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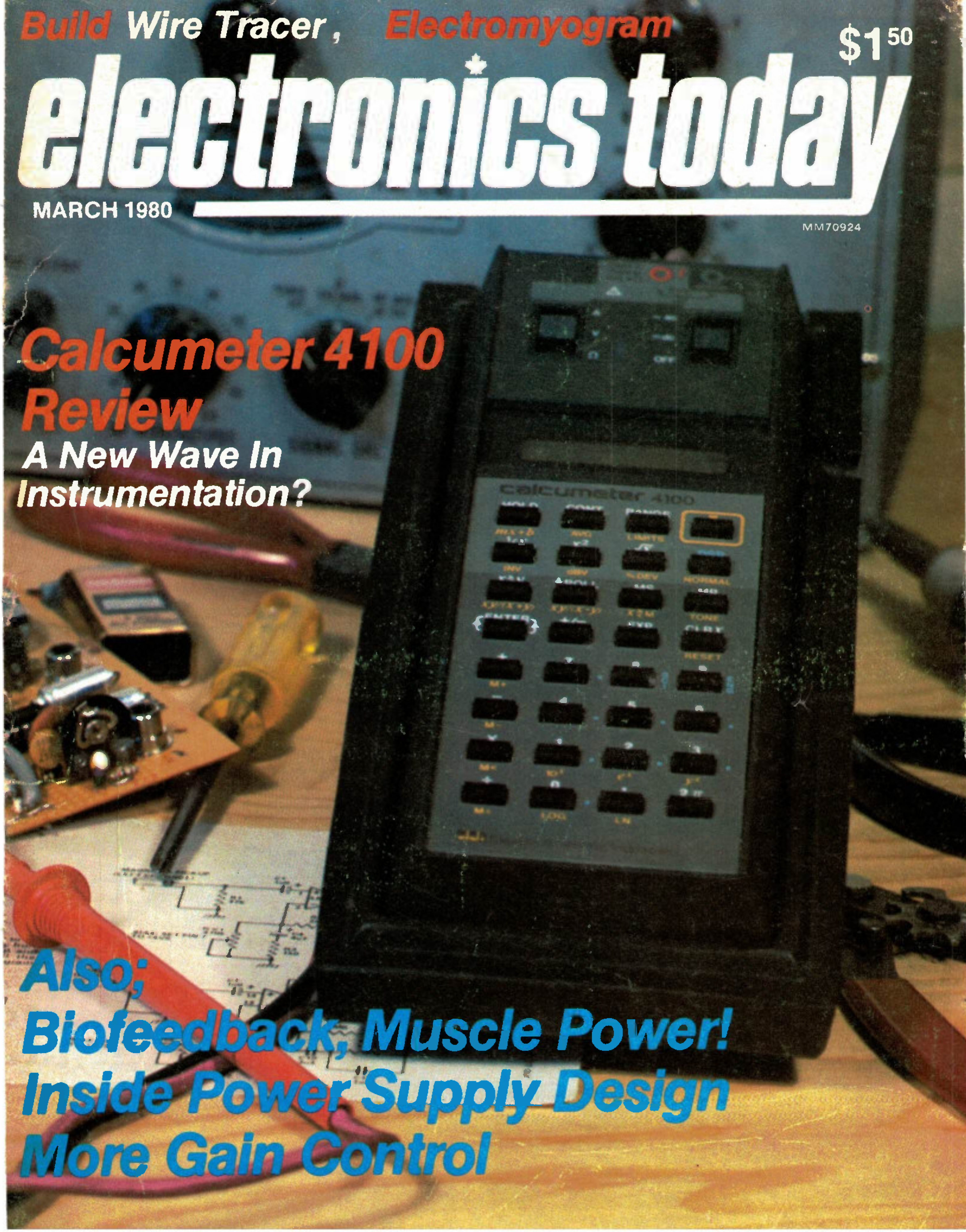
MARCH 1980

MM70924

Calcumeter 4100 Review

A New Wave In Instrumentation?



Also;

Biofeedback, Muscle Power!

Inside Power Supply Design

More Gain Control

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INCORPORATING **ELECTRONIC WORKSHOP**

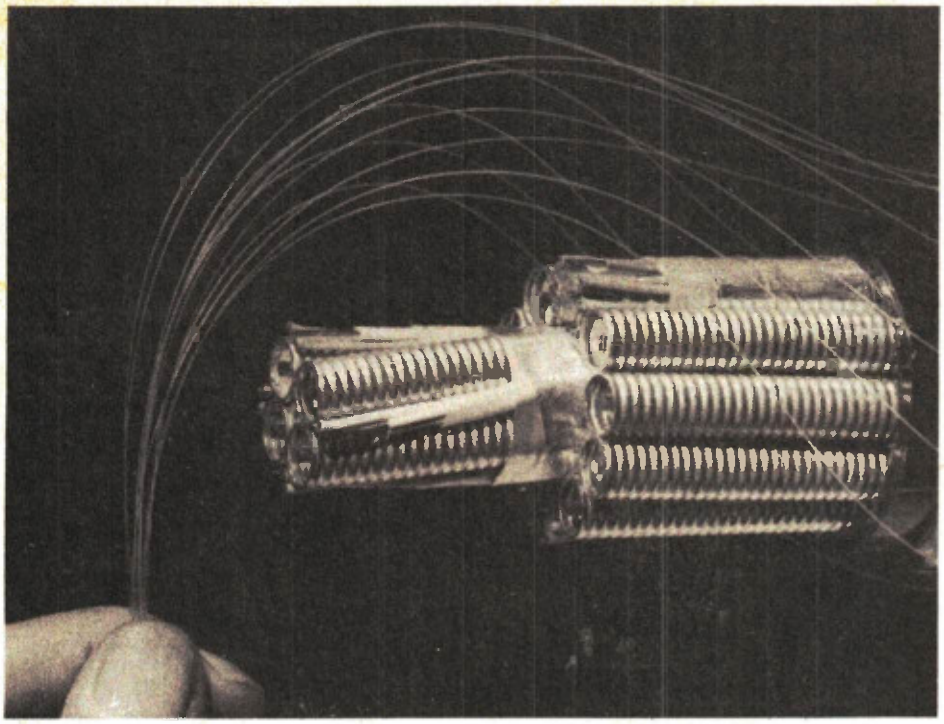
PROJECTS

FEATURES

NEWS & COLUMNS

INFO & MISCELLANEOUS