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COVER: No — Maree! We meant transient intermodulation distortion sometimes helps! (exclusive ETI article page 16 onwards). Apart from bending amplifiers, Maree designs some of ETI's pc board layouts and prepares all those immaculate drawings.

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MAGNETIC MONOPOLE DISCOVERY

The existence of magnetic monopoles was predicted in 1931 by P.A.M. Dirac and most physicists have been confident that sooner or later Dirac's belief would be confirmed.

A magnetic monopole is a basic unit of magnetism analogous in many ways to an electron.

In the same way that an electron has only negative charge, a magnetic monopole — as its name implies — has only one pole and whilst an electronic at rest is surrounded by a magnetic field (and acquires a magnetic field when in motion), a monopole has a magnetic field when at rest and acquires an electric field when in motion.

The apparent discovery of a monopole was made during upper atmosphere research, the object of which was to seek out ultra-heavy cosmic rays.

Such rays are detected by sending aloft a package containing three separate detectors. The first is a fine-grained photographic emulsion, the second is a sheet of plastic with a high refractive index coated on one side with another layer of film. The third is a pack of 33 sheets of carbonate plastic (Lexon).

The first component of the detector (fine grained emulsion) is used to record the track of electrically charged particles. The second is a so-called Cerenkov detector (it detects the light emitted when a particle passes through the medium at a speed greater than the speed of light in that medium). The third component (33 Lexon sheets) indicates some properties of particles striking the plastic and thus disrupting the molecular structure of the polymer.

The actual experiment concerned took place in September 1973, when the balloon-borne package was sent aloft over Sioux City, Iowa. When the several components of the package were subsequently analysed it appeared that a particle had passed through all three components.

The emulsion track indicated that the particle had either an atomic number of 80 or a magnetic charge of 137 and was travelling at a velocity about half that of light. However the fact that the particle passed right through the 33 plastic sheets indicated that the particle had a velocity almost that of the speed of light *and* an atomic number greater than 125. Or that it was a magnetic monopole with a charge of 137 and an unknown velocity.

The final conclusion after nearly two years study is that the particle must have been a magnetic monopole with a charge of 137 and a mass more than 200 times that of a proton and was travelling at a velocity half that of light.

If confirmed, the existence of the magnetic monopole would appear to put rather a large dent into modern theories of electro-magnetism.

OUTDOOR SOLDERING

Scope Laboratories Melbourne have released a new soldering iron, that connects directly to a 12 volt car battery.

The new soldering iron has a powerful 150 watt capacity, heats in five seconds, offers fingertip temperature control and comes with 7 metre high-current extension lead for complete mobility.

The Scope outdoor soldering iron features standard parts of the famous Scope Superspeed soldering system but has the added advantage of not having to rely on conventional 240 V power operation. This new product release from Scope offers the user soldering mobility and complete safety as the iron operates only from 12 volts.

A second new iron from Scope laboratories is energized by rechargable nickel cadmium 'D' cells.

Extensive research has shown that around 100 typical electrical connections could be completed during one working day. On the other hand between 200 and 400 joints have been achieved with lighter connecting wire and by completing a number of joints in close sequence. This enables the copper tip to retain its heat and places lighter drain on the cells. Heavier joints will mean proportionately less capacity.

Recharging of the two nickel cadmium D cells is made convenient by a choice of three accessories, each requiring the normal 14-16 hours if the cells are fully discharged. One accessory suits the cigarette lighter plug in your car or utility, a second is for the normal 240 volt power point, and another very simple option is for people already owning a Scope soldering iron transformer.

Designed and manufactured by Scope Laboratories, Melbourne, this Cordless soldering iron uses the same heating element, tip and barrel design as is incorporated in their widely used 6-second low voltage Superspeed irons. Their system gives the user full control of tip temperature with 60 watts of available soldering power. The iron sits comfortably in the hand and the relatively heavy nickel cadmium cells have been placed in a way which counter-balance very well.

The Scope Cordless 60 W is packed complete with instruction book plus a set of spare tip and element .

Both irons will be distributed to electrical and electronic wholesalers and retail outlets, plus major hardware retailers.

news digest

RADIO ON THE MOVE!

A new two-way radio system which a motor cyclist can use while on the move will soon go into service in Australia.

Designed and built by Amalgamated Wireless (Australasia) Limited, this latest model cycle phone is especially designed for the Honda 750 motor cycle, a model widely used by Australian and overseas police forces. The Tasmanian police will be the first Australian police-force to use the new system.

Previous motor cycle radios have required the operator either to take one hand from the handlebars to operate the microphone — an obvious safety hazard — or to stop the machine to make contact with base.

The control head of the Cycle Phone also designed for the Honda 750, is set at an angle facing the rider. Made of splash-proof white fibreglass, with rounded edges it has from left to right the power on-off switch, receiver mute control, volume control, and channel selector with ten channel selection.

An inbuilt speaker is underneath the control head, also facing the rider and protected from the weather. A hand microphone clips onto a mounting bracket attached to the handlebars.

For operation while the rider is moving, the rider uses a modified safety helmet which incorporates earphones and a small microphone resting in front of his mouth. Once the helmet is plugged into the set, all inward and outward calls go through the helmet.

A press to talk switch is mounted on the left handlebar, within easy reach of the rider's thumb, so that he can communicate easily with his base while on the move. This type of operation has been tested at speeds of up to 120 km/h and found effective.

Once the rider stops and unplugs his helmet, all communication reverts to the loudspeaker under the control head and the hand microphone.

The advantage of the Cycle Phone in police pursuit operations is obvious. However, there is another advantage. In stake-out operations and other procedures where quiet is essential, the older cycle radios, with loudspeakers giving a high audio level, could well warn criminals of the police presence. With the new arrangement, calls from base through the helmet headphones are inaudible, and the officer can communicate back by merely whispering.

The transceiver can be supplied to operate in either the 70-85 MHz band, the 156-174 MHz band, the 403-420 MHz band, or the 450-520 MHz band.

BIG PAYOFF FROM MEMORY RESEARCH

Few areas of electronics have developed so rapidly as that of memories. Existing technologies have been continually improved both in core and semiconductor, and new ones are emerging. Bubble memories, for example, are now coming out of the laboratory and commercial devices are expected to be available later this year.

In addition, two new approaches to fast, high capacity, memories are at an advanced stage of development and could easily stand the computer peripheral business on its head. Two Research groups are confident that they can engineer memory systems that will operate at speeds in excess of 100 Mbit/s and provide storage in excess of 10^{12} bits.

Chemists at the Plessey's Allen Clark Centre (Caswell, Towcester, Northants UK) have developed a range of fatigue-free photo-chromic materials upon which it is possible to "write" data at the molecular level and therefore realise very high bit-packaging-densities. These materials change colour when exposed to intense light and can be re-used as many as 10 million times simply by wiping them clean (thermally). Preliminary tests suggest that the early problems of thermal deterioration have been overcome with the new photochromic materials which are expected to have a life time equal to or longer than conventional film, when stored at room temperature. Reading photochromic materials has a detrimental effect but tests suggest it should be possible to access information at least a million times before unacceptable error rates occur.

A drawback of holographic storage systems has been the slow writing speeds compared with the reading rates attainable. Plessey workers have overcome this problem by applying serial multiplexing techniques to produce high-capacity bit pages. This has been made possible by developing electro-optic modulators that can be driven at switching speeds in excess of 1 Mbit/s.

A 40-channel device developed for use in a 120 Mbit/s holographic recording system which will have a capacity of 10^{13} bits/1000 m of 16 mm film has been operational in the laboratory for several months. More recently a 50-channel electro-optic modulator has been constructed and is currently undergoing tests. Both modulators have been built on PLZT ceramics, a material more commonly employed in transducers for audio systems.

Similar speeds and packaging densities to the holographic/photochromic approach are expected by Marconi engineers, who are working on a system which features an electron beam scanning microscope and inexpensive thermoplastics tape at the company's Great Baddow Research Laboratories (Chelmsford, Essex, UK). The high reading and writing characteristics of simple scanning electron microscopes and the high charge sensitivity of thermoplastics suggest that it may be possible to achieve a packaging density of 2×10^7 bits/cm^2. This assumption is based on the fact that it is possible to resolve bits of information only one micrometre in diameter with an electron beam microscope.

It should therefore be possible to store 10^{12} bits of information on a 300 m reel of 25 mm tape. In television terms, this is equivalent to about three hours of digitally encoded colour.

Speed of operation is restricted by the scanning technique employed and the amount of beam current used. With a beam current of one microampere it should be possible to enter data at rates in excess of 100 Mbit/s and achieve the packaging densities mentioned. Larger currents would permit a higher operational speed but would spread the size of the "information dot" and thus restrict the packaging density.

Information is stored on the thermoplastics tape by depositing a charge pattern across its surface with a modulated electron beam. Then the tape is exposed to heat which causes the charged areas to be pulled towards the aluminium base of the tape. As a result a permanent modulation pattern is imprinted on to the surface of the thermoplastics tape.

Research workers elsewhere have

(Continued on page 11)

Packed with features from front to back, Pioneer's new CT-F9191 cassette deck leaves even the best reel-to-reel decks out in the cold.

The CT-F9191 starts out by delivering top performance via access to the front. A newly-designed tape carriage employs hexagonal reel shafts plus twin-link stays. The cassette is completely visible for checking tape movement and direction (a Pioneer exclusive). And since there's no rattle-prone ejection mechanism, changing tapes is a "snap."

In the CT-F9191, two motors provide the key to stable tape transport. An electronically controlled DC motor with built-in generator guarantees accurate record/play tape speed. A second motor for high speed fast-forward and rewind. As a result, wow and flutter is no more than 0.07% and speed deviation is within ±1.0%.

Next, a high-performance ferrite-solid head and a built-in Dolby* Type-B noise reduction system join to increase the S/N ratio to more than 62dB.

Operating the CT-F9191 is easy. Light as a snowflake user-oriented controls activate solenoid circuits thereby eliminating inconvenient mechanical linkages. After that, an advanced Memory Rewind device permits quick location and playback from any point on a prerecorded tape automatically. And for capturing the full spirit of the Yuletide carol, make your own music tapes. An LED peak level indicator reacts instantly to warn of any distortion +5dB over the reference level.

Pioneer's new CT-F9191 cassette deck. Brimming over with merrymaking features. No matter how you play it... at this time or any time... 'tis the season to be jolly.

	Cassette Position	Drive System	Control Operation	Tape Selector	Wow & Flutter	Signal Noise Ratio	Frequency Response
CT-F9191	Vertical	2 motors	Solenoid activated	Independent BIAS, EQ, (automatic chrome tape selector)	Less than 0.07% (WRMS)	Dolby OFF, 52dB Dolby ON 62dB (normal tape over 5kHz)	25 – [illegible] 35 – 13,000Hz (±3dB)
CT-F7171	Slanted [illegible]	1 motor	Mechanical	Independent BIAS, EQ	Less than 0.10% (WRMS)	Dolby OFF, 45dB Dolby ON 56dB (normal tape over [illegible])	[illegible] 40 – 12,000Hz (±3dB)
CT-F6161	Slanted [illegible]	1 motor	Mechanical	Independent BIAS, EQ	Less than 0.12% (WRMS)	Dolby OFF [illegible] Dolby ON 56dB (normal tape over 5kHz)	[illegible] – 13,000Hz 40 – 11,[illegible]
CT-F2121	Slanted [illegible]	1 motor	Mechanical	Independent BIAS, EQ	Less than [illegible] (WRMS)	Dolby OFF [illegible] Dolby ON [illegible] (normal tape over 5kHz)	[illegible] – 13,000Hz

*Dolby is a trademark of Dolby Laboratories, Inc.

Pioneer Electronics Australia Pty. Ltd.
178-184 Boundary Road, Braeside, Victoria 3195. Phone: 90 9011. Sydney 93-0246, Brisbane 52-8213, Adelaide 433379, Perth 76 7776

PIONEER
leads the world in sound.


GALE
....NATURALLY
We first tried comparing Gale with other loudspeakers of a similar price. We then realised the error of our ways. It wasn't a fair comparison. Gale loudspeakers should only be compared with the natural sound ... naturally.
INSTROL HI-FI
SYDNEY: Cnr. Pitt & King Sts. Sydney. (Phone: 290-1399)
MELBOURNE: 375 Lonsdale St., Melbourne. (Phone: 67-58

news digest

attempted to exploit this technique but have not progressed owing to difficulties in achieving an adequate signal-to-noise ratio when operating at high data rates. Marconi's people are reluctant to say exactly how they have overcome this problem, other than to indicate that it concerns the way in which electrons are collected and that the new method of readout improves the signal-to-noise ratio by two orders of magnitude.

Information can be written on to the thermoplastics tape as a transversely modulated or depth modulated channel, or as a pattern of discrete dots. So far, the resolution order is in the order of 12 micrometres, but this is fully expected to be nearer one micrometre with the prototype data storage unit now under construction. A commercial large-capacity store could be available in about two years' time.

No serious difficulties are foreseen. Accurate mechanical registration of the transport mechanism is not considered to be a problem, since the scanning of the beam can accommodate any irregularities in the drive mechanism. Also, since the tape has to be read in a vacuum, dirt would not appear to pose a hazard.

Magnetic bubble memory technology is now at an advanced stage in Britain; commercial devices at the 8 kbit level are expected to be available later this year from The Plessey Company. Research work at the Allen Clark Centre is at the system development stage and prototypes have been delivered to the Royal Radar Establishment, a Government research station. Built on $Sm_{0.4}Y_{2.6}Ga_{1.2}Fe_{3.8}O_{12}$, eight kilobit serial memories have been constructed that can be operated at speeds in excess of 10 kHz over the temperature range −10 +60°C. New compounds are now being investigated, including materials that contain calcium and germanium instead of gallium. These are operable over a wider temperature range (−20 +100°C) and at higher speeds — into the MHz region.

Bubble memories have been constructed using well-proven integrated circuit fabrication techniques; the researchers at the Allen Clark Centre, where there is a pilot plant, are said to be confident of achieving a 16k chip within two years. This would certainly lead to megabit stores on standard printed-circuit card frames.

There has also been a good deal of progress in semiconductor memories. The 4k memory is now available from several manufacturers and the 1k chips have been improved in recent months. The industry standard 1103, for example, is now in its third phase and bears little relationship to the original chip developed in the United States of America. Access times of 330 ns were typical for first-generation devices. Now 180 ns is common and the design team of ITT Semiconductors[3] in England have cut this back to 150 ns as well as improving the basic design.

Column disturb problems have been minimised by removing the critical timing relationships between the precharge and chip enable clocks. And a much higher safety margin has been achieved by enlarging the operating envelope around the specified operating region of the device. In addition, the problem of reduced data output when a column change and data transition occur simultaneously has been solved. Quantities of these 1024 bit random-access memories are now being shipped all over the world, including the USA.

CALENDAR/CALCULATOR

This desk top calendar from American Microsystems Inc. (Santa Clara, California) incorporates an eight digit calculator.

Other related products include a leather-bound notebook with built-in calculator, a ring binder with built-in calculator, and a digital clock built into a memo pad holder

SPAIN TO GO PAL

As reported in our News Digest pages last month, Italy has now officially decided to use the PAL system of colour TV.

Following this decision it is now expected that Spain will follow suit. Large scale PAL transmission tests are currently being conducted in various parts of the country — and an official announcement is expected soon.

PLESSEY PLANTIME SELLING

Success in Great Britain of Plantime, an electronically-controlled flexible working hours system has encouraged Plessey Communication Systems, the local agents, to step up its selling campaign to government departments, business, commercial and banking and insurance enterprises.

The company has already installed three Plantime units for evaluation by Victorian and Tasmanian Government Departments and the Perth City Council.

Each staff member has an individual Plantime key to record, at the entry unit times of arrival and departure. This information is stored in a memory module of the master control unit and provides hard copy printouts for payroll calculations and overall management control, doing most of the work associated with timekeeping.

The system can operate on weekly, fortnightly or monthly accounting periods. Hours to be worked for every

period are pre-arranged between employer and employee to suit each other's wishes.

Each day, and throughout the period, the employee can activate electronically controlled digits showing how many hours he has worked for the day, and progressive total.

He then knows how many extra hours will have to be worked to reach the total required at the end of the accounting period. If in credit, he can take the time during the following period.

The system, of course, is different from staggered hours, which merely shifts starting and finishing time from one hour to the other. What it does is to allow the employee – particularly working mothers with home responsibilities – to choose their working hours within agreed parameters.

Employees, according to the system's manufacturers, like Plantime because they can plan their own working day, overcome the frustrations caused by fixed hours, regulate their travelling time to avoid the rush, have freedom to meet personal commitments at their convenience, and as their contact with the machine is a personal one, feel honour-bound to fulfill the hours laid down for each accounting period.

Endemic occurrences such as transport strikes, traffic jams, floods, a morning visit to the dentist and so on do not – as with fixed hours – mean a day's absence from the office but only the time (which is made up later) needed to sort them out.

Plantime, Plessey executives says, is ideal for large employers – particularly banks and insurance offices – because flexible hours are not only advantageous for existing staff but will attract many experienced women who need to start earlier or finish later.

Plessey Communication Systems Pty. Ltd.,
87-105 Racecourse Road,
Melbourne North. 3051. Vic.

TV THEFTS AVERTED

To stop unwanted removal of TV sets and monitors, AWA Rediffusion have imported and offer the Lucasey range of security TV set mounts and brackets.

The extensive range provides ceiling, wall, table and pillar mounts, all of which are lockable using a five tumbler lock. These units are ideal for hotels, hospitals or other similar public areas where security could be a problem.

Moderately priced and easily installed, Lucasey mounts offer a practical and attractive means of mounting TV receivers or CCTV monitors.

TELEWRITER

The Cygnet telewriter, a more efficient system of person-to-person communication by manuscript over any distance, is being marketed for the first time in Australia by Watson Victor Limited.

Australian Telecom approval for use over the public telephone network is being sought.

The Cygnet telewriter, which say Watson Victor, can be installed for under $2000, enables an exact copy of a message written in longhand in one office to be received instantly by the addressee at a remote location.

Manufactured by Feedback Instruments Limited, United Kingdom, the Cygnet operates with ordinary roll paper and carries messages written with a standard ball-point pen, which can be refilled in seconds, for both transmitting and receiving.

A great advantage of the system is that it has high combined following speed of writing and accuracy, and operates efficiently over telephone networks. It has the added advantage of producing three copies – the original and two carbons.

The Cygnet telewriter is of robust construction, with pleasant office style appearance and is designed for easy servicing. It operates on the well-known pantograph basis, but with completely modern components and circuits.

Watson Victor Limited. P.O. Box 100.
North Ryde. 2113.

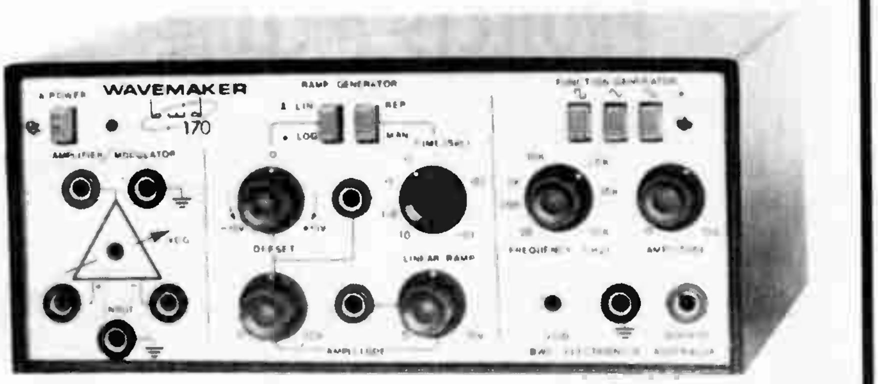
BWD 'WAVEMAKER'

A new multi-purpose instrument, the model bwd 170, has now been released by BWD Electronics Pty. Ltd. It can operate as a self-contained function/sweep generator over a 20 Hz to 50 Hz range, or as a companion unit to almost any function generator – in particular the newly released bwd 160. It provides a log or linear ramp to sweep VCO's and amplitude modulation facilities using its own function generator as the modulation source, or any suitable external source.

Its wide range of applications include : 20 Hz to 50 Hz sine, square or triangle source, manually adjustable or internally swept over the entire range. Log or linear ramp source for VCO's, together with a linear ramp for oscilloscope/recorder drive. Amplitude or balanced modulator with internal or external modulation source. Voltage controlled variable gain amplifier. Frequency Doubler or two input Multiplier.

The self-contained bwd 170 Function Generator covers 20 Hz to 50 Hz approx. in one uncalibrated range. Sine, square or triangle are switch selected and available at 5 V p-p into 600 ohms or 10 V p-p O/C. The entire range or any part of it may be swept by the log/linear ramp generator.

BWD Electronics Pty Ltd.,
Miles St.,
Mulgrave, Vic. 3170.



news digest

NEW PHILIPS DIGITAL MULTIMETER

In-house developed LOC-MOS circuitry is used throughout in this new Philips multimeter in order to combine low cost with high reliability and accuracy. During the lifetime of the instrument, designated the PM 2522, the specified accuracies are guaranteed — there is no need to recalibrate.

In order to make the lifetime accuracy as high as possible (.02% on dc voltage) the PM 2522 uses a unique analogue -to-digital conversion technique which eliminates the need for filters and rejects series-mode signals down to 0.1% of their original value. Together with the common mode rejection of 10 dB and high 10 megohm input impedance, this ensures that specified accuracies are maintained, even under unfavourable measurement conditions.

State-of-the-art techniques are also found on the front panel. The 3½ digit LED display is easy to read and has an automatic decimal point as well as polarity and over-range indication. All functions and controls are push-button selected and there is no need for lead changing when going from voltage to resistance measurements.

Protection against overloads is foolproof. Up to 1000 V can be applied to the voltage ranges. The current ranges are fuse-protected. Full mains voltages can be applied to the resistance ranges.

The extensive use of LSI circuitry and the LED display also make this

(Continued on page 107)

THE SOUNDS OF AMPLIFIERS

~amplifier distortion may sometimes be advantageous!

In this article written specially for Electronics Today International, Gordon King explains transient intermodulation distortion and how it affects amplifier/speaker combinations.

OF RECENT MONTHS I have been endeavouring to establish meaningful correlation between the measured parameters of amplifiers and the listening room sound. This is a very difficult area of research because there are so many inter-related and variable factors involved; also because the net result is obviously a subjective impression rather than a meter reading! Nevertheless, a number of points of interest have emerged which merit discussion.

For starters, it would appear that certain parameters are advanced out of sheer 'specmanship' rather than on a basis of electro-acoustic requirements; in fact, it is sometimes possible to enhance the sound by deliberately *diminishing* a parameter. There would also appear to be a fairly important link between the subjective and the objective at the electrical interface between the amplifier and the loudspeaker. The sound field is certainly affected by the acoustical interface between the loudspeaker and the listening room.

Although this article is concerned primarily with electrical parameters, it is necessary to look at some of the acoustical aspects, too, for after all, it is the resulting sound that we listen to, not electrical signals.

The loudspeaker 'loads' both electrically into the amplifier and acoustically into the listening room; in other words, the amplifier is the electrical source for the loudspeaker and the loudspeaker the acoustical source for the listening room. It is well known of course that the output into or across a load, is influenced by the nature of the source and the load, this being applicable to acoustics as well as electrics. Sound *pressure*, in fact, is the acoustical analogue of voltage.

It is reasonable to conclude, therefore, that just as some electrical sources are more critical of loading than others, so are some loudspeakers. The acoustical load presented by a particular listening room may be more acceptable to some loudspeakers than others, which is one reason why a pair of loudspeakers which yield acceptable results in one room may audition less favourably in a different room. There is a case, therefore, for the loudspeaker and listening room to be measured in partnership. Although free-field (anechoic) pressure *versus* frequency plots are commonly adopted for optimising the design of loudspeakers, they are far from revealing how different loudspeakers will audition in different rooms.

The acoustical load presented by a particular listening room may be more acceptable to some loudspeakers than others . .

It is neither difficult nor expensive for a hi-fi dealer or audiophile to measure loudspeaker/room combinations, and an inexpensive, though surprisingly accurate, method is based on the reproduction of a third-octave bands of pink noise. A 'linear' sound level meter at the normal listening position is then used to measure the sound pressure level at each band in turn over the range of 20 Hz-20 kHz, leading to the construction of a graph. This simple technique reveals eigentones and absorption effects quite dramatically, thereby indicating the adjustments required for improving the results.

Noise signal has the effect of automatically averaging the sound in the listening room. Steady-state sinewave signal cannot be used. Pink noise, which is white noise with −3 dB/octave (or −10 db/decade) weighting, is used because it correlates more closely with the spectral distribution of music than unweighted noise, which is white noise. It is noteworthy that the voltage of white noise is proportional to the square root of the bandwidth, and contains frequency components of constant energy per unit bandwidth. The weighting thus endows pink noise with components of constant energy per octave bandwidth.

It is neither difficult nor expensive to measure loudspeaker/room combinations . . .

Bruel and Kjaer have produced a calibrated record of third-octave pink noise bands (Type QR2011) which, along with a B&K sound level meter, such as Type 2206, makes it possible to 'sweep' the loudspeaker and room. The resulting overall response needs to be interpreted with care, however,

Detailed measurements may place two amplifiers well into the accepted hi-fi category yet, in a common signal source, loudspeaker and listening room situation, one may produce a very fine sound and the other a distinctly fatiguing sound. Fact or fiction?
FACT!

Given an amplifier of top-flight-measured parameters and two pairs of similar style but different make, measurement-acclaimed loudspeakers, one pair to a critical ear can be far more acceptable than the other pair, yet if the amplifier is changed the other pair may then be preferred.
Fact or fiction?
FACT!

since at the higher trequencies the response fails to correlate to what we hear. This is because we judge a sound more on its starting transient rather than on its overall integrated energy. Nevertheless, low-frequency standing waves are brought to light, and modifications to loudspeaker positions, furniture positions and amplifier tone controls can often improve matters. It is hoped to publish an article in these pages later describing listening room optimisation.

The prime discrepancies between what the meter reads and what the ear discerns are related to non-linear effects both in the amplifier and loudspeaker; also, sometimes, to how the non-linearities interact electrically and acoustically. One problem in obtaining subjective correlation from a meter reading lies in the nature of the signals we are obliged to use for the measurements. Sine and square wave signals are useful, being component parts of music signal, but real music signal is much more complicated than both of these.

If it were possible to feed a loudspeaker with a perfect electrical representation of the originating sound, it is likely that the reproduction would be less palatable than that obtained by first passing the source signal through a distorting amplifier! A non-distorting signal would tend to emphasise the loudspeaker non-linearities in terms of crossmodulation of spatial, spectral and temporal co-ordinates. The reproduction would thus be modified by all the practical inadequacies of even the best of loudspeakers. Further modification would result from distortion on the electrical signal, and there is reason to believe that distortion on the signal prior to its application to the loudspeaker can, in certain circumstances, lead to more acceptable reproduction[1]. (So much for the straight piece of wire with gain theory — Ed)

The loudspeaker distortion co-ordinates would then themselves be crossmodulated by similar distortion

. . . a perfect representation of the original sound may be less palatable than by first passing it through a distorting amplifier!

co-ordinates on the signal before the loudspeaker, leading to an acoustical result more closely related to the originating sound as humanly judged, than if the loudspeaker distortion alone were present.

The nature of the distortion produced by both the amplifier and loudspeaker is thus critical, so that different types of distortion would give different subjective impressions, which is not uncommon in a system of units of different distortion types. For example, the distortion from a radio tuner can interact with the distortion of an amplifier to which it is connected in such a way that the instrument-indicated *change* in the net distortion from the partnership, as the FM tuning is adjusted within the passband of a tuned signal, lacks subjective correlation. A test condition can be established where a fall in meter distortion is accompanied by an obvious rise in subjective distortion!

It thus seems to be perfectly feasible that after establishing the most acceptable reproduction by selection

. . . a fall in measured distortion may be accompanied by a rise in subjective distortion.

of the amplifier and loudspeaker partnership, a detraction in subjective acceptability could well result by changing either the amplifier or loudspeaker. I believe that this is one reason why a hi-fi system whose amplifier parameters measure in advance of those of another may not necessarily audition any better. Indeed, it could be judged subjectively inferior!

It should be understood that we are now considering hi-fi at the top equipment level, where the amplifier distortion figure is, at least, *one* place to the right of the decimal point. Distortion from this class of amplifier seems to be falling more swiftly than the distortion from comparable class loudspeakers, which is not making it particularly easy to select suitable loudspeakers for the parameters of the amplifiers.

One amplifier from the Pioneer range comes to mind. In the lab this was found to have a very low level of distortion — one of the lowest ever measured — with harmonic components down to the distortion threshold of the measuring oscillator (0.002%) over the whole dynamic range, as measured with a wave analyser to read below the wideband noise power of the simple distortion factor meter. The intermodulation distortion was also correspondingly low and there was no crossover discontinuity; yet, in partnership with acclaimed well known loudspeakers, the amplifier was judged to be less subjectively acceptable than a counterpart of similar power, bandwidth, etc. but of much higher measured distortion.

Clearly, it is becoming more important to audition loudspeakers in partnership with the amplifier with which it is going to be used. The ultimate performance of the Pioneer, just exampled, was eventually realised only after careful loudspeaker selection.

Most of the important parameters of amplifiers are measured into resistive loads, which does not make much sense because no loudspeaker presents a purely resistive load to an amplifier. The load analogue of a loudspeaker is an impedance composed of resistance, capacitance and inductance, but the impedance is not very easily defined since it is affected to some extent by the electrical drive signal and, of course, by the impedance of the separate units and nature of the frequency dividers. Different designs of loudspeakers present different loads to amplifiers, and it is not feasible to construct load analogues corresponding to all loudspeakers for testing amplifiers! Neither is it good for the loudspeakers (nor the neighbours!) to use real loudspeakers at test loads. Thus for testing we are back to R with, perhaps, a dash of C and/or L.

There has been a tendency for designers to optimise in terms of the smallest rise-time into resistive loads, and rise-times as small as 2 μsec. can be seen in the specs. However, there can be a dramatic change in scene when the load is made reactive by the addition of C.

THE SOUNDS OF AMPLIFIERS

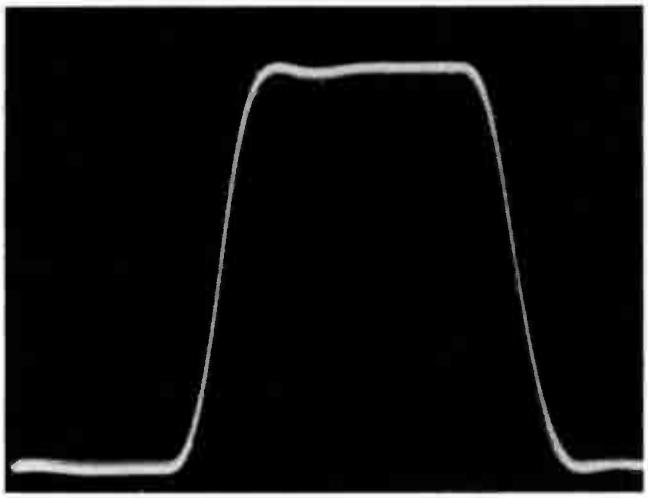


Fig. 1. Amplifier of small rise-time. (a) resistive rise-time about 4µsec.

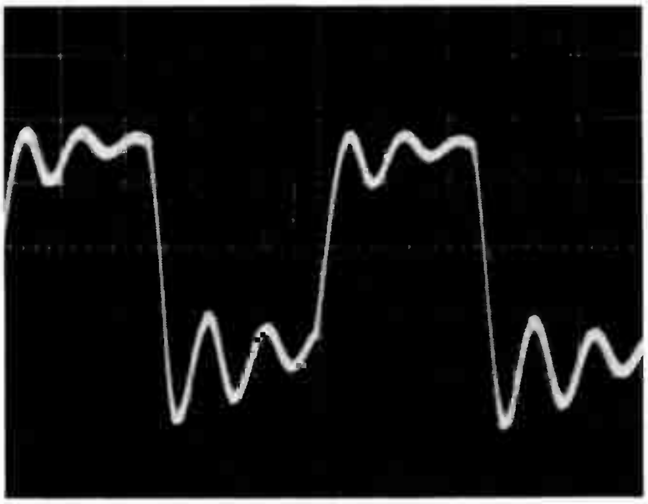


Fig. 1(b). Severe rings into reactance resulting in protracted 50µsec. settling-time.

For example, in Fig. 1(a) the step function applied to the input of an amplifier was around 100 nsec. rise-time. The oscilloscope was set to 5 µsec./div., giving the display a rise-time, via the amplifier and *resistive* load, of about 2 to 3 µsec., corresponding to about 140 kHz −3 dB upper-frequency response.

The trace at (b) shows the same signal from the same amplifier, but this time with the load consisting of 8 ohms in parallel with 1 µF. Rings as bad as this can certainly affect the tonal quality of an amplifier, depending on their amplitude and period. I have suggested[2] a definition of settling-time as an important parameter of amplifiers when measured into a reactive load arranged either to evoke the worst condition (i.e., by selecting shunt C for the most prolonged ring, when R corresponds to the rated load) or to the load analogue of the loudspeaker which will be used with the amplifier. The definition of settling-time under ref. 2, is the time elapsed from the application of the step-function to the time that the amplifier enters and remains within a ± 5% error band, corresponding to $E_0 \pm \Delta E$, where E_0 is the final settling voltage. With the settling-time referred to $\Delta E/E_0 \times 100$, it is in advance of 50 µsec. in Fig. 1(b), which is unacceptable for hi-fi.

Too long a settling-time, therefore, appears to be another valid reason why some amplifiers fail to audition as well as might be expected from distortion measurements alone; also another reason why a change in loudspeaker may modify the subjective result (i.e., by changing the electrical transient performance of the amplifier).

The oscillograms in Fig. 2 reveal a more acceptable state of affairs. That at (a) is based on a 3 µsec./div. sweep and corresponds to the resistive rise-time of a different amplifier of around 7 µsec. (50 kHz − 3 dB response), (b) shows what happens when the resistive load is shunted by capacitance. There are no rings in this case, just a mild kink at the leading and trailing corners of the squarewave, with the settling-time corresponding to about 10 µsec. (waveform on 20 µ sec./div. sweep). This shows the worst condition obtained with a shunt capacitance of 0.68 µF.

There appears to be a definite tendency for amplifiers designed for dramatically small resistive rise-times (some as small as 1.8 µsec. have been measured) to suffer prolonged settling-time as the result of severe rings into reactive loads, and hence tonal impairment when used with loudspeakers constituting critical load conditions.

The value of designing for very small rise-times and hence for extended small-signal high-frequency response is thus obvious. A rise-time of 1.8 µsec. implies that the amplifier is responsive well up to 200 kHz (the LW radio band!). Rise-time is related to the upper-frequency response by K/f,

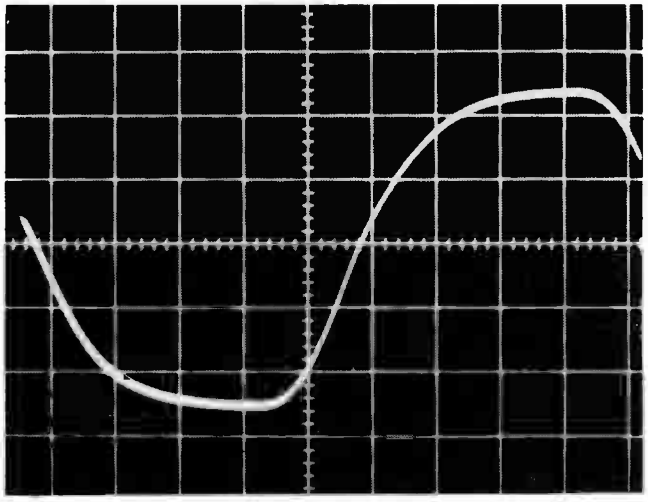


Fig. 2(a). Resistive rise-time about 7µsec.

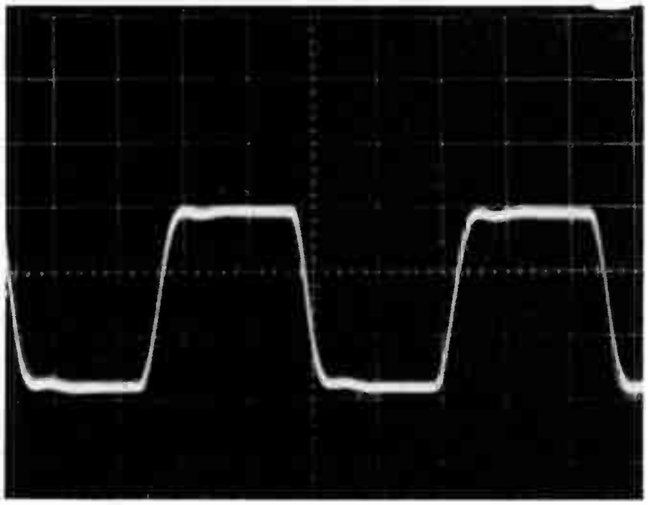


Fig. 2(b). Well controlled overshoot into reactance resulting in settling-time of 10µsec.

where K is a constant defined by the response characteristic of the amplifier or network, and f the upper-frequency where the response is 3 dB below the mid-spectrum response. When the upper-frequency roll-off approaches the so-called gaussian characteristic (i.e., when the −3 dB upper-frequency is approximately half the −12 dB frequency), K is close to 0.35; but it can range between 0.3 and 0.5, depending on the nature of the roll-off.

Of course the upper-frequency response needs to extend beyond audibility to accommodate the transient components of the music signal and thus to preserve the musical attack. However, it is difficult to argue in favour of a response much above 30 kHz, corresponding to around 12 µsec. rise-time. We have seen that an extended response might encourage rings and increased settling-time. There is also the possibility that it might encourage 'blocking' following fast transient signals. This is called transient intermodulation distortion.

Transient components of music *signals* rarely exceed about 16 µsec. owing to the limitations associated with the response and transfer characteristic of their sources. For example, a high quality FM transmission has an upper-frequency response limit of 15 kHz, with a swift fall into the 19 kHz pilot tone notch, thereby limiting the maximum equivalent rise-time to about 20 µsec. Few gramophone records carry high energy information much above 18 kHz, and the same applies to tape recordings, so even from sources of this kind the music transients are not likely to be much faster than 17 µsec. It is thus difficult to commend small-signal responses down to 2 µsec. or less and up to 200 kHz or more!

Transient components of music signals rarely exceed 16 µsec.

If one regards the source as a network of a given response, then, clearly, further limiting by a relatively slow amplifier response is undesirable. However, it must be remembered that the total rise-time (T_O) of two cascaded networks of rise-times T_1 and T_2 is equal to the vector sum (not to the simple sum), such that $T_o = \sqrt{T_1{}^2 + T_2{}^2}$. Thus the degree of response limiting of the source signal by the amplifier is relatively small — certainly not calling for a rise-time as small as 2 µsec.

Contemporary hi-fi amplifiers rely on negative feedback for extending and flattening the frequency response and for reducing non-linear distortion, particularly of the power amplifier section. The open-loop bandwidth of a power amplifier is dictated by the transistors which are available to drive the required audio power into reactive loudspeaker loads without veering too close to the secondary breakdown characteristic. This generally means that quite a lot of negative feedback must be applied to yield a viable closed-loop power response, and that lead and/or lag networks are necessary to maintain a reasonable stability margin. Unless the ratio of the response of the power amplifier in the open-loop mode to the response of the preamplifier is of unity or greater value, the amplifier is likely to exhibit transient intermodulation distortion — tid, for short.

In other words, the overall frequency response of the hi-fi amplifier should be dictated by the roll-off of the preamplifier section and not by the power amplifier section[3]. This, then, clearly places a limit on the small-signal response or rise-time of the preamplifier, beyond which it is subjectively imprudent to engineer.

The mechanics of tid can be described in the following way. The total input to a feedback amplifier consists of the sum of two signals, the source signal proper and the error signal fed back antiphase. If the source signal is a very fast transient and the error signal slightly delayed owing to a relatively slow power amplifier response, the input stage of the power amplifier will momentarily receive a signal of greater amplitude than it is designed to accommodate, and severe overloading may ensue. The transient may thus be distorted, and the sudden 'shock' to the input stage may result in this closing down for a brief period, followed by a relatively slow recovery due to the action of circuit time-constants, so that information immediately following the transient is lost.

. . . overall frequency response should be determined by the roll off of the pre-amplifier . . .

A method for the display of tid has been promulgated[4] and attempts have been made to measure it[5], but so far there is no accepted standard for the measurement.

THE SOUNDS OF AMPLIFIERS

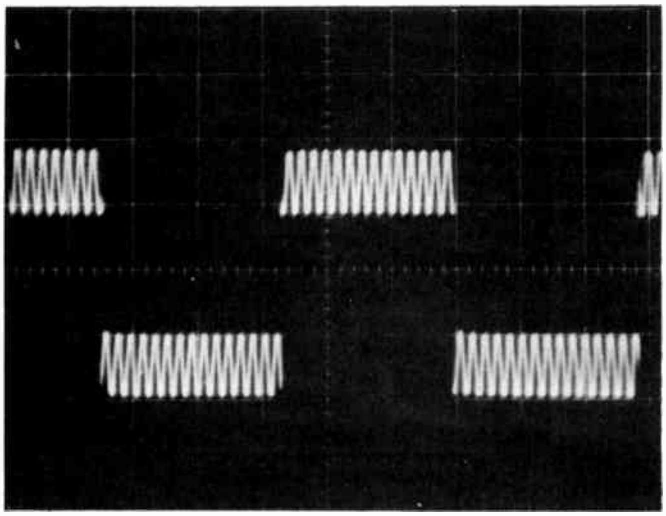


Fig. 3. Transient intermodulation distortion. (a) Test signal of squarewave plus sinewave.

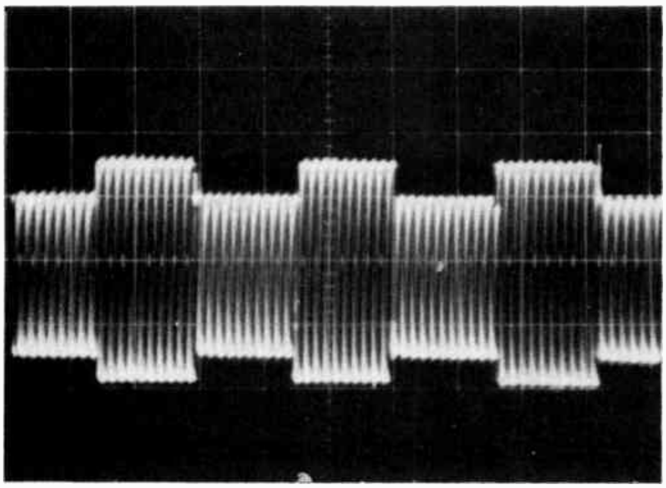


Fig. 3(b). Severe form of tid.

