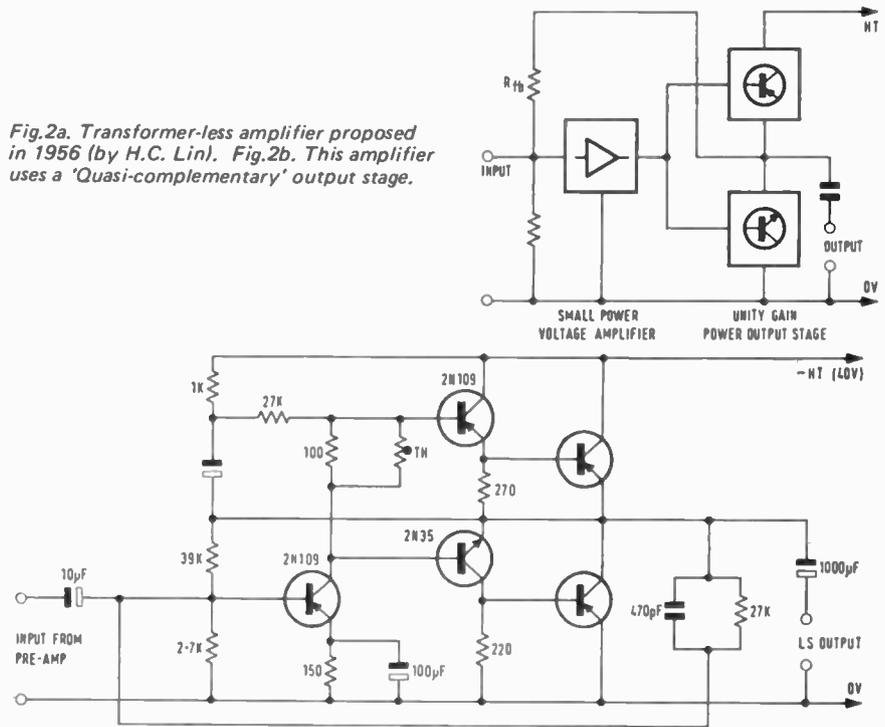


Fig.3. How dissimilar opposed halves of a quasi-complementary output stage causes distortion.

Fig.2a. Transformer-less amplifier proposed in 1956 (by H.C. Lin). Fig.2b. This amplifier uses a 'Quasi-complementary' output stage.



implied. This style of design has not attracted a large following in the design field because of the inherent difficulty of getting reproducibly good performance from low cost transformers, and because of the greater technical challenge offered by the solution of the problems of the transformerless systems.

The faults of this early style of design and its immediate successors, which are now fairly widely realised, stemmed from the unsatisfactory matching of the push-pull halves in the output stage, the presence of 'crossover' distortion (which is an inevitable feature, to some extent, in class-B or class-AB operation) and the use of excessive amounts of negative feedback (limited only by the steady state resistive load stability considerations) to try to alleviate the intrinsic non-linearity of the system.

IMPROVED TRANSISTOR-OPERATED POWER AMPLIFIER DESIGNS

Although the steady state harmonic

distortion characteristics of amplifier systems can be improved by the use of negative feedback, limitations in the use of this are imposed by the need to maintain close-loop stability, even if the requirement of good transient performance is not considered and the fact that the utility of this diminishes as the open-loop phase shift enters the second quadrant, as shown experimentally by the author.³ This is because the classical formulae omit the possibility that the application of negative feedback may reduce the magnitude of the fundamental to a greater extent than that of the unwanted harmonic. To a large extent, therefore, the performance of a feedback amplifier, when feedback has been applied, is determined by the characteristics of the design without the benefit of this. Thus, such things which can be done to improve open-loop performance will show benefits in the final result obtained after feedback has been incorporated. In the case of transistor amplifiers, the open-loop characteristics are largely

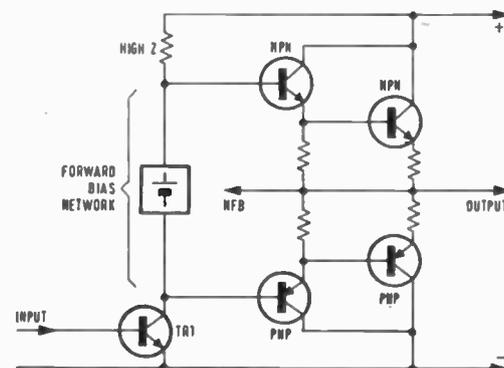


Fig.4. This transistor output stage is fully symmetrical.

AMPLIFIER TECHNOLOGY

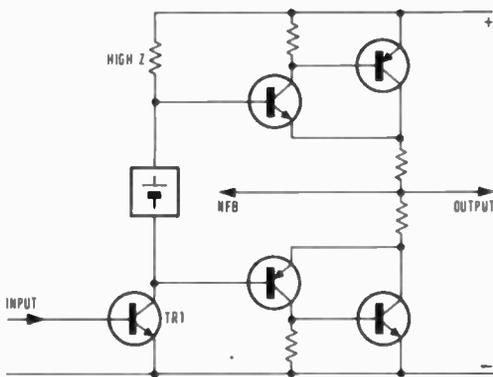


Fig.5. Alternative form of circuit shown in Fig. 4.

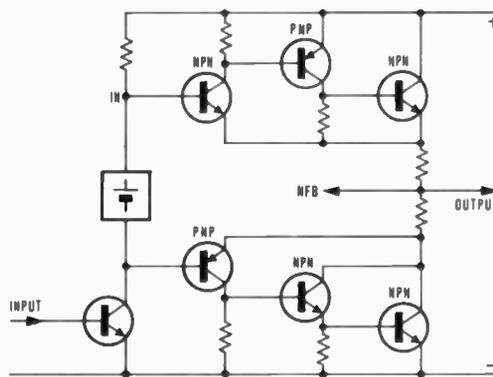
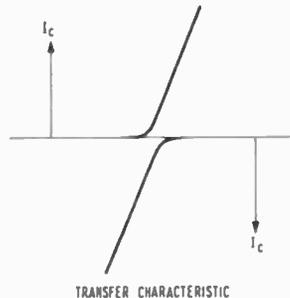


Fig.6. Quad output triple circuit.

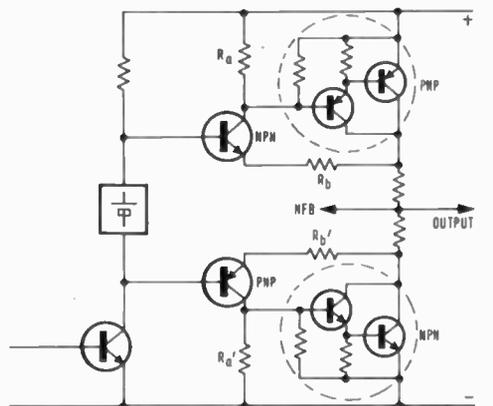
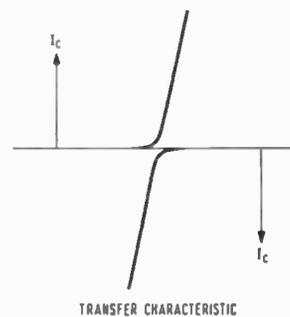
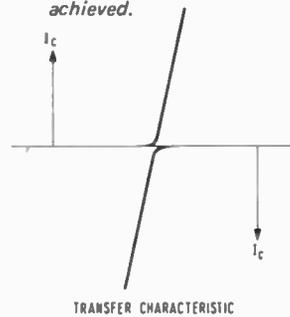


Fig.7. Darlington output stage has very good symmetry-distortion figures, as low as 0.003% can be achieved.



determined by the form of the output stage, and residually influenced by the performance of the preceding low power voltage amplifier stage.

The most obvious requirement for improvement in the open-loop linearity of the quasi-complementary transistor amplifier was the removal of the asymmetry of the output devices, which, in turn, required the production of fully complementary power transistors. When these became

available, fully symmetrical designs employing these, of the type shown in Fig. 4, were evolved by Locanthi⁴ and Bailey.⁵

The major advantage of this type of output transistor configuration is that it allows a much closer match in the transfer, at the crossover point, of the two output halves than is obtainable by other simple systems. However, it has snags. These are that the proper operation of the output stage

demands; a correctly-chosen forward bias (like any other class-B push-pull system), but this depends on the temperature-dependent characteristics of the output transistor base-emitter junctions. It will be found, therefore, that if the quiescent current is set at some optimum value for minimum harmonic distortion, with the output transistors at normal idling temperature, and the amplifier is then driven hard for a minute or two, the quiescent current will alter to some less favourable value. If some temperature-sensitive device is mounted on the output heat-sink to compensate for this effect, the result will be complicated by the temperature lag between output transistor base-emitter junction and sensing device. An additional but minor disadvantage of this configuration is that the available output swing delivered to the load is lessened by the presence of two forward biased base-emitter junctions in each output stage half. Additional imperfections are that the output stages, even when employing apparently mirror-image types of device, are not truly symmetrical at high powers and at operating frequencies approaching $F/10$, as shown by the author⁶, and that even when a notionally good match has been obtained at lower powers and frequencies the crossover transfer is still discontinuous⁷ (Blomley).

Designs using an alternative output configuration of the type shown in Fig. 5, which minimises the first two of these problems, have been described by Teeling,⁸ Ruehs,⁹ the author,¹⁰ and Hardcastle and Lane,¹¹ until the advent of monolithic complementary (pnp and npn) power Darlington output transistors at economical prices (which have tended to encourage the use of output stages of the form shown in Fig. 4 but with a substantially worse thermal stability than that obtainable using separate driver transistors) this latter form would represent the majority of the better power amplifiers having output powers of 30-75W into eight or four ohm loads designed in the USA. Numerous examples of this system can be found in the application notes of the semiconductor manufacturers.

In all of these systems, it is important that the output stage should not present a significant load upon the driver transistor ($Tr1$ in Figs. 4 and 5) which means that in general it is easier to obtain good steady state harmonic distortion characteristics if a 'triple' is used as the output 'half'. However, this leads to rather greater difficulties in obtaining the high degree of loop stability needed for satisfactory transient performance.

FURTHER IMPROVEMENTS

If, then, this is the representative state of the bulk of the good quality audio power amplifiers, of medium power, how does this compare with the state attained by valve-operated designs, at their highest stage of evolution in the late 1950s, and what further steps in transistor design are necessary or have already been taken to provide improvements in performance or higher output powers?

Taking first the question of comparative performance, it can be said at once that the general transient behaviour of the transistor circuit is considerably superior to that of even the good valve amplifiers of the '50s, and this definitely shows. Although most circuit designers would admit to shortcomings in power amplifier transient behaviour, this reflects mainly a greater understanding of the problems involved, particularly with the highly reactive loads offered by current multiple-driver loudspeakers in the contemporary 'monitor' class.

Further improvements need to be made if the designs currently offered are to yield a 'good transient fidelity' at output levels approaching their rated power maxima. On the subject of steady state harmonic distortion or overload behaviour, the situation is not nearly so satisfactory. Although most of the better contemporary designs offer harmonic distortion figures of the order of 0.05% or better at maximum and lesser powers, the structure of the harmonic distortion tends to be richer in higher order 'odd' harmonics which are by their nature alien to the ear and are therefore noticed and found unattractive.

Also, these relatively low THD figures are conditional upon the amplifier in question having been set up correctly in the first place, and upon the design being of a form which allows this adjustment to be preserved through the changes in operating characteristics imposed by ageing and ambient temperature. This is nowhere so automatically a product of careful design as in the case of their valve forerunners. Additionally, there is an insidious type of fault which can arise in the case of the 'solid-state' design, that of transient instability on reactive (ie real life) loads due to the designers having been tempted into the use of excessive amounts of negative feedback in the pursuit of impressively low THD figures, without being sufficiently cautious about the subsequent effects.

For the necessary stability of the quiescent current in the output stages of the amplifier — essential for preservation of the desired crossover continuity — it is desirable that the base-emitter junctions of the output

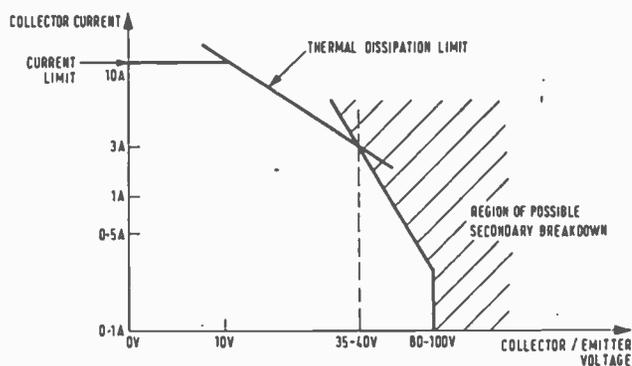


Fig.8. This graph shows secondary breakdown characteristics of typical silicon power transistors.

transistors should not be included in the forward bias determining system. The forms shown in Fig. 5, the celebrated 'Quad' triple of Fig. 6, and the arrangement shown in Fig. 7 using power Darlington transistors are much to be preferred. In particular, the latter form has a very high degree of symmetry, even up to high operating frequencies, due to the nature of the construction of the power devices, and allows the design of power amplifier circuits having distortion figures in the region 0.003-0.006% at 1 kHz. (A circuit of the type evolved by the author's laboratories using this configuration, for high output powers, is shown on page 22).

The other remaining problems, those of somewhat greater frailty of the semiconductor systems under overload and the need for improved transient performance, require either better devices or a better understanding of the problems involved. Taking the first of these, the present disadvantage of the transistor, *vis-a-vis* the thermionic valve is, in part, due to the relatively diminutive size of the power transistor 'chip' (about 0.1g) and its consequently trivial thermal capacity, to which is added the further problem of secondary breakdown of the junction. This type of failure occurs, typically, in modern silicon power transistors when currents in the range 100 mA-3A are drawn from the device at voltages in excess of 35 or 40, the nature of this voltage/current relationship being shown in Fig. 8. If this region is transgressed in the operation of the device for any significant length of time, the semiconductor material begins to heat up in such a manner that the forward base-emitter junction potential begins to decrease. Since the effect of this heating is inevitably non-uniform, if only because of microscopic variations in the thermal conductivity or degree of doping of the emitter, some regions of the emitter will heat more than others, with a consequent further

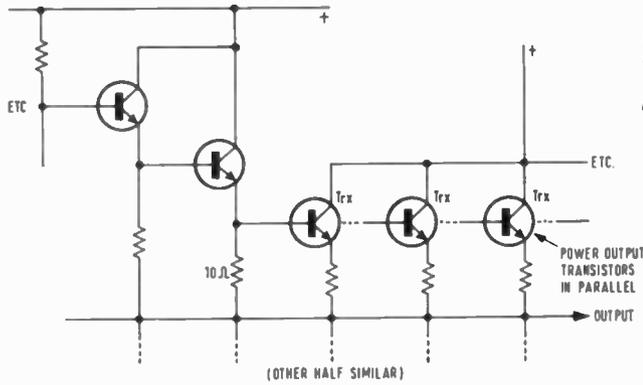
decrease in their junction potential and a further increase in the current flow. This situation is obviously an unstable one and can lead to rapid destruction of the semiconductor device if the current flow persists, or the rate of generation of heat exceeds the rate of possible lateral diffusion of it. One of the big advantages offered by the use of power FETS, of the type developed by Yamaha is that this type of self-destruction mechanism doesn't occur, and the device characteristics are more akin to those of the thermionic valve in this respect apart, of course, from the still small size of the active component.

Two alternatives are therefore available to the designer of semiconductor circuitry of high powers — to use relatively low collector voltages, so that the secondary breakdown regions are avoided, or to develop very rapid action protection circuitry. The first of these involves the restriction of the use of the circuit to low load impedances, if the Lin type transformerless construction is adopted, or the use of transformer output systems. These latter designs are, in general, the mainstay of present high-power amplifier units (250W or greater), but it is difficult to obtain harmonic distortion figures much below 0.5% with this configuration because of the limited amount of negative feedback which is practicable.

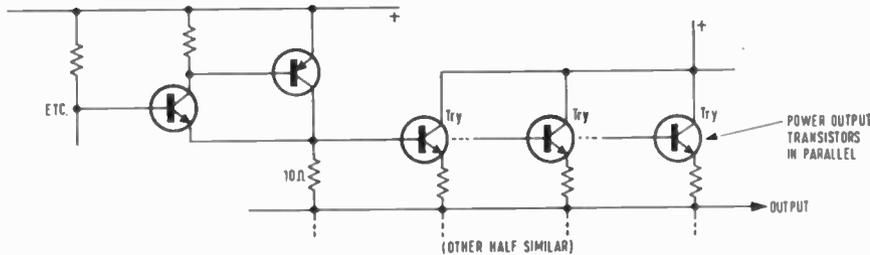
If sufficiently effective protection circuits are employed, so that the transistors can be used safely in proximity to the secondary breakdown region, the transformerless form can be used with low distortion, and with output powers up to 500 W into four ohm loads.

Two notable examples of power amplifiers in this power bracket are those developed in the USA by Crown (Amcron) and Phase-Linear. The type of output transistor configuration used in these is shown in Fig. 9a and 9b, and is subject to patents covering its

AMPLIFIER TECHNOLOGY



Figs. 9a/b. Output stages used by Crown and Phase Linear — power output transistors are paralleled.



employment. In these output stages, the transistors Tr_x and Tr_y are normally non-conducting, but come into conduction when the transistors Tr_a and Tr_b pass sufficient current through their emitter circuit resistors.

An apparent snag with this arrangement, even though it does, conveniently, allow the use of output transistors in parallel, is that it produces an even more complex crossover transition, with the

consequent need for large amounts of negative feedback to minimise the ensuing distortion. Presumably for this reason the preceding voltage amplifier stages in both the Crown and Phase-Linear designs are highly complex, with great care taken to ensure the linearity of phase within the effective pass band of the system. It was mentioned earlier that the use of negative feedback becomes less useful as a means of reducing distortion when the open loop phase angle enters the second quadrant, and from this certain guide-lines can be laid down for the design of low distortion feedback amplifiers.¹³ In general these require the use of transistors which have adequate hf response, and the use of as few signal amplifying stages within the overall negative feedback loop as practicable. If more gain is required, this should be obtained by separate, and separately linearised, voltage amplifiers, with their own loop feedback.

intermodulation may occur. At least one commercially available design has been offered in which this parameter has been optimised in the manner suggested by Otala. However, there is some body of opinion that this is not the whole story, particularly since, even with sensitive test methods and amplifiers of a type which are likely in principle to suffer from transient intermodulation distortion, this phenomenon only tends to show up at power-levels close to the output maximum of the design. It is, in any case, an awkward parameter to define. In the form suggested by Otala, in which the input stage of a feedback amplifier will overload and produce gross, short-term intermodulation effects when the rate-of-change of the input signal exceeds the possible rate-of-change of the voltage or current feedback, the propensity of the design to suffer from this defect can be predicted by knowledge of the output slew-rate. If the possible output slewing rate divided by the feedback ratio is greater than the input signal slewing rate, then this form of distortion will be made less likely, or eliminated altogether; this is true regardless of the internal form of hf compensation employed within the amplifier.

In view of the need to define the transient performance of an audio amplifier in a manner which is as simple to comprehend and as unambiguous as the defined total harmonic distortion or intermodulation distortion for the steady state condition, the author has suggested the adoption of the concept of 'settling time',¹⁷ as the parameter to optimise, partly because this is now in widespread use as a means of defining the performance of operational amplifiers, and partly because it seems evident that when an amplifier has 'settled' following a transient disturbance, the known steady-state parameters will apply. From this argument, it would follow that the shorter the settling time of the amplifier (defined as the time which it takes the output signal voltage to arrive within, and stay within, some small, specified, error band on either side of the true steady-state value, following the application at the input of a transient disturbance — usually a step-function in voltage) the more faithfully will the amplifier reproduce signals containing transient-type level changes. It is interesting in this context that the types of circuit design and hf stabilisation which lead to short settling times also provide good transient intermodulation distortion performance, and good reactive load

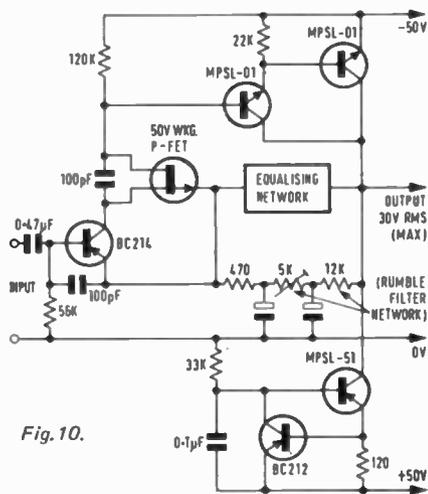


Fig. 10.

TRANSIENT DISTORTION

Over the past few years, the importance of good transient behaviour, particularly when used with reactive loads which may well exaggerate incipient tendencies to malfunction, has been much more widely realised, mainly due to the work of Otala^{14 15 16} who has shown the conditions in which transient

stability. Unfortunately, the converse is not always true. However, as mentioned earlier, these are the parameters which concern the designers of high quality solid-state circuitry, in which a very much higher standard has already been reached than was practicable with the valve designs of the late '50s. What would be possible in the light of present knowledge, with the use of hybrid valve-transistor designs using transistors for the small-signal stages for which they are ideally suited, and power output valves coupled to high quality toroidal output transformers to minimise hf phase-shift, is an interesting field for speculation, but it seems unlikely to attract commercial interest.

PREAMPLIFIERS

If anywhere, this is the field where the transistor and, in the near future, the monolithic integrated circuit, has really come into its own, with the elimination of heater-circuit wiring, the facility of the use of npn and pnp devices (for right-way-round and upside-down usage), junction and mos field-effect transistors for very high input impedance applications and the minimisation of circuit stray

capacitances by virtue of the small physical dimensions of the elements in use. Also, because of the absence of heater circuit and cathode-heater capacitance complications, much greater freedom is available to the designer in the choice of signal and feedback injection paths. As ever, the requirements remain for good signal-to-noise ratios, low hum and radio-break-through pick-up, good linearity and good overload margins to cope with inadvertent maladjustment of the gain controls. Only in this latter context has the thermionic valve a significant advantage over the solid-state device and this advantage, stemming from the limited voltage capability of the low-noise small-signal transistor, is being eroded by design improvements. A circuit arrangement giving a very low input noise level, a low distortion factor, and an output of up to 30 V rms, is shown in Fig. 11.

For very low noise levels, the impedance of the input circuit is of primary importance, in order to minimise the thermal noise originating at this point. At the moment, discrete transistors offer a significantly better performance than the best of the available integrated circuits, and pnp bipolar transistors are better than npn devices because of their lower surface

recombination noise. With good small-signal transistors, device input noise values over the 10 Hz-20 kHz bandwidth of the order of 0.15 μV have been claimed, but under circumstances where the input circuit itself would introduce some 0.5 μV of wide band noise.

With practical devices, and low input-impedance arrangements, a figure of the order of 0.25 μV , referred to the input would appear to be the lower practical limit. Such circuits must use series feedback configurations, of the type shown in Fig. 10, in order to take advantage of the low input impedance offered by, say, a microphone transformer. This leads to the penalty, as shown previously, that the distortion with feedback will be higher than with a shunt feedback arrangement.^{18 19} This arises because of 'common mode' failure in the feedback path, but can be substantially reduced, as in Fig. 10, with a single input transistor, if the input device is operated in 'cascade' to minimise the extent to which the feedback voltage applied at the emitter is able to modulate the emitter-collector voltage. Also, as shown earlier,²⁰ the distortion in the bipolar transistor is an input characteristic function, and decreases

Power output: 270W, continuous power, into 4 ohms. (500W + in bridge connection into 8 ohms).

Frequency response: dc - 40 kHz (-3 dB point).

Harmonic distortion: Less than 0.01% at maximum and lesser powers, 10 Hz-3 kHz. No crossover products detectable at max output - 3 dB.

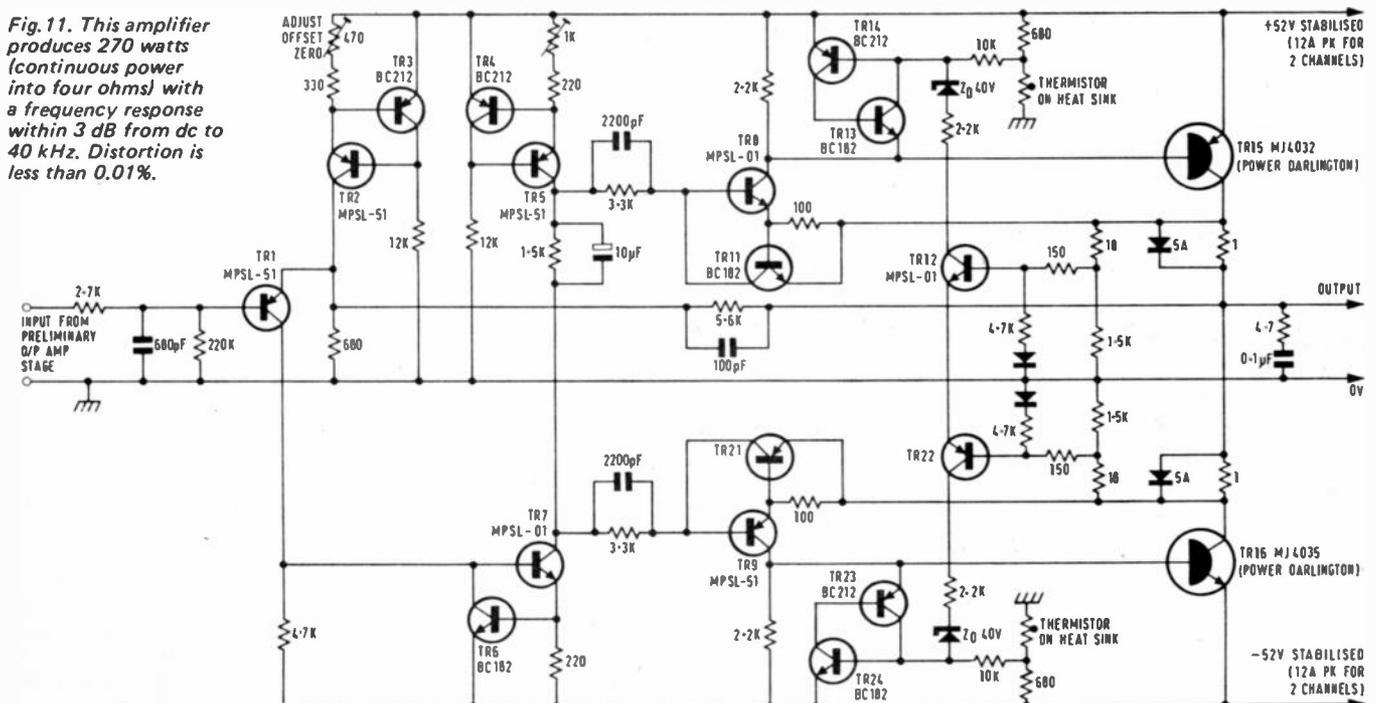
Settling time: < 5 μs .

Output impedance: (1 kHz) 0.02 ohms.

No instability or alteration of square-wave response on reactive loads up to 2 μF + 4 ohms. Unaffected by o/c operation, system closes down and draws negligible power from power supply if s/c or improperly low impedance load is connected across outputs.

S/N ratio: -90 dB ref max output.

Fig. 11. This amplifier produces 270 watts (continuous power into four ohms) with a frequency response within 3 dB from dc to 40 kHz. Distortion is less than 0.01%.



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as the input device gain is increased. This is obtained in practice by keeping the emitter circuit impedance low, and the collector circuit impedance as high as practicable.

At the typical 0 dB level at which much signal handling and mixing is done, there seems now to be little reason why devices of the type of the third-generation monolithic operational amplifier integrated circuit should not be used, since these are reliable, have good transient intermodulation distortion and settling-time characteristics into fairly high impedance loads and have excellent supply-line, signal and ripple rejection, which simplifies the task of isolating signal channels.

A PRACTICAL HIGH-POWER, HIGH QUALITY AMPLIFIER

The design of good quality, transformerless systems of the general structure shown in Fig. 2a requires the use of output transistors of 'complementary' structure unless one of the several possible circuit artifices 24 22 23 is used to provide an operational equivalent using only npn

power transistors. Of the complementary power transistor types available at an economical cost, the choice at high working voltages is restricted to power Darlington devices, constructed using an epitaxially grown base region. This indicates the use of the output configuration shown in Fig. 7 which can, if operated with suitable component values, give a very high intrinsic linearity coupled with excellent transient behaviour and negligible load on the preceding class-A driver stage.

This allows the use of a low-power high voltage driver transistor, operating under conditions of very high voltage gain into a two-transistor constant-current-generator load. Since the forward bias for the output transistor 'triple' is defined by the characteristics of the input transistors in the 'triple', and these remain at ambient temperature, it is possible to use the characteristics of the constant current generator circuit to provide the necessary compensation for the influence of ambient temperature on the quiescent current. Since the transistors determining this remain cold, even under high power drive, the power output of the amplifier does not influence the quiescent current setting. This is a necessary requirement for ensuring low distortion. Moreover, since the stages which determine the I_Q setting handle only small powers, their parameters will remain constant with time; again, this is a desirable feature.

In order to minimise the effect of common mode distortion at the input, while preserving the facility of a direct coupled structure, the customary input 'long-tailed pair' has been replaced by a single transistor, in which the offset which would otherwise arise due to its base-emitter voltage and the emitter circuit current flow through the feedback resistor, is removed by an additional constant current source employed to inject a sufficient quantity of current into the emitter of the input transistor to offset this voltage. Again, since the input transistor remains at ambient temperature, the constant current source can be arranged to track this thermally, and remove errors in dc offset due to ambient temperature changes.

The input preamplification is provided by a monolithic operational amplifier integrated circuit, which minimises the gain requirement of the power amplifier circuit. Very

fast-acting output transistor protection is provided by $Tr_{11,12,13,14}$ and $Tr_{21,22,23,24}$ of which $Tr_{13,14}$ and $Tr_{23,24}$ are connected to act as small signal thyristors.

Prototype amplifiers built to the design shown in Fig. 11 have given measured performances as shown in the data panel (of Fig. 11).

ACKNOWLEDGEMENTS

The author wishes to thank the Group Technical Director, British Cellophane Ltd, for permission to publish details of the power amplifier circuit described above, of which the input stage configuration, and the method of operation of the power transistors, are the subject of patent applications.

Although the circuit, as described, was intended for a high quality industrial application, for which high linearity, direct coupling from input to load, and minimal phase-shift within the operating region were desired, the characteristics of this amplifier would appear to be ideally suited to use in high quality audio and studio applications, should the circuit shown be of interest to companies operating in this field. ●

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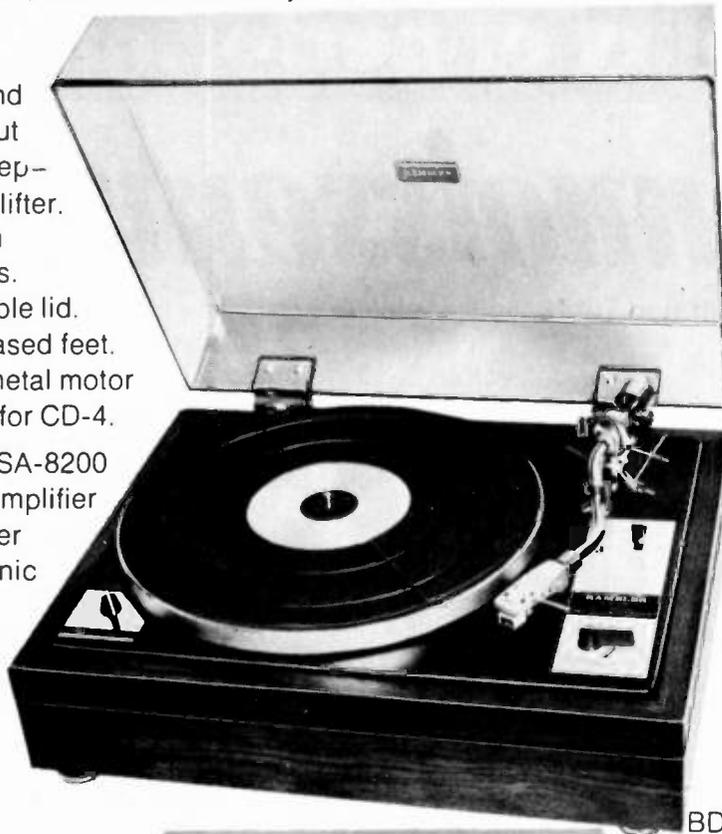
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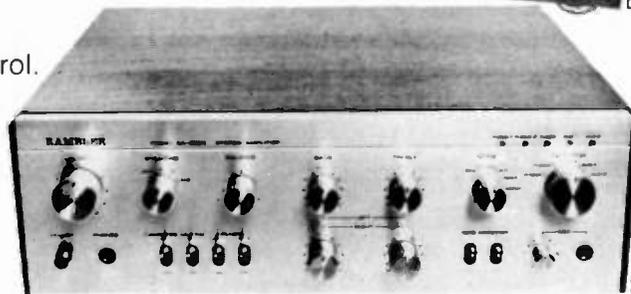
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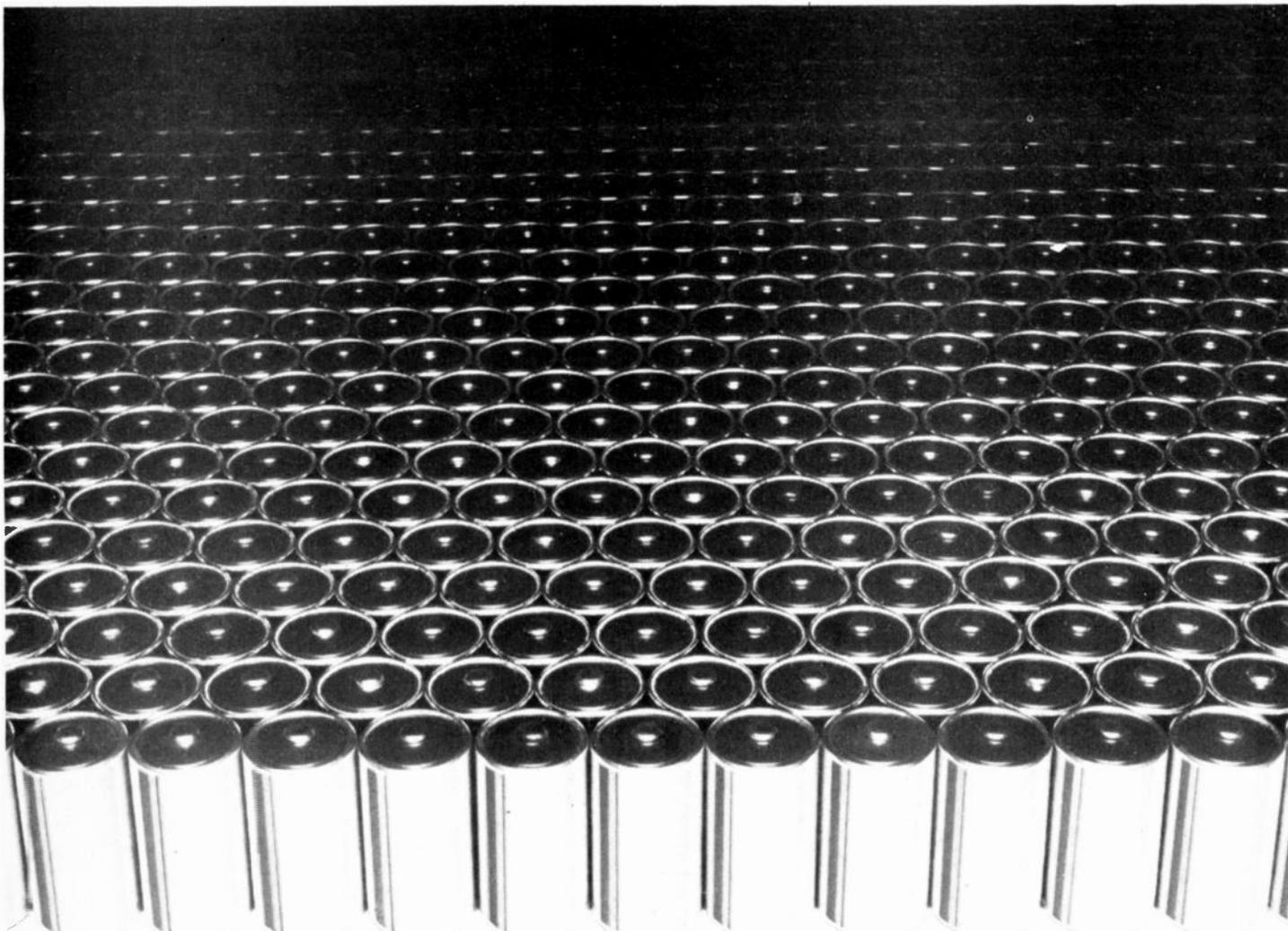
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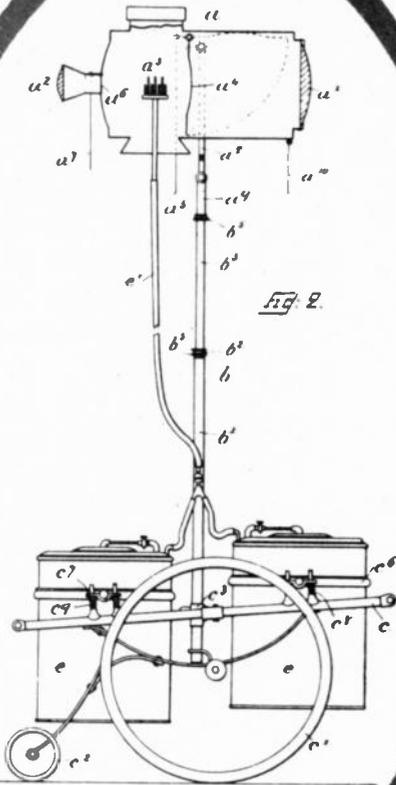
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PART 1

EARLY RADIO PATENTS

— a pot-pourri of early ideas in 'wireless' and telecommunications.

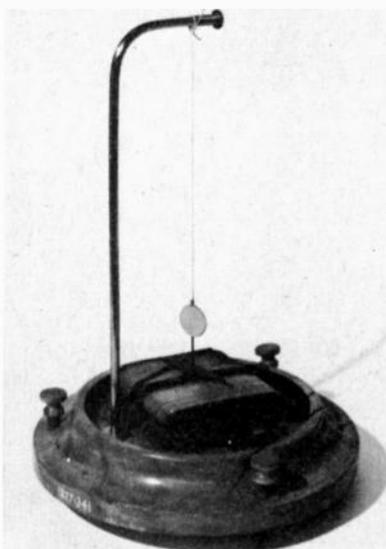


THE EDISON EFFECT

"If a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and the said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt-circuit includes a portion of the vacuous space within the lamp."

US patent No 307031, 21 Oct. 1884 to Thomas Alva Edison.

AT the close of the 18th century, communication systems using optical signalling techniques were in widespread use, but there were already signs of changes to come.



Schilling's magnetic-needle detector, proposed in 1832 for use in a five-wire telegraph.

In 1747, for example, a certain Dr. Watson transmitted static electricity through 2800 ft wire and 8000 ft water, thereby demonstrating both long distance transmission of electric signals and also the use of an 'earth' conductor.

Six years later, in the *'Scots Magazine'*, Charles Morrison proposed an electric signalling system using 26 wires, one for each letter of the alphabet. An electrostatic generator was used as the transmitter and 26 spark gaps as the receiver.

At the start of the 19th century a more convenient source of electrical energy than the electrostatic generator was developed — Volta's electric battery. Inventors were not slow to recognise its advantages. Thus, in 1809 a 26-line galvanic telegraph was devised using the electrolytic action of the electric current for detection purposes. A major problem however was still that of finding a suitable detector, for the electrolytic detector was little more reliable than the spark gaps and suspended pith balls used with the electrostatic systems.

A satisfactory solution to this problem was finally found in the

1830's, inspiration being derived from Oersted's discovery in 1807 that a current carrying wire was capable of deflecting a nearby compass needle. The use of a magnetic needle type detector was proposed by Schilling in 1832 for use in a 5-wire system, and single wire systems were proposed the following year by Schilling and also Gauss and Weber.

Up to this time there were few British patents in this field, perhaps partly due to the fact that until the latter part of the 19th century patenting was a dauntingly complex and expensive procedure (due to the large number of irrelevant officials, including someone called the *Deputy Chaff-Wax*, who had to be approached and amply paid), and perhaps partly due to the fact that much of the work done had been by way of pure experiment rather than as a commercial enterprise.

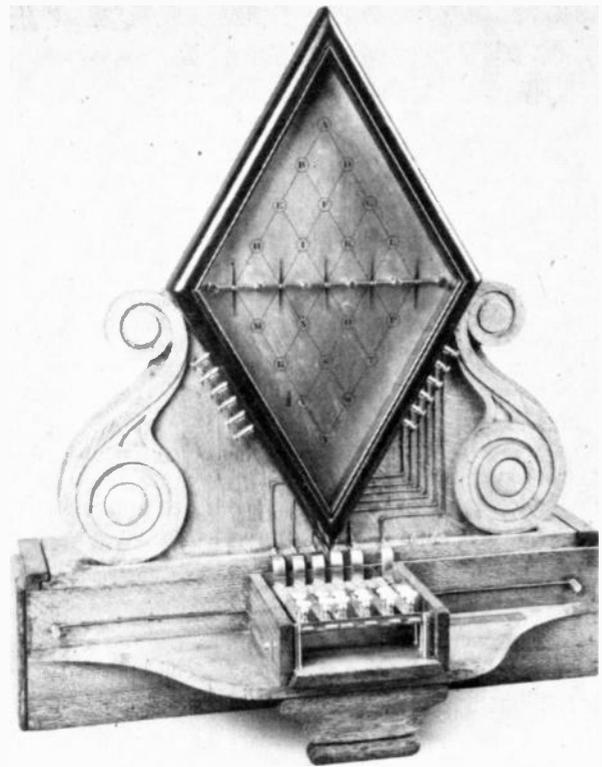
This situation changed most definitely in 1837. That year Cooke and Wheatstone obtained Patent No. 7390 for "improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits".

In the specification of their patent they described a "five needle telegraph" which worked "by the simultaneous deflection of two of the magnetic needles whose coils are included in the circuit, the required letter being found on a dial at the point to which they converge". This proved to be a practical proposition and was put into use on the Great Western Railway almost immediately.

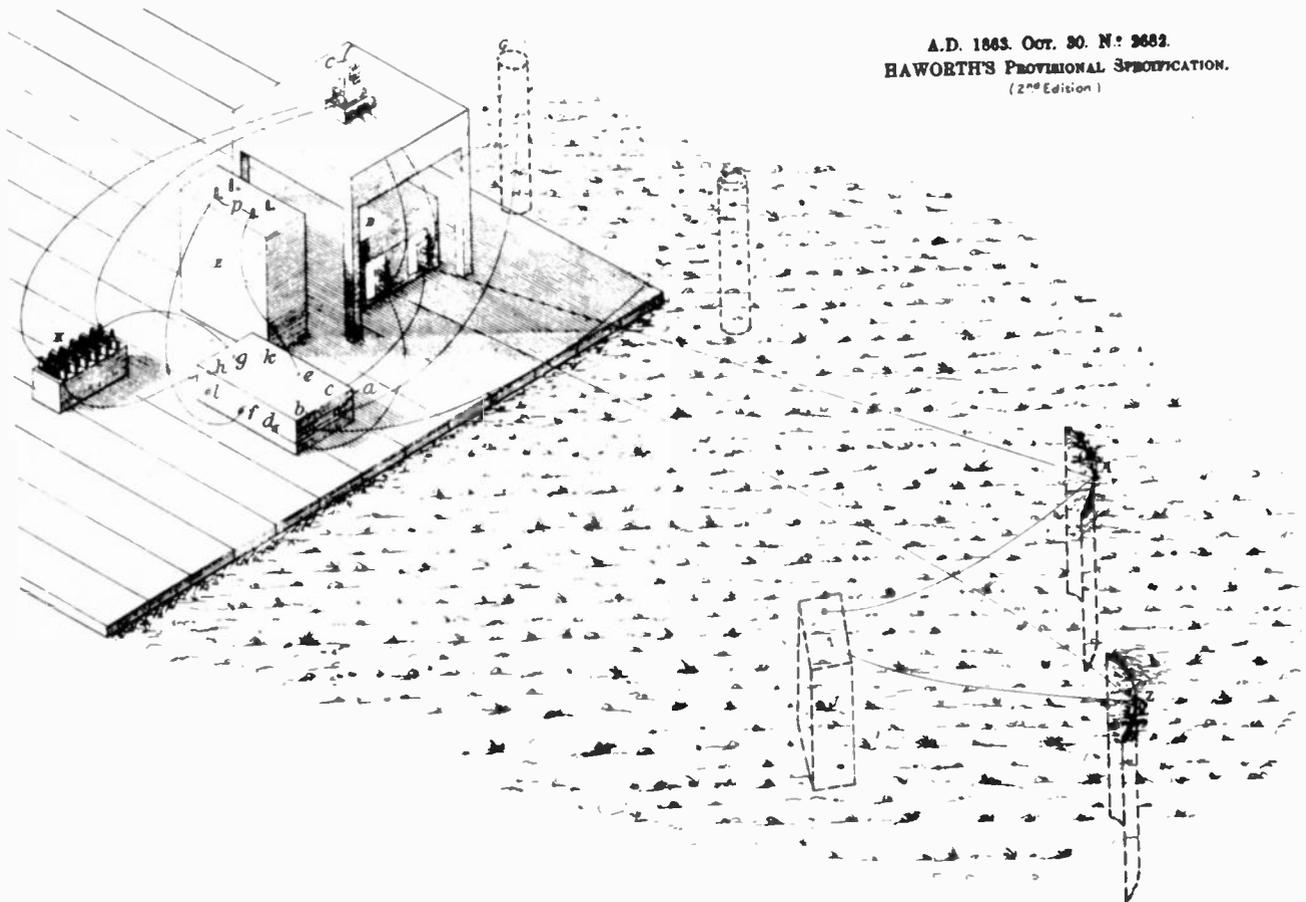
At about the same time, in the USA, Morse, deriving inspiration not from Oersted's discovery but rather from Sturgeon's development in 1825 of the electromagnet, was working on a telegraph system using a single wire and an electromagnetically operated 'tapper' as the receiver.

Morse also used the electromagnet to enable signals to be transmitted over very long distances from relay station to relay station. Cooke and Wheatstone also described the use of a 'relay' in their original patent. Their relay was for use in sounding an alarm bell at the receiving station and comprised a wire on a magnetic needle which dipped into mercury on deflection of the needle and thereby completed a local alarm circuit.

Having solved the problem of transmitting signals overland, the next



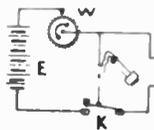
Cooke and Wheatstone's five-needle telegraph (patented in 1837). The instrument operates by simultaneously deflecting two magnetic needles so that they point to the required letter on the dial.



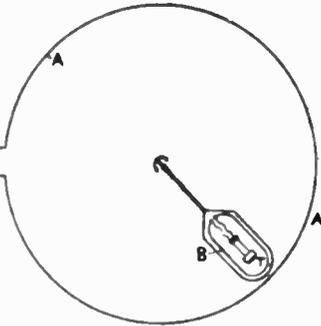
A.D. 1843. OCT. 30. N: 2682.
HAWORTH'S PROVISIONAL SPECIFICATION.
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Pre-dating Marconi by 33 years, this system used both electromagnetic induction and earth leakage currents — it is not clear how the circuit operated — the relevant patent (2682 of 1863) admits that "the method of working is not clearly specified."