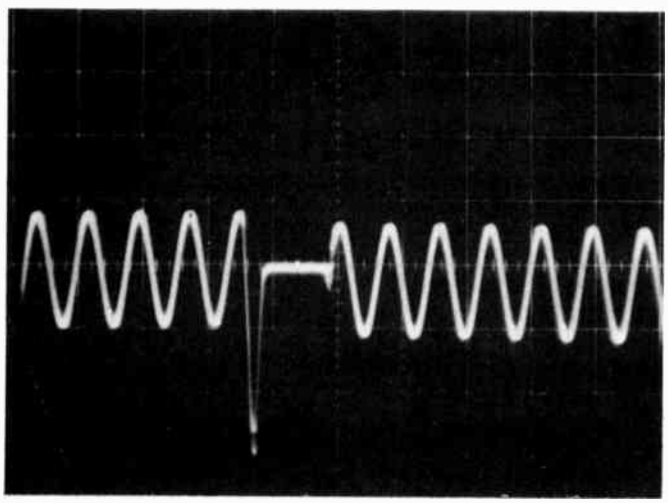


Fig. 3(c). Showing 'blocking' effect.

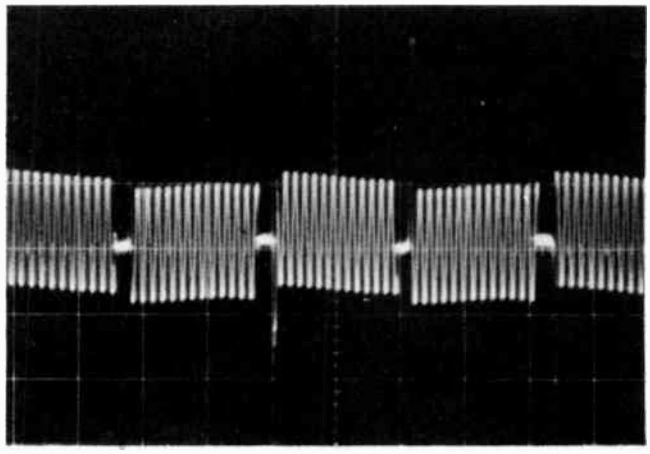


Fig. 3(d). 'Blocking' following each squarewave transient.

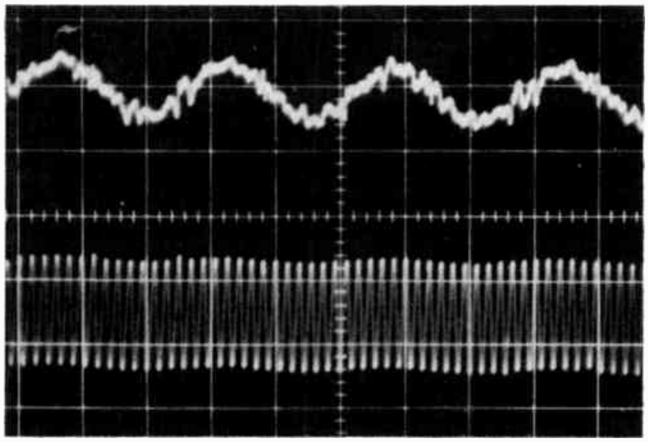


Fig. 3(e). Relative freedom from tid; bottom trace reconstituted sinewave; top trace distortion content of waveform.

The oscillograms in Fig. 3 may be of interest. Display (a) shows a test signal consisting of the addition of sinewave and squarewave signals. This composite signal is applied to the input of the amplifier under test, and at the output the squarewave component is cancelled out so that the sinewave component only is left for oscilloscope analysis. The squarewave is cancelled by applying to a bridge circuit an inverted *replica* of the squarewave component of the composite signal.

Display (b) shows a severe form of tid, giving asymmetrical sinewave components on the positive and negative going squarewave cycles. Display (c) shows the 'blocking' effect following transients. (d) is a similar display but with less expansion. Display (e) shows the sinewave components fairly well fitted together on the bottom trace, thereby indicating minimal tid, and the distortion signal on the top trace, after passing through a distortion factor meter.

Transient intermodulation distortion tends to affect the quality of the reproduction more towards the full power drive of the amplifier, and is emphasised by treble lift. It manifests as stridence and harshness on signal peaks. While there is a real possibility of tid being responsible for lack of objective/subjective correlation (for it does not appear as a parameter in specifications or reviews), it can only occur when the rate of rise of a signal transient at the *power amplifier* input is in advance of the response speed of the power amplifier in open-loop mode. It is thus encouraged by a very small rise-time which is not matched by the response speed of the power amplifier, indicated by a poor or mediocre slew-rate.

It is becoming apparent that an amplifier of very low distortion factor may not necessarily produce better sound than a counterpart which fares objectively less well. In fact, the latter may audition better! Here, then, is still another reason why an amplifier of very low measured distortion may fail to perform subjectively as one might expect.

A clue to this paradox is contained in the oscillograms shown in Fig. 4. A distortion factor meter responds to the average energy in the distortion signal, but the ear is more critical of signal peaks composed of high-order harmonics than lower-order harmonics of higher energy. Display (a) indicates relatively high energy third-harmonic distortion, which would produce a fairly substantial reading on a distortion factor meter compared with display (b), where the energy is small but the amplitude of the peaks large at the crossover points. The distortion factor of (a) was around 0.25% and of (b) a mere 0.05%, yet the amplifier responsible for (a) was more acceptable in the listening room than that responsible for (b), in spite of (a) being the much greater readout!

When comparing amplifiers in terms of distortion factor, it is essential to take account of the *nature* of the distortion, since the figures alone rarely provide adequate comparative information. Alternatively, attention should be directed to the intermodulation distortion, for with suitably high measuring frequencies, such as f_1 = 5 kHz and f_2 = 9 kHz (1:1 ratio), a relatively high $2f_1 - f_2$ readout is a sure indication that the crossover distortion is not very well tamed, particularly when this order increases as the power of the amplifier is reduced. Crossover distortion is generally more troublesome at low amplifier power, than at high power, the converse of tid.

Another form of bad crossover distortion is shown by display (c), where the energy is also high. This corresponds to about 0.4%, which is barely hi-fi. A commendable result is shown by display (d), the distortion being virtually down to noise threshold with no crossover artifacts; this corresponds to 0.02%.

. . . it is essential to take account of the nature of distortion — figures alone are insufficient.

Other factors responsible for the auditioning differences of amplifiers include asymmetrical overload allied with abnormally long recovery time-constant and changing quiescent current under dynamic conditions. The damping factor, too, has a bearing on the amplifier/loudspeaker partnership, and it is desirable for the amplifier's source impedance to remain at a low value right down to infrabass.

In conclusion, it is hoped that this article has given a few interesting points over which to ponder. We are learning all the time, which is half the fun of hi-fi . . .

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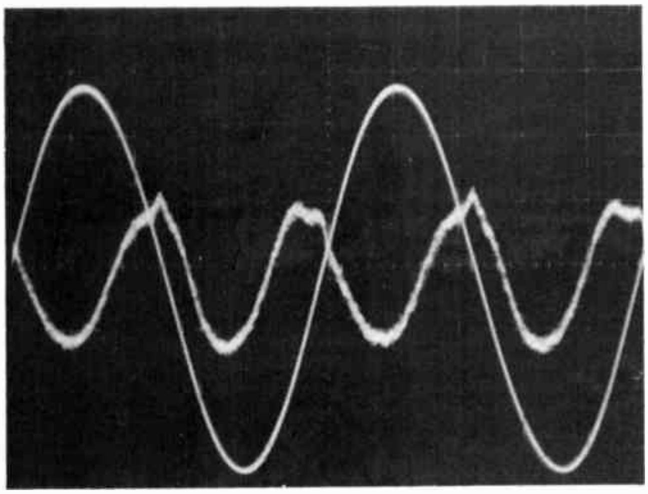


Fig. 4. Distortion factor oscillograms. (a) relatively high energy third-harmonic distortion.

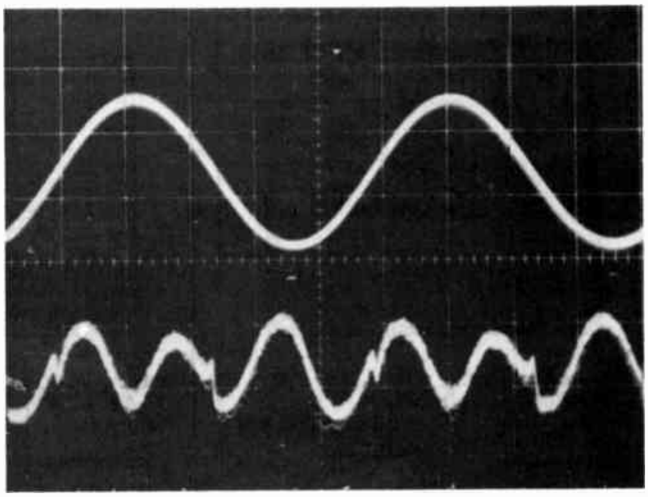
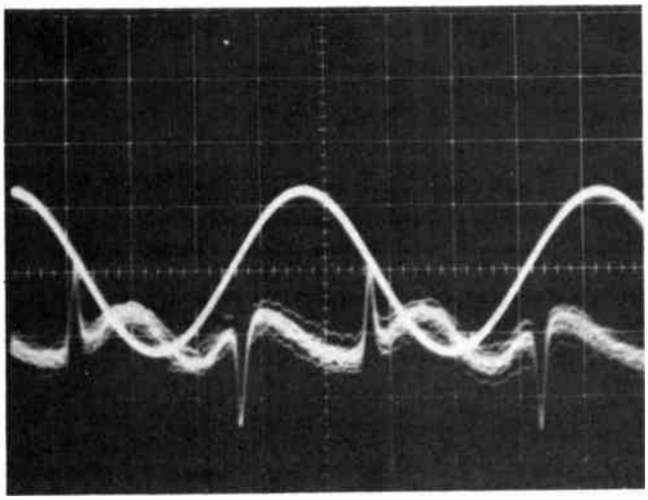


Fig. 4(c). High total energy, including crossover distortion.



ig. 4 (b). Low total energy but 'peaky' crossover.

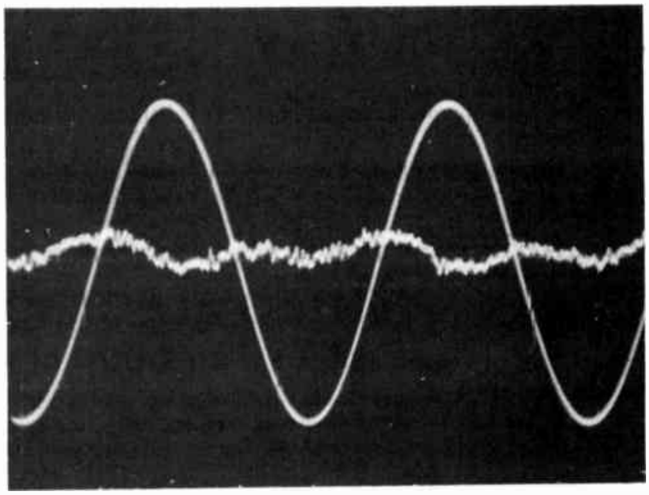


Fig. 4(d). Low energy harmonic distortion without crossover artifacts.

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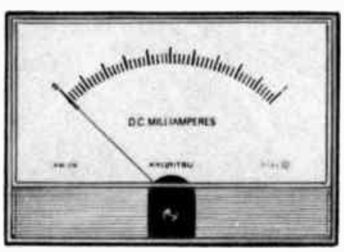

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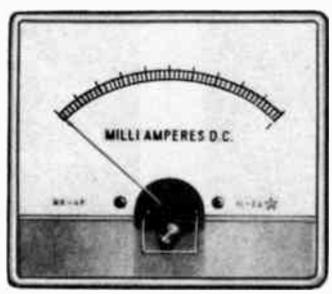

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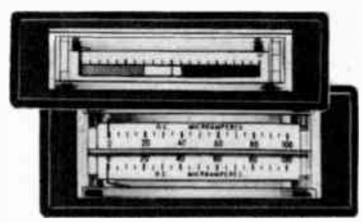

Moving Coil Type
DC Ammeter/Voltmeter
Range: 50 μA ~ 500 μA
1 mA ~ 500 mA 1 A ~ 100 A
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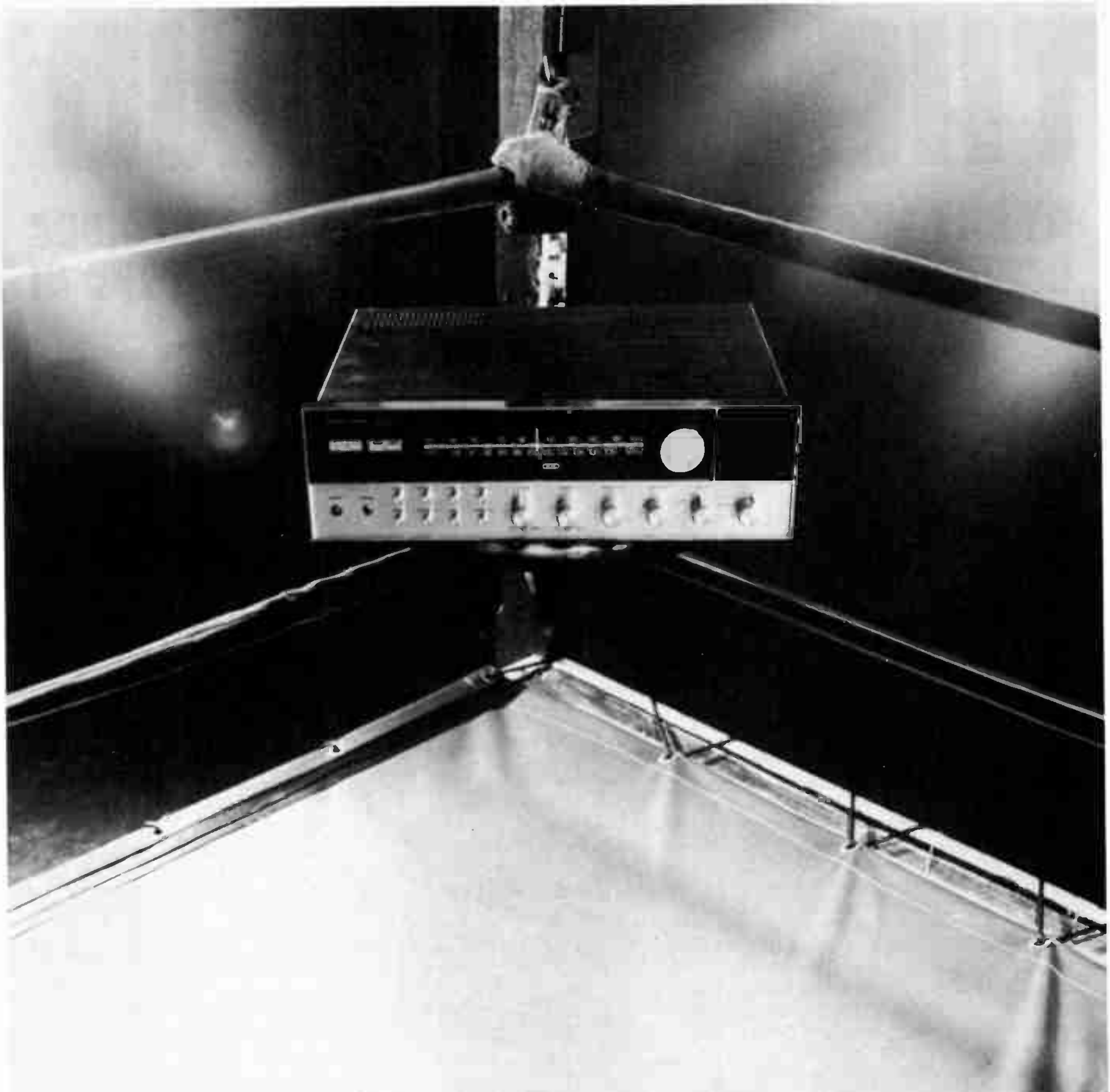

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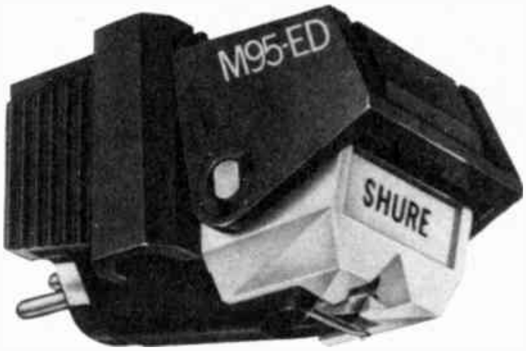

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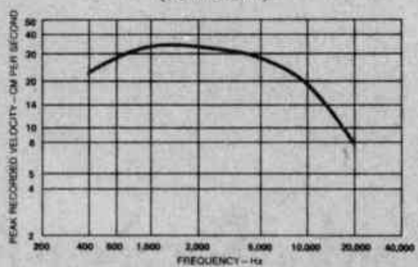

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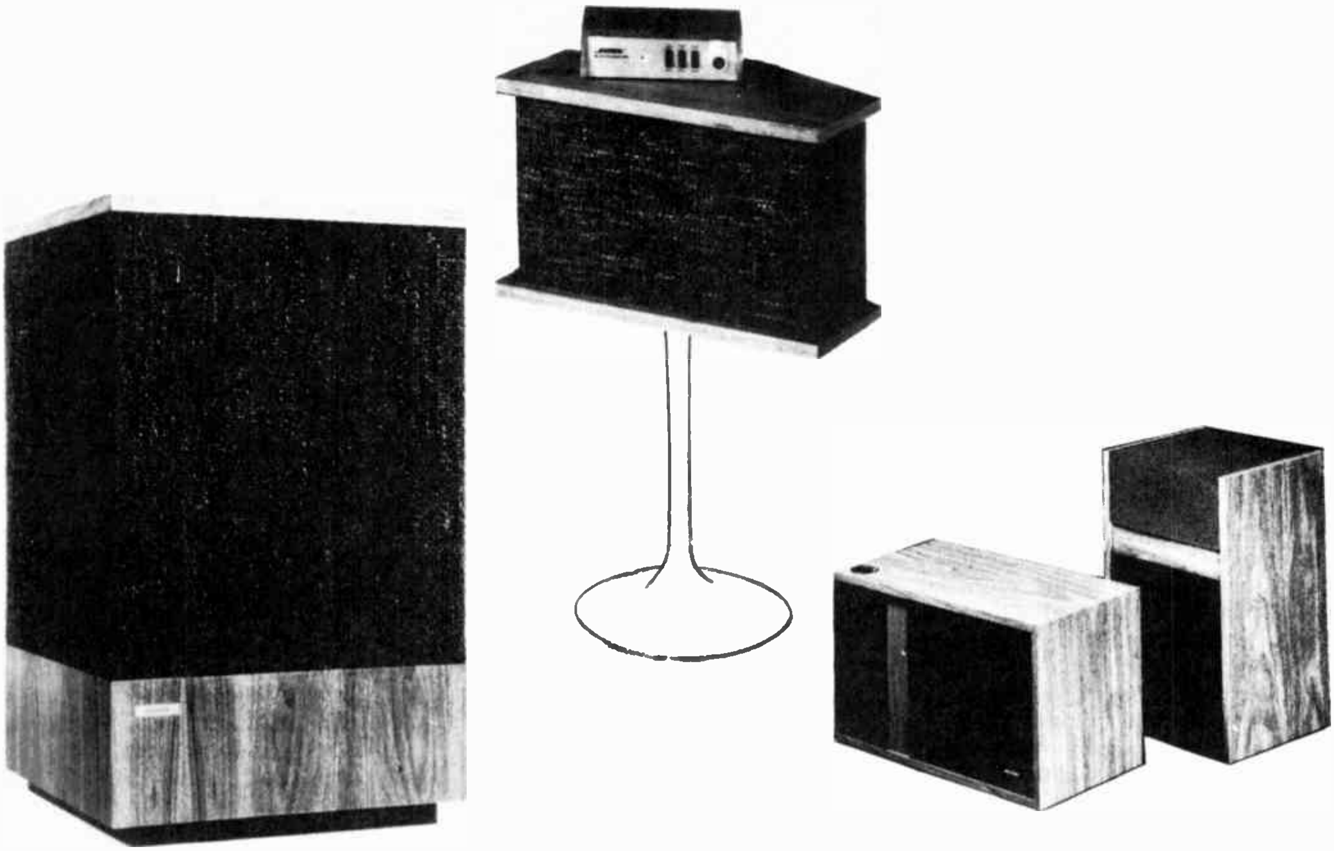

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DESIGN YOUR OWN FM RECEIVER PART 2

Brian Dance explains . . .

MINIATURE 10.7 MHz ceramic filters are manufactured by Toko (type CFS). Vernitron (type FM-4) and Murata. They can be used to replace the tuned circuits formerly used in FM receivers and have the advantage that no alignment is required. These filters have three connections; the centre one should always be earthed, whilst the other two interchangeable connections are the input and output.

A single ceramic resonator is employed in the filters. This is equivalent to a complex multi-section LC filter and provides excellent selectivity. The frequency response of Vernitron FM-4 filters is shown in Fig. 7. A single filter is adequate for most locations, but the use of two filters provides the really high adjacent channel rejection which is valuable when one is situated near to a transmitter.

Unfortunately two ceramic filters cannot be coupled *directly* together or their frequency response will be affected. An amplifier of moderate gain is normally inserted between two filters. The external circuit on each side of the filter should present an impedance of about 330 ohms, the parallel capacitance being under 10 pF. Although these values are not very critical, the selectivity curve will suffer if they are not within 20%.

Ceramic filters cannot be manufactured with extremely narrow centre frequency tolerances. Manufactured filters are therefore colour coded. If two filters are to be used in a receiver, the colour coding of each should be the same, but it does not matter what colour is used. Manufacturers will supply matched pairs.

Ceramic filters are almost immune to shock. They are compact and light in weight, easy to mount and require no adjustment. The change of the centre frequency with temperature is around −40 kHz for a change from −10°C to +50°C. The loss in the pass band is only about 5 or 6 dB.

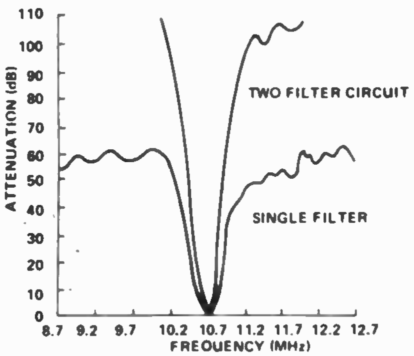


Fig.7. Typical response of circuits employing one and two Vernitron type FM-4 ceramic filters.

CFK FILTERS

The Toko CFK 10.7 MHz filter contains a single tuned input circuit which is coupled to a ceramic filter. The input impedance is about 5 k, so it is suitable for use following circuits of a relatively high output impedance. It is, however, necessary to adjust the tuned input circuit.

AMPLIFICATION

The earlier FM demodulator ICs did not incorporate a high gain internal 10.7 MHz amplifier. It is necessary to amplify the incoming signal from the front-end before feeding it to one of these circuits. Although only modern high gain demodulator ICs will be covered by this article, many readers will be interested in details of FM amplifiers.

THE μA753

The Fairchild μA753 device is especially suited to receivers using ceramic filters since it has input and output impedances of 330 ohms. The device has two outputs. The normal one at pin 5 is taken from the third amplifier stage where the overall voltage gain is about 300 (50 dB). A lower level output is available from pin 7 where the overall gain is about 50 (34 dB).

A circuit using the μ A753 is shown in Fig. 8. Two ceramic filters, F1 and F2 are used. If the output impedance of the front-end is 75 ohms, the value of R1 should be about (330 − 75) = 255 ohms (so that the input of F1 is matched to the correct impedance). In practice, a 270 ohm resistor of 10% tolerance is quite suitable.

The output of F1 is matched by the internal 330 ohm resistor of the μA753. Similarly, the output of the μA753 provides the required 330 ohm impedance for the input of F2, whilst the output of F2 requires the matching resistor R2. The value of R2 should be selected to provide a 330 ohm output impedance when it is in parallel with the input impedance of the succeeding stage. For example, if the output feeds a circuit with an input impedance of over 3 k, the value of R2 should be about 330 ohms. If the following circuit has an input impedance of 660 ohms, the value of R2 should be about 660 ohms also. (A 680 ohm resistor would be quite satisfactory).

The μA753 provides a stabilised output of 7.8 V from pin 6. This can be used as the power supply to a front-end unit, as in Fig.8. The total current consumption of the circuit in Fig. 8 is around 16 mA plus any current taken from pin 6. The μA753 is an 8-pin dual-in-line IC.

Quite a number of other integrated circuits are suitable for use as 10.7 MHz amplifiers. The RCA CA3076 can be used in the simple circuit of Fig. 9. R1 and R2 are the filter matching resistors. A gain of about 80 dB at 10.7 MHz can be obtained using this device if the load is about 2 k. In the circuit shown the gain will be reduced by the filter matching resistor R2 and the loss in the two filters. However, it should still exceed 50 dB.

TDA 1200/CA3089E

The SGS-Ates TDA 1200 and the RCA CA3089E are equivalent 16-pin dual-in-line devices which form a complete FM IF and demodulation system. They contain over 80 transistors. The connections are shown in Fig.10, and the internal circuit is shown in block form in Fig. 11.

The devices include a three-stage high-gain differential amplifier which drives the level detector circuits. The latter feed the field strength meter circuit, whilst the first level detector also provides delayed AGC for the RF stage in the front-end. The last stage of the differential amplifier also drives the quadrature detector. This provides signals to the audio amplifier, the AFC amplifier and the muting circuit.

Figure 12 shows a typical high-performance tuner using a normal front-end (gain about 26 dB), a transistor 10.7 MHz amplifier, one ceramic filter (marked F) and a TDA 1200 circuit. R5 and R7 are the filter matching resistors. The value of R10 should be chosen so that a suitable AFC characteristic is obtained.

Two coils are employed in the circuit. L1 is a 22 μH choke which can be obtained as a very neat Toko coil (type 144 LZ220K). The coil ·L2 with the parallel capacitor C9 is available under the Toko type numbers KACS-K-586HM and 94AES 30465N. The former type includes an 82 pF capacitor for C9 and the latter a 120 pF capacitor. The Q factors are quoted as 100 and 65 respectively, but R8 reduces this. The value of this resistor has been chosen to give a suitable compromise between the distortion level and the amplitude of the audio output signal. In the case of all three coil types, the connections are taken from the outer pair of the row of three connections, the other leads remaining unused. (The 94AES 30465N has an additional coupling coil which is not used in this application).

The coil L2 can be roughly aligned by tuning it for maximum audio output. If no wobbulator is available, reasonable alignment of L2 can be effected by adjustment of the core until the meter M2 swings almost symmetrically from one side through the centre to the other side as one tunes the receiver through a station. Correct tuning is, of course, obtained when M2 is at the centre null point.

The circuit of Fig. 12 provides a total harmonic distortion at the output of around 0.5%. Lower distortion can be obtained by using the double tuned circuit shown in Fig. 13(a) as a modification. This double-tuned circuit is claimed to have a distortion of around 0.1% In addition it provides a lower capture ratio.

A suitable double-tuned circuit can be made by using the Toko type 34342BM coil with a separate Toko 343431AUO coil connected as shown in Fig. 13(b). This circuit is electrically equivalent to that of Fig. 13(a). Although these coils for the double-tuned circuit are readily available, a wobbulator is required to align them, since any change in the setting of the core of either coil affects the tuning of the other coil. Many readers will therefore prefer to use the simpler single tuned demodulator circuit of Fig. 12.

All of the Toko coils mentioned for both the signal and double tuned circuits are housed in miniature 10 mm square cans.

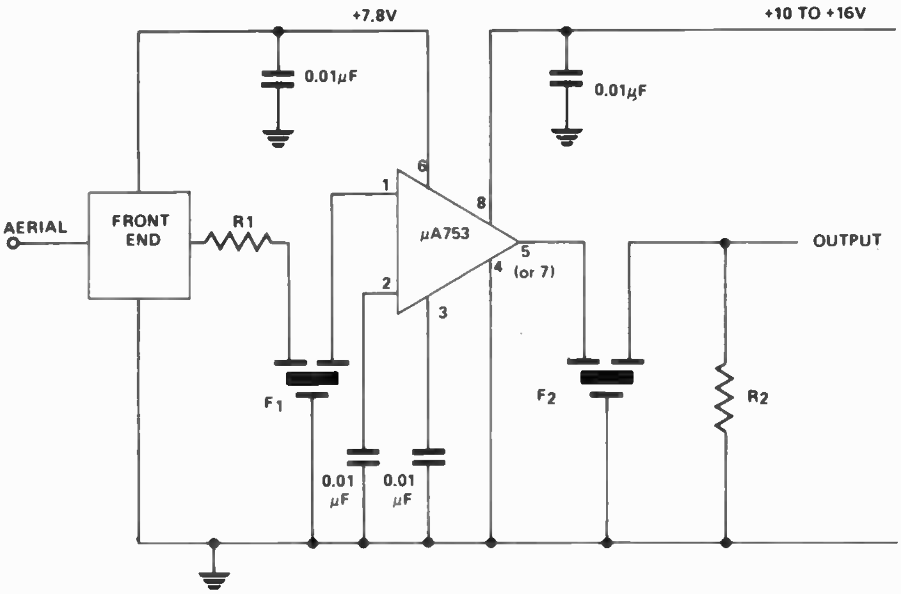


Fig.8. Amplifier circuit using the Fairchild μA753 with two ceramic filters.

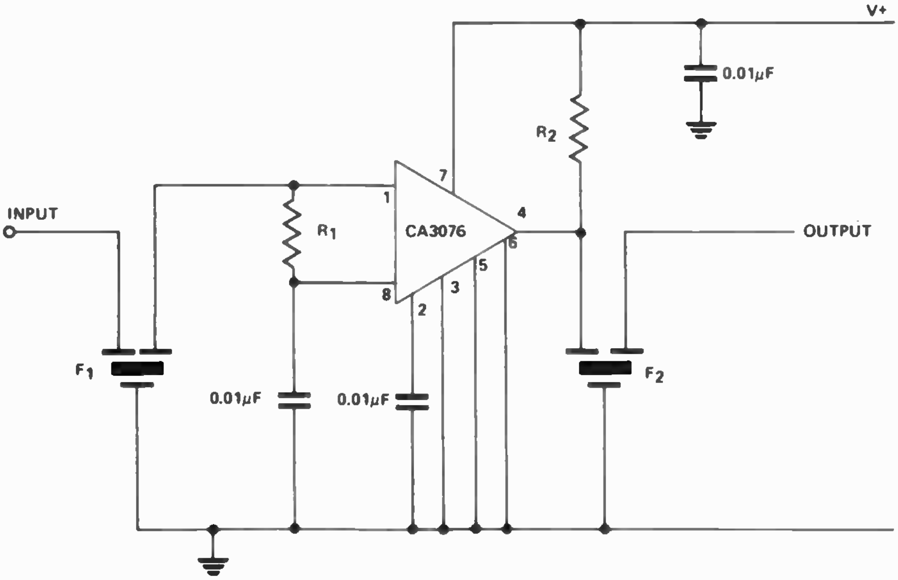


Fig.9. A CA3076 amplifier stage.

The capacitor C13 in the Fig. 12 circuit provides the normal 50 μs de-emphasis in conjunction with the sum of the resistance of R12 and the 5 k ohm output impedance of the pin 6 circuit. If the output is fed to a stereo decoder circuit, R12 and C13 should be omitted. The de-emphasis components must be placed at the output of the stereo decoder.

The variation in the potentials of pins 13 and 15 with the input signal level is shown in Fig. 14. It can be seen that the AGC output from pin 15 remains almost constant at about +4.7 V until the input signal to pin 1 reaches a level of about 3 mV. Then the potential at this pin falls with increasing signal level. The front-end circuit must not impose a load of less than 10 k ohms on the AGC output from pin 15.

It can be seen from Fig. 14 that the potential of pin 13 rises almost as the logarithm of the input signal strength over much of the working range of input levels. Thus the meter M1 can indicate a very wide range of input signal levels.

The FM rejection provided by the type of circuit shown in Fig. 12 is

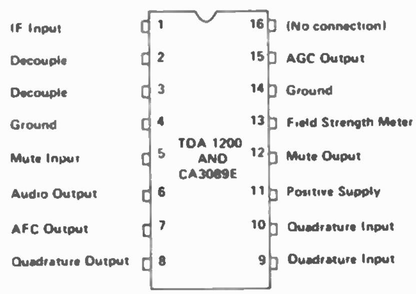
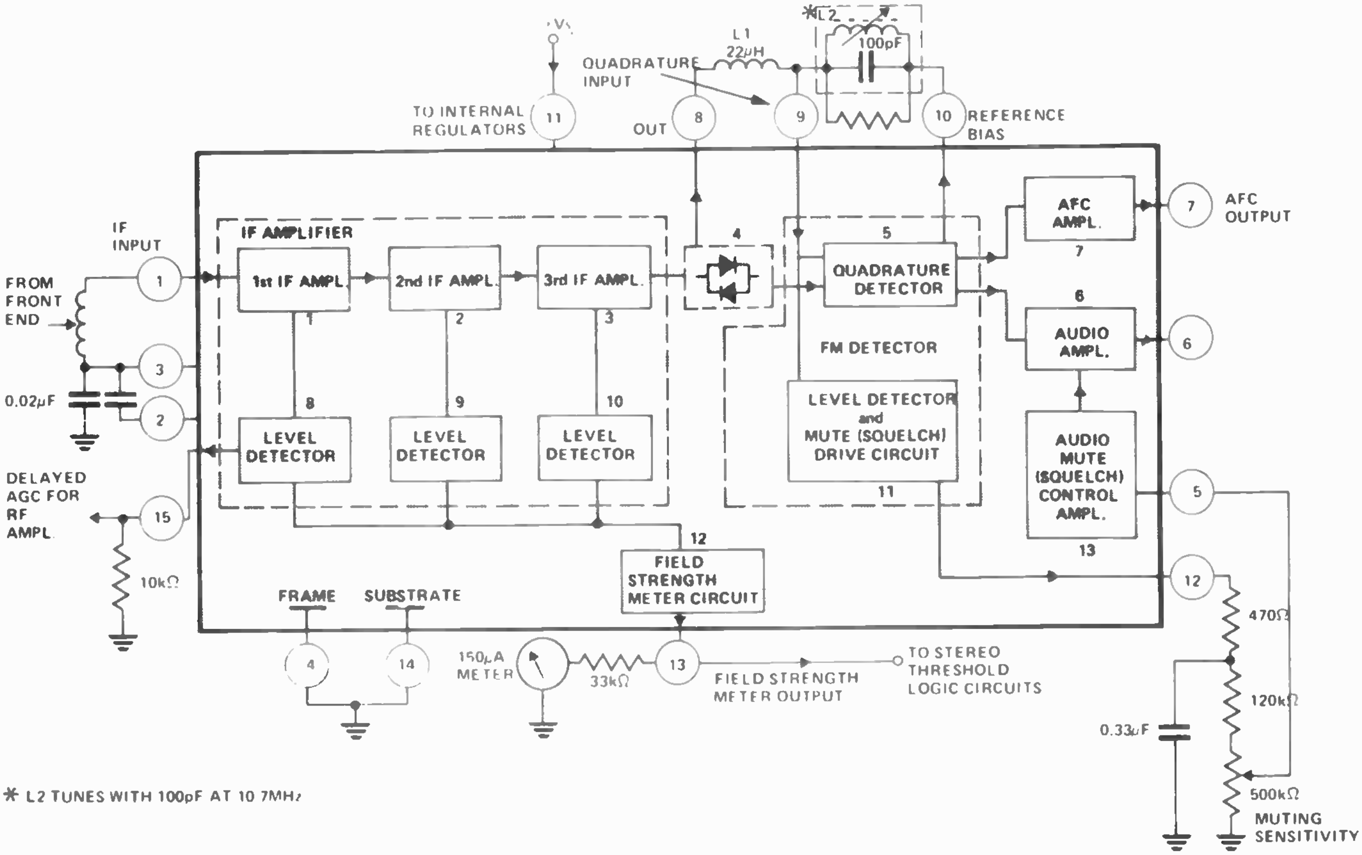


Fig.10. Connections of the TDA 1200/ CA3089E devices.

DESIGN YOUR OWN FM RECEIVER



* L2 TUNES WITH 100pF AT 10.7MHz

Fig. 11. Internal circuit of the TDA 1200/CA3089E in block form with basic external circuit.

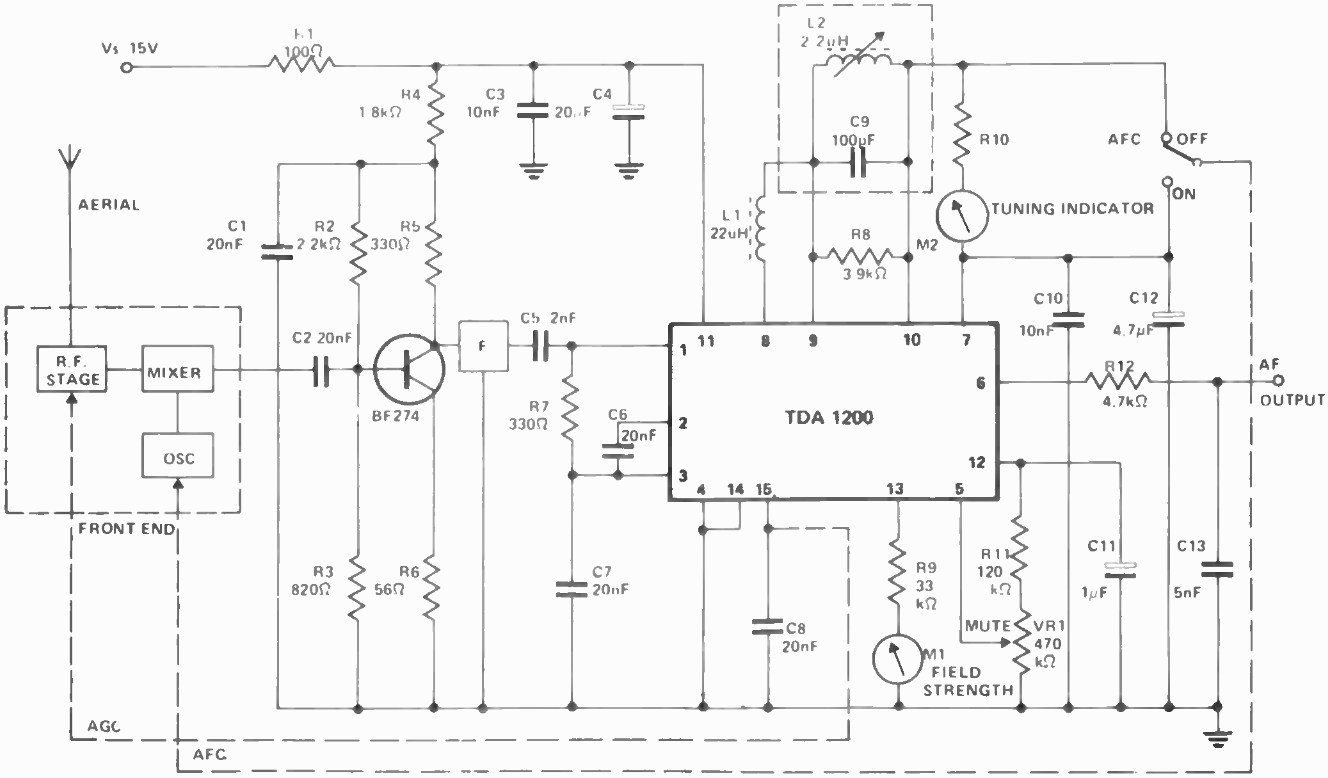
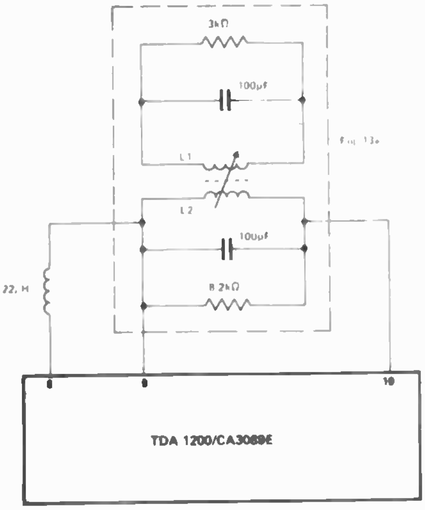


Fig. 12. A typical FM tuner using the TDA 1200.



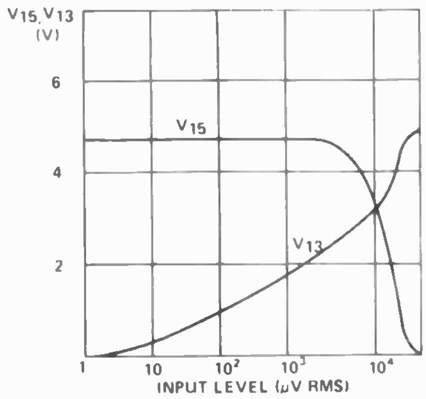


Fig.14. Variation of the pin 13 and pin 15 potentials with input signal level.

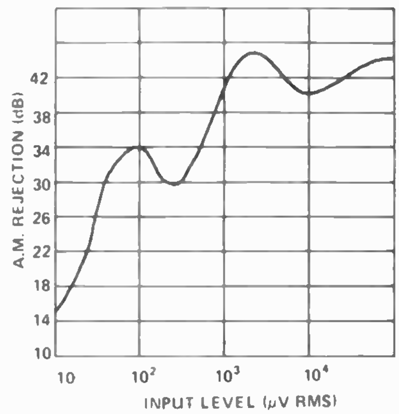


Fig.15. A.M. rejection provided by the CA3089E/TDA 1200.

Fig.13. Low distortion circuit using a double tuned quadrature coil.

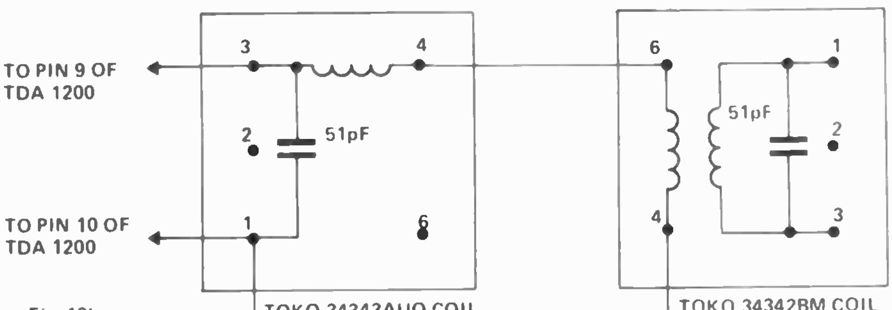


Fig. 13b.

plotted in Fig.15. It can be seen that for signal levels exceeding about 1 mV the rejection of unwanted AM signals (including car ignition noise) exceeds 40 dB. The circuit can handle inputs of over 500 mV without any deterioration of the AM rejection factor. A signal to noise ratio at the audio output of over 20 dB can be obtained with input signals to pin 1 of the order of 12 µV RMS.