EARLY RADIO PATENTS



This 'wireless' system of 1892 used electromagnetic induction between loops 'A' and 'B' to provide a communications link between land and a lightship.



goal was to cross the seas. In 1845, in British Patent 10939; the patentee, J. Brett, described an improved form of printing telegraph and referred to the possibility of using it with an 'Oceanic Line'.

Five years later concessions were granted to certain Messrs. Brett for a cross-channel telegraph and the line was finally laid in 1851. A trans-Atlantic cable came into use in 1858.

Two major problems arose in connection with underwater cables: that of satisfactorily insulating the conductors from each other, and that of attaining high transmission speeds despite the retarding effect of the interconductor capacitance.

One suggestion for overcoming these problems appeared in British Patent No. 1909 of 1853. This involved the use of two separate conductors contained not in the same cable but

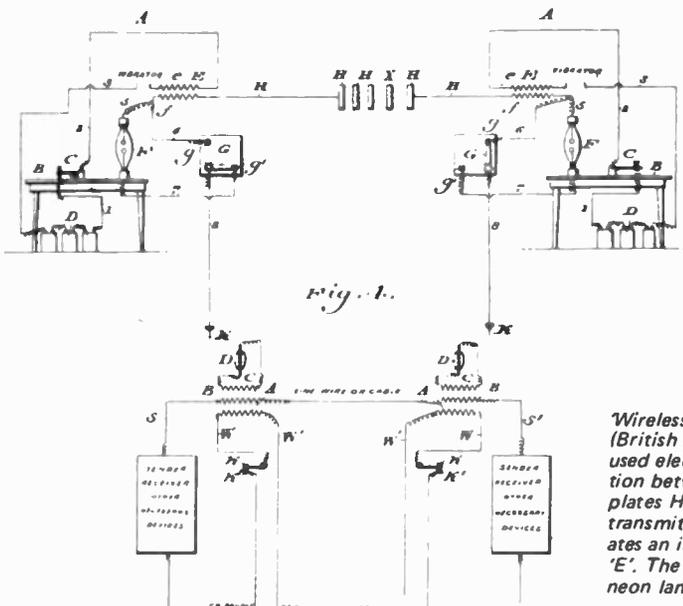
separated by an appropriate distance — and totally un-insulated. In the case of a trans-Atlantic link the appropriate separation, advised the patentee, could be achieved by running one wire from Land's End, in the South of England, and the other from any convenient point on the Scottish coast. The problems were in the end solved in a more mundane manner, by the improvement of insulation techniques and materials and by the invention by W. Thomson (later Lord Kelvin) of a particularly sensitive receiver, the mirror galvanometer, which is described in British Patent 329 of 1858. Later, in 1867, Thomson patented (No. 2147) a variation of his mirror galvanometer, a sensitive ink marking receiver known as the syphon recorder, which became widely accepted.

The electric telegraph was clearly one of the wonders of the 19th century. But it had its shortcomings. Quite apart from all the problems involved in manufacturing, insulating and laying miles of cable, there was the problem of providing a reliable link in situations in which it was obviously not possible to use a fixed cable, as for example between ships, between shore and lighthouse and between station and train.

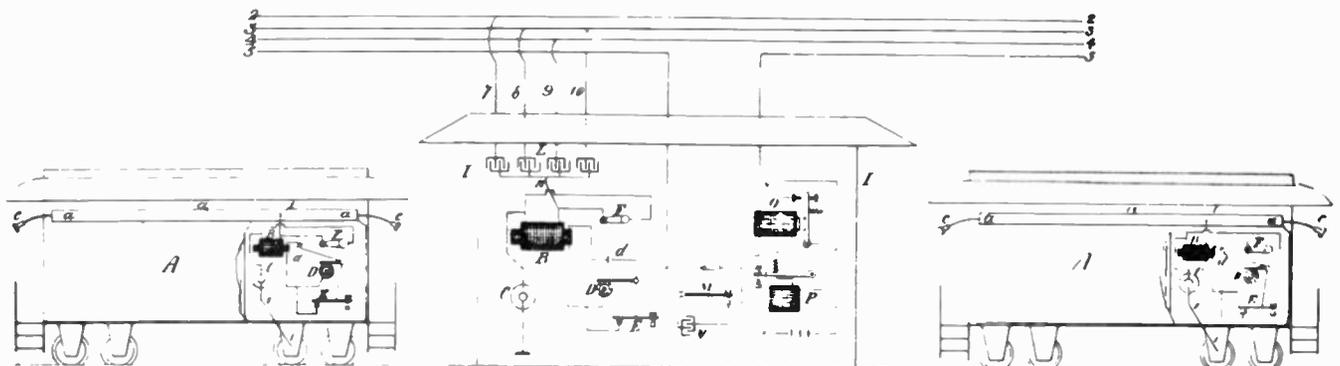
Patent No. 10929 of 1895 represented one attempt to solve the problem of ship-to-ship communications. Each ship was provided with conductors around its hull and all that was required to link two ships was to manoeuvre the ships so as to bring their conductors into contact with each other!

The need for a system involving no contact, a 'wireless' system, was clearly apparent: indeed this was by no means a new idea. In 1788, for example, in the fictional 'Voyage du Jeune Anarchsis' the author, Abbe Barthelemy suggested a system using "synthetic magnets" of sufficient power as to transmit their influence to each other over great distances.

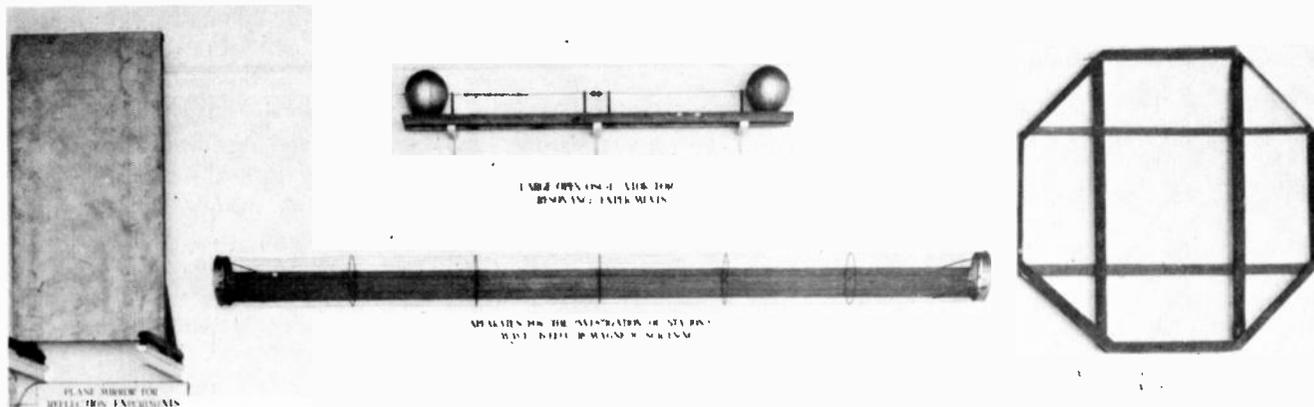
On a more practical level, in patents



'Wireless' system of 1895 (British patent 22600) used electrostatic induction between spaced plates H. The transmitter incorporates an induction coil 'E'. The receiver is a neon lamp 'F'.



Train to rail-side link patented by Edison in 1885. This 'wireless' system used electrostatic induction between a metal surface (a) on a railway carriage and overhead wires connected to a rail-side transmitting/receiver shack.



Replica of apparatus originally used by Hertz.

Nos. 843 of 1862 and 2682 of 1863 the first of many ideas relating to inductive and earth leakage current transmissions appeared. These patents describe the use of coils and also conductive plates buried in the ground. The coils and plates of the transmitting station face those of the receiving station and seemingly the idea was that electrical signals would pass between transmitter and receiver, part by earth leakage currents and part by induction, although the circuitry is bafflingly complex. In the Official Patent Office abridgement of the earlier of the two patents it is admitted that "the method of working is not clearly specified".

Patent No. 974 of 1871 is an example of a popular variation on the earth leakage current theme. The patent in question describes a trans-oceanic link using at one station a zinc electrode and at the other a copper electrode. The electrodes are immersed in the sea and are linked by a single conductor. With this arrangement the sea acts not only as the other conductor but in conjunction with the electrodes as a giant battery. For transmitting across both land and sea the inventor suggested that "rivers of acidulated or salt water can be constructed and so placed as to communicate through porous substances with the sea".

The induction theme is taken up in patent No. 3132 of 1879 which describes telegraphic transmissions to a light-ship by induction between a fixed underwater cable connected to the land based station and a trailing cable towed behind the ship.

Patent No. 14496 of 1884 described an inductive link between a train and track side stations, and patent No. 10161 of 1892 described an inductive link between shore and lighthouse.

Inductive systems were at one time popular and in certain circumstances provided a quite satisfactory form of communication, as for example, between shore and lighthouse, where

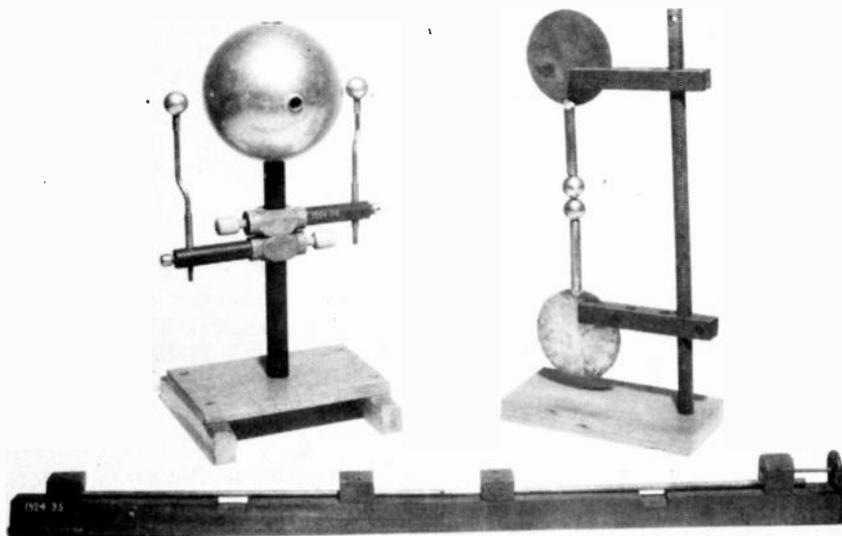
Letters Patent date back to the 15th century. They were — in fact in Britain they still are — open letters from the Sovereign to his or her subjects granting dignities, appointments and privileges. One of these privileges is the monopoly right in an invention. The grant of a patent gives the inventor the right to prevent anyone copying his invention, or passing it off as his own. But in return for the monopoly right, the patent holder is legally obliged to publish information about the invention in such a form that the invention may be understood and worked by others. This fact is not widely understood. If it were, we would hear less silly tales about patents being bought by manufacturers to conceal inventions (such as razor blades that last for ever, or cars that run on water). Patent specifications are a valuable source of technical information and serve also as a fascinating link with the past. Indeed the development of virtually all present-day technologies can be traced through patent records.

reliable communication was important but fixed cables out of the question.

In 1885, Edison patented (No. 7583) a telegraphic system employing electrostatic induction. Metal plates were positioned on top of a train and also alongside the rail track. The idea

was that electrostatic charges could be transmitted between the plates.

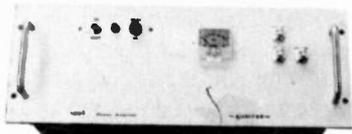
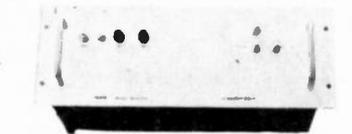
A system using electrostatic induction is also described in patent No. 22600 of 1895. In this patent, the transmitter incorporates an induction coil, the secondary of which is



Experimental apparatus used by Lodge.

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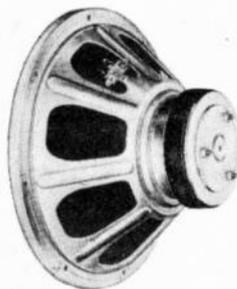
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connected to a line wire and to earth. The receiver has a neon tube also connected to the line wire and earth. The line wire is not continuous but is broken and incorporates parallel spaced plates across which electrostatic charges can be passed.

By the 19th century the idea of using the earth as one conductor was of course well known. Patent No. 4220 of 1883 however went one further and replaced the other conductor as well — by the air! The transmitter and receiver were each provided with an aerial and "moist air, mist or clouds" was required to complete the circuit.

In 1883, Hertz laid the practical foundations of what we now understand by the term 'wireless' telecommunications.

He confirmed Maxwell's predictions by detecting with a broken loop of wire radio signals radiated by a spark from an induction coil. A spark was produced at the break in the loop.

A more sensitive detector of radio waves was however required to enable experimental work on the properties of radio waves to be taken much further and this was provided in the form of the 'coherer' by a Frenchman, Eduard Branly. As far back as 1850 the coherence of conductive particles and the consequent lowering of their resistance in an electric field had been observed and in 1879, Hughes noted a similar effect with a microphone invented by him and comprising carbon rods resting on a steel plate (the Hughes microphone is shown in Patent No. 2202 of 1878).

In 1890 Branly developed a coherer in a practical form, a sealed evacuated glass tube with conductors at each end and metal filings between them. This was used in England, by Lodge, to demonstrate the transmission of radio waves over short distances and his experiments roused much interest.

In 1895 a Russian, Popov, celebrated in the East, much as Marconi is in the West as the 'inventor of radio', was also experimenting with Branly's coherer although he was mainly interested in detecting radio waves produced by lightning flashes.

Branly, Lodge, Popov and a whole host of others who experimented with 'Hertzian' waves before 1896 had one thing in common, they were primarily interested in examining the nature and properties of these waves from an academic point of view.

... to be continued.

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When he said he owned a MARANTZ he said a lot of nice things about himself.



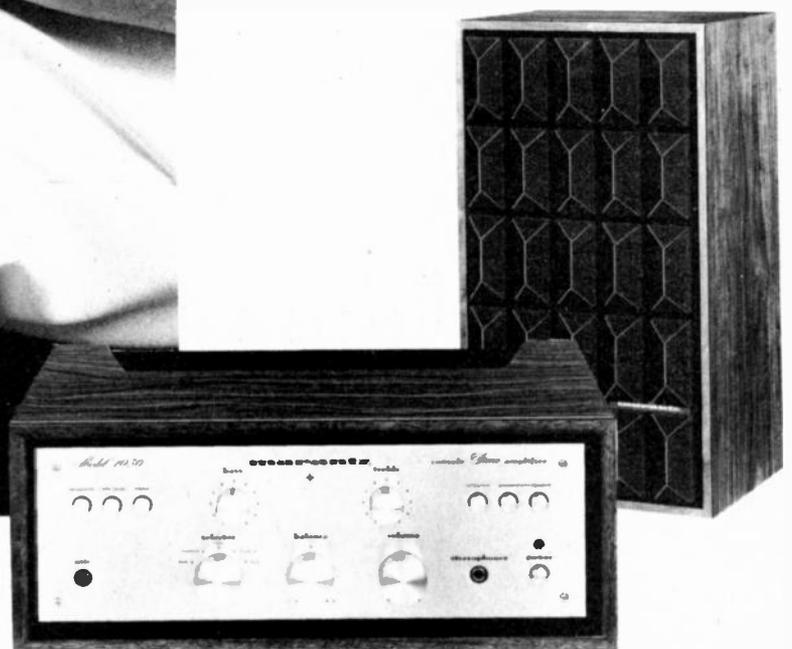
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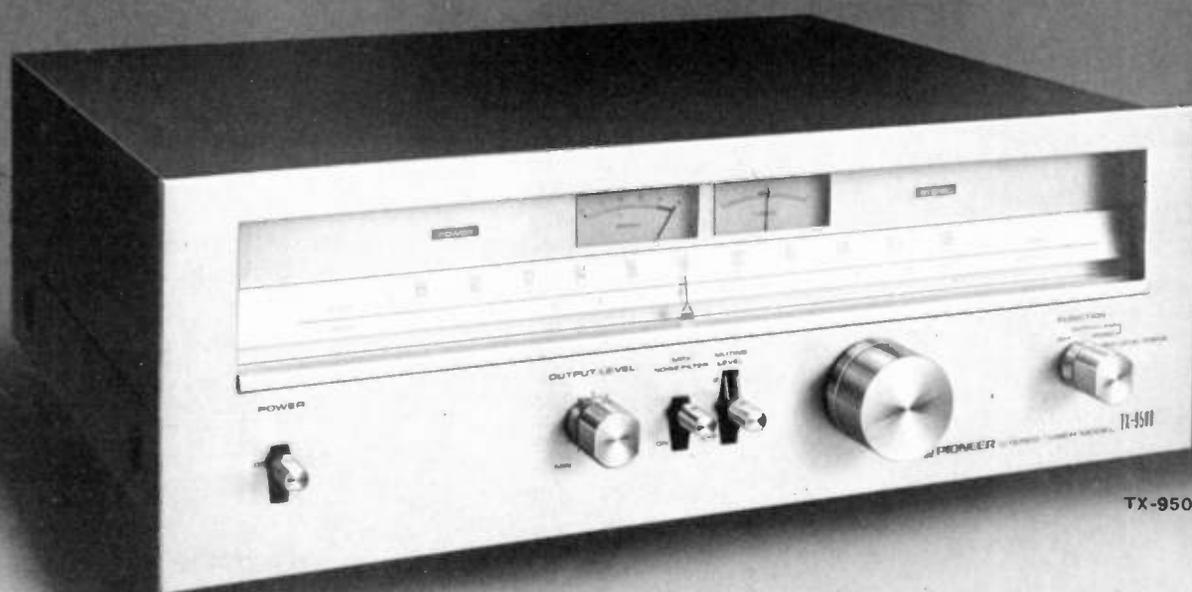
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FM. How to find a needle in an electronic haystack.



TX-9500

The recent advent of FM stereo broadcasting opens up an entire world of musical opportunity. FM is the only broadcasting method capable of meeting the standards of high fidelity. Frequency range, quietness of background and dynamic range. At the same time, FM presents certain problems for clear, accurate reception. FM is subject to the same physical laws as TV. Distance from the station, steel buildings, mountains or other terrain features may reduce or partially block signals. In low-lying valleys, reception is usually difficult. Sometimes, tuning in your desired FM station can be best described by comparing it to the metaphorical "needle in the haystack". You have the approximate location all right, but just being close isn't enough. The atmosphere is clogged with a jumble of transmissions and finding the right one requires an outstanding tuner. Which brings us to the Pioneer TX-9500.

Generally, *sensitivity* is of foremost

importance because it describes a tuner's ability to pull in weak or distant stations. The TX-9500 offers a usable *sensitivity* of $1.5\mu\text{V}$ (IHF). More than enough for even those in hard to reach fringe areas.

For those who may be in the center of congested signal areas, *selectivity* is a vital consideration because this determines the ability of the tuner to choose between two stations directly adjacent to each other on the dial. Here again, the TX-9500 excels. A rating of 85dB guarantees you receive the station you want without a lot of annoying noise and interference.

Making matters even more complicated is the occurrence of being in the middle of two FM stations in different cities broadcasting on exactly the same frequency. In this case, the *capture ratio* of a tuner comes into play. Good *capture ratio* enables a tuner to concentrate on the stronger of the two signals and reject the weaker one. The TX-9500 provides a highly discriminating 1.0dB.

Certainly another important characteristic of a tuner is the *signal to noise (S/N) ratio*. This indicates the strength of the signal compared to the amount of noise accompanying it. The TX-9500 delivers a hushed 75dB (stereo) with total harmonic distortion of no more than 0.2% (stereo) at 1KHz.

But, numbers only tell part of the story. The TX-9500 is from Pioneer and Pioneer is people. People who create some of the world's finest audio components—like the TX-9500—for people like you. All these talents combined—just to make your FM reception easier than finding a needle in a haystack.

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SPECIFICATIONS	Stylus Radius	Tracking Force	Nominal Frequency Response	Nominal Output	Nominal Channel Separation	
Model No.						
XV-15/1200	Elliptical .0002 × .0007	$\frac{3}{4} \pm \frac{1}{16}$ Gram	10 to 30,000 Hz	4.4 mV	35dB	
XV-15/750E	Elliptical .0003 × .0007	$1 \pm \frac{1}{2}$ Gram	10 to 25,000 Hz	4.4 mV	35dB	
XV-15/400E	Elliptical .0004 × .0007	$1 \frac{1}{2} \pm \frac{1}{2}$ Grams	10 to 25,000 Hz	5.5 mV	35dB	
XV-15/350	Spherical .0007	2 ± 1 Grams	10 to 25,000 Hz	6.0 mV	35dB	
Accessory Stylus For L.P. Records	L.P. Monophonic Records	Spherical .001	4 ± 1 Grams	10 to 17,000 Hz	8.0 mV	Monaural
Accessory Stylus For 78 r.p.m. Records	78 r.p.m. Monophonic Records	Spherical .0027	5 ± 2 Grams	10 to 17,000 Hz	8.0 mV	Monaural

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CASSETTE SPEED REGULATION

Control the speed of your cassette recorder with these easy-to-use ICs.

THE SPEED of a small cassette recorder can vary with the supply voltage, with the ambient temperature and with the torque applied by the tape to the motor spindle. Such variations of speed can produce a

considerable effect on the sound reproduction.

The extremely simple circuits described in this article can be used to stabilize the motor speed against variations caused by any of these

effects. They can also be employed for the stabilization of the speeds of small dc motors used for other purposes.

THE INTEGRATED CIRCUIT

The circuits to be described employ one of four similar types of integrated circuit manufactured by the S.G.S.-Ates Company.

The devices coded TCA600 and TCA900 are suitable for use in portable cassette players operating from power supplies in the range of 5.5 V to 12 V. The types TCA610 and TCA910 are most suitable for the speed control of motors driven from a car battery, since they can operate from power supplies in the range of 9 V to 18 V. (The absolute maximum supply voltage is 20 V, but the normal maximum of 18 V allows a safety margin.)

The TCA600 and TCA610 are encapsulated in TO-39 circular metal cans, whilst the TCA900 and TCA910 are in flat plastic packages known as the TO-126 type. Each of these devices has three connections which are numbered in Fig. 4 and in the circuits to be discussed.

The maximum power dissipation of the TCA900 and TCA910 (0.8 W) is greater than that for the other two devices (0.55 W). A heat sink can be fitted if a greater power dissipation is required.

LOW VOLTAGE CIRCUIT

A circuit suitable for use in a typical battery or mains powered cassette player is shown in Fig. 2. The speed of the motor can be varied by the adjustment of RV1.

The power supply for the motor is obtained from pin 2 of the device. The output from this pin shows negative resistance characteristics. That is, if the motor takes an increased current (owing to an increase in the force resisting the rotation of the motor), the driving voltage from pin 2 will increase in proportion.

The maximum motor operating current is 150 mA, although approximately 400 mA can be supplied when the circuit is first switched on.

CAR BATTERY OPERATION

A circuit suitable for operation from power supplies in the range 9 to 18 V is shown in Fig. 3. The motor should

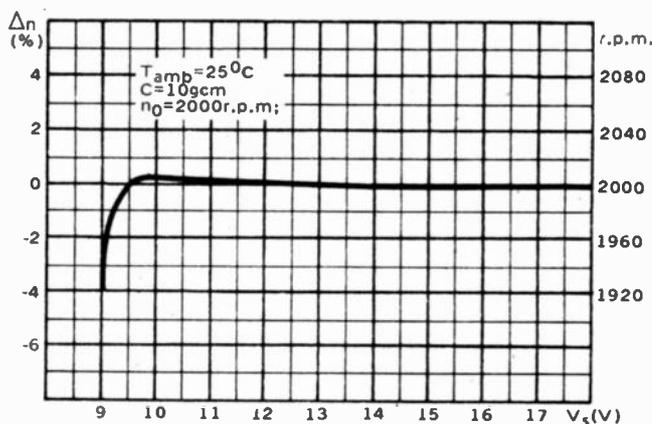


Fig. 1. Speed variation (using the circuit in Fig 3).

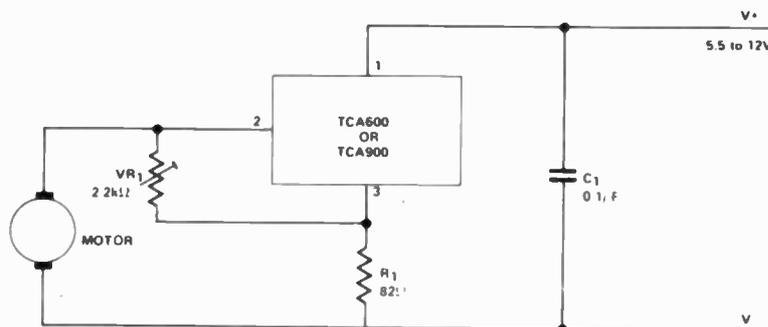


Fig. 2. Typical speed control circuit of a cassette player running from batteries or mains.

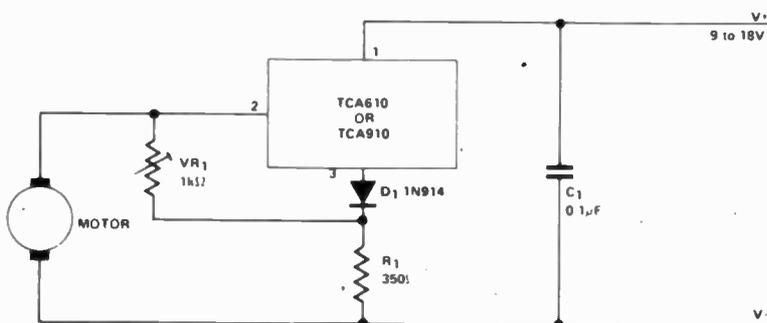


Fig. 3. Circuit for use in a car (or where the supply voltage is 9 to 18V).

produce a back emf of about 6 V, the internal resistance of the motor being typically 44 ohms.

The diode used in this circuit reduces variations of the motor speed with changes in the ambient temperature. However, this system of compensation can be used only with motors producing a back emf greater than 4 volts.

The typical variation of motor speed with the supply voltage when using this circuit is shown in Fig. 1.

PERFORMANCE

The variations of the motor speed with temperature are around 2% for a 25°C temperature change in the circuit of Fig. 2. If, however, the diode is used in the circuit of Fig. 3, the speed variation is very small below 20°C and is about 1% for a rise in temperature from 25°C to 50°C.

The variation of the motor speed with torque is typically little more than 2% when the torque changes by a factor of two; this applies to both the circuits of Fig. 2 and Fig. 3. This variation can be reduced by increasing the value of R1, but care must be taken to ensure that oscillations do not occur.

The minimum permissible back emf from the motor varies linearly from about 2.9 V when R1 is 40 ohms to 3.7 V when R1 is 290 ohms.

The capacitor C1 can be omitted if the power supply is well decoupled.

ADVANTAGES

These motor speed control circuits

TYPE	V _S RANGE (V)	V _M OUT. VOLT. (V)	LIMITING OUTPUT CURRENT (mA)	R th j-c/j-a (°C/W)	REF. VOLTAGE (V)	LINE REGUL. (%/V)	LOAD REGUL. (%/mA)	PACKAGE
TCA 600	5.5-12	3.6	400	25/175	2.6	0.1	0.005	TO-39 (3)
TCA 610	10-16	5.6	400	25/175	2.6	0.1	0.005	TO-39 (3)
TCA 900	5.5-12	3.6	400	10/100	2.6	0.1	0.005	TO-126 (1)
TCA 910	10-16	5.6	400	10/100	2.6	0.1	0.005	TO-126 (1)

employ only four or five components. They are much smaller and simpler than speed stabilizing circuits which employ discrete components and this reduces the assembly costs. The circuits provide a high starting torque

from the motor even at very low ambient temperatures.

It must be made quite clear that these circuits can be employed only to control dc motors; ac motors require a different type of speed control circuit.

SUPPLIERS

The IC's described in this article are handled in Australia by Warburton-Franki (Sydney) Pty Ltd, 199 Parramatta Rd, Auburn, NSW, and will be obtainable directly from any Warburton-Franki office or from their distributors — listed below.

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S.T.A. Electronics,
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Electronic Shop (Colorview),
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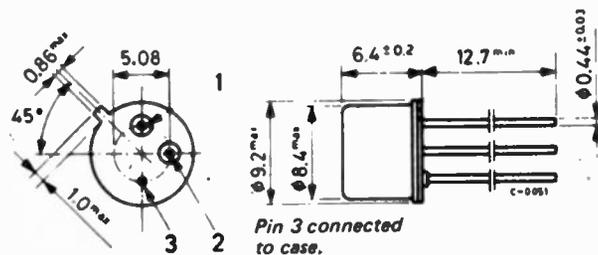


Fig. 4(a) TO 39 metal case for TCA600/610

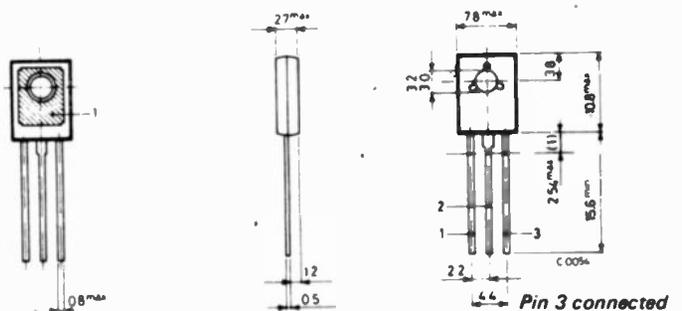


Fig. 4(b) TO 126 (SOT-32) plastic package for TCA900/910

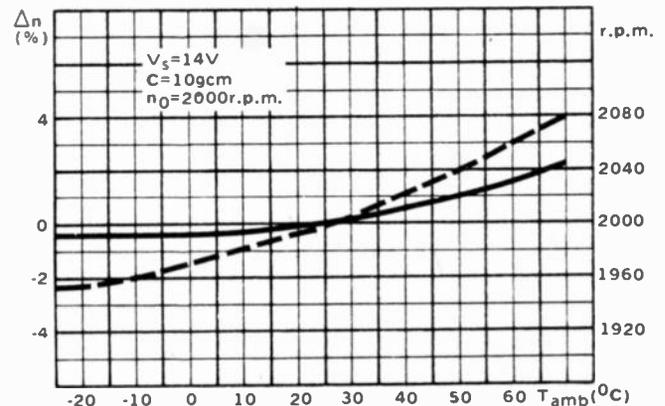


Fig. 5. Typical speed variation versus ambient temperature. Solid-line curve shows effect of diode compensation.

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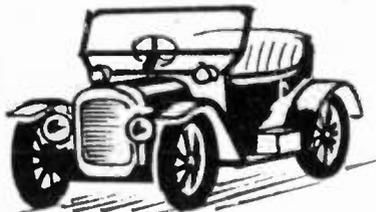
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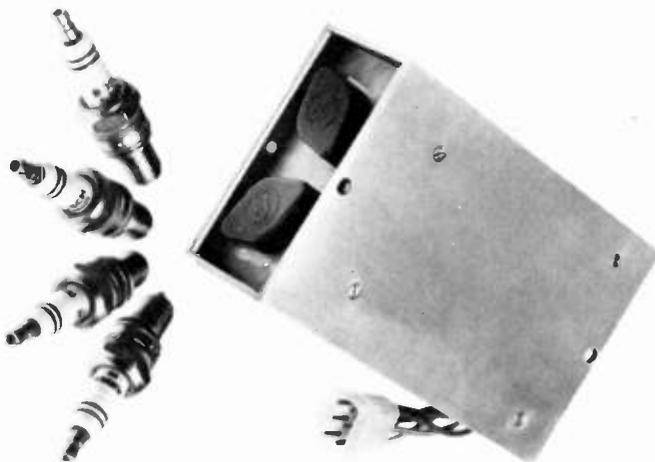
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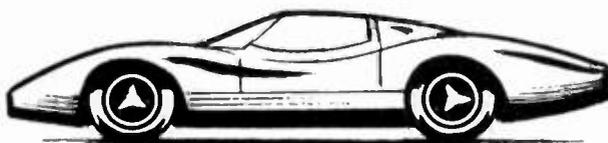
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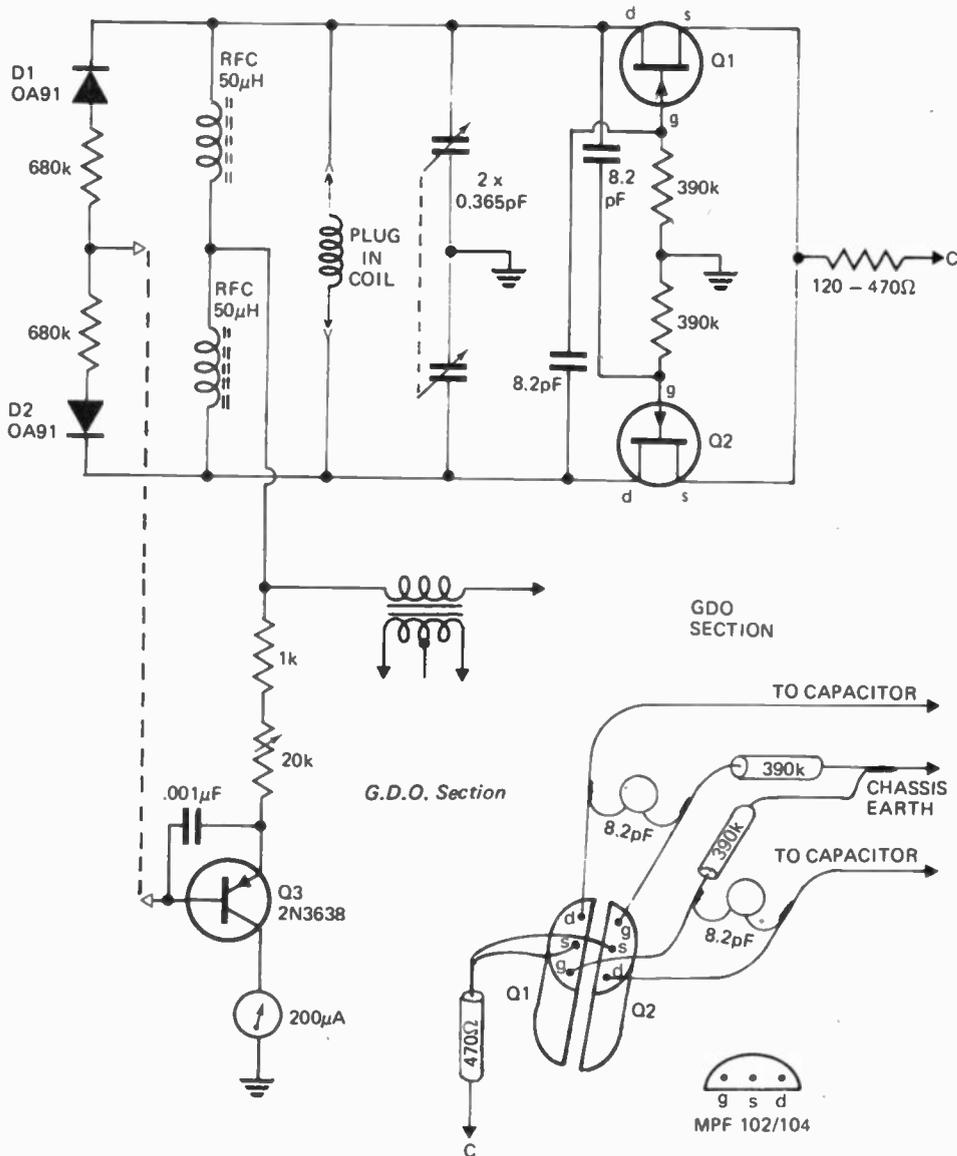
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ETI-6

VERSATILE GDO



GRID DIP OSCILLATORS are commercially available, but most are either expensive (\$60 upwards) or have various performance failings – in particular frequency variations with different potentiometer settings and a very large amplitude variation across the dial.

This unit does not suffer from either problem.

It is unique in that if it is switched to 'Diode', the oscillator is switched off – if it is now brought near an oscillating tuned circuit the unit will not only indicate oscillation but in the 'Dip' position the unit will oscillate at exactly the same frequency as the external oscillating tuned circuit. (This facility has hitherto only been possible with valve GDO's.)

Another most useful facility is that the frequency of prototype tuned circuits can be speedily checked by connecting the coil to a spare plug, plugging it into the GDO unit and then measuring the frequency on a digital frequency meter.

MODULATOR

The low-level modulator provides AM and very slight FM. The AM level is about 5%, quite adequate for most applications. If the dc resistance of the primary winding across EF is too low (less than 50Ω), the circuit may not oscillate. The circuit is switched on by connecting "H" to ground via the function switch.

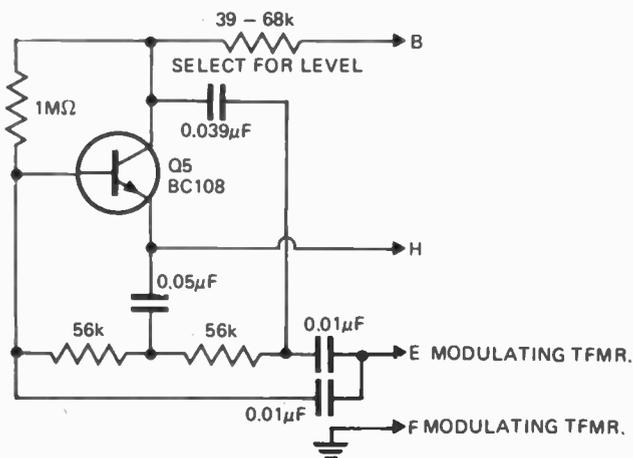
The alternative high-level modulator modulates over 100%. Connect EF across the low impedance side of the transformer.

CRYSTAL CHECKER

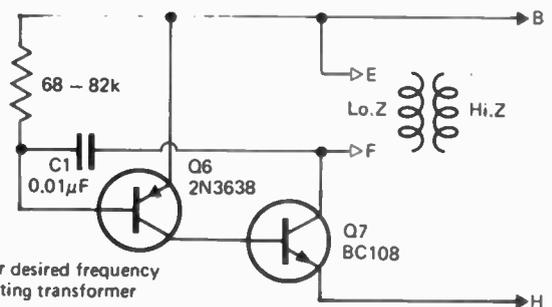
Useful range of this section is 2-20 MHz. When (if) the crystal oscillates, diodes D5 and D6 rectify the waveform and apply a turnoff bias to the base of Q8.

To use this facility the GDO section is switched to "DIP" and the coil is removed, (although this is not

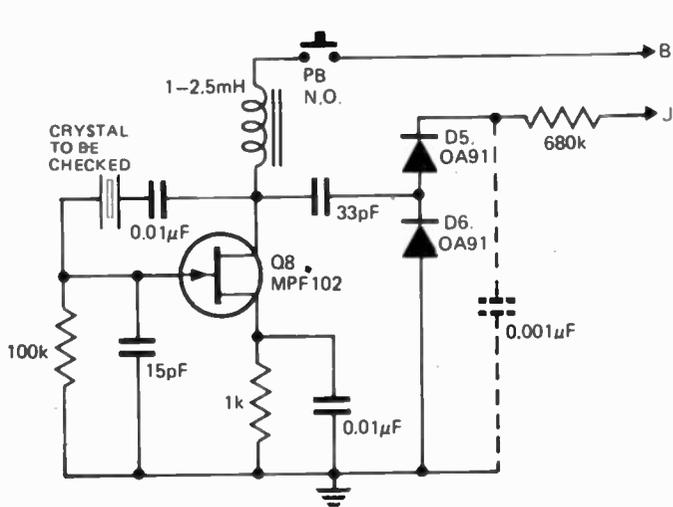
Active grid-dip oscillator performs several functions – designed by C. Włodarczyk – VK2 ZCW



Low-level modulator (~5%)



High-level modulator (~100%)



Crystal checker.

essential). Unplugging the coil causes the circuit to oscillate at VHF and a bias is generated turning on Q8. If the pushbutton on the xtal checker is depressed, the circuit will oscillate at the xtal's fundamental frequency and diodes D5 and D6 will generate a voltage opposing that generated by D1 and D2 and the needle will dip.

If it is desired that the reading be made in the forward direction, the alternative connection for the diodes can be made and the GDO function switch set to the "DIODE" position.

Note however that with this device crystals will be oscillating in their fundamental mode, and sometimes a crystal that will not operate in any other circuit will still operate in this circuit.

POWER SUPPLY

The power supply regulates the voltage supplied to the oscillator. This ensures long term stability.

CONSTRUCTION NOTES

The meter section should be left as is and not converted to npn as many may be tempted to do.

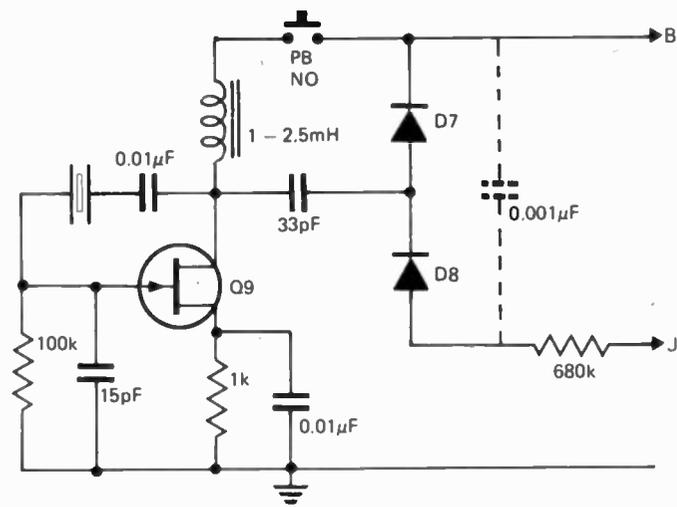
The more sensitive the meter the better but an ordinary 0-200µA edge type uncalibrated meter is suitable. An 0.1 mA is satisfactory up to about 40 MHz. Use thick wire or brazing rod from capacitors to coil socket.

The modulation transformer is from the junk box. It should be a miniature type - one side centre tapped - both sides should have fairly high dc resistance. Some work better than others. If more than one is available try them.

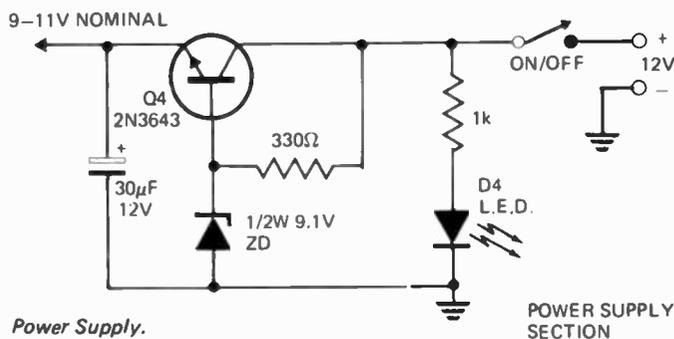
Two versions of the basic current have been built, one - as shown - using 0.365 pF and another version using 0.15 pF dual gang capacitors.

If the device will not oscillate reliably, increase the 8.2 pF capacitors to 12 pF or so, and the rf chokes to about 100µH (for use below 15 MHz).

If the oscillator does not start



Alternative connection for diodes in crystal checker for forward meter reading with GDO in 'diode' position. Capacitor shown in dotted lines, may not be needed.



Power Supply.

POWER SUPPLY SECTION

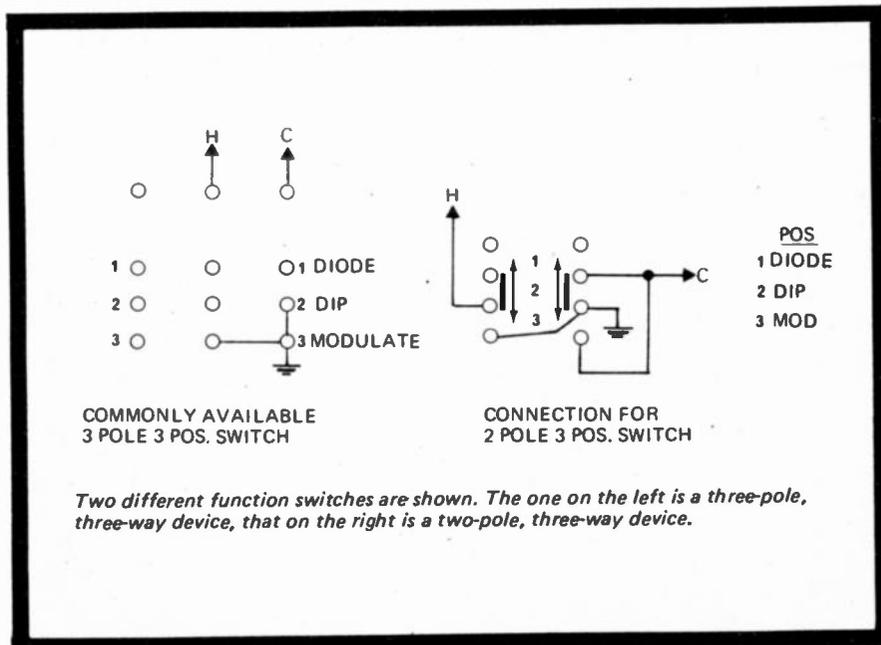
instantly, pull the coil out. The unit should now be oscillating at VHF. If not, double check connections and check the earth on capacitors.

The two FETs, 8.2 pF capacitors and two 390 k resistors are assembled as shown, and mounted directly on the capacitors. Keep leads from capacitors to coil very short.

Note that even if the unit is

assembled in a metal box, with only the coil protruding, it can cause severe TVI at distances up to 100 metres (on the fundamental frequency).

Harmonic content is low but nevertheless there is some, the strongest appearing at 3 f. FM deviation is very slight but can be useful on harmonics due to the multiplier effect.



COMMONLY AVAILABLE 3 POLE 3 POS. SWITCH

CONNECTION FOR 2 POLE 3 POS. SWITCH

Two different function switches are shown. The one on the left is a three-pole, three-way device, that on the right is a two-pole, three-way device.

MOVE WITH THE TIMES

Ultra modern appearance combined with silky smooth action, long operational life and minimal noise factor make Soanar slide potentiometers the natural choice for those designers concerned with tomorrow's electronic equipment.

Costing little more than their rotary counterparts, slide potentiometers offer several distinct advantages.

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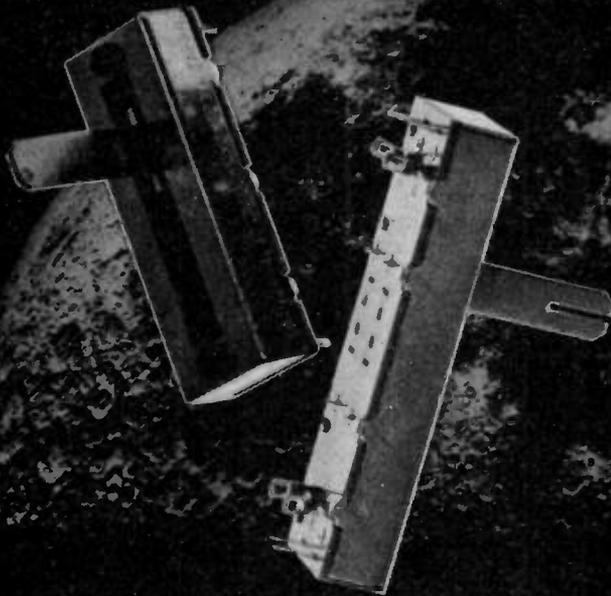
MECHANICALLY: They allow more freedom in mounting position, have a rigid fixing system, an electrically isolated control shaft and may be attached directly to a printed circuit board.