If the AFC facility is not used, it is advisable to link pin 7 with a 4.7 k ohm resistor to pin 10 to avoid the possibility of added distortion at the audio output.

The CA3089E and the TDA1200 incorporate circuitry which enables inter-station noise to be muted. When a signal is tuned in correctly, the potential of pin 12 is approximately zero volts. If, however, only noise is present, this potential will rise and a portion of it is tapped off by VR1 of Fig. 12. If the potential of pin 5 exceeds about +1.5 V, the circuit is muted and little signal reaches the output. If a high gain front-end unit is employed, it may be necessary to employ a capacitive attenuator between the front-end and the TDA 1200/CA3089E in order to achieve satisfactory muting.

. . . to be continued

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OPERATIONAL AMPLIFIERS Part 3

In this down-to-earth three-part series, J.T. Neil explains the basic theory and practical applications of op amps.

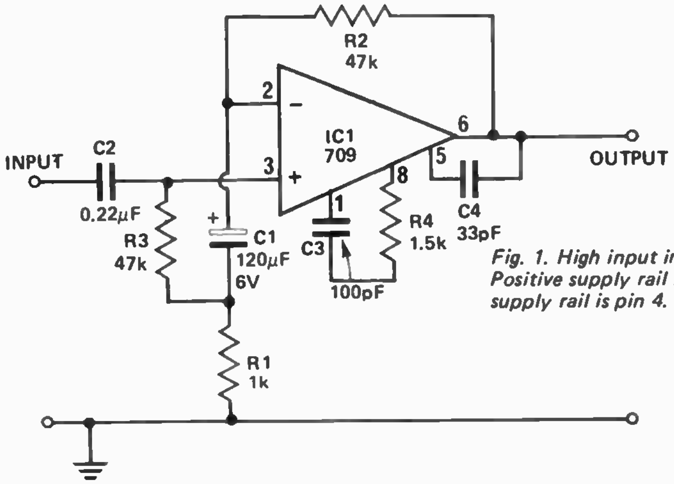


Fig. 1. High input impedance ac amplifier. Positive supply rail is pin 7 and negative supply rail is pin 4.

THE SINE WAVE oscillator described in the previous article was an example (albeit an extreme one) of how frequency selective feedback is used with operational amplifiers. We shall now go on to consider an amplifier employing non frequency-selective feedback and then amplifiers using feedback of such a nature as to produce two particular forms of frequency response. Then to conclude, there is a description of the use of an op. amp., as a dc amplifier, to increase the sensitivity of a moving coil meter — in this case the frequency is required to be limited to dc up to a few Hz only.

Figure 1 gives the circuit of a high input-impedance amplifier with a nominal voltage gain of 48 and a bandwidth of from 10 Hz to at least 50 kHz. In the prototype the measured value of input impedance was 10M Ω at 1 kHz. This value will vary slightly with frequency and with the particular layout employed, but in any case is likely to be as high as will normally be required for most applications.

As an ac connection, via a capacitor, is provided at the non-inverting input there would be no dc return for bias current, at that input, if R_3 were not present. The value of R_3 is 47 k however, bootstrapping is used to raise the apparent value of R_3 to the value of 10 megohm as quoted, in the following manner.

Due to the extremely high gain of the op. amp, and to the feedback between the output and the inverting input pin 2, there is very little difference in the signal levels at the +ve and −ve inputs, and, since C1 has a negligible reactance, there is similarly very little difference in signal voltage at either end of R_3. Accordingly, very little signal current can flow into R_3 from the signal input, thus R_3 appears, to the input signal, to be many times its actual value.

With the op. amp. arranged in the non-inverting configuration, the voltage gain is:

$$Av = \frac{R_1 + R_2}{R_1} = 48$$

This amplifier set-up is most likely to be used in the design of a pre-amplifier for an oscilloscope or millivoltmeter, where the high value of input impedance is necessary in order to load the circuit under test as little as possible.

In audio applications, a 'tailored' frequency response is often called for; for example, the output of a tape replay head should be fed to a stage with a gain rising at 6dB per octave below about 2.5 kHz, and a flat response above that frequency. (The actual value of the break frequency depends on the tape speed and the particular replay characteristic employed). Such a response is readily arrived at by replacing R_2 of Fig. 1 with the network shown in Fig. 2a.

At high frequencies C_5 has a reactance low compared to R_6 and hence it can be ignored. Thus the gain is determined by R_6 alone (although R_5 is in parallel its value is large enough to be disregarded). As the frequency is lowered, the reactance of C_5 rises and consequently the feedback is reduced, so giving the frequency response shown in Fig. 3a. Resistor R_5 provides a dc connection for the negative input of the op. amp. and limits the gain at very low frequency.

The voltage gain of this circuit at high frequencies is about 16 times; this will make the tape head output comparable to that from a magnetic pick-up. If more gain is called for, this is best done by increasing the value of R_6 and reducing the value of C_5 in proportion.

What if a response suitable for pre-amplification of the output of magnetic pick-up is required? In this case the network of Fig. 2b is a suitable replacement for R_2 in the original circuit; the overall response of the stage is now as given in Fig. 3b.

Similar reasoning to that given for the tape head amplifier applies here also — the gain rises at lower frequencies as C_6 reactance becomes larger, falling at the higher frequencies as the reactance of C_6 and C_7 both fall. As before, R_7 sets the low-frequency gain.

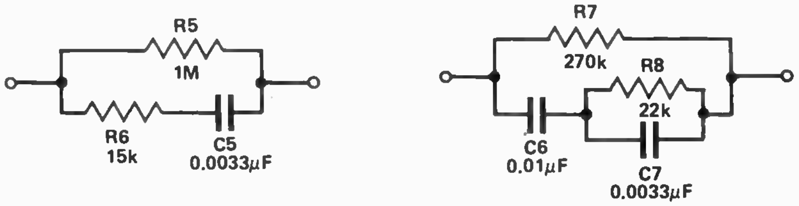


Fig. 2. Alternative feedback networks. (a) Tape head; (b) Magnetic pick-up.

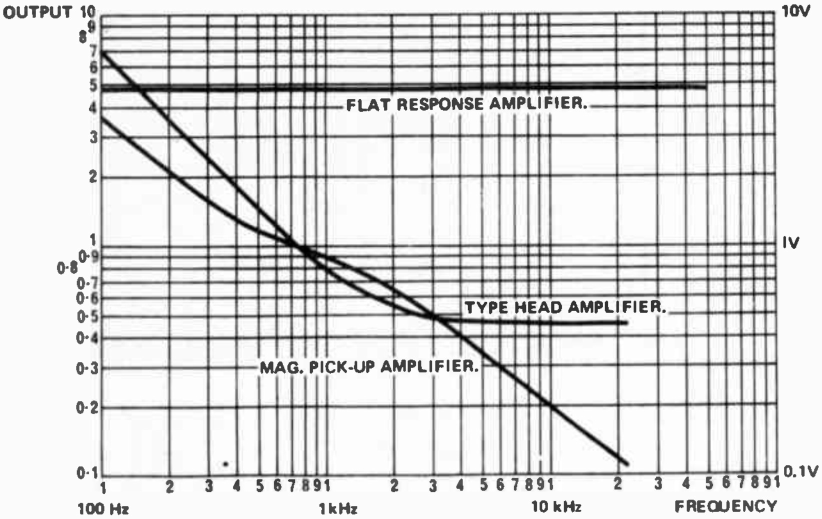


Fig. 3. Responses of the three different amplifiers.

These two latter configurations are good examples of the shaping of a frequency response to suit a particular need – as indeed was the audio oscillator of Part 2. Note that the response and the overall gain can be adjusted independently.

All the circuits given so far in Part 3 are intended to make use of type 709 op. amps., although a 741 or an LM301 could be used with the appropriate equalizing network changes as detailed last month.

The amplifier configuration described is an inherently stable one and almost any convenient layout can be employed. A small piece of Veroboard was used in the prototypes, with a dual-in-line IC holder soldered in place and the remaining components placed around it.

PARTS LIST

Flat response amplifier

IC1	Integrated Circuit 709 8 pin DIL			
R1	Resistor	1k	¼ watt	5%
R2	"	47k	"	5%
R3	"	47k	"	5%
R4	"	1.5k	"	5%
C1	Capacitor	120 μF 6V electro.		
C2	"	0.22 μF polyester		
C3	"	100 pF ceramic		
C4	"	33 pF ceramic		

Tape head network plus all of Fig. 1

R5	Resistor	1MΩ	¼ watt	5%
R8	"	15k	"	5%
C5	Capacitor	3,300 pF polyester		

Pick-up network plus all of Fig. 1

R7	Resistor	270k	¼ watt	5%
R8	"	22k	"	5%
C6	Capacitor	0.01 μF polyester		
C7	"	3,300 pF polyester		

Meter amplifier

IC1	Integrated Circuit 741 8 pin DIL			
R1	Resistor	1k	¼ watt	5%
R2	"	6.8k	¼ watt	5%
R3	"	33	¼ watt	5%
R4	"	1k	¼ watt	5%
R5	"	10k	¼ watt	5%
R6	"	10k	¼ watt	5%
R7	"	10k	¼ watt	5%
RV1	Potentiometer 22k linear			
C1	Capacitor 0.1 μF polyester			
M1	Meter 1 mA movement			

Miscellaneous
IC holders, Veroboard, small aluminium boxes etc.

For convenience, it is best to build the whole amplifier in a small metal box, either mounting this in existing equipment or leaving it as a separate unit for greater flexibility. The box must be earthed to give a measure of screening to reduce hum pick-up. This is especially necessary if the feedback networks of Figs. 2a or 2b are employed as both of these provide considerable bass boost thus aggravating the hum problem.

METER AMPLIFIER

Now for the dc meter amplifier which uses a 741 type IC. The circuit is given in Fig. 4. The values shown give full scale deflection on a 1 mA meter with only 10μA flowing into the input.

Circuit function depends on there being negligible difference between the voltages at the two inputs of an op. amp. when arranged in a negative feedback configuration. Accordingly, whatever voltage is applied to the non-inverting terminal, that is, across R_1, will appear at the inverting terminal, that is, across R_3. However, R_3 is only 1/100th of the value of R_1, so that the current through R_3 must be 100 times larger than that through R_1. It is, of course, the current through R_3 that flows through the meter, and it is worth noting that the value of this current is not affected by resistor R_2 in series with the meter – provided of course that R_2 is not too large to allow the required meter current to flow. The value of R_2 is chosen here to limit meter current to about twice the FSD current, so providing a useful safety device should an unexpectedly high voltage be applied to the non-inverting terminal.

Thus we have a circuit incorporating a meter of 1 mA basic sensitivity but which appears to be a meter of 100 times that sensitivity.

Resistor R_4 is included to improve the performance with regard to drift, of the meter reading, as temperature changes cause changes in the op. amp. bias currents. It is best selected by experiment, although the value given was found to be satisfactory with three individual 741's.

The voltage at the slider of RV_1 is fed via R_7 to the inverting input to provide a means of setting the meter zero. It can, if desired, be used to give a centre zero, so producing a 5 μA–0–5 μA meter. The capacitor C_1 ensures that the gain falls at high frequencies.

With a basic sensitivity of 10 μA., this amplifier enables a dc voltmeter of 100 kohm per volt to be constructed, by connecting the appropriate resistor in series with the input. The value of the resistor is given by:

R = 100 V kilohms

where V is the input voltage required to give FSD

Note that the basic meter of 1mA is

(Continued on page 41)

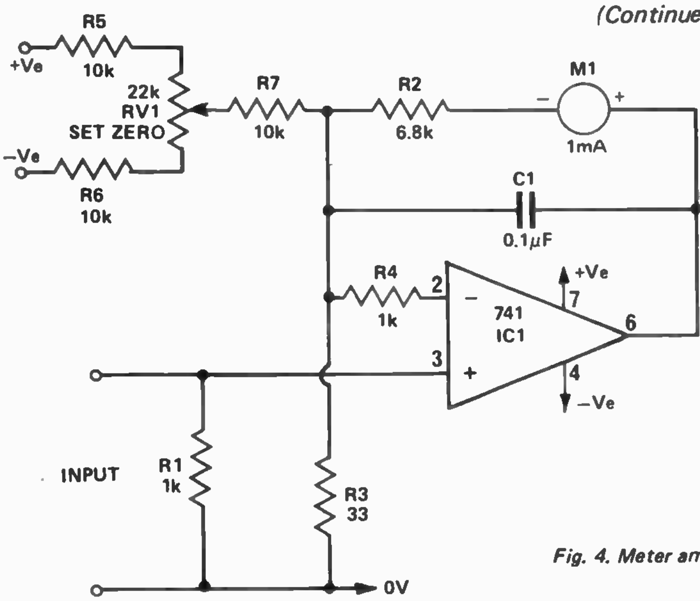
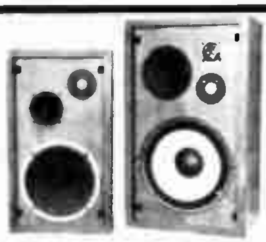


Fig. 4. Meter amplifier.

KITSETS



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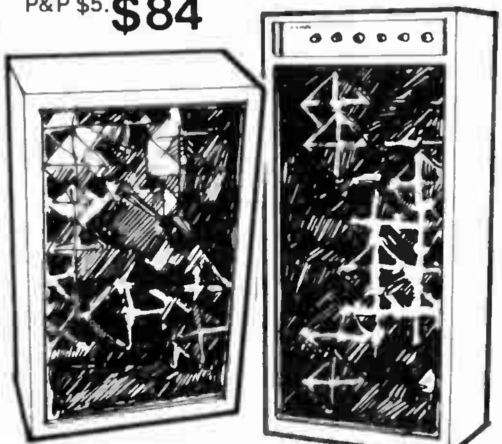

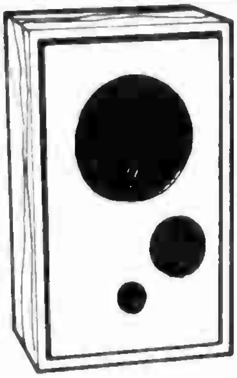

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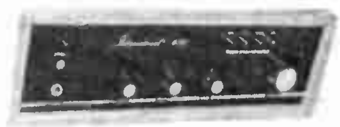

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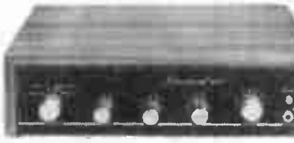

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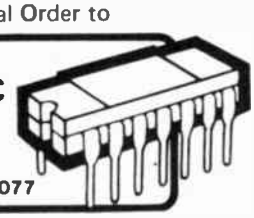

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THREE SIMPLE RECEIVERS

PROJECT 705 (A,B&C)

Biased diode; voltage multiplier; or solar powered — three simple but unusual receivers.

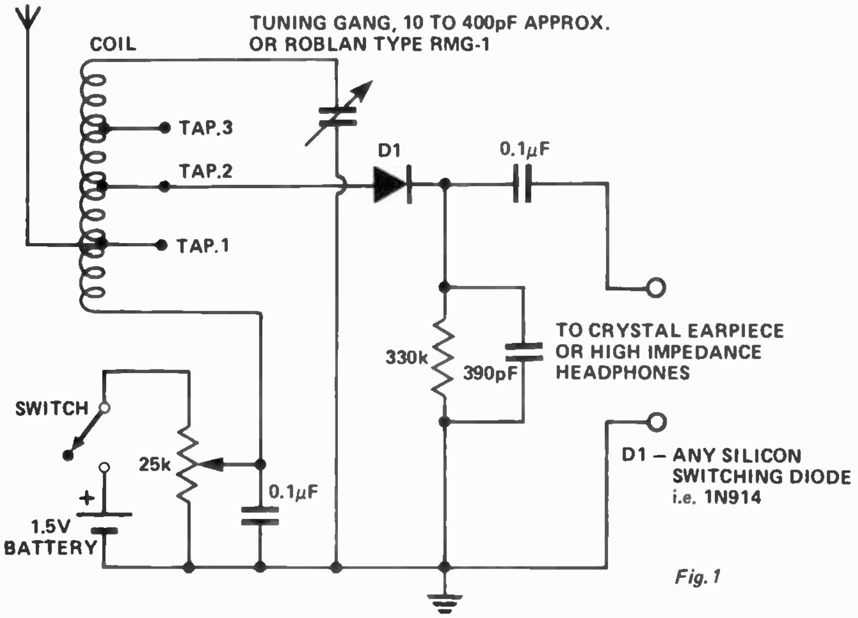


Fig. 1

BIASED DIODE CRYSTAL SET

THE CLASSIC "beginning beginner's" project is the crystal set — the workhorse of the pioneers and first popularised in the 1920's. For utter simplicity there is nothing to beat it. However, one can make various improvements and refinements on the basic circuit. One such refinement is shown in Fig. 1. In this version, a biasing voltage is impressed across the diode detector.

One failing of a basic crystal receiver (in which a diode is used as a detector) is that the diode will not commence conducting in the forward direction (from anode to cathode) until the anode-cathode voltage exceeds a certain (small) value. For germanium

VOLTAGE MULTIPLIER CRYSTAL SET

THE DIODE detector, as in a crystal set, is basically a special use of a rectifier circuit. Borrowing from rectifier circuitry, a 'voltage-multiplier' can be used to increase the output (the loudness in the headphones) of a crystal set. The circuit in Fig. 2 uses what is known as a 'Cockcroft-Walton' multiplier (after the original designers).

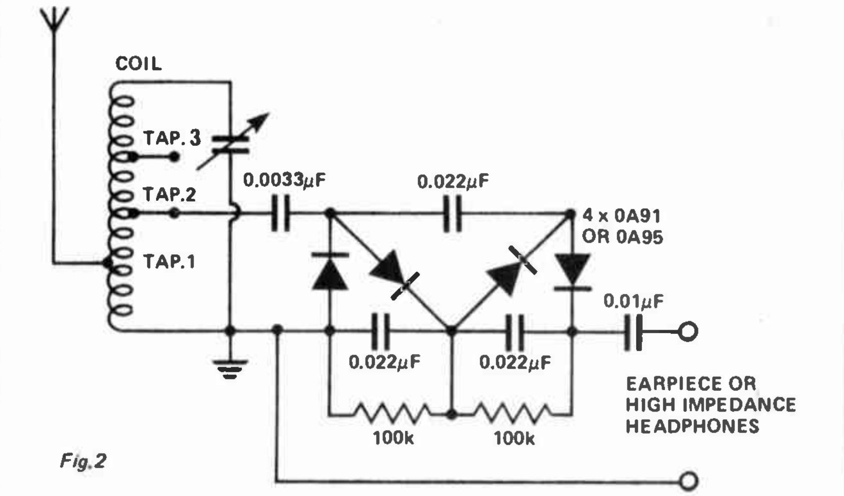


Fig.2

Here, a voltage multiplication of four is obtained. You may wonder 'why not use a higher multiplication?'. The answer is that one runs into the ubiquitious 'law of diminishing returns'. For this application, a multiplication of four is all that is practicable as any further increase results in excess load being placed on the tuned circuit, reducing sensitivity and the ability to separate stations (selectivity).

The coil details are the same as for Fig. 1 in the Biased Diode Receiver (see Tables 1 and 2 on page 13). See also the comments in the project concerning use of the taps on the coil. The best diodes to use in this circuit are OA2 or OA5 germanium diodes as they have the lowest forward conduction voltage and are thus the most sensitive.

Construction is also simple, matrix board and pins may be used here again. This tuning capacitor was salvaged from an old broadcast receiver (only one gang being used).

diodes, this is between 200 and 400 millivolts (0.2 to 0.4 V), for silicon diodes it is between 0.6 V and 1.0 V. However, if the diode detector has a voltage almost equal to its forward conditioning voltage impressed upon it (called 'bias') then it becomes a more sensitive and efficient detector. This arrangement also reduces distortion.

Construction is simple and not critical. The unit may be built up on a matrix board as in our prototype – or assembled on tag strips.

Coil details are given in Table 1. Find the best tap for the diode and the aerial by experiment. The aim is to find the combination which gives the clearest signals for the best rejection of unwanted stations.

For short length aerials, say three to six metres of wire, tap high up the coil or across the full turns. Make the diode tap about half-way to three-quarters of the way up the coil in this case. For a long aerial, use the lower taps and tap the diode between one-quarter and half-way up the coil.

The tuning capacitor used was salvaged from an old valve-type broadcast receiver (only one of the three gangs is used) but any unit having a range of about 10 to 400 pF may be used.

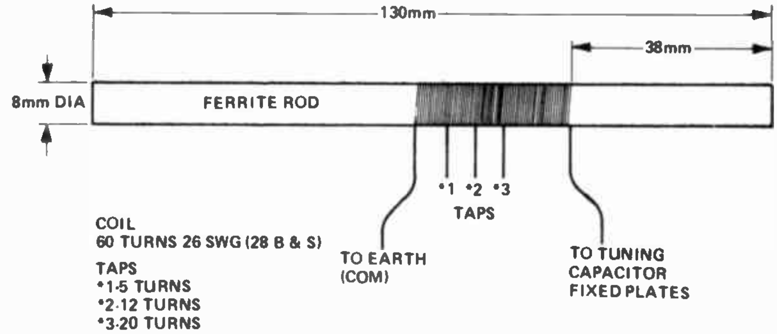
The best headphones to use for a crystal set are the high impedance type – having an impedance between 1000 ohms and 5000 ohms or more (if obtainable). Crystal earpieces may also be used but are not as sensitive as good headphones.

With the control potentiometer set at minimum, tune in a station that is not too strong but can be clearly heard. Advance the potentiometer slowly and an increase in volume and a reduction in distortion will be noticed. The point at which this occurs will vary from station to station but is not critical, there being some range of adjustment.

TABLE 1
For coils wound on cardboard former.
NUMBER OF TURNS FOR WIRE GAUGE

COIL DIA.	22 SWG	24 SWG	26 SWG	28 SWG	TAPS
1¼"				110	at ¼, ½ and ¾ of the turns. You may tap every ten turns if you wish for more range of adjustment.
1½"			96	90	
1¾"		88	80	70	
2"	82	72	68	60	
2¼"	71	64	60	52	
2½"	61	56	54	47	
2¾"	54	52			

TABLE II Coil wound on ferrite rod



SOLAR-POWERED RADIO

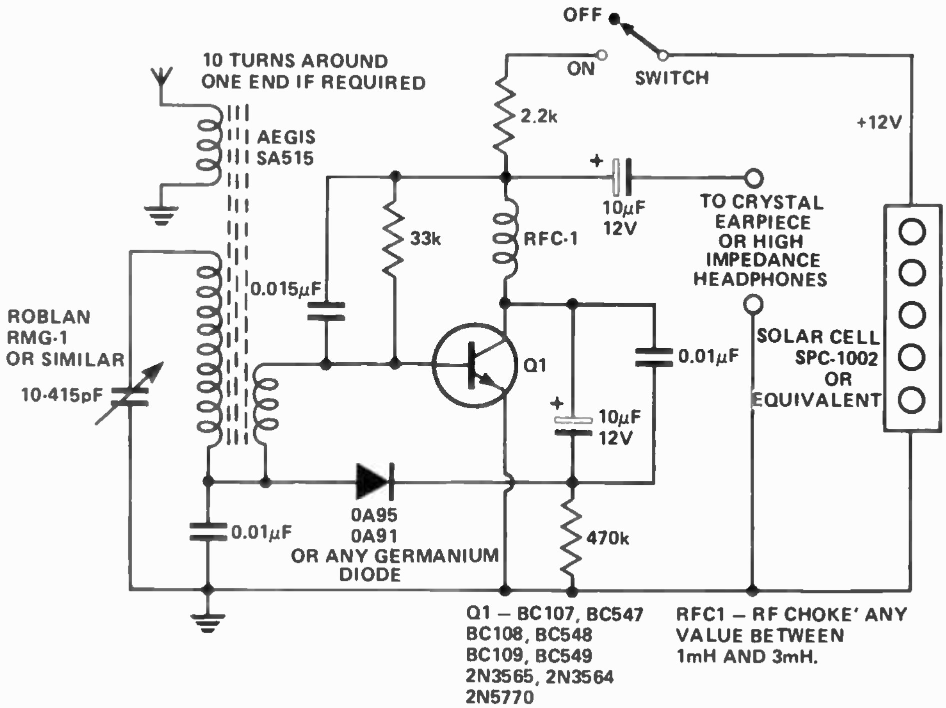


Fig.3. Solar powered reflex receiver.

SOLAR CELLS are dropping rapidly in price. They will continue to drop in price as they gain acceptance and use in more and more applications. Solar cells require no maintenance and the energy source (being the Sun) is free and presumably almost everlasting.

Modern solar cell arrays will deliver over one watt in bright sunlight from a single array, or about 200 milliwatts in cloudy conditions. A representative unit is the Solar Power Corporation's (USA) SPC-1002 (available from Joseph Lucas Pty. Ltd. in Australia). This consists of five wafers mounted on a printed circuit board, wired in series, and encapsulated. Output is about two volts. Similar units are available from other manufacturers.

The solar array can be used to drive a low-voltage radio receiver or to trickle charge rechargeable batteries such as the small nickel cadmium (Nicad) cells that are commonly available. These cells can be used to run a low voltage radio. Mercury cells, such as used in cameras, also make good low voltage power sources.

OPERATIONAL AMPLIFIERS

(Continued from page 33)

a type of movement that is much more robust, and yet cheaper, than others of greater sensitivity.

The actual method of construction can be adapted to suit individual requirements. If a 1 mA meter is bought for the job, almost any housing capable of containing it will have room for the 741 and the few other components required, whilst only three short lengths of wire are required for connection to the power supply. The test-meter used in the prototype had a 1 mA range, so a small aluminium box was used for the circuitry, with two output terminals for the test-meter connections, and, again, three leads for the power supply.

As with the audio amplifier, it is best to use a small piece of Veroboard to mount the IC holder and components, and to bolt the board to the box with insulated spacers if required. ●

THREE SIMPLE RECEIVERS

(Continued from page 39)

The circuit in Fig. 3 is a simple one transistor 'reflex' receiver that can be run from any of the above power sources, or a combination of them. It has been especially designed for maximum sensitivity using a low voltage collector supply. This supply may be of any voltage from two to four volts — but no more — it oscillates above that.

The transistor, Q1, amplifies both the radio frequency signal picked up by the ferrite rod antenna coil and the audio signals recovered by the diode detector. Thus both RF amplification and audio amplification are achieved using the one transistor. Surprising sensitivity is obtained, no external antenna is necessary in metropolitan areas — it even receives 2JJ in inner city Sydney suburbs!

If you live in the country, an external antenna may be necessary. A length of wire 10 m or more long, mounted 5 m to 10 m high is usually adequate. An added winding, as shown in Fig. 3, provides coupling for the external antenna. An earth connection may improve reception also.

CONSTRUCTION

Construction is straightforward and non-critical. Matrix board and pins, or tag strips are used to support the small components. Two rubber grommets are slipped over the ends of the ferrite rod and the assembly tied down to the matrix board with short lengths of *insulated* hook up wire around the grooves in the grommets.

As we said at the beginning of this article, solar cell arrays are still expensive. However, like so many other electronic components the price may realistically be expected to fall dramatically as soon as demand increases. At present, the cost of an array varies from \$20 to \$50 plus — but this may well fall by a factor of ten.

In the meantime, why not build it and run it from Nicad or mercury cells. These have terminal voltage of about 1.2 V to 1.3 V per individual cell, so two or three in series may be used to power this receiver. Current consumption from a two volt supply is about 0.5 mA. Alternatively, ordinary dry cells may, of course, be used. ●

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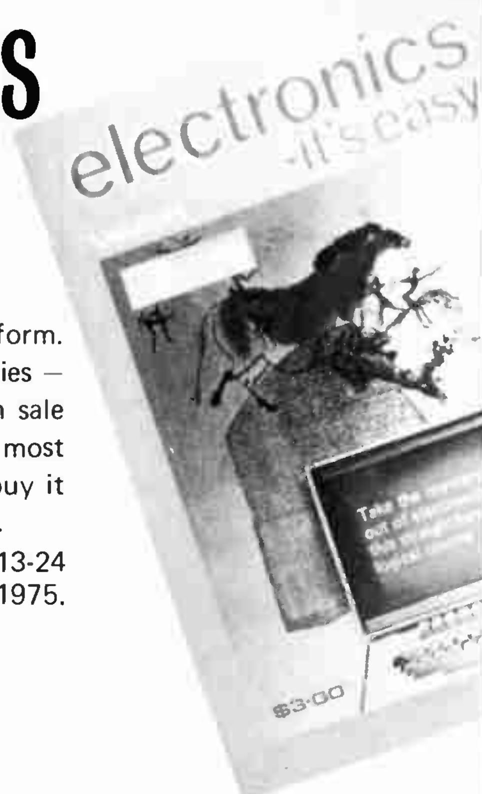

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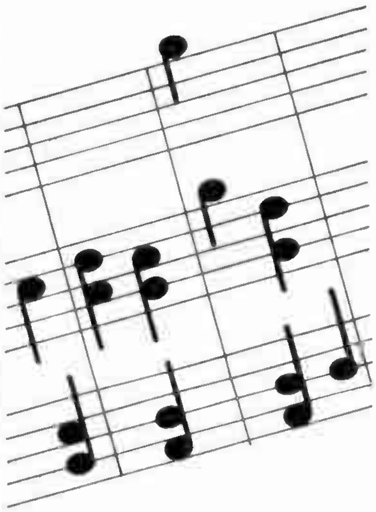

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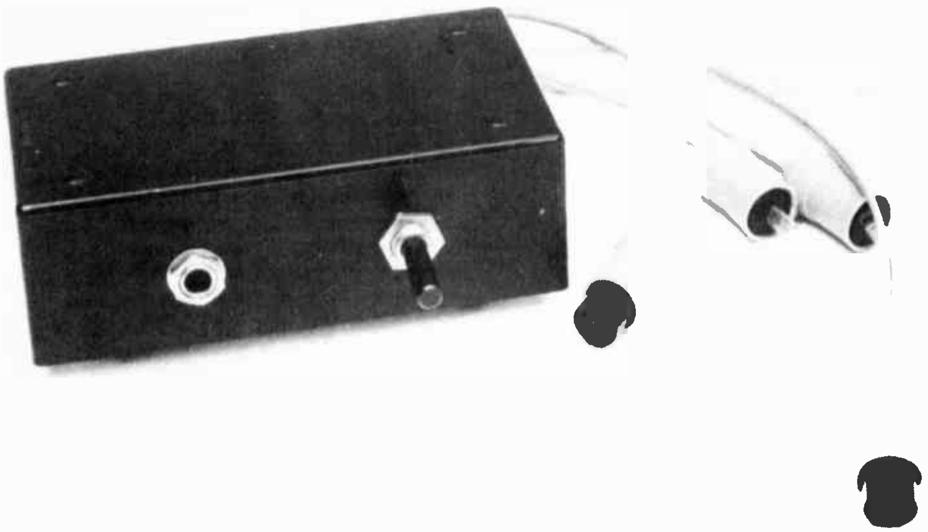


PROJECT 238

PARTS LIST — ETI 238

Two	100 ohm 1 watt resistor
Two	10 ohm ½ watt resistors
Two	4-way screw type speaker connectors
One	100 ohm linear potentiometer
One	stereo headphone socket with double-pole break contacts
One	box (as required)
Two	2-pin DIN plugs (if required)
Two	2-pin DIN line sockets (if required)

HEADPHONE ADAPTOR

Unit restores damping and natural stereo separation.

HEADPHONES have impedances which range from 8 ohms to 2 k ohms or more and handle a typical maximum power of 500 mW. To limit the power that may be delivered into the 8 ohm types, commercial amplifiers generally supply the headphones from the amplifier output via series resistors of around 220 ohms.

Although this technique allows the use of practically any type of headphones without fear of damage the series resistor drastically reduces the amount of damping the amplifier can apply to the phones.

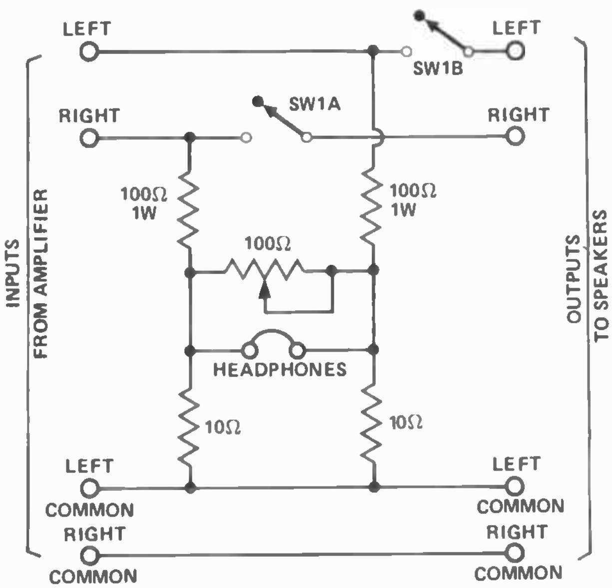
A further problem with headphone listening is that the stereo separation is unnatural in that there is little right channel information fed to the left ear and vice versa.

This simple little adaptor is inserted between the amplifier and the leads to the speakers. It restores damping, by supplying the phones from a 10 ohm source, and has a blend control by which the separation between channels can be varied to obtain a more natural sound.

CONSTRUCTION

We mounted the two four-way terminal strips onto the lid of a small box and the headphone socket and potentiometer through one side. The stereo-headphone socket should be the type which incorporates double-pole break contacts. This type is generally of sealed construction and has 8 pins on the back. Such a socket is necessary so that normal speaker operation is obtained until the headphones are plugged in whereupon the speakers are automatically disconnected.

Wire the unit as shown in the interconnection diagram, and, if the amplifier has DIN connectors, attach short leads, with DIN plugs and sockets, to the unit as shown in the main photograph. ●



NOTE
SW1A AND SW1B ARE PART OF THE SOCKET USED FOR THE HEADPHONES

Fig. 1. Circuit diagram of the headphone adaptor.

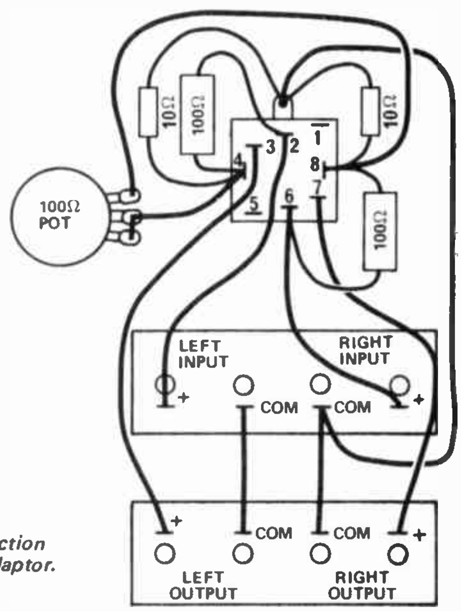


Fig. 2. Interconnection diagram for the adaptor.

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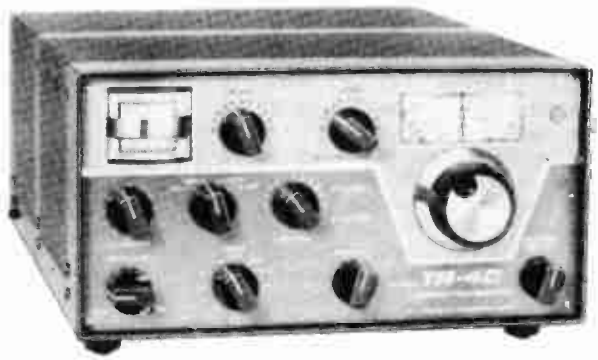

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SILENT A-B SWITCH

Speakers may be A-B tested using this simple modification to our tone-burst generator

WHEN evaluating speaker systems in A-B listening tests, the first few seconds of listening convey the truest impression of sound quality. Listening for longer than a few seconds not only fails to give further information, but may well give a false indication. For this reason it is usual to switch rapidly between the reference speaker and the speaker under test. This is generally done by using the amplifier's A/B speaker selector switch, or by wiring a change-over relay in the speaker wiring.

Whilst such switching methods are simple and reliable they have one major drawback. That is that switching may take place at any point in the waveform and as a consequence switching transients may be introduced which tend to mask the subtle differences for which one is listening. Hence a method of switching at zero-crossing points would be of great value.

When the ETI Tone-Burst Generator was constructed it was realised that it contained all the circuitry needed to performance this switching task and that it could be modified to do so very simply.

The switching must be done at low level and hence the unit is used at the input of a stereo power amplifier. The reference speaker and the speaker under test are each connected to one channel of the amplifier and the silent switch switches the input to the amplifiers as required. Thus the arrangement is mono only but this is all that is required to assess the transient response and performance of a speaker in comparison to a reference speaker.

HOW IT WORKS – ETI 124 AB

As this unit is based on the operation of the tone-burst generator ETI 124 described last month, that article should be thoroughly read first. Only the changes necessary to that unit are detailed in this article.

Whilst an A-B switch would be a little simpler if designed specifically for that purpose, the modifications required to the tone-burst generator are so simple that we thought it not worth while to design a special circuit.

To make the generator act as an A-B switch it is necessary to disable the existing mode switch. We do this by plugging in an external control switch, SW6, via a stereo phone socket. The phone socket has two change-over contacts fitted which are used to disconnect the plus and minus six volts supplies from SW3 when the jack is inserted. One of the phono contacts also disconnects the plus six volts from the common of the socket when the jack is removed. As the common of the socket is required to be at plus six volts the phono socket must be insulated from the front panel which is at 0 volts.

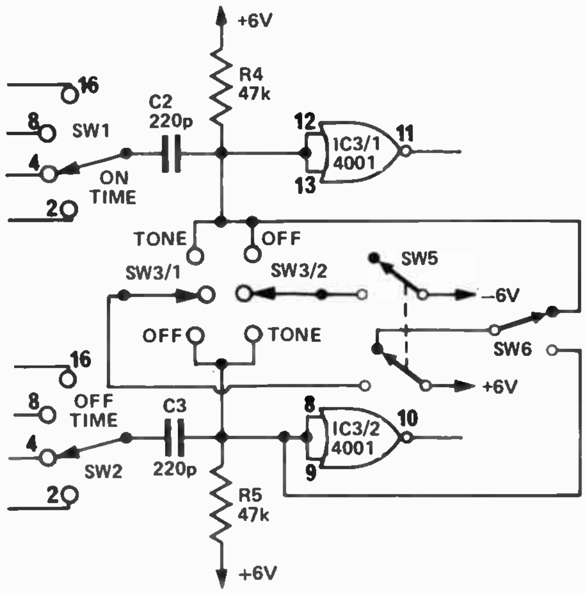
The control switch, SW6, effectively shorts either R4 or R5 thus stopping the pulses from C2 or C3 triggering the flip-flop. When the switch is actuated there is a delay until the number of cycles as set by the front panel switch have occurred and then, at the next zero crossing, the change-over occurs. The delay is necessary to ensure that any contact bounce of the SW6 contacts does not cause unwanted switching of the circuit.

CONSTRUCTION

The ETI 124 Tone-burst Generator should first be constructed, as detailed last month, except that the wiring to SW3 is changed as detailed in Fig. 1 and 2 of this article. The dual-RCA socket and the phonq socket are then mounted on one side of the box. If a metal box is used make sure that the phono socket is insulated from the case of the box as it is at a potential of six volts. The switch, SW6, should be mounted in a small pill container or similar housing and fitted with a three-core cable that is terminated at the other end by a stereo phone jack. Note that the common of the switch should be connected to the common of the jack but that the other wires may be wired to either of the remaining contacts.

USING THE SWITCH.

The audio switch requires a reasonably high level of signal to ensure correct zero-crossing switching. There are two suitable points in a conventional amplifier. The first position is between the tape-in and tape-out sockets but the second and preferable position is between the pre and main amplifiers provided that the main amplifier has a volume control that is independent of the preamplifier.



PROJECT 124 AB

Fig. 1. Partial circuit diagram of the tone-burst generator modified to perform AB switching.

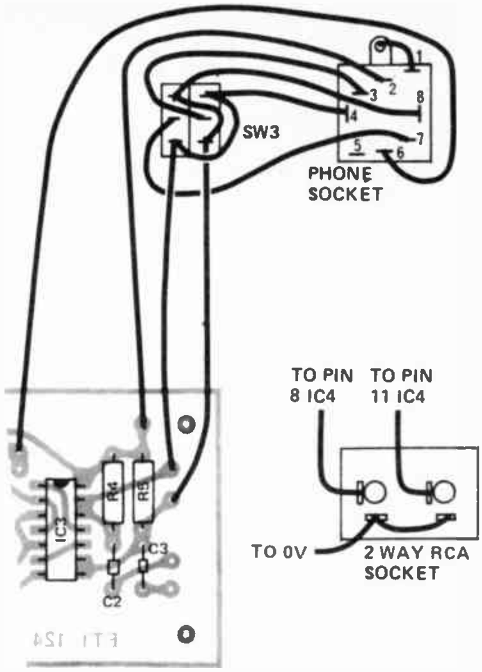
To connect the unit for AB testing apply a single input, from the preamplifier (switched to mono), to the normal input socket of the generator. The normal output socket of the generator is not used but the two RCA output sockets are connected back to the left and right channel inputs of the main amplifier. When SW6 is operated the mono input will be silently switched between right and left channel speakers.

If using the tape sockets the monitor switch should be in the 'monitor' position and the balance control should be adjusted so that the levels from the two speakers are apparently the same. Make sure that the tone controls are in the flat position, as they can cause phase shifts which prevent the switching occuring at the zero-crossing point.

If the pre and main amplifier terminals are used the preamplifier volume should be adjusted to about half way and separate volume controls used to balance for the difference in efficiencies of the two speakers. If the main amplifier does not have separate volume controls then external ones must be added if balance is to be achieved. In this case the tone controls may be used if required without upsetting the crossover point.

Change over may be effected by using either a toggle switch or a push button. The tone-burst generator controls should be set for eight cycles on and off as this position will effectively remove any contact bounce. ●

Fig. 2. Interconnection diagram to phono socket and RCA output sockets of AB switch.



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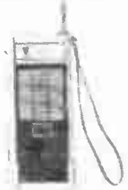

MODEL NC-310 DE LUXE 1 WATT 3 CHANNEL C.B. TRANSCEIVER
- WITH CALL SYSTEM
- EXTERNAL AERIAL CONNECTION

SPECIFICATIONS, NC-310
Transistors: 13
Channel Number: 3, 27.24 OMHz Citz. Band
Transmitter Frequency Tolerance: ±0.005%
RF Input Power: 1 Watt
Tone Call Frequency: 2000 Hz
Receiver type: Superheterodyne
Receiver Sensitivity: 0.7μV at 10 dB S/N
Selectivity: 45 dB at ±10 kHz
IF Frequency: 455 kHz
Audio Output: 500 mW to External Speaker Jack
Power Supply: 8 UM-3 (penlite battery)
Current Drain: Transmitter: 120-220mA
Receiver: 20-130mA.

$49.00 each or $95 a pair.
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1 watt 2 channel transceiver with call system. 27.240 MHz. 12 transistor. PMG approved type.

SPECIFICATIONS: Transmitter — Crystal Controlled: 1 Watt input power to RF stage. Operating frequency — Any 2 channels in the 11-meter Citizens Band. Receiver — Crystal-controlled superheterodyne circuit with 455 Kc IF. Antenna — Built-in 60" telescopic whip antenna. Audio Output — 0.8 watt maximum. Power supply required — 12 volts DC (Eight 1.5 volt DC battery cells). Loudspeaker — 2¼" PM type (built-in) function as microphone on transmit.

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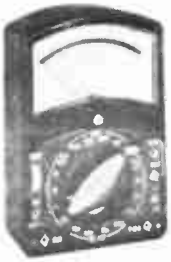

MODEL C-7077/P MULTIMETER. Specifications: 100,000 ohms/volt DC; 10,000 ohms/volt AC; DC volts — 5,5; 25; 50; 250; 500; 1,000. AC volts — 10; 50; 250; 500; 1,000. DC amps — 10μA; 2-5 mA; 25 mA; 500 mA. Ohms — 10 kΩ; 1 MΩ; 10 MΩ; 100 MΩ. Centre scale — 150Ω; 15 KΩ; 150 KΩ; 1-5 MΩ. Decibel — —20 to +22 dB. Dimensions — 151 x 102 x 48 mm Diode protected movement. Carrying case available Model C.

$27.95 P&P $1.50.

MODEL OL64 D/P MULTIMETER. Very ruggedly constructed this model is particularly suitable for workshops. It features special scales for measurement of capacitance and inductance. Diode protected movement. **Specifications:** 20,000 Ohm/Volt DC. 8,000 Ohm/Volt AC. DC volts — 0.25; 1; 2.5V; 10; 50; 250; 1,000; 5.000. AC volts — 10; 50; 250; 1,000. DC amps: 50μA; 1 mA; 50 mA; 500 mA; 10 A. Ohms — 4 KΩ; 400 KΩ; 4 MΩ; 40 MΩ. Centre scale — 40Ω; 4,000Ω; 40,000Ω; 400,000Ω. Decibel: —20 to +62 dB, Dimensions: 6" x 4-1/5" x 2"; 152 x 107 x 51 mm. Capacitance: 250 pF to 0.02 uF. Inductance — 0/5000H Carrying case available Model C.

$22.50 P&P $1.50.

MODEL AS100 D/P MULTIMETER. This meter features double zener diode meter protection and 3½" full view easy to read 2 colour scale. It is fitted with polarity reversing switch and housed in a strong moulded case with carrying handle. Specifications: 100,000 ohm/volt DC. 10,000 ohm/volt AC. DC volts — 0.3; 12; 60; 120; 300; 600; 1,200. AC volts — 6; 30; 120; 300; 600; 1,200V. DC amps — 2 KΩ; 200 KΩ; 20 MΩ; 200 MΩ. Centre scale — 20Ω; 2,000Ω; 20,000Ω; 200,000Ω; 20 MΩ. Decibel — —20 to +57 dB. Dimensions — 7-3/5" x 5-2/5" x 2-3/5" 193 x 137 x 66 mm. Carrying case available model I.

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Latest military design multi-band radio, 30 transistors and diodes. With exclusive (LED) light emitting diode tuning indicator for positive station selection.
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NEW PRICE $49.50
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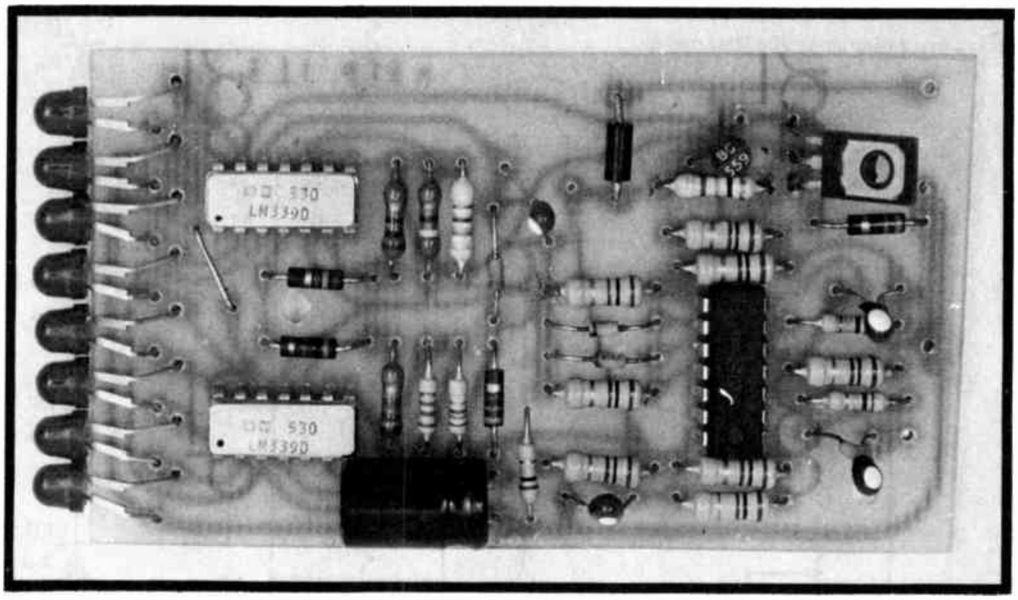
APPROVED BY ELECTRIC SUPPLY DEPT. BEWARE OF MORE EXPENSIVE IMITATIONS.

AUDIO LEVEL METER

PROJECT 438



Peak and average audio levels are indicated by a bar of light.

HIGH-POWER amplifiers usually incorporate meters to indicate the output-power levels in each channel. These meters are often called VU meters but in most cases they resemble proper VU meters only in the way they are scaled.

A professional VU meter is the industry standard for measuring the levels of complex music waveforms. It has a scale marked from −20 to +3 VU (on a steady state signal VU correspond to dB) where '0' VU corresponds to a level of one milliwatt into 600 ohms. The meter has a carefully controlled time constant such that if a reference tone level is applied the pointer of the meter will take 0.3 seconds to reach 99% of the reference level, and will then overshoot by not more than 1.5% and not less than 1.0%.

The professional VU meter is thus an instrument that has been designed to give a reasonable compromise between indicating the fast peaks and the average levels of a complex music waveform.

In contrast the meters fitted to some amplifiers have scales calibrated in VU but usually relying on the inertia of the meter movement to provide meter averaging. Apart from this the 0 VU point corresponds to the rated power output of the amplifier — not to 1 mW into 600 ohms (equivalent to 75 mW in 8 ohms). Strictly speaking therefore such meters should be called level or power meters, not VU meters.

Even the best of such meters are not fast enough to indicate accurately the peak levels which occur in music and hence are useless for detecting the onset of amplifier clipping. This is vital as at clipping amplifier distortion rises rapidly.

One alternative is to use in addition to the level meter a clipping indicator that detects fast peaks which exceed a preset level. The ETI 417 OVER-LED project was such an instrument — it flashed an LED when a music transient exceeded clipping level.

The circuit described in this project is best described as a 'level meter'. It uses an array of LED diodes set to illuminate at successively higher increments in music level. With this type of display an estimate can quite easily be made of channel balance, and all transients, no matter how fast, are detected and indicated.

SPECIFICATION

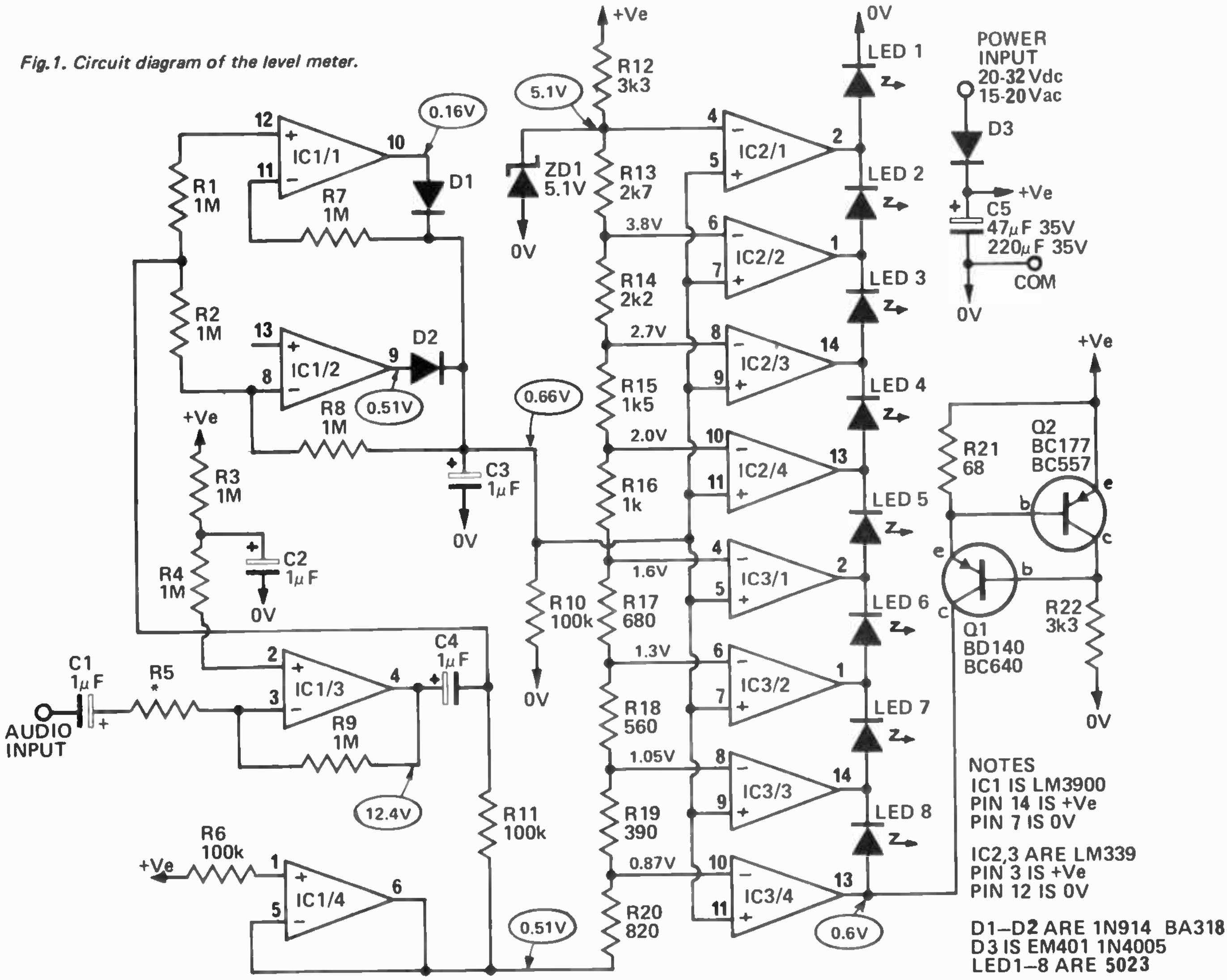
Supply voltage	20 to 32 volts dc 15 to 20 volts dc
Supply current	16 mA dc approx,
Input sensitivity (VU meter)	500 k/v
Indication	8 LEDs 3 dB apart
Attack time	1 ms
Release time	0.5 sec.

DESIGN FEATURES

The ETI 438 Level Meter can be arranged to indicate levels either in 'VU meter' format or in output power format. In the 'VU-meter' format the eight diodes light at 3 dB intervals from −18 to +3 VU where 0 VU corresponds to the nominal voltage required. Alternately as a power meter (remember that an amplifier cannot be driven beyond the clipping point) the top LED indicates maximum power and each lower LED indicates half the power of the one above it. The LEDs of the meter could thus be labelled,

AUDIO LEVEL METER

Fig. 1. Circuit diagram of the level meter.



VOLTAGES GIVEN ARE OF THE PROTOTYPE BUT SHOULD BE TYPICAL MEASURED WITH 25Vdc SUPPLY AND NO INPUT SIGNAL

HOW IT WORKS – ETI 438

Although the circuitry of the level meter looks complicated the complete instrument only uses three ICs. These are an LM3900 which is a quad amplifier and two LM339s which are quad voltage comparators.

The input signal is amplified and buffered by IC1/3 to provide about 2.5 volts out at 0 VU input. The value of R5 is selected to give the sensitivity required for amplifiers of different power outputs. The gain of this amplifier is equal to the ratio of R9/R5.

A positive peak detector, IC1/1, and an inverting negative peak detector, IC1/2, give an output which represents the absolute peak level. Capacitor C3 and resistor R10 provide the peak hold and decay time. IC1/4 provides compensation for the 0.6 volt offsets of the LM3900 inputs.

The eight comparators are connected to a resistor divider chain the top of which is fed from a 5.1 volt supply which is stabilized by a zener. The resistor values are calculated to provide reference voltage steps at 3 dB intervals. The output of the detector is applied to all the non-inverting inputs of the comparators.

The LEDs are all connected in series and supplied with a constant current of 10 mA by the source consisting of Q1 and Q2. The outputs of the comparators are via open collector transistors which are "ON" if the input is lower than the reference voltage at the particular comparator input. With no input signal at all the comparators are all on thus shorting out all the LEDs so that none is on. As the input voltage rises the comparators turn off in sequence allowing the 10 mA to flow through the LEDs. Thus as the voltage increases a bar of light of increasing height is formed by the LEDs.

The current drawn from the power supply is about 16 mA and is independent of the number of LEDs which are on. Supply voltage is not critical and may be anywhere between 20 and 32 volts. Providing the supply is between these limits the unit will also be insensitive to supply ripple. When working from a dc supply a 47 microfarad filter capacitor is required but if an ac supply is used then the capacitor should be increased to 220 microfarad to minimize ripple. A single diode is used to both rectify the ac input and to prevent damage due to accidental reversed polarity if a dc supply is used.

PARTS LIST – ETI 438

R21	Resistor	68 ohm	½W	5%
R19	"	390 ohm	½W	5%
R18	"	560 ohm	½W	5%
R17	"	680 ohm	½W	5%
R20	"	820 ohm	½W	5%
R16	"	1k	½W	5%
R15	"	1k5	½W	5%
R14	"	2k2	½W	5%
R13	"	2k7	½W	5%
R12,22	"	3k3	½W	5%
R6,10,11	Resistor	100k	½W	5%
R1,2,7,8	"	1M	½W	5%
R3,4,9	"	See Table 1	½W	5%
R5	"	See Table 1	½W	5%
C1,2,3,4	Capacitor	1 µF	35V electro	
*C5A	"	47 µF	35V electro	
*C5B	"	220µF	35V electro	

* use 47 µF for dc operation 220 µF for ac operation

IC1 Integrated Circuit LM 3900
IC2,3 Integrated Circuit LM 339

D1,2 Diode IN914, BA318 or similar
D3 " EM401, IN4005 or similar
ZD1 Zener diode 5.1 V 400 mW

Q1 Transistor BD 140, BC640
Q2 " BC177, BC 557

LED 1-8 L.E.D. 5023 or similar

PC board ETI 438

NOTE: Electronics Today is adopting the European standard method of showing component values — i.e. 1k5 = 1.5k, 2k7 = 2.7k, etc.

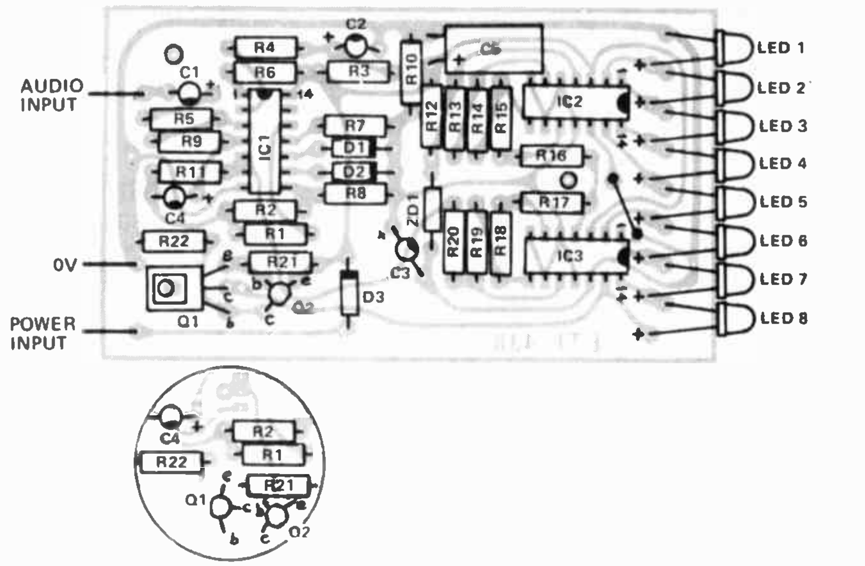


Fig.2. Component overlay using BD140 for Q1. Circled diagram shows use of alternative BC640

for example (for a 100 watt amplifier) 100, 50, 25, 12.5 watts etc.

The fast attack time of the meter (less than one millisecond) ensures that even very short transients are detected, whilst the relatively slow release time (0.5 seconds) provides a reasonably-accurate, average – level indication.

In most previous designs for such meters, discrete transistors were used to build level detectors. Temperature effects and variations in gain led to inaccuracies and to calibration difficulties. These problems have largely been overcome in the ETI 438 meter by using the LM339 IC which contains four accurate level detectors in one package. Additionally the LM339 also has an open-collector output stage which enables a constant current supply for the LEDs to be used. Thus the current and LED brightness are the same no matter how many LEDs are alight.

If required the interval between LEDs may be altered by changing the values of R13 to R20. Thus for example, a 6 dB interval could be used. Additionally the display could be extended to 12 or even 16 diodes by adding comparators and LEDs and by substituting another divider chain for R20 (values would have to be calculated for the levels required). The positive inputs of the comparators would also be fed from C3 and R10.

A separate current source would be required as there is insufficient supply voltage available to light 16 LEDs in series. If the bottom LED in such a system indicates a level more than 30 dB down it may also be necessary to use a trimpot as the bottom resistor of the second divider chain to adjust for offsets etc.

The LM3900 is a quad differential amplifier which uses a current balancing technique at the input rather than the voltage balancing that is used with conventional operational amplifiers. Both the inputs "look" like the base-emitter junctions of normal transistors and both are at 0.6 volts with respect to ground. The currents into the two inputs must be equal if the output of the amplifier is to be in the linear region. In the case of IC1/3 the current into the positive input is set at about 12 microamps by R3 and R4. Current into the negative input is provided from the output by R9. If the current into the negative input is too low the output voltage will rise thus increasing the current into the negative input until balance is achieved. This self balancing ensures correct static biasing.

Gain is obtained by feeding a signal into R5 which adds or subtracts current into the negative input. For

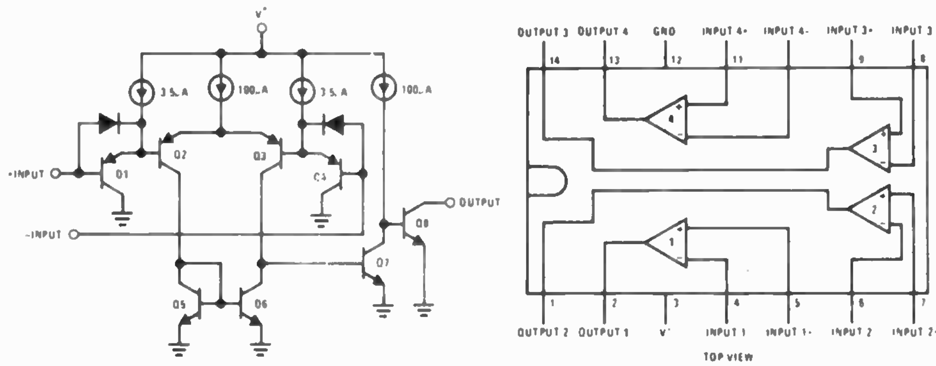


Fig.3. Internal circuitry and pin corrections of the LM339 IC.

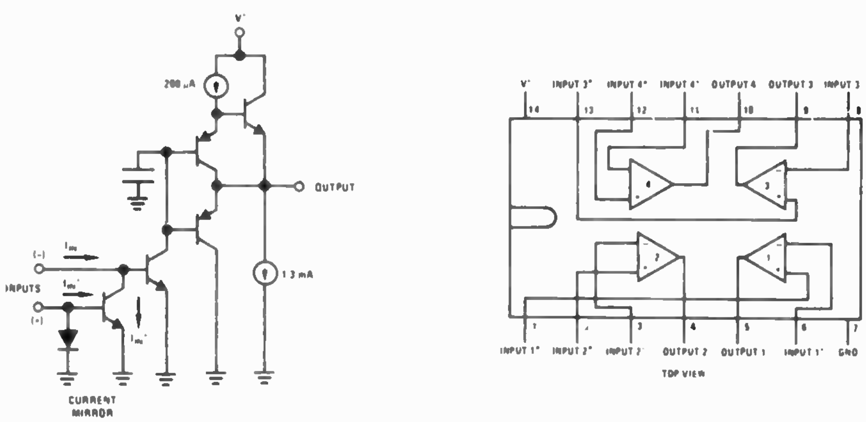


Fig.4. Internal circuitry and pin connections of the LM3900 IC.

AUDIO LEVEL METER

the amplifier to remain balanced there must be a corresponding shift in output voltage. The voltage gain is the ratio of R9 to R5.

SPECIFICATION LM3900

Maximum supply voltage	32 V
Supply current	6 mA typical
Voltage gain	2800 V/V typical
Input current range	1 μA – 1 mA
Current balance	0.9 – 1.1 at 200 μA
Bias current	30 nA typical
Output current capability	18 mA source typical. 1.3 mA sink typical

The LM339 is a quad voltage comparator where the output of each is an NPN transistor which has an unterminated collector and its emitter connected to ground.

TABLE 1A – VU METER
FSD = +3 dB
R3, 4 and 9 are 1 megohm

SENSITIVITY	VALUE OF R5*
50 mV	22 k
100 mV	47 k
250 mV	120 k
500 mV	220 k
1 V	470 k

**Sensitivity equals R5 x 500 000 ohms.*

TABLE 1B – POWER METER
FSD = 0 dB
R3, 4 and 9 are 100 k

POWER OUTPUT IN WATTS	VALUE OF R5 4 Ohms	8 Ohms	16 Ohms
5	150 k	200 k	270 k
10	200 k	270 k	390 k
15	240 k	330 k	470 k
20	270 k	390 k	560 k
25	330 k	430 k	620 k
30	360 k	470 k	680 k
40	390 k	560 k	820 k
50	430 k	620 k	910 k
75	560 k	750 k	1.1 M
100	620 k	910 k	1.2 M
150	750 k	1.1 M	1.5 M
200	910 k	1.2 M	1.8 M
250	1 M	1.5 M	2 M

$R5 = 32\sqrt{PR}$ Where P = power in watts
R = speaker impedance in Ohms.

SPECIFICATION LM339

Maximum supply voltage	36 V
Supply current	0.8 mA typical
Voltage gain	200 000 V/V typical
Offsett voltage	2 mV typical
Bias current	25 nA typical
Response time	1.3 μS typical
Output sink current	16 mA typical
Input common-mode voltage range	0 to (V^+ – 2 volts)

CONSTRUCTION

The meter will most likely be mounted in an existing amplifier or piece of equipment and for this reason the board construction only is given.

Layout of components is non-critical but, as with any multiple IC device, construction is greatly simplified by using the printed-circuit board specified. The usual precautions with polarities of components, such as capacitors, diodes, ICs and transistors should be observed. Some care must be taken when mounting the LEDs in order to obtain even spacing and good alignment. The long lead of the LED should be inserted in the hole furthest from the edge of the board. Put a slight curvature in the leads so that the LEDs can be aligned against the edge of the board (see photo). Take care not to bend the leads too often or too close to the body of the LED as the leads break very easily.

CALIBRATION

Resistor R5 is selected from Table 1 and this will ensure a result within 10 percent of that required. Greater accuracy may be obtained by using a variable potentiometer in series with R5. To adjust this potentiometer inject a signal (around 1 kHz) equal to 0 VU (VU meter) or maximum power ($E = \sqrt{RP}$, e.g. 4 ohms and 100 watts, E = 20 volts) and adjust such that the second top LED (VU meter) or the top LED (power meter) just lights. ●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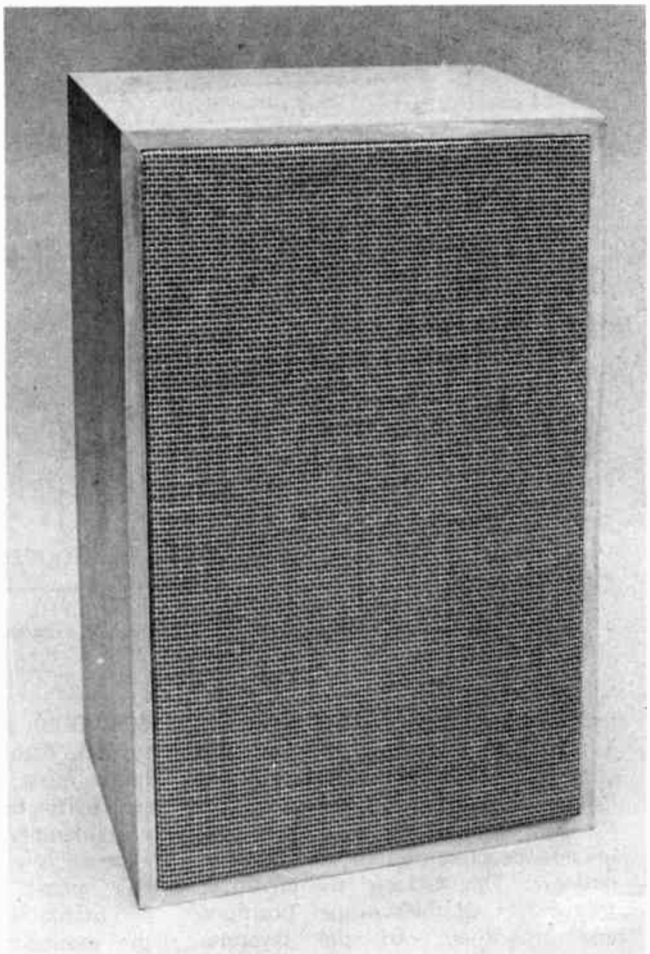
THREE-WAY SPEAKER SYSTEM



A high quality system for use with conventional amplifiers, or with the ETI 435 Crossover Amplifier.

ETI PROJECT 439

MANY of our readers have asked us to publish a design for a medium to large sized three-way speaker system.

As we were in any case planning to design an enclosure suitable for our previously described active crossover and amplifier project we decided to kill two birds with one stone and to design an enclosure suitable for either purpose.

We originally started our investigations by using a design supplied to home constructors by one of the major speaker manufacturers. Surprisingly we found that the original design had a number of failings — to the extent that little has been retained except for the original cabinet dimensions.

Several problems had to be overcome. Firstly, the original enclosure was found to cause bad colouration due to flexing of cabinet walls. Consequently the first modification was to brace the box walls. It was then determined that the sensitivities of the three drivers were different, the main problem being that the mid-range was about 4 to 5 dB down on the tweeter and the woofer. This problem was overcome by adding an attenuator network to the tweeter and by winding coil L1 with two to three ohms resistance for the woofer. The increased dc resistance of the coil attenuates the woofer slightly as well as allowing a much cheaper coil to be used. Both coils in the bass mid crossover (L1 and L2) were wound this way as a higher resistance in the coil L2 does not have any serious effects and avoids the necessity of using two different coils.

Tests then showed that the crossover frequencies were higher than they should be and there were deep holes in the response. This was caused by the rising impedance of the drivers in the crossover region which caused

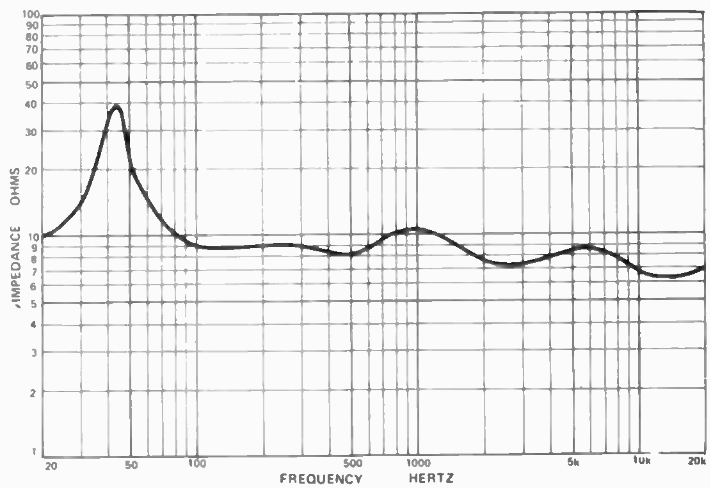


Fig. 1. Impedance versus frequency of the ETI 439 system (conventional cross-over).

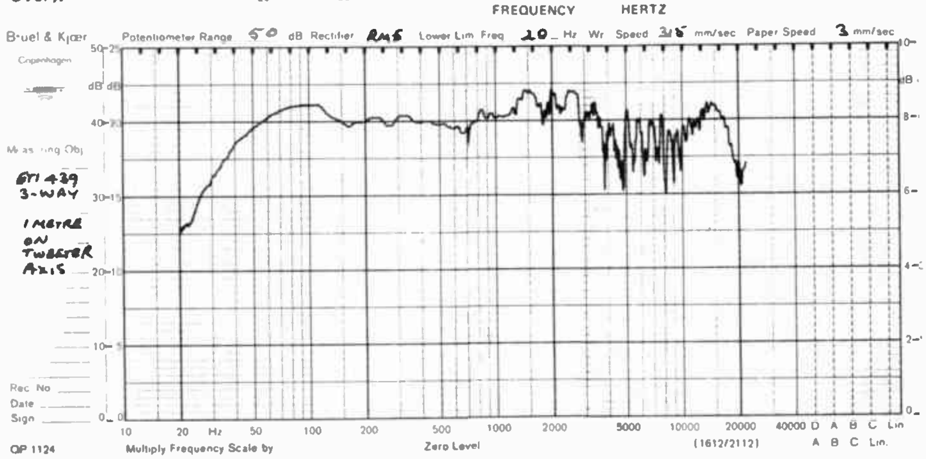


Fig. 2. Frequency response of the conventional system. Large dips in the response between 3 kHz and 10 kHz are due to measuring microphone positioning not to speaker deficiency.

THREE-WAY SPEAKER SYSTEM

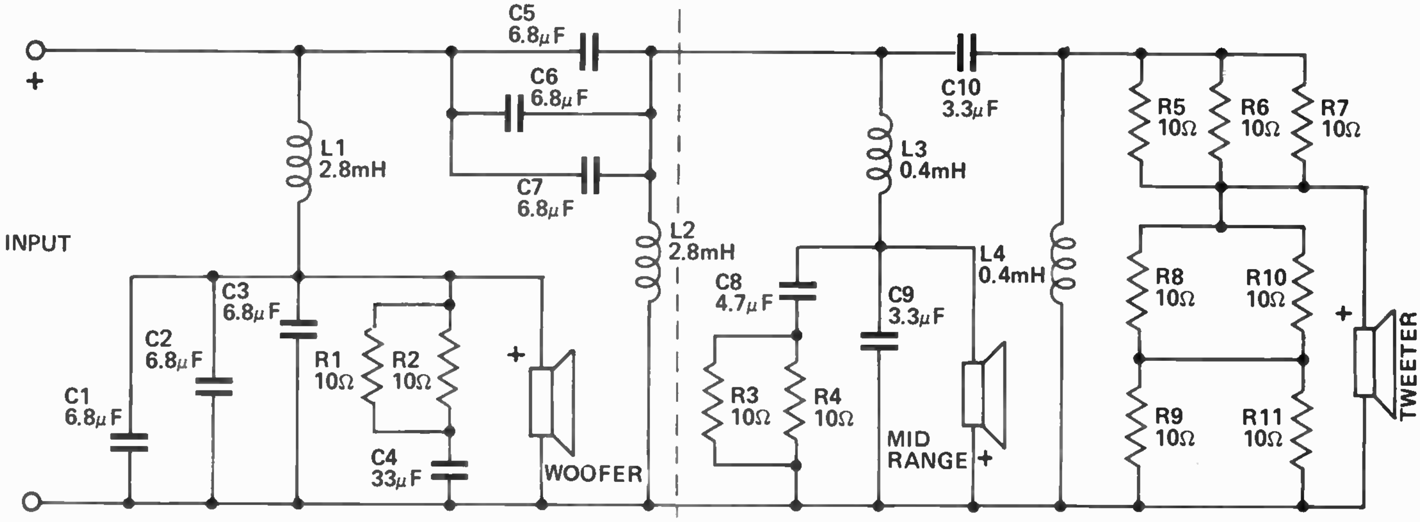


Fig. 3. Circuit diagram of the three way crossover. If crossover amplifier is used only the components to the right of the dotted line are required.

impedance mismatch and phase errors. This was cured by adding compensating networks, R1, R2 and C4 for the woofer and R3, R4 and C8 for the midrange, to control the impedance presented to the crossover network. This restored the crossover frequencies to their proper positions and smoothed out the response considerably. Further tests showed that the positioning of the drivers in the original system was causing cancellation between woofer and mid, and mid and high off-axis and the drivers were therefore positioned in a vertical line. This improved the smoothness of the off-axis response considerably.

Finally a new 50 mm dome midrange (AD 0210/SQ8) was substituted for the 125 mm cone type (AD 5060/SQ8) specified for the original system. Although the 50 mm unit is much more expensive it has similar sensitivity but wider dispersion and considerably lower distortion. If expense is a limiting factor however the cone type will give quite acceptable results. Note however that the mounting hole for the 50 mm dome is 112 mm and is *larger* than that required for the 125 mm cone type (108 mm).

CONSTRUCTION

The Crossover.

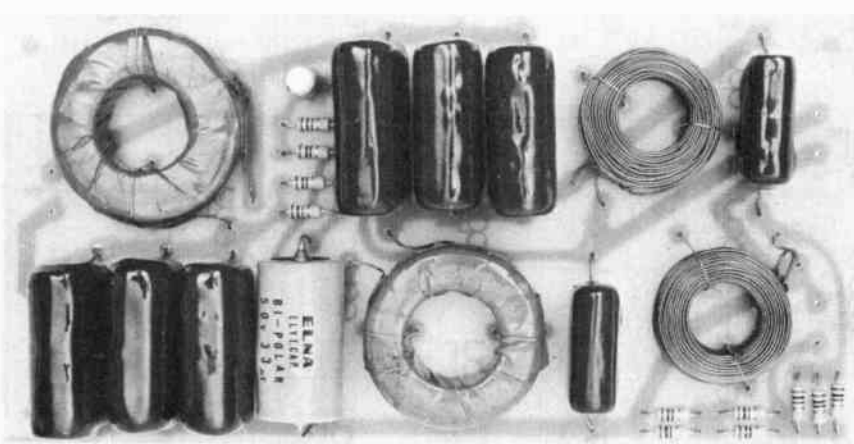
All the crossover coils are wound with 0.063 mm (22 B & S) wire. Coils L1 and L2 are wound on a 13 mm former and coils L3 and L4 are wound on a 10 mm former. These coils do not have many turns and are quite easily wound by hand. Try to keep the turns in layers as far as possible but some jumbling of turns will not materially affect results.

Polyester capacitors should be used in all positions except for C4 and C8 which may be non-polarised electrolytics. Note that the resistors are made up by series – parallel combinations of 10 ohm half-watt resistors. This is cheaper than using individual high-power resistors for these positions.

The polyester capacitor are available from many sources including Philips and Soaner. Space has been allowed for the physically largest type.

After mounting all components on to the boards, attach leads to the

The completed crossover network contains all the components for the conventional three-way system. The same board may be used if crossover amplifier is used simply by leaving off the unnecessary components.



PARTS LIST — ETI 439

R1-R11	Resistor	10 ohm ½ W 5%
C1-C3	Capacitor	6.8 μF polyester
C-4	"	33 μF non polarised electro
C5-C7	"	6.8 μF polyester
C8	"	4.7 μF non polarised electro
C9,10	"	3.3 μF polyester
L1,2	Inductor	2.8 mH see table 1
L3,4	"	0.4 mH " " "

PC Board ETI 439

Philips AD12100/W8 woofer
Philips AD0210/SQ8 or AD5060/SQ8 mid range
Philips AD0160/T8 tweeter

Wood Box to Fig. 5.

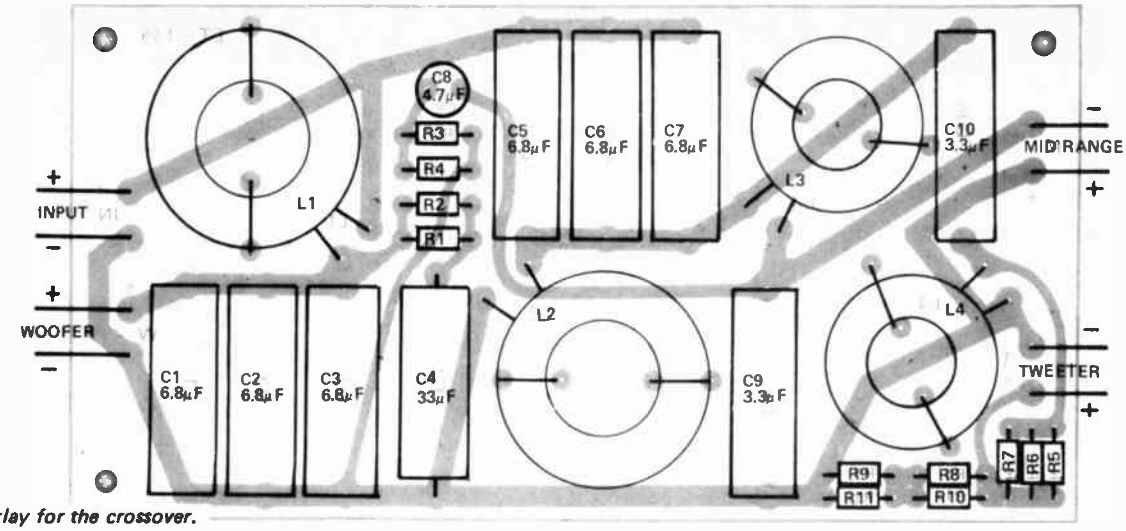


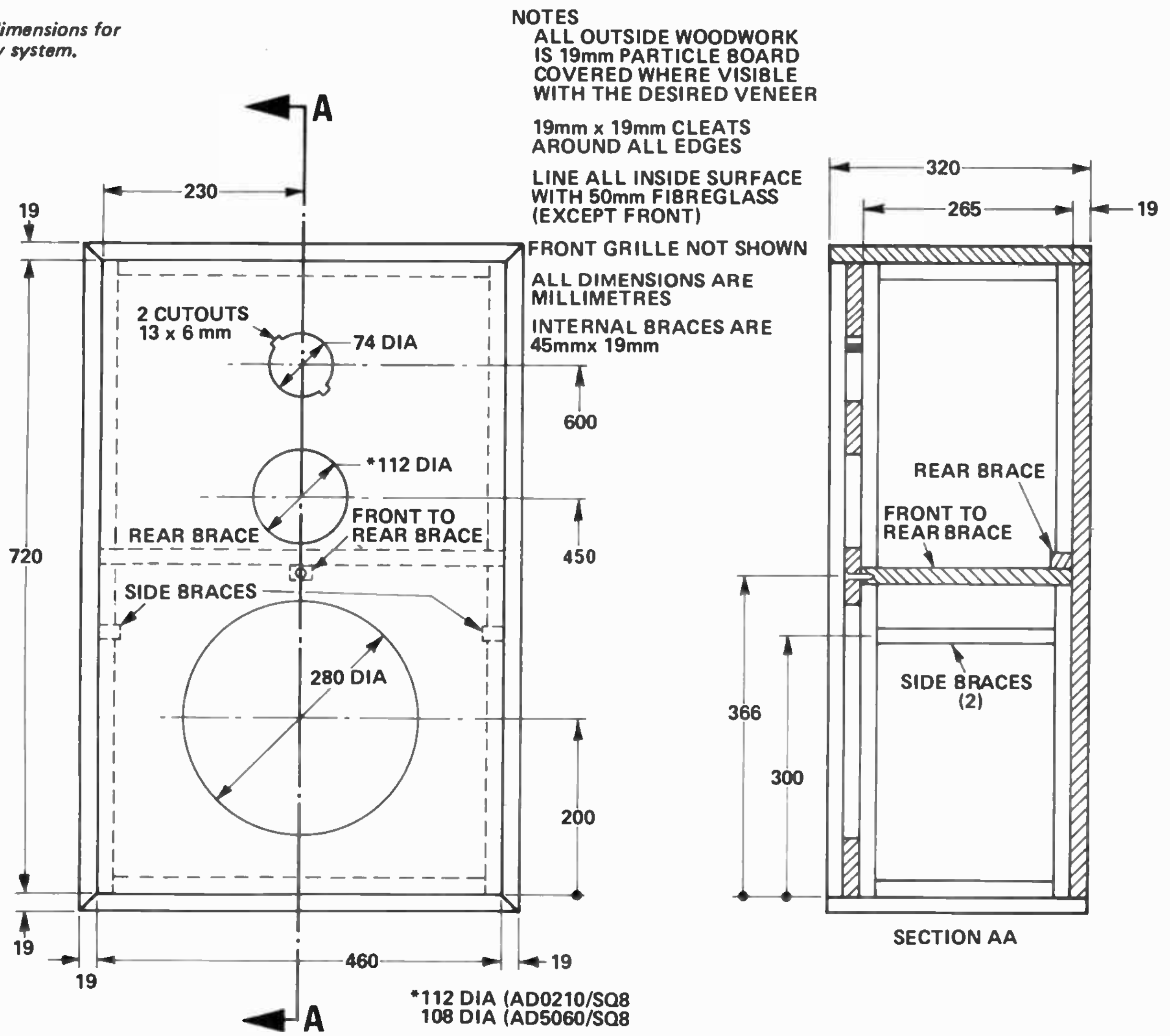
Fig. 4. Component overlay for the crossover.

crossover long enough for later connection to the drivers, and to the rear panel terminals.

The Box.

The enclosure volume is 82 litres (2.9 cubic feet), the outside dimensions of the box are 756 x 496 x 320 mm. Two boxes may both be cut from a single 1800 by 1200 mm sheet of 18 mm veneered pine board except for the front and rear panels which are cut from plain 19 mm pineboard. The internal bracing is 45 x 19 mm hardwood glued on edge in the positions shown in the drawings. A further brace between centres of front and rear panels may also be added. Cleats of 19 mm square timber should be glued into all internal corners of the box and care should be taken to ensure that the box is absolutely airtight.