Already established as the contemporary control for colour TV, AM/FM radio, stereo and quadrasonic equipment, slide potentiometers are extremely versatile and have great potential for other electrical/electronic applications, such as audio-mixers, speed controls, light-dimmers, etc.

Soanar slide potentiometers are available from stock in all popular resistance values in log, antilog and linear law types. In addition, there is a choice of single and double ganged configurations in 30 and 45mm lever-travel lengths.

Other types are also available and enquiries are welcomed for non-standard values, multiple ganging and special styles.

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PROJECT 532

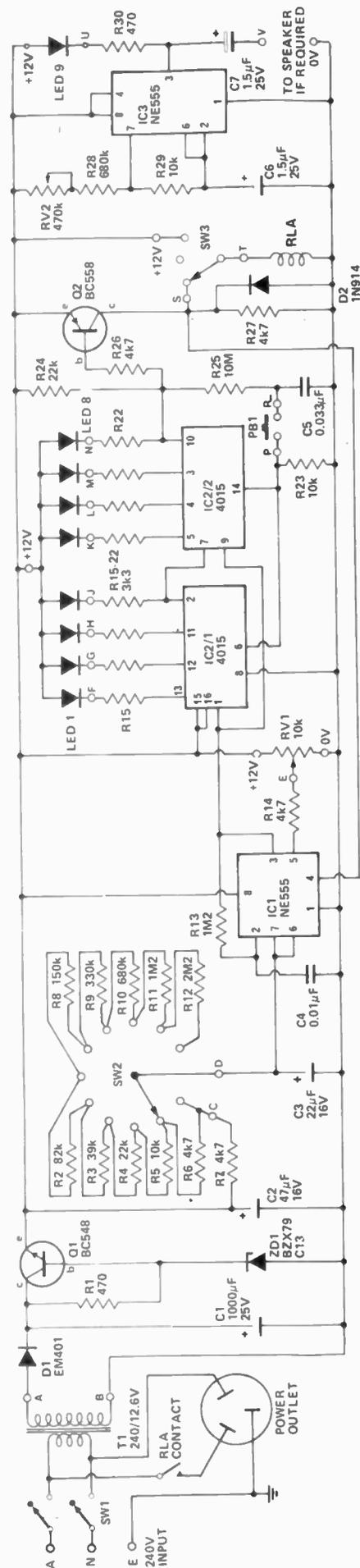


Fig. 1. Circuit diagram of the timer.

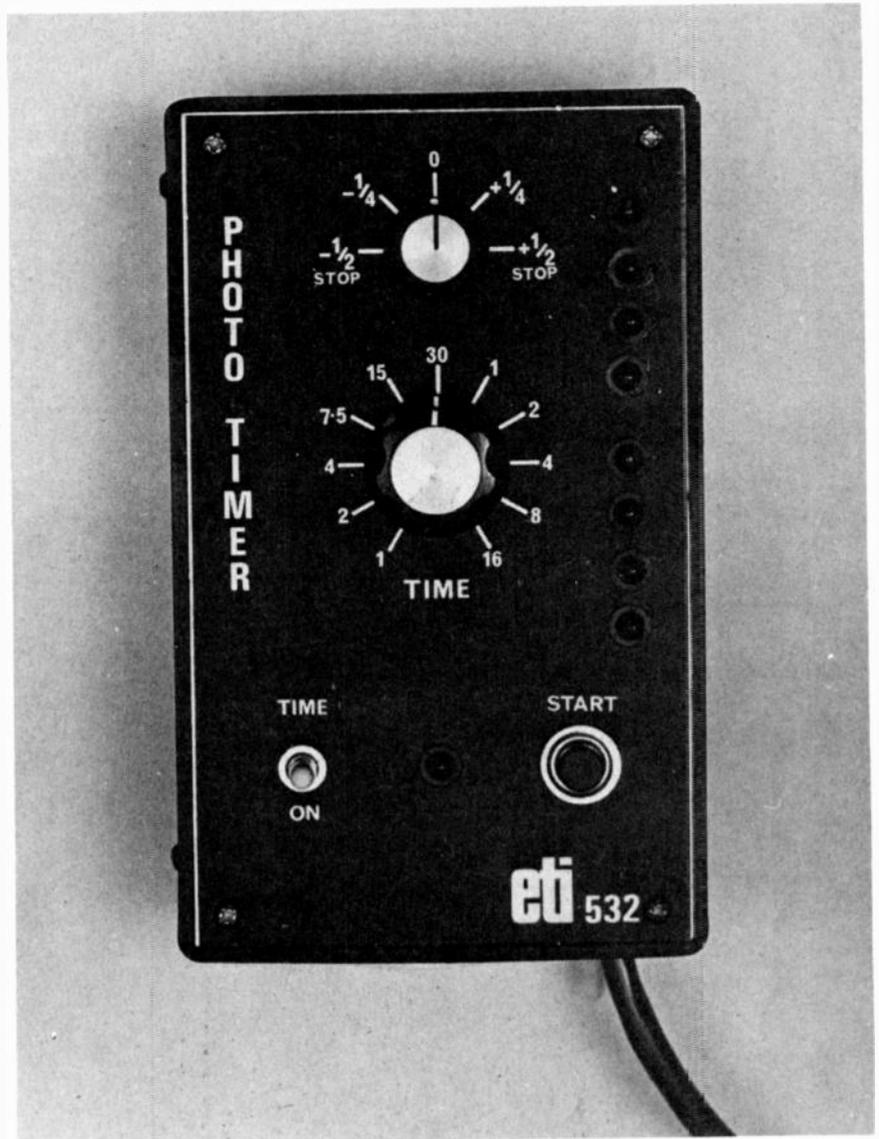


PHOTO TIMER

Versatile and accurate unit displays progress through time interval.

WHEN making multiple photographic prints the repeatability of exposure timing is considerably improved by using an accurate timer.

Mechanical timers, give excellent results but must be set for every exposure. Conventional electronic timers, do not need resetting but give no indication of the time remaining in the selected interval — as do mechanical timers.

Indication of progress within the selected time interval is very helpful,

particularly if parts of a print need burning in. Such indication also helps co-ordinate other activities which may be carried out during the exposure period.

The electronic timer described here divides the total selected time into eight equal periods and indicates the elapse of each portion of the interval via light emitting diodes.

Eight LEDs are arranged in a vertical

Text continued on page 44

PHOTO TIMER

HOW IT WORKS — ETI 532

The basic timing is performed by an NE555 timer, IC1. The timing is varied by selecting a charging resistor via the range switch SW2. The range may then be varied around the SW2-selected period by providing a variable threshold voltage (normally two-thirds supply) to pin 5 from RV1. Resistor R13 and capacitor C4 are used to ensure that C3 is completely discharged at the end of each charge cycle thus ensuring accurate timing.

Integrated circuit IC2 is a dual, four-bit shift register connected as an eight-bit shift register. For those unfamiliar with shift registers a brief explanation follows. There are eight outputs (labelled 1-8) a clock input, a data input, and a reset. When the unit is clocked the information at the data input is transferred into the '1' output. The information which was at the '1' output transfers to the '2' output, and so on, so that the information, at outputs 1-8, shifts along sequentially one place on each clock pulse — hence the name shift register.

The clock input to the shift register is the output from the 555 timer and the data input is connected directly to the +12 volt rail. Hence after eight clock pulses all outputs will be high. An LED is connected between each shift register output and +12 volts such that they are only illuminated when the associated shift-register output is low.

If push button PB1 is pressed all outputs of the shift register are set to zero and all LEDs will light. These then go out one at a time as the 'high' at the data input is clocked through the shift register.

The relay is driven by transistor Q2 which, in turn, is driven from the last LED. The relay can be switched out by SW3 and the LED display may then be used without the relay. Alternatively the relay may be switched on or off, without using the timer, again by SW2. When the shift register is reset the relay closes and when the last light goes out the relay opens.

The output of Q2 also controls the reset line of IC1 thus ensuring accurate timing in the first cycle.

The third IC is also a 555 timer which provides an output of one 10 millisecond pulse per second. This pulse drives LED 9 and a speaker if required.

A 12.6 volt transformer, rectifier D1, and filter capacitor C1 feeds a regulator consisting of Q1 and ZD1 to provide an output of 12 volt dc.

If required an external push button, or foot switch, may be paralleled across the local one to enable the start. Another may be used between the relay (point T) and +12 volts to allow the relay to be closed remotely.

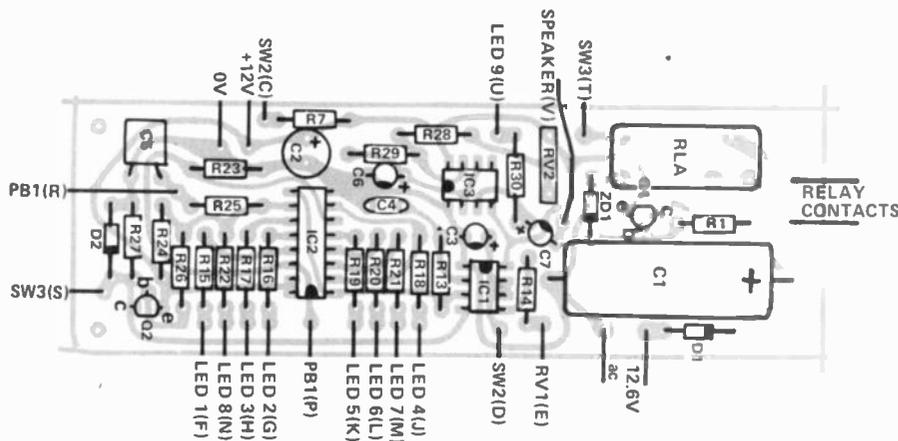


Fig. 2. Component overlay.

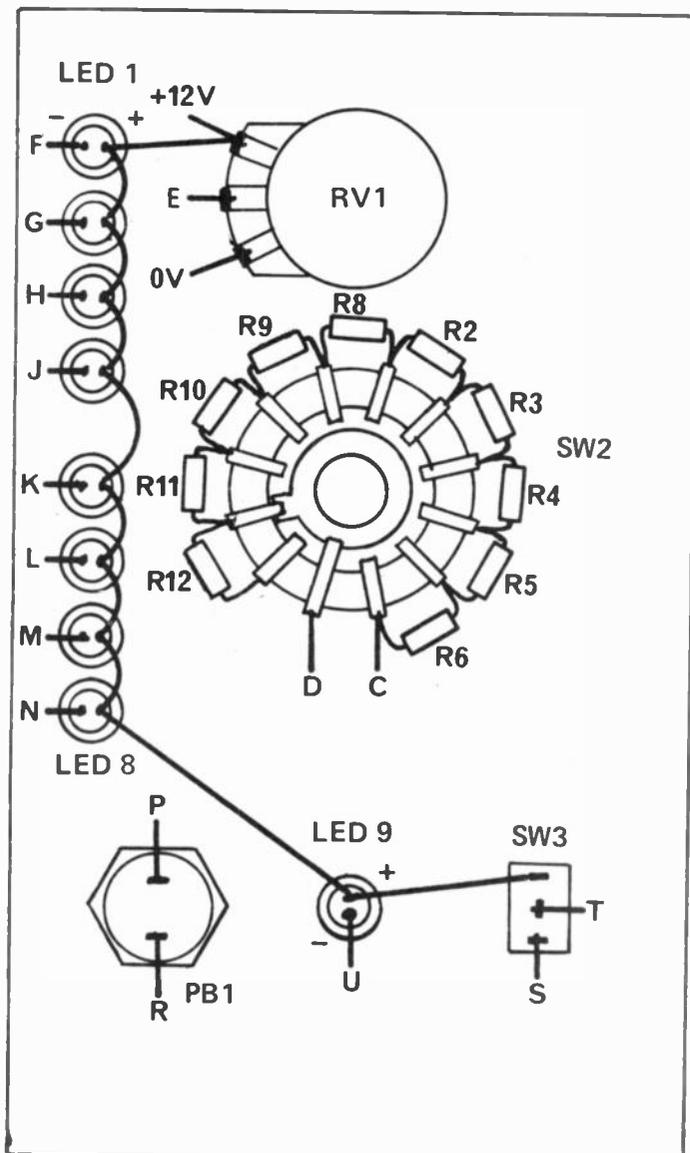


Fig. 3. Front panel wiring details.

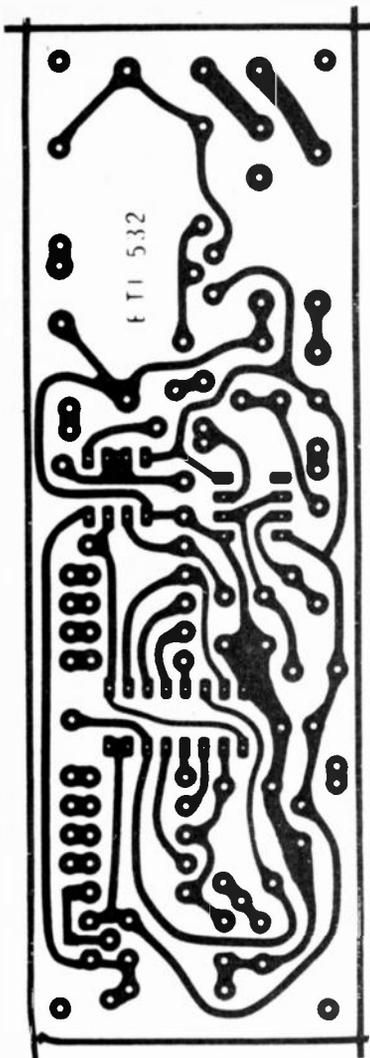


Fig. 4. Printed circuit layout. Full size 133 x 44 mm.

PARTS LIST

R1,30 Resistor	470	1/4 or 1/2W	5%	C2	"	47 μ F 16V electrolytic
R15,16,17,18	"	3 k Ω	"	C1	"	1000 μ F 25V
R19,20,21,22	"	3 k Ω	"	Q1	Transistor	BC548 or similar
R6,7,14	"	4 k Ω	"	Q2	"	BC558 "
R26,27	"	4 k Ω	"	D1	Diode	EM401 or similar
R5,23,29	"	10 k Ω	"	D2	"	1N914 "
R4,24	"	22 k Ω	"	ZD1	Zener Diode	BZX79 C13
R3	"	39 k Ω	"	LED	1.9 Light Emitting Diode	
R2	"	82 k Ω	"	IC1,3	Integrated Circuit	NE555
R8	"	150 k Ω	"	IC2	"	4015,14015
R9	"	330 k Ω	"	SW1	Switch	DPDT switch 240V toggle
R10,28	"	680 k Ω	"	SW2	"	11 position 1 pole rotary
R11,13	"	1 M Ω	"	SW3	"	SPDT, with centre off, toggle
R12	"	2 M Ω	"	RLA	Relay 12V coil, 240 Vac 6 amp contacts type E3201	
R25	"	10 M Ω	"	T1	Transformer 240V/12.6V DSE 2851 or, A&R PT 6474 or similar	
RV1	Potentiometer	10 k lin rotary		PB1	Push Button	Press to make.
RV2	"	470 k trim				
C4	Capacitor	0.01 μ F Polyester				
C5	"	0.033 μ F "				
C6,7	"	1.5 μ F 25V electrolytic				Plastic Box UB1 or similar 240V outlet C11psal 415 or similar 3 core flex & plug.
C3	"	22 μ F 16V TAG				

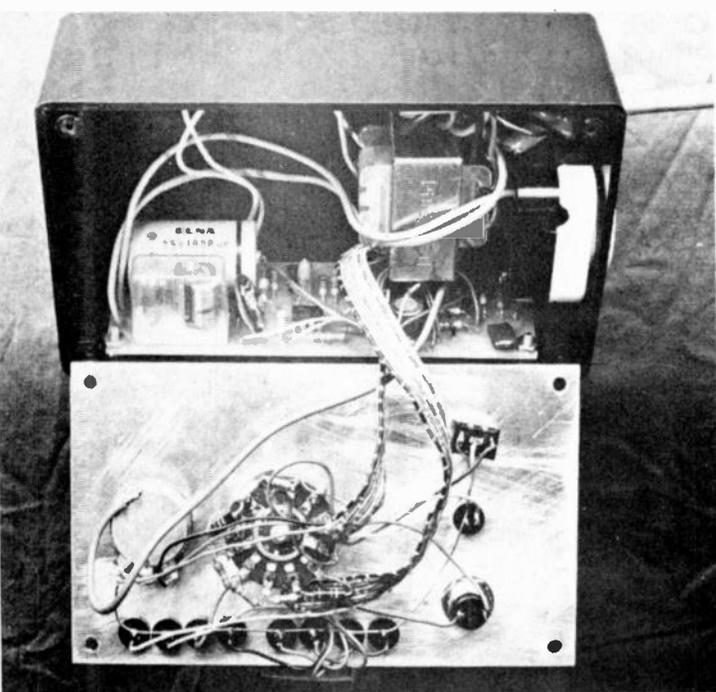


Fig. 5. This internal view shows how the components are mounted within the box. If the size of box specified is used watch component clearances — there is not much room.

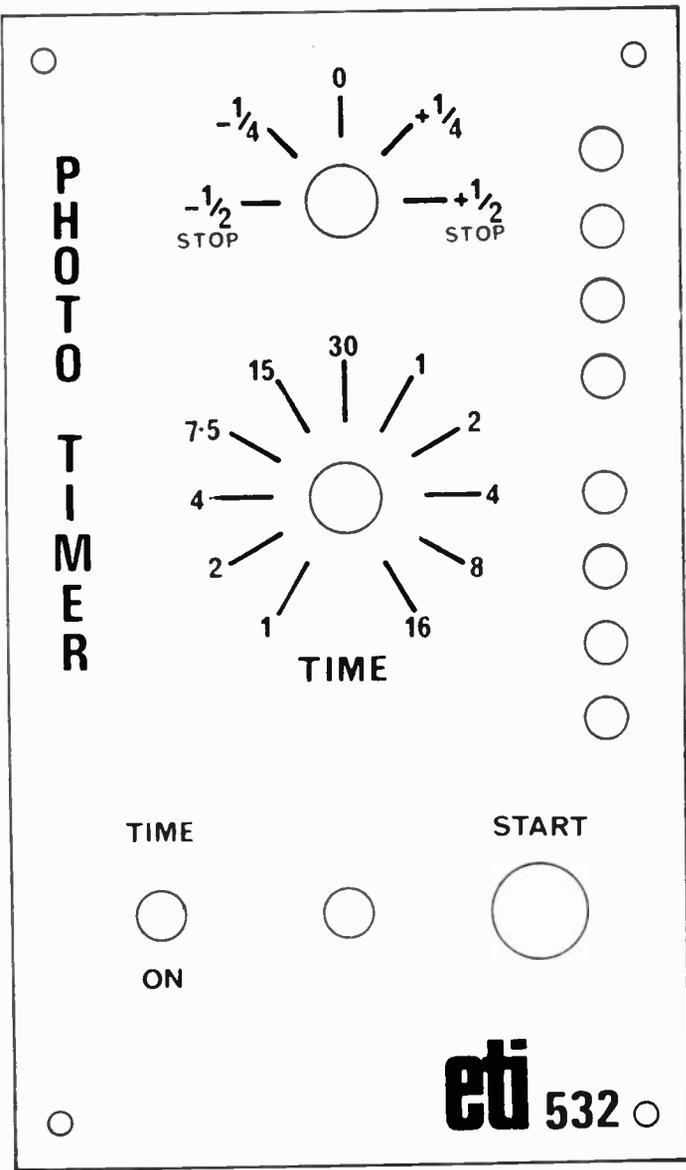


Fig. 6. Front panel artwork.

PHOTO TIMER

row. When the timing interval is initiated all LEDs light up. As time elapses the lights go out progressively, until all are out and the timing is complete. An internal relay is held on until the last of the LEDs is extinguished. This relay controls the mains output to the enlarger, or other device, via a standard three-pin power outlet.

The timing interval can be varied from one second to sixteen minutes in eleven switched ranges. Starting from the lowest, each range covers twice the time interval of the receding one. Thus the exposure may be increased or decreased, by one stop simply by switching up one range or down one range respectively. A variable potentiometer allows the range-selected time to be adjusted by half a stop either side.

As a further aid to timing another LED is provided which flashes once per second, regardless of selected range. This once-per-second pulse may be fed to a small loudspeaker, if

desired, to provide an audible one-per-second tick.

CONSTRUCTION

Our prototype was built into a small plastic box, 160 x 95 x 50 mm. The front panel shown in Fig. 6 is designed to suit that box. All the electronics apart from switches and LEDs are mounted on a single printed circuit board. It is recommended that this board be used as construction would otherwise be much more difficult.

Assemble components to the printed circuit board with the aid of component overlay Fig. 2. Make sure that the polarities of transistors, diodes and capacitors are correct and that integrated circuits are correctly orientated. Note also that IC2 is a CMOS device and should therefore be the last component to be fitted. The pins of this device should not be handled unnecessarily and an earthed soldering iron should be used. Solder the supply pins (16 and 8) first. Capacitor C5 and transistor Q2

should be mounted such that they are flat on the printed circuit board otherwise they may touch the power-outlet socket.

The components, mounted on the lid of the box, should be wired as illustrated in Fig. 3. Note that resistors 2 to 12 (with exception of R7) are mounted on SW2.

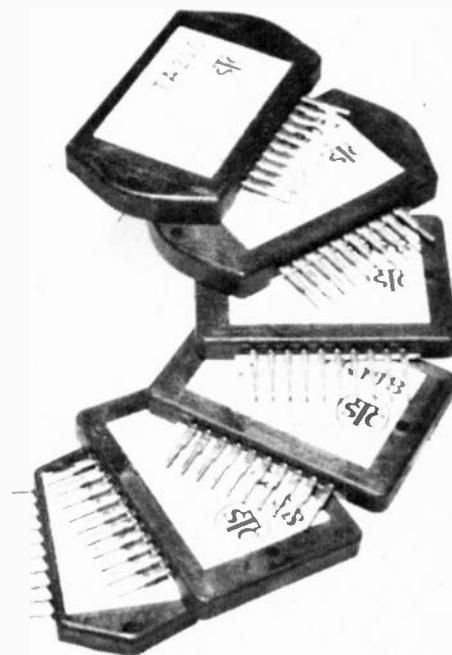
Before drilling any holes in the box for the transformer etc, make sure that all components are clear when the lid is in place as there is not a great deal of room in the box. The photograph of the box shows where components should be located.

All 240 volt ac wiring should be 23/0076 wire rated for 240 volts ac, and any bare terminals should be well covered with insulation tape to prevent accidental shorts or personal contact.

The range of timing available — one second to 16 minutes makes this timer suitable for a variety of applications other than photographic printing — it is an extremely versatile and useful device. ●

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TA5B	8	5	25	339250
TA10B	13	10	32	339250
TA15B	18	15	38	339250
TA20C	30	20	±22	339771
TA25C	35	25	±24	339771
Preamp	—	—	—	339251



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4009 Hex Buffer (inverting)		1.00	
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4013 Dual D Flip/Flop		1.30	
4016 Quad Bilateral Switch		1.25	
4017 Decade Counter/Divider		2.95	
4020 14 Stage Counter/Divider		3.20	
4027 Dual J-K Flip Flop		1.40	
74 Series TTL	\$	c	\$
7400	.35	7451	.35
7401	.35	7453	.35
7402	.35	7454	.35
7403	.35	7460	.35
7404	.35	7470	.50
7405	.35	7472	.60
7408	.35	7473	.90
7409	.35	7474	.90
7410	.35	7475	1.00
7413	.35	7476	.80
7420	.35	7480	1.70
7430	.35	7482	1.80
7437	.60	7483	1.40
7440	.35	7486	.60
7441	1.20	7490	.80
7442	1.00	7491	1.20
7447	1.50	7492	.80
7450	.35	74121	.60

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Red LED (large including mounting clip)	\$	c	.30
NSN 71 0.3" C Anode Display			2.15
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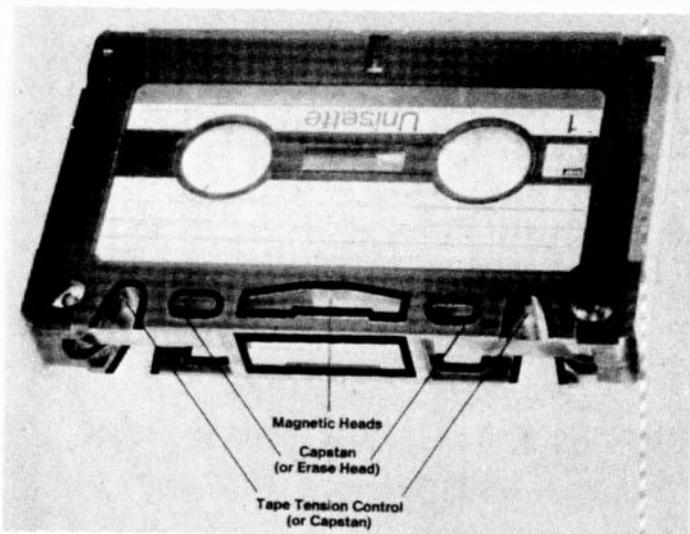
THE ELECTRONIC MAILBOX,

P.O. Box 355, Hornsby, NSW 2077



THE UNISETTE CASSETTE

Will this be the hi-fi cassette of the future?



This illustration shows the various access points for the audio systems.

THE conventional tape cassette was developed by Philips, some ten years ago, specifically for use in portable dictating machines.

There is a substantial body of informed opinion that the cassette should have been kept for that purpose and that purpose only!

Certainly today's top cassette recorders perform as well as many reel-to-reel machines. But this excellence has been achieved by applying the most complex and sophisticated engineering to a device that is basically inappropriate for the application.

For instance, in order to obtain reasonably long playing times, tape speed must be low. But this results in a reduction in the maximum usable recording level, reduction of signal/noise level, and increased dropouts.

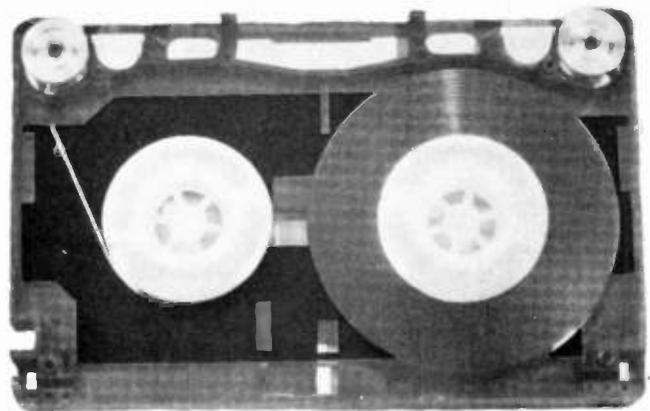


Fig. 1. The tape is located by the two tabs and guide rollers.

The Unisette cassette has two removable pins, that block the recording device and thus prevent accidental erasing.

Decreasing tape thickness (again to obtain longer playing times) reduces the amount of magnetic coating — which in turn degrades low end performance.

The standard cassette relies on the cassette housing for tape alignment — this causes azimuth alignment problems and major deviation of the magnetization vector of the recorded signal from the perpendicular position to the replay head gap. This is particularly disadvantageous if a cassette is recorded on one machine and then played back on another.

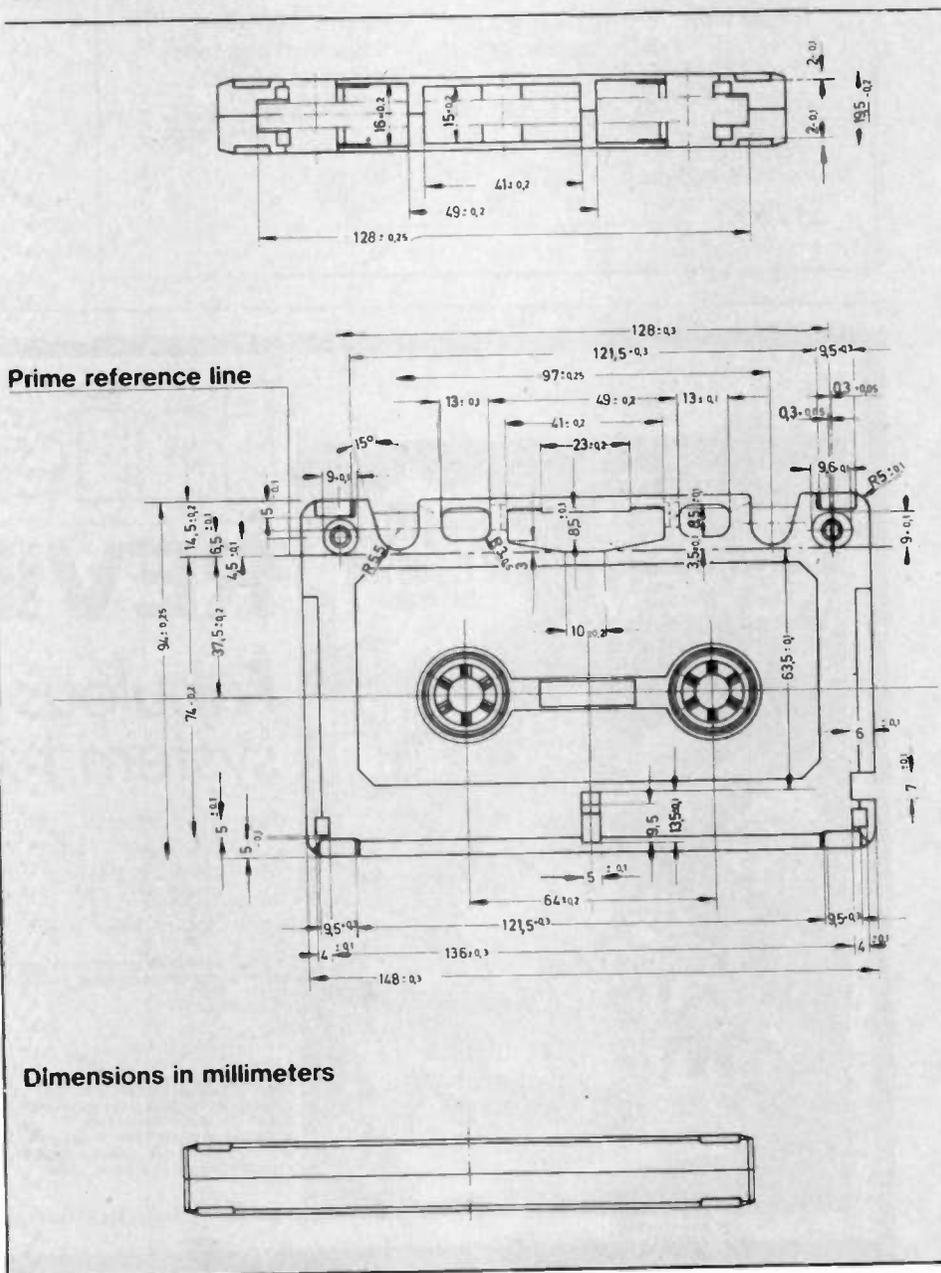
Clearly some of the problems outlined above have been at least partially overcome. The necessarily reduced recording level has been balanced out to some extent by the use of special tape formulations and increased equalization — the inherently poor signal/noise ratio has been improved by the introduction of Dolby and other noise reduction systems — azimuth errors have been compensated for (to some extent) by the incorporation of adjustable heads on the Nakamichi recorder.

But these are at best palliatives. Would it not be better to use a cassette format that was *fundamentally* more suitable for high quality reproduction?

Thankfully, BASF have come to the same conclusion. As reported in recent issues of this magazine, BASF have developed their so-called 'Unisette cassette specifically to provide a cassette format that is capable of meeting the most exacting standard of professional sound recording' — to quote BASF's own literature.

Although BASF spokesmen claimed initially that the Unisette format was intended solely for automated broadcasting stations and language laboratories, the company now admit that the format is also intended to

Cassette dimensions



THE UNISLETTE CASSETTE

compete with the Philips-type cassette for use with appropriately designed professional and amateur hi-fi machines.

The basic mechanism of the Unislette cassette is shown in Fig. 1. As can be seen, the tape (1/4" width) is located only by the transport mechanism — not the cassette housing itself. The tape is transported from one hub to the other and is guided by two roller guides all of which lock into a mechanical drive and guidance system which forms part of the 'Unislette player itself'. Thus the Unislette cassette's casing is in effect only a dust cover. The whole casing could be removed when the cassette is in

position without in any way affecting operation!

The Unislette cassette is designed for a tape drive mechanism with either one or two capstans with a maximum diameter of seven millimetres. A very large symmetrical opening is provided for the head configuration. This enables separate record and playback heads to be used if required. A further opening is included for the erase head, and two further ones for tape tension control or the capstan.

Head to tape contact can be achieved either by tape tension and a suitable wrapping angle — as used on professional machines — or by pressure

pads mounted on the machine itself.

The Unislette cassette is much larger than its conventional Philips counterpart — it is about the size and weight of a paper back book. Accurate drawings of the cassette are included within this article.

Various types of tapes may be used depending upon the particular application. Playing times for various tapes are shown in Table (below left).

HAROWARE

At the time of going to press, we know that a number of audio manufacturers are actively developing cassette players for use with the new cassettes. According to BASF, Revox, Nordisk and Rink aim to have Unislette recorders on sale later this year

We also have reason to believe that certain aspects of the BASF mechanism *may* infringe patents held by Philips. However neither company will at present comment on this.

Looks like it's going to be an interesting year!

Type of tape	maximum tape length (m)	maximum playing time (min) at a tape speed of 9.5 cm/s (3 3/4 ips)
Long play tape	86	30 (15)
Double play tape	114	40 (20)
Triple play tape	171	60 (30)

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MAY 1975 80¢

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SYSTEM 4A	2 x AD8066/W8 woofers 2 x AD5060/SQ8 mid range 2 x AD0160/T8 tweeters 2 x ADF300/4500/8 3way x overs 2 x enclosure kits	10M speaker wire Innerbond, grill cloth terminals	ONLY \$129.00
SYSTEM 5A	2 x AD8066/W8 woofers 2 x AD5060/SQ8 mid range 2 x AD0160/T8 tweeters 2 x ADF300/4500/8 3way x overs 2 x enclosure kits	10M speaker wire Innerbond, grill cloth terminals	ONLY \$142.00
SYSTEM 6A	2 x AD10100/W8 woofers 2 x AD5060/SQ8 mid range 2 x AD0160/T8 tweeters 2 x ADF300/4500/8 3way x overs 2 x enclosure kits	10M speaker wire Innerbond, grill cloth terminals	ONLY \$179.00
SYSTEM 7A	2 x AD12100/W8 woofers 2 x AD5060/SQ8 mid range 2 x AD0160/T8 tweeters 2 x ADF300/4500/8 3way x overs 2 x enclosure kits	10M speaker wire Innerbond, grill cloth terminals	ONLY \$196.00

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12SA-1	\$32.00 EACH
10SA-1	\$30.00 EACH
8SA-1	\$27.00 EACH

8" CORAL SPEAKER SYSTEM KIT 8SA-1

The features as assembled in a designed cabinet are as follows:

Features (8SA-1)	
Type of cabinet	Closed vpe
Type of speaker	3-way 3-spe. car
Input Impedance	8 Ohms
Crossover frequency	4,000 : 9,000 Hz
Frequency response	70 ~ 20,000 Hz
Sensitivity	93 dB
Capacity	35 W

35W, 3-way 3-speaker system in kit form includes all speakers, crossovers, terminals, wire, screws, coral emblem for front of box.

\$32 PAIR
\$2.00 P&P

10" CORAL SPEAKER SYSTEM KIT 10SA-1

50W, 3-way, 3-speaker system in kit form includes all speakers, crossovers, terminals, wire, screws, coral emblem for front of box.

The features as assembled in a designed cabinet are as follows:

Features (10SA-1)	
Type of cabinet	Closed type
Type of speaker	3-way 4-speaker
Input Impedance	8 Ohms
Crossover frequency	1,000 : 10,000 Hz
Frequency response	30 ~ 20,000 Hz
Sensitivity	95 dB
Capacity	60 W

Price \$50 PAIR
\$2.00 P&P

12" CORAL SP. SYSTEM KIT 12SA-1

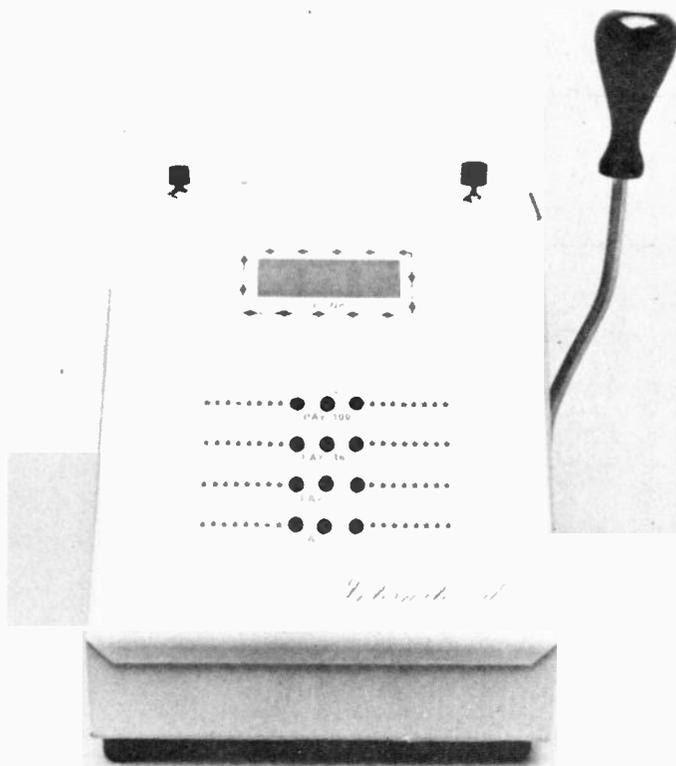
60W, 3-way, 4-speaker system in kit form includes all speakers, crossovers, terminals, wire, screws, coral emblem for front of box.

The features as assembled in a designed cabinet are as follows:

Features (12SA-1)	
Type of cabinet	Closed type
Type of speaker	3-way 4-speaker
Input Impedance	8 Ohms
Crossover frequency	1,000 : 10,000 Hz
Frequency response	30 ~ 20,000 Hz
Sensitivity	95 dB
Capacity	60 W

Price \$77 PAIR
\$2.00 P&P

ELECTRONIC POKER MACHINE



ETI
**PROJECT
529**

commence by installing links to the logic board in accordance with overlay diagram Fig. 4. Make sure that the supply-rail decoupling capacitors C2, 3, 16, 17, 22 and 23 are ceramic types for best possible bypassing.

On the display board Q1, Q2 and C1 should be laid flat on the PC board so that there is sufficient clearance when the board is mounted to the front panel. The leads of the LEDs were bent to form the shape of a circle (don't bend close to the body of the LED or the lead will fracture) thus giving a spring action against the rear of the panel.

When assembling the main logic board, use care with integrated circuits IC11, 12, 13, 14 and 17. These are CMOS devices and are easily damaged by static discharges. Avoid handling the pins, insert them after all other components are mounted and insert them as quickly and cleanly as possible. Lastly with these ICs, and indeed all semiconductors avoid overheating the device when soldering. Apply the iron only long enough to obtain a good joint.

Interconnect the two boards as shown in Fig. 8. Keep the leads as short as possible especially power supply leads E, D and G as interference picked up on these leads could affect the operation of the machine. Also at this time attach leads to the outputs of the boards which are long enough to reach the switches and power supply.

Both boards may now be mounted on the rear of the sloping front panel. Making sure that the LEDs are aligned with the holes, mount the display

Constructional details.

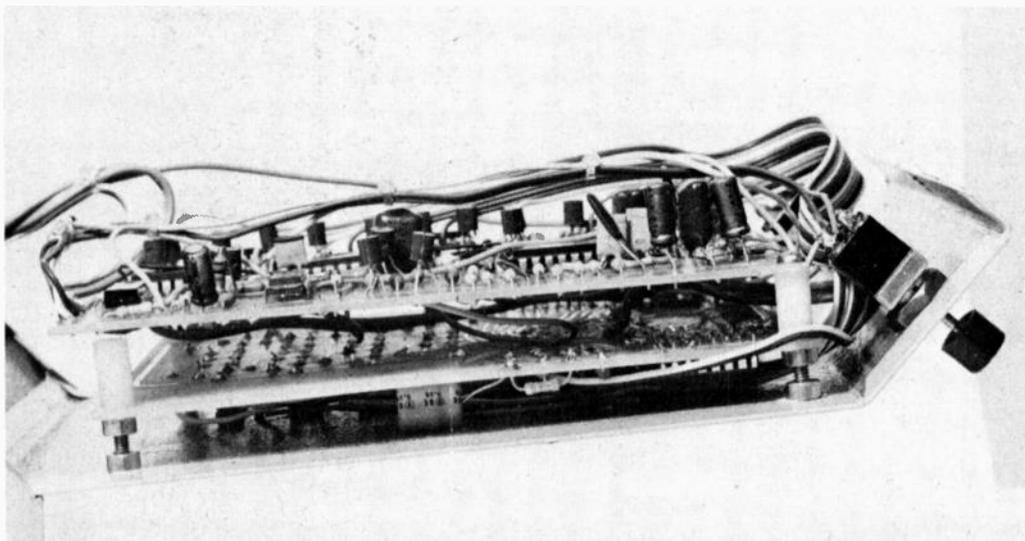
LAST month we introduced the basic system philosophy of the ETI 529 Poker machine and gave a functional block diagram of the complete machine.

We now continue with full constructional details of the machine which, when completed, should give many hours of pleasure to players young and old.

CONSTRUCTION

Because of circuit complexity it is recommended that printed-circuit boards be used as their use will greatly simplify construction.

When assembling components to the printed circuit boards take particular care to correctly orientate integrated circuits, electrolytic capacitors, diodes and transistors. Construction should



This picture shows how the two boards are mounted to the rear of the front panel

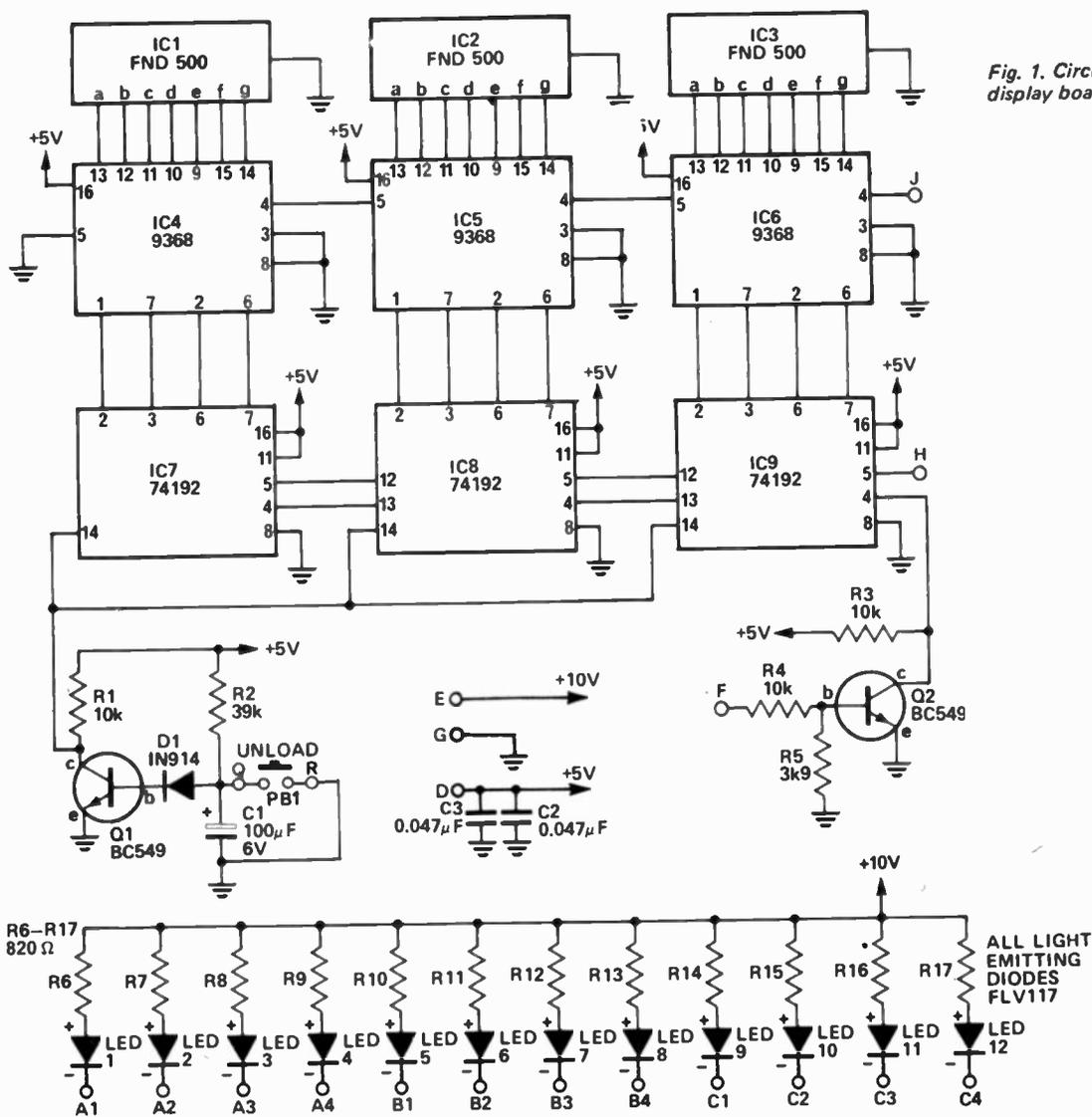
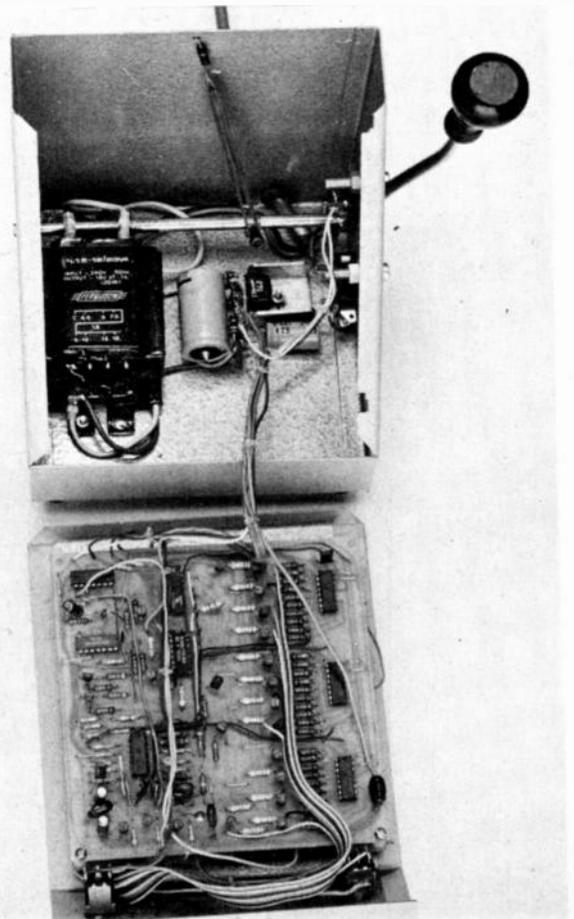


Fig. 1. Circuit diagram of the display board.

panel (component side towards rear of panel) by means of 19 mm countersunk screws. Space the board from the front panel about 8 mm by means of a pair of nuts or plain spacers. Hold the board in position by screwing 12 mm spacers onto the protruding screws. Now attach the logic board by screwing to the 12 mm spacers (component side away from front panel).