Fig. 5. Box dimensions for the three-way system.



THREE-WAY SPEAKER SYSTEM

TABLE 1

INDUCTOR WINDING DETAILS

L1, 2

2.8 mH
300 turns
0.063 mm (22 B&S) wire
25 mm inside diameter 13 mm long

L3-4

0.4 mH
130 turns
0.063 mm (22 B&S) wire
20 mm inside diameter 10 mm long

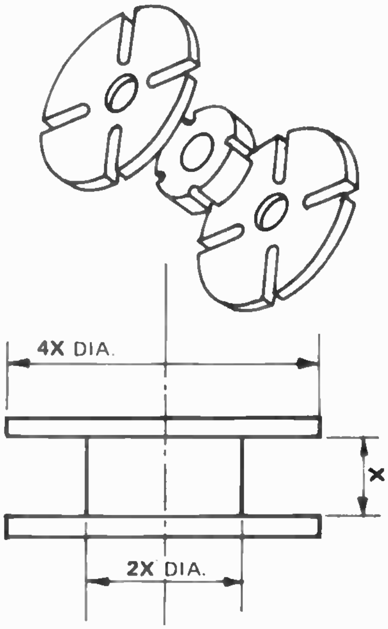
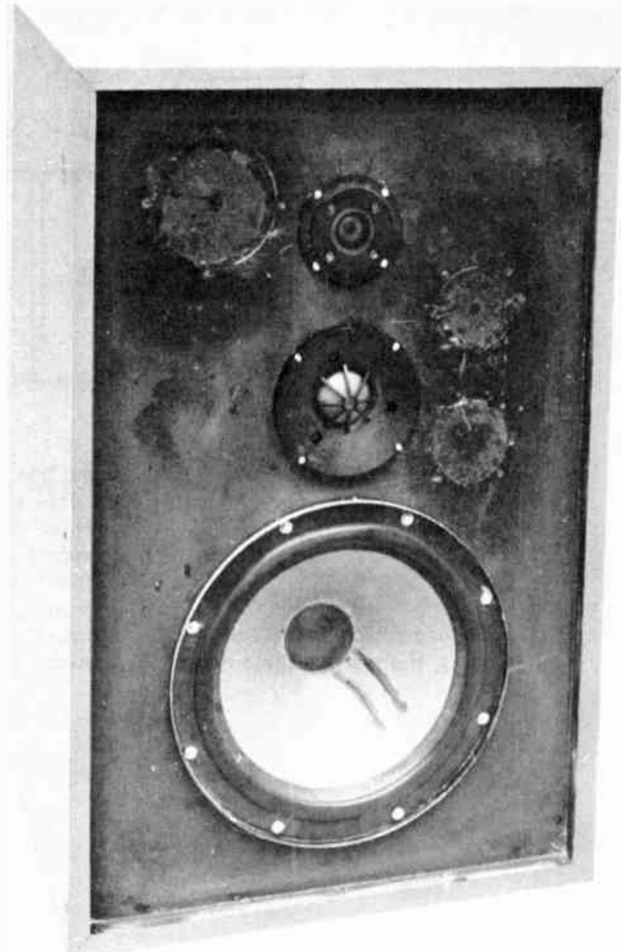


Fig. 6. Dimensions of bobbins used to wind coils L1 to L4. For L1 and L2 'x' = 13 mm, for L3 and L4 'x' = 10 mm.



The prototype speaker with grille removed. The plugged holes were for trial positioning of midrange and tweeter.

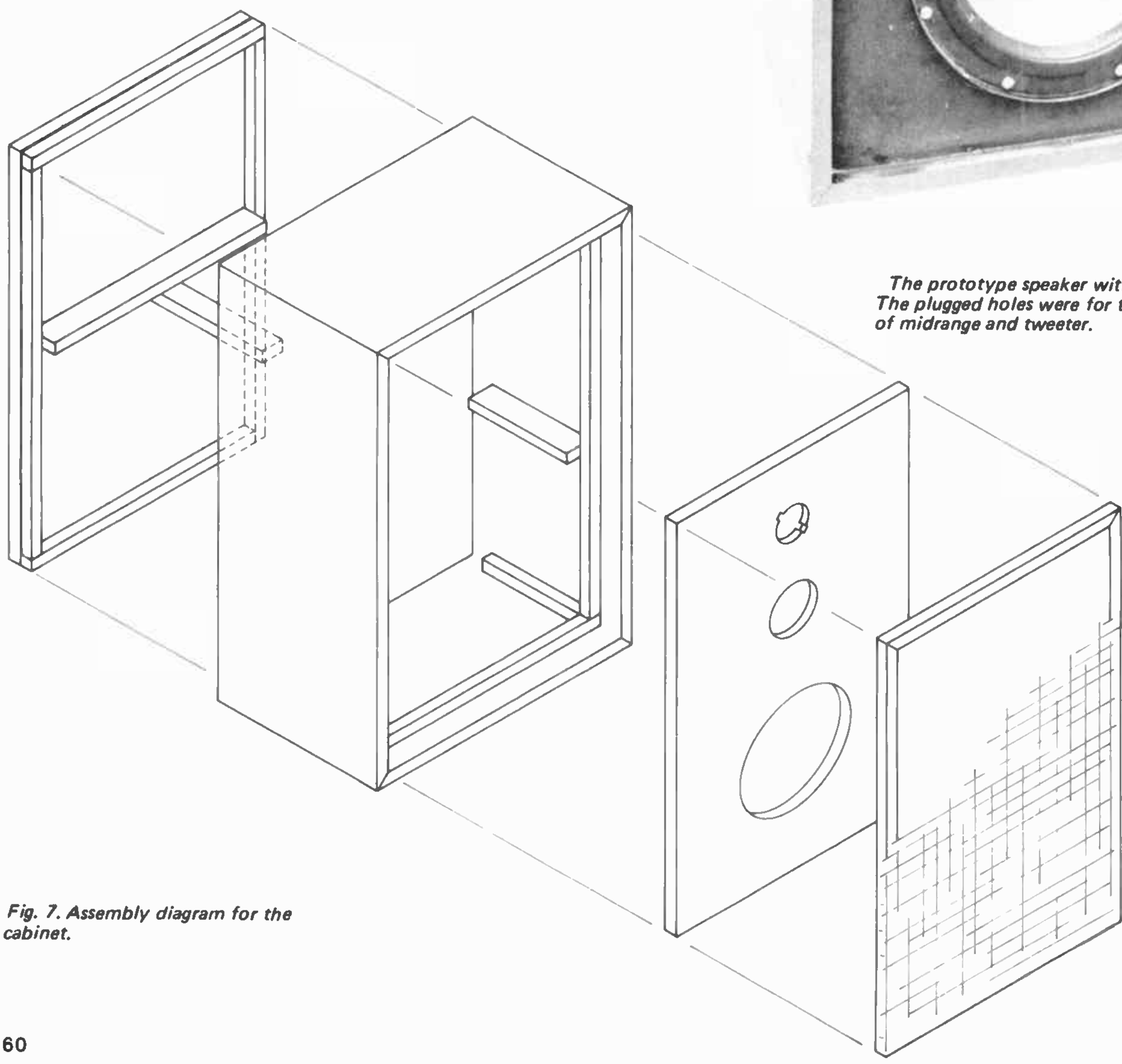


Fig. 7. Assembly diagram for the cabinet.

The box should be lined on all sides and the back with 50 mm – thick fibreglass and the cross-over network mounted in the vicinity of the woofer. Mount the terminals to the rear panel, connect them to the crossover network and drape the leads for the drivers out of their respective holes. Roll out some plasticine such that its diameter is about 2 or 3 mm and apply it around the circumference such that a good seal will be obtained when the driver is mounted in position. Finally, carefully fit the drivers into their holes and secure them with wood screws.

If an oscillator is available drive the speaker with a low frequency, about 20 to 30 Hz, and listen carefully to determine if there are any air leaks. These will be evident as whistling or hissing sounds. If any leaks are found they must be cured as the performance of the box will otherwise be adversely affected.

Make the grille frame from 18 mm square timber and staple or glue the grille cloth to it. Finally polish the boxes by any suitable method – we found that a Scandinavian-oil finish is easy to apply and looks very professional.

Electronic Crossover.

The crossover amplifier, as described in the October 1975 issue of ETI, may be used with this speaker system by making a few simple changes. The woofer is driven directly from the low channel of the crossover amplifier whereas the mid and high, although driven from high-channel amplifier, still require a passive crossover. Thus three terminals are required on the terminal panel, a common, one for woofer input and a mid-high input terminal.

The crossover required for the mid-high is the circuitry to the right of L2 in Fig. 1. Note that with this system the woofer must be connected in the same phase as the mid-range rather than in anti-phase as shown in fig. 1 for the conventional system.

We noticed that in frequency response tests the electronic crossover definitely gave a much smoother response at the low end of the range. Comparative listening tests have not been carried out at the time of writing so we cannot say whether the smoother response is audible. But the performance, even as a conventional system, is really excellent and comparable with many of the top quality commercial systems. It is not an inexpensive system to build but its cost should be about half that of a comparable commercial system. ●

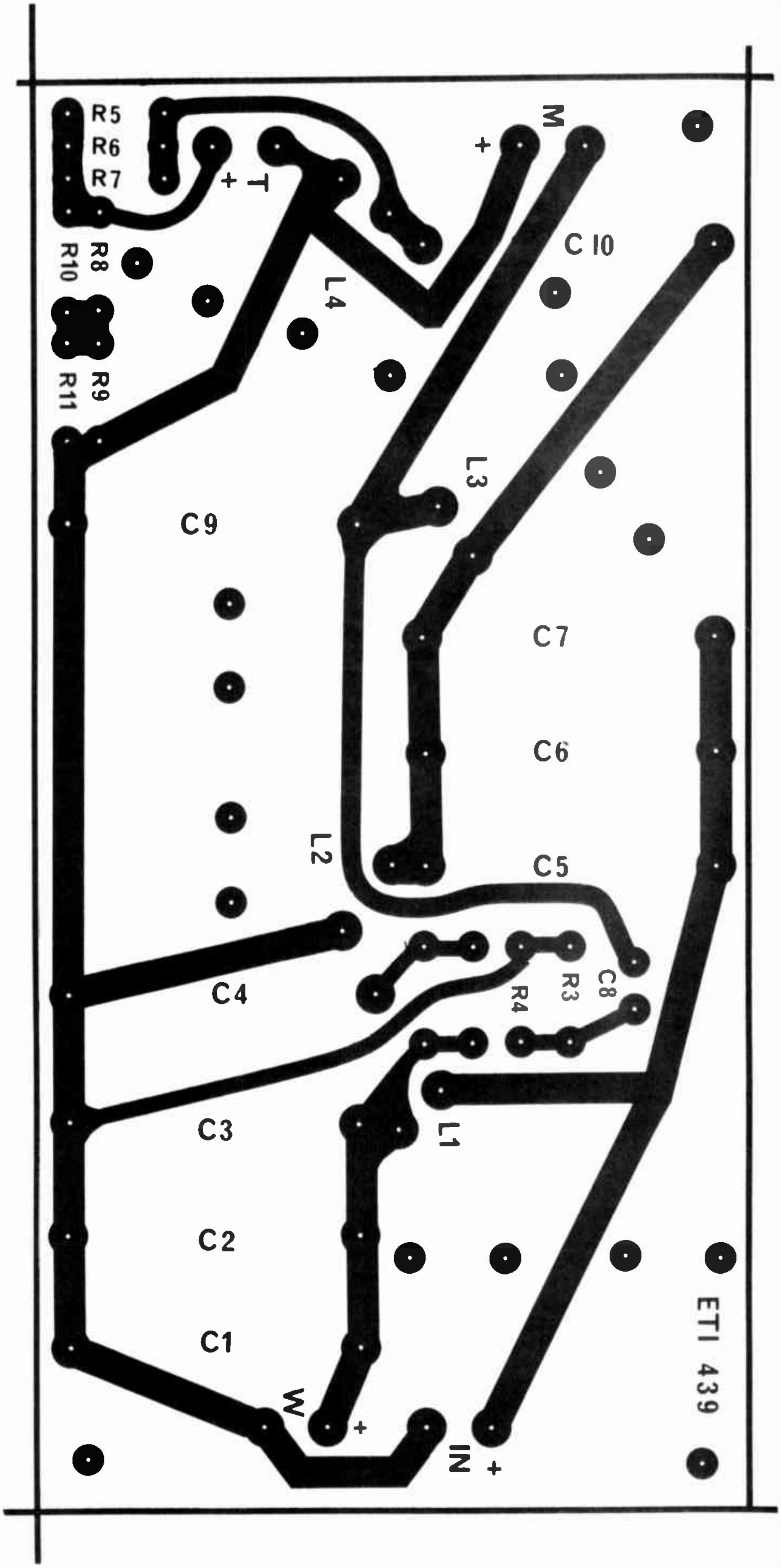


Fig. 8. Printed circuit layout for the crossover board. Full size 224 x 113 mm.

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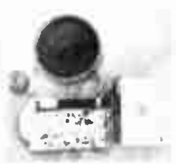

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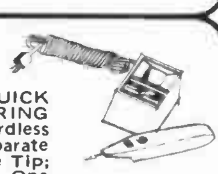

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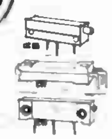

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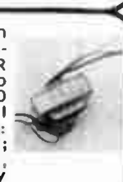

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BC 107	25c	20c
BC 108	25c	20c
BC 109	25c	20c
BC 177	28c	23c
BC 178	28c	23c
BC 179	28c	23c
BC 547	25c	20c
BC 548	25c	20c
BC 557	25c	20c
BC 635	50c	45c
BC 636	50c	45c
BD 139	80c	70c
BC 140	80c	70c
BF 115	65c	55c
TIP 31C	95c	85c
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2N3638A	55c	45c
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EM 402	10c	8c
EM 404	10c	8c
EM 406	15c	13c
EM 408	16c	14c
EM 401	17c	15c
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4012	35c	33c
4013	95c	90c
4016	95x	90c
4017	$2.15	$2.05
4020	$2.30	$2.20
4027	$1.00	95c
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NE 556	$2.00	1.75
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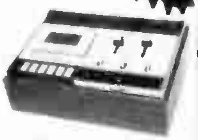

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12" Model 366	twin cone 130W rms 30-12.5 kHz	$129.00
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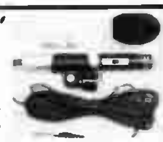

A versatile high quality mike. For professional recording in studios and perfect for use with tape recorders. Freq. response: 50-13 kHz. Power supply: AA type, UM-3 (1.5v). Output level: (1000Hz) — 68 dB $\pm$ 3 dB. Comes complete with swivel mount stand adaptor, wind screen and a 15' cable. ONLY $12.50 each P&P $1.25.

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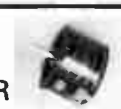

2.5 ohms 5 watt. Robustly constructed. Standard ¼" x ¾" shaft. ONLY $2.50 each P&P 50c.

World famous 'JENSEN' Dyna-mount car speaker system. Not just an ordinary speaker but one of the finest surface mount speaker systems available. 5¼" air suspended, twin cone with 20 oz. magnet. 8 ohm impedance. $68.00 per pair P&P $3.00 .

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Part No: PC1. as currently used for the Charger 4, also as used in E.T.I. Projects 118 & 704. Outside dimensions are 140mm wide x 133mm deep x 83mm high. Made with high impact Bakerlite & supplied complete with undrilled rear and front aluminium panels. ONLY $3.60 each P&P 75c.

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THE PHILIPS 2" HIGH POWER DOME SQUAWKER TYPE AD0210/SQ8

Power handling capacity: 50W rms (with cross-over filter type ADF600/4000/8) Impedance: 8 ohms. Resonance freq: 270 Hz. Freq. range: 300 Hz-7 kHz. Operating power: 5W rms. Power handling capacity: 15W rms. Magnet material: Ferroxdure Wt. of loudspeaker: 1 Kg. M.S.C.'s SPECIAL INTRODUCTORY OFFER $34.00 ea. P&P $2.00

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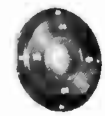

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PHILIPS 3-WAY CROSS-OVER NETWORK. ADF500/4500/8.

Rated impedance: 8 ohms. Cross-over freq: 500 & 4500 Hz. Power handling capacity: 40W rms. $12.00 each. P&P $1.50 PR

LAST STOCK CLEARANCE OF "RODAN" DIGITAL INDICATOR TUBES — TYPE GR-211

Type GR-211. Electronic Gas-filled Cold Cathode display device. In-line 9 — 0 Side viewing.

Specifications: Anode Supply Voltage (Vdc) Min: 200v. Ionization Voltage (Vdc) Max: 170v. Cathode Current (mA DC): 5 m/a. Power consumption per Electrode: 1W. Diameter of Glass Tube: 30 mm. Height of Tube (Excluding pins): 63mm $\pm$ 3. Height of Digits: 35 mm. Colour of Display digits: Neon Red. Only $2.50 each to clear P&P 40c per unit.

THE E.M.I. LIGHT LEVEL AUTOMATIC SWITCH TYPE 38

This unit has been designed to enable lights to be switched on automatically when the ambient light level drops below a preset value. The unit will also switch off the lights at any desired light level above the "switch on" point. All "solid state" apart from the reed relay which energises an external contactor, the unit has extremely high reliability and long life.

Specification: Light level to switch "on" presettable from 1 to 100ft. candles. Light level to switch "off" presettable from 1 to 100ft. candles. Contact rating: +20°F to +150°F. Wall mounting box size: 8¼" x 4¾" x 2¼". Weight: 3 lbs. Light Sensing unit may be included in box or may be mounted externally at any distance from the control unit. Made to sell at $50 each. $20.00. P&P $2.00.

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- **SPEAKER CABLE**, colour codes twin flex 20c yd.
- **CAR RADIO ANTENNA**, 5 section lock down $2.50 each P&P 75c
- **CAR EXTENSION SPEAKER CONTROLS.** Use both speakers together or separately. $1.50 P&P 30c.
- **JACKSON SLOW MOTION DRIVES** 6:1 ratio $2.30 P&P 30c.

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INDEX Vol. 5 (Jan. 1976–Jan. 1975

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ERRATA & AD

Active cross-over. Sept '75.
Change R24, R39, R43, R46 from 220 ohms to 390 ohms.

Amplifiers. ETI 420, 422.
Both amplifiers may suffer from interference from power mains transients when refrigerators etc switch on and off. The interference is picked up by the pre-amplifier and may be greatly reduced by adding 10 k resistors in the emitter leads of Q9 and Q10. This may be done by cutting the tracks between Q9 (Q10) and R53, C35 (R54, C36) and soldering a 10 k resistor across the break.

25 Watt Amplifier. ETI 440, July '75.
Printed circuit board layout for this project is on page 102 of the October '75 issue.
Components overlay page 68. The capacitor across the primary of transformer T1 should be labelled C35 not C42. The capacitor C41 (centre of PC board) is shown with reversed polarity (circuit diagram is correct).
Page 70 — measured performance is to +0 −0.5 dB between 15 Hz — 30 kHz (the figure 15 Hz was accidentally omitted.
Resistors R51 and R52 should be 330Ω. In Fig. 5 the 'b' and 'c' of the BD 266 should be reversed and the 'e' and 'c' of the BC548 likewise. Zeners ZD1 and ZD2 were omitted from the parts list and are BZX79 8V2 and BZX79C10 respectively.
In the overlay it is best to join the earths between the aux. input and tape outputs and to break the shield on the tape output co-ax at one end.
The dimensions marked 42 and 122 for the position of the transistor mounting holes should be 47 and 127 resp. (page 72, Fig. 10).

50 Watt Stereo Amplifier. ETI 422, May '74.
Several people have experienced failure of the power-switch specified for this amplifier. Another switch by ISOSTAT is available, but its use requires shifting the power transformer.
A recommended replacement is the SCHADOW type NE15 No 4 chassis-mounting switch distributed by IRH Industries. This can be fitted without moving the transformer.

Audio Projects Vol. 1.
Due to a printer's error, one illustration was omitted from the article on the ETI 422 Stereo Amplifier in our recently-published Audio Projects Volume 1.
We reprinted as many copies as possible, but some had already gone out to our distributors. These were put on sale with an errata slip inserted, showing the missing illustration.
We regret any inconvenience this may have caused.
Fig. 7 page 31. Transistor Q15 should be a BD139 and Q17 should be a BD140.

Car Alarm. ETI 313, November '74.
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 EM-401 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.

Digital Voltmeter. ETI 117, Aug. '75.
Parts list, C5 should be 68 pF. PC board should be ETI 117B not ETI 1178 as published.

Doppler Radar. ETI 702, May '75.
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.

It has been found that some types of 555 IC from other manufacturers do not have the same characteristics as the Signetics NE555 used in our prototype. With these other ICs the alarm will close, or latch, during initial switch on.

This may be cured by adding a IN914 diode between pin 6 and pin 2 (cathode bar to pin 2) and by changing R20 to one megohm.

Links A & B have been reversed on the overlay.

Electronic Ignition System. January '75.
Fig 5, page 58.
Wires joining points A & B on the circuit board to pins 1

DENDA -1975

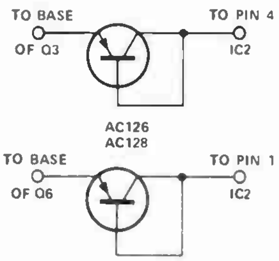
and 2 of the octal socket are shown crossed over. Point A should in fact go to pin 2 and point B to pin 1.

Page 56, add to parts list, diode D8, IN914.

Page 57, Table 1. Second heading should read 'REV LIMIT — value C14' not 'C15' as published.

Under certain conditions IC2 may be damaged due to excessive loading of Q3 or Q6. To overcome this, diodes are required between the outputs of IC2/3 and IC2/4 and the bases of Q3 and Q6 respectively.

To minimize forward-voltage drop we recommend that germanium PNP transistors (eg AC126 or AC128) be used rather than actual diodes (connect collector and base together). Fitting these is easy as two links may be removed and replaced by the diodes.



Electronic Music Synthesizer. ETI 3600, Apr. '75.

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.

Voltage Controlled Filter. May '75. page **63.**

The printed-circuit board artwork supplied to some kitset suppliers differs slightly from the one published.

On these boards provision has been made to obtain gain from IC4 and IC5. This consists of resistors between pin 6 and pin 2, and from pin 2 to +7 volts on each IC. This gain is not now required and a link should be installed between pins 2 and 6 on each of the relevant ICs.

Oscillator. Nov. **'73.**

The accuracy of the zero volt reference may be improved by adding a 10 k resistor between pin 9 and pin 12 of IC6.

Excessive current in IC6 has also been found to cause latch-up of the power supply. This may be cured by removing the link marked 10, directly under IC6, and by replacing it with a 1 k resistor.

This errata supersedes that published in the October 1975 issue; as the changes noted here have been found to be simpler and more effective.

Electronic Music Synthesizer. June '74.

Parts list page 70.

IC1 should be type 4001 CMOS not 4011 as previously specified.

Flip-Flop Flasher. Jan. '75.

Page 64.

The captions for figures 3 & 4 should be interchanged. The circuit on the right is the positive earth version.

Intruder Alarm, Jan. '75.

Circuit diagram Fig 1, page 68.

Delete connection incorrectly shown between point D and base of transistor Q1, (pç board etc is correct).

The 12 volt battery has been drawn the wrong way round. Positive terminal should be connected to PB1.

Low Battery Warning. Feb. '75.

Page 61.

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

Resistors — ¼ or ½ watt 5%.

R12k2

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

Mast-head Amplifier. Dec. '74

Page 51.

Parts list, transformer DSE 2581 should read DSE 2851 or PF 2851.

Fig. 1. C2 should be 25 V rating. C1 should be labelled C3.

Parts list page 52.

ZD1 should be BZX79C24 or similar.

Diodes D1, D2 are EM 401 or similar.

Circuit diagram page 50, ZD1 should be BZX79C24.

Speaker System. ETI 400. June '75

The chokes used in the cross-over may if desired be wound with 0.8 mm (20 B&S) wire rather than the 1.0 mm (18 B&S) specified.

Both chokes will be electrically similar but the 0.8 mm wire is cheaper and will fit onto the specified bobbins more easily.

Transistorized fishcaller. Jan. '75.

Page 111.

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

Warning

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

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

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

Simple Speaker. Nov. **'75.**

Philips have advised that the AD7061/W8 speaker, as recommended, has been superseded.

The replacement type is: AD7063/M8 10 watt.

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4. 20ft. Single Shielded Cable — high quality grey. **$1.00.**
5. 12ft Twin Shielded Cable — Fig.8 grey. **$1.00.**
6. 4 — Alignment Tools — useful radio/T.V. types. **$1.80.**
8. 200 — Assorted Screws/Nuts — suit electronics assembly. **$1.00.**
9. Bonanza Jackpot — a wealth of all types of electronic parts for the Hobbyist/Experimenter. $25 value for only **$5.00.**
10. 2-Way Intercom — Master/Slave with 50ft Cord. **$10.95.**
11. 50ft Plastic spaghetti tubing — asstd. sizes/colours. **$1.00.**
12. Crystal Microphone) high imp. 200-6000 Hz. **$1.95.**
14. 25ft Nylon Dial Cord — c/with 5 dial springs. **$1.00.**
15. 27 MHz CB Crystals — Miniature type 3/8" pin spacing, matched transmit/receive, PAIR for only. **$5.00.**
16. 5-NE 2 Neon Bulbs — 60V operation, 100's uses. **$1.00.**
17. 10 — Volume Controls — some with switch, ganged. **$1.00.**
18. 10 — Preset Pots — tab. mtg. TV types. **$1.00.**
19. 4 — Transistor Sockets — 3 pin suit TO5, TO18 etc. **$1.00.**
20. 3 — Transistor Sockets — T03 Power Transistor. **$1.00.**
21. P.C.B. Etching Kit — all the requirements including P.C.B. to make professional P.C. Boards. **$2.95.**
22. 2-2 Pin Din Plug/Sockets — best quality. **$1.00.**
23. 2-5 Pin Din Plug/Sockets — cheapest and best. **$1.20.**
24. 3-4 x 1015 Pnelight Battery Holders black plastic. **$1.00.**
25. 12 — No. 216 Battery Clips — High Grade types. **$1.00.**
26. Tuning Dial Kit — incl. tuning spindle, 3 x 3/8" pulleys, drum and dial cord etc. and instructions. **$1.00.**
27. 3 — Magnetic 8 Ohm Ear Pieces — c/w 3.5mm Plug. **$1.00**
28. 2 — Crystal Ear Pieces / c/w 3.5mm plug. **$1.20**
29. 15 — Fuses, Std. 3AG — your choice ½A, 1A, 2A, 3A, 5A, 10A. **$1.00.**
30. 2 — Panel Fuse Holders — Std. 3AG Screw In. **$1.00.**
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32. 50 — Rubber Grommets — Asstd. useful sizes. **$1.00.**
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34. 4 — 2 Pin Speaker Plug/ Socket sets — Polarised Type. **$1.30.**
35. 3 — Push-button Switches — 1P Push to make. **$1.20.**
36. 2 — Neon Screwdrivers — tests 180 — 500V A.C. or D.C. **$1.80.**
38. 20 Rubber Feet — Asstd. sizes, black. **$1.00.**
39. 20ft — 5 core solder — 16G 60/40 multicore. **$1.00.**
40. 20 — Brass Spacers — 4BA clearance hole, Asstd. sixes. **$1.00.**
41. 2 — pair multimeter test leads — 3mm prods each end. **$1.50.**
42. 2 — I.C. Test Prods — mini-hooks, 1 red, 1 black. **$1.20**

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45. Remote Control, T.V. Listener — easy to install device for private listening and for hard-of hearing persons — outputs for 2 earphones (not incl. but available at 50c each) with volume control. **$3.50.**
46. Extension Speaker Box — high quality hi-fi speaker box c/w volume control and 5" dynamic speaker 5W. Size 230 x 140 x 125mm, giving a beautiful clear sound. This is the deluxe model with aluminium trim. SP4. **$13.50**
48. Wall mounting Extension Speaker — front panel slopes downwards for wall mtg at approximately 6 — 8ft. high. Uses a super 5", 5W speaker and includes volume control. Size 240 x 165 x 95mm. Finished in imitation wood-grain vinyl. SP2. **$12.50.**
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57. Record Cleaner — a deluxe model free standing cleaning arm with cleaning brush and anti-static roller to clean the dirtiest of records. Arm is counter-balanced so it will not affect speed of turntable. Fits all record players and comes with spare foller. A "must" at only. **$3.95.**
58. 4 Channel Stereo Adaptor — universal 4 channel adaptor uses a novel new circuit to provie 4 channel sound from conventional 2 channel sources and for sound enhancement of "encoded" 4 channel stereo records. Connects to speaker output of almost any stereo amplifier — requires no power source. Imported — introductory price — Cat. No. 17-120-010. **$15.50.**
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60. Car Stereo Speakers — flush mounting with long-life chromed grille. Incorporates 5" speaker of 4-5 Watts handling power. Available in 4 or 8 ohms impedance. Supplied with mounting screws and connecting wire. GK705. **$11.80 pr/ or $6.25 ea.**
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64. Lock-Down Car Antenna — beat the vandals with this superb lock-down car radio antenna. Extra high quality chrome finished — extends to 40 inches c/w approximately 6ft. lead-in. **$3.95.**
65. Top Cowl Spring Loaded Antenna — a "snazzy" new spring loaded car radio antenna for fender mounting, beautifully chromed for all weather conditions. Complete with 6ft lead-in. **$5.50.**
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67. Crystal Microphone — a lapel or hand-held microphone for small tape recorders and hobbyist projects. Supplied with 3.5mm earphone type phone plug. MG62. **$1.95.**
68. Crystal Microphone — quality mic. for hand-held or table operation — suit most tape recorders and hobbyist projects, c/w 3.5mm plug. MC22. **$3.20.**
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71. Dynamic Microphone — attractive high impedance (50k ohms) microphone for hand-held or table operation. Suits most tape recorders etc. MD391. **$5.99.**
72. Dynamic Cassette Type Microphone — a low impedance (200 ohms) dynamic mic. for use with most types cassette tape recorders — features on-off switch for remote control of tape recorder if required. For hand-held or table operation — comes complete with 3ft lead and "earphone-type" 3.5mm plugs. Freq. response 200Hz to 10kHz. A real bargain. MD17. **$3.25.**
73. Deluxe Hi-Fi Dynamic Microphone — this omni-directional hand-held ball type microphone has a die-cast housing of satin chromed finish, on-off switch, mic. holder and approx. 9ft. shielded cable. Would suit high quality tape recorders, PA or singing use, store advertising or G.P. applications. Imp. 50k ohms, freq. response 100Hz to 10kHz, sensitivity — 58 dB at 1000 Hz, c/w 20ft. lead and 6.5mm phone plug. MD109. **$16.95.**
74. Crystal Mono Cartridge — suit most imported record players. M110. Cat. No.12-200-010. **$1.95.**
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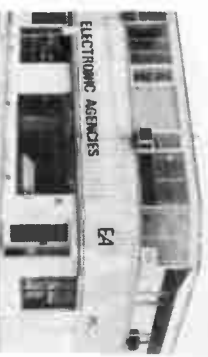

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101. 2 — 3PDT Rotary Wafer Switches — standard OAK Type, as above. **$1.00.**
102. Rotary Wafer Switch — 3 position 9 hole triple wafer OAK switch, latest type, 3/8" diameter mounting hole, ¾" long shaft. **$1.00 ea.**
103. 2 — Rotary Wafer Switches — 3 position plus mains on-off, 3 pole, 3/8" diameter mounting hole, ½" long knurled shaft. **$1.00.**
104. 2 — Rotary wafer switches — 6 pole 3 position, dual wafer, OAK 'H' type 3/8" diameter mounting hole, ½" long shaft. **$1.00.**
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106. Selenium Bridge Rectifier — 20 volt, 6 amp suit battery charger, compact size 2¾" x 3¼" x 2". **$4.50.**
107. Plug-in Headshell — standard replacement for most Japanese turntables and tone arms. ½" mtg holes suit all modern magnetic cartridges — attractively finished in matt black with chrome trim. **$4.50.**
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109. Din to Din Lead — 6ft cord with 5 pin din plugs each end for connection between stereo amplifier and tape recorder for record/playback. **$2.95.**
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112. 2 — Neon Indicator Bezels 250V A.C. — a very attractive square type red indicator. **$1.00.**
113. 2-6 Volt Indicator Bezels — a beautifully chromed bezel complete with 6 Volt mini-globe. Available in red, green, amber. **$1.00.**
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115. 2 — Mono 6.5mm Plug/Socket sets — very useful for microphones, guitars, speakers etc. Comprises 2 plugs and 2 sockets (panel mounting) with changeover switch. **$1.00.**
116. 2 — Stereo 6.5mm Plug/Socket sets — for all stereo applications, comprises 2 plugs and 2 panel mounting sockets. **$1.50.**
117. 6 — RCA type plug/socket sets — standard audio input connectors for amplifiers etc. Comprises 6 plugs and 6 panel mounting sockets. **$1.00.**

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118. Stereo headphone control box — allows 2 pairs of stereo headphones to be operated from any amplifier fitted with a standard 6.5mm headphone socket. Each pair of headphones has its own slider volume control and a stereo/mono switch is included. **$5.50.**
119. 5-2 Pin Polarised Line Plug/Socket sets with covers. **$1.00.**
120. 8 — Standard 3AG In-Line Plastic Fuse Holders. **$1.00.**
121. Radio Dial Kit — handspan clear plastic circular dial, all states dial scales, bush, etc., to suit most Japanese plastic tuning condensers. **$1.00.**
122. Tuning Condenser with dial — standard ¾" x ¾", 200pf gang with radio dial kit as described above. **$2.00.**
123. 10 Asstd. potentiometers — ideal for experimenters and hobbyists. All new and useful — includes preset, ganged, switched and standard types. **$1.00.**
124. 12 Pot — Nuts and washers — shiny brass nuts and steel lock-washers. Keep 'em on hand — very useful. **$1.00.**
125. 6V DC — DC Car Convertor — plugs directly into any car cigarette lighter socket. For use with cassette tape recorder, transistor radio etc and provides regulated output up to 300 mA. **$6.90.**
126. 9V DC — DC Car Convertor — similar to above but 9V output **$6.90.**
127. Cassette Tape Splicer — for the adverturous cassette enthusiast or for repairing broken tapes, you need this handy little unit. Cuts and trims tapes in 2 operations — complete with instructions. **$3.95.**
128. 6" side — Cutting Pliers — real forged steel; hand finished by continental craftsmen. Made in Sheffield England; best quality for all radio work, with insulated handles. Normally priced around $2.95, our price just. **$1.95.**
129. 60 — Self-Tapping Screw Assortment. All Cadmium plated steel, various sizes suit radio and electronics work. **$1.00.**
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138. Super Experimenters Pak containing 50 most popular useable electroytic capacitors, guaranteed new and high quality. Range 22μF to 3300μF, 6VW to 160VW. The normal price would be $11.48; but the price now is only **$4.50 (just 9c each).**
143. 2000mfd, 25VW Ducon Electros — brand new and guaranteed, insulated can type. 2 for **$1.50.**

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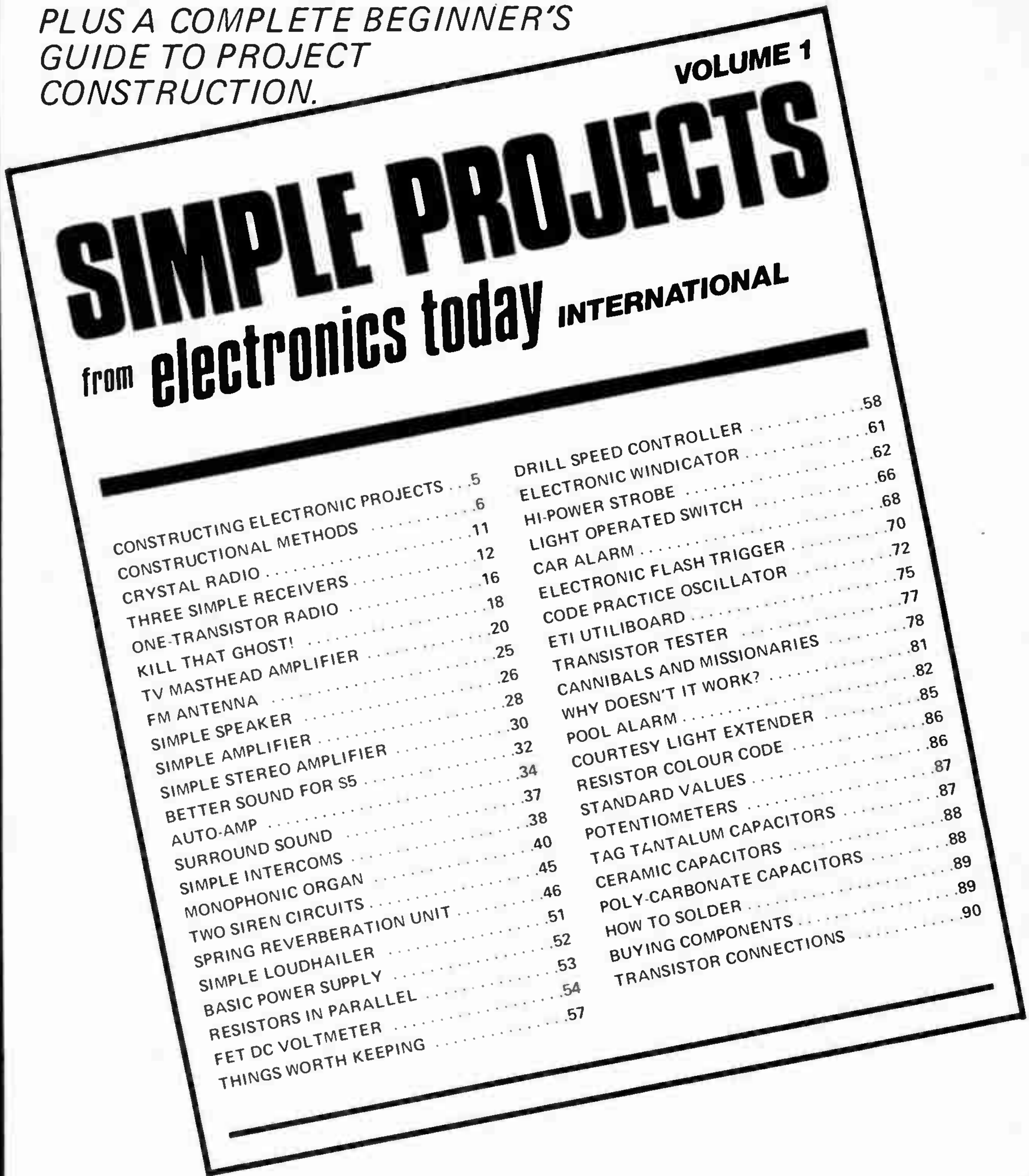

VOLUME 1

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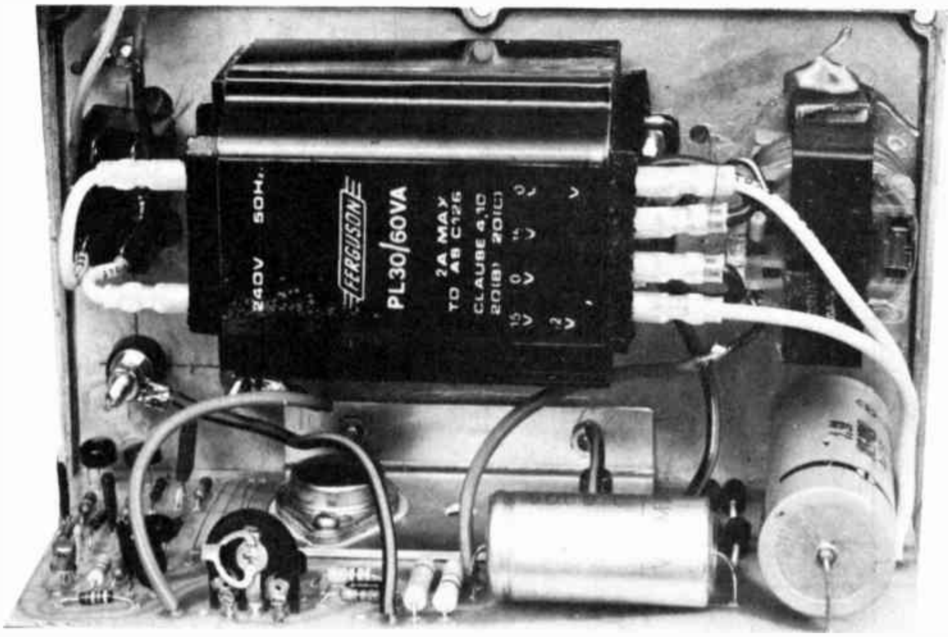
SWITCHING REGULATOR SUPPLY

PROJECT 119



Drive those TTL circuits with this 5 volt 10 amp (max) supply.

WHILST the introduction of CMOS has lowered the power requirements of digital equipment using it, many large scale systems, because of cost and availability, are still designed around TTL logic. For such systems a five-volt supply having a capability of up to 10 amps is often required.

The choice of power supply for a system depends very much on the output requirements. In very low power applications a shunt regulator consisting of a series resistor and a zener may be entirely adequate. For medium power systems however a series-pass transistor regulator is normally used.

Whilst the series pass regulator is very good with regards to ripple and regulation the specification of the transformer is critical if the supply efficiency is to be above 50%. In a larger system this can be a very important factor.

With a switching regulator the requirements on the transformer are greatly relaxed and an efficiency of 70% or more can readily be obtained with mains-input variations of from 160 to 260 volts.

A fourth type is the switch-mode supply where the mains voltage is first rectified and filtered. The rectified mains then drives a high-frequency inverter which employs a ferrite transformer. Regulation is obtained by controlling the inverter and by this means very high efficiencies may be obtained. Nearly all the components in such a system work at mains voltage and hence for safety reasons this approach was not used in our project.

CONSTRUCTION

All components, with the exception of the transformer and the choke are best mounted on a printed-circuit board such as the one specified. The choke should be wound as detailed in Table 2 with four layers close wound of 14 gauge B&S wire. Due to the dc current in the choke an air gap is necessary to avoid saturation. The easiest method of adjusting this gap for best performance is to run the supply at the maximum current required and adjust the gap by inserting that thickness of insulation between the cores which gives minimum ripple voltage. We found that a 3 mm gap was required at 10 amps for a ripple of 50 mV peak-to-peak.