The power supply is built into the bottom of the box and wired up as in Fig. 7. An eight-way tag strip being used to support all the components. Make sure that the polarities of the diodes and electrolytic capacitors are correct. The five volt regulator, IC 18, is bolted to the bottom of the box after first scratching away the paint so that good thermal conduction is obtained — a little silicon grease between tab and box will help. When mounting the tag strip make sure that both earth lugs have good electrical contact with the box.

Internal view of poker machine showing location of major components. Note rubber band arm-return spring.



Main text continued on page 54

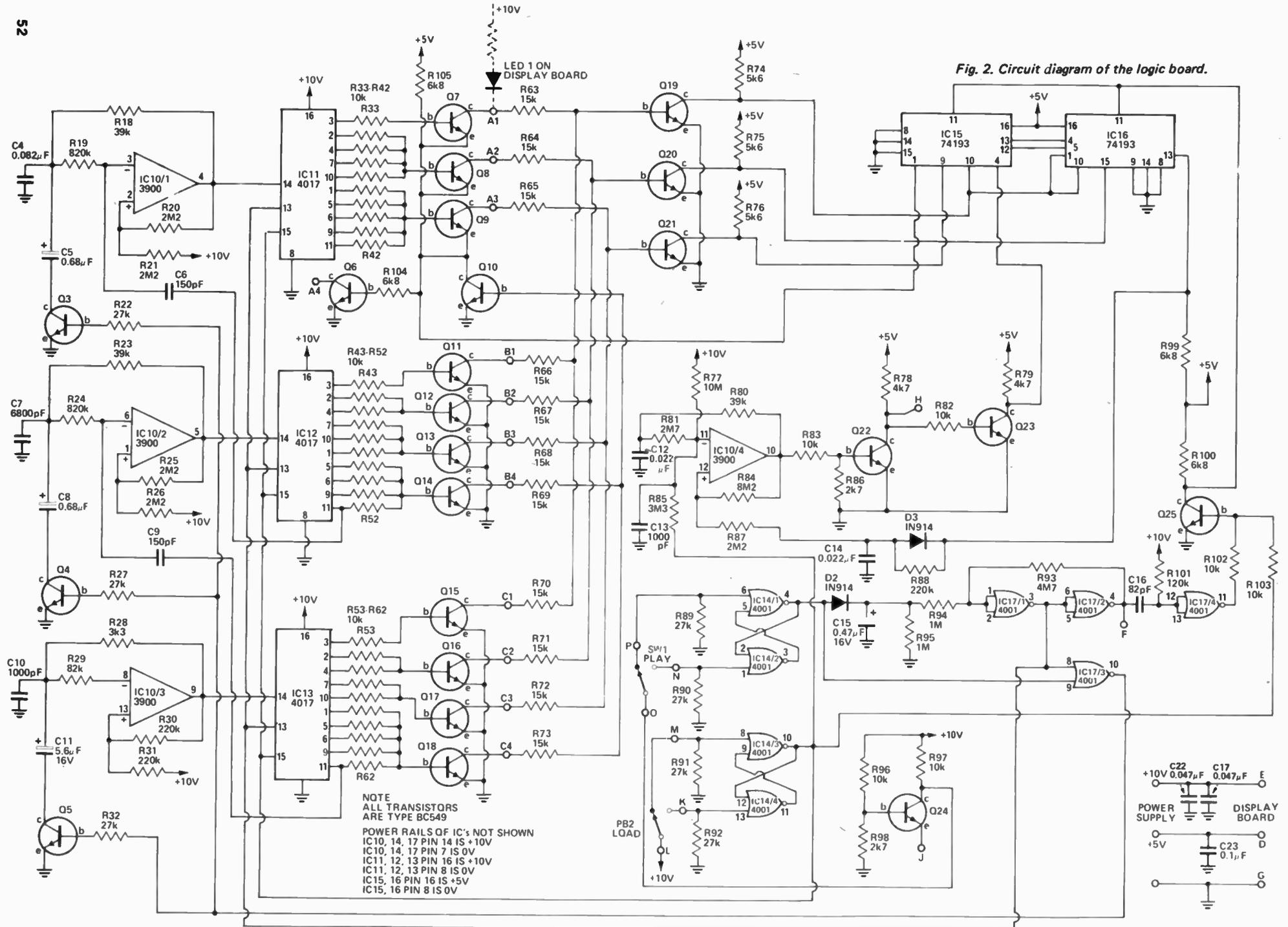
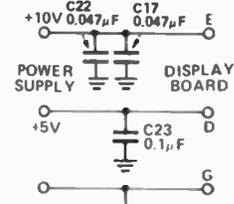


Fig. 2. Circuit diagram of the logic board.

NOTE
 ALL TRANSISTORS
 ARE TYPE BC549
 POWER RAILS OF IC'S NOT SHOWN
 IC10, 14, 17 PIN 14 IS +10V
 IC10, 14, 17 PIN 7 IS 0V
 IC11, 12, 13 PIN 16 IS +10V
 IC11, 12, 13 PIN 8 IS 0V
 IC15, 16 PIN 16 IS +5V
 IC15, 16 PIN 8 IS 0V



ELECTRONIC POKER MACHINE

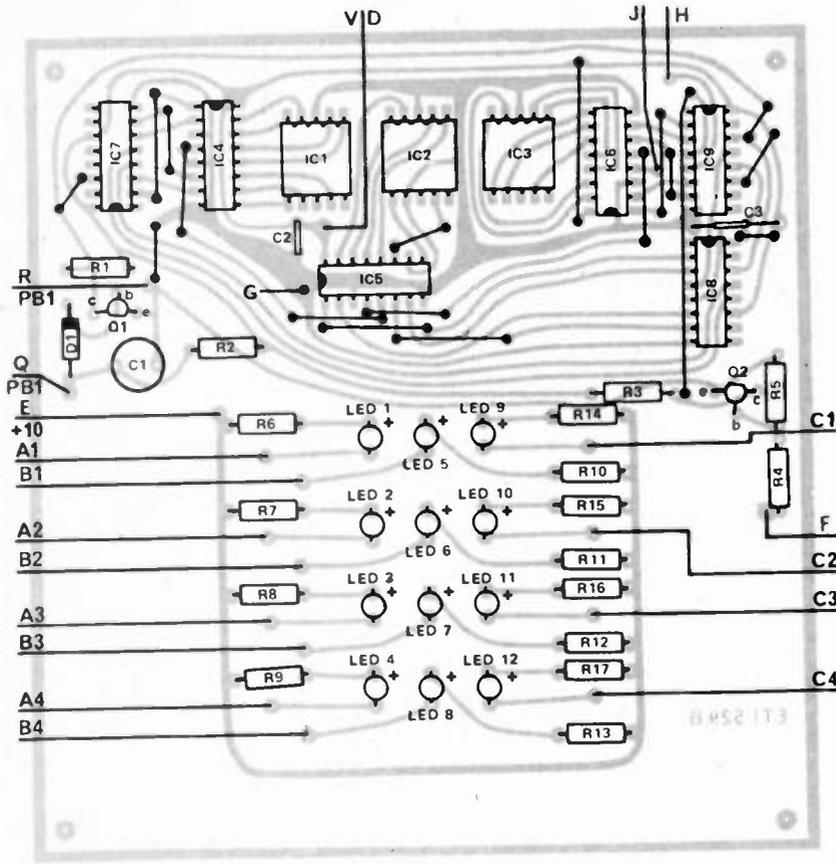


Fig. 3. Component overlay for display board.

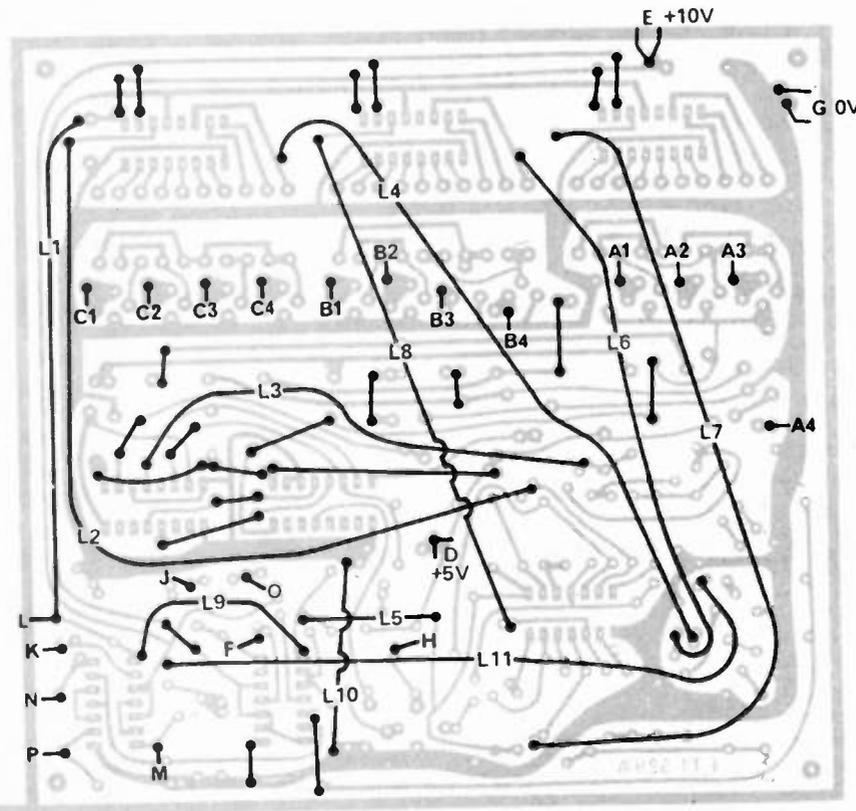


Fig. 4. Linking diagram for the logic board.

PARTS LIST - ETI 529

R106	Resistor	33 ohm	1W 5%
R6-R7	"	820 ohm	1/4W 5%
R86,98	"	2k7	" "
R28	"	3k3	" "
R5	"	3k9	" "

R78,79	"	4k7	" "
R74,75,76	"	5k6	" "
R99,100	"	6k8	" "
R104,105	"	6k8	" "
R1,3,4	"	10k	" "
R33-R62	"	10k	" "

R82,83,96	"	10k	" "
R97,102,103	"	10k	" "
R63-R73	"	15k	" "
R22,27,32	"	27k	" "

R89,90,91,92	"	27k	" "
R2,18	"	39k	" "
R23,80	"	39k	" "
R29	"	82k	" "
R101	"	120k	" "

R30,31,88	"	220k	" "
R19,24	"	820k	" "
R94,95	"	1 M	" "
R20,21,25	"	2M2	" "
R26,87	"	2M2	" "

R81	"	2M7	" "
R85	"	3M3	" "
R93	"	4M7	" "
R84	"	8M2	" "
R77	"	10M	" "

C16	Capacitor	82pF	Ceramic
C6,9	"	150pF	"
C10,13	"	0.001μF	Polyester
C15	"	0.47μF 16V	electro-

C7	"	0.0068μF	"
C12,14	"	0.022μF	"
C2,3,17,22	"	0.047μF	Ceramic
C4	"	0.082μF	Polyester
C18,21,23	"	0.1μF	Ceramic
C5,8	"	0.68μF 16V	"
C11	"	5.6μF 16V	"
C1	"	100μF 6V	"
C20	"	220μF 16V	"
C19	"	2200μF 25V	"

Q1-Q25	Transistor	BC109, BC549	or similar
IC1,2,3	Integrated Circuit	FND 500	(DISPLAY)
IC4,5,6	"	"	9368
IC7,8,9	"	"	74192
IC10	"	"	3900
IC11,12,13	"	"	4017

IC15,16	"	"	74193
IC14,17	"	"	4001
IC18	"	"	7805

D1,2,3	Diode	IN914 or similar
D4,5	"	EM401 or similar
LED1 - LED12	FLV117	or similar

PB1	Push Button	normally open
PB2	Push Button	1 pole change over
SW1	Switch	see text.
SW2	"	2 pole 240V toggle

T1	Transformer	240V/9V-0.9V @ 1A
		PL 18/20VA or PL1.5-18/20VA
		or similar

PC Boards	ETI 529A, 529B
Metal Box	SF 6, (150 x 150 x 150 mm sloping front)
	8 way tag strip
	3 core flex and plug
	front panel escutcheon
	handle
	nut & bolts
	12mm threaded insulated spacers

ELECTRONIC POKER MACHINE

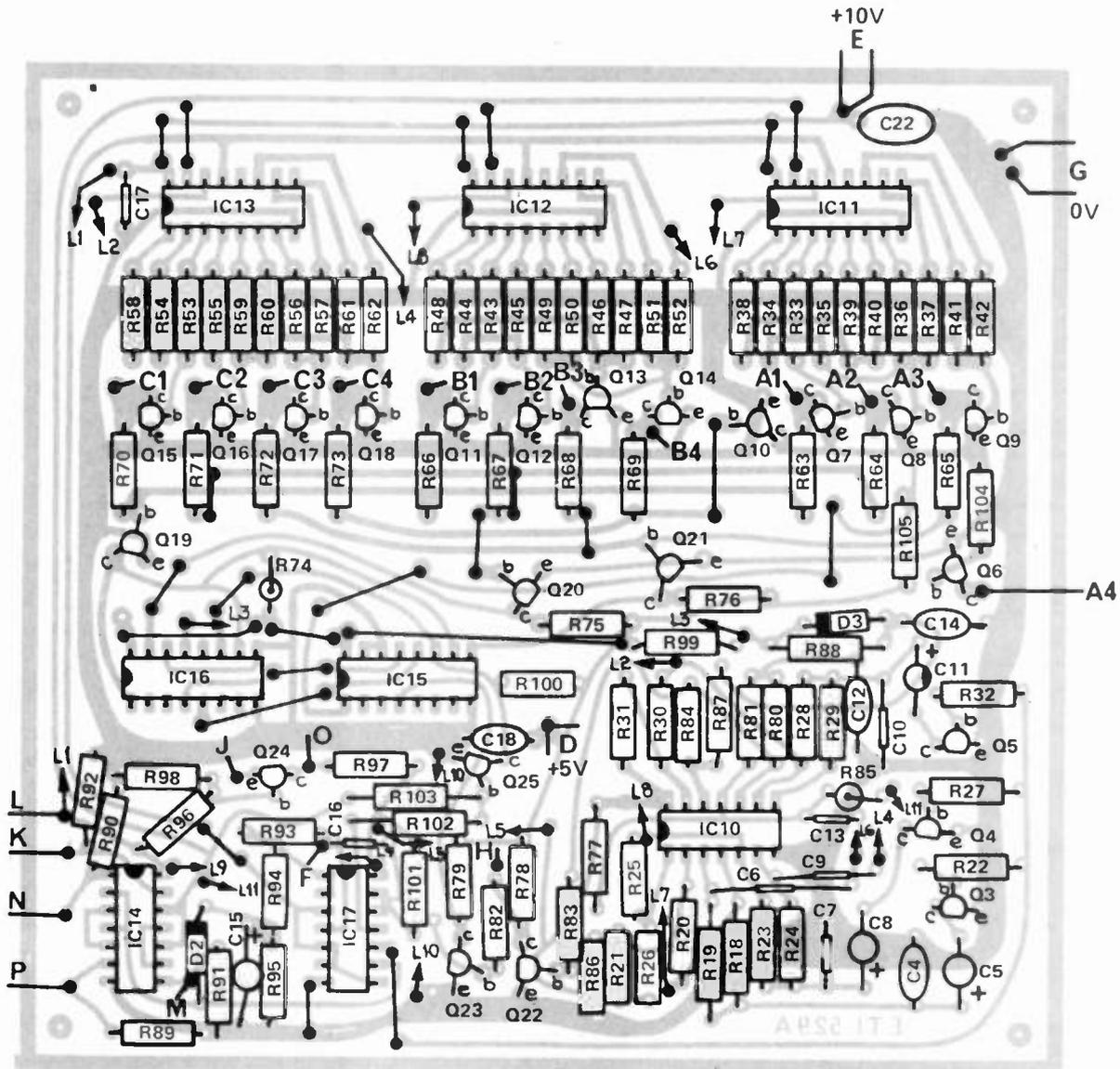


Fig. 5. Component overlay for the logic board.

The play handle may be fashioned from a piece of 6 mm metal rod, formed into an 'L' and fitted with a wooden handle (a file handle is just right). The handle should be passed

through holes drilled in either side of the box and held in position by split pins or small collars and grub screws.

A microswitch may then be mounted such that it is actuated by the grub screw (or end of the split pin) when the arm is pulled forward. A pin and spring should be fitted such that

the handle returns to the upright position when released. The travel of the handle should be restricted by means of two bolts through the side of the case. Rubber grommets may be mounted under the head of the bolt to cushion the end stop.

The 'load' and 'unload' switches may then be mounted on the top of the front panel and the unit interconnected.

Note that, if desired, extra realism may be added by using two microswitches to replace SW2 (the play switch). The first microswitch is operated with the arm fully vertical and the second one with the arm fully forward as before. This means that the arm must be fully depressed and then fully returned for each play. Connection of the microswitches is illustrated in Fig. 9.

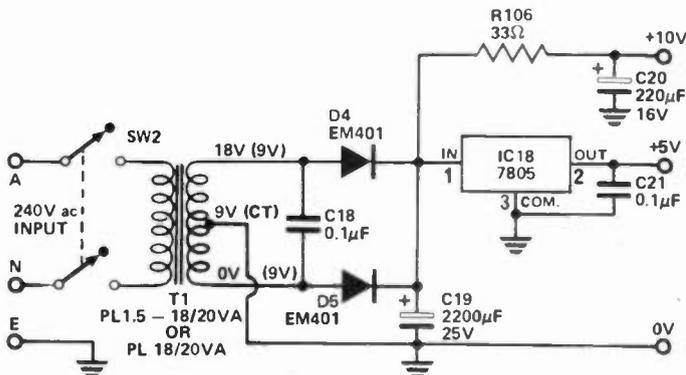


Fig. 6. Circuit diagram of the power supply.

HOW IT WORKS ETI 529

Before reading this section it is advisable to read last month's general description to obtain an understanding of the overall system used.

The roller counters IC11, 12 and 13 are CMOS decade counters and decoders. These counters provide a high output on only one of the ten output lines for each and, when enabled, this high will shift through the outputs at a rate determined by an oscillator (IC 10A, B and C respectively) associated with each counter. The oscillators run continuously but the counters are only enabled when pins 13 are taken low.

The outputs of the roller counters are taken via resistors R33 through R62 to the 'odds decoders' Q7, 8, 9, and 11 through 18. These transistors are wired as resistor/transistor NOR gates. Thus, for example, the collector of Q14 will be low when ever any of IC12 pins 5, 6, 9 or 11 are high. When the collector of Q14 is low the roller indicator LED, connected to B4, will be illuminated.

Note that the emitters of Q7, 8 and 9 are grounded via Q10. Therefore if Q10 is off Q7, 8 and 9 are disabled. Transistor Q10 is off only when Q14 and Q18 are both on, in which case Q6 is also turned on illuminating LED A4.

The four pay conditions are decoded by Q19, 20, 21 and Q10 which are all wired as NOR gates. For example, when a jackpot occurs, pins 3 on IC11, 12 and 13 all will be high causing Q7, 11 and 15 to conduct. Hence Q19 base will be at ground potential and its collector at +5 volts. This high will be transferred to the payout counters IC15 and 16. These ICs are up/down binary counters which can be preset to any desired count by applying a four line code to pins 1, 9, 10 and 15. Pin 15, 1, 10 and 9 have weights of 1, 2, 4 and 8 respectively on IC15 and, as IC15 drives IC16, will have weights of 16,

32, 64 and 128 on IC16.

Returning now to our jackpot conditions, the high from Q19 will appear at pin 10 of IC15 (weight 4) and pins 1 and 10 of IC16 (weight 32 and 64 respectively). Hence the counter will be loaded with $64 + 32 + 4 = 100$. When the counters are not at zero the 'borrow' output pin 13 will be high. This high is delayed by R88 and C14 and passed to oscillator 4 (IC 10d) gating it on. A train of positive going pulses is generated which is inverted by Q22 and passed, via terminal H, to pin 5 of IC9 thus incrementing the display counter. At the same time IC15 and 16 are also decremented by the same pulse train via Q23. When IC15 and 16 reach zero the borrow output goes low stopping oscillator 4. Diode D3 discharges C14 rapidly ensuring no delay in switch off.

The switch-on delay allows time for the counters to be loaded before the oscillator starts - hence ensuring an accurate count. By this means the count loaded into IC15 and 16 is loaded into the display counters and simply adds to any count already displayed.

If no prize is decoded by Q10, 19, 20 and 21 zero will be loaded into the pay out counter and oscillator four will not be started.

THE PLAY SEQUENCE

The play switch SW1, and the load button, PB1, are both shown in the non-operated position. Both switches are connected to RS flip-flops (IC14) which eliminate any contact bounce.

When the handle is pulled SW1 sets the output of IC14-1 'high' charging C16 to 10 volts. This causes the output of IC17-1 to go 'low' and this low enables roller-counters IC11, 12 and 13. The same low gives a high at the output of IC17-2.

When the handle is released the IC14 latch resets and, as C15 discharges only slowly through R95, both inputs to IC17-3 will be low.

Transistors Q3, 4 and 5 will therefore turn on switching capacitors C5, 8 and 11 in parallel with C4, 7 and 10 respectively. The oscillators 1, 2 and 3 therefore slow from 20 kHz, 2 kHz and 200 cycles respectively and continue at a much slower speed. This slow speed operation is maintained to give the appearance of wheels spinning to the roller indication LEDs and has little bearing on the final roller display. This being mainly determined by the period of high speed oscillation that is gated to the roller counters.

After a delay of several seconds C16 discharges to the threshold point of the Schmitt trigger formed by IC17-1 and IC17-2 causing IC17-1 output to go high thus disabling the roller counters IC11, 12 and 13. At the same time the output of IC17-2 goes low triggering the monostable formed by C16, R101 and IC17-4. The output of IC17-4 is a narrow positive pulse which turns on Q25 momentarily, loading IC15 and 16 with whatever is at the input terminals.

The output of IC17-2 also is connected to the down-count of the bank counters via the level translator and inverter Q2. Thus at the time the rollers stop one is also subtracted from the display. If a prize has been won this will immediately be added to the display and the one deduction will not be seen but still occurs.

Should the display counters all be at zero, after this pulse, the display decoders IC4, 5 and 6 will detect the all zero condition (by the leading edge zero suppression feature of IC6) and ground the emitter of Q24. Transistor Q24 will therefore conduct and ground the +10 volt supply to SW1 inhibiting any further play.

To restart playing, the load switch PB1 must be pressed. This resets counters IC11, 12 and 13 to the zero position and, since the zero position is also the jackpot position, Q19 will detect a jackpot. Pressing PB1 also

generates a load pulse via R103 which causes 100 to be loaded into the payout counter. Whilst PB1 is pressed oscillator 4 is inhibited via R85. When PB1 is released oscillator 4 starts (because the payout counters are no longer at zero) and 100 counts are added to the display counters.

The three counters of the display section IC7, 8 and 9 are cascaded decade counters providing a maximum count of 999. The output of these counters is decoded to seven segment format by IC4, 5 and 6 to drive the displays (IC1, 2 and 3). On switch-on C1 charges slowly delaying the turn-on of Q1. Until Q1 turns on, IC7, 8 and 9 are held, reset to zero, the delay allowing the payout counters time to settle. To clear the machine pressing the unload button cuts off Q1 thus generating a positive going pulse which clears IC7, 8 and 9.

The power supply is a simple full wave rectifier and capacitor filter the output of which is regulated by IC18 to +5 volts. This IC has thermal cutout and overload protection. Resistor R1 provides an unregulated supply of 10 volts which is smoothed by C20.

The play switch SW1 was described previously as a single pole push button, or microswitch, activated by pulling the handle. A more realistic handle action may be obtained by using two microswitches to replace SW1. The first microswitch is actuated when the handle is at the rest position and the second when the handle is at the end of its forward travel. These switches should be interconnected as shown in Fig. 9, and such connection means that the handle must be pulled all the way forward, and then, all the way back to operate the machine.

THE OSCILLATORS

Oscillators 1, 2, 3 and 4 are based on the LM3900 IC which contains four, identical Norton operational amplifiers. These amplifiers operate a

little differently from conventional devices.

Unlike the conventional op-amp both inputs of the Norton amplifier are about 0.6 volts above ground (one base-emitter junction) and the output is dependant upon the ratio of the currents into the two inputs. That is the output will remain centred if both currents are varied from say $10\mu\text{A}$ to 1 mA providing there is never any differential current between them. However if the current into the negative input is higher than that into the positive, the output will go low and vice versa. The amount of difference in the currents depends on the open-loop gain of the amplifier. We, at the moment, are only concerned with their operation as an oscillator.

Referring to the main circuit diagram and to IC10-1 we can assume that its output is low and C4 is discharged. (Ignore for the moment Q3 and C5). Under these circumstances a current of $4.5\mu\text{A}$ flows into the positive input (10V/R21) and none into the negative input. This causes the output to go to +10 volts. As a result the current into the positive input rises to $9\mu\text{A}$ and C4 begins to charge via R18. As C4 charges R19 passes current into the negative input and when the voltage across C4 reaches about 7.5 volts the current in R19 will equal the current into the positive input thus forcing the output hard low (since the current through R20 is now lost).

The voltage across C4 will now drop and when it reaches about 3.5 volts it falls below the positive input and the output goes high again. This process continues producing square wave oscillation.

There are two ways to stop the oscillator. One is to remove the bias current into the positive input and the other is to swamp this bias current by adding a higher bias current into the negative input. Both these methods are used on oscillator 4.

ELECTRONIC POKER MACHINE

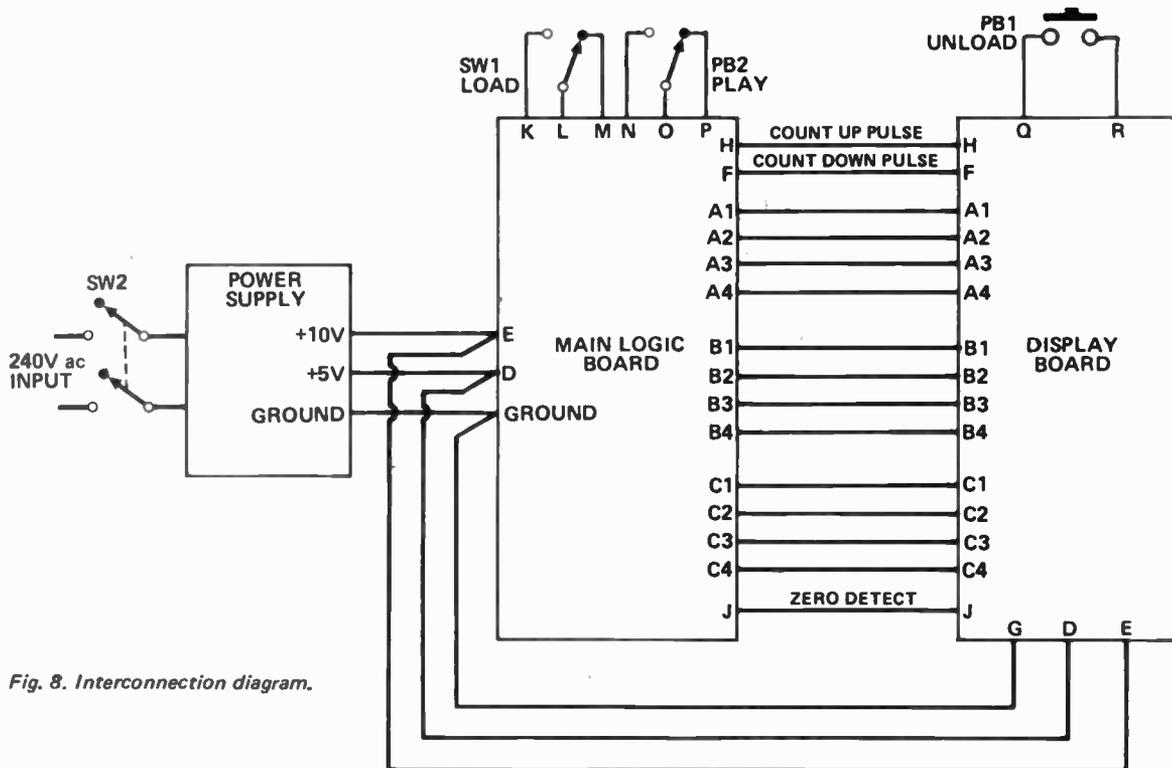
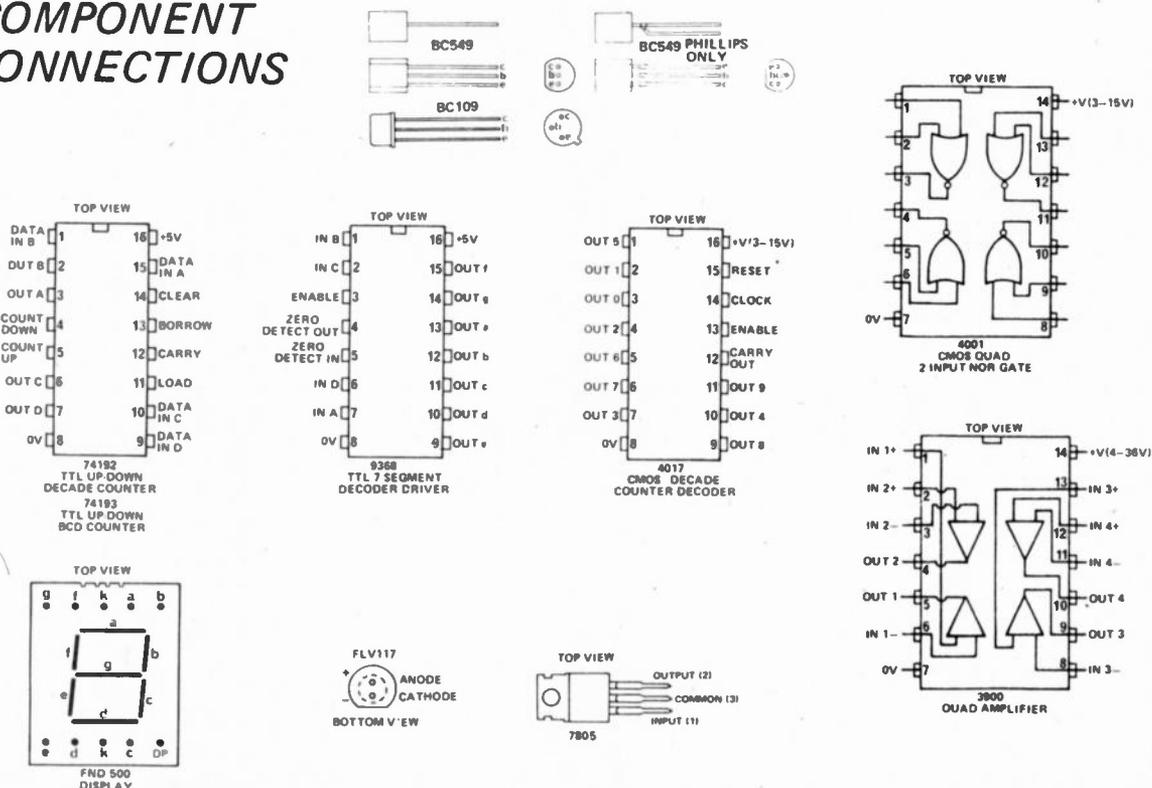


Fig. 8. Interconnection diagram.

COMPONENT CONNECTIONS



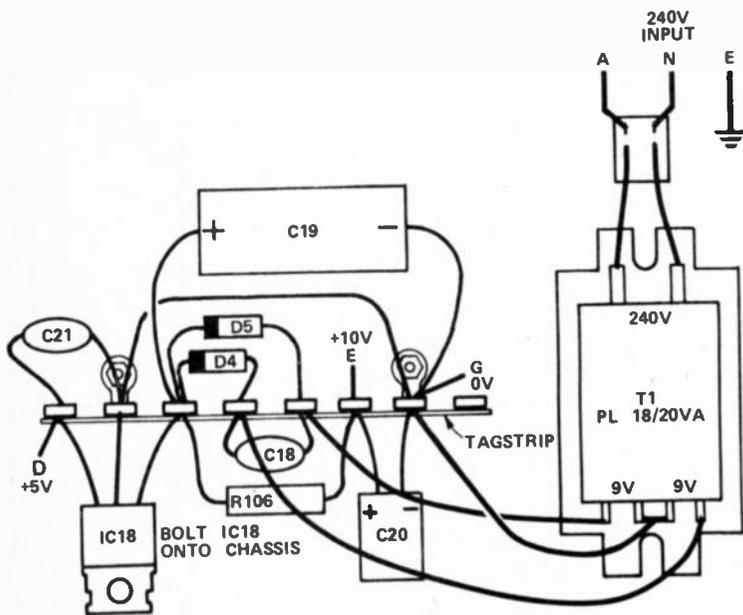


Fig. 7. Wiring of the power supply.

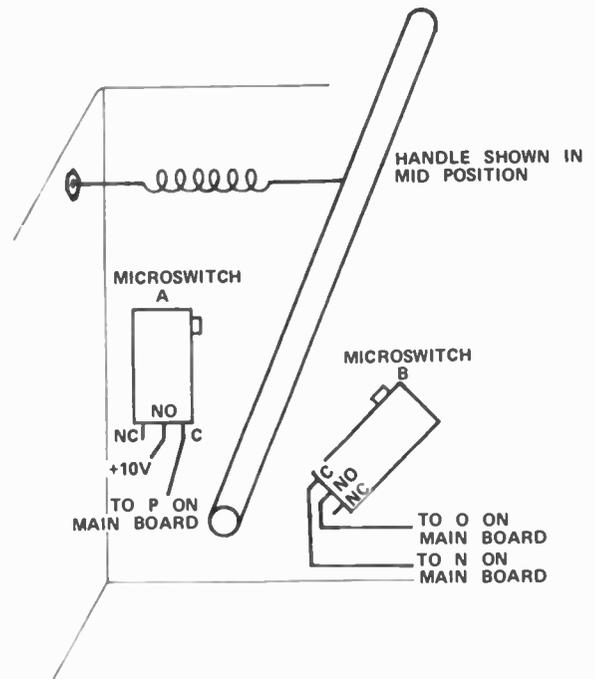


Fig. 9. Alternate arrangement of two microswitches on the play handle.

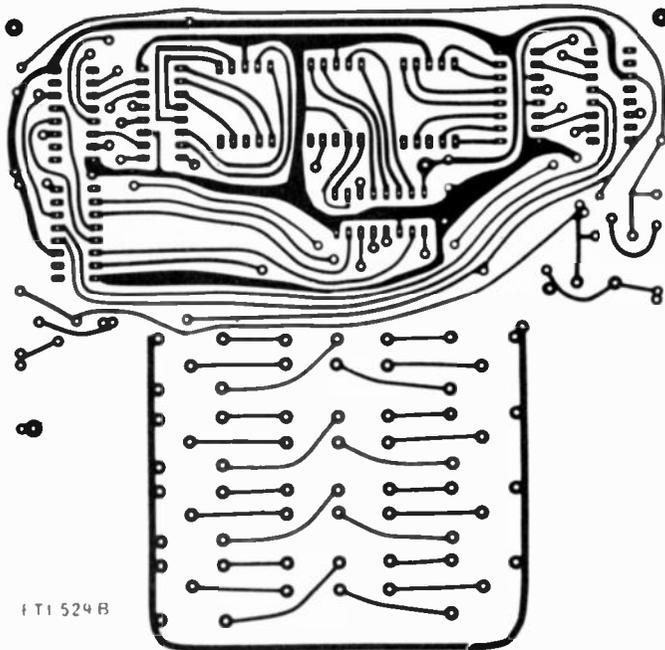


Fig. 10. Printed circuit layout for the main logic board. Full size 147 x 142 mm.

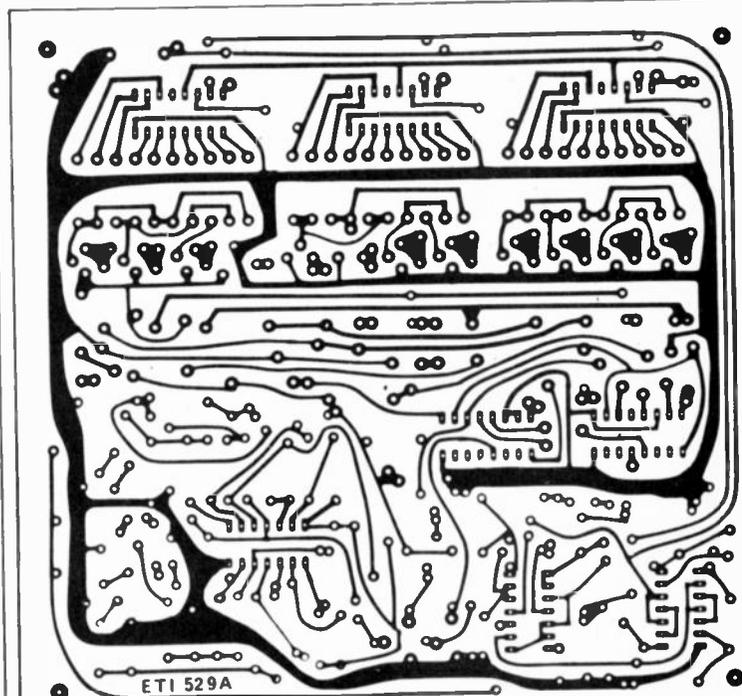


Fig. 11. Printed circuit layout for the display board. Full size 147 x 142 mm.

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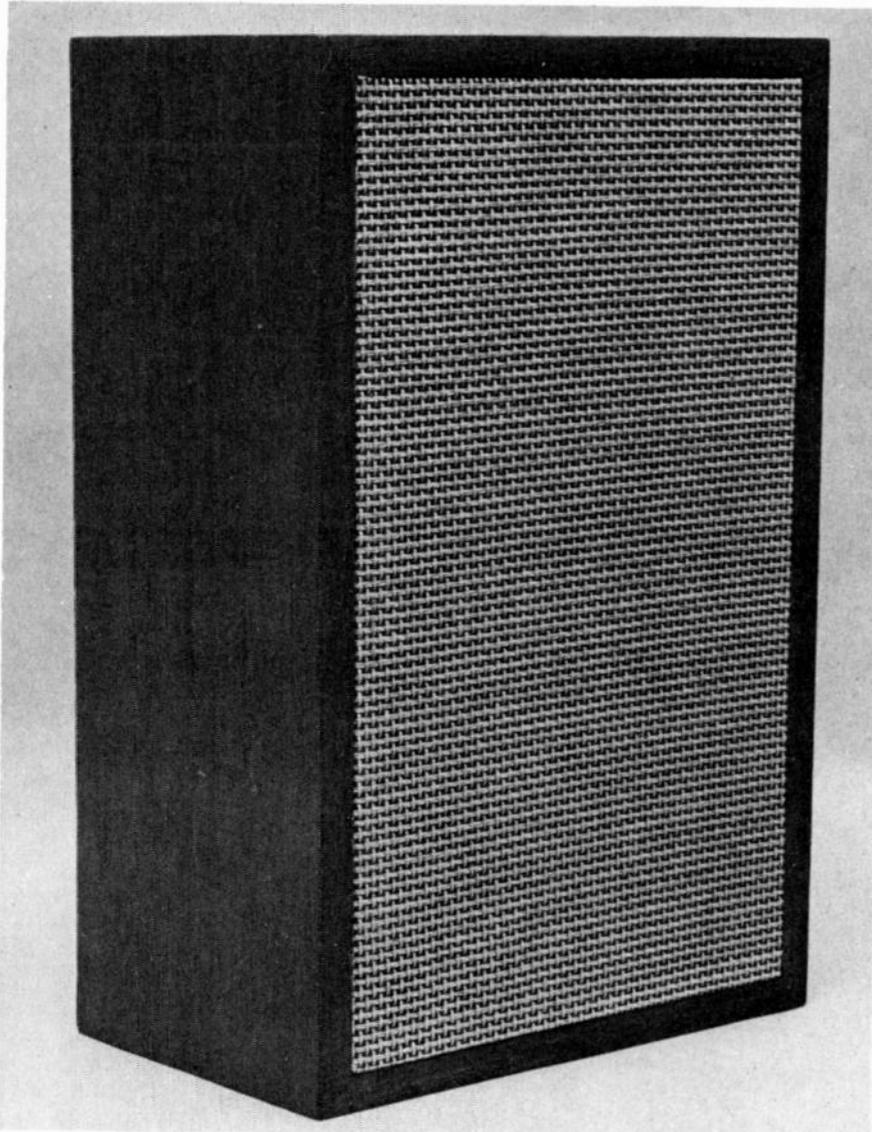
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ETI 400 SPEAKER SYSTEM

Acoustic suspension design has big sound.



EVER since we published our extraordinarily successful Magnavox 8-30 speaker design some three years ago many readers have asked us to design a loudspeaker system that had at least equivalent performance but of smaller overall dimensions.

The design published here will we are sure satisfy the needs of these readers. It is an 'infinite baffle' design based on Philips drive units.

When we first started to investigate this project, we based our prototype on a system described in the Philips Elcoma publication 'High Fidelity

Loudspeakers and Enclosure Designs'.

The Elcoma design is simple and effective but the basic cross-over network does not really do justice to the truly excellent design of the drive units specified. It just is not possible to obtain really top-class performance from a multi-speaker enclosure unless a good cross-over network is used. And a good cross-over network cannot be built cheaply.

Initial experiments showed that truly excellent performance was obtainable using a better cross-over. This being so we concentrated on designing the

The cross-over network described in this article must be used exactly as specified if the intended performance is to be obtained.

A simpler version of this network — or a simple series capacitor — is not 'almost as good'. Suppliers are warned that to market the ETI 400 design in any other than the form specified here is a breach of the Trades Practices Act.

enclosure before finalising the cross-over network described later in this article.

THE ENCLOSURE

The design of an enclosure for an acoustic suspension speaker system is determined by making compromises on three basic quantities:

- (1) The volume of the enclosure.
- (2) The efficiency of the system.
- (3) The low frequency cutoff.

There is no mandatory volume for an acoustic suspension system but tests over hundreds of different systems have shown that the optimum volume for a 200mm (8 inch) driver lies between 14 litres (0.5 cu ft) and 42 litres (1.5 cu ft). The 14 litre enclosure will sacrifice bass response and efficiency but will handle more power whilst the 42 litre enclosure has extended bass response is more efficient but will handle much less power. We opted for a 20 litre (0.7 cu ft) enclosure as the one which offered reasonable bass response and good power handling with the particular driver being used. (This is in contrast to the recently released kit from Philips using the same drivers that has a volume of 15.6 litres — which in our opinion sacrifices bass response for a smaller albeit cheaper enclosure).

The ETI 400 speaker uses the Philips 203 mm (8") bass driver and the 25 mm (1") dome tweeter.

The dome tweeter is known to be more efficient than the bass driver — in fact our measurements showed that this was of the order of 4 dB. We have therefore included a 4 dB resistive attenuator pad before the tweeter to

match it to the woofer. (Philips have specified an 8 dB attenuator for their recently released kit but both measuring and listening tests confirm that 4 dB attenuation is better). The resistor pad has a fortuitous advantage in that it provides extra tweeter damping, considerably improving its sound — especially at the top end where the undamped tweeter (due to crossover impedance) tends to be a little harsh.

The resistive pad and tweeter is fed from C3 and L2 (see Fig. 3) which form a 12 dB per octave high pass filter allowing only frequencies above 2.2 kHz to pass — a 12 dB per octave crossover *must* be used if damage to the tweeter is to be avoided. Some people who built up the Magnavox 8-30 system, previously described in ETI, complained of tweeters burning out. We investigated many of these complaints and found that the problem was caused by using a single capacitor feed to the tweeter rather than the specified network. The Philips tweeter has a pronounced resonance around 900 Hz and if this is not adequately suppressed the tweeter will be damaged by excessive cone excursion at this frequency.

A 12 dB per octave network has also been provided for the woofer and again this should be used if proper mid-range response is to be obtained. Network R1 and C1 provides compensation for the rising impedance of the woofer (with frequency) and effectively keeps the response reasonably level up to the crossover frequency.

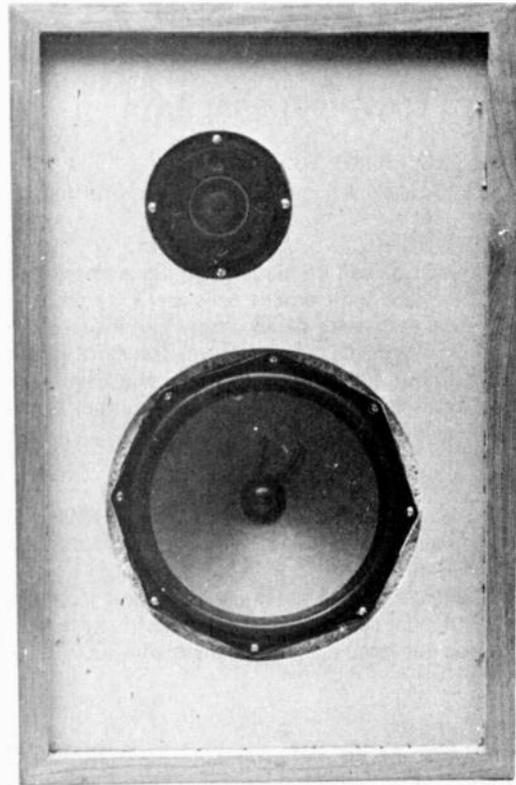
Capacitors C2 and C3 should be polyester types — not non-polarized electrolytics! However C1 may be a non-polarized electrolytic if desired.

The coils should be of air wound construction (see winding details) and *not* of the iron cored variety. Iron cored coils tend to saturate at high levels, producing a very nasty kind of distortion similar to amplifier clipping.

Resistors R2 and R3 may be constructed from jug element as follows. Measure out a length of jug element having the required resistance and wind it around the body of a 1 watt resistor (any value above 100 ohms) soldering one end to each of the resistor leads. The wire may be fixed in position on the resistor by a little 5 minute epoxy.

Note that the tweeter is connected out-of-phase. This is necessary due to phase shifts in the crossover. Conventional connection results in a deep hole in the response at about 3 to 4 kHz in addition to a 10 dB peak at around 2 kHz!

The coils may be hand wound, in accordance with Table I, on the former shown in Fig. 4.



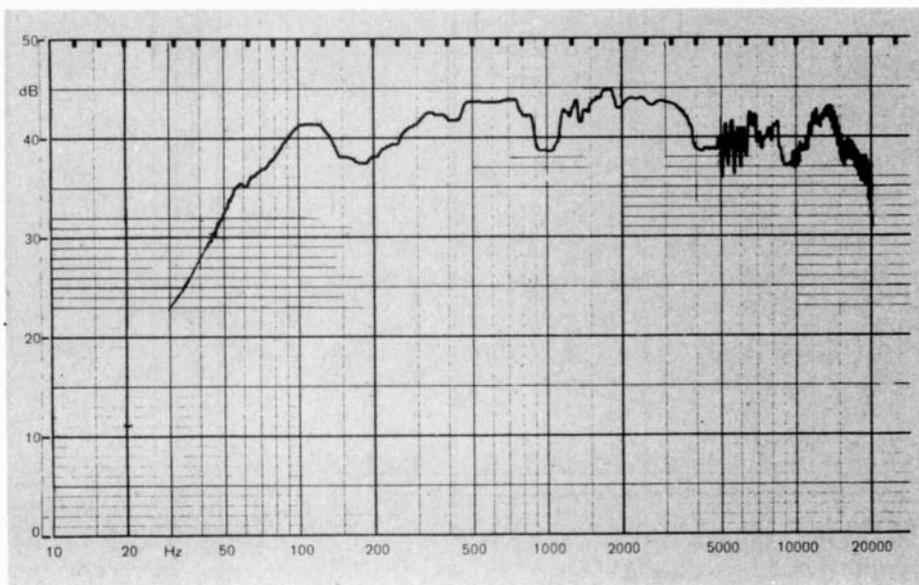
The completed speaker before front panel is painted or grille cloth fitted.

We must emphasize again that the crossover is the heart of any good speaker design. The circuit as described for the ETI 400 *must* be used if good results are to be obtained.

CONSTRUCTION

Dimensions of the enclosure and its assembly are illustrated in Figs. 1 and 2. Note that 19 mm square cleats should be glued into all corners. It is absolutely essential that all joints be airtight, for, if the enclosure leaks at all, the air rushing in and out will produce hissing sounds and the bass response will be seriously degraded.

Note that we used veneered pine-board for our prototypes and hence the drawings show mitred joints at the corners. If such joints are beyond your woodworking capability it may be well to use plain, unveneered pineboard and butt joints. The whole box may then be covered with iron-on veneer or with self-adhesive vinyl. Self-adhesive veneer or vinyl does not adhere too well to plain pine-board and tends to lift or bubble after some time. We found that adhesion could be improved by applying one coat of clear lacquer to the pine-board before veneering. This has the effect of



Frequency response of the ET1400 speaker system.

ETI 400 SPEAKER SYSTEM

TABLE 1 CONSTRUCTIONAL DATA

CHOKES 0.8 mH, L1 & L2

170 turns of 1 mm (18 B & S) on former shown in Fig. 4.

RESISTORS

Resistors can be made from jug element as follows. Standard jug element coils are 300 mm long and have a total resistance of 38 ohms. Therefore a 25 mm length (unstretched) will have a resistance of 3 ohms, and a 120 mm length (unstretched) will have a resistance of 15 ohms. That is use 8 mm of coil per ohm of resistance required.

CUTTING

Two speakers can be cut from one 1800 x 900 mm sheet of veneered pine board (including front and back panels if required).

Alternatively 4 speakers can be cut from one 1800 x 900 mm sheet of veneered pine board if the fronts and backs are cut from a separate sheet of 1800 x 900 mm plain pine board.

CAPACITORS

Any value of polyester capacitor between 5.6 and 6.8 μF can be used for C2 and C3 if difficulty is experienced in obtaining the correct value. Both must be the same value. Such change will shift the crossover frequency slightly but will not have other serious effects.

sealing and strengthening the pine-board surface thus preventing veneer lift due to break-up of the pine-board surface.

When the box is completed paint the front panel matt black and finish the veneer surface as desired — a Scandinavian oil finish is easy to apply and very attractive.

Mount the input terminals to the back panel, the crossover network to the inside of the back panel and connect the terminals to the crossover. Attach leads to the crossover for the woofer and tweeter and drape these leads out through the respective driver holes.

Now line the box on all sides (except the front) with 50mm glass wool. Connect the leads to the drivers (watch polarities) and mount the drivers in position using plasticine or sealing putty around the rim of each driver to ensure an airtight fit.

Make the grille-cloth frame from 12mm square timber and attach the grille cloth by stretching it around the frame and then stapling it at the rear. If a stapler is not available the cloth may be glued on.

The speakers will safely handle 40 watts RMS. Although decidedly not recommended, our lab staff fed them with music peaking to 200 watts. Apart from our production department (located next door to the lab) stopping work no difficulty was encountered in handling this level. We therefore consider that the system is entirely safe with amplifiers which deliver 40 watts RMS per channel. ●

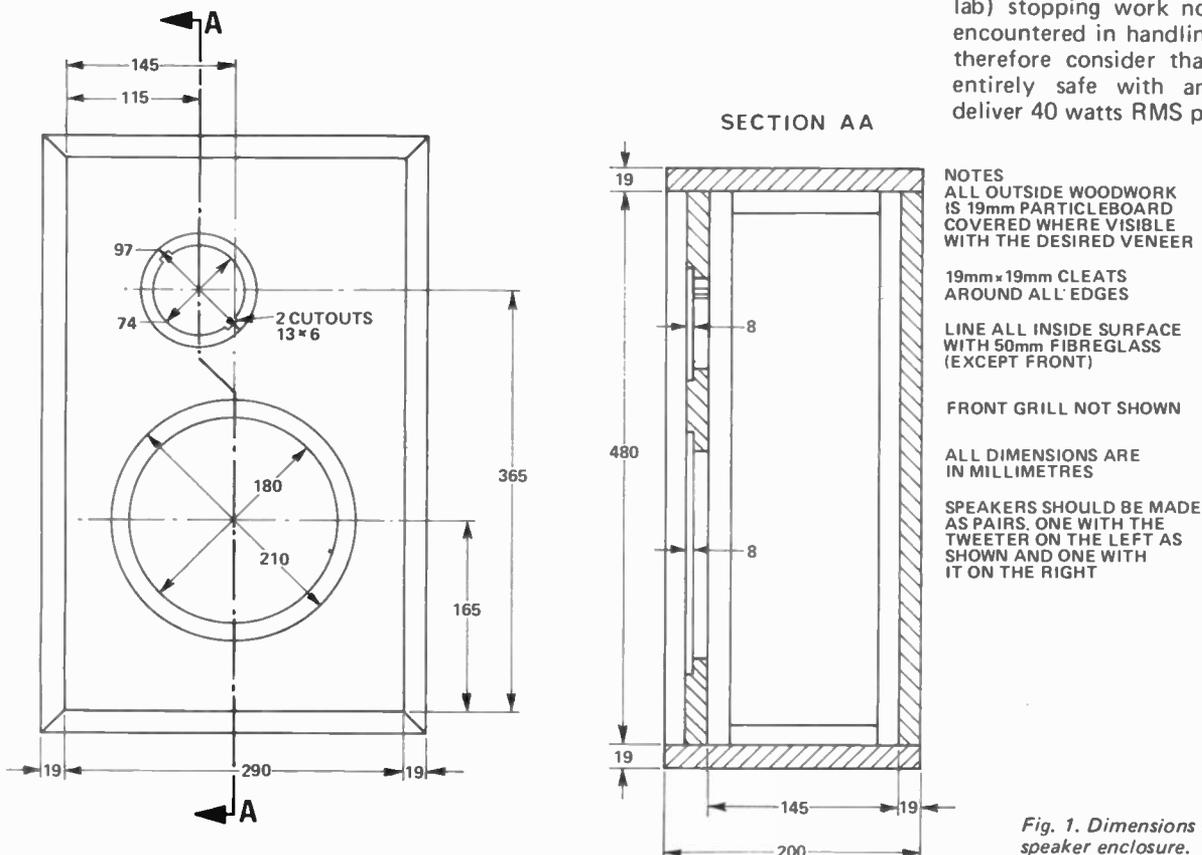


Fig. 1. Dimensions of the ETI 400 speaker enclosure.

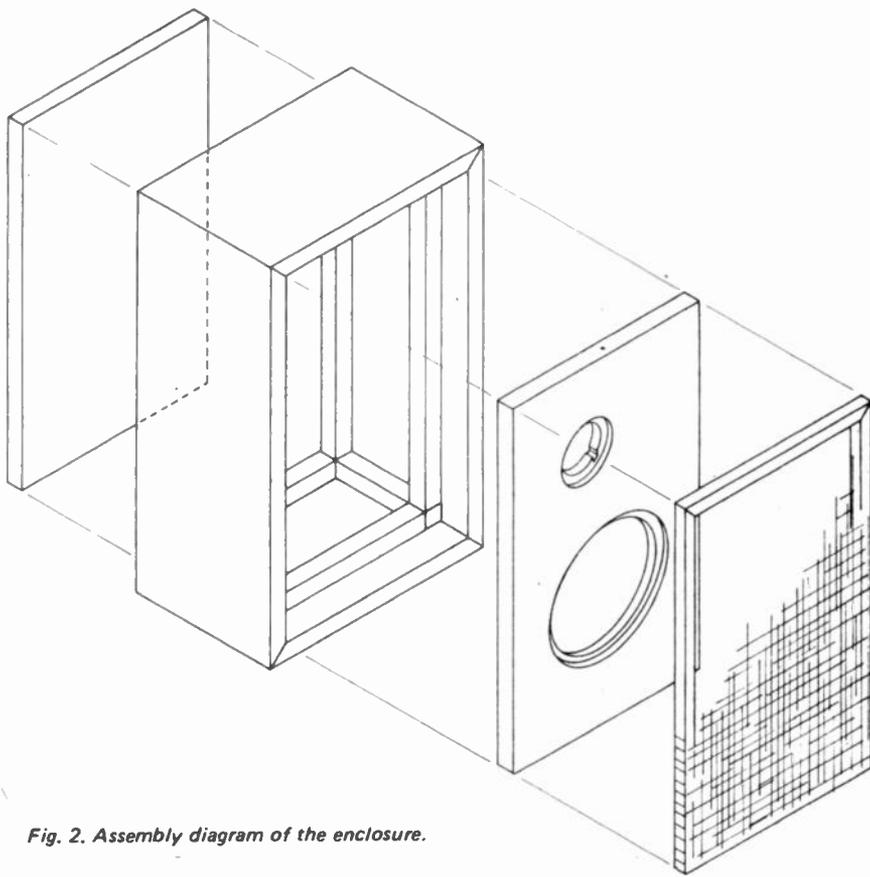


Fig. 2. Assembly diagram of the enclosure.

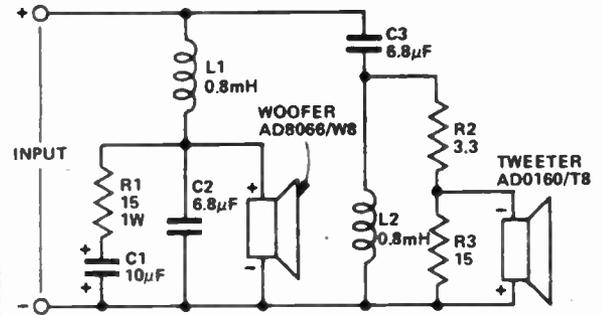


Fig. 3. Circuit diagram of the crossover network. This is the heart of the system and must not be changed if best results are to be obtained.

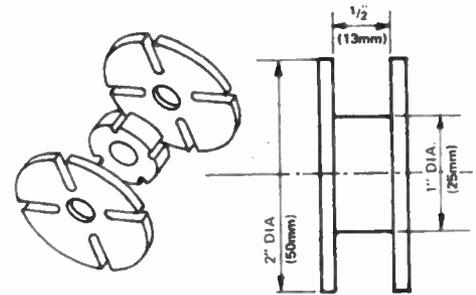


Fig. 4. Former for winding chokes L1 and L2. Chokes may readily be wound by hand, try and keep wire in uniform layers but a little jumbling will not appreciably affect the final value of inductance.

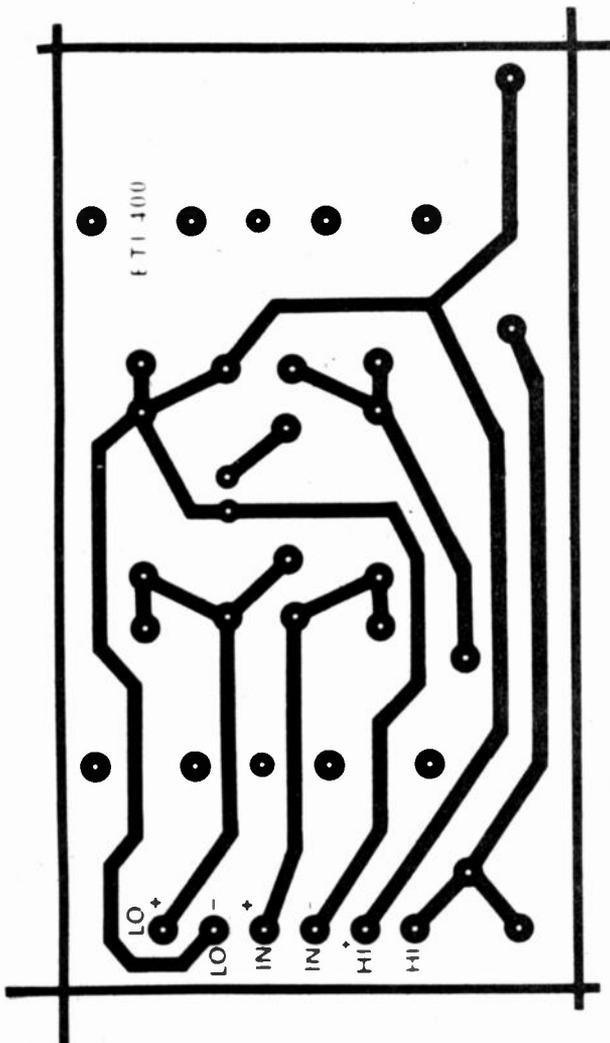


Fig. 5. Printed circuit layout for the crossover network. Full size 145 x 78 mm.

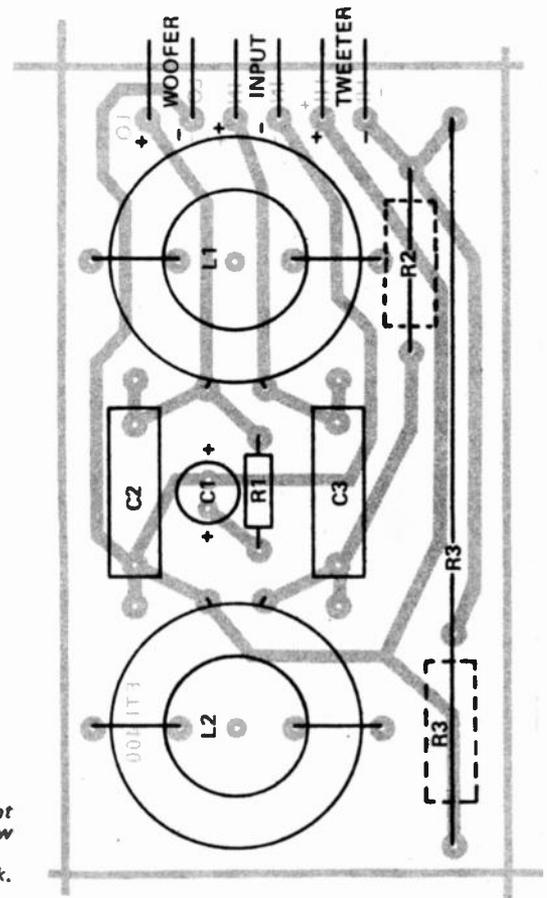


Fig. 6. Component overlay shows how to assemble the crossover network.

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This is the standard broadcast band.
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- ★ **FM**
88-108 MHz covers TV channels plus the new Frequency Modulated radio service
- ★ **TV2**
covers all the hi band TV channels.
- ★ **Air**
103-136 MHz covers AM aircraft bands, automatic weather and landing information aircraft approach and departure instructions, aircraft to aircraft communications, VOR etc. In fact listen to all the aircraft from International Jumbos to trainers. Hear all the instructions from the control tower.
- ★ **PB**
135-174 MHz starts with the 2 metre amateur band covering both mobiles and repeaters etc. Then the International marine band, harbour control, tugs, ocean liners coming into port, distress frequencies etc. HI band VHF covers ambulance, fire brigade, police, business, paging, 2 way car radio, radio doctor, taxis, TV service, road patrols, councils and many many more.

Warning Do not confuse with similar looking receivers with only limited coverage.

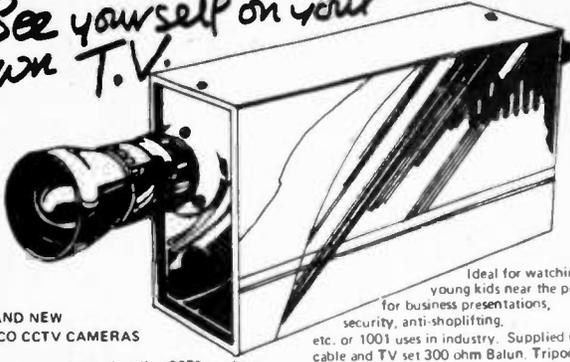
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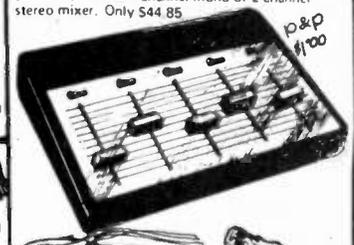


BIG DICK POWER SUPPLY

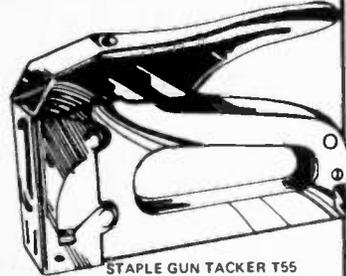
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29.75 p&p \$1.00

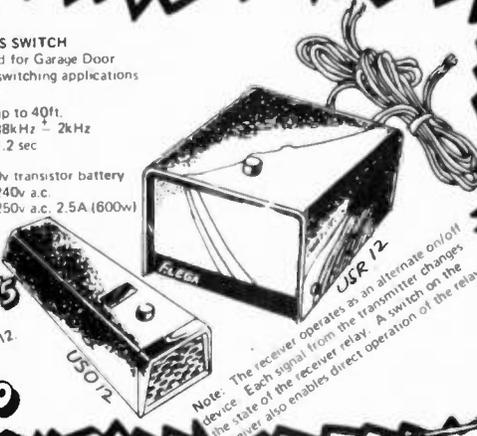
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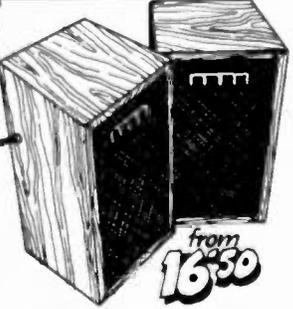
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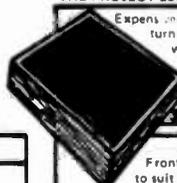
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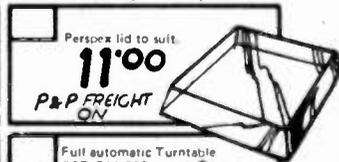


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CERAMIC CARTRIDGE PREAMPLIFIER

Use of charge amplifier improves performance of ceramic cartridges.

MOST amplifiers of commercial design, including our own ETI designs, omit facilities for ceramic cartridges and allow only for the use of magnetic cartridges. This is because magnetic cartridges are capable of much better performance than ceramic although top line magnetics are much more expensive.

Magnetic cartridges are expensive to build whereas ceramic cartridges are relatively cheap to build so there is a crossover point, and many top line ceramic cartridges are much better value-for-money than are magnetic cartridges in the same price range. Hence many people with limited funds have asked for details of a preamplifier input stage specifically tailored for use with ceramic cartridges.

The two types of cartridge, ceramic and magnetic are entirely different in terms of electrical qualities. The ceramic cartridge has a much higher output, the working load impedances of the two are entirely different and the magnetic type requires equalization whereas the ceramic type does not (or does it?). The magnetic provides an output which is proportional to stylus velocity whilst the ceramic provides an output proportional to acceleration. This means that where a record is recorded with constant acceleration characteristic the output from a ceramic cartridge would be flat with frequency whereas the output from a magnetic cartridge would be a response rising with frequency at 6 dB/octave. Conversely if a constant velocity record characteristic were used the ceramic output would fall with frequency at 6 dB/octave.

Today all records are recorded to the RIAA standard of equalization. This attenuates bass and boosts treble to provide a characteristic very close to constant acceleration. This procedure gives best compromise between the conflicting requirements signal-to-noise ratio and of pickup trackability. To replay an RIAA equalized record with a magnetic cartridge we must use a preamplifier having the reverse characteristic, i.e., bass must be boosted and treble must be cut in order to obtain a flat frequency response. This process is

used on all preamplifiers for magnetic cartridges and is loosely just known as equalization.

However a *perfect* ceramic cartridge, when replaying RIAA equalized material would give an unequalized response as shown in Fig. 1. In order to make ceramic cartridges easier to use manufacturers build in a broad mechanical resonance at the high frequency end to boost the response. At the low end, the rise in response below 50 Hz is cured by selecting a terminating impedance which causes a roll off at about 130 Hz. The response of such a cartridge would be as shown in Fig. 2. If the bass end were not

corrected rumble of the turntable would be accentuated and this is clearly not desirable.

Thus clearly, the impedance into which a ceramic cartridge works is of great importance and with this in mind we investigated different methods of matching the cartridge to the amplifier with a view to obtaining the utmost from ceramic cartridges.

DESIGN APPROACH

The ceramic pickup may be simulated by a voltage source and a series capacitor.

The value of the capacitor and the magnitude of the voltage source vary

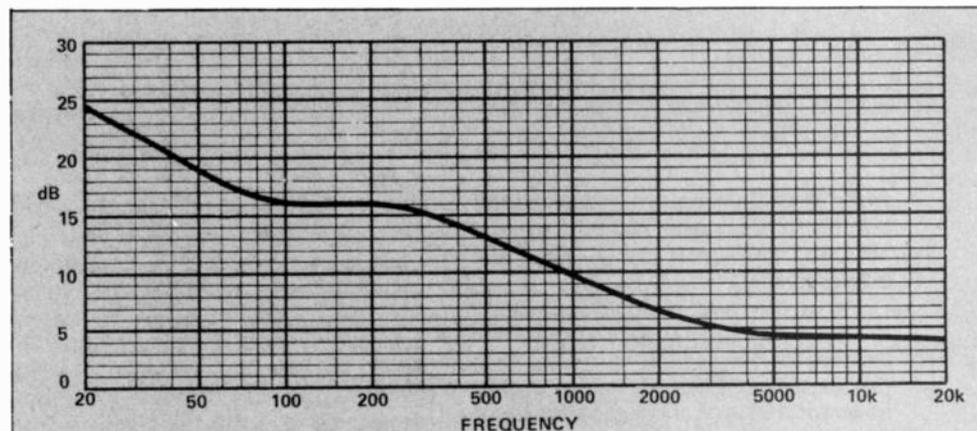


Fig. 1. Typical response of a ceramic pickup without mechanical equalization.

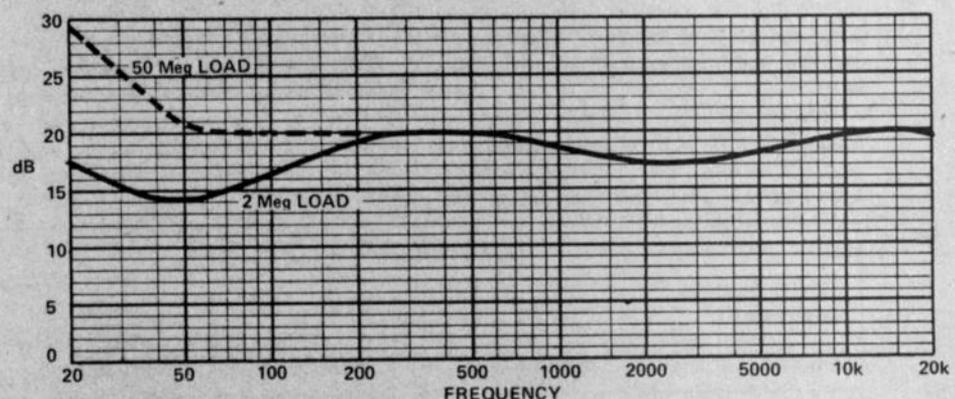


Fig. 2. Response of Decca Deram showing effect of terminating impedance at low end and of mechanical equalization at top end.

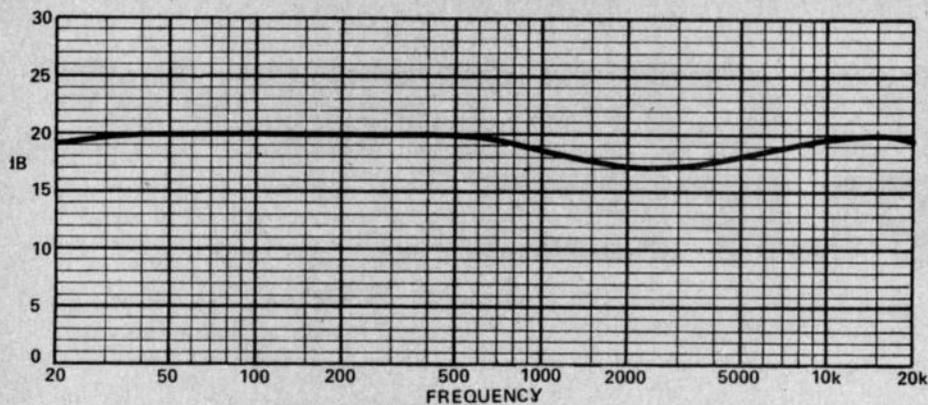


Fig. 3. Overall response of a Decca Deram into a charge amplifier.

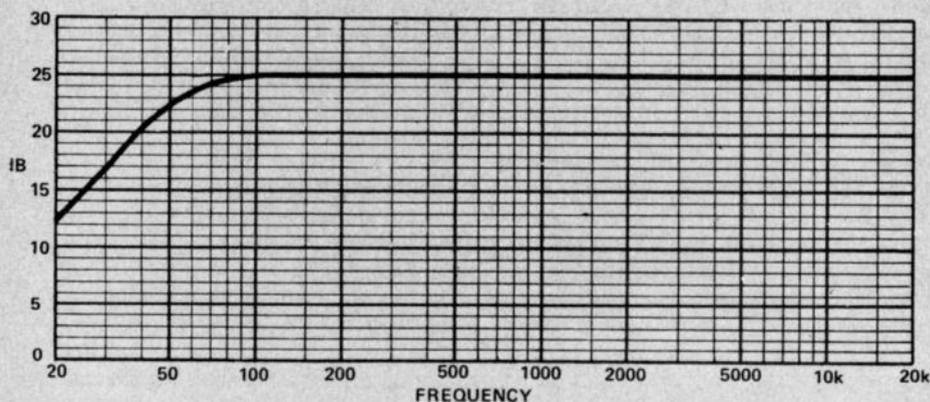


Fig. 4. Response of charge amplifier. Roll off at low end is designed to compensate for rising response of cartridge in this area.

from manufacturer to manufacturer but lie in the range 200-900 pF and 100 to 1000 mV at 1 kHz and 5cms/second.

One of the most popular and readily available cartridges is the Decca Deram and we performed all our tests with this cartridge. The unit has an output of about 150 mV and a capacitance of 600 pF. The recommended load impedance is 2 megohms and this gives the response as shown in Fig. 2. The bass response can be improved but only at the expense of greatly increasing the rumble. The dip at 2 kHz can readily be compensated for but we have not experimented in this area.

Another system commonly used is to load the unit with a low impedance (e.g. 75 k ohm) which causes a loss of bass below 3 kHz, and then boost the

bass again electronically. This overcomes the need for a very high impedance. Such a technique combined with a rumble filter to cut the rising response below 50 Hz can give good results. However due to the large differences between various makes a different network needs to be designed to suit the bass roll-off characteristic of each cartridge type.

A third system which we propose, and to our knowledge this is the first time such a system has been described, is to use a "charge" amplifier.

CHARGE AMPLIFIER

With the charge amplifier the input impedance is zero — how then does it work? A conventional inverting amplifier is shown in Fig. 5. and, as anyone familiar with amplifiers will know, the output voltage will be:—

TABLE 1			
GAIN (600 pF cartridge)	C2	C3	R4
unity	560 pF	0.0082μF	390 k
6 dB	330 pF	0.015μF	180 k
12 dB	150 pF	0.039μF	47 k

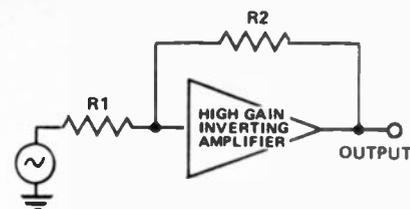


Fig. 5. Conventional inverting amplifier stage.

$$V_{out} = \frac{R2}{R1} \cdot V_{in}$$

What is not always realized by beginners is that R1 and R2 need not be resistive — they may be capacitors, inductors or combination of impedances. It is only the impedance that is important. Since the output of the ceramic pickup is a capacitor we may connect it directly to the input of an inverting amplifier and use a capacitor as the feedback element. The gain of the stage now becomes the ratio of the two capacitor impedances. Although the impedance of the capacitor drops with increasing frequency the ratio remains constant. Therefore, with a 'perfect' amplifier, the frequency response is flat at all frequencies.

In real circuits we generally need a bias resistor across the feedback capacitor. This causes a roll-off at the low end similar to that obtained when using a FET amplifier.

If a response down to 10 Hz is required a resistance of 50 megohm minimum is required. However this is

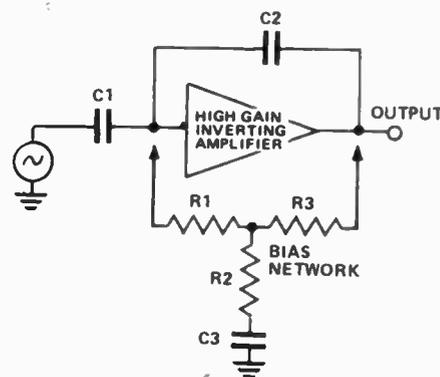


Fig. 6. Basic charge amplifier with bias and filter network. Gain control elements are capacitors. Bias network R1, 2, 3 and C3 are required for dc stability and to roll off of bass response.

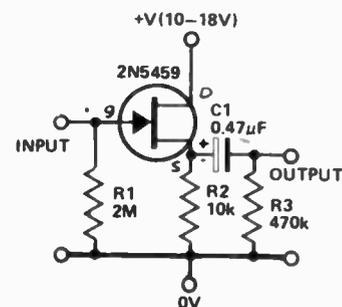


Fig. 7. Circuit of FET follower used to obtain the responses shown in Fig. 2.

much too high for correct biasing and a different technique is called for.

With the arrangement illustrated in Fig. 6, the effective resistance is:—

$$R_{\text{eff}} = \frac{R_2 + R_3}{R_2} \cdot R_1$$

provided $R_2 \ll R_1, 3$ and $X_{C_3} \ll R_2$

If the value of X_{C_3} approaches R_2 the effective resistance drops and, if the value of R_2 and C_3 are properly chosen, a 12 dB/octave cut-off at the low end can be obtained which effectively removes the rising low-end response due to the recording characteristic.

Other advantages of the charge amplifier are firstly that it is easy to obtain gain (unlike the source — follower FET approach) and secondly that cable capacitance does not affect the performance in any way. One disadvantage is that the cables are slightly microphonic and movement of the leads can cause an output — this however is not an insurmountable problem.

The overall response of the Decca Deram Cartridge into a charge amplifier is given in Fig. 3, and as can be seen the response at the low end is greatly improved. As said before the drop around 2 kHz could readily be

compensated for but this was not considered necessary.

If a pickup having a different capacitance were to be used the only change would be in the gain of the amplifier — the frequency response (of the amplifier) remains the same. If the gain is too high then simply changing the feedback capacitor to a higher value will restore it. However, if the low frequency cut-off is to be maintained both R_4 and C_3 must also be altered. Table 1 illustrates the values required.

CONCLUSION

Cost for cost the ceramic cartridge is better value for money than the magnetic type. The use of a properly designed preamplifier can produce a substantially flat response.

However whilst an almost perfect frequency response can be obtained by properly processing the output from a cartridge like the Decca Deram it can never sound like the Shure V15 MK 3! Other factors such as transient response and channel separation are generally not as good as those of a magnetic cartridge. Whether the inbuilt mechanical resonance is actually responsible for the poor transient response is probably known only to the cartridge manufacturers —

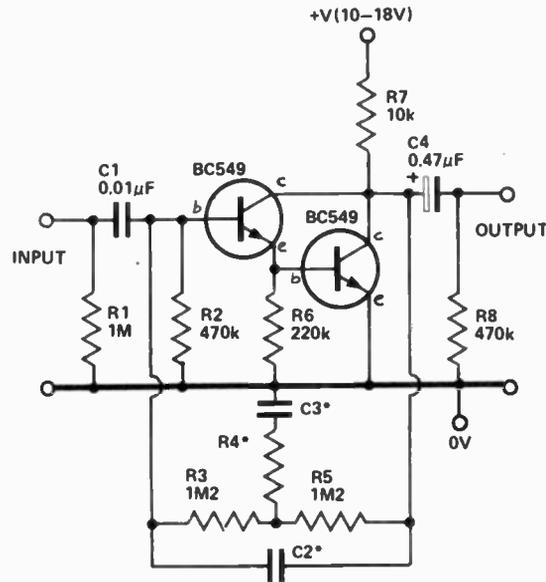


Fig. 8. Circuit of practical charge amplifier for ceramic cartridges which gave the overall response as in Fig. 4. For values of $C_2, 3$ and R_4 see table 1.

one feels that if it were done electronically it may well be better.

This has not been presented as a normal project but rather as a basis for experimentation. The circuit described has been built up and does give the response expected. Try it. The results may be surprising.



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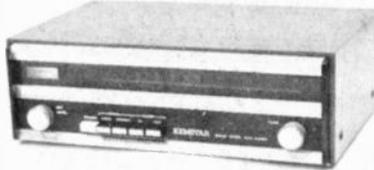
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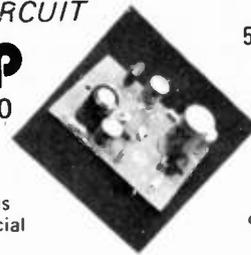
Stereo Amplifiers, Tuner/Amplifiers, Record Players, Belt-Drive Turntables, Stereo Cassette Decks, Speaker Systems, Leads and Connectors, Stereo Headphones, Car Radio, Cartridge and Cassette Players, AM Radio Cassettes, Digital Clock Radios. etc. etc.

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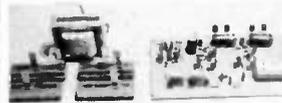
mini-amp

with TBA-810

As featured in the January edition of "EA", this latest solid state IC amplifier is available ex stock at special introductory prices.



6.5W in, 4Ω at 16V
5.5W in 4Ω at 14.4V
2.3W in 4Ω at 9V
1W in 4Ω at 6V
MONO KIT \$6.20
IC only \$5.50
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Stereo kit complete with mag input and bass/treble, incl. chassis, transformer, slider controls etc. \$29.00 P/P \$2



2 mini-amps

WITH TONE CONTROLS AND POWER SUPPLY - in kit form. 6W/CH Stereo Amplifier.

Great Value **\$29.00**
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Features 2 TBA-810 Mini-Amps, plus IC Pre-Amplifier with all tone controls (bass, treble etc). Suit magnetic cartridge, includes transformer, chassis, instructions. Amazing performance, easy-to-build.

2 SPECIAL OFFERS FOR JUNE

Expo 3 Piece MODULAR STEREO

AM/FM/FM STEREO

\$169 P&P \$7.50



We made a special purchase of these compact systems. Walnut wood-grain finish, de-luxe amplifier, 5W per channel with slider controls, loudness switch, headphone and tape and auxiliary input sockets, all combined with AM/FM radio with inbuilt FM stereo decoder and AFC (auto frequency control), BSR auto record changer with cueing device plus 2 matching full range speakers. Fully guaranteed in original cartons. Normally around \$212.00 Save \$43 this month only.



36W AMPLIFIER

DIAMOND 2000 STEREO

- 10W per channel in 8 ohms.
- 20 Hz - 40 kHz frequency response.
- Signal-to-noise - better than 50 dB.
- A or B speaker switching.
- Walnut woodgrain cabinet.

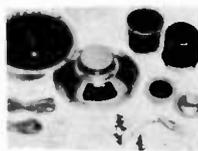
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SEE OUR RANGE OF QUALITY CABINET KITS



CORAL 8 \$17.50

From one of Japan's leading makers, the model 8SA-1 Kit is an 8 inch 3 way 3 speaker system with capacitive crossover and capable of 70Hz to 20KHz response in recommended cabinets. Power rating 35W peak, 17.5W average, sensitivity 93 dB, crossover frequencies 4KHz, 9KHz, impedance 8 ohms. Complete to the last detail with wire, screws, terminals, cabinet instructions and badge. Speakers: 8" woofer, 4" mid-range, 2 1/2" tweeter. Easily assembled and good value for money

Post/Package \$2.00 each **\$17.50**

CORAL 10 \$27.50

A fine 10" 3 way speaker system from Coral Audio Corporation (10SA-1), capable of 50W peak, 25W average power, and wide 40Hz - 20KHz frequency response. The capacitive type crossover network operates at 2KHz, 6KHz for smooth response and distinctive performance from each speaker individually. Comprises 10" free-edge woofer, 5" mid-range and 2 1/2" tweeter, plus all accessories. Comprehensive instructions are provided. Impedance 8 ohms.

Post/Package \$2.00 each. **\$27.50**

CORAL 12 \$39

The Coral 12SA-1 3 Way 4 Speaker System is rated at 70W peak, 35W average and includes the high performance L-C crossover. The 12" bass speaker, with free-edge, high compliance cone, the 5" heavy duty mid-range and the two 2 1/2" tweeters are perfectly matched, and in the recommended cabinet design, provide 30Hz-20KHz hi-fi response, 8 ohms. The "do-it-yourself" instruction book, plus all accessories, are included.

Post/Package \$2.50 each.

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NOVICE LICENCES - AT LAST!

Roger Harrison comments:

THE long-awaited Novice Licence is finally a fact. Now, the many potential amateurs who, for various reasons, had to sit in the wings and be discontent with a half view or less of the fascinating world of radio communications can realise their ambitions and join the world of amateur radio.

Hobby-type communications between persons of like bent is traditionally (and by law) restricted to those who have passed the appropriate examination and hold an amateur radio licence. In Australia, only people over the age of 15, and who could successfully gain a 70% or better pass in the examination on radio communications techniques, basic theory and radio regulations, and a morse code test at 10 words per minute (for the 'full' licence), could engage in amateur communications. For those with the appropriate background, the requirements rarely proved much of a hurdle. But for

many others, just getting to the hurdle proved too great a task or consumed too much time and so they settled for less than their desires, or took to 'pirating', or let their interest die altogether and took up golf or karate. Too many saw the technical examination as beyond them, or 'something for them that knows that sort of thing'. To my mind, amateur radio is not some crazy sort of exclusive club with strict entry standards.

Even Marconi always considered himself a radio amateur, regardless of his professional standing and historical position.

Surely, those who wish to trace his footsteps, within the realm of modern technology, need not be restricted by vocational, educational or chronological limits. Without some incentive, a 'bite at the cherry', the drive of self-discovery and self-education (sheer curiosity) withers on the vine. And one of the fundamental tenets justifying amateur radio is this motivation of self-education and self-discovery through practical experience. It seems logical to place only those restrictions necessary to preserve the 'natural resource' of the radio spectrum along with the rights, privileges and enjoyment of others.

Now, Australia joins with many other major and minor countries in introducing a 'minimum requirements' or novice license. Scenes of throwing streamers, fluttering confetti, shouts of HUZDAH!, and dancing in the streets!

The novice license should give amateur radio in Australia a healthy and much needed shot in the arm. Or a kick in the pants. Either way, it needs it. A crop of keen, enthusiastic operators will serve to sharpen the wits of those for whom the amateur bands have become somewhat passe. "What, only five watts and working more DX than me and my FTDX10,000 Super Deluxe and Tri-band beam?" Doubtless, QRP (low power) techniques and the art of QRP communications will flourish again. "To hell with the 20 metre pileups, guess I'll dust off the old 6V6 rig, dig out that old Acos mike and go and join the novices on 27 MHz."

"AMATEUR RADIO SERVICE"

The Postmaster-General, Senator Reg Bishop, announced today that arrangements have been made for the introduction of Novice Amateur Radio Station Licences.

Senator Bishop stated that the Novice Licence is being introduced to enable persons who have not passed the standard Amateur Examination to engage in radio as a hobby on a restricted basis and gain the knowledge and experience necessary to qualify for a normal licence. This move by the Government had the wholehearted support of the Wireless Institute of Australia.

To become eligible for such a licence, persons will be required to qualify for a Novice Amateur Operator's Certificate of proficiency.

The Certificate will be issued to any person, regardless of age, who passes a comparatively simple examination in radio theory and regulations and a Morse Code test at five words a minute.

He said that the fee for a Novice Amateur Station Licence had been set at half the normal rate and would be \$6 a year. The fee for the Examination will be \$2.

Novice Amateur Station Licencees will be permitted to operate within the bands 3.525-3.575, 21.125-21.200 MHz and 26.960-27.230 MHz. All transmitters must be crystal controlled. Powers of up to 10 watts for double sideband and 30 watts for single sideband transmission will be authorised.

Persons wishing to obtain more information concerning the new Novice Licence should contact the Regulatory and Licensing Section of the Postmaster-General's Department in the State in which they reside."

"VK2NIP calling VK2CBC", are you there dad, can I come down to the shack?" "Sure, and I'm working a BY1 on 20 metres, now put that thing down and get on with your homework!" (First things first!).

WHAT CHANGES ARE IN STORE?

Operating practices need not suffer, providing the present atmosphere of tolerance, patience and gentle persuasion continues. Telling some novice, who may be a novice in more ways than by licence, "Jeez you're a lousy operator, yah better clean er up a bit son" is obviously no way to communicate (and that's what it's all about) what is or is not acceptable.

Circuit techniques will receive a welcome graft with the obvious emphasis on efficient, low power transmitters and receivers. There are obvious applications for direct-conversion receiver techniques and low power consumption SSB generators (passive SSB generators?). Efficient antenna systems will obviously receive much scrutiny — and rightly so.

There will probably be an initial rush on 27 MHz, as that band is well catered for with cheap, readily available hand-held rigs that satisfy the PMG requirements. No doubt conversions will be performed for operation on the 21 MHz and 3.5 MHz bands. I suspect though, that homebrew equipment will prevail on these latter bands and the ubiquitous 'walkie-talkie' on 27 MHz for quite some time. I would not be surprised to find 27 MHz rivalling two metres FM for popularity in a few years.

I doubt that the five words per minute code test will prove a barrier (hardly!), but it will be interesting to see how many novices make use of the facility.

With a taste of 'life on the air', many will probably find the motivation to find time, courage, extra effort to go for a limited license or a full license. Lessons learned on the way, by means of practical experience will doubtless stand them in good stead.

With the provision of privileges on the 27 MHz band, the Novice Licence, was obviously designed to alleviate the 'pirate' problems on that band. It should certainly have some effect. With greater legitimate occupancy, piracy should become that much more difficult. No doubt, the few with a warped sense of values (or none) will continue their illicit activities. Poor bastards.

Examinations will be held for the Novice Licence in the capital cities shortly. More details are available from the PMG Radio Branches in each State.

Piece de Resistance



SOME TWO OR THREE years ago we ran a couple of competitions in which readers were asked to work out the value of resistances in apparently simple networks. In fact the problems were rather more difficult than at first appeared!

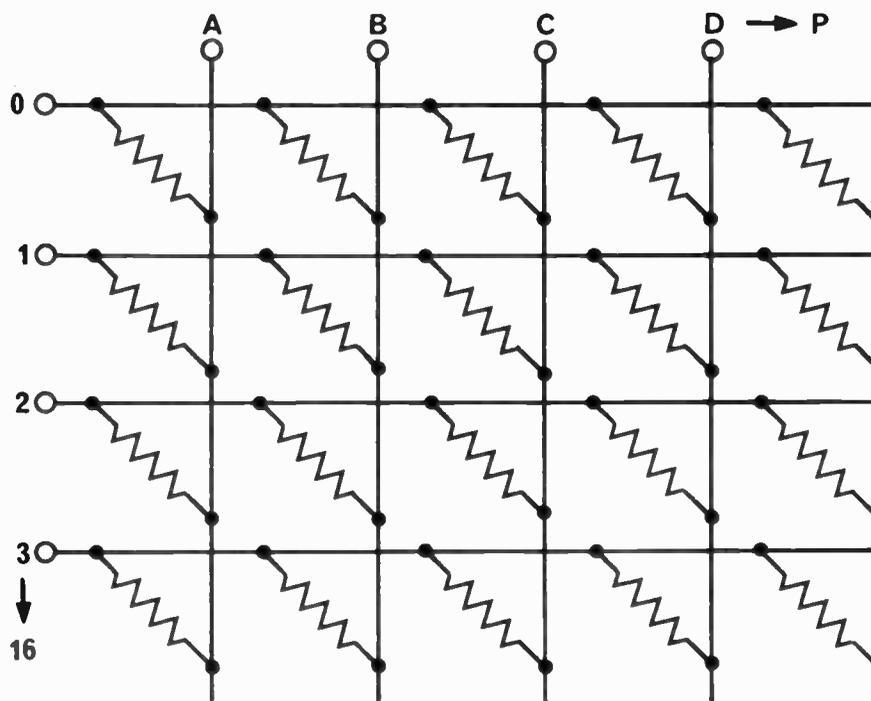
Many readers have asked us to continue to publish the puzzles — so here is another.

As previously, we will give a year's free subscription to the reader who submits the best explained (correct!) answer.

Please address entries to:—

Piece de Resistance No 4
Electronics Today International,
15-19 Boundary St.,
Rushcutters Bay,
NSW 2011.

Closing date for entries is June 16th. The winning entry will be published in the earliest possible issue.



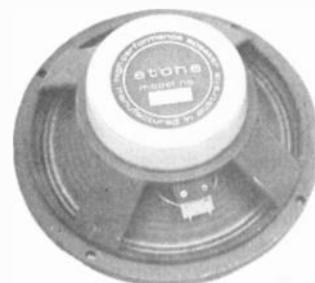
A 16 x 16 matrix has 10 ohm resistors connected across intersections as shown in our partial drawing.

What is the resistance between lines 8 and F?

How does resistance change if any other pair of lines are chosen instead?



ETONE the ROCK and ROLL LOUDSPEAKER



model 231 illustrated

ETONE Musical Instrument Speakers, previously sold only to manufacturers and trade suppliers, are now available for sale direct to the public.

ETONE Speakers feature aluminium coil formers bonded with high temperature epoxy and heavy duty cone assemblies for years of lasting service.

To test for power handling, Etone use a 300 Hz bandwidth random noise signal with centre frequency 250 Hz. The continuous power handling is the amount of power in watts R.M.S. of this signal the loudspeaker can accept without damage for one hour.