The prototype was mounted in a ▶

TABLE 1
Comparison of typical series and switching regulators

	SERIES	SWITCHING
Output Voltage	5 V	5 V
Output Current	10 A	10 A
Efficiency		
240 V in	50%	70%
260 V in	40%	70%
Ripple Voltage	< 5 mV p-p	50 mV p-p
Regulation 0-10 A	< 0.05 V	0.3 V
Input Voltage	240 ± 10%	160 to 260 V
Transformer Secondary	8.5 V @ 12 A	20 to 30 V @ 80 VA
Diodes Required	10 A	3 A
Filter Capacitor	33 000 μF	2 200 μF
Short Circuit Current	15 A	15 A

SWITCHING REGULATOR SUPPLY

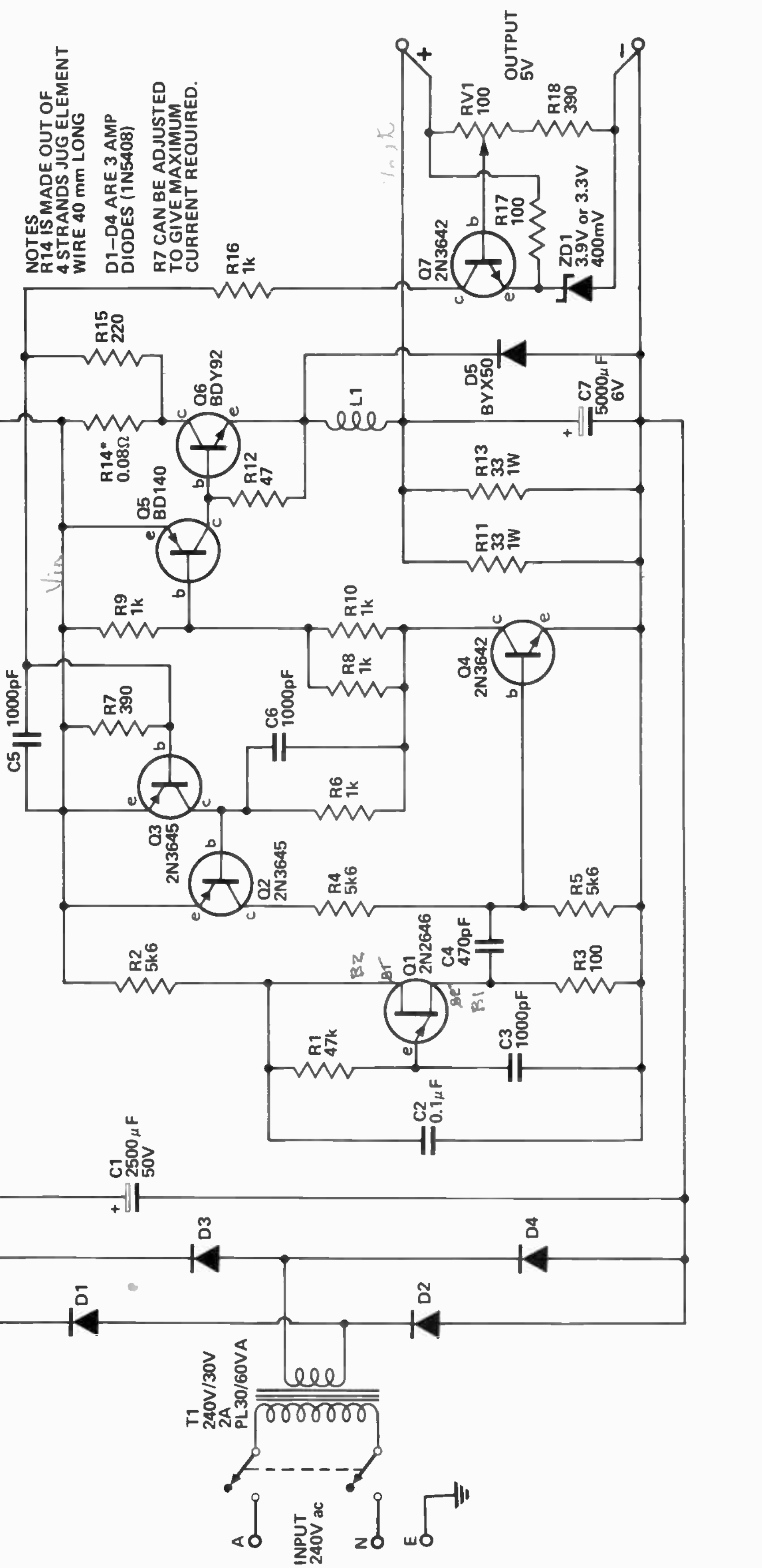


Fig. 1. Circuit diagram of the regulator.

die-cast box which acted as the heatsink as well as a shield to prevent the radiation of RFI generated by the switching action of the supply. If another form of box is used a heatsink must be added to the transistor-diode bracket for cooling.

An external LC filter will reduce the ripple even further if required. For example a series choke of 20 turns of 1.6 mm wire on a 10 mm ferrite rod and a parallel combination of 1000 μF electrolytic and 0.47 polyester capacitors external to the box will provide considerable extra ripple attenuation.

PARTS LIST – ETI 119

R14	Resistor	0.08 Ω *		
R11,13	"	33 Ω	1W	5%
R12	"	47 Ω	½W	5%
R3,17	"	100 Ω	½W	5%
R15	"	220 Ω	½W	5%
R7,18	"	390 Ω	½W	5%
R6,8,9	"	1k	½W	5%
R10,16	"	1 k	½W	5%
R2,4,5	"	5k6	½W	5%
R1	"	47 k	½W	5%

RV1 Trim Potentiometer 100 Ω

C4	Capacitor	470 pF ceramic
C3,5,6	"	0.001 μF polyester
C2	"	0.1 μF polyester
C1	"	2500 μF 50 V electro
C7	"	5000 μF 6V electro

D1-D4 Diode 3 Amp 100V IN5408 or similar
D5 " BYX50-200

ZD1 Zener Diode 3.3 V or 3.9 V 400 mV

Q1	Transistor	2N2646 or similar
Q2,3	"	2N3645 or similar
Q4,7	"	2N3642 or similar
Q5	"	BD140 or similar
Q6	"	BDY92 or similar

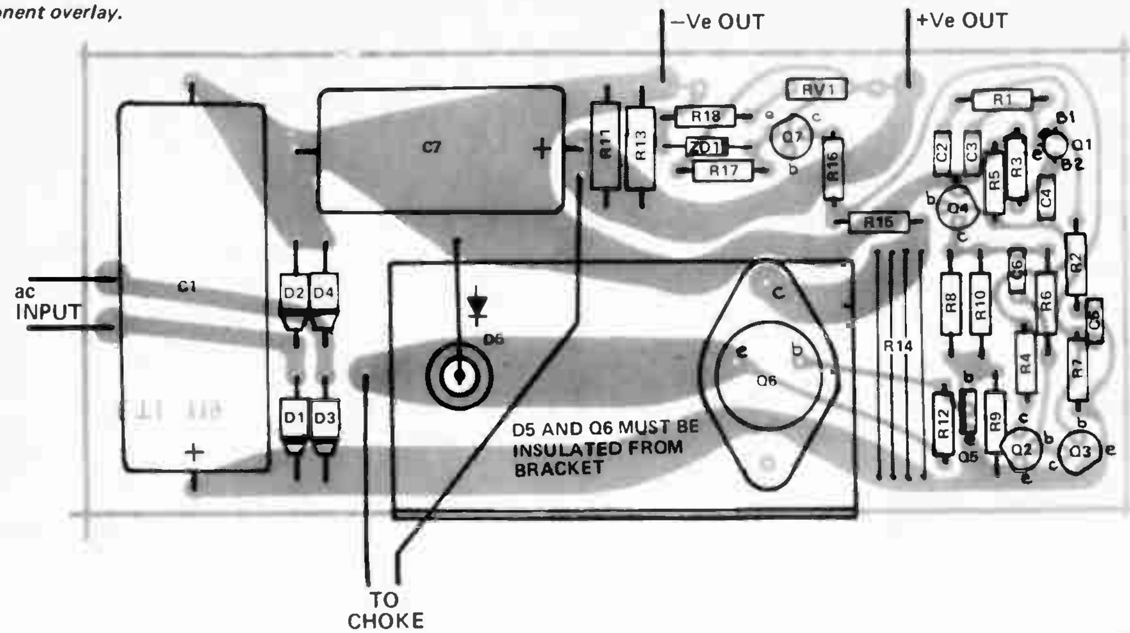
L1 choke see Table 1.

T1 Transformer 20V — 30V @ 60VA (7.5 Amp output) 75VA (10 Amp output)

SW1 Toggle switch 2 pole 240 V rated.

Heatsink bracket to Fig.3
Diecast Box 6357p
PC Board ETI 119
Insulation kit for Q6 and D5
* R14 is made out of 4 strands of jug element each 40 mm long.

Fig.2 Component overlay.



HOW IT WORKS – ETI 119

IN a conventional series regulator power supply the resistance of a series transistor is controlled in order to maintain the correct output voltage. The series transistor dissipates considerable power and therefore at very high load currents series regulators are quite inefficient. In the switching regulator a series transistor is still used but does not operate in its linear range. Instead it switches ON and OFF at high speed such that the load is alternately connected and disconnected to a supply voltage that is higher than that required across the load. By controlling the ratio of ON to OFF time we effectively control the average voltage as seen by the load. For example if it is on for 25% of the time the average output voltage will be 25% of the input. Thus by controlling the ON/OFF ratio the output voltage may be stabilized whilst dissipation in the series transistor is very greatly reduced.

However since most loads do not like their supply to be in the form of a square wave an LC filter is used before the load to pass only the dc component.

Referring to the main circuit diagram we see that transistors Q5 and Q6 are used as the series switch. L1 and C7 form the output filter. Due to the inductance of the choke a flywheel diode is required, not only to protect the transistor, but to provide proper operation. When the switch is on, the load current flows through the transistor, the choke, and into the capacitor and the load (Fig. A). When the switch is opened the load current must continue to flow through the choke and this is done via the flywheel diode D5 (see Fig. B). The current through the choke will thus rise during the on period and fall during the off period. The current never falls to zero except at very low load currents and the average is the same as the load current.

The operating frequency is set by the UJT Q1 which runs about 20 kHz; the higher the operating frequency the lower the ripple voltage on the output. However as the operating frequency goes up so also do switching losses in both transistor Q6 and diode D5. The 20 kHz was chosen as a compromise. It is high enough not to be audible but low enough to keep these losses to a minimum. A fast transistor and diode are still required however. For example if an MJ802 transistor is used the power losses increase by 5 to 10 watts at 10 amps output current.

When the UJT fires the pulse generated is coupled into the base of Q4 by C4 turning Q1 on. This, inturn, turns on Q2 and the switch Q5/6. When Q2 turns on Q4 also turns on and both latch on. If the current through Q6 rises above about 12 to 14 amps Q3 will turn on robbing current from the base of Q2 allowing both it and Q4 to turn off. This also turns off the output switch Q5/6. This is the current protection circuitry.

A voltage proportional to the output is provided by RV1 to Q7 for comparison to the voltage of ZD1. If Q7 is turned on sufficiently it will also turn on Q3 thus unlatching Q2/4 and turning off the output switch. Once the supply has stabilised this action will control the on time of the switch in each cycle of the 20 kHz, such that the output voltage is maintained at a voltage as set by RV1 in a smooth and even manner.

We used a 240 V to 30 V 2 A transformer, which is adequate for supply currents of up to 7.5 amps, however any transformer having an output of 20 to 30 volts and a power rating of 60 VA would do. If up to 10 amps output is required then a transformer with a rating of 75 to 80 VA would be required.

It is also possible to supply the regulator from a dc supply of 10 to 40 volts. If the voltage available is less than 20 volts R2 should be replaced by a link to ensure that the UJT operates correctly.

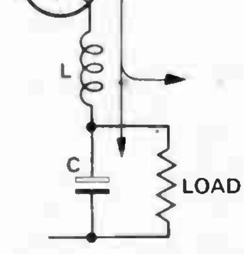


Fig. A. Current paths with switching transistor on.

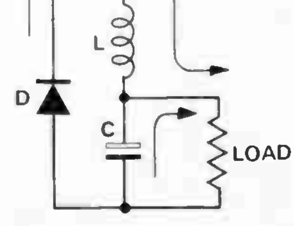


Fig. B. Current paths with switching transistor off.

SWITCHING REGULATOR SUPPLY

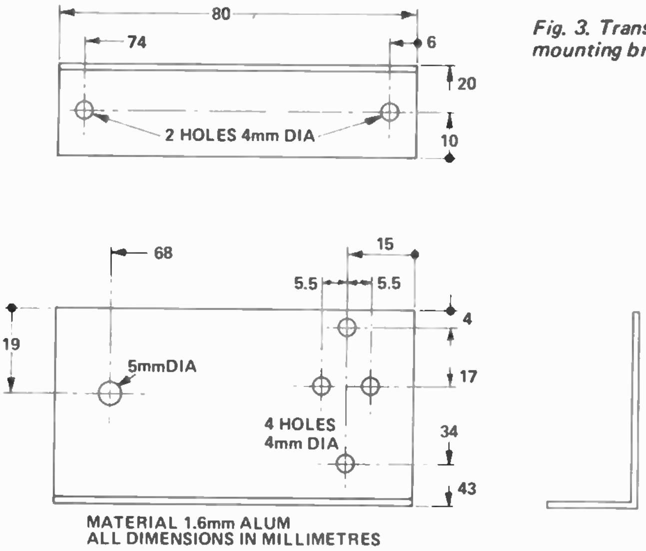


Fig. 3. Transistor/diode mounting bracket.

TABLE 2 Choke winding details.
CORE Philips E core 4322-020-34720 two required
FORMER Philips 4322-021-31830 or 4312-021-23622 one required
Four layers close wound of 1.6 mm wire core gap 3 mm (see text).

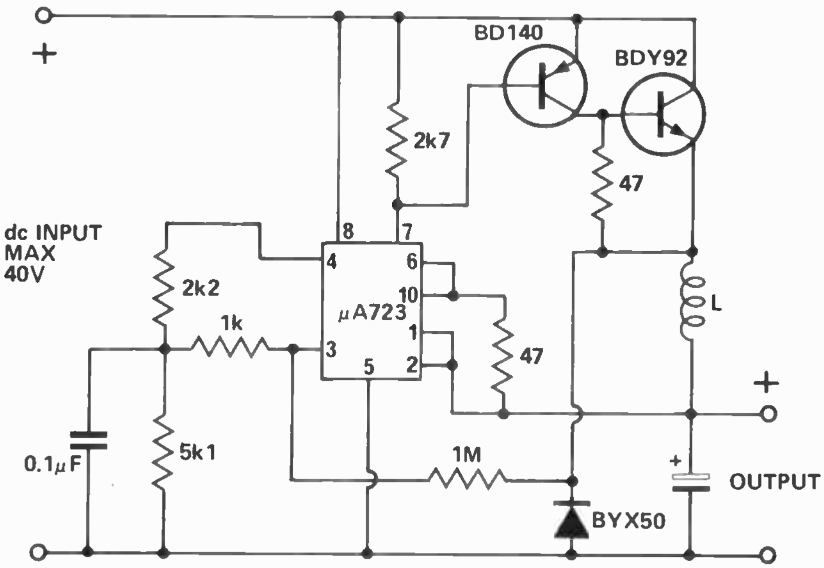


Fig. 4. This circuit recommended by a components supplier is simple but lacks short-circuit protection. Such protection is difficult to add to this circuit.

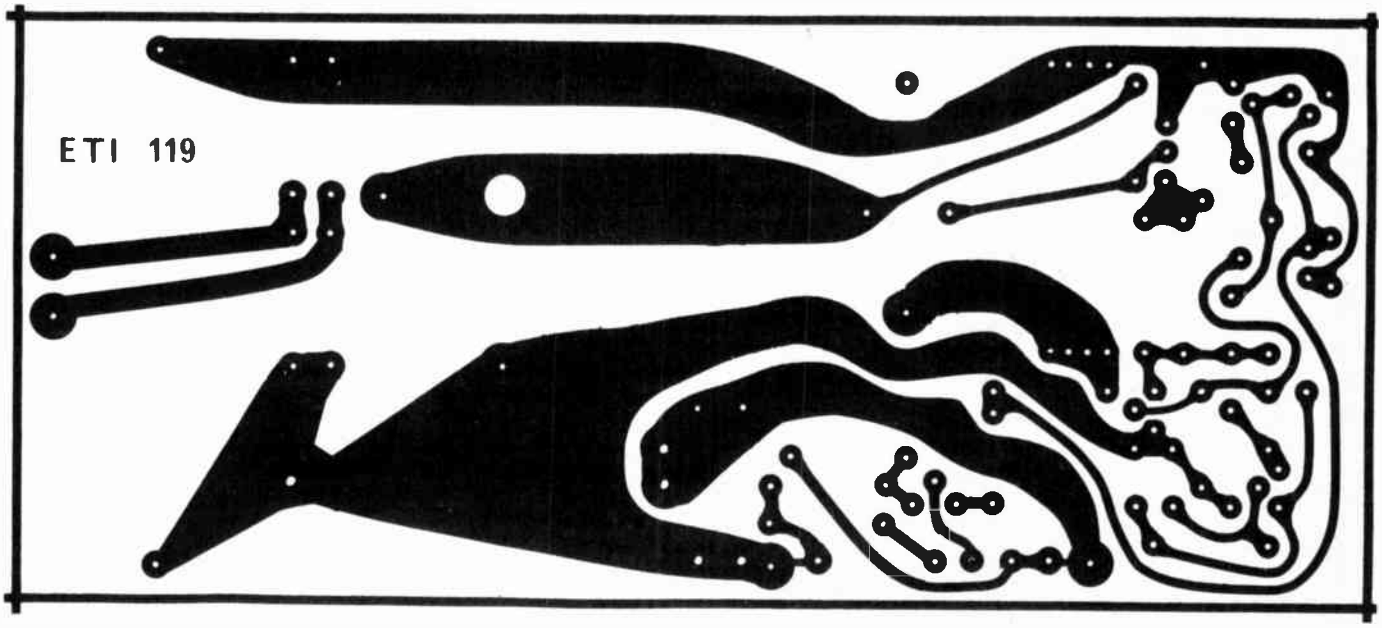


Fig. 5. Printed circuit-board layout. Full size. 178 x 78 mm.

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C90 LN	2.20	2.00	1.80
C120 LN	2.95	2.80	2.65
CDC 60	2.35	2.14	1.93
CDC 90	3.10	2.90	2.60
CDC 120	3.95	3.80	3.65

MEMOREX MRX2

	1	12	24
C45	2.10	2.00	1.90
C60	2.30	2.15	2.00
C90	3.20	3.00	2.80

TDK

	1	12	24
C45 LN	1.80	1.70	1.60
C60 LN	1.95	1.85	1.75
C90 LN	2.80	2.60	2.40
C180 LN	5.45	5.30	5.05
C90 SD	3.65	3.45	3.25

CONCORDE

	1	12	24
C60	1.20	1.10	1.00
C90	1.60	1.50	1.40

SONY

C90 LN	2.55	2.25	2.05

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NEW KITSET SUPPLIER

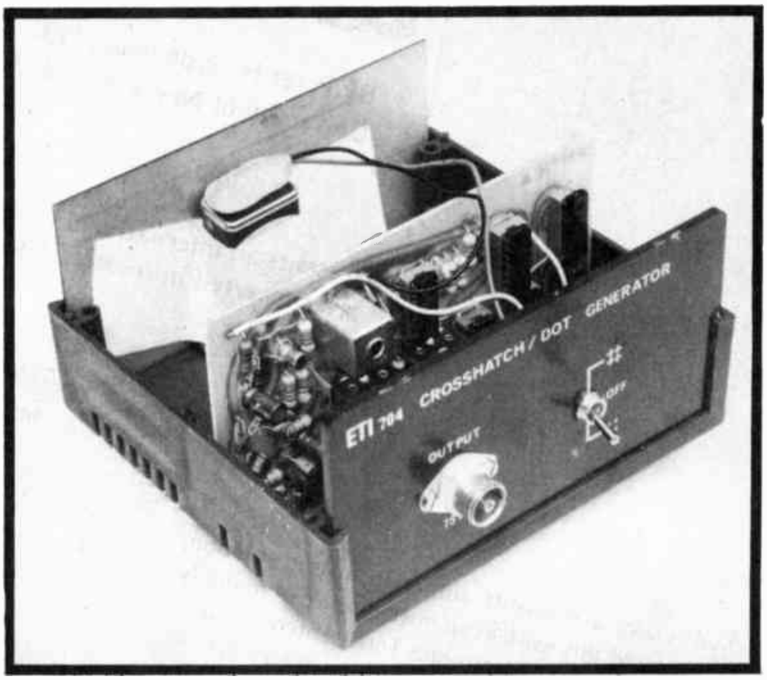
A RECENT and most welcome entry into the electronic kit business is Applied Technology Pty. Ltd. of Hornsby, NSW. The company is headed by Owen Hill, B.E. a very experienced electronic design engineer. Applied Technology are currently marketing a selected range of kits for ETI projects.

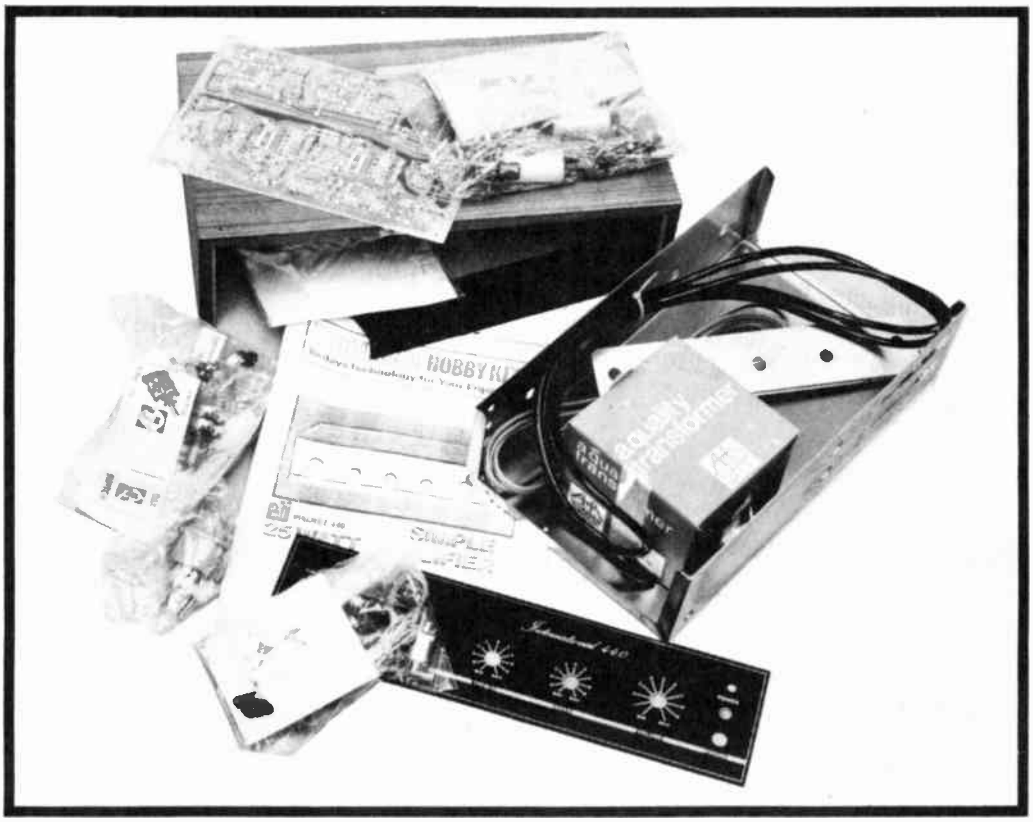
We recently received three of these kits for evaluation. These were the crosshatch generator (ETI 704), the simple 25 watt amplifier (ETI 440) and a CDI ignition system based on an overseas design. All three kits were very well presented. The packing was excellent, the printed circuit boards were made of glass fibre (except for the CDI unit where phenolic resin was used) and to aid assembly the component overlay was silk-screened on the component side of the board.

The front panels were silk-screened. All components were supplied in packs logically grouped as they would be used. Full instructions were supplied and it was obvious that great care had been taken to ensure that even a rank beginner would have a minimum of difficulty.

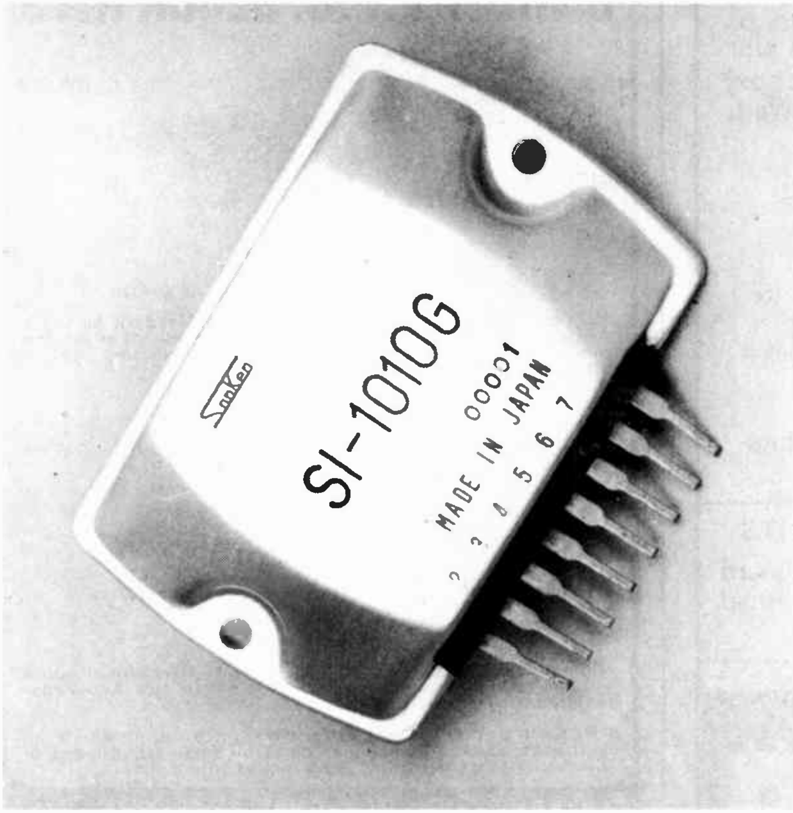
All three kits were assembled by two relatively inexperienced people both of whom reported no difficulties. The finished projects looked good and worked well. They are of very high quality and have features that few other suppliers even begin to approach and yet they are still competitively priced.

Apart from supplying the kits, or in fact any individual parts of a kit (such as metalwork), Applied Technology offer a back-up service which ensures that a constructor who has difficulties can obtain assistance for a small service fee. Applied Technology obviously intend to build their business on a basis of quality and service. We thoroughly recommend their products. ●





ETI 420 UPDATED



The new 10 watt power module.

New printed circuit layout enables latest modules to be used in four-channel amplifier.

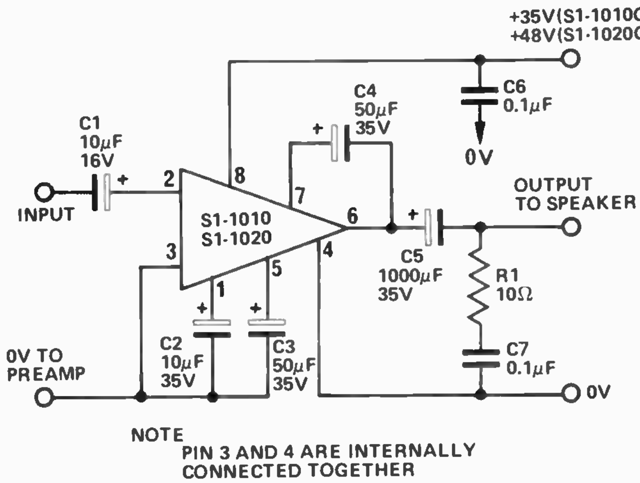


Fig. 1. Circuit diagram of the power-amplifier module.

WHEN designing our simple 25 watt amplifier, ETI 440, we used discrete transistors in the output stage rather than one of the readily available hybrid power modules that are inexpensive and easy to use. The main reason for this decision was that we have been caught in the past by manufacturers who update their modules by bringing out new versions which are not pin-for-pin replacements. This happened on the ETI 416 and, as a result, readers who built that amplifier could not obtain a replacement module if needed.

The same thing has happened to our ETI 420 four-channel amplifier. The Sanken SI-1010 Y is no longer available and the replacement module, the Sanken SI-1010 G, is not a pin-for-pin replacement.

For those readers who need to replace this module we have designed a new printed-circuit board which is the same size as the original board and, may be used to replace it directly. The new power module does not have the facility to alter the gain, as did the original, between front and rear channels and the rear volume control will need to be set higher for the same relative volume. There should however still be ample volume available.

One advantage with the new series modules is that the 20 watt version (SI-1020 G) has identical requirements except that it needs a higher supply voltage. Therefore by simply changing the power transformer and a few components in the power supply the amplifier may be uprated to 20 watts per channel.

For constructional details and wiring information please refer to the original article in Electronics Today International January 1973 or Audio Projects, Volume 1.

PARTS LIST — ETI 420G

R1	Resistor	10 Ω ½ W 5%
C1	Capacitor	10 μF 16 V electro
C2	"	10 μF 35 V "
C3,4	"	50 μF 35 V "
C5	"	1000 μF 35 V "
C6,7	"	0.1 μF polyester

Hybrid Module SI-1010G (10 watt) or SI-1020G (20 watt)*

Two off all above components
PC Board ETI-420G

*Power supply must be changed if 20 watt module is used — see text.

CHANGES TO POWER SUPPLY FOR 20 WATTS

Transformer	A & R 5755 (40 V at 2 A) should be suitable for domestic use.
R3	should be 1k 2 watt (2 x 470 ohm in series)
R4	should be 3.9 k ½ watt
C1 and C2	must be 65 volt working
D1 to D4	should be A15A

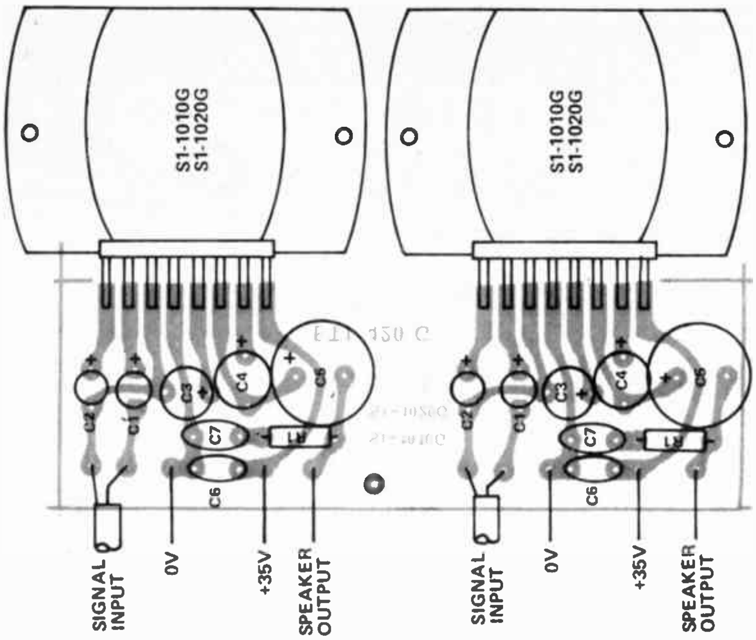


Fig. 2. Component overlay.

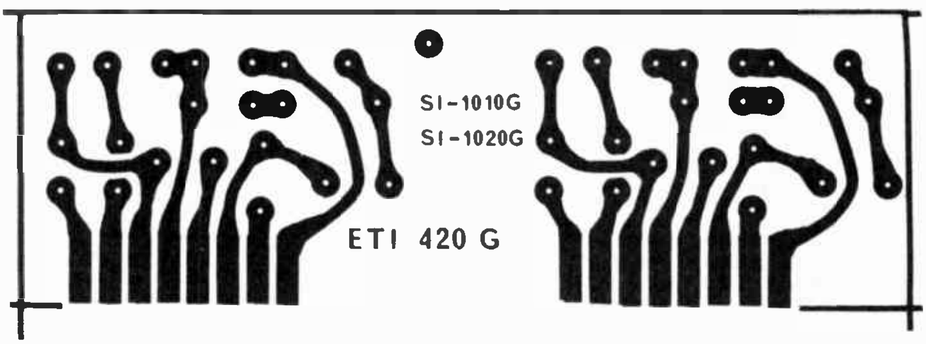


Fig. 3. Printed-circuit board layout. Full size 118 x 38 mm.

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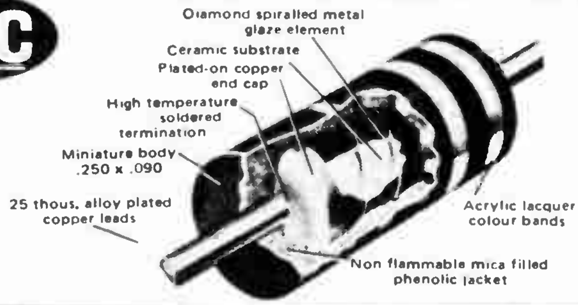

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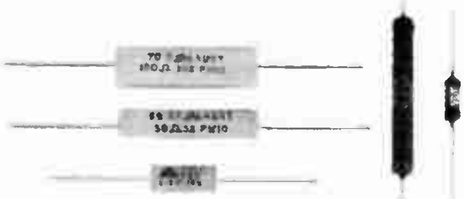

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ELECTRONICS —it's easy! PART 25

Digital displays — historical development and forms

THE HUMAN operator of a piece of digital equipment often needs to know the results of a measurement or to monitor progress in a process etc. The most effective way of conveying the required information is by means of a visual display. The display must provide the information in a readily understandable form — that is, in the decimal numbers, alphabetic characters and symbols (such as pi, decimal point, plus and minus signs etc) of common visual experience.

Everyone will be familiar with common examples of digital display such as the now ubiquitous calculator, digital clock radios and cash registers etc. As the amount of information to be displayed increases we find much more complex displays, such as CRT terminals, which can not only display a full page of alpha-numeric information but can generate graphical data and line drawings.

In this section we will study the various types of device that are used to generate the displays of calculators, digital multimeters and similar instruments.

Decoding techniques used to convert those numbers held within the system (in the binary or binary-coded-decimal form) into decimal numbers and alphabetical characters are discussed in the next section. Displays are dealt with first because their requirements partly dictate the decoding techniques that must be employed.

HISTORICAL DEVELOPMENT

Originally the display of the digital numbers held within the circuitry was performed using single lamps for each binary bit position in the counter or register of interest. A light ON represented a 1 and OFF a 0. Occasionally this may suffice where binary readout is needed but the inconvenience experienced where decimal display is really needed overwhelms the relatively small additional cost required to convert the binary code to its decimal equivalent.

Decimal displays using several quite different means were developed. An obvious starter was the columnar method which used ten individual lamps placed in a vertical column behind graticules of the figures 0-9. The decimal number being displayed showed up as a single value in each decade digit position. The non-illuminated numbers do not show if a suitable contrast graticule is used. This technique was certainly better than a pure binary-display and many instrument systems of the late 50's and early 60's used this method. A considerably reduced peak power-supply demand results with decimal displays as only one lamp in each decade needs power at any time. Disadvantages of the columnar display were the sheer mechanics of arranging numerous light-globe holders on a panel (Miniature Edison Screw MES lamps were used), the non-aligned number appearance which was awkward, and the character size that had to be small to keep the panel within reasonable proportions.

To overcome size and alignment difficulties a number of manufacturers marketed ingenious opto-mechanical modules. One method used a moving-coil meter movement to rotate a graticule, containing the 0-9 numbers, inside a projection system. The filament lamp illuminated the rear of the projection screen to make a quite large number appear at the front. In this way numbers were generated at the same position giving a visually well-proportioned multidigit decimal number. A sketch of this method is shown in Fig.2. Watching such a display is somewhat disconcerting, for the individual numbers wobble into position with changing values. Another method used ten individual-lamp projection systems each with its image plane set on the same viewing location on the rear of a screen. Provided only one lamp was energized at a time the number was easily read.

Projection systems were, by today's standards, delicate, costly and far from ideal. Their continued use and acceptance occurred mainly because they did not require high voltage levels to operate them. Voltage-wise they were quite compatible with early solid-state circuitry although considerable current gain was needed between the counter circuitry — the flip-flops — and the lamp.

NEON INDICATOR TUBES

In parallel development were indicating display tubes based on the principle of the neon tube. These have become universally known as "Nixie" tubes, a name really applicable only to tubes of Burrough's origin. As these are still designed into new equipment today — projection devices are seldom used now — we will study how they operate in some detail.

The basic neon lamp has two electrodes, see Fig.3a, passing into the interior of a glass envelope filled with neon gas. With a low voltage difference applied between the electrodes the gas acts as an insulator and no current flows between the electrodes. At around 70 V the gas conducts producing a red glow on the wires. If the voltage rises above this value the neon continues to glow; if it falls below, the discharge extinguishes. As there is no concept of rectification in this double electrode system the neon will light with ac or dc excitation of

Fig. 1. This typical digital multimeter uses a neon-indicator tube display.

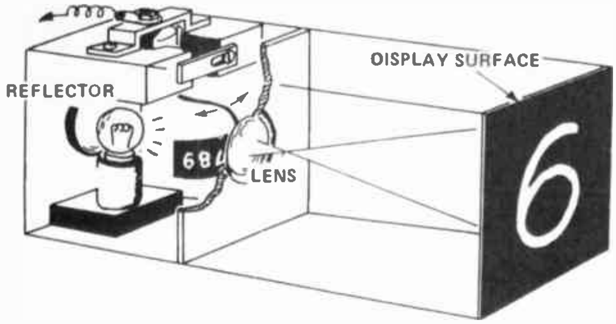


Fig.2. The moving-coil numerical character display is based on an optical projection system. The numbers are on a graticule which is rotated behind a lens by a meter-like movement.

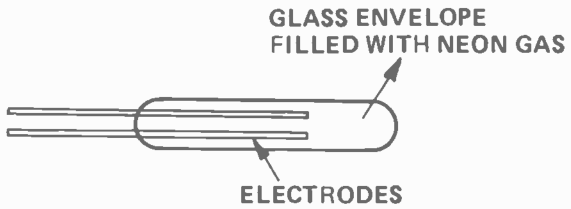
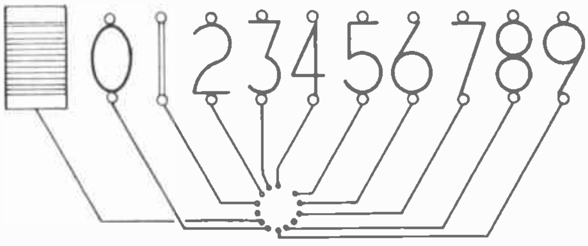


Fig. 3a. Construction of the basic neon lamp. b. How a multi-digit neon indicator is constructed from an anode grid and ten separate character-shaped cathodes.



sufficiently high voltage magnitude. Single neon indicators are used extensively for "mains-on" indication in instruments, power points and appliances, in which case a series resistor is added to obtain operation at 240 V.

The neon-indicator tube, developed from the basic neon lamp, incorporates 10 cathodes (when numbers are to be generated; letters and other symbols are available) one for each 0-9 number, which are stacked on top of each other behind a fine mesh. Each is insulated from the others and has a connection lead brought out through the glass envelope as shown in Fig.3b. The mesh acts as a common anode electrode for whichever cathode is selected. The tube displays just one of its number set. Non-energized grids remain dark and are unseen because they do not glow.

Numerical neon-indicator tubes are made such that the numbers appear either at the side of the glass cylinder or at the end. Character sizes ranging from 10 to 50 mm are available. This form of display has remained popular for reasons of the very acceptable readability, nicely shaped character format and low-costs. They require a relatively high voltage supply (180 Vdc is typical) and are not as robust as the solid-state devices described later.

The format and connections of a typical neon-indicator tube are illustrated in Fig.4. Note that only one input drive signal is required to energize any particular display character. The majority of all other displays in use require several inputs to be energized in order to produce the desired character. We will see later, however, that the amount of decoding circuitry needed for neon-indicator systems and the solid-state alternatives is similar.

It is possible to construct neon-indicators needing lower input — command voltages. In the Mullard Digitube, for example, the discharge remains on continuously. The trigger voltage, a 5 V level change, causes the discharge to transfer from an out-of-sight cathode to a visible one. This single-bit principle has been applied to a 10 step unit in, which individual separate numbers are illuminated as needed. This form of neon display has not become popular, probably because the numbers are arranged in a circle, giving small numerals which do not line up when several displays are used to form a multi-digit decimal number. (One early variety produced a dot glowing at the side of the numbers printed around a circle).

Neon-indicators radiate red light, which (more by chance than design) happens to be at a wavelength of reasonable sensitivity to the eye. Red is particularly suited to strong ambient daylight viewing.

MULTI-SEGMENT FORMATS

Each of the above displays uses characters generated by the application of a single signal that provides the character complete. This is said to be of simple format. An alternative method is to produce the character from individual segments or dots arranged to build-up the shape needed.

After the very active development period of the 60's designers and suppliers are now settling on the use of seven-segments, hexa-decimal 7 by 4 dot and 7 by 5 dot matrix formats.

Seven-segment format — This is the simplest and most used composite matrix method. It consists of seven equal-size bars placed to form the 0 through to 9 series of numbers. Several distinct alphabetical characters and a

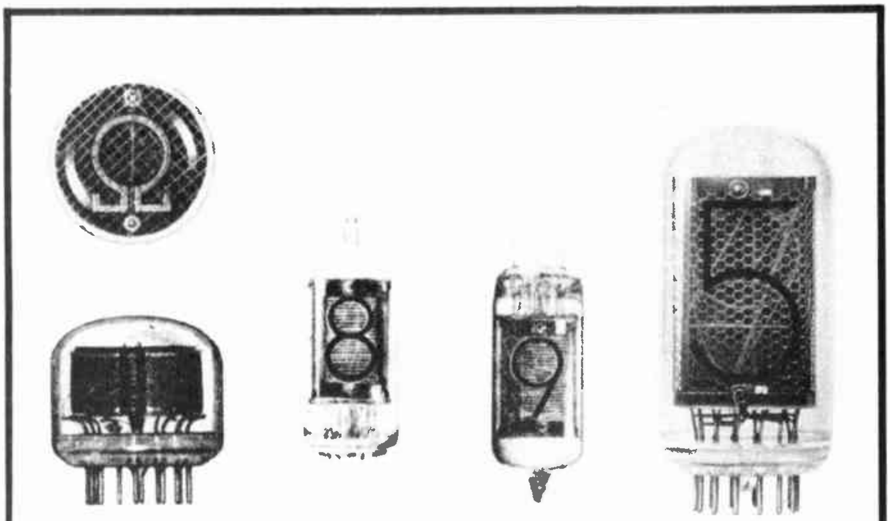


Fig.4. Different types of neon display.

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minus sign are also possible. The appearance of seven-segment numbers and letters is as shown in Fig.5. This system is based upon a stylised figure of eight. Of particular note is the requirement that the individual characters are generated with different combinations of bars being illuminated.

Methods for illuminating a bar include separate filaments for each, separate incandescent bulbs, luminescent phosphors lit by filaments, light-emitting diodes (LEDs) and liquid crystal indicators – more of these later.

Hexadecimal format – these rely on the formation of a character by illumination of the necessary dots (or small squares) of a 4 by 7 dot matrix. Figure 6 gives the appearance of number characters generated this way. Note again the need to energize selected positions to provide the required character.

Alpha-numeric matrix format – the above 7 by 4 matrix is limited in that whilst it can generate all numbers, it cannot provide all 26 alphabetic characters. If the matrix size is increased to 7 by 5 the full 36 alpha-numeric characters can be generated. Figure 7 gives the characters of the American Standard Code for Information Interface ASC11.

SOLID-STATE DISPLAYS

Incandescent lamps are very inefficient at converting electrical energy into radiant visible energy – conversion is generally only around 20-30 lumens per watt. Neon-indicators consume less power in general and deliver a brighter output but do require a high voltage that is not directly compatible with the new standard 0-5 dc TTL signal levels. The life and robustness of both filament lamps and neon devices is also far from ideal. The breakthrough came several years ago when light-emitting diodes (LEDs) were developed.

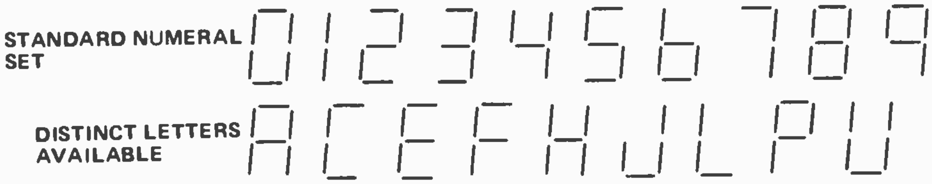


Fig. 5. Format of seven-segment numeric and alphabetic characteristics.

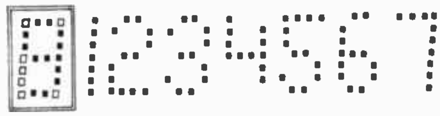


Fig. 6. Typical format of characters of the hexadecimal system using a 4 by 7 dot matrix.

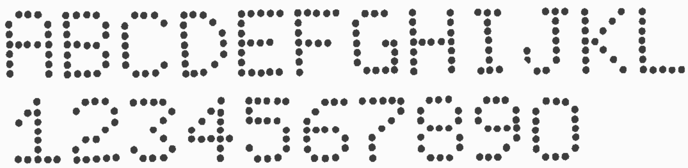


Fig. 7. Alpha-numeric characters as generated by 5 x 7 dot matrix.

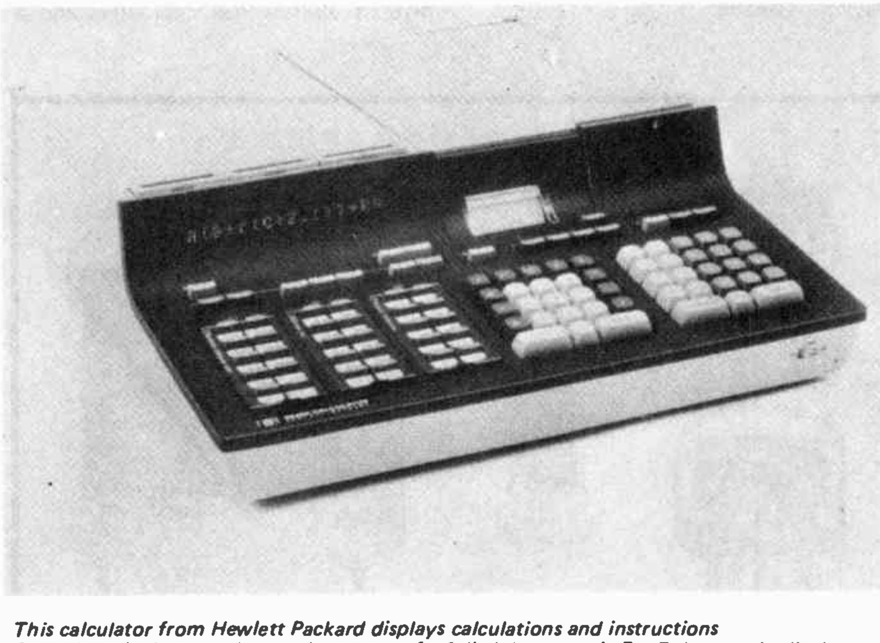
Light Emitting Diodes – LEDs are semiconductor junctions (formed by the same processes used to make solid-state signal diodes) which emit radiation from the junction when current is passed through it. The basic materials used are gallium arsenide phosphide GaAsP and gallium phosphide GAP.

This form of light source generates relatively narrow wavelength energy centred on red yellow or green colours. (Typically 635 mm, 583 mm and 565 mm wavelength respectively) with high luminous efficacies of 140, 460 and 610 lumens per watt. Compare these efficacies against that for a typical tungsten filament lamp of 20 lumens per watt. The term efficacy should not be confused with efficiency. Efficiency is the percentage of radiant power compared to input power whereas efficacy refers to the effectiveness of the *radiant* power produced in stimulating the eye. For example an LED producing infra-red radiation will have an efficiency of say 3% but an efficacy of zero.

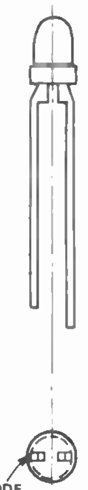
The high efficacy of LEDs means reduced power supply requirements, and high visibility is obtained even when LEDs are driven via a resistor directly from TTL.

Another feature of LED sources is the high speed of response – 100 ns is typical. The operating voltage is nominally 2 V and current requirement varies around 20 mA.

Single and multiple format LED displays are now available in a wide variety of forms and they are the most



This calculator from Hewlett Packard displays calculations and instructions from the calculator to the user by means of a full alpha-numeric 5 x 7 dot matrix display.



CATHODE

Fig.8a

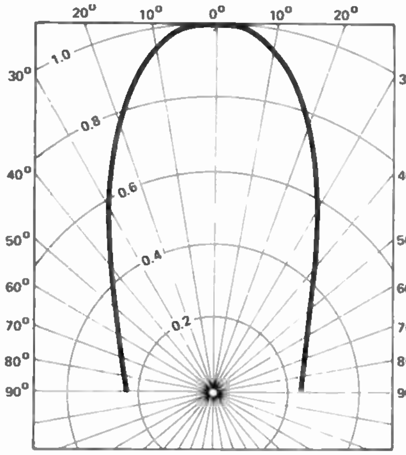


Fig.8b

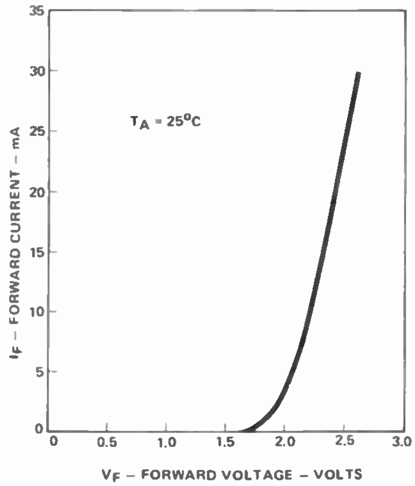


Fig.8c

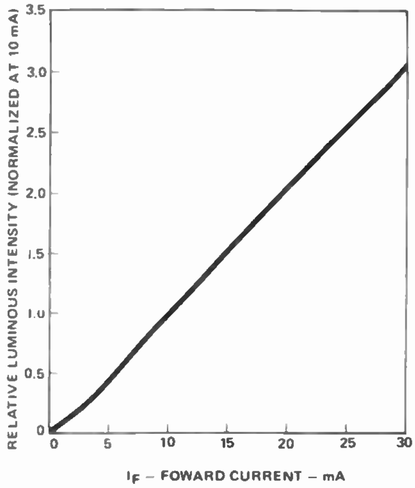


Fig.8d

Fig.8e

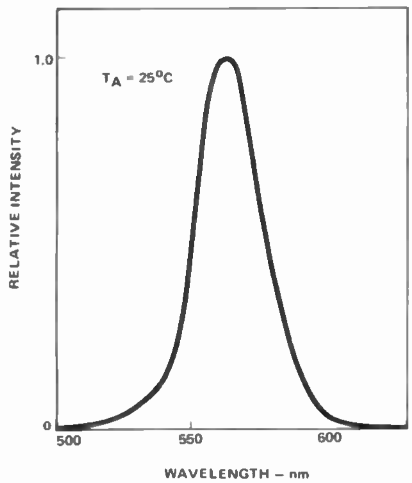


Fig.8f

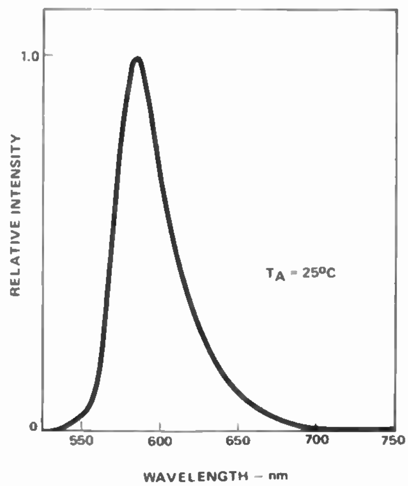


Fig.8g

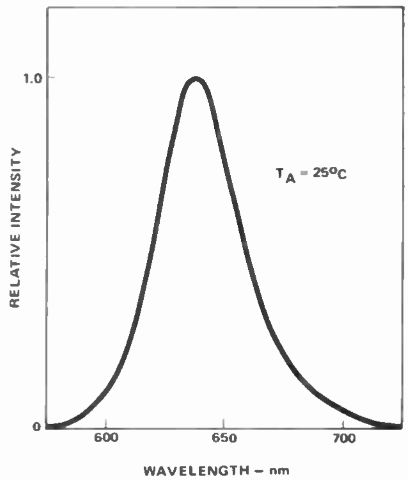
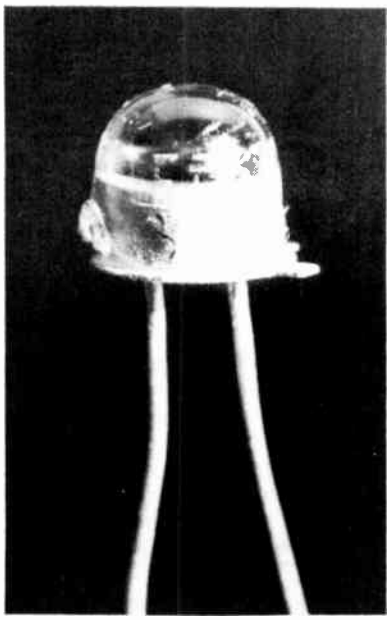
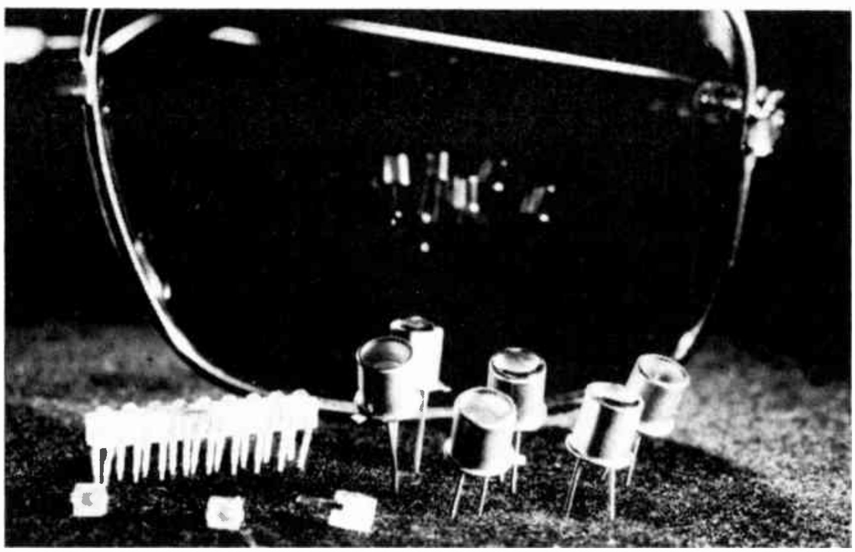


Fig. 8. Characteristics of the HP 5082 mini-LED series lamps.
(a) the shape of the lamp; (b) relative luminous intensity versus beam angle; (c) Forward current versus forward voltage.
(e) Intensity versus wavelength of green lamp; (f) Intensity versus wavelength of yellow lamp; (g) Intensity versus wavelength of red lamp.



◀ *A typical LED indicator lamp.*

An array of 10 light emitting diodes as used for paper tape reading.



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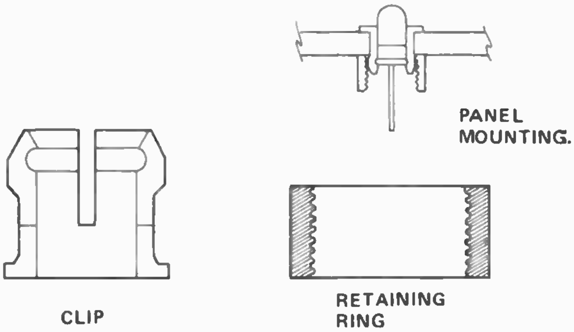


Fig. 9. LED lamps such as this may be mounted directly onto a PC board or onto a front panel by means of the clear plastic clip.

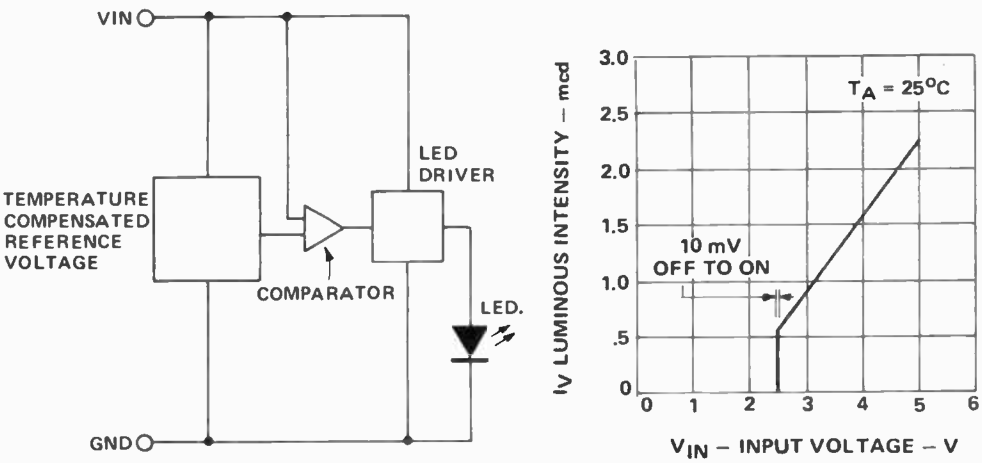
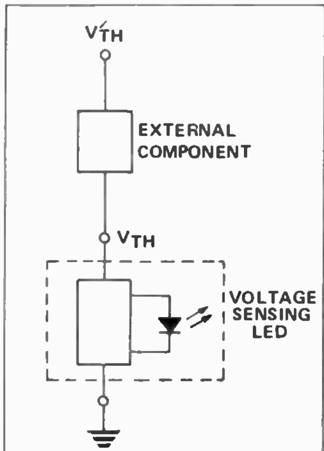


Fig. 10. LEDs with integrated voltage sensing amplifiers turn on when the applied voltage exceeds a built-in value.
LEFT: schematic. RIGHT: luminous intensity versus input voltage. BELOW: ways of increasing threshold voltage.



EXTERNAL COMPONENT	V'_{TH}	$TC = \frac{\Delta V'_{TH}}{\Delta T_A}$ (mV/°C)
SCHOTTKY DIODE (HP 5082 – 2835) V'_{TH} V_{TH}	V_{TH} + 0.45V	–2
P – N DIODE (1N914) V'_{TH} V_{TH}	V_{TH} + 0.75V	– 2.5
LED V'_{TH} V_{TH}	V_{TH} + 1.6V	– 2.9
ZENER DIODE + – V'_{TH} V_{TH}	V_{TH} + V_Z	–1 + ZENER TC
R SERIES RESISTOR V'_{TH} V_{TH}	V_{TH} + $I_{TH}R$ NOTE 1.	NOTE 2.

NOTES: 1. I_{TH} IS THE MAXIMUM CURRENT JUST BELOW THE THRESHOLD, V_{TH}. SINCE BOTH I_{TH} AND V_{TH} ARE VARIABLE, A PRECISE VALUE OF V'_{TH} IS OBTAINABLE ONLY BY SELECTING R TO FIT THE MEASURED CHARACTERISTICS OF THE INDIVIDUAL DEVICES (E.G., WITH CURVE TRACER).
2. THE TEMPERATURE COEFFICIENT (TC) WILL BE A FUNCTION OF THE RESISTOR TC AND THE VALUE OF THE RESISTOR.

used display medium. Figure 8 gives the various data of a typical unit. Figure 9 shows how a single lamp can be mounted in practice.

Developments arising out of the basic single LED lamps are units incorporating an integrated resistor (for direct TTL connection) those having an integrated voltage sensing amplifier (Fig.10) which provides a lamp that triggers on or off as the input level passes up or down through a 2.5 V level and the opto-electronic relay or isolator discussed in a previous section. Hermetically sealed units and military approved units that will operate from -65°C to +100°C with very high reliability over a life measured in years of operation are also available.

Given a matrix of LED lamps it is quite practicable to generate numbers and characters by what is called an addressable system in which decoding logic decides the diodes to be illuminated. LED character displays are marketed as single unit 7 segment modules and as 4 by 7 and 5 by 7 dot matrices. Integration has gone as far as incorporating a complete decade counter stage (Fig. 11), with the necessary decoders, buffer amplifiers and LED display all integrated on a single LSI unit. As LED manufacturing techniques are the same as conventional integration methods it is possible where large quantity production is economic, to integrate the display with the circuitry – examples are to be found in some styles of IC wristwatch.

Seven segment LED displays have the eight diodes placed on a common transparent GaP substrate. (The eighth diode provides a decimal point). A typical single unit is shown in Fig.12 – they are available in red, yellow and green colours. The 7.6 mm letter size is visible at 3 m; a larger 11.0 mm size can be readily seen at 6 m. Another series, shown in Fig.13 includes an integral optical magnification technique that provides improved readability for low drive power (1 mW per segment). These are available as 3, 4 and 5 character units which are mechanically compatible with standard printed-circuit board hole spacings.

To meet the demand for portable calculators manufacturers also supply special units with 8 or 9 digits mounted on a small plug-in printed-circuit board.

The range of dot generated character displays is also extensive. A 39 mm high character is available that can be read from 20 m. This, as can be seen in Fig.14, is based upon a large size

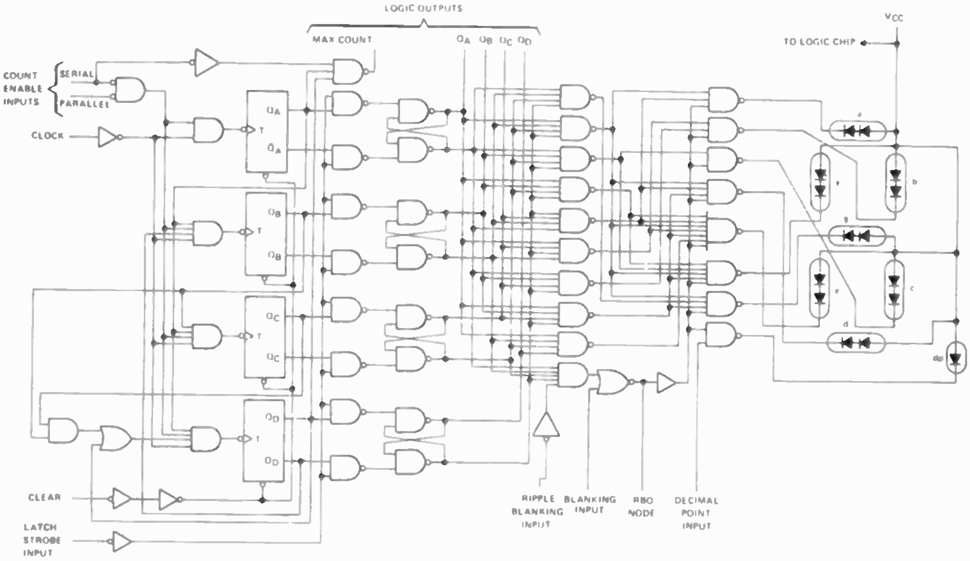
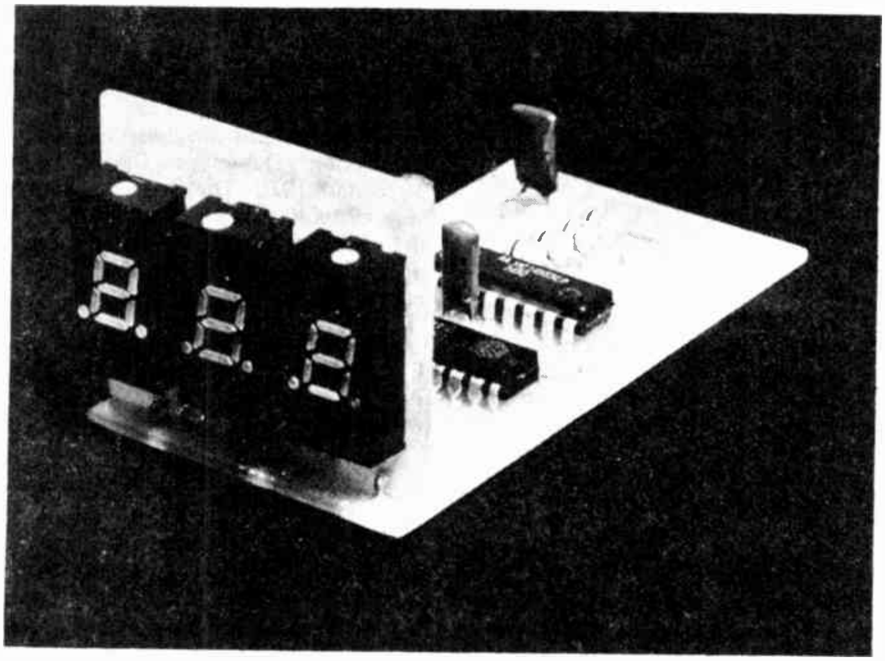
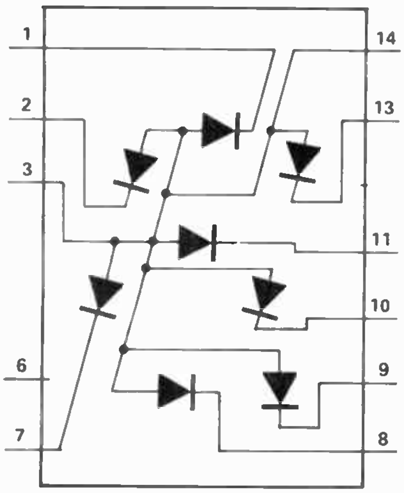


Fig. 11. The Texas Instruments TIL306 display integrates all the logic of a complete decade counter onto the same chip as a 7-segment display. The circuit shown is the schematic of the device.





'Fig. 12. (a) Three seven-segment LED (DL704) displays mounted on a common PC board. (b) Internal diode positions for a right-hand decimal point seven-segment display module.

5 by 7 dot matrix and includes the decoder/driver unit for the most commonly used BCD code — the 8421-logic input (decoders are discussed in the next part). Dot matrix displays with characters as large as 45 cm height are produced. These, however, are not usually solid-state but use electromagnetic drives to rotate reflective dots into or out of the viewing aperture. Such units, given adequate ambient light, are visible at 300 . m. Multi-digit dot matrix solid-state displays are also made.

Liquid Crystal Displays. Although LED displays consume little power compared with earlier filament displays very little of the power used is actually transmitted as radiant energy. Efficiencies of visible diodes are typically only 0.1%! Thus an LED display often consumes considerably more supply power than the rest of the associated digital system. Indicators of all types, except liquid crystal, require about 300 to 500 mW per character (all segments illuminated).

The power requirements of the display could be reduced considerably if the circuit could switch available ambient light rather than actually generate light. Naturally such a method will only work when ambient light is available.

In the dark, displays which generate radiation would still be required. Displays are available which do switch ambient light. They are known as liquid crystal displays and by virtue of their mode of operation consume very little power.

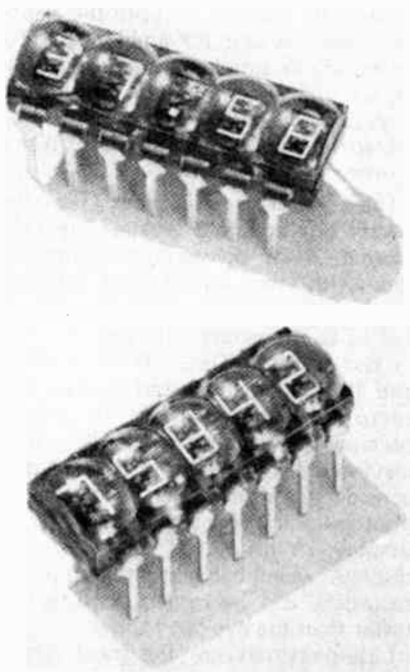


Fig. 13. Some seven-segment displays suitable for calculators etc are assembled in groups and have plastic lenses to increase character size.

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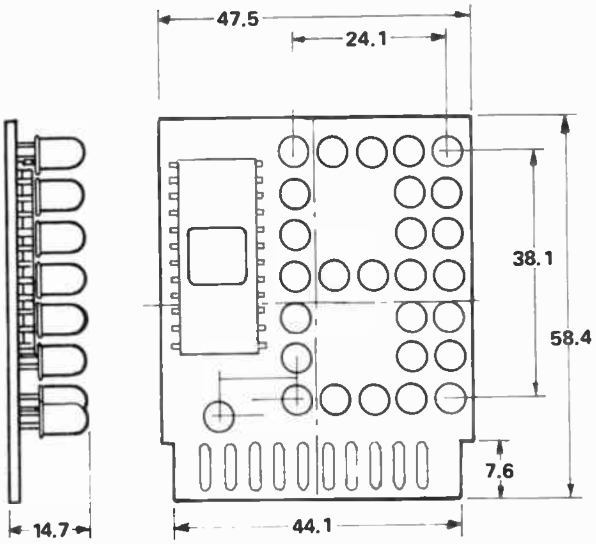

MECHANICAL DETAILS

PIN	FUNCTION
1	V_{CC}
2	DP
3	X1
4	X2
5	X4
6	X8
7	GROUND
8	NC
9	NC
10	V_{LED}

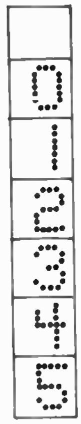

Fig. 14. A large size (38 mm character) alpha-numeric display constructed from discrete LEDs and a decoder/driver IC. (HP5082-7500).

FORMAT

Basically liquid crystal displays consists of a minutely thin layer of liquid-crystal material placed within two thin glass covers. The glass covers have transparent electrodes deposited on them in the shape of the characters or segment needed. This is shown in Fig.15a. With no excitation the whole unit appears transparent, for the liquid crystals remain stationary allowing light to pass through virtually unattenuated, that is, no light is reflected. When an alternating voltage (40-1000 Hz) is applied to the electrodes forming the character shapes, the resultant electric field causes the liquid layer to become turbulent, scattering light between the confines of the deposited areas. The display then shows an optically dense character because the ambient light is reflected. In simple terms application of an input signal causes the liquid crystal in the vicinity of the transparent electrodes to act like a mirror.

The power requirement for the circuit driving liquid crystal displays is around 20µW per segment (compare this with the lowest 100 µW per segment but more usually 20 000 µW for LED characters). Response is not as fast as for LEDs — 20 ms rise-time and 100 ms fall-time, but that is not a serious shortcoming in visual observation applications. In some instances faster response is needed — consider, for example, the use of photographic recording of a character display. With LED displays the display, when being photographically recorded, can be cycled considerably faster than the eye can follow.

Liquid-crystals are the most recent solid-state display to be developed and it is still too early to state with certainty if they will eventually compete seriously with LED techniques. At present the life of the display is inferior to LED units. Although manufacturers quote 10 000 hours minimum life (just over a year) experience has shown that units often fail after only a 1000 hours.

Seven segment displays are also made using neon lamps, self contained filaments and separate incandescent bulbs. It is to be expected that these will not be in use in new designs of the future for the price alone of solid-state devices will usually undercut the available alternatives.

Regardless of the display used it is necessary to decode the binary logic of digital circuits into a code suited to illuminate the required number and combination of characters in the system used. The next section will look at the schemes used and at more efficient methods of driving multiple character displays.

YOUR LIBRARY

The use of solid-state displays is straight-forward in simple applications. In each case, however, design information is vital to ensure that the displays are used within ratings. Advanced display design has become a high-level art and generally Application Notes are the essential guide to their successful use.

Hewlett-Packard produced an "Opto Electronics Designer's Catalog" in 1973 and 1975. The former included several applications notes, the latter a list of the range of relevant application notes now available from HP: both contain a wealth of practical data.

"Digital display systems", written by E.G. Breeze and available as Fairchild Application note 212/1, 1972 is also worthwhile having.

Many other manufacturers — Texas Instruments, RCA, National, Hawker Siddeley Electronics, Monsanto, Mullard, Atron, Litronix, Siemens — also provide service data that gives practical advice on how to use their display products to best effects. ●

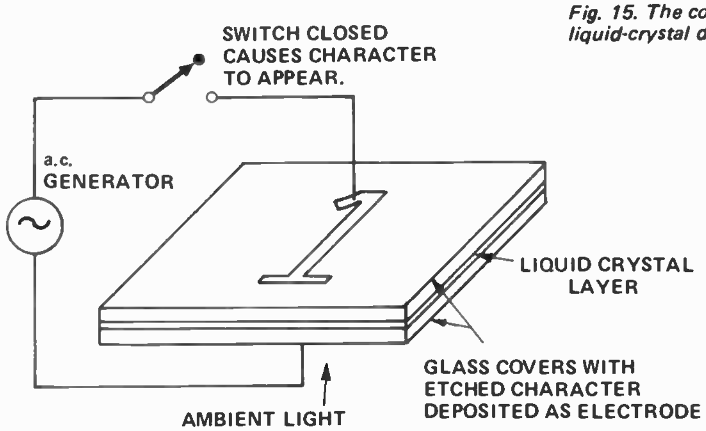

Fig. 15. The construction of a liquid-crystal display.

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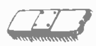

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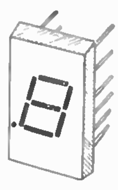

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The RCA DR-2010 Numitron display tube supplied with this kit is an incandescent seven-segment display tube. The .6" high number can be read at a distance of thirty feet. RCA specs. provide a minimum life for this tube of 100,000 hours (about 11 years of normal use).

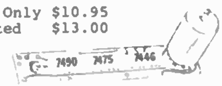
A 7490 decade counter IC is used to give typical count rates of up to thirty MHz. A 7475 is used to store the BCD information during the counting period to ensure a non-blinking display. Stored BCD data from the 7475 is decoded using a 7447 seven-segment decoder driver. The 7447 accomplishes blanking of leading edge zeroes, and has a lamp test input which causes all seven segments of the display tube to light.

Kit includes a two-sided (with plated through holes) fibreglass printed circuit board, three IC's, DR-2010 (with decimal point) display tube, and enough Molex socket pins for the IC's.

Circuit board is .8" wide and 4 3/8" long. A single 5-volt power source powers both the IC's and the display tube.

CD-2 Kit Complete Only $10.95
Assembled and Tested $13.00

Board Only $2.50



RCA DR2010 NUMITRON

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

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COUNTER DISPLAY KIT—CD-3

This kit is similar to the CD-2 except for the following:

a. Does not include the 7475 quad latch storage feature.
b. Board is the same width but is 1" shorter.
c. Five additional passive components are provided, which permit the user to program the count to any number from two to ten. Two kits may be interconnected to count to any number 2-99, three kits 2-999, etc.
d. Complete instructions are provided to pre-set the modulus for your application.

CD-3 Board Only $2.25
IC's, 7490, 7447 $2.75
RCA DR2010 tube $5.00

Complete kit includes all of the above plus 5 programming parts, instructions, and Molex pins for IC's. Only $9.25

LM309K: 5-VOLT REGULATOR

This TO-3 device is a complete regulator on a chip. The 309 is virtually blowout proof. It is designed to shut itself off with overload of current drain or over temperature operation. Input voltage (DC) can range from 10 to 30 volts, and the output will be five volts (tolerance is worse case TTL requirement) at current of up to one ampere.

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Babylon Electronics Inc.

Post Office Box J, Carmichael, California. 95 608 U.S.A.

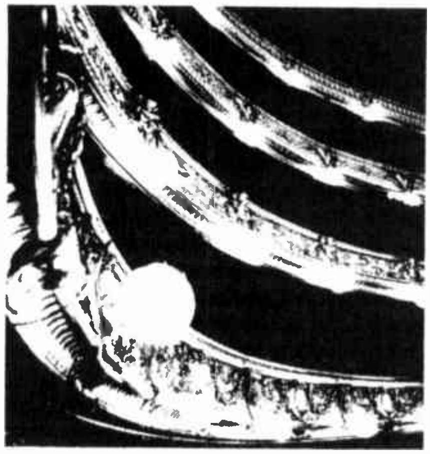
'The AR-6 is just about the finest inexpensive speaker one could hope to encounter.

At Acoustic Research our first aim is to produce the most accurate speakers we can make, regardless of size or cost. The only limiting factors are the state of the art and our own engineering skill.

Low-cost loudspeakers
We have also designed speakers in which price was a consideration. But the performance standard has remained the same – the natural reproduction of music without exaggeration or artificiality of sound. And in designing the lower-cost AR speakers, it has been our aim to choose those compromises with cost that would have the least effect on the accuracy of sound reproduction.

This approach has resulted in a number of speakers in various price ranges whose performance often comes surprisingly close to that of the most expensive AR speakers.

The AR-6
One such speaker is the AR-6, which *Stereo Review* described this way:
'It is noteworthy that the bass response measured for the AR-6 was almost identical to that we measured for the AR-5 . . . This is exceptional performance for a speaker of this size and price . . . As we have mentioned, the AR-6's polar response was very good . . . quite similar to that of the more expensive AR speaker system

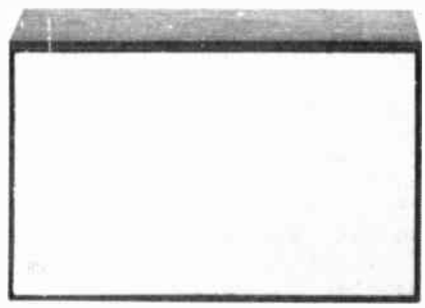


'All in all, the AR-6 acquitted itself very well in our tests. It was not quite the equal of the much more expensive AR models, whose sound it nevertheless resembles to an amazing degree, but on the other hand it out-performed a number of considerably larger and far more expensive systems we have tested in the same way. We don't know of many speakers with as good a balance in overall response, and nothing in its size or price class has as good a bass end.'

Musical realism
High Fidelity magazine characterized the AR-6 as 'another great bookshelf speaker from AR . . . a really terrific performer. The AR-6 has a clean, uncolored, well-balanced response that delivers some of the most natural musical sound yet heard from anything in its size/price class, and which indeed rivals that heard from some speakers costing significantly more.'

Our headline, quoted from Robert C. Marsh, writing in the *Chicago Sun-Times*, summarizes these observations. A low-cost speaker system that embodies so many of the performance characteristics of more expensive speakers would obviously provide exceptional value.

And, as with all AR speakers, the performance characteristics of the AR-6 are guaranteed for five years.



The AR-6: 'The finest inexpensive speaker one could hope to encounter'.

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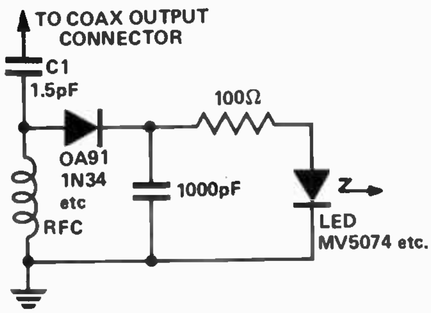
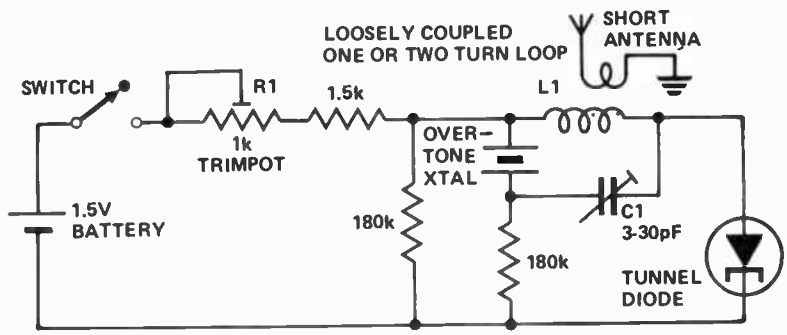
IDEAS FOR EXPERIMENTERS

LED RF INDICATOR



An RF output indicator using a LED is very useful for monitoring the output of a transmitter. This circuit will give indication from a 5 W transmitter. The capacitor C1 and the RFC are chosen for the appropriate frequency. The RFC could be replaced by a resistor for wideband use. The sensitivity depends on the value of C1 and the resistor used if the RFC is replaced. For high power transmitters, C1 could be a small 'gimmick" capacitor.

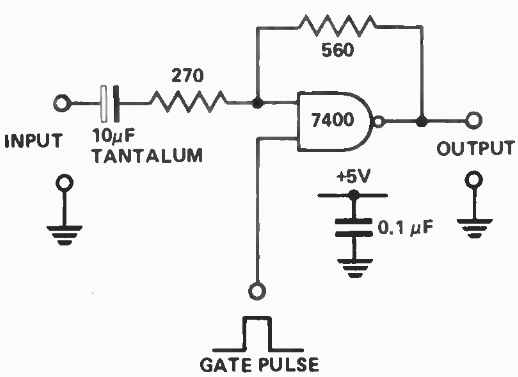
LOW CONSUMPTION VHF WEAK-SIGNAL SOURCE



A tunnel diode oscillator makes an excellent low consumption VHF weak signal source. The above circuit consumes under 1 mA from the single 1.5 V battery and provides a useable weak signal 10 m to 20 m away from a VHF receiver antenna.

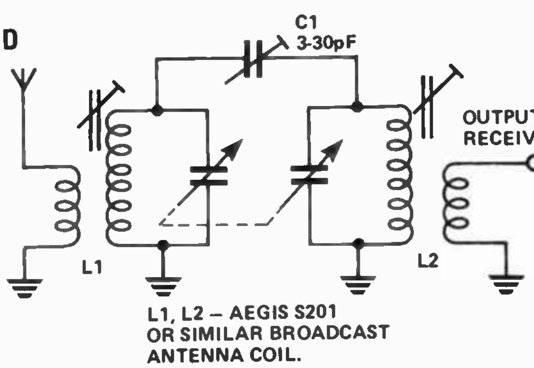
The tuned circuit L1/C1 should resonate at the crystal overtone frequency. Cl can be used to trim the crystal exactly to frequency. Almost any tunnel diode will operate in this circuit, the one used was a GE. LT1038. The low consumption allows for extended testing periods or as a personal 'beacon'. Harmonic output can be increased by increasing the bias current.

WIDEBAND GATED AMPLIFIER



A 7400 Nand-gate can be biased into the linear region as shown above and works well as a low gain amplifier with a gain of about two (i.e. 6 dB) between approx. 100 Hz and 10 MHz. A TTL logic pulse applied to the unused gate can be used to gate the output on and off. The quiescent supply current to the gate should be between 18 and 20 mA.

BROADCAST BAND PRESELECTOR



When chasing distant broadcast band stations, some front-end selectivity helps in sorting out the stations. This circuit is very simple and markedly improves the selectivity of the front end of any broadcast band receiver.

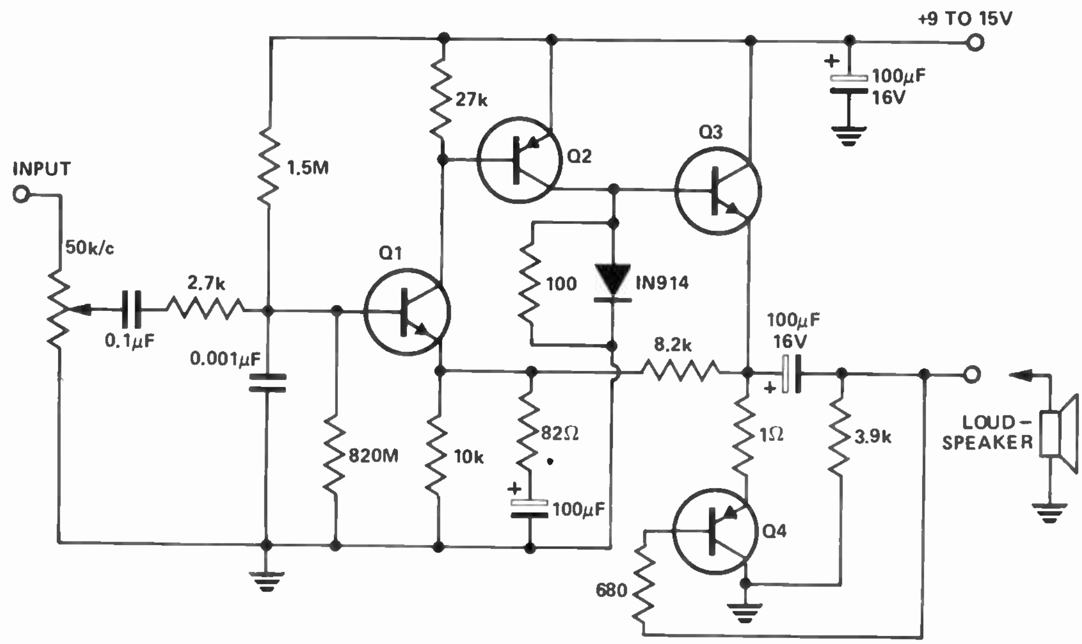
The trimmer C1 is a selectivity adjustment. At maximum capacity the selectivity is broadest. It should be adjusted to suit the particular situation. The tuning gang is a standard broadcast gang of either 10 – 380 pF or 10 – 415 pF range. An alternative to L1 and L2 could be two ferrite rod antenna coils salvaged from a transistor radio. They would need to be shielded from each other and enclosed in a shield to avoid extraneous pick-up.

As the name of this section implies, these pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory.

Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we provide constructional details.

Electronics Today is always seeking material for these pages. All published material is paid for – generally at a rate of $5 to $7 per item.