**5 YEAR
FACTORY
WARRANTY**

There's an ETONE loudspeaker for any application—

<p>model 231 \$41 P&P \$2.50</p>	<p>12" For Guitar, Bass Guitar, Organ Features straight cone, ribbed around the circumference, integrated surround. Flux density 13,500 gauss; total flux 170,000 maxwells, 40-7000Hz response.</p>	<p>30 WATTS RMS</p>	<p>model 451 \$92 P&P \$4.00</p>	<p>15" For Guitar, Bass Guitar, Organ. Features straight cone, ribbed around the circumference, integrated surround. Flux density 13,000 gauss, total flux 236,000 maxwells, 40-5000 Hz response.</p>	<p>50 WATTS RMS</p>
<p>model 246 \$54 P&P \$2.75</p>	<p>12" For Vocals, PA, Electric Pianos. Popular model, straight cone, ribbed around the circumference, integrated surround with "whizzer" cone. Flux density, 12,400 gauss, total flux 190,000 maxwells, 40-12,500 Hz response.</p>	<p>40 WATTS RMS</p>	<p>model 467 \$138 P&P \$4.00</p>	<p>15" For Guitar, Electric Piano, Vocals. Latest curvilinear cone, ribbed around the circumference, with integrated surround. Flux density 13,600 gauss, total flux 255,000 maxwells, 50-6000 Hz response.</p>	<p>80 WATTS RMS</p>
<p>model 365 \$114 P&P \$3.00</p>	<p>12" For Bass Guitar, Organ, Horn Loading. Very efficient speaker with straight cone, ribbed around the circumference; "free edge" cloth surround. Flux density 14,400 gauss, total flux 270,000 maxwells, 30-6000 Hz response.</p>	<p>65 WATTS RMS</p>	<p>model 474 \$135 P&P \$4.00</p>	<p>15" For Bass Guitar, Organ. Heavy duty performer with curvilinear cone, "free edge" cloth surround. Flux density 11,600 gauss, total flux 260,000 maxwells, 30-4000 Hz response.</p>	<p>80 WATTS RMS</p>
<p>model 366 \$129 P&P \$3.25</p>	<p>12" For Vocals, Electric Piano, Full Range. All purpose use — straight cone, ribbed around the circumference "free edge" cloth surround plus "whizzer" cone. Flux density 13,600 gauss, total flux 255,000 maxwells, 30-12,500 Hz response.</p>	<p>65 WATTS RMS</p>	<p>model 475 \$144 P&P \$4.50</p>	<p>15" For Horn Loaded Systems. Deepest of them all — straight cone, ribbed around the circumference, "free edge" cloth surround. Flux density 9,600 gauss, total flux 290,000 maxwells, 30-3500 Hz response.</p>	<p>100 WATTS RMS</p>
<p>Model 367 \$123 P&P \$3.50</p>	<p>12" For Guitar, Electric Piano. Specially developed curvilinear cone with "free edge" cloth surround. Flux density 13,600 gauss, total flux 255,000 maxwells, 40-10,000Hz response.</p>	<p>65 WATTS RMS</p>	<p>Quantity Discounts</p>	<p>● 1 to 3, no discount ● 4 to 11, less 5%, may be assorted types ● 12 plus, less 10%, may be assorted types ● Further quantity discounts available by negotiation only.</p>	

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welcome here

YOU DESERVE A BREAK!



If you want to build your own loudspeakers, but don't fancy yourself a master cabinet-maker, we can offer you a speaker box kit which isn't really a kit.

We've taken all the back-breaking, time consuming work out of your hands to make it easier for you.

Here's how:—

Firstly, we supply the cabinet shell ready-assembled and finished — no wood-work, edging or staining and polishing needed.

Secondly, we supply a modern "continental-styled" wood grille front which eliminates difficult and time-consuming grille cloth fixing and gives a professional "factory finish" appearance.

Thirdly, we supply front and back panels pre-cut and ready-to-mount.

Basically, all you do is mount the front and back panels and wood grille front with materials supplied and install acoustic wadding and speakers. If it was any easier, we couldn't call it a kit. We know you'll probably finish a pair of speaker boxes in less than 2 hours with our "know-it-all" instructions, so why not assemble your own speakers. YOU CAN DO IT TONIGHT!

SPK-10 CABINET

Popular size for all small speaker systems. Pack & Post \$2

Size — 455 x 295 x 230 mm. Cabinet Kit only — \$27.00 ea. (We supply ex stock, SPK-10 or SPK-20 kits for popular speakers as listed. Others: advise speaker size etc., available within 24 hours).

\$27ea

COMPLETE SPEAKER AND CABINET KITS

MAGNAVOX 6" 2 way 12 watts. \$39.00 ea. Pack and Post \$4.00. MAGNAVOX 8" 2 way 16 watts. \$41.00 ea. Pack and Post \$4.00. PLESSEY C80 8" (D) 2 way 20 watts. \$45.00 ea. Pack and Post \$4.00. MSP 8" 3 way 20 watts. (8" bass, 5" mid, 3" tweeter). \$45.00 ea. Pack and Post \$5.00. CORAL 8" 3 way 15 watts. \$42.00 ea. Pack and Post \$4.00. PHILIPS 8" (D) 2 way 20 watts. \$47.50 ea. Pack and Post \$5.00.

SPK-20 CABINET

Best size for great, all-round sound performance.

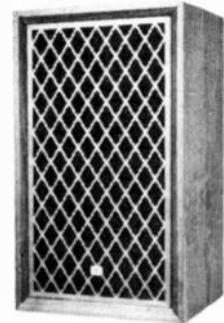
Size 600 x 360 x 290 mm. Pack & Post \$3.

\$33ea

COMPLETE SPEAKER AND CABINET KITS

PLESSEY 8" 2 way (D) 20 watts. \$53.00 ea. Pack and Post \$5.00. MAGNAVOX 8-30 2 way (D) 30 watts. \$57.00 ea. Pack and Post \$6.00. MAGNAVOX 8-30 3 way (D) 30 watts. \$65.00 ea. Pack and Post \$6.00. MAGNAVOX 12" 2 way 16 watts. \$49.00 ea. Pack and Post \$6.00. PLESSEY 12" 2 way (D) 30 watts. \$61.50 ea. Pack and Post \$6.00. PLESSEY 12" 3 way (D) 30 watts. \$69.00 ea. Pack and Post \$7.00. CORAL 10" 3 way 25 watts. \$58.00 ea. Pack and Post \$6.00. CORAL 12" 3 way 35 watts. \$68.00 ea. Pack and Post \$7.00.

All Kits include crossover networks etc. (D) Signifies PLESSEY or PHILIPS 1" Dome Tweeters supplied.



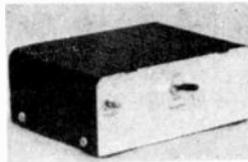
ANTI-THEFT

SOLID-STATE BURGLAR ALARMS

Protect your home and contents — TODAY!

This complete package Installation Kit will suit most homes — a solid state CMOS alarm kit (ETI Project 528) coupled to a loud electronic siren detects attempted forced entry. A 30 second time delay permits exit or re-entry. Also includes 12 magnetic door/window switches (extras \$1.56 ea), keyswitch, weatherproof horn speaker, emergency push-button, 150 ft. hook-up wire and full anti-theft Instructions. (Individual parts cost \$70.00).

DO-IT-YOURSELF KIT **Save Money**



Complete installation kit for average household. **\$49** P&P \$2.50

IT'S TOO LATE THINKING ABOUT IT AFTER THE FACT.

Burglars don't give a damn who they rob. You might be next on their list. Once it happens, it's no good wishing you had installed a modern electronic alarm in the first place. THE TIME TO DO IT IS NOW — BEFORE A POSSIBLE ROBBERY TAKES PLACE.

For less than \$100, you can install a DO-IT-YOURSELF Alarm System in your house, shop, office factory or car, and protect your goods and personal belongings worth much more.

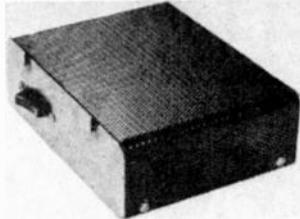
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ALARM

Save your car today! Install the most effective Complete car protection device available. This E.T.I. Project 305 is easy to install — provides entry/exit time delay to protect your car and its contents. Includes twin flashing red LED module as powerful burglar deterrent.

Complete Kit only \$29.00, Pack and Post \$2.00.



\$29

ETI-702 MICROWAVE INTRUDER ALARM

Detects moving objects at ten metres range.

The ETI-702 Radar Alarm uses the Philips Elcoma CL8960 Radar Module to provide one of the most efficient space detection systems available. The alarm rings as soon as the burglar penetrates the beam transmitted by the radar module. Two sets of switching contacts are provided to switch an electronic siren or alarm bells. The Kit is complete and includes the CLB960 module.



Complete Kit only **\$59** P&P \$2

LATEST PRE-RECORDED CASSETTES from Pre-Pak \$4.95ea.

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 NB7311 Cliff Richard. Live.

UNWANTED AUDIO SIGNALS

Breakthrough of unwanted broadcasts into audio systems can be infuriating — here's how to stop them.

PERHAPS THE MOST infuriating form of RF pollution is breakthrough of unwanted broadcasts into audio systems.

With the current proliferation of broadcasting stations, radio amateurs, taxi companies, walki-talkies etc the problem is now a major headache to manufacturers and users of hi-fi systems, public address systems, hearing aids — even electronic musical instruments may be affected from time to time.

The 'fault' that results in audio breakthrough is almost invariably within the 'interferes' audio equipment. It is hardly ever caused by a fault within the transmitter or even faulty operational procedures.

The phenomenon is now becoming generally known as 'audio rectification'. In essence the unwanted RF energy is picked up by some part of an audio system — which acts as an antenna. The energy is then rectified by an element operating non-linearly in the equipment. This can take the form of a valve, transistor, IC — or even a poorly soldered joint! The rectified signal is then amplified by the remainder of the audio system (although in at least one instance personally known to the author the unwanted signal was picked up on the leads between the power amplifier and speakers on a large PA installation — and then rectified by a faulty connection on one of the speakers).

Hopefully audio rectification will be only a short term problem because cases are now becoming so numerous that audio equipment may soon have

to be designed with suitable rejection circuitry included.

In the meantime the USA's Federal Communications Commission and the Electronics Industries Association have devised a number of procedures for identifying the specific part of the circuit into which the signal is introduced — and a number of ways by which the interference may be eliminated or substantially reduced. This article is based on these procedures.

Ninety nine times out of a hundred the offending RF content will be introduced into the early stages of a pre-amplifier, or will be picked up and introduced by the mains power supply leads. To check that this is in fact so just turn down the volume control next time interference occurs. If the interference *is* reduced then it is being introduced before the volume control (which will be in the output stage of the pre-amplifier — or its equivalent in an integrated unit). If the level remains constant — then it is being picked up *after* the volume control.

VOLUME CONTROL AFFECTS INTERFERENCE

The most common causes of this type of interference are signals introduced via the mains power leads, via interconnecting cables between main amplifier and auxiliary equipment, or via the speaker leads themselves.

It may also be caused by a poor or non-existent earth connection and this should be checked before looking any further.

Having checked out the earth connections it is advisable to next check the speaker leads. At first sight it might seem that RF picked up by the speaker leads would produce a constant level signal — or that the level itself would be very low because of the low impedances involved. But this is not *necessarily* so, for the RF signal is fed back via the negative feedback loop. And whilst feedback is applied *after* the volume control, some of the RF signal may be radiated into the earlier stages of the pre-amplifier.

It is not unknown for speaker leads to be of such a length that they actually resonate at the interfering frequency — in which case an instant cure can often be effected merely by lengthening or shortening them. Murphy's Law can operate here though. One person we know eliminated interference from a local TV station that way — only to pick up his local taxi radio service at Strength 9!

Twisting the speaker leads or using shielded cable is also generally effective. Connecting a capacitor across the amplifier output terminals or from each terminal to earth is also effective. Note that high frequency response will not be degraded as impedance is very low at this point in the circuit.

A capacitance of about $0.1 \mu\text{F}$ is generally sufficient to remove most RF. Use the smallest value that fixes the problem and always use a ceramic capacitor for the purpose.

If the above checks don't cure the problem the next thing to check is

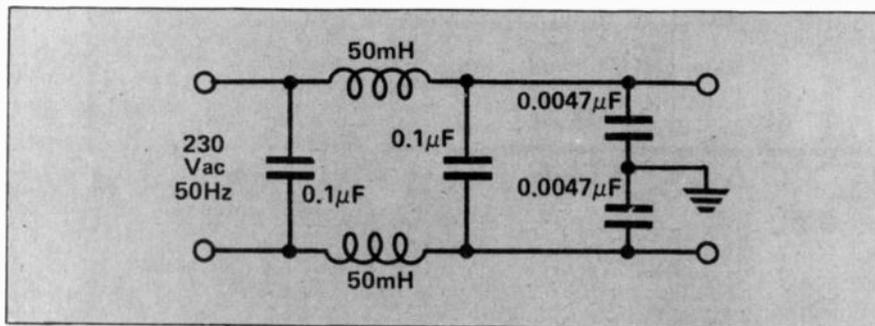


Fig. 1. Mains filter, available commercially or can be home-constructed. If you make it yourself it is essential to use capacitors rated for ac mains operation.

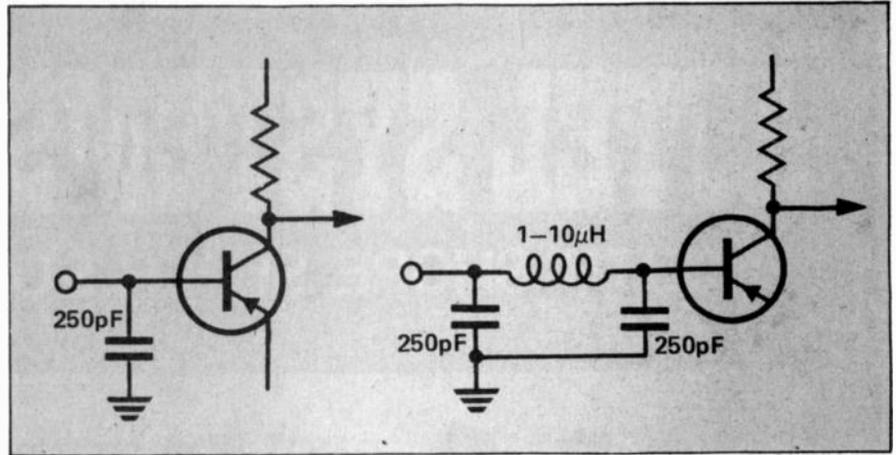
whether or not the signal is being introduced via the signal leads. Here the quickest check is to disconnect all externally connected units — such as the turntable, cassette recorder, radio tuner etc. If disconnecting a unit eliminates the interference then the cable connecting that unit to the amplifier is not properly screened. Lastly check for mains-borne interference by connecting a line filter in series with the incoming power line. These filters are commercially available from RCS Radio in Sydney or can readily be made as shown in Fig. 1. If you make this filter yourself do not under any circumstances increase the values of the capacitors shown — and make absolutely sure that the capacitors are rated for 250 volt ac operation (AEE Miniprint series for example).

In areas where the strength of the unwanted signal is very high (as it may well be if, for instance, you live close to a TV transmitting antenna) the signal may still find its way into the input circuitry despite the precautions suggested. This is particularly likely if the amplifier has a non-metallic case — or if it has a metal case that is not earthed satisfactorily. The cure here is obvious — aluminium foil makes a good shield — make sure it's earthed correctly.

If, despite all the precautions outlined, the RF signal is still finding its way into the pre-amplifier, more drastic treatment will be necessary.

Firstly check that there are no poorly soldered joints — for a dry joint can act as an almost perfect rectifier. Resolder any joints that look at all suspicious.

Electrolytic capacitors tend to have high inductive reactance at RF



Figs. 2/3. These simple filters, connected in series with the pre-amplifier input, will prove effective in many cases.

frequencies thus preventing them by-passing unwanted RF to ground. Check them out by temporarily wiring an $0.01 \mu\text{F}$ ceramic in parallel. Wire in permanently if this cures the problem. If the problem still remains it will be necessary to modify the amplifier as outlined below.

VOLUME CONTROL DOES NOT AFFECT INTERFERENCE

Sometimes unwanted level signals will be heard at a constant level — not affected at all by volume control settings. If this is your problem (or if unwanted signals are breaking through in the manner described in the last paragraph) it will be necessary to use RF filtering at the input to the power amplifier. Figure 4 shows one way of doing this that has proved very satisfactory. Unfortunately it is impossible to quote actual component values as these will be determined by the circuitry of the individual

amplifier. The main thing to remember is that the components should be selected so as to cause no significant change in audio frequency response. (In really severe cases however it may be necessary to trade off frequency response against interference removal).

The capacitors used for this purpose should be ceramics — not paper types. Inductor L1 may be a ferrite bead.

If despite all the foregoing you *still* have problems there seem to be only two remaining solutions.

Dynamite the offending source — or move!

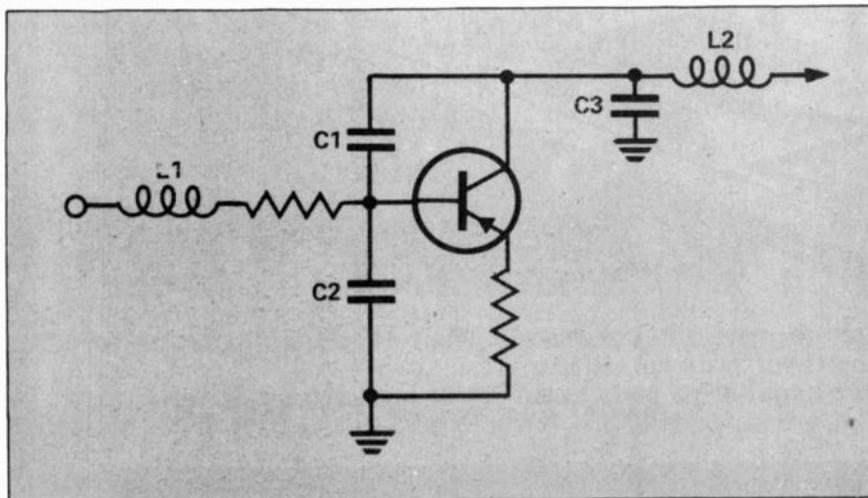


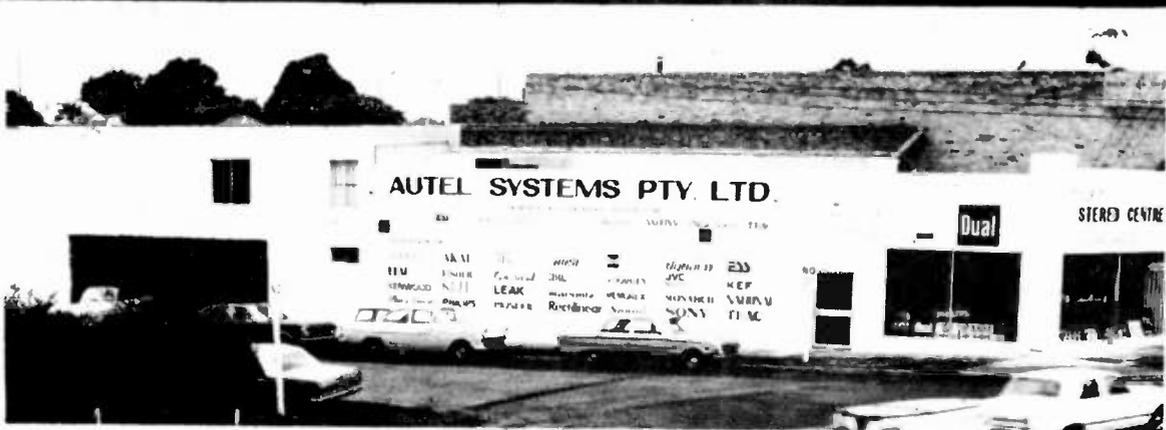
Fig. 4. Although more complex than the circuits shown in Figs. 2/3 the RF filter shown here will almost invariably eliminate unwanted signals. We regret that it is impracticable to show component values as they depend totally on the circuitry of the amplifier to which it is to be installed. Note two similar filters are required — one for each channel. The filters should be wired in series with the input to the power amplifiers.

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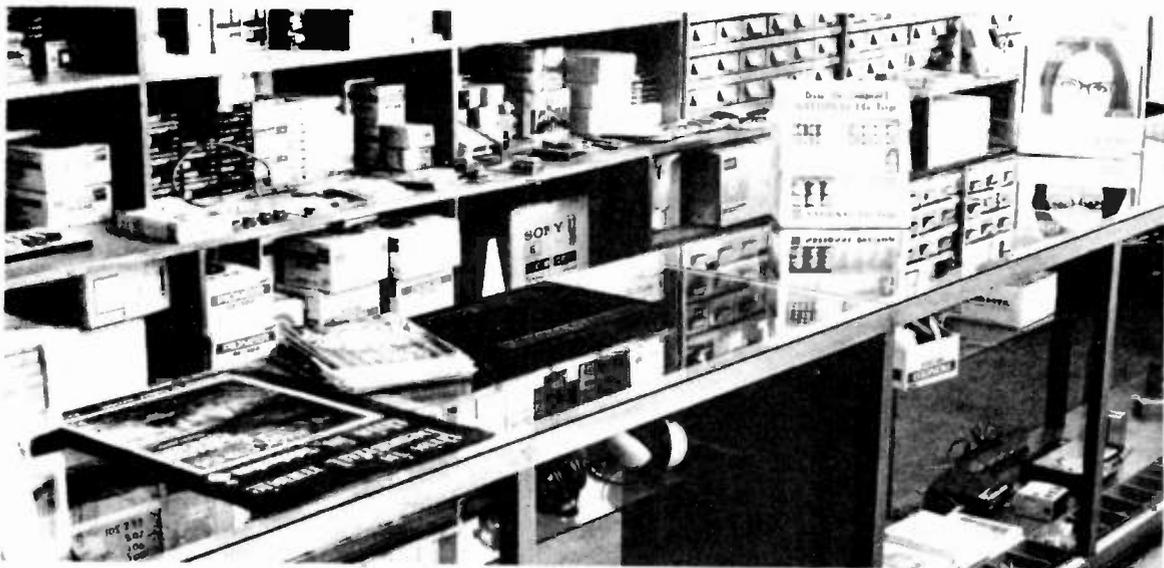
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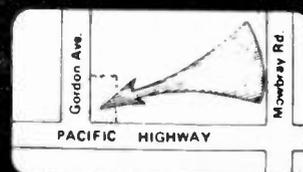
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PROJECT
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ANTENNA MATCHING UNIT

Peak up your short-wave signals with this simple antenna matching unit.

END-CONNECTED wire antennas are generally used for reception over the 1.7 MHz – 30 MHz range. They may consist of a metre or two of insulated wire located indoors or a long high outdoor installation.

Such antennas can and do provide good long-distance reception, but the matter of matching the antenna impedance to the receiver is often totally disregarded. Nevertheless there is a maximum transfer of energy from the antenna to the receiver only when the end impedance of the antenna approximately matches the input impedance of the receiver antenna circuit.

Many specialised short wave receivers have an antenna input impedance of about 75 ohms. With other receivers, the input impedance may be unknown, and in any case it is likely to alter with changes in operating frequency.

The end impedance of the antenna, in its turn, depends on the length of the antenna system in terms of wavelength. If the antenna is a half wavelength long, or a multiple of half wavelengths, its end impedance is high – it may easily exceed 1000 ohms. On the other hand, if the antenna is a quarter wavelength long, or an *odd* multiple of quarter waves, its end impedance is low. In fact it will probably be under 50 ohms at some frequencies.

The length of a half-wave, in metres, is found with sufficient accuracy from length = 143/MHz. As much

specialised short wave listening takes place on the amateur bands, and these are spaced nicely through the spectrum it is convenient to use them as examples.

Adopting a centre-frequency for the 20 metre band of about 14.2 MHz, the length is 143/14.2, or near enough to 10m for this to be used. Suppose 10m of wire forms the antenna and down-lead, the near end being taken to the receiver. The end impedance is high at the frequency which corresponds to a half-wave – about 14.2 MHz in the 20 m band. At twice this frequency, or about 28.4 MHz in the 10 m band, 10 m is two half-waves so the end impedance is also high. But at half the frequency, or about 7.1 MHz, the antenna is one-quarter of a wavelength long, and its end impedance is low. In fact, if the antenna impedance were measured through the range 30 MHz to 1.7 MHz, it would be found to make excursions from one extreme to the other, reaching a low figure as the frequency falls and the wire becomes short in terms of a half wavelength.

Similar effects arise with any length of antenna. To compensate for them, an antenna matching device such as that described here may be placed between the antenna and receiver.

MATCHING CIRCUIT

This is shown in Fig. 1 and uses a tapped inductance, L1, and variable capacitor CV1. The switch S1 has 10 positions. At '0' all of L1 is shorted

out. At '2' two turns are in circuit. At '4' two plus two turns, or four turns, are in use. This continues for the remaining switch positions, so that 0, 2, 4, 7, 11, 16, 22, 29, 39 and/or 60 turns may be selected.

To cover the widest possible range of conditions, the matching unit can be employed in any of the ways shown in Fig. 2. The choice of such a large number of circuits may make it seem that operation is complicated. However this is not so, as it is only necessary to use any one which allows the switch and capacitor to be adjusted for best results. As a guide, the following will be helpful:

- A. Capacitor CV1 is at the antenna side. Rotate the switch S1 from '0', meanwhile swinging CV1 from minimum to maximum to peak up signals. Use S1 and CV1 settings which prove best. (This is the most commonly used way to connect in the unit.)
- B. Antenna and receiver plugs are reversed. Try this if A proves unsatisfactory. Adjust as for A.
- C. Simplified inductive loading, broad-banded.
- D. Series capacitor only. Not likely to be needed often, but useful with some receivers.
- E. CV1 and L1 in series. This will allow many unknown antenna impedances to be matched.

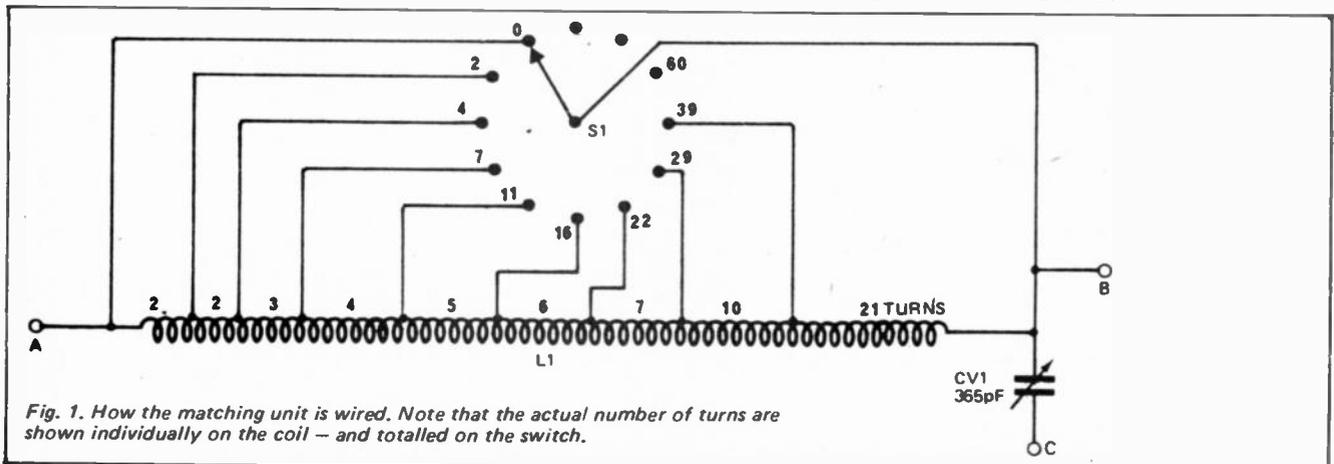


Fig. 1. How the matching unit is wired. Note that the actual number of turns are shown individually on the coil – and totalled on the switch.

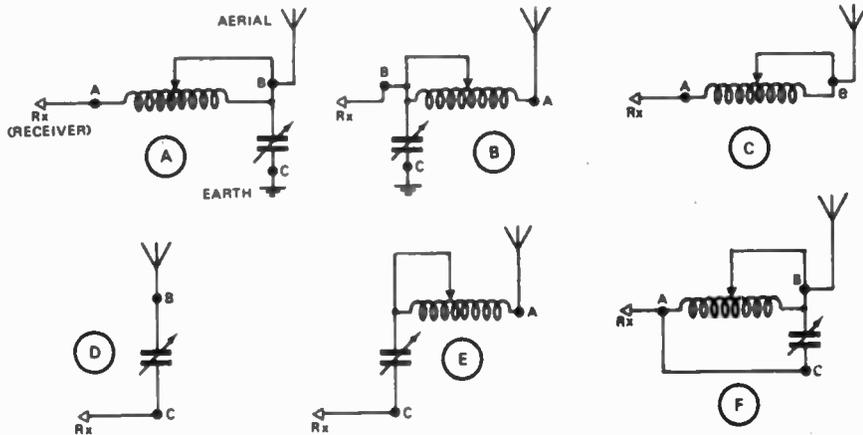


Fig. 2. The various permutations that can be obtained from the circuit in Fig. 1.

F. Parallel tuning by joining sockets A and C. This can prove useful with very short antennas on low frequencies, allowing the whole system to be tuned to resonance.

If the receiver has a tuning indicator, watch this while making adjustments. If there is no indicator, but an automatic volume control switch, put the AVC off so that changes in volume are more easily heard. If the AVC cannot be switched off and there is no tuning indicator, adjust the matcher with a weak signal. The benefit it can give is not necessary with strong signals, which will in any case operate the AVC system and mask the change in signal strength at the receiver aerial terminal.

MAKING THE INDUCTOR

This uses 24 swg enamelled wire, wound on a paxolin tube about 1½" (40 mm) in diameter and 10 mm long. Anchor the wire about 6 mm from one end, and wind on two turns. Scrape the wire, twist a small loop, and wind a further two turns. Make a further loop, and wind three turns. Continue in this way until the coil is finished. A small space is left between each section. Anchor the end as when starting.

A little adhesive may be applied at the ends and tappings, to prevent turns moving, but the whole winding must not be treated in this way.

ASSEMBLY

The panel is approximately 150 x 100 mm and is drilled or punched for three insulated sockets, S1, CV1. The latter requires a suitably sized three 4BA countersunk screws. These must be short to avoid damaging the capacitor.

The coil is placed directly behind the switch, and leads are soldered from the tappings to the switch tags as shown. No other support for the coil is necessary.

Audio gain potentiometer knobs numbered from 0-10 were fitted to S1 and CV1. '0' corresponds to '0' in Fig. 1, and the numbers 1 to 9 for the other positions, two positions of the 12-way switch being unused. As CV1 rotates only 180 degrees, numbers beyond 7 here can be blocked out.

USE OF MATCHING UNIT

Tuning adjustments are relatively flat with a longish aerial, but peak more sharply with a short aerial. Any circuit in Fig. 2 which gives best results can be used.

The matcher is not intended for use with universal AC/DC mains receivers where the chassis and other circuits are connected directly to the mains. These are rarely encountered in Australia but are often used in the UK — so watch out if your set is imported.

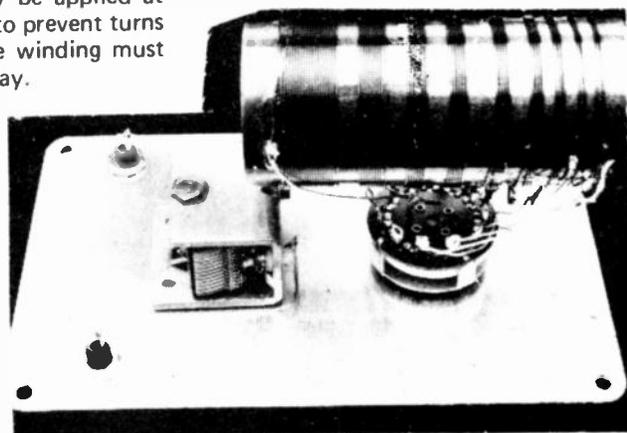


Fig. 3. Capacitor and selector switch connections.

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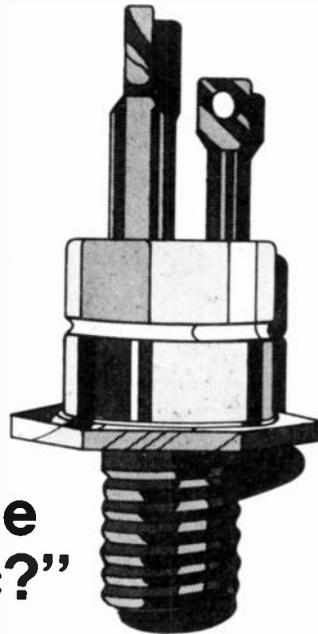
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$V_{RRM} = V_{DRM}$	(V)	400 to 1200	600 to 1600
$I_{T(RMS)}$ at 85°C T_{mb}	(A)	25	45
I_{TSM}	(A)	250	400
dV_D/dt at 125°C	(V/ μ s)	100	200
dV_D/dt of Commutation	(V/ μ s)	30	30
Voltage			

There are still some circuits for which a triac can't replace a thyristor. In these cases you need one of our thyristors from the BTW30 range . . . featuring 1200V maximum rating (for use with 415V mains) and very fast turn-off times. Just the thing for solid-state inverters and choppers for instance. The specs . . .

		BTW30	BTW31	BTW32	BTW33
$V_{RRM} = V_{DRM}$	(V)	300 to 1200	300 to 1200	600 to 1200	600 to 1200
$I_{T(AV)}$ at 85°C	(A)	12	16	25	65
dI_T/dt	(A/ μ s)	100	100	100	100
dV_D/dt	(V/ μ s)	200*	200*	200*	200*
t_q at $T_j = 125^\circ\text{C}$	(μ s)	<6	<12	<25	<25
		and <12	<20		

*1000V/ μ s on request

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This unusually-stable dc coupled amplifier can be used from dc up to very high frequencies — Laurie Cachia explains.

THIS IS AN unusually stable dc-coupled amplifier. It can tolerate a large amount of negative feedback and, because of this, voltage changes at the transistor collectors due to thermally caused variations in the collector-to-base leakage current are reduced by a factor equal to the circuits' open-loop amplification.

The only frequency-conscious components are the two transistors but even using quite ordinary transistors a bandwidth from dc to 60 MHz can be achieved. If high cut-off frequency devices are used the frequency bandwidth can be very much wider still — the high degree of negative feedback assists considerably of course by maintaining a constant output level.

Each stage of the amplifier is biased into class A operation, and the distortion, which is in any case inherently low, is further reduced by the negative feedback.

The gain of the amplifier is approximately

$$G = \frac{R7 \cdot R4}{R1 \cdot R6}$$

(assuming R7 is much larger than R6).

The emitter resistors R3 and R5, apart from providing subsidiary negative feedback within the main feedback loop, reduce phase shift through each stage. This is of importance if feedback is substantial —

and if the amplifier is to be used at frequencies approaching the cut-off frequency of the transistors.

Actual component values are not shown in Figs. 1 and 2 since each circuit must be tailored to individual requirements for dc stability, gain, working frequency, supply voltage and so forth. Instead, design logic is given here as a guide to value selection.

(a) The voltage at the collector of Q2, with the amplifier in the quiescent state, should be of the order of 2/3 of the supply voltage since Q2 is operated in Class A and is considered (here) to be the output stage.

(b) To achieve two-thirds supply voltage at the collector Q2, R4 should be of the order of one-half (R5+R6) since the voltage at the collector of Q1 is chosen so that at its peak positive excursion it is about one-third supply voltage.

(c) By the same token the voltage at the collector of Q1 (in the quiescent state) is chosen to be 2/3rds of 1/3rd (ie. 1/9th) of the supply voltage and in this example R2 should be greater than R3 and the quiescent voltage at the base of Q1 about one-ninth of supply voltage.

(d) If it is desired to adjust the values of resistors experimentally, then the loop should be opened and a requisite bias applied to the base of Q1. After adjusting values, the voltage at the

junction of R5/R6 should be nearly equal to the bias on the base of Q1. Closing the feedback loop then stabilizes the quiescent potentials around the circuit.

(e) If higher amplification is required, resistors R7 or R4 may be increased in value. Alternatively, R1 or R6 may be reduced in value.

(f) At a sufficiently high frequency, the combined phase shift in the transistors would be sufficient to render the feedback regeneration. Steps must be taken therefore, to reduce the amount of feedback at the high frequency end. One method of doing this is suggested in Fig. 1 by the insertion of C1 (shown dotted).

(g) If a higher loop gain is required, then R3 may be by-passed capacitively, provided that the required low-frequency performance is not adversely affected.

A more sophisticated version of the circuit is shown in Fig. 2. A power amplifier, Q2, is added to drive the output stage Q3. The feedback network is split into R5 and R8 and capacitor C2 added. A good degree of control over the frequency response of the amplifier is afforded by C2 and C3. Increasing capacitor C2 affords high frequency boost and a larger C3 a high frequency cut in the response.

Figure 3 shows the circuit built up as

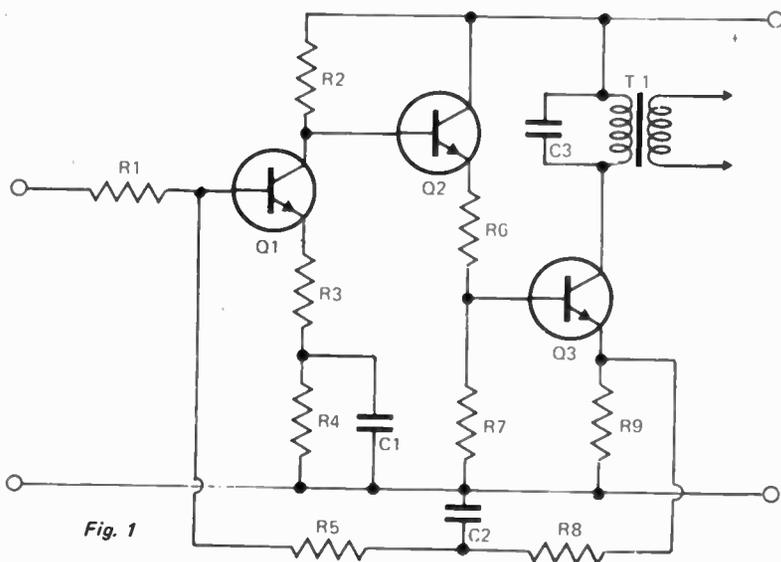


Fig. 1

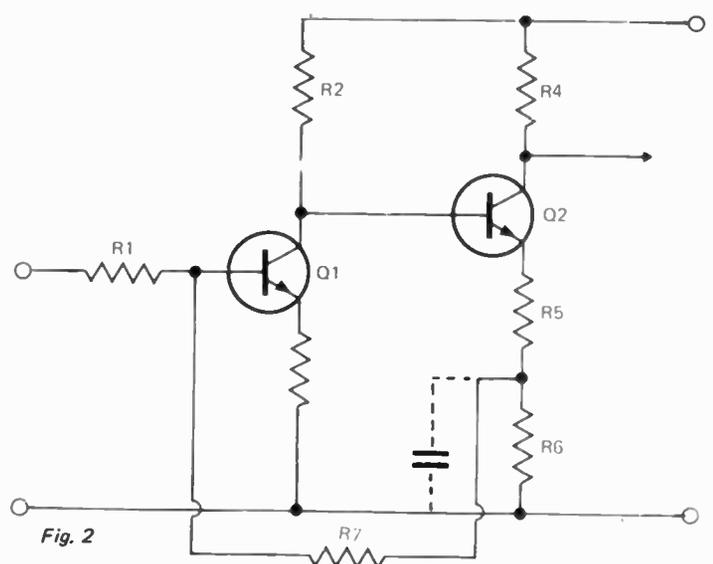


Fig. 2

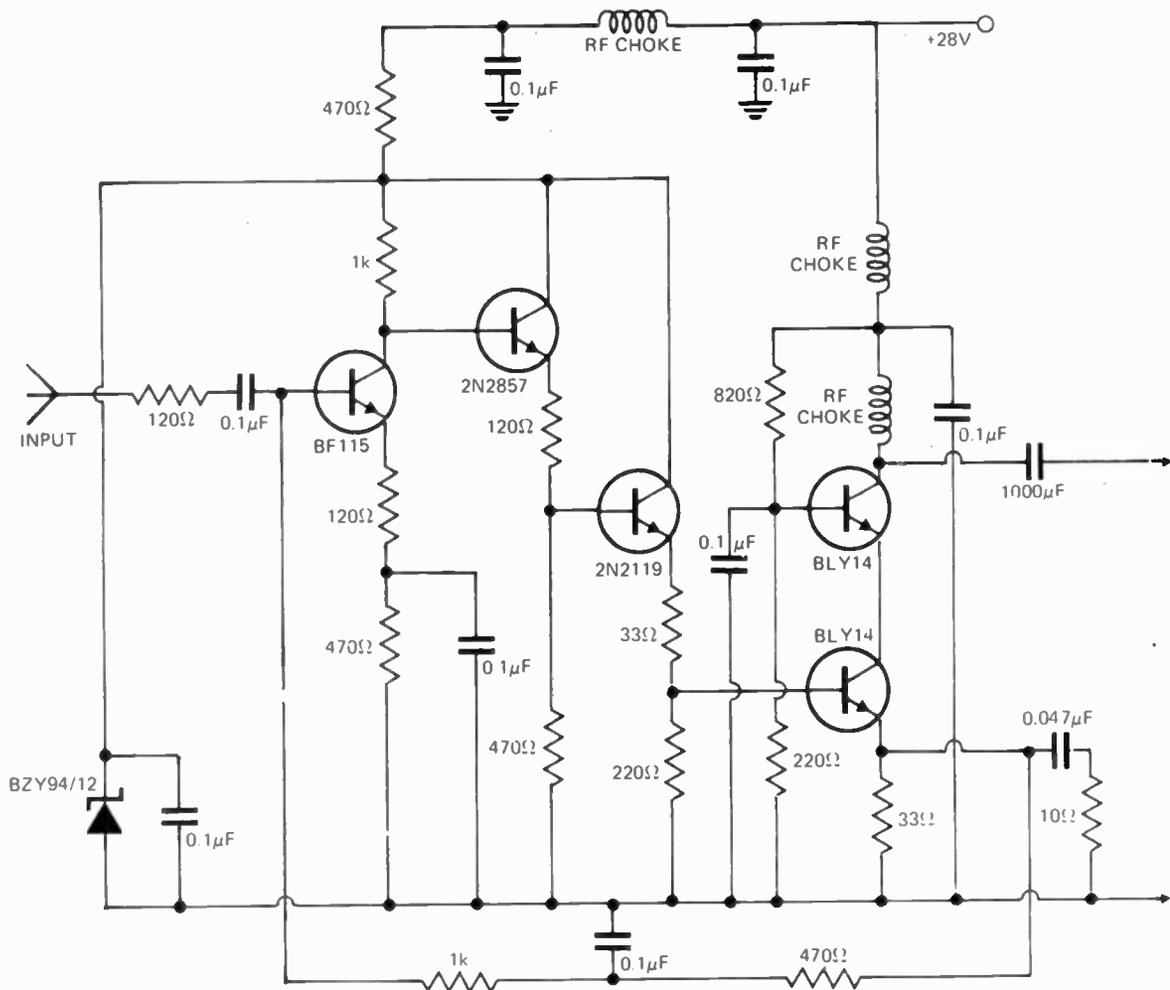


Fig. 3

a 10 watt rf amplifier. In this application the transformer in the collector circuit of Q3 (in Fig.2) is replaced by a transistor connected in the grounded base configuration and with a choke as its collector load. Thus the output stage is converted to a cascade circuit which largely eliminates the effect of the Miller capacitance in Q3.

Performance figures which are indicative of the potentialities but in

no way the limitations of this circuit are:—

- Voltage gain 55 dB
- Power output 10 watts
- Frequency response 0.5 to 38 MHz at -1 dB points
- Feedback Amplitude linearity 34 dB
- 0.1 dB change in gain for 60 dB range of input levels.

The circuit also gives excellent performance at audio frequencies in which application a flat response from dc to many megahertz is obtainable (which should give rise to some fascinating audio adverts — Ed).

Treble cut is provided by C3 while treble boost could be produced by reducing C2. A capacitor introduced in series with R5 would provide bass boost.

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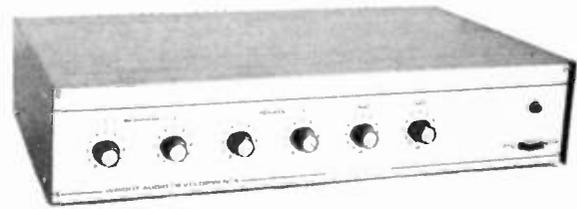
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UNDERSTANDING COLOUR TV

Driving the shadowmask tube

by Caleb Bradley B.Sc.

THE 'SHADOWMASK' colour cathode ray tube was first demonstrated by Radio Corporation of America in 1950. It has been the display device for virtually all domestic colour receivers throughout the twenty five year history of colour television and has been improved throughout this time to reach its present standard of colour fidelity.

To produce a realistic colour picture, the red, green and blue 'brightness copies', which are transmitted in encoded form in the PAL television signal and recovered as separate vision signals by the receiver decoder, must be reproduced in lights of these colours and additively combined in the viewer's eye. The shadowmask tube uniquely achieves this by reproducing all three pictures *at once* on a single screen. Each picture is fragmented into dots and the three sets of primary coloured dots are intermixed evenly over the screen area. At normal viewing distance the individual dots

are not seen and their lights merge together to produce the picture containing a full range of colours.

ELECTRON GUNS

Electrically the shadowmask tube is like three monochrome cathode ray tubes combined in one glass envelope. The neck of the tube contains three electron guns, each resembling the single gun of a monochrome tube — see Fig. 38. The parts of each gun are as follows:

Heater This is a spiral of high resistance tungsten wire which is run at red heat by an ac supply of, typically, 6.3 Vrms, 0.3 A per gun. The wire is coated with alumina to insulate it from the cathode.

Cathode This is a small disc of nickel alloy which is supported by a ceramic disc. The end of the cylinder is coated, as in a valve, with oxides of barium, strontium and calcium to encourage electron emission when heated.

Control Grid Unlike the wire mesh

grid of a valve suggested by the schematic diagram this is a closed-end metal cylinder with a small hole to pass the electron beam. The intensity of the beam current of each tube is controlled by the difference in potential between its grid and cathode, and in this way the quantities of primary coloured lights at the screen are controlled. The grid voltage with respect to the cathode varies within the range 0 V to -150 V at cut-off.

PRIMARY OR COLOUR-DIFFERENCE DRIVE

The grid-to-cathode voltage for the red gun must be the original red camera signal E_R , likewise E_G for the green gun and E_B for the blue gun. In practice there are two ways of connecting the decoder to the tube to achieve this — see Fig. 39. Both methods are used in commercial receivers.

The receiver decoder always initially demodulates the signals U and V from the PAL subcarrier. In the primary drive system these two signals are fed to a matrix of summing resistors together with the luminance signal Y. By appropriate summing proportions the three primary colour signals are obtained and fed to the tube cathodes via drive amplifiers to give the necessary voltage swings. The tube grids are strapped together to a fixed voltage which can be varied by the brightness control. Thus the three beam currents are controlled by E_R , E_G and E_B .

The alternative colour-difference drive method applies signals to both the grids and cathodes of the guns which themselves perform most of the matrixing. Luminance is applied directly to all three cathodes. U and V are simply fed to the blue and red grids via drive amplifiers of weighted gains to convert them to $(E_B - E_Y)$ and $(E_R - E_Y)$ respectively; $(E_G - E_Y)$ is obtained from U and V by a simple matrix (in effect just two summing resistors) and is similarly fed to the green grid.

Remembering that it is the relative grid-to-cathode voltages which control the beam currents it is clear that for, say, the red gun, -R on the cathode

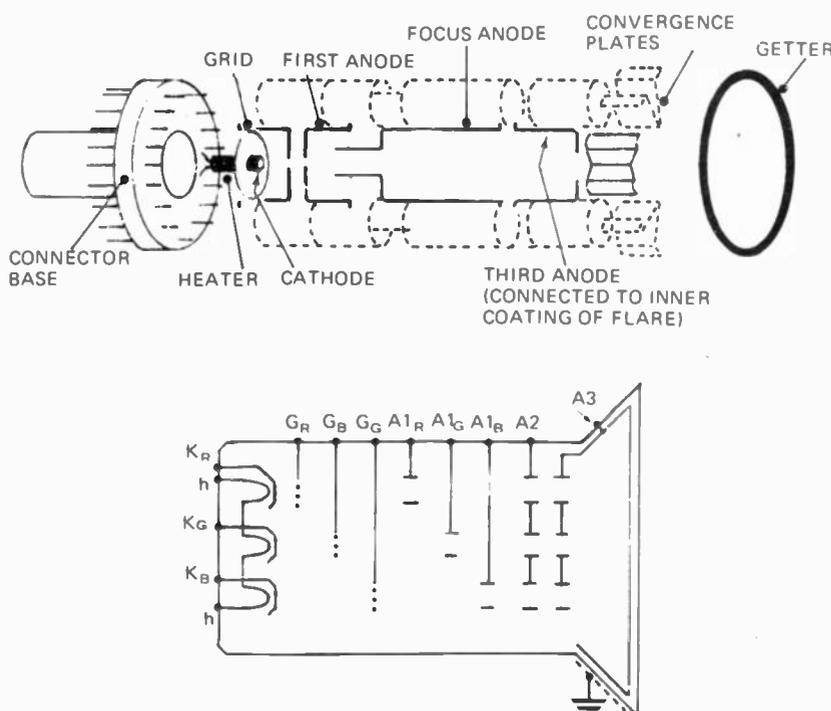


Fig. 38a) Triple electron gun assembly of the shadowmask colour tube, showing one gun in detail (remaining two are shown dotted). b) Schematic diagram for the tube.