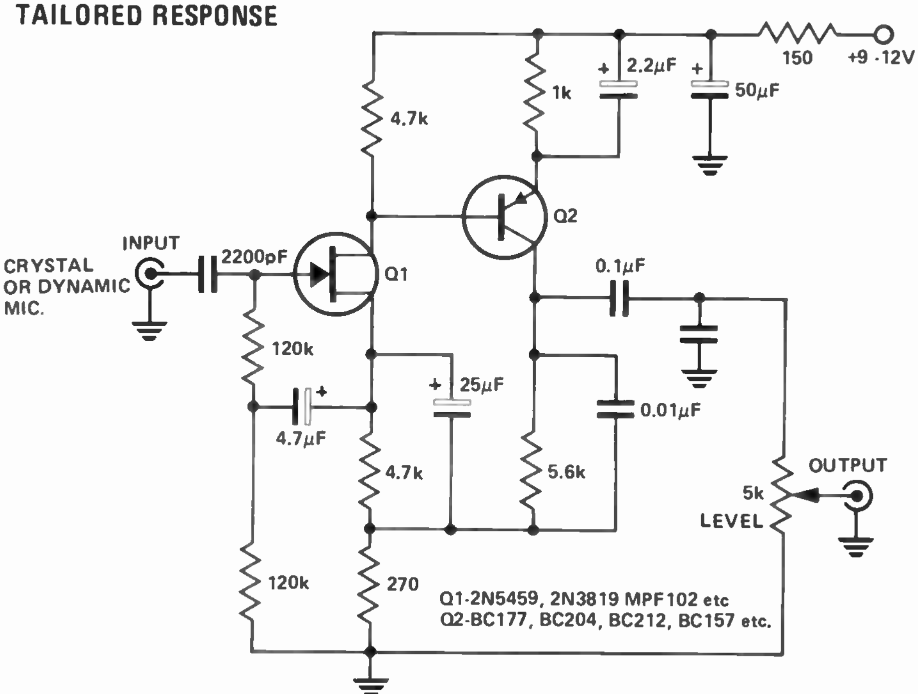
LOW COST AUDIO AMPLIFIER



Q1	Q2	Q3	Q4	
BC107,8,9	2N3638	2N3053	BFY50	CURRENT COST ≈ $1.60 THE PAIR
2N3564,5	2N3644,5	2N3567	BFY51	CURRENT COST ≈ $1.50 THE PAIR
BC547,8,9	BC212,3,4	2N3568	BFY52	
BC182,3,4		2N3643	2N3644	CURRENT COST ≈ $1.00 THE PAIR
AY113				

It is possible to build this simple audio amplifier for under $4 with judicious selection of transistors. This compares favourably with the cost of an equivalent power IC audio amp. Power output is 1 to 2 W depending on the output transistors used, the power supply voltage and speaker impedance. Do not use a 4 ohm speaker. It requires 100 to 200 mV input for full output depending on the gain of Q1. A BC109 or 2N3565 seems to work best here. The bias on Q1 may need to be adjusted for different transistors. The voltage between the emitter of Q3 and ground should be half the supply voltage. The 27 k resistor in the base of Q2 may be varied to set this. It is excellent as a general-purpose audio amp or for a signal tracer or tuner amplifier. A 50 NTC resistor may be substituted for the IN914.

MICROPHONE AMP HAS TAILORED RESPONSE

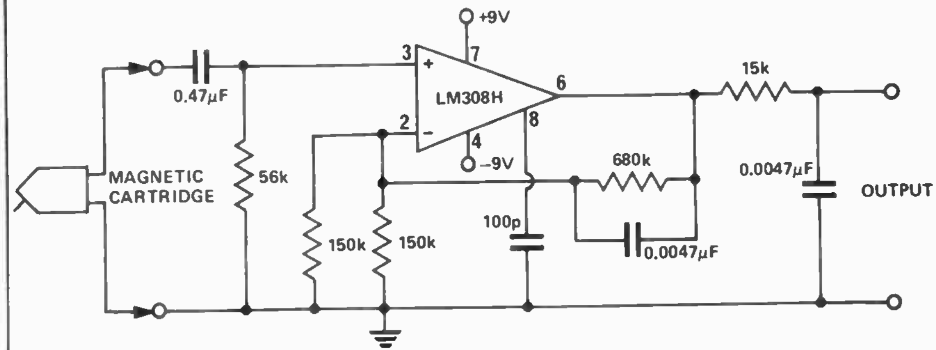


This preamp is suitable for a crystal or dynamic microphone. Its response is tailored so that it rolls off rapidly below 300 Hz and above 2800 Hz, i.e. the speech band. It improves intelligibility in phone transmitters regardless of the type of modulation. Q1 forms a bootstrapped audio amplifier, the imput impedance is several megohms.

The pot is set at midrange initially and the audio generator set at any convenient frequency at a comfortable level. The substitution box is then switched until a coarse null is observed. The pot is then rotated to improve the null. If the pot wiper has to move *towards* the unknown component the unknown value is *smaller* than the value given by the substitution box; conversely, if the pot wiper is away from the unknown component. Keep leads to the unknown component and the substitution box short. The pot can be calibrated with known components if so desired and only a coarse value substitution box is necessary.

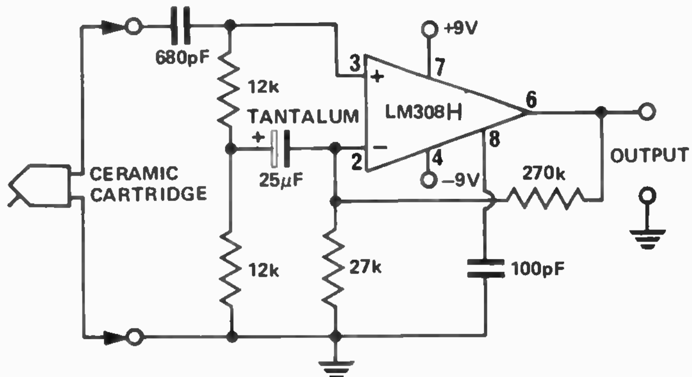
IDEAS FOR EXPERIMENTERS

MAGNETIC CARTRIDGE IC PRE-AMP



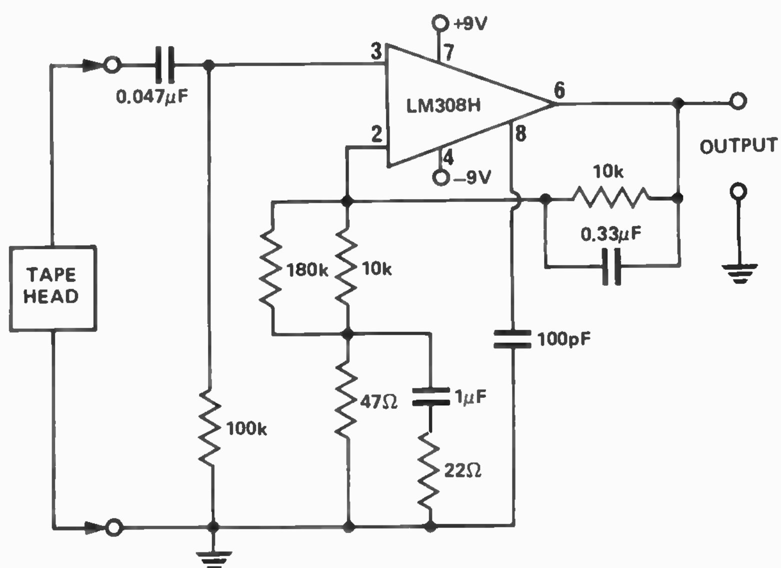
The above circuit provides RIAA equalization for a magnetic pick up over the range 20 Hz to 20 kHz. Distortion at an input of 300 mV is less than .05% up to at least 5 kHz and only about 0.1% at 10 kHz.

CERAMIC CARTRIDGE IC PRE-AMP



The LM 308 low noise op-amp serves well as a preamp for popular high-output ceramic cartridges. The above circuit yields a gain of about 25 dB and has a flat frequency response with a slight peak in the bass region. The above component values provide a proper load to the ceramic cartridge.

IC TAPE-HEAD PRE-AMP



This circuit is suitable for a tape speed of 3.75 inches/sec. and provides a rising gain at low frequencies (about 40 dB below 100 Hz) a minimum gain of about 15 dB around 2-3 kHz and a 6 dB boost (to about 21 dB) above 10 kHz for reasonable compensation. A low noise op-amp is used.

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Tape Questions, Tape Answers. Whether you've just built your own Hi-Fi system, or you're thinking about your first recorder, this is a mine of information. Selecting the right tape, or cassette, sound mixing, microphones, editing and splicing, recorder maintenance, adding sound to film, and more. 120 pages with 100 illustrations and diagrams.

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BA4711

AUDIO FACTS

TWEETER LEVEL CONTROL

A new level control for mid range and tweeter speakers is now available. Realistically priced, the AT-40, distributed by the components division of Plessey Australia Pty Ltd, is an additional item in the company's range of hi-fi accessories.

This type of level control, usually fitted to the front or rear of the speaker enclosure, allows for greater flexibility and selection of performance in establishing a hi-fi system.

The major significant feature of the AT-40 is an ability to ensure that constant impedance and crossover frequency are maintained in the system.

BLACK BOX INCREASES CAR STEREO POWER BY 300%

Music buffs who want the same power in their car stereo that they have in their home should see the new 'black box' from Pioneer – a power amplifier called the AD-304. This amplifier fits under the dash, even in the boot, and gives out a minimum 15 watts RMS per channel, compared with the average 3 to 4 watts RMS of most stereo players.

A word of warning! Ordinary speakers cannot handle the power this amplifier, and Pioneer recommend that speakers rated maximum 20 watts or higher be used e.g. TS-160, TS-161, TS-692, TS-693.

PIONEER CT-F9191

Pioneer's latest front loading cassette deck features two independent drive motors, one an electronically-controlled dc motor for record/play operation, and a second motor for fast forward/rewind.

Separating the two functions in this manner has enabled wow and flutter to be reduced to 0.05% – 0.07% claim the manufacturers.

STEREO GENERATOR ALIGNS FM RECEIVERS

Philips PM6456 Stereo Generator provides a logical sequence of test signals for accurate and fast alignment of stereo decoders and complete stereo receivers.

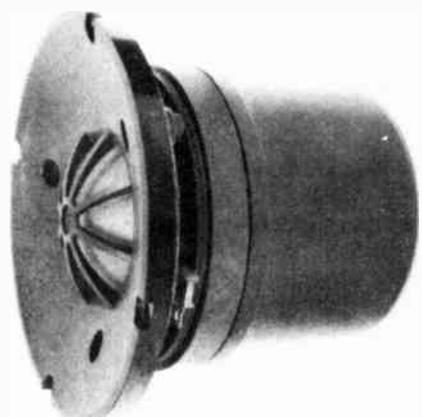
The sequence of test signals includes a crystal-controlled 19 kHz pilot signal; internal 1 or 5 kHz audio-frequency modulation, with provision for external modulation; and right-channel only, left-channel only, and right-channel equals minus left-channel signals. A 100 MHz ± 1 MHz RF signal is provided for checking complete receiver systems.

$1000 CAR RADIO!

Described by its manufacturers as a 'limited edition', this new car sound system from Blaupunkt incorporates a four-band AM radio, stereo FM, and a stereo cassette player. The unit may also be used for dictation.

The control unit, shown here, is about the size of a packet of cigarettes. It is mounted on a flexible arm to enable it to be located in a position convenient to the driver.

NEW MIDRANGE FROM PHILIPS



Philips have introduced a new mid-range loudspeaker known as the AD0210/Sq.8. It is a 50 mm dome unit suitable for inclusion in speaker systems rated at up to 50 watts rms.

The unit comes with a sealed back allowing it to be mounted straight onto the baffle without the need for a separate enclosure. Frequency range is stated to be 300 Hz to 7 kHz and its power-handling capacity (without filter) is stated to be 15 watts rms.

Although more expensive than the 75 mm unit which is still available, the new speaker, whilst having the same sensitivity, offers wider dispersion and much lower distortion. Further details from Philips Elcoma offices in all states.

CANNIBALS and MISSIONARIES

— *the final river crossing problem*

Designed by A.J. LOWE

eti PROJECT 803

Fig. 1. The finished model. Lettering done with press-on letters on white Contact.

HERE'S a particularly perplexing problem provided for people with painstaking propensities. It's an electrical model of the puzzle which goes like this:

Three missionaries and three cannibals come to a river they want to cross. A little boat at the bank will carry only two people. All the missionaries can row, but only one of the cannibals can row — he'd been to Oxford. He also wears a white shirt! If at any time, on either side of the river, cannibals outnumber missionaries then the cannibals will eat the missionaries, which, understandably, the missionaries don't want. Problem: how do they cross safely?

In the model shown in Fig.1 the missionaries are represented by three switches M1, M2 and M3, and the cannibals by three switches C1, C2 and C3. The missionary switches have yellow levers. Two of the cannibal switches have black levers, but the switch representing the cannibal who wears a shirt and learned to row at Oxford — C2, has a white lever.

By operating the switches to represent crossings of the people involved — never more than two at a time as that's the limit of the boat, you try to solve the problem. If at any time a situation arises where, on either bank, cannibals outnumber missionaries then an alarm sounds and you've failed.

The circuitry detects situations where cannibals can satisfy their taste for eating missionaries, but it does not detect cheating — such as putting three people in the boat, or allowing a cannibal who can't row to be in the boat on his own.

CONSTRUCTION

The prototype was assembled in a plastic box 140 mm x 100 mm x 75 mm high with an aluminium front panel. Modern telephone-type key switches were used each having four changeover switches on each side of the switch.

Figure 3 shows the bottom view of one of the switches and how its terminals are laid out. It also shows, by means of the arrow-headed lines, which terminals connect with the moving parts of the switches. The eight changeover switches which comprise one key switch have been lettered a to h for convenience and to tie in with the lettering in Fig.2.

Note carefully that the switches in Fig. 3 are shown making the circuits which they make when the switch lever is in its *central* position. When the switch lever is moved from the central position to the start side of the river it changes over only the switches on the opposite half of the switch — i.e. switched a, b, c, d. When the switch lever is moved from the centre position to the far side of the river it changes over only switches e, f, g, h.

These key switches can be bought with push-on handle covers of various colours. The prototype used yellow covers for the missionaries, black for two of the cannibals, and white for the cannibal C2 who wore a shirt (and went to Oxford).

Although key switches each containing a total of eight changeover switches were used in the original, actually it is only the missionaries who need all eight switches. The cannibals need only five changeovers, but it was thought simpler to buy six identical switches.

Those with access to disposal stores could probably buy enough old style key switches comparatively cheaply, to build up the necessary number of switching functions needed.

The panel aperture dimensions for a standard key switch are shown in Fig.4.

The buzzer alarm and battery holder are all one piece — taken from a bicycle horn.

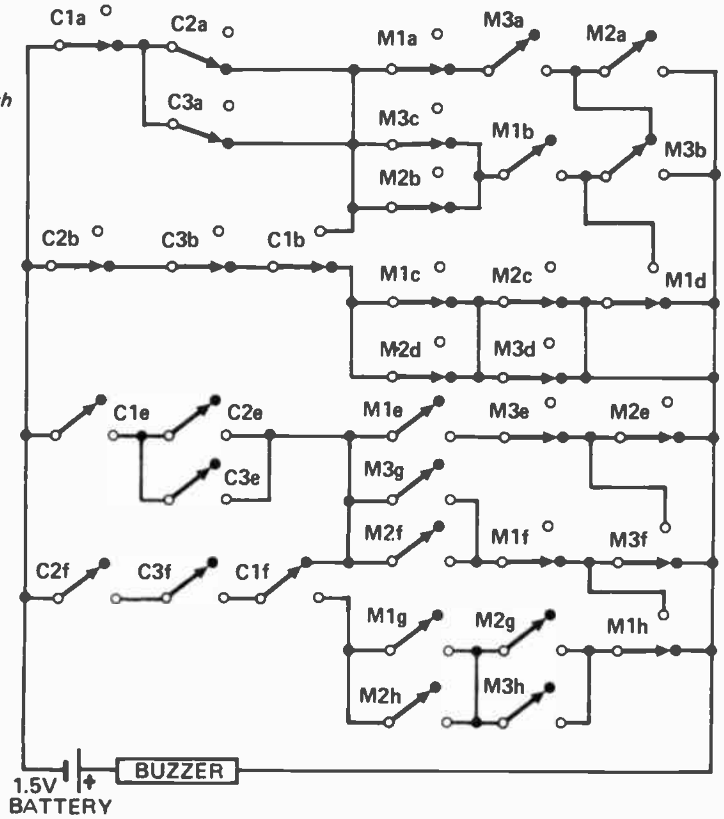
Wiring must be done carefully — very carefully! Bare wire was used in the prototype. Figure 5 shows the wiring diagram for the start side half of the switches and Fig. 6 shows the wiring of the other half. They are shown separately to minimise confusion. As can be seen from Figure 7, the switch wiring needs considerable care. On each of Fig. 5 and Fig. 6 one lead is marked 'To Buzzer' and another 'To battery —ve'. These leads, i.e. both buzzer leads are joined together and to the buzzer; and both battery —ve leads are joined together and run to battery —ve.

When wiring up — work logically. Start with switch M3 which is on the left when the panel is upside down. Start with the top left hand terminal and make all connections to it. Then move down each terminal in turn down the left hand row of terminals. Proceed row by row to the right making and checking connections to each terminal. It's a good idea to cross off with a pencil, each connection shown on the wiring diagrams, as soon as that connection has been made on the switches. Be sure not to miss the short connection between switches M3e and M3f.

If you want to check through the wiring diagrams, the circuit, and the switch diagram — bear in mind that the switch diagram shows connections with the switch lever in the central position, and the circuit diagram shows the connections with the levers in the start side position.

On completion of the wiring and after insertion of the cell, the puzzle should work. Check out all the alarm

Fig. 2 The circuit diagram with all switches shown with levers on the start side of the river



HOW IT WORKS

The circuit is a switching logic circuit. See Fig. 2. The cell and buzzer are between the outer vertical rails, and if ever a way between these two rails is set up by the switches then the alarm sounds. The circuit shows all the switches in the *starting* position i.e. all the missionaries and cannibals are on the near bank. Note that when any person goes over the river *all* switches changeover. The customary dotted lines showing the connections between coupled switches have been omitted for clarity. Thus, if M1 crosses the river, switches M1a, M1b, M1c, M1d, M1e, M1f, M1g and M1h all changeover.

You can work out the circuits for the alarm to sound. Here are three examples. Suppose all three cannibals stay on the start side and M1 goes over. Then the cannibals outnumber the missionaries on the start side and so the alarm sounds — through C2b, C3b, C1b, M2d, M2c and M1d which has changed over.

Similarly, if M2 went over alone then the alarm would sound through C2b, C3b, C1b, M3d, M1d, M3b and M2a which has changed over.

And if M3 went over alone the alarm sounds through C2b, C3b, C1b, M1c, M2c, M1d and M3b which has changed over.

You can check all the 'alarm should sound' configurations on each bank of the river by visualising an alarming situation — cannibals outnumbering missionaries, and then tracing through the switches to find a circuit. Similarly the 'alarm should not sound' circuits, or rather 'no' circuits can be checked in the same way.

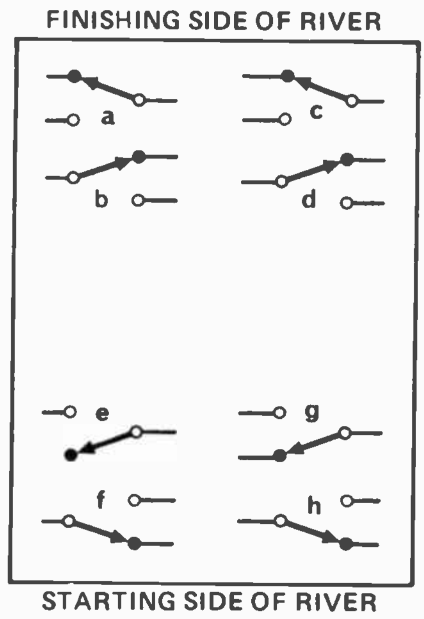


Fig. 3 Terminal layout on standard key switch with four changeover on each half. Contacts shown as being made in this diagram are with the lever in the central position.

PARTS LIST

Six standard phone type key switches type 4CL/4CL which means 4 changeover locking switches on each half of the switch.
The prototype used MLK lever switches code number MLK 10
One buzzer and battery holder — ex bicycle horn
One suitable box and panel
Hook up wire etc.

CANNIBALS and MISSIONARIES

situations on both banks and see that the alarm sounds when it should. Also check the no-alarm situations – i.e. when cannibals do not outnumber missionaries on either bank of the river.

Fault finding is not as daunting as it may appear at first. A logical working through the circuit diagram should help to pin point any problem.

HAVE A GO

Having built the puzzle – try to solve it. It's far from easy. If all else fails – check the correct answer which we'll publish in our News Digest pages next month.

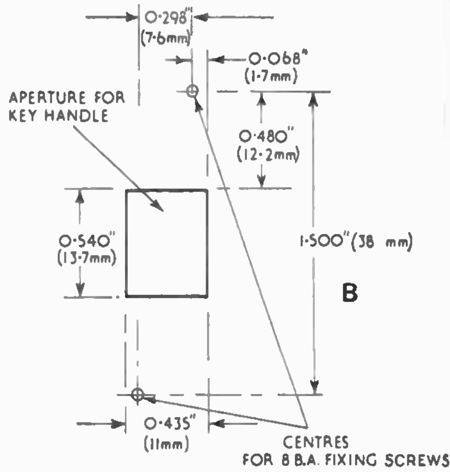


Fig. 4 Dimensions of aperture needed and hole positions for standard key switch.

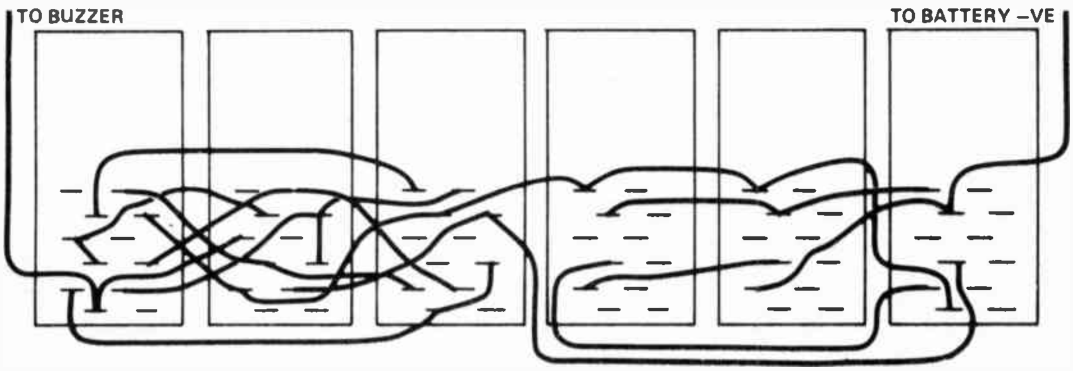


Fig. 5 Wiring on switches on the start side i.e. on switches 'e' to 'h' of each key switch.

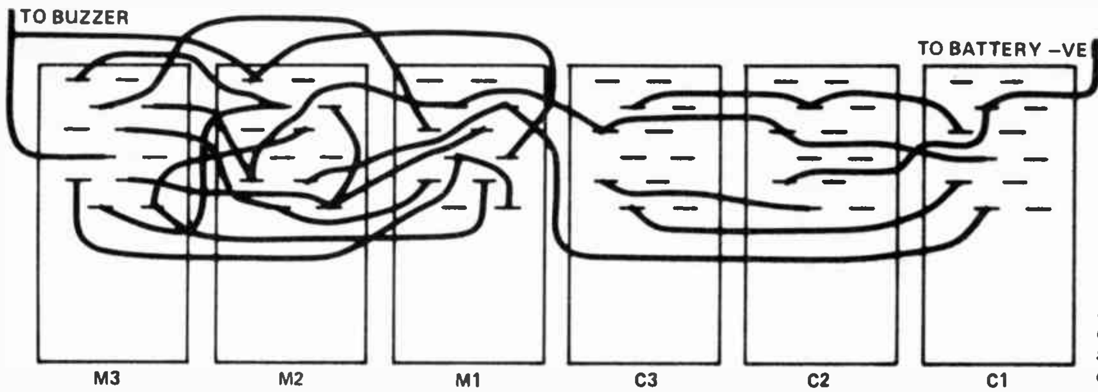


Fig. 6 Wiring on switches on finish side i.e. on switches 'a' to 'd' of each key switch

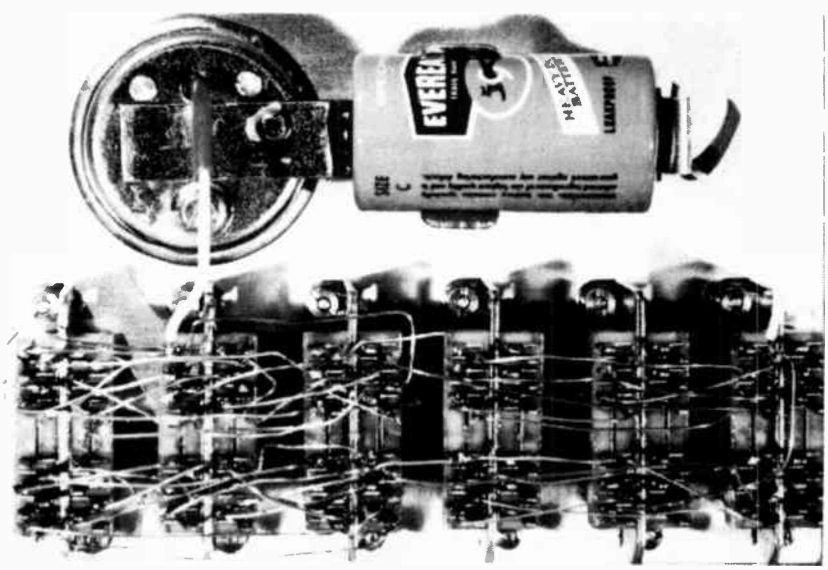


Fig. 7 Underside view of the panel.

PARTS LIST
Six standard phone type key switches type 4CL/4CL which means 4 change-over locking switches on each half of the switch.
The prototype used MLK lever switches code number MLK 10
One buzzer and battery holder — ex bicycle horn
One suitable box and panel
Hook up wire etc.

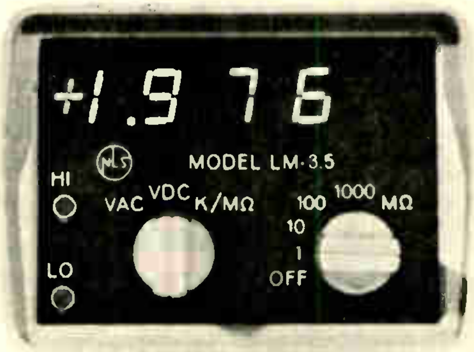
High quality at low cost from the company that has led the Digital Revolution since 1952 when we developed the world's first Precision Digital Voltmeter.

PORTABLE DIGITAL MULTIMETERS

THE VOLKSMETERS

Now there are three—with the NEW!! LM-3.5

USE THEM ANYWHERE!



Actual Size

THE VOLKSMETERS +

3½ digits

3 digits + 100% over-range

Active Filter Input!

With Rechargeable Batteries & Charger Unit and Three Current Shunts. **$127***

*All prices plus 15% sales tax if applicable.

LM-3

Full three digits.

THE VOLKSMETERS

With Rechargeable Batteries & Charger Unit **$99***

- They are small & rugged - Ideal for service personnel.
- Priced comparable to analog pointer meters.
- Automatic polarity, decimal and overload indication.
- Battery operated - NiCad batteries; also AC operation.
- No zero adjustments and no full scale ohms adjust.
- Measures DC volts, AC volts, ohms - plus current.
- Large LED display for easy reading without interpolation.
- Parts and labor guaranteed for one year.

LM-4

Full four digits.

LAB ACCURACY VOLKSMETERS

With Rechargeable Batteries & Charger Unit **$180***

Non-Linear Systems 23 Years of Progress

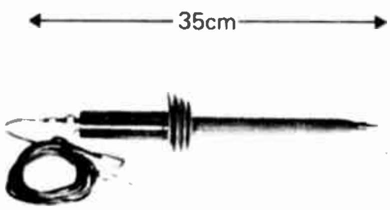
SPECIFICATIONS

MODE	RANGE	ACCURACY LM-4	RESOLUTION LM-4	ACCURACY LM-3/†LM-3.5	RESOLUTION LM-3/LM-3.5	INPUT RESISTANCE	TEST CURRENT
VOLTS DC*	1 10 100 1000	±0.02% of Range	100 µV 1 mV 10 mV 100 mV	±(0.1% Rng. + 1% Rdg.) †±(.05% F.S. + 1% Rdg.)	1 mV 10 mV 100 mV 1 V	10 MΩ	
VOLTS AC*	1 10 100 1000	±(0.1% Rng. + 0.2% Rdg.); 50-400Hz (All ranges) ±(0.1% Rng. + 1% Rdg.); 400-50KHz (1V range) ±(0.2% Rng. + 10% Rdg.); 400-5KHz (10V & higher ranges)	100 µV 1 mV 10 mV 100 mV	±(0.3% Rng. + .8% Rdg.) †±(.15% F.S. + .8% Rdg.) 50/400 Hz +(0.3% Rng. + 10% Rdg.) †±(.15% F.S. + 10% Rdg.) 400/5000 Hz	1 mV 10 mV 100 mV 1 V	10 MΩ, 20 pF	
KILOHMS**	1 10 100 1000 10000	±0.1% of Range	100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ	±(0.1% Rng. + 1% Rdg.) †±(.05% F.S. + 1% Rdg.)	1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ		1 mA 100 µA 10 µA 1 µA 100 nA

* 1000 VDC or peak AC maximum any range.
**5VDC maximum test voltage in K/MΩ mode.
† LM-3.5 has 100% over-range - full scale readings are 1.999, 19.99, etc.

Common features of all three "Volksmeters" are: • Overload indication - The numeral "1" flashing in the LM-3 and LM-4 and the numeral "1" and the left-most zero flashing in the LM-3.5. • Overload protection in KΩ mode - Up to 120 vdc or rms ac may be applied (not to exceed 30 seconds). • Operating temperature range - 0° to 45°C. • Power source - Three AA size NiCad batteries with 240V charger unit. • Weight - 9.2 ounces (with batteries). • Current shunts, in values of 0.1 mA, 1 mA, 10 mA, 100 mA and 1 A, are available as options in the LM-3 and LM-4; the LM-3.5 includes shunts in values of 10 mA, 100 mA and 1 A.

OPTIONAL ACCESSORIES

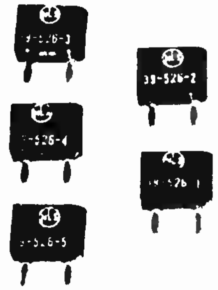


$26*

A HIGH VOLTAGE PROBE

$11*

B LEATHER CASE

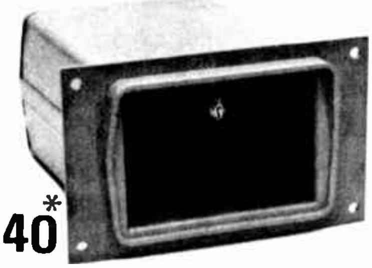


$4·10ea*

C CURRENT SHUNTS

$2·40*

D TILT STAND



$2·40*

E PANEL-MOUNT FLANGE

Other Products include panel meters, digital voltmeters, data acquisition systems Mil Spec DVMs, comparators, serializers, digital clocks, word generators, signal conditioners, scanners, digital printers, special-purpose digital instruments, and MOS/LSI array testers. For more information on these NLS instruments/systems, contact:

Non-Linear Systems, (Australia) Pty. Ltd.
P.O. Box 122, Glen Waverley, Victoria, 3150, Australia.
Telephone: (03) 232 4506/232 7535 Telex 34082

Volksmeters are now available throughout Australia at the following local distributors, radio shops, hobbies & electrical stores:

Melbourne: Radio Parts (all stores), Lawrence & Hanson, I.E.I. Pty. Ltd.
Sydney: Dick Smith, (all stores), Lawrence & Hanson, Radio Despatch Service, I.E.I. Pty Ltd.
Adelaide: Compar Distributors Pty Ltd.
Brisbane: Lawrence & Hanson
Perth: Lawrence & Hanson
Newcastle: Digitronics, Division of Edmonds, Moir & Co.
Geelong: Teleparts (also new store at Morwell).
Hobart: Lawrence & Hanson.
New Zealand: Pye Ltd., Systems Divison.

If there is not yet an LM stockist in your city you can send your cheque or money order direct to N.L.S. for immediate delivery. (In which case if you are not completely satisfied your Volksmeter may be returned within 10 days for a full refund. **Please include 15% Sales Tax if applicable. Plus $2.00 for freight & handling.**

Send me ...... LM's ....@........ each
Options as above ...... A @ $26.00 ...... B @ $11.00; ...... C @ $4.10 ea, Current Shunts ...... 1 mA ...... 100 µ A ...... 10 µA .... 1 µA ...... 100 nA; ...... D @ $2.40; ...... E @ $2.40.
Please include your name and full address

Continued from page 14.

new instrument highly resistant to shocks.

In order to extend these features to in-the-field service the PM 2522 can be supplied with rechargeable batteries. They fit inside the cabinet and give about eight hours of operation. The batteries are conveniently recharged through the mains supply of the instrument in about 15 hours.

Other optional accessories include HT and HF probes a dc shunt and an ac current transformer.

Dc voltage range is 200.0 mV to 1000 V; Ac voltage 200.0 mV to 600 V; ac/dc current ranges 200.0μA to 2 A and resistance ranges 200.0 ohm to 20 megohms. Frequency range is 30 Hz – 30 kHz.

The HT probe extends the dc voltage range to 30 kV while the HF probe takes the multimeter to 700 MHz.

ANTI-TANDY PROTESTS

The giant US-owned Tandy Corporation's launch of their Store Manager Incentive Agreement Scheme, Sydney Oct 28, was accompanied by a noisy anti-Tandy demonstration organised by employees of Dick Smith Electronics.

Tandy's 'SMIA' scheme enables 'managers' to operate Tandy stores on a profit sharing basis. The managers are in fact employees of Tandy but pay into that company an amount – generally between $15,000 and $20,000 – which gives them a right to participate in profits of their individual store.

The Tandy company operate similar schemes in the USA and Canada – the company currently operate 80 stores in Australia and intend eventually to operate them all under their SMIA scheme.

Dick Smith Electronics, together with other specialist Australian retailers, claim that Tandy are trying to force them out of business.

They claim that Tandy will initially accept huge losses in order to squeeze out the local retailers and then increase prices substantially once they have a monopoly position. Dick Smith points to Tandy's reported loss of nearly half a million dollars in that company's first six months trading in Australia, and also comments that 'there is no real Australian control as opposed to monetary participation in Tandy's operation here'.

Dick Smith Electronics say that it is in the Australian public's long term interest to buy from Australian owned retailers – Tandy however point out that they now employ 350 Australians – that a substantial investment in Tandy is increasingly held by Australians – and that all electronics retailers here buy almost all their stock from Japanese, American and European sources anyway. 'What's specially Australian about that' says Dean Lawrence, Managing Director of Tandy's local operation.

Dick Smith however feels that this misses the whole point which he says is that 'Tandy is wholly American controlled'. This Dick thinks 'may not be in the average Australian's long term interests'.

A LOCK-IN AMPLIFIER PRIMER: 1351

An unusual new technique note from Princeton Applied Research features a cartoon introduction. In brief lucid style, this note describes and compares the theory of operation of the many different types of lock-in amplifiers available today. Eight pages long and replete with illustrative curves and diagrams, the new primer describes basic building blocks like mixers, low pass filters, and phase-sensitive detectors, as well as broad band, tuned, heterodyning, and two-phase/vector types of lock-in amplifiers. As a handy, easy-to-read reference, the primer offers useful information to the technical and scientific community interested in the use of lock-in amplifiers to recover signals buried in noise.

Specific technical information about Princeton Applied Research Corporation's lock-in amplifiers, preamplifiers, and accessory equipment is contained in a newly revised catalogue giving complete details on these instruments and their function. Forty-four pages long, the catalogue includes charts, curves, tables, specifications, and prices for the instruments described and also has a convenient lock-in amplifier comparison chart and a concluding section on applications that is useful to scientific researchers.

Eight different lock-in amplifiers, together with options and accessories available to the user, are detailed, including a synchronous heterodyning simplicity, dial-in sensitivity, wide-range time constant settability, and unsurpassed performance. Typical accessories, in

addition to a variety of preamplifiers, include impedance matching transformers, an ac zero off-set, light choppers, a ratiometer, a selective amplifier, and a multiplier/divider, all of which are thoroughly delineated in the new literature.

The primer is available now and the Lock-In Amplifier Catalogue in approximately four weeks.

Technico Electronics, Premier St, Marrickville. 2204. N.S.W.

Tecnico Electronics, 2 High St., Northcote, 3070 Vic.

NEW AGENCY FOR TECNICO

Tecnico Electronics announce that they have just been appointed exclusive Australian Distributors for the Cimron Division of California Instruments.

The Cimron Division of California Instruments manufacture a wide range of high accuracy, high stability digital multimeters suitable for laboratory and systems usage.

Tecnico Electronics advise that some models are now ex-stock and a free eight page selection guide for digital multimeters is available on request.

For copies please apply to:

Tecnico Electronics, Premier St., Marrickville. 2204 NSW.

Tecnico Electronics, 2 High St., Northcote, 3070. VIC.

C&K THUMBWHEELS

A wide range of highly-specialised but low-cost thumbwheel switches for digital control applications made by the internationally-known American company, C&K Components, is now available in Australia.

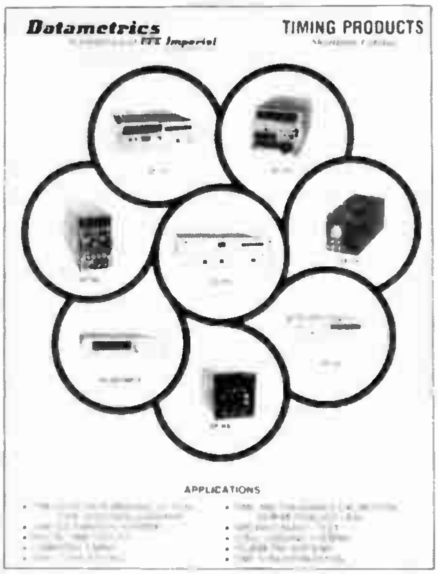
The thumbwheels are the latest addition to C&K's extensive production of sub-miniature toggle, rocker, illuminated-rocker and paddle-handle switches together with sub-miniature and micro-miniature pushbutton switches.

The rotary-type switches come in seven different types – suitable for rear, or front snap-in mounting – and have been designed for instrumentation, test equipment, computers and peripherals, process control equipment, numerically – controlled machine tools and for consumer products such as hi-fi and telecommunications.

They serve both decimal and BCD types in various combinations.

Professional Components,
Plessey Australia,
P.O. Box 2,
VILLAWOOD. 2163.

DATAMETRICS – TIMING PRODUCTS SHORTFORM CATALOGUE



Datametrics has a "Timing Products Shortform Catalogue" available. This catalogue lists in tabular form all standard Datametrics digital clocks, time code generators, time code readers and remote time display products. A brief description of the theory of operation of clocks and generators, as well as the application of time code from time synchronization, calibration, data indexing and time distribution systems is also provided.

From John Morris Pty Limited, 61-63 Victoria Avenue, Chatswood, NSW 2067.

DISTRESS BEACONS FOR AUSTRALIAN SHIPPING

Australian coastal shipping is being progressively fitted with emergency radio beacons which will help aircraft find shipwrecked crews.

The Marine Division of Amalgamated Wireless (Australasia) Limited has so far delivered 150 emergency position-indicating radio beacons (EPIRB's) to shipping companies. Deliveries will continue at the rate of 70 a month.

Early this year the Australian Department of Transport notified shipowners that the British-made Clifford and Snell EPIRB model CS1A, was the first to be granted type approval for Australian coastal shipping. AWA are sole agents for the Clifford and Snell beacon, which they fit and service from their 11 marine depots around Australia.

Under new regulations, every liferaft on an Australian registered passenger and cargo ship will have to be fitted with an EPIRB. The fitting will be progressive. If a ship has inflatable liferafts, the EPIRB's will be stowed in the ship's chartroom or wheelhouse, easily accessible to be put in the liferafts in an emergency. They will be transferred to the liferafts when the liferafts undergo annual safety servicing.

The Clifford and Snell EPIRB is a two foot long cylinder, some three inches in diameter which floats upright behind the liferaft on a line. This separation is necessary to ensure the best possible radiation from the transmitter. Before releasing into the water, the EPIRB's spring loaded antenna is released by simply pulling two straps. Transmission begins immediately the antenna is released. Power is supplied by a cadmium battery.

The beacon transmits signals on two standard distress frequencies – 121.5 MHz (commercial aircraft) and 243.0 MHz (military aircraft) over a range of 500 km at 9100 metres.

ERRATA AND ADDENDA

SIMPLE SPEAKER
November 1975

Philips have advised that the ADO 7061/W8 driver recommended for the above project has just been superceded.

The replacement unit is the AD7063/M8.

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electronics TODAY SERVICES

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We make no charge for replying to readers' letters, however readers must enclose a foolscap-size stamped addressed envelope if a reply is required. Queries concerning projects can only be answered if the queries relate to the project as published. We cannot assist readers who have modified or wish to modify a project in any way, nor those who have used components other than those specified.

TELEPHONE QUERIES

We regret that we cannot answer readers' queries by telephone.

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Our subscriptions dept can supply most back issues of ETI for the twelve months preceding the date of this current issue. Some earlier issues are also available.
The price of back copies is currently 75 cents, plus 40 cents postage and packing. Please address orders to Subscriptions Dept, Electronics Today, 15 Boundary St, Rushcutters Bay, NSW 2011.

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CONTRIBUTORS

Material is accepted from time to time from outside contributors. Payment is based on quality and is paid 30 days after the date of publication. Constructional projects will be considered for publication but the standard of design must be to fully professional level. All material must be typed using double spacing and wide margins. Drawings, circuit diagrams etc need not be to professional standards as they will be redrawn by our staff. It is advisable to contact the Editor before submitting copy.
A large stamped addressed envelope must be included if unsolicited material is required to be returned.

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Queries concerning goods advertised in ETI should be addressed directly to the advertiser — not to ourselves.

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News Digest items are published free of charge. Manufacturers and importers should send material at least four weeks before the date of publication. Photographs should be of high contrast and preferably at least 100 by 150 mm. Press releases must be of a factual nature — these pages are not free advertising. The Editor reserves the right to accept or reject material at his discretion. Preference will be given to components and equipment of an essentially practical nature.

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