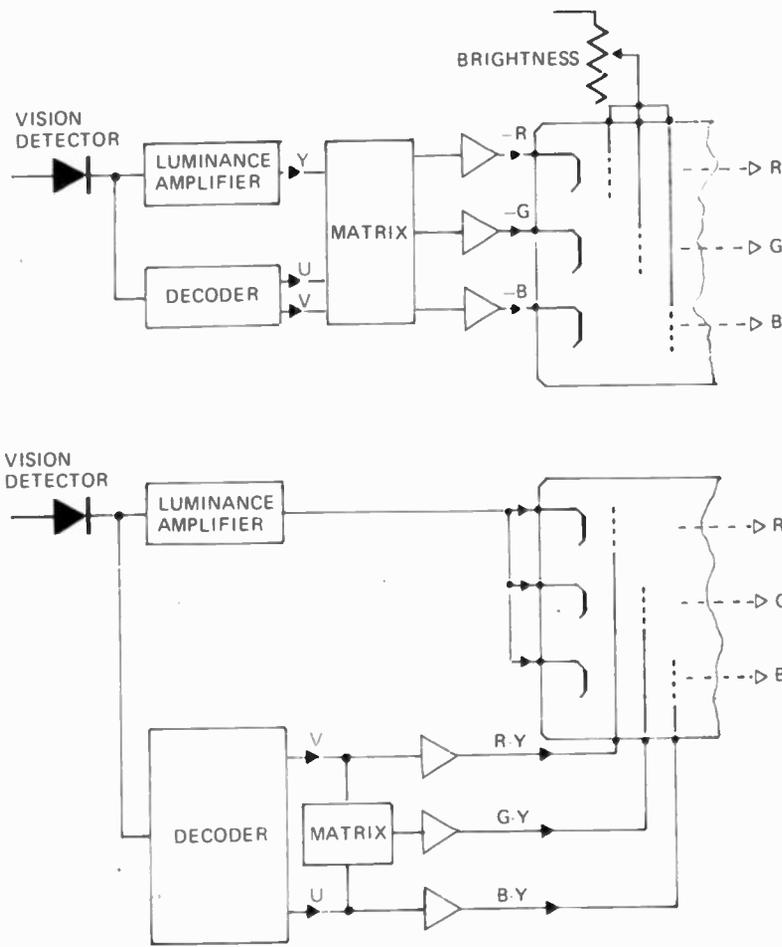


Fig. 39a) Primary colour drive. b) Colour-difference drive.

with the grid fixed gives exactly the same beam modulation as does R-Y on the grid with Y on the cathode. The decoder we described in Part 5 (Fig. 34) was one intended for colour-difference drive.

The pros and cons of the two methods are various. Colour-difference drive has the advantage that most matrixing is eliminated. Only the luminance amplifier needs to have a wide frequency response since the three colour-difference signals have small bandwidth. Brightness control is not simple to apply though and involves clamping the luminance signal to a variable voltage. Primary colour drive involves only three identical drive amplifiers and many aspects of receiver design are simpler. Primary colour drive to the grids is also possible but cathode drive, as used in nearly all monochrome receivers, has the advantage of greater tube gain.

To continue our dissection of the electron guns:—

First Anode This is held positive with respect to the cathode by 200 to 500 V and attracts the electron beam from the cathode through the grid. The three 'A1' voltages can be adjusted in the receiver to allow the efficiencies of the three guns to be matched; these controls are often

called 'background' controls since they are intended to balance the guns near cutoff to ensure neutral dark grey tones. Switches are usually provided for removing individual A1 supplies. This ability to disable individual guns is necessary for the vital adjustments of purity and convergence, to be described.

Focus Anode All three focus anodes are linked inside the tube and are operated at about 4500 V.

Third Anode This is formed by a conductive coating on the inside of the tube flare with a special connector moulded into the glass. It is operated at the very high potential of 22 to 25 kV.

The effects of the three anodes at progressively higher potential are:

a) To accelerate the electron beam to a very high velocity towards the screen phosphors which it strikes at about 320 000 000 km/hr! A monochrome tube can provide adequate brilliance with rather less electron energy (a typical third anode voltage is 16 kV) but, as will be seen, the shadowmask colour screen is less efficient than a simple monochrome phosphor.

b) The potential differences between A1 and A2 and between A2 and A3 (using alternative nomenclature for the anodes) represent electrostatic lenses which focus the electron beams on to a small spot on the screen. The second anode is called the focus anode because the spot size is optimised by adjusting its voltage.

Convergence Plates These serve to concentrate magnetic fields applied from outside the tube on to individual electron beams to adjust the relative positions of the three images on the screen.

Getter Ring During manufacture its barium filling is evaporated on to the tube glass. This 'gets' or absorbs any gas molecules left in the tube after evacuation and sealing; these molecules tend to escape from inner surfaces during use.

Shadowmask This is a steel plate perforated with thousands of tiny holes which is mounted in the path of the electron beams just before the screen phosphors deposited on the inside faceplate. Its function is to ensure that through each hole each electron gun can 'see', because of its position, only a dot of the correct primary colour phosphor — see Fig. 40. Thus more than 2/3rds of the electrons emitted by each gun are merely absorbed by the shadowmask while the remainder pass through to a particular set of phosphor dots. Hence the inefficiency of light production compared with a monochrome tube which has a continuous phosphor and of course no shadowmask.

Enormous precision is needed in the positioning of the phosphor dots relative to the shadowmask. First the

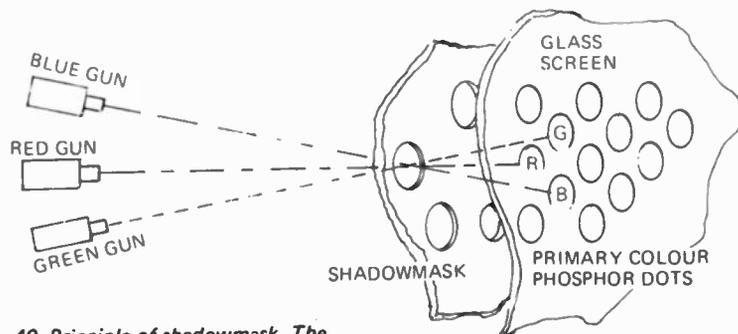


Fig. 40. Principle of shadowmask. The beam from each gun can only reach the phosphor dots of one colour.

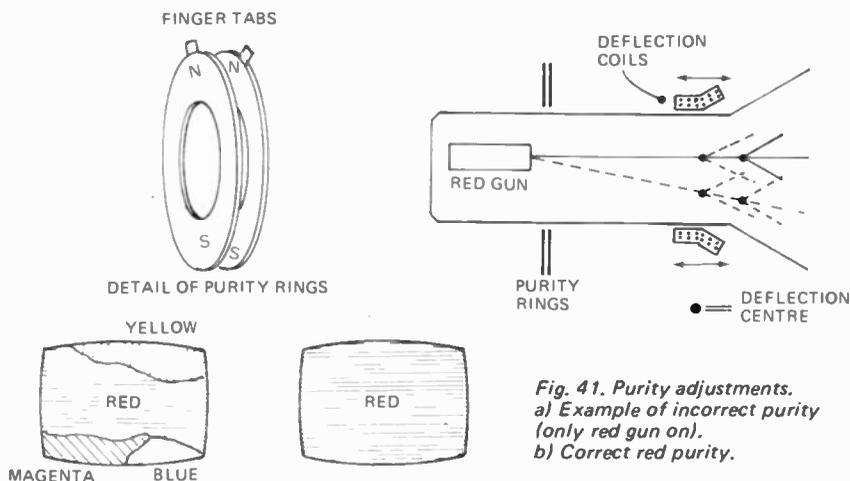


Fig. 41. Purity adjustments. a) Example of incorrect purity (only red gun on). b) Correct red purity.

shadowmask is fixed in place. Then a slurry of photosensitive material and the phosphor of one primary colour is run onto the screen through the shadowmask. A small ultraviolet light is then shone on the shadowmask from the position the relevant electron gun will occupy. The dots of light cast on the slurry cause the phosphor to be fixed in place at these points; the rest is washed away. The process is repeated for the other two phosphor colours with the light in different positions to yield a three-colour screen as in Fig. 40.

PURITY

The three electron beams are magnetically deflected in unison by a set of horizontal and vertical deflection coils mounted on the tube neck. These are fed with sawtooth waveform currents at the correct scanning frequencies to cause the beams to scan the standard television raster.

Although the beams are actually bent along a curve as they pass through the field of the deflection coils there is an abstract 'deflection centre' from which all deflected beams from a particular gun seem to originate. This deflection centre must lie exactly where the

corresponding ultraviolet source was placed during manufacture of the tube, otherwise the shadowmask cannot allocate the three beams to the three types of phosphor properly. Because of the manufacturing tolerances involved it is necessary to provide adjustments to the deflection centres, known as purity adjustments since they ensure the raster scanned by each gun is a pure primary colour.

The adjustments available are shown in Fig. 41. Immediately after the focus anode the electron beams pass through a steady magnetic field across their path produced by two rotatable ring magnets — the 'purity rings'. The strength of this field can be adjusted by relative adjustment of the rings toward assisting or counteracting each other, and its direction can be varied by rotating the rings together. The effect of the field is to bend the paths of the three beams slightly (only the red gun is shown in Fig. 41). The purity rings resemble the picture shift magnets fitted to monochrome tubes but have the different purpose of shifting the effective beam deflection centres up or down, right or left inside the deflection coils. The normal procedure is to switch on one gun alone (usually red) and adjust the purity rings for a pure red raster.

However the best obtainable may resemble Fig. 41a). Here purity is only correct near the centre of the screen i.e. zero deflection current. The cure is to shift the deflection centres fore or aft. The deflection coils are held in a sliding mount to allow this adjustment. After achieving red purity (Fig. 41b), only slight trimming is needed to obtain equal purity from the blue and green guns.

MAGNETIC EFFECTS

Since electrons are readily deflected by magnetic fields it is important that only wanted magnetic fields are allowed to exist inside the shadowmask tube if good purity is to be obtained. A magnetic shield of iron or steel sheet is fitted around the outside of the tube flare to minimise the effect of stray alternating fields in the receiver e.g. from the line output and possibly mains or audio transformers.

The earth's magnetic field, although weak, can permanently magnetise the steel shadowmask and cause purity errors. The tube may be exposed to other magnetic fields during its life, e.g. from vacuum cleaner motors, under-floor electric heating or from railway equipment if ever transported by train! These possibilities are dealt with by arranging for the shadowmask to be automatically demagnetised every time the receiver is switched on. This is done by applying a strong ac field (500 ampere-turns copes with all likely magnetisation) for a fraction of a second, decaying progressively to a negligible value (0.3 ampere-turns causes no visible effect on registration). A similar process is used for bulk erasing magnetic tapes; it is loosely called *degaussing*. The degaussing coil is fixed around the tube shield in such a way that the shield acts as a pole piece for the alternating field to help direct it on to the shadowmask. A typical degaussing circuit makes use of a ptc (positive temperature coefficient) thermistor and a vdr (voltage dependent resistor) — see Fig. 42.

At switch on, the thermistor is cold, (low resistance) so heavy ac current flows through P, vdr and the coil L. Power dissipated in P causes its temperature and resistance to rise so less voltage appears across vdr and L. Since the resistance of vdr increases with decreasing voltage, the current in L rapidly diminishes and diverts to R which keeps P hot during viewing.

In the early days of colour a portable mains-powered degaussing coil was standard equipment for servicemen but automatic degaussing circuits as in Fig. 42 now make this unnecessary except for extreme cases.

To be continued . . .

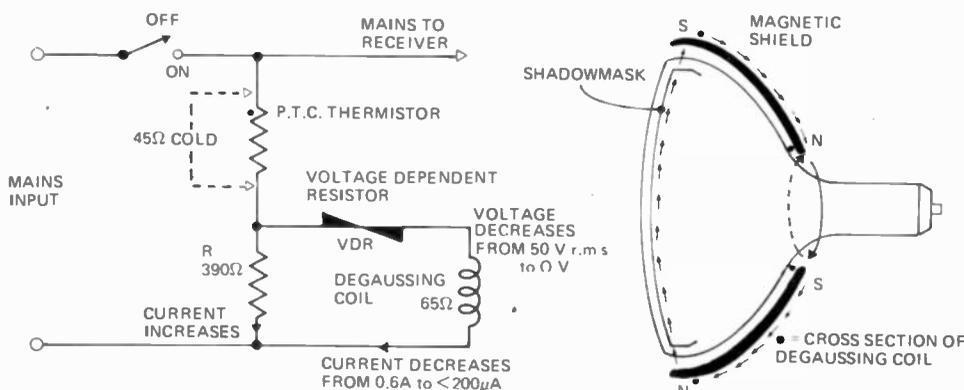


Fig. 42a) Automatic degaussing circuit. b) Cross section of tube showing instantaneous flux during degaussing.



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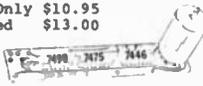
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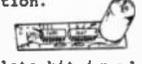
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ELECTRONICS

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PART 19

All about electronic filters

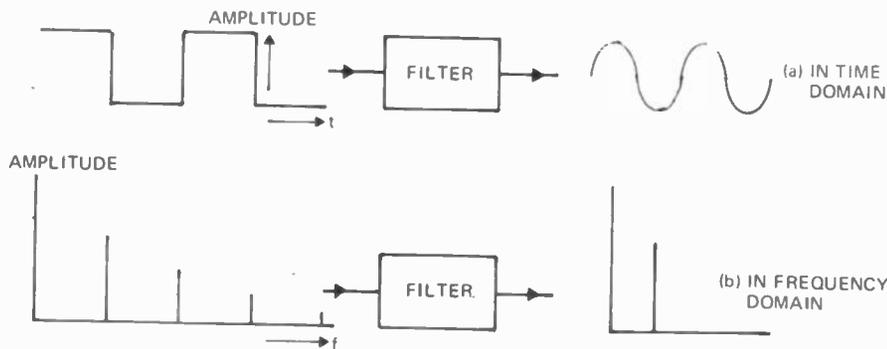


Fig. 1(a). A filter alters the frequency content of a signal. This means the wave shape is changed when displayed as an amplitude-time graph. (b). Using the frequency spectrum form of display the filter removes (or enhances) certain frequencies.

correct for the non-linear attenuation versus frequency which occurs with long-line telephone communications.

ALTERING THE FREQUENCY RESPONSE

Electronic filters, in a general sense then, alter the frequency content of signals. Their action can be comprehended first by considering the stage as a unit that alters the amplitude/time shape of an input waveform. This concept is illustrated in Fig. 1a where a square-wave is filtered to remove all but its fundamental sine wave. Alternatively, filters may be thought of as devices that change the frequency spectrum. This is illustrated in Fig. 1b. Both concepts are correct, each finding use to suit different needs.

TO SEPARATE peas from boiling water, or dirt from engine oil, one must use an appropriate filter. When the term filter is used, in any discipline, the meaning is always the same — it is a device for separating or selecting something from an available mixture or range of things.

Filters are also extensively used in electronics where they are used to select a desired part of the range of frequencies which make up a particular signal. We have seen many examples of this throughout our course so far. For instance, in our discussion of multiplexed telephone

systems, we saw how it is necessary to *separate* the various frequency channels and pass them to individual outlets. We also saw how an LC tuned circuit is used to *select* only one desired radio broadcast station from the many available.

Other examples of the use of filters are the crossover networks used in hi-fi speaker systems, to divide the audio bandwidth between two or more speaker drive units, the compensation stages in instrumentation control systems which improve performance by attenuating or enhancing relevant frequencies or the filters used to

We generally think of filters as devices which change the amplitude of the signal with frequency. However, filters may also change the phase of the signal. In many applications the phase shift is undesirable and must be considered when making the selection of filter type.

Unlike other circuit blocks which are available as built up units, filters are generally made specifically for the task.

Many filters are extremely simple — varying from two components to (say) ten and the design procedures of most are easily found in texts. This is not, however, to say that filters are trivial and not worth learning about. Filter designs may be grouped into two main classes — those called passive filters (Fig. 2a) that use passive components only — such as resistors, capacitors and inductors; and those called active filters (Fig. 2b) that are based upon an op-amp using single or multiple path feedback loops. Design procedures can be quite complicated but because of the universal need for a few basic types of response, most design is now a matter of applying simple formulae or using graphs to arrive at the component values.

By way of interest the design philosophy of filters — or any network requiring a given frequency response — can proceed two ways. First, one can propose a network configuration and then mathematically analyse it to get the generalised formula. This is called network analysis. The alternative and more modern approach (in the last few decades, that is) is to start with a mathematical expression of the

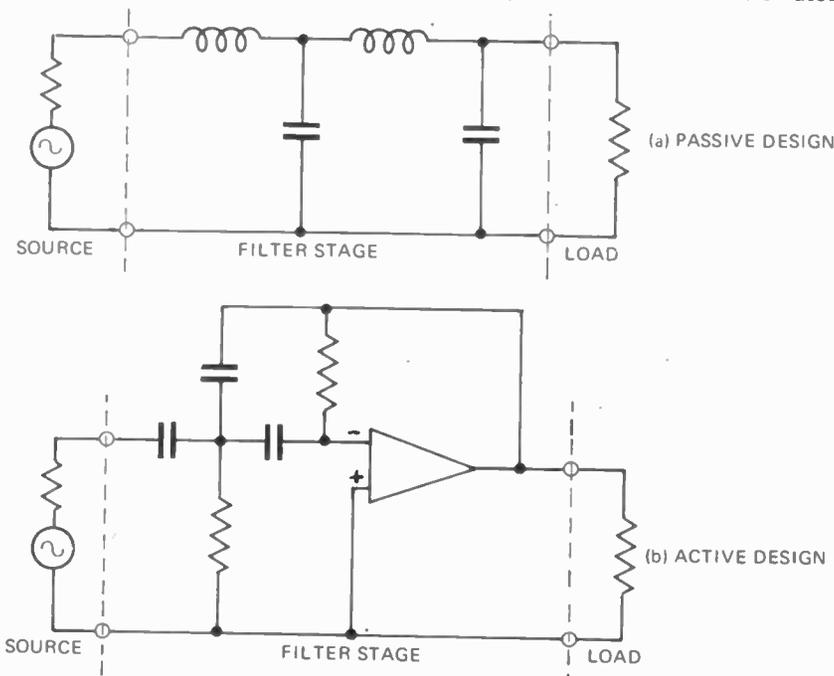


Fig. 2(a). Passive filters use R, L, and C components only. (b). Active filters incorporate active elements with passive elements to great effect.

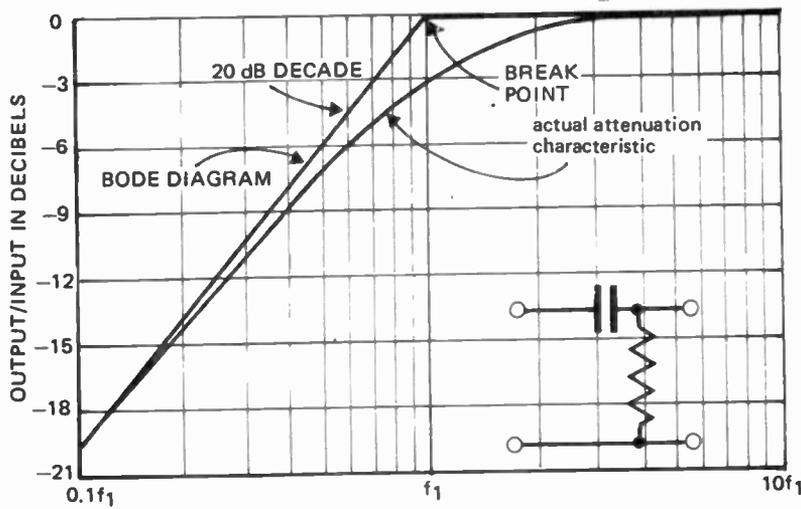


Fig. 3. Bode diagrams usually express amplitude (and phase) variation with frequency in terms of simplified responses consisting of straight lines turning at break points. The actual response will be more gradual near the breakpoint.

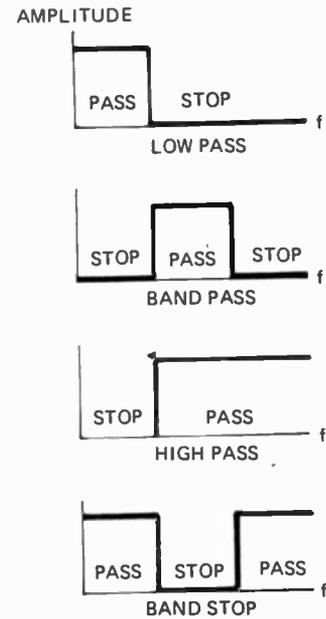


Fig. 4. Idealised responses of various categories of filter.

frequency response needed and, by using appropriate mathematical procedures, create on paper the circuit needed to provide such a response. This is called circuit synthesis. The latter method has a certain fascination because it provides the answer in a more logically direct manner than the cut and dried analysis process (although sometimes one ends up with a requirement for non-realisable circuit needs such as negative frequency!). On the other hand, however, synthesis requires mathematical ability and considerable experience.

In the following sections we will analyse a few of the more common filter stages.

THE BODE DIAGRAM

One of the, now classical, works on network analysis is a book "Network Analysis and Feedback Amplifier Design" by H. W. Bode published by Van Nostrand in 1945. Today Bode's work is mostly remembered by the

graph which carries his name and relates the amplitude, or phase shift, to frequency for an amplifier, feedback system or a frequency modifying stage such as a filter. There is, at least, in principle, no distinction between the frequency response plots we have discussed to date and the Bode diagram. In practice, however, Bode diagrams are usually mathematical simplifications in that they are drawn with straight lines only, these lines changing direction at what are known as break-points and sloping at known rates.

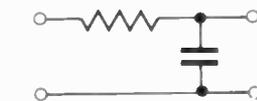
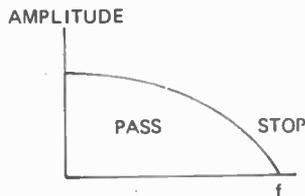
The Bode diagram exemplifies the behaviour of a circuit as a tool, and is derived from mathematical knowledge of the system, not from actual tests. In truth, the linearization simplification is usually not far from reality, and we will meet Bode diagrams in our study of filters. Fig. 3 shows the difference between a Bode diagram and an actual response plot for an RC filter. The Bode diagram plots signal amplitude in

decibels on a linear scale against frequency on a logarithmic scale.

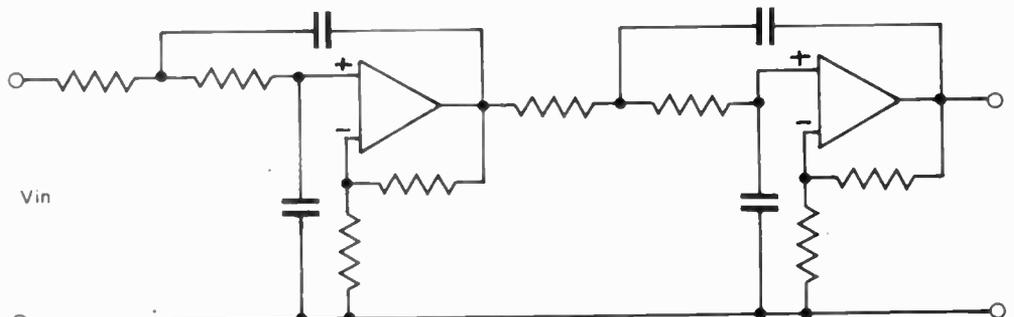
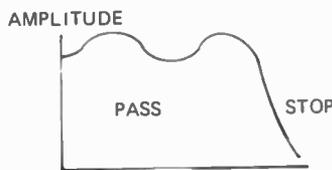
TYPES OF RESPONSE

As with amplifiers, filter frequency responses are grouped into low-pass, band-pass and high-pass. Theoretically, ideal filters would have responses as shown in Fig. 4. There is also a constant need in electronic systems for a band-stop stage.

In reality it is impossible to obtain exactly square response curves. The response always rises or falls, within the transition region, with a rate of steepness that depends on the design used. A general rule is that the simpler the design (least number of components) the more gradual will be the transition. Also the more rapid the transition the more likely are effects of "ringing" encountered. Do not confuse these concepts of shape with amplitude-time wave shape graphs: these are amplitude (phase) - frequency curves. To illustrate this concept compare the two extremes given in Fig. 5. Figure 5a is for a most basic RC stage, Fig. 5b is for a response having rapid cutoff - a Chebyshev filter stage.



(a) SIMPLE R.C. LOW PASS FILTER STAGE



(b) FOURTH ORDER CHEBYSHEV STAGE

Fig. 5. As a general rule the more complex the filter circuit, the sharper the roll-off but the more variable the response in the passband region. (a) RC low pass stage. (b) Advanced Chebyshev stage.

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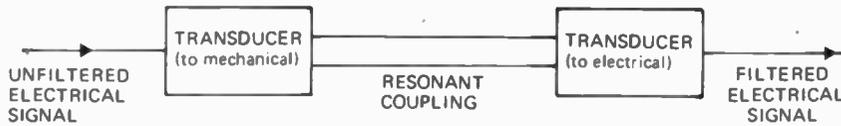


Fig. 6. By converting the electronic signals to mechano-acoustic form it is possible to make use of the extreme sharpness of mechanical resonant systems.

It is also worth noting that no filter is perfect, for frequencies are only attenuated relative to each other. If a signal appears at a high enough level at the input of a filter stage it will appear at a reduced level in the output and could be troublesome. Acknowledging this, the degree of attenuation chosen should be matched to the circumstances expected. It is pointless (and unnecessarily expensive) designing a stage to provide, say, 120 dB reduction of the unwanted frequency if it never reaches more than, say, 10 dB of the wanted frequency, apart from which an unwanted signal which is more than 60 dB down on the wanted one rarely causes problems.

DEFINING THE RESPONSE BANDWIDTH

As realistic filters fall short of being ideal there is no clear-cut point, where the response changes markedly enough, to use as the criteria for defining bandwidth. In some simple filters we could use the apparent position of the breakpoint but this would not hold for all filters.

The convention used is that the cut-off point is defined as where the response power falls to one-half of the passband value. Half power, expressed as a voltage change, is 0.707 of the passband voltage level which is -3 dB in decibel units. (Often called the '3 dB down' point.)

The bandwidth of bandpass (or bandstop) filters is, therefore, the frequency interval between the two cut-off points situated on each side of the bandpass (or stop) region. Bandwidth of a high-pass design has no real meaning as the frequency rises to infinity. Low-pass units have a band-width from zero frequency (dc) to the cut-off value.

In the case of complex designs the stated response often omits what happens at frequencies remote from the usual frequencies of interest. It is wise never to assume that, say, a bandpass filter only passes frequencies between the design points. It may well have "windows" much removed from that region. Additional stages are added in some system designs to exclude these effects.

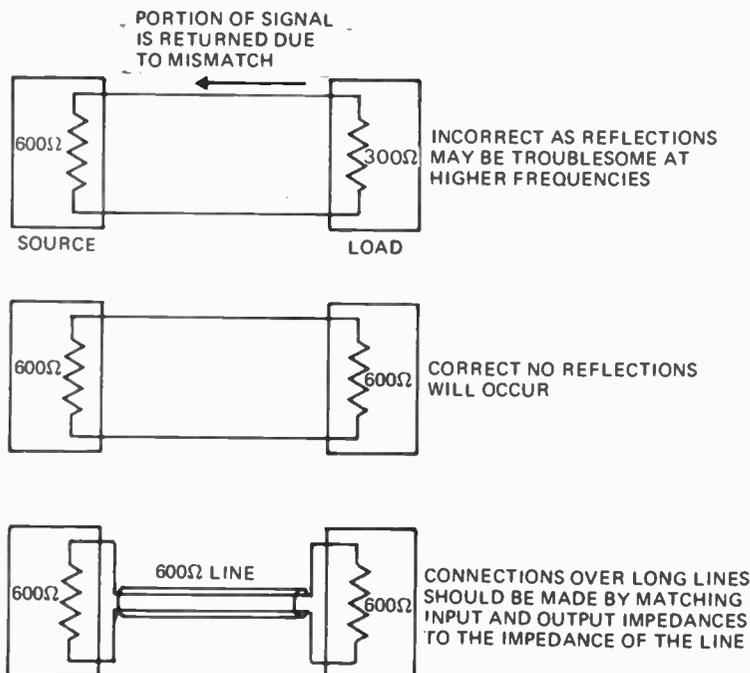


Fig. 7. Reflection of RF energy will arise if stages are not terminated into each other with the same impedance. Filter stages should observe this requirement.

Whereas the majority of filters used in electronic systems are made solely from electronic components there do exist circumstances where transduction to mechanical principles for filtering, and back again to electrical, are advantageous. One example is the use of tuned resonant reed filters, such as is depicted in Fig. 6, which exhibit extremely narrow band-pass characteristics.

Often the response of a bandpass is expressed in terms of its quality factor - that is the Q-factor of the peak. This definition was discussed when we dealt with resonant circuits earlier in the course.

THE EFFECT OF ADDING A FILTER

When the main purpose of adding a filter is to alter the frequency composition of signals it is not unexpected that the other effects brought about by its insertion might be overlooked.

As in any system changed by the addition of a cascaded 'box', the output of the preceding stage and the input of that following must be considered from the loading point of view. It is quite unrealistic to design a stage in isolation, unless the filter stage is adequately buffered, for the impedances connected to its input and output will alter the cut-off points - and hence different values will be required to achieve the designed characteristic.

The term 'Insertion Ratio' will often be encountered, it describes the ratio of output voltage with and without the filter, that is, the voltage Insertion Ratio = $\frac{V_{out} \text{ (no filter)}}{V_{out} \text{ (with filter)}}$

Expressed in decibels of loss we arrive at the term Insertion Loss = $20 \log_{10}$ (Voltage Insertion Ratio). In practical cases, however, one may well design a stage to provide insertion gain (especially in active filter stages).

When matching a filter into a system it may be important to conserve power, voltage or current. To ensure maximized power transfer the input impedance to the filter must be of the same value as the output impedance of the stage before. Similarly, its output must be terminated into the same value. If voltage levels are to be maximized then the filter input impedance must be much higher than the output impedance of the driving stage. Current maximization requires the reverse relationship.

When the frequency of operation is high another problem becomes significant - that of reflections. When energy is launched into a network containing storage elements - a filter stage is such - some of the energy

may be returned to the source which, in turn, may reflect it again, the final situation being that the net sum of all of these travelling waves of energy cause excessive power losses in the line (and distortion). This effect is very pronounced in radio-frequency transmission lines.

The extent to which a reflection occurs is decided by the degree of difference in the impedances seen in both directions at a system block junction. If a filter is terminated into the source with the same impedance in both directions there is no mismatch and no reflection occurs. This concept is depicted in Fig. 7.

As the two impedances differ in magnitude so does the amount of signal reflected. A similar situation applies at the output of the filter.

Mismatch terminations begin to generate noticeable spurious signals this way from megahertz frequencies upwards. This is the reason why wide-bandwidth amplifiers, such as videoamps, must be designed with output impedances that match the feeder cable. Coaxial cable can be shown to have a characteristic impedance set by the ratio of size and spacing of its conductors. It is invariant with length of cable. Typical coaxial cables have impedances of 50 or 75 ohm. Alternatively another kind of cable having two wires with a fixed separation between them may be used. Such transmission lines have typical impedances of 200, 300 or 600 ohms. Whilst on this subject, one way of locating open-circuit and short circuit faults in cables is to send a sonic pulse (these travel much slower than electromagnetic waves) down the cable — timing the arrival of reflected pulses produced by the gross mismatch that exists at the fault.

Filter stages, as said before, also introduce phase shifts. A sine-wave input will appear at the output shifted in time by some fraction of the electrical cycle. In the compensation networks of feedback controllers phase shift must be carefully controlled, for a wrong value of phase shift may cause the system to become unstable. That is, if the phase shift approaches 180°, the feedback becomes positive, instead of negative, and the system oscillates.

PASSIVE DESIGNS

THE RC FILTER

The simplest passive electronic filter is the RC network set to act as a low-pass or high-pass stage. The two alternatives are shown in Fig. 8. In Fig. 8a it is easy to see that at low frequencies the capacitive reactance is very high and the output is the same as the input, provided the load

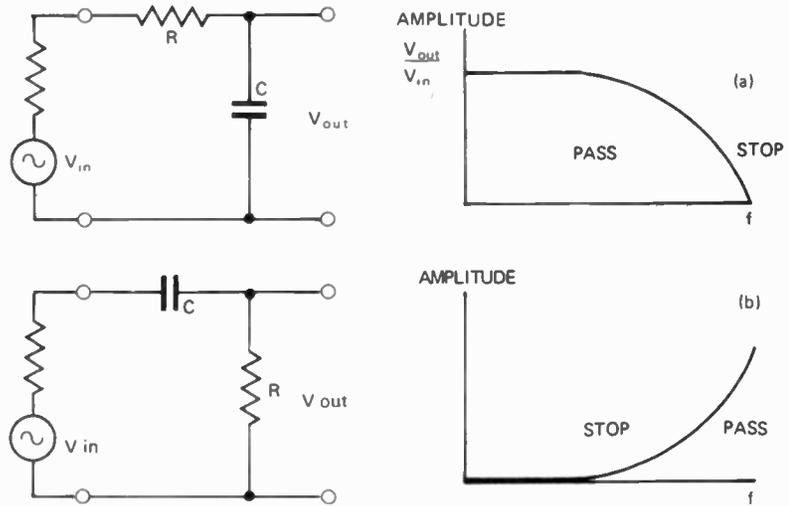


Fig. 8. Basic RC filter stages (a) low-pass (b) high-pass.

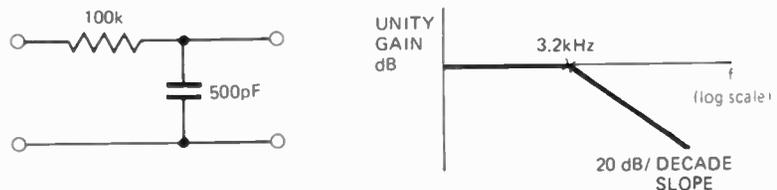


Fig. 9. Bode diagram for low-pass RC filter in which source and load are not significant.

impedance connected is significantly higher than the value R. As the frequency rises X_C decreases, lowering the output voltage. The reverse situation applies for the high-pass unit.

Mathematical analysis shows that the response plot — the Bode diagram — for these can be constructed by recognizing that there is just one breakpoint and that the response falls away at 20 dB/decade change in frequency (ie 6 dB/octave). An octave change corresponds to 2 : 1 frequency ratio; a decade change is a 10 : 1 ratio. The jargon used is that the response rolls-off at the stated rate. Regardless of the values of RC chosen the roll-off rate stays the same. The breakpoint occurs at $f_c = \frac{1}{2\pi RC}$.

To illustrate this consider the construction of the Bode diagram for a low-pass filter with $R = 100$ kilohms and $C = 500$ pico-farads. The breakpoint occurs at

$$f_c = \frac{1}{6.28 \times 100 \times 10^3 \times 500 \times 10^{-12}}$$

and it slopes downward from there at 20 dB/decade to give the plot shown in Fig. 9.

This much may seem almost trivial and, indeed, it is over-simplified. In

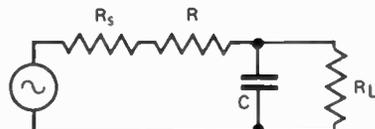


Fig. 10. Practical RC filter designs should allow for source and load resistances.

practice there will be a source and a load impedance connected to the filter terminals. Fig. 10 shows the practical case in general.

It is also not hard to reason out what happens when the source and load impedances are taken into account for R_s is in series with R and R_L is in parallel with C. By expanding our mathematics we find that the formula becomes

$$f_c = \frac{1}{2\pi [R_s + R] // R_L C}$$

Hence, if the stage is not buffered the breakpoint can be quite different from that arrived at from the time-constant of the filter alone. For example if load and source impedances are both 1 k in our previous example the breakpoint changes from 3.2 kHz to 2.66 kHz. Further, the stage will introduce attenuation: the gain in the passband becomes

$$\frac{V_{out}}{V_{in}} = \frac{R_L}{R_s + R + R_L}$$

$$\text{for our example} = \frac{1000}{1000 + 5000 + 1000} = 0.4$$

By use of appropriate values of source and load resistance it is possible, therefore, to set the attenuation and draw an appropriate Bode diagram.

The high-pass RC filter is considered in the same way — to arrive at

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$$f_c = \frac{1}{2\pi (R_S + R // R_L) C} \text{ and}$$

$$V_{out} = \frac{R // R_L}{R_S + R // R_L}$$

for the practical case where source and load impedances cannot be ignored.

The observant reader will probably have realised that an amplifier stage with capacitive coupling has an equivalent circuit that is a combined highpass and lowpass filter with gain added between. The high-pass response arises from the coupling capacitor and the stage input impedance, the low-pass response from the output impedance and the stray capacitance existing to ground.

It is possible to combine a low-pass RC stage with a high-pass stage to arrive at a bandpass filter. These,

however, are not particularly selective bandpass filters because of the relatively poor roll-off slopes (20 dB/decade). Further, if the bandwidth required is small, the two stages interact producing a non-constant passband gain. To obtain a satisfactory design it is important to ensure that the second stage resistance (the shunt of the high-pass stage) is at least ten times that of the first (the series resistance of the low-pass stage). Also the two break points should be at least a decade apart.

RC NOTCH FILTERS

Some applications call for rejection of a narrow band of frequencies, the reduction of 50 Hz or 100 Hz noise, for example. A very effective, yet, inexpensive technique makes use of a type of Wheatstone bridge which requires only resistors and capacitors and yet provides very sharp roll-off.

The Twin-T or parallel-T notch filter is such a circuit and is shown in Fig. 11. (It can be redrawn as a more-obvious bridge circuit and comprises two T circuits connected in parallel). At high or low frequencies it is easy to see that the capacitances either go to low or high reactances providing in both instances a virtually unaltered signal level through the stage. At the balance point, of a twin-T bridge, there exists a frequency — the so-called notch — at which the output falls very nearly to zero. This occurs for the circuit of Fig. 11 at

$$f_c = \frac{1}{2\pi RC}$$

Loading will reduce the depth of the notch.

In some applications it is desirable to be able to tune the notch to varying frequency values. In the Twin-T design this requires that all three resistors (or capacitors) be varied simultaneously. A ganged multi-unit potentiometer or capacitance bank is used.

Other forms of bridge filter exist, each having its own particular feature. No simple RC circuits exist that exhibit the reverse characteristic of the notch filter — that is spike acceptance

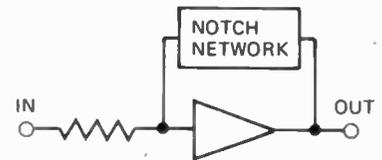


Fig. 12. Notch acceptance can be provided by using a notch-rejection circuit in the feedback of an op-amp.

of a particular frequency. This response however, can be provided by using a notch-filter as the feedback impedance in an op-amp that is set up as a simple inverter. This is shown in Fig.12. In this way the gain of the stage rises rapidly with increase in effective feedback resistance at the notch frequency.

IMPROVING THE ROLL-OFF

RC filters, apart from notch circuits, cannot provide much selectivity between signals due to their poor 20 dB/decade rolloff. This slope can be improved by cascading stages but this is not a preferred method for there exist other more economical designs.

The next stage of complexity is to use designs combining inductors and capacitors: no resistors are needed. That these provide improved roll-off is to be expected for we have seen earlier in this course that a resonant circuit can provide very sharp responses. By way of example a single stage LC filter can provide at least 12 dB and up to 25 dB/octave rolloff compared with only 6 dB/octave for an RC stage, and furthermore methods have been established (discussed in next part) that enable these to be cascaded without difficulty — a four stage unit can achieve 100 dB/octave rolloff! It is even possible to 'peak up' a specific frequency in the passband. In the next part we will also explain the virtues of adding amplifiers to form active filter circuits.

FURTHER READING:

Electronic Instrumentation Fundamentals" — A.P. Malvino, McGraw Hill, 1967. (This has a fine chapter on RC and LC filters which is not complicated with circuit analysis and mathematical symbology).

"Radiotron Designers Handbook" — F. Langford-Smith, A.W.V. 1955 and subsequent editions. (Covers RC filters and supplies response graphs in a small section).



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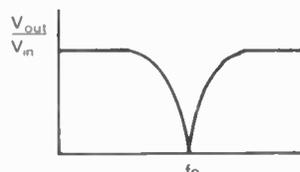
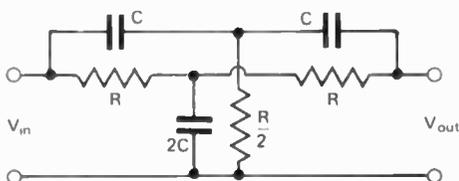


Fig. 11. The Twin-T notch filter provides very narrow rejection of a particular frequency.

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7423	.32	7491	1.00	74180	1.00
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7426	.29	7493	.79	74182	.89
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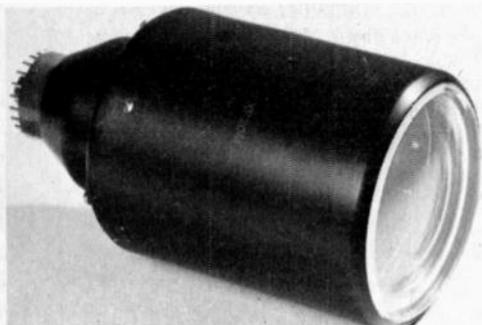
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COMPONENT NEWS

FAST RESPONSE PHOTO-MULTIPLIERS HAVE TWO NANOSECOND RISE TIMES



The XP2040 and XP2041 are two new fast response photomultiplier tubes designed for nuclear physics applications. They are marketed by Elcoma — the Electronic Components & Materials Division of Philips. Both tubes are extremely fast for their use where the number of photons to be detected is very low, or where good time characteristics are required, such as in coincidence measurements and Cerenkov counters.

The XP2040 is a head-on 14-stage tube with a semi-transparent extended UV S11 (type A) photocathode having a typical spectral sensitivity of 70 mA/W at 437 nm. The XP2041 is a similar tube with an extended UV bi-alkaline (type D) photocathode with a spectral sensitivity of 85 mA/W at 401 nm. The useful photocathode diameter of both tubes is 110 mm.

The tubes are supplied with planoconcave plastic adapters having transmission starting from 300 nm; for transmission down to 200 nm, the tubes can be supplied with quartz adapters under type numbers XP2040/Q and XP2041/Q.

PRAGMATICALLY-SPECIFIED TRANSISTORS FOR POWER CONTROL

Motorola has introduced a series of power transistors specifically designed for high-voltage power switching applications. Initial devices in this series are 2N6542 through 2N6547 NPN, triple-diffused, silicon transistors.

The so-called Switchmode series may be beginning a new way of characterising semiconductors for power applications. Before Switchmode, designers of power



equipment had to use devices that were often only specified for resistive loads at room temperature operation. But real applications do not always conform to such simple constraints. Consequently, the designer was faced with the task of using minimally-specified power devices that had to operate at high temperature and had to control reactive loads. The characterisation of the Switchmode devices will alleviate the designer of such problems.

Features in the Designers Data Sheets are all significant specifications at high temperature ($T_C = 100^\circ\text{C}$) for secondary breakdown under base forward-biased and base reverse-biased conditions.

Dynamic voltage capabilities, test conditions, switching circuit examples and applications information are also included on the data sheets.

Motorola Pty Ltd, 37 Alexander St, Crows Nest, NSW 2065.

OPTOELECTRONICS STATUS GUIDE

A new guide being offered by National Semiconductor succinctly portrays the company's rapidly expanding optoelectronics product line.

The Optoelectronics Status Guide lists all current and many future products: numeric arrays, single numeric digits, LED lamps, opto couplers, display dice; and accessories.

The guide also lists apparent size and magnification for the arrays, indicates package styles for the lamps, and recommends new alternates for certain, older, digital displays.

A copy of the single page, three-ring-punched optoelectronics Status Guide may be obtained by writing to NS Electronics, Cnr. Stud Road & Mountain Highway, Bayswater, Vic 3153. Telephone: 729-6333.

CONTACT BOUNCE ELIMINATOR

The MC14490 Hex Contact Bounce Eliminator is the latest addition to Motorola Semiconductor Product Division's "14400 series" CMOS digital subsystem family.

This bounce eliminator takes a signal from any mechanical closure (switches, relays, etc.) and generates a clean, digital signal that is free from the spurious noise normally generated by such a closure.

The new device 'debounces' any switch type (even single-pole, single throw), has six debouncers per package and pullup resistors on the chip. In addition, it has an internal oscillator for setting debounce delay and it dissipates little power.

The MC14490 is one of the more universal functions in Motorola's "14400 series", in that it can be used anytime there is a digital design requirement to interface with a signal generated by a mechanical closure. Although it can be used to debounce any type of mechanical switch configuration, it is most cost effective in those applications,

such as the telephone industry, where debouncing of a single-line signal is required.

This debouncer, like other devices in the Motorola "14400 series", comes in several varieties to fill varying customer operating needs.

Motorola Pty Ltd, 37 Alexander St, Crows Nest, NSW 2065.

GUIDE SUMMARIZES NATIONAL'S LED LAMPS

A new guide to National Semiconductor's broadening line of LED lamps is now available. The two page, loose leaf sized LED Lamps Guide lists all the numbers of all NSC lamp series, plus future lamp products soon to be available.

For each part listed, the guide's first page gives a brief lens description, and power dissipation, I_f Max., PIV V_f and luminous intensity (I) figures. All packages are fully described and dimensionally defined.

The second page is a replacement guide, which lets LED users easily select the proper National LED replacements for lamps made by 10 other major, competing manufacturers.

NS Electronics Pty Ltd, Cnr Stud Road & Mountain Highway, Bayswater, VIC 3153.

HOW TO AVOID FAILURES IN OPERATING SILICON IMPATT DIODES

Four factors that contribute to failures in operation of silicon double-drift IMPATT diodes are discussed in detail in this new Hewlett-Packard Application Note 959-1. The four-page note describes problems caused by fabrication defects, excessive junction temperature, bias circuit related burnout and tuning induced burnout. Designers of high power pulsed or CW microwave sources can avoid, in most cases, failures by taking into consideration these four predominant failure mechanisms.

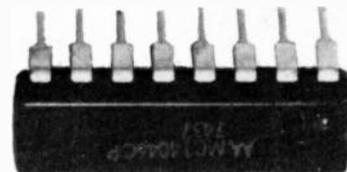
Hewlett-Packard Application Note 959-1, 'Factors Affecting Silicon IMPATT Diode Reliability and Safe Operation' is available free of charge, by writing to:

MARCOM Department, Hewlett-Packard Australia Pty. Ltd., P.O. Box 36, Doncaster East, VIC. 3109.

CMOS PHASE LOCKED LOOP

Motorola Semiconductor Products Division has announced the availability of its first CMOS phase locked loop.

Designated the MC14046, the new device



COMPONENT NEWS

contains two phase comparators, a voltage controlled oscillator (VCO) and a zener diode to assist in supply voltage regulation. It operates at a VCO frequency up to 1.4 MHz ($V_{DD} = 10$ Vdc). Power dissipation is in the micro-watts for typical applications.

Like Motorola's bipolar PLL devices, this CMOS PLL compares the frequency and phase of the incoming data to the output of a VCO. If the two signals differ in frequency and/or phase, an error voltage is generated and applied to the VCO, causing it to correct in the direction required for decreasing the difference. The correction procedure continues until lock is achieved, after which the VCO will continue to track the incoming signal.

The medium speed and lower power of the CMOS PLL are needed for applications such as frequency synthesis and multiplication, voltage-to-frequency conversion, and data synchronization and conditioning. Its use is a cost-effective approach in computer peripheral, communications, instrumentation and motor controls design.

Motorola Pty Ltd, 37 Alexander St, Crows Nest, NSW 2065.

HIGH CURRENT OIGIT DRIVER DEVELOPED BY NATIONAL

A new LED digit driver, specifically designed to be used in digital clocks and

desk-top calculators has been developed by National Semiconductor Corp. Called the DS8863, the new digit driver contains eight independent channels, each of which is capable of sinking up to 500 milliamps. It is intended for use in display systems employing LED's in a common cathode multiplexed configuration. Because of its large current carrying capability, the DS8863 can be used with LED displays 0.6 inch high and with digits made up of individual lamps.

The DS8863 interfaces directly with MOS clock and calculator circuits so a complete system can be assembled with a minimum of components. All that's required to drive the DS8863 is a maximum of two milliamps at the input.

For further information: NS Electronics Pty Ltd, Cnr. Stud Road & Mountain Highway, Bayswater VIC 3153.

USING SILICON IMPATT DIODES IN HIGH POWER MICROWAVE PULSE APPLICATIONS

With double-drift IMPATT diodes, larger power outputs are available than from single-drift diodes. A new 12-page Application Note from Hewlett-Packard compares single drift and double drift diodes showing how higher powers are achieved with the double-drift construction.

Factors to be considered in microwave circuit design are discussed in detail, as well as the pulse performance capabilities of these diodes.

Hewlett-Packard Application Note 961 also describes pulse amplifier and adder circuits which meet the general requirements presented by pulsed silicon double-drift IMPATTs.

Application Note 961, 'Silicon Double-Drift IMPATT Diodes for Pulse Applications' is available free of charge, by writing to:

MARCOM Department, Hewlett-Packard Australia Pty. Ltd. P.O. Box 36, Doncaster East, VIC. 3109.

NEW OICK SMITH CATALOGUE

A new 64-page Dick Smith catalogue is now available.

Apart from some price changes, the latest edition of this most valuable catalogue contains a substantial number of items not previously included.

The catalogue costs 50 cents, but contains two vouchers each of which returns the sender 25 cents for goods ordered to a value exceeding \$10.

Dick Smith Electronics Pty Ltd, P.O. Box 747, Crows Nest, NSW 2065.

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The finest value low cost 100% solid state oscilloscope available today. Thousands in use around the world serving education, colour T.V. servicing and industry.

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River Ohm micro resistors are eminently suitable for low power applications where long life, economy, microminiature size, high stability and close tolerance are required. The resistive element is of a CERMET construction encapsulated in a heat resistant insulating paint in standard international colour codes for ready identification.

Leads are of solder coated copper wire with a minimum 15 mm length and 0.3 mm diameter. Excellent solderability is ensured when using either manual or dip soldering techniques.

Characteristics

Resistance value: 30 ohm to 100 K ohm $\pm 5\%$, E-24 grid
 Wattage rating: $\frac{1}{16}$ W.
 Maximum operating voltage: 100V/Maximum overload voltage: 100V/Temperature coefficient: $+ 700$ p.p.m./ $^{\circ}\text{C}$

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AC100/R1

How to upgrade your speakers for a few extra cents

The sound that comes out of those beauties is the sound that's on the cassette. No better, no worse. And if you're using discount cassettes, chances are you're hearing discount sound, delivered with breathtaking clarity.

A classic case of pennywise and sound foolish. Drop a TDK cassette in there next time and hear the difference.

Vibrant sound, rich in colour and detail, with the depth and harmonics that were there when the music happened.

One TDK cassette. One time. One listen. That may be the *first* time you'll *really* hear your speakers. And all for as little as a few extra cents. A few extra cents more than the cassette you're probably using now.

Wait till you hear what you've been missing.



TDK For the sounds you feel as well as hear. Available at all good hi-fi dealers and record shops.
 sole Australian agents Convoy International Pty. Ltd.
 4 Dowling St., Woolloomooloo 2011

10-MHz STORAGE OSCILLOSCOPE

The new Portable Storage Oscilloscope (Model 314) from Tektronix is claimed to have the lowest weight of any available dual-channel storage oscilloscope with a 10 MHz bandwidth. Bistable storage with four-hour viewing time, dual channels, and 10 MHz bandwidth with 1 mV/div sensitivity are combined in this lightweight, portable instrument. Rugged construction for operation over a wide range of environmental conditions, operation from either ac or dc power sources, and a functionally laid out, colour-coded control panel combine with light weight to make this new portable storage oscilloscope a convenient measurement tool for field servicing and production.

Applications for the 314 occur in the areas of computer peripherals, industrial control systems, biomedical instrumentation, communication terminals and point-of-sale terminals.

The crt is a direct view bistable device with an internal graticule and an 8 x 10-division display area (0.25 in/div). An auto erase capability provides the capability to view changes in slow moving phenomena, such as the output of a pressure transducer, without manually recycling the erase and single sweep controls. Erase cycle time can be



varied from one sec to five sec to match the speed of the changing display. An enhanced writing rate in the single sweep and auto erase modes facilitates the capture of fast transients. Low repetition rate signals are intensified by an integration capability.

Dual vertical amplifier channels provide dc-to-10 MHz bandwidth with calibrated deflection factors of 1 mV/div to 10 V/div.

Horizontal sweep rates extend from 5 sec/div to 1 μ s/div and a 10X sweep magnifier increases this to 0.1 μ s/div. Sweep modes include automatic, normal, and single sweep. A horizontal amplifier with deflection factors from 20 mV/div to 2 V/div provides XY operation.

Tektronix Australia Pty Ltd, 80 Waterloo Rd, North Ryde, NSW 2113.

INTERACTIVE TERMINAL PERMITS 16 FUNCTION SELECTIONS

A new video terminal, manufactured by Lear Siegler, Inc., CA, has been announced by Amalgamated Wireless (Australasia) Limited. The release of the ADM-2 follows the successful introduction of the VTE-5 by AWA and complements the programmable terminal equipment manufactured by the company.

A "second generation" terminal of the ADM type, the new unit is designated ADM-2. It provides the user with almost total flexibility of format, editing, interface and transmission. Among the features of the terminal is the incorporation of 16 function keys to permit the operator a wide choice of commands.

The basic keyboard of the terminal is a standard 53-key TTY and, in addition to the 16 function keys, also contains a numeric 10-key pad. The CRT utilized in the terminal measures 300 mm diagonally, with a P4 phosphor and can display 960 or 1920 characters on a 12 or 24 line format. The ADM-2 can display characters in both upper and lower case.

Other primary features of the new terminal are optional polling, teletype compatibility and free form output mode for hard copy presentation.

Editing capabilities of the ADM-2 are extensive. The operator may clear the screen, use a destructive cursor for character change, insert and delete characters or insert and delete entire lines. Total cursor control also permits the user to skip, backspace, forespace, move up, down, return, home and originate a new line.

A "field protect" mode incorporated in the terminal also enhances its user-oriented appeal. In this mode, one part of the display is held in a protected field and presented at a lower light intensity than is other data. This enables the operator to retain forms, instructions, or other fixed data, while transmitting only the "unprotected" information.

Generally, the ADM-2 was developed to meet the requirements for a more flexible terminal with greater capabilities, at a comparatively low price.

AWA Data Systems Dept, Engineering Products Division, 422 Lane Cove Road, North Ryde, NSW 2113.

MINUS 40°C FROM COMPRESSED AIR

With no moving parts, the Hilsch Tube divides a supply of compressed air into two streams, one hot and one cold, by utilizing the principle of conservation of angular momentum. A range of sizes is available. Its current uses include cooling electronics and air conditioning.

Our illustration shows a model 600 complete with magnetic swivel base. It is 250 mm long and will generate a cold jet of air at -40°C for dry machining operations such as drilling, reaming, tapping, grinding, turning and milling, (including drilling printed circuit boards) where liquid coolants can not be used. Tool life is extended, tolerances maintained and production rates increased.

Redpoint Associates Limited, Lynton Rd, Cheney Manor, Swindon SN2 2QN England.



Career Opportunities for COLOUR TECHNICIANS

Large international marketing organisation with offices in all states invites applications from experienced Television Technicians with some knowledge of colour.

Company specialises in colour television only and is building a large comprehensive national sales and service network.

Opportunities will exist in each capital city but immediate requirement is for cities of Sydney, Melbourne and Brisbane.

For Sydney, workshop technicians will be required to work at area service centres located at Pagewood, Rydalmere and Greenwich.

For Brisbane area location will be Albion, and Melbourne location, Richmond.

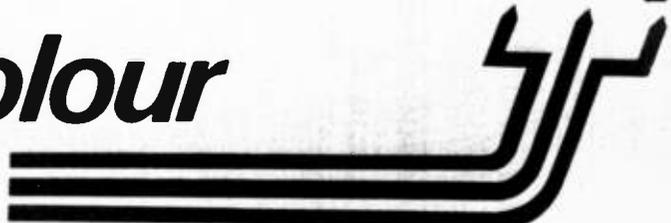
Field Technicians will be required to operate from area service centres and will be provided with suitable vehicles.

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152 Bunnerong Road,
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EQUIPMENT NEWS

MINIATURE BATTERY CHARGER

A & R Soanar Electronics Group have released advance information on a new miniature battery charger that they will be marketing shortly under the name CHARGETTE.

This is a high performance, low cost unit for charging lead-acid batteries of the type fitted to cars, boats, caravans, motorcycles etc.

The unit has modern functional styling and is extremely robust. Its very small size (95 x 52 x 70 mm) and lightweight (500 grams) enables it to be easily carried in a glove box or even a jacket pocket.

There are no mains leads to get tangled as the charger body plugs directly into the mains power socket. A pilot lamp, within the unit, glows when the power is switched on. The unit also incorporates an automatic circuit breaker to protect the unit from damage in the event of a short circuit, an overload or the inadvertent reversal of leads when connecting the charger to a battery.

Designed to run continuously over long periods CHARGETTE provides a full 1 amp output at 12 volts, and will maintain a fully charged battery in peak condition or re-energise a discharged battery. One amp is the recommended rate for all extended and continuous charging programmes.

Continuous charging ensures that a battery is always available fully charged when required. This is particularly important for batteries which are only used intermittently such as those in power boats, caravans, emergency lighting systems or the second car.

Regular overnight charging can reduce the starting problems with any car, particularly during the winter months when cold starting and the extensive use of head lamps, parking lamps and ancilliary equipment places an extra burden on the car battery.

A & R Soanar Electronics Group, 30-32 Lexton Rd, Box Hill, VIC. 3128.

COMPUTER-AIDED-DESIGN PACKAGE SPEEDS LINEAR CIRCUIT DESIGN

Hewlett Packard have introduced a computer package called OPNODE, aimed at solving a wide range of linear circuit design problems. OPNODE assists in design investigation, breadboard circuit evaluation and in analysing proposed changes to the production circuit.

The new software is used with the Hewlett-Packard Model 8542B Automatic Network Analyser, the Model 8580B Automatic Network Analyser and with the Model 8580B Automatic Spectrum Analyser. It reduces cost of computer-aided circuit design for owners of these automatic test systems.

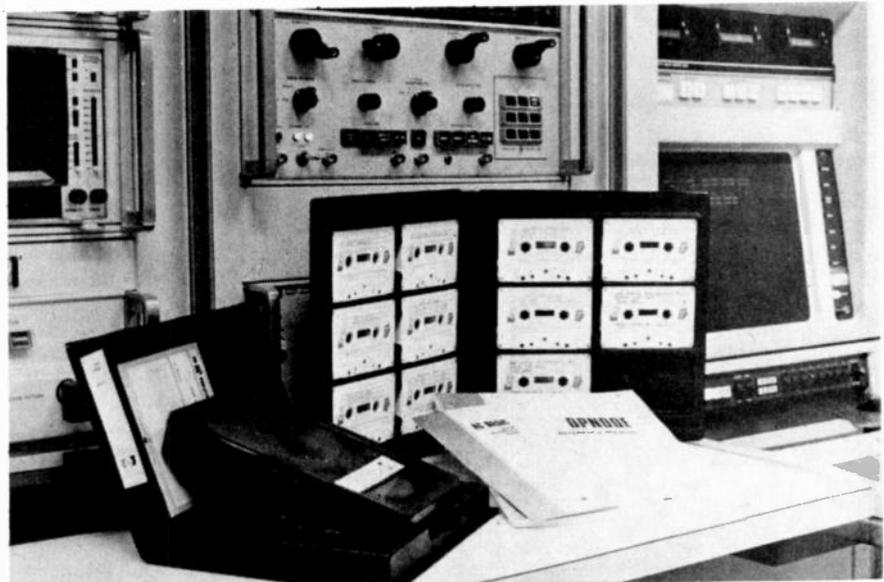
Among the capabilities of the software are S-parameter analysis, sensitivity analysis,

feedback system analysis, optimisation and worst case analysis. Up to 40 nodes and 200 components in a circuit can be analysed in real time. Outputs, including plotting of results, are provided in from 0.1 to three seconds per frequency.

Design parameter inputs including constants, variables or complex equations are entered from the keyboard or cassette tape. Outputs are presented on the system CRT or on a plotter as tabular, log or linear rectangular plots, and polar plots.

Programming is in BASIC. Using high-level NASIC statements, the designer can develop his own programmes and add analysis techniques such as constant gain and stability plots and mapping.

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



New software package from Hewlett-Packard for computer-aided linear circuit design.

AT LAST!

A HI-FI MAGAZINE FOR NON-EXPERTS



IT'S CALLED HI-FI REVIEW and you don't need a degree in acoustics to understand it!

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with laboratory balanced synchronous motor. Adjustable balance — anti-skate — lift and heavy platter including Shure magnetic cartridge. Less than 1/2 price at only \$47.50ea. P/P \$3.00.

TRANSFORMERS. 30V — lamp C.T. secondary, 240V A.C. primary. \$4 ea. P/P 75c. 60V C.T. and 6.3V at 1 amp secondary 1 1/2" x 1 1/2" x 3/4" \$2.00 ea. P/P 75c.

LEVEL METERS 200 micro amp sensitivity size 1" x 1" x 3/4" \$1.50 ea. P/P 20c.

SOLENOIDS — tape recorder type. 12V D.C. 550 coils. 1 1/2" x 1 1/2" x 3/4" \$2 ea. P/P 30c.

5 Push Button Permeability Tuners. Complete with coils \$3 ea. P/P 75c.

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M.S.P. 8" x 4" 15Ω heavy duty speakers \$3.50 ea. P/P 50c. M.S.P. 5" 15Ω dual cone tweeters \$4 ea. P/P 50c.

2 position 3 pole rotary switches 50c ea. P/P 20c

Ferrite Loopsticks 8" x 3/8" complete with broadcast coil. 70c ea. P/P 30c

Dual Ganged Carbon Pots. 50K.A. — 50 K.C. — 2 meg and 1 meg. 60c ea. P/P 20c. Single Carbon Pots. 500Ω 1 K.A. and 250K.A. 30c ea. P/P 20c

Valves — New in Carton. 5Y3GT — 5V4G — 6N7G — 6SF5GT and 807 \$1 ea. P/P 25c

Battery Leads 30" long. Complete with 2-25 amp crocodile clips 30c ea. P/P 20c

Intercom Telephones with 5 push button controls. Operate on 3V D.C. includes terminal box \$6 ea. P/P \$1.50.

T.V. Legs. 10" long. Teak wood. Taper square section. 80c set of four P/P 50c

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EQUIPMENT NEWS

STABILISED VERY HIGH VOLTAGE POWER SUPPLY

A stabilised high voltage power supply (1400 Series), capable of producing up to 200 kV at 1400 W in steps of 8.33 kV, has been produced by Britain's Miles-Hivolt Ltd, (Shoreham by Sea) Sussex, UK).

The system, designed and developed by the United Kingdom Atomic Energy Authority is claimed to provide significant advantages over mains frequency systems in greatly improved peak-to-peak ripple, output voltage stability and reliability, and in a reduction in both stored and dissipated energy.

Stability of the output voltage after a 30 minute warm-up period is within 0.1 per cent over any one hour period and within 0.05 per cent over any five minute period. The peak-to-peak ripple voltage at full load is less than 0.06 per cent.

The system is flexible and is in three separate sections. These are a transformer unit, a converter unit and a high voltage unit. They can be supplied as one complete system in cabinet form or individually for inclusion in existing equipment.

The system is flexible and is in three separate sections. A transformer unit, a converter unit and a high voltage unit can be supplied as one complete system in cabinet form or as individual units for inclusion in existing equipment. The transformer unit incorporates an isolating transformer, a high voltage transformer and chokes, thus keeping all the heavy components together.

The converter unit consists of a 12 kHz thyristor inverter, the output of which is inherently current limited, preceded by a stabilised dc supply: comprising a series transistor regulator backed by a coarse thyristor controller. This unit carries all the controls and is small enough to be mounted in a control panel only 180 mm high.

A compact modular assembly comprising two columns of plug-in 8.33 kV discs is the basis of the high voltage unit. One column is a voltage multiplier generating 8.33 kV (25 kV per three discs) with the resulting output linked by a smoothing capacitor and voltage divider. Any number of discs may be stacked together to produce voltages up to a maximum of 200 kV, the output current being defined by the 1400 W power rating.

PORTABLE CALIBRATOR FOR ON-SITE USE

A portable ac-dc voltage and resistance calibrator especially designed for use with digital voltmeters has been introduced by John Fluke Manufacturing Co., Inc., Seattle, Washington manufacturer of precision measurement instruments and automatic calibration systems.

The new calibrator, Model 515A, offers a basic accuracy of 30 parts per million per year over an unusually wide temperature range, 18°C to 28°C. Applications for the new instrument include use as a basic ac/dc reference standard, as an inspection tool at receiving depots for all inbound and newly

calibrated voltage devices and as a portable standard providing the on-site ability to take advantage of the best short term performance characteristics of digital voltmeters and multi-meters.

Functional controls are coherently organized and color coded for clarity and ease of use. All specifications are summarized on a decal mounted on the bottom of the case so the user can conveniently determine the exact accuracies of a given measurement. To simplify operation, there is only one set of output terminals.

Specifications include dc volts from 0 to 999 μV continuous with 0.2 μV resolution, 0 to 1.0 V in 0.1 V steps, 0 to 10 V in 1 V steps, and a precise 100 V output. AC voltage tests can be made at three frequencies, 400 Hz, 4 kHz and 50 kHz. One volt, 10 V and 100 V rms sine wave outputs are available at 400 Hz. An output of 10 V rms is available at 4 kHz and 50 kHz. Basic ac voltage accuracy is ±0.04%. Resistance ranges from 10 ohms through 10 megohms in decade steps to a mid-range accuracy of ±0.015%.

General measurements which can be made with the Model 515A include zero offset, zero stability, autoranging, and overranging. DC voltage, input offset current, A/D linearity, AC voltage, frequency response, converter linearity, residual noise. Resistance, linearity, residual resistance.

Further details may be obtained from Elmenco Instruments Pty. Ltd., P.O. Box 334, Brookvale, NSW, 2100.

ATOMIC FREQUENCY STANDARD MODULES FROM RACAL

Two new miniature atomic frequency standards, each contained within the dimensions of a 100 mm cube, have been introduced by Racal Instruments Limited for the accurate generation of frequency and time signals. Both models combine the stability of atomic standards with the low cost advantages of quartz crystal oscillators.

In their design, both models use the atomic resonance of rubidium to control the frequency of a quartz crystal oscillator. This technique gives particularly low ageing characteristics several orders better than even the best conventional crystal oscillators. In the case of model L-RK-H long term stability is better than 1 part in 10¹¹ per month and for model L-RK-L it is better than 1 part in 10¹⁰ per month.

Because of their small size, low weight and modest power consumption, they can be easily incorporated as components in fixed or portable systems. Both models feature near instant warm-up characteristics and are capable of operating over a wide temperature range. Excellent spectral purity coupled with a high signal-to-noise ratio make the 10 MHz output ideal for multiplication into the microwave bands.

Typical applications include radio communications, navigation, radar, data instrumentation and other systems requiring a high degree of accuracy in their design.

Plessey show that great sounds can come from small packages

The PE800

An addition to the PE series—the PE800 is superbly engineered for enthusiasts who want quality performance without sacrificing too much valuable living space.

The PE800 provides impressive overall response with a high performance low compliance

8-inch driver and two 3-inch curvilinear tweeters.

Cabinets are beautifully finished in hand-rubbed American walnut woodgrain and the easily removable open cell polyurethane foam grille brings good looks as well as acoustic transparency.

PE800's are supplied as matched pairs and carry a five-year guarantee. Also in the series is the PE1000, an acoustically tuned 3-way three speaker system.

	Frequency Response	Power Handling	Dimensions
PE800	45 Hz to 20 kHz	20w RMS 40w Programme	555 mm h 370 mm w 240 mm d
PE1000	40 Hz to 30 kHz	20w RMS 40w Programme	597 mm h 390 mm w 299 mm d



PLESSEY



Further information is available from the listed outlets or direct from: Plessey Australia Pty. Limited, Components Division, The Boulevard, Richmond, Vic 3121

Available now from: NSW—Lawrence and Hanson Pty. Ltd., Martin De Lannay Pty. Ltd., Dick Smith Wholesale Pty. Ltd., Haberecht's Radio & TV Services. VIC—Lawrence and Hanson Pty. Ltd., Radio Parts Pty. Ltd., Fidelity Hi-Fi, McGrath Radio. QLD—The Lawrence and Hanson Electrical Co. (Qlc.) Ltd., L. E. Boughen & Co. SA—Gerard & Goodman Pty. Ltd., K. D. Fisher and Co. WA—Atkins Carlyle Ltd., H. J. McQuillan Pty. Ltd. TAS—Quantum, W. & G. Genders Pty. Ltd. CANBERRA—Allied Hi-Fi.

AR72

KITSETS



KIT'S KOLUMN

I don't know if I like this place or not anymore.

Over the last week or so Expense-Account seemed to be displaying singular prowess in ESP and it was getting me a bit rattled.

I mean, he seemed to know the exact location of my birthmark and what sort of lace bits I had been wearing and so on, and as there's only one way he could possibly know, I was a bit on edge. (Simply because with him, the one way it is a big no-no despite his bags of boiled lollies.)

Then the penny dropped. Or rather crashed to the floor.

The nasty old voyeur had installed one of those closed-circuit TV's in the ladies' room and I would never have found out if it hadn't been for the heavy breathing.

Anyhow, he removed the beast, and since then, we've been having a great time playing with it. You can read more about it at right.

What with that, and all our new stock, we've been run off our feet and things have fallen a bit behind. (Our Ad Agency has suffered 2 heart attacks, 5 new ulcers, and 18 migraines, not to mention some terribly rumpled grey flannel suits.)

Despite falling over our feet, we haven't forgotten to include a real Hi-Fi special this month. All of you who have been drooling over our colour-plan L&G gear, please take note: if you're quick, you will be able to pick up an L&G amplifier at way under usual store price. Like the L2600 (30W RMS per ch both into 8 ohms) \$199; or L2400 (22W RMS per ch both into 8 ohms) \$179. That's all of our promotional stock and when new shipments arrive, prices go back to normal. Yes, we'll take your Bankcard.

Our new Box Hill (Vic.) branch is doing well, thank you. And your letters to me are appreciated. But please, Alfred E. — no more locks of hair. A sacrifice like that makes me embarrassed.

Keep your iron hot —

Kit



SOLDERLESS ELECTRONIC KITS \$3.60 to \$17.95

The perfect introduction to electronics. Spring terminals eliminate soldering. All have illustrated instruction manuals.

Marvellous as gifts. Our prices are well under you-know-who. Crystal radio. Really works. No bat required. Complete. P&P 30c. \$3.60

10 projects in 1: Make radios, TV trouble detector etc. Has solar cell. Takes AA bat. P&P 60c. \$7.40

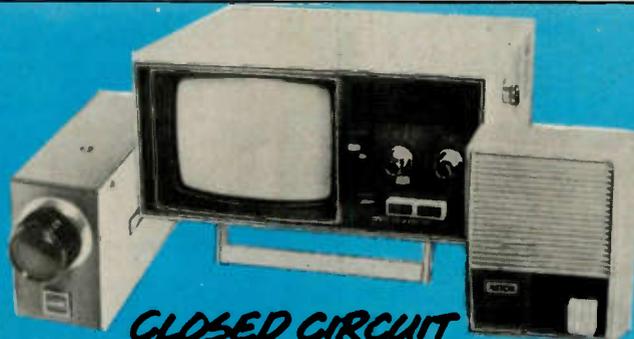
20 in 1. Radio, water purity tester, impulse gen. etc. P&P 75c. \$10.25

65 in 1. Sonic fish caller; burglar alarm, solar cell. P&P \$1.50. \$15.40

80 in 1. Similar 65, but with 20 more experiments. P&P \$1. \$16.45

100 in 1. Has IC, solar bat. relay, Wood case like 65. P&P \$1.50. \$17.95

Attache 150. Suitcase job. Really a portable electronic lab. Makes 150 different projects. Even buffs will drool over this one. Case measures 16" x 8 1/2" x 3 1/2". P&P \$1.50. \$30.40



CLOSED CIRCUIT TV WITH INTERCOM \$195

Ideal for offices, hospitals, homes, shops, banks, warehouses. Consists of camera, interphone unit, and monitor. When talk button on the interphone unit is pressed screen gives instant picture and talk-back. Monitor also has button to call plus picture controls. NOT just a simple observation device but a

true audio-visual unit. Use to observe and communicate. Many security applications. (See and talk to callers without opening the door.) Stand-by switch gives automatic turn-off when talking is finished. Auto picture adjust for poor light. Complete, ready to plug into 240 mains. Has 10m cable. Unlimited uses. P&P \$4.

GIVE MUM A POTENTIOMETER



Doubles

While they last, at lid prices. Single gang 1K-1M ohm. Double gang 5K to 1M ohm. Specify linear or log and value. P&P as for gizmo boxes.

70c



Singles

35c

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You know Philips. And you know Philips quality. Now we can offer you Philips speakers for virtually any sound system. Plenty in stock. Here's a sampling:

AD1060-T8 1" dome tweeter. P&P \$1. 88-50

AD8066-W8 8" woofer. P&P \$1. 812-50

AD1256-W8 12" woofer. P&P \$2. 821-50



5 1/2" x 3 1/2" x 1 1/2" GETCHA GIZMO BOXES 80c EA.

Beautiful hard plastic; pin hinge things with clear lid, black base. Lid recess allows nesting. (Hohol). P&P 40c. 60c. for 2. \$1 up to 10.

MODULES

Exciting new Modamp kit range. all assembled ready for power & wire connections. Combine units for power & performance you want. Hi-Fi, guitar amps, P.A. Amp modules have heat sink. Stereo power amps: 15W RMS into 8 or 15 ohms. Use 22V \$31 30W RMS 8-15 ohms. 32V. \$39.50 Mono power amps: 60W RMS into 4/8 ohms, or 30:15. 32V. \$39.50 120W RMS into 4 or 8 ohms. 60 into 15. Needs 48V power \$49.50 Stereo mag. cartridge equalizer or stereo low imp. mike pre-amp, or stereo high imp. mike pre-amp, or stereo guitar pre-amp, or tape head pre-amp. Ea. \$12.50 Stereo tone cont: Bass, treble, vol, bal pots on board. Inc. loudness control & baxandel. Price \$25.50 Mono filter: Rumble 20-200 Hz; Scr 5-50KHz. 2 pots for adjust of crossover point. \$9.50 AM tuner module: \$19.50 FM-AM tuner mod: IC multiplex stereo decoder. \$45 NOTE: P&P each module \$1.50

TRANSISTORS: 10 OF ONE TYPE \$1.50

Eat your heart out, Alfred E. Plastic equivalents of these BC's BC107(207 or 547). BC108 (208 or 548). BC109 (209 or 549). BC177 (307 or 557). BC178 (308 or 558). BC179 (309 or 559). P&P 40c. pack. 60c. for 2 packs; \$1 up to 10 packs.

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to him you're everything

To you he's no-one.
To him you're everything.
You're his warmth.
His full belly.
You're what turns
his wondering face into
a cheeky grin.
You're the hope in his eyes.
You're the person who
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and he'll go away.
For good.

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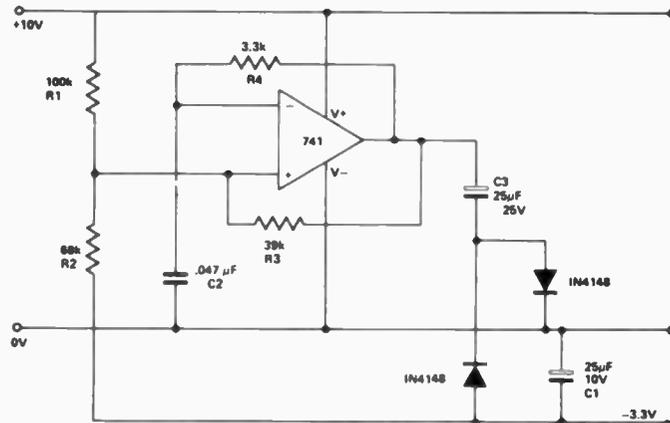
IDEAS FOR EXPERIMENTERS

SIMPLE DC-DC CONVERTER

Often in circuit design it is handy to have a low-current negative rail available to bias FETs etc. This circuit generates a supply rail 2 to 5V below its 0V line.

If the lower end of R2 is connected to 0V, then the circuit is seen to be an op-amp relaxation oscillator driving a pair of diodes that charge C1 negatively. R3 provides positive feedback, changing the switching point of the op-amp, according to whether C2 is charging or discharging through R4. When the voltage on C2 reaches the switching point, the circuit changes state, and the C2 voltage sets out for the other switching point.

When the lower end of R2 is attached to the negative output, then as the negative charge on C1 increases,



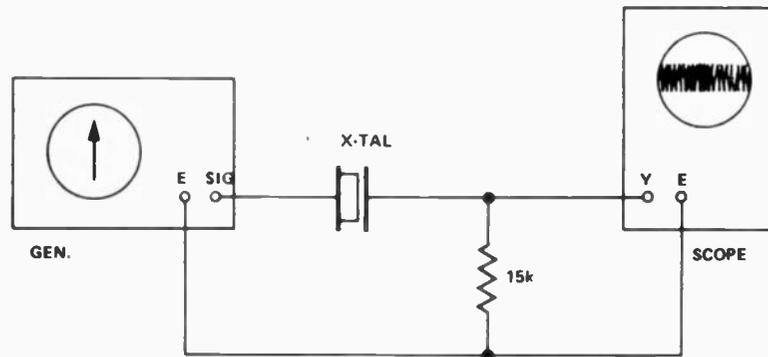
the operating range of the oscillator is pulled down until it is outside the operational range of the 741, and the charging ceases. This provides a form of switching regulation of the output voltage, roughly halving the output impedance. The output voltage can be

set to the desired value by altering R2. For 3.3V output the prototype showed about 10mV ripple on full design load of 1mA.

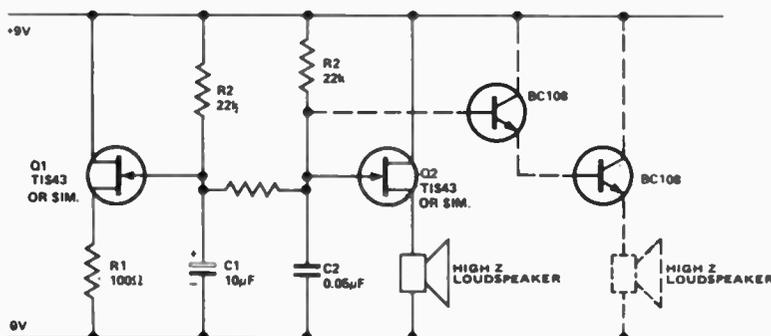
The output is inherently short-circuit protected by the current-limiting action of the 741.

CRYSTAL CHECK-UP

If one has access to a signal generator and oscilloscope, the hook-up shown will check both the generator and crystal. As the frequency is increased, the low impedance series vibration of the Xtal can be observed by a sharp increase in Y amplitude. This is followed by a dip as the Xtal goes into the high impedance parallel mode. The harmonic activity can be checked by comparison with the fundamental.



SIMPLE SIREN



The circuit consists of two unijunction relaxation oscillators, Q1 for low

frequency and Q2 for audio frequency. R3 couples the slow rising

voltage across C1, determined by the time constant C1 and R2, to the audio frequency across C2, determined by the time constant of C2 and R4. The effect is that the audio frequency generated by Q2 rises in pitch as the slow rising voltage across C1 is applied, via R3 to the time constant C2/R4.

This type of sound carries much further than a continuous note from a single oscillator. Extra amplification can be achieved, by adding two transistors in a super-alpha arrangement as shown dotted. R5 should be replaced by a 100 ohm ¼W resistor.

Connected to a pressure mat (from across C2), this unit would make an excellent baby snatch alarm for prams.

ETI by jaycar

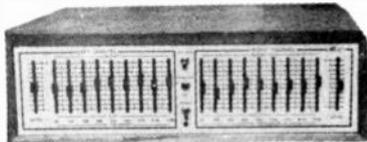
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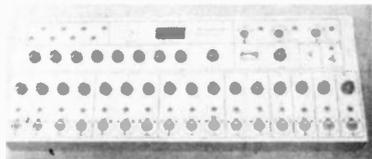
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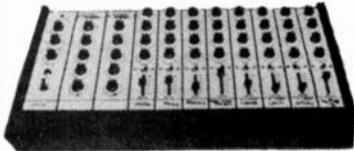
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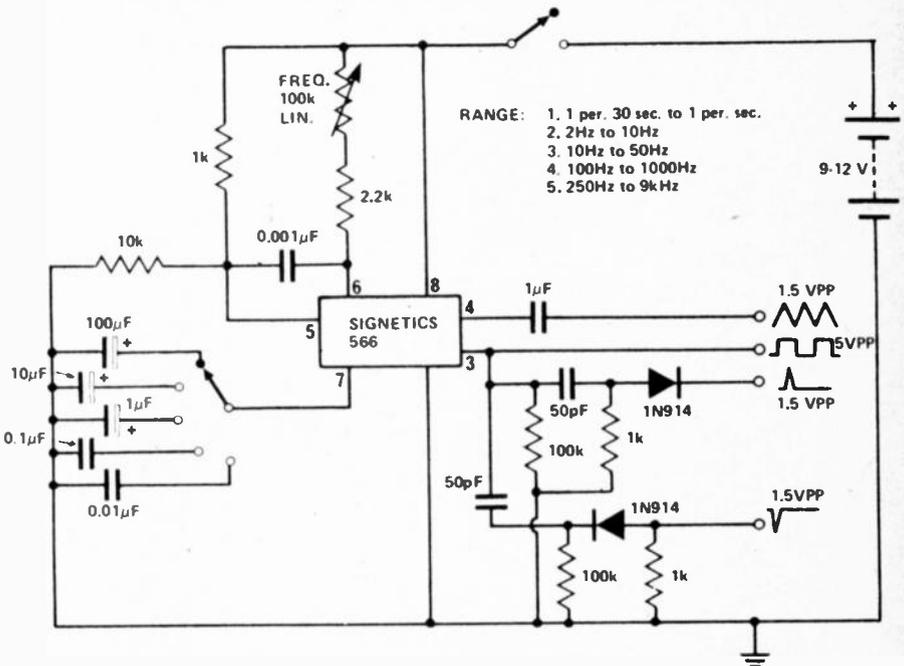
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IDEAS FOR EXPERIMENTERS

VARIABLE FREQUENCY MULTIPLE WAVEFORM GENERATOR



Signetics 566 IC chip lends itself ideally as a test generator by utilising its internal voltage controlled oscillator (VCO).

The circuit will deliver separate outputs giving triangular and square waves and both positive and negative going spikes.

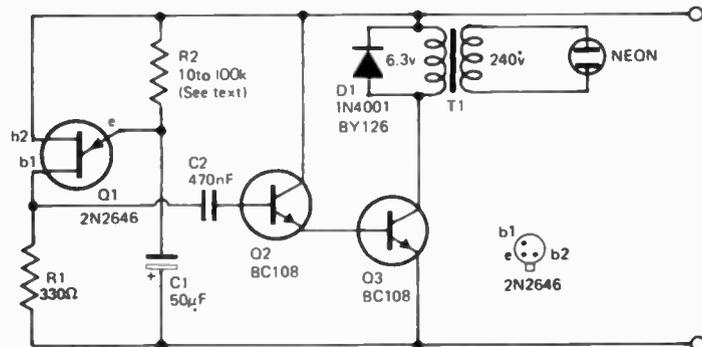
The square wave amplitude is 5 V pk-pk, all other waveforms are 1.5 V pk-pk.

Frequency is determined by the value of the capacitor connected to pin 7.

It is preferable to use tantalum capacitors rather than electrolytics.

The outputs are designed to operate into high impedance loads. A transistor buffer stage is needed to match to low input impedance devices.

NEON TUBE FLASHER



Flashing neon globes have use in many applications, however their relatively high working voltage precludes their general use where a mains supply is not available.

This circuit enables neon tubes or bulbs to be operated from a low voltage dc supply.

The voltage required to ignite the

neon tube is obtained by using an ordinary filament transformer (240-6.3V) in reverse.

Battery drain is quite low — being in the region of 1 to 2 milliamps for a nine volt battery.

Q1 is a unijunction transistor and operates as a relaxation oscillator. Its

frequency of operation is determined by R2-C1.

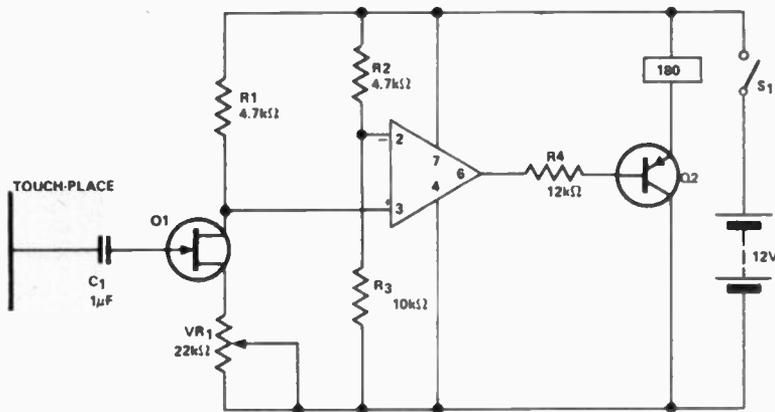
The pulses from Q1 are directed to Q2 which in turn drives Q3 into saturation.

The sharp rise in current through the 6.3V winding of the transformer as Q3

goes into saturation induces a high voltage in the secondary winding causing the neon to flash.

The diode D1 protects the transistor from high voltage spikes generated when switching currents in the transformer.

TOUCH-SENSITIVE SWITCH



The circuit illustrated can be set to energise the relay when the plate is lightly touched. Under certain circumstances the proximity only of the body is sufficient to operate the switch.

A high impedance input is provided by Q1, a general purpose field effect transistor such as 2N3819. A general purpose 741 op-amp is used as a sensitive voltage level switch and this in turn operates the current buffer Q2, a medium current pnp bipolar transistor, thereby energising the relay which can be used to control equipment, alarms etc.

In the quiescent state, the voltage at pin 3 of the op-amp is set higher than the voltage at pin 2 by adjustment of VR1. This ensures that the voltage at pin 6 is high and Q2 and the relay are off. Upon lightly touching the touch-plate, a decreasing reverse bias V_{GS} increases the drain current

flowing through Q1 and the resultant voltage drop across R1 lowers the voltage at pin 3 below that at pin 2. The voltage at pin 6 falls and switches on the relay via Q2. Resistor R4 may need to be selected to ensure that the relay is held off since a small positive voltage at the output remains even though the voltage at pin 3 is lower than that at pin 2 in the quiescent state. This problem can be overcome by using dual power supply for the op-amp in the more usual mode of operation of this device. Component values are not critical and there is considerable scope for experimentation.

The sensitivity of the circuit to the proximity of the body depends upon the nature and strength of the surrounding electromagnetic fields produced by mains wiring and equipment in the vicinity, for it is the pick-up of this energy which the body couples to the circuit.

LOW-SPEED ASTABLE USES CMOS

One of the advantages to be gained from using CMOS logic gates in RC oscillator circuits arises from the almost infinite input impedance of the basic CMOS gate. The RC components suffer negligible loading and can therefore have very large values.

To demonstrate this, an astable multi-vibrator is described which can employ an RC network with values as high as 200 MΩ and 25 µF. A simple modification makes it possible to vary the mark-space ratio between wide

limits. Mark-space ratios higher than 5000:1 can be achieved.

The basic circuit of the NAND gate on which the astable is based is shown in Fig. 1 (a).

The gates in the astable multivibrator, shown in Fig. 1 (b), are used as simple inverters with the second inputs being employed to provide an inhibit function. Normally these inputs, pins 2, 6, 8 and 13, are connected to the positive supply line through two resistors and are at logical 1.

Three gates from the astable G_1 , G_2 and G_3 , and the fourth gate, G_4 ,

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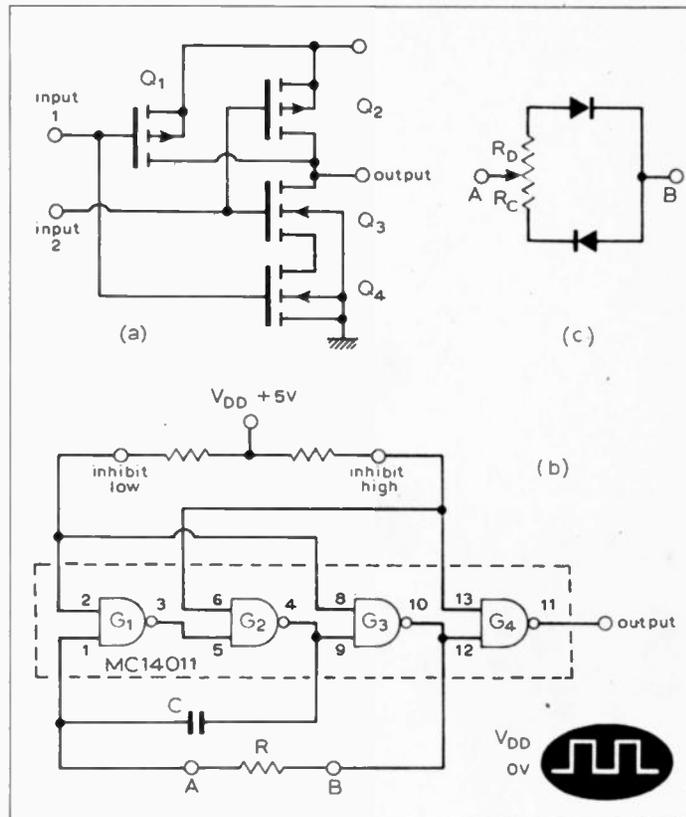
Written applications stating name, age, qualifications, experience and giving sufficient information to indicate suitability for interview, together with the names and addresses of two referees should be addressed to the Principal, Royal Melbourne Institute of Technology, Box 2476V, G.P.O., Melbourne, Victoria. 3001.

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IDEAS FOR EXPERIMENTERS



performs the function of output buffer.

Gate G_1 monitors the potential at the junction of the timing capacitor (C) and resistor (R). When this potential is below the threshold of G_1 , gate 2 connects one end of C to ground and G_3 connects one end of R to V_{DD} .

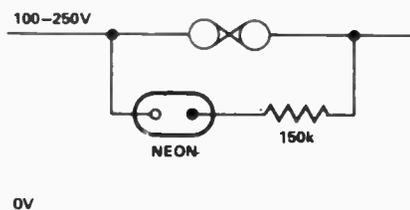
The capacitor charges through R until the potential at the input of G_1 exceeds the gate's threshold. When this occurs, the output of gate 1 falls to 0, G_2 rises to 1 and G_3 falls to 0. The gates have now connected the resistor to ground and the capacitor to V_{DD} . The capacitor discharges through the

resistor until G_1 again switches off. The circuit therefore oscillates at a frequency determined by C and R with a mark-space ratio close to unity.

If the circuit shown in Fig. 1 (c) is connected between A and B in place of R , the two diodes isolate the capacitor charge and discharge paths. Variable resistors in the two paths, or the potentiometer shown, allow the mark-space ratio to be varied over a very wide range.

Grounding the inhibit inputs stops the astable from oscillating and puts the output at either 1 or 0 depending upon which inhibit input is used.

BLOWN FUSE INDICATOR



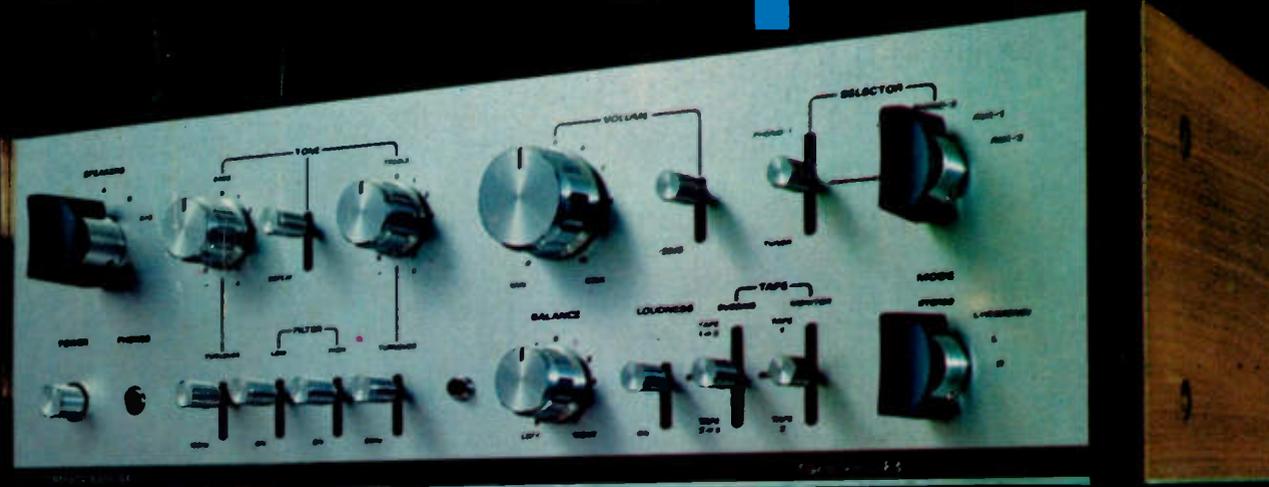
Here is a very simple method of identifying a blown fuse. This is of

course more advantageous on systems employing several fuses.

Across the fuse holder is wired a neon in series with a resistor. When the short circuit, or whatever, blows the fuse, the neon will light indicating immediately the area of the fault. Neons with built-in resistors need not of course have an extra 150k as shown.

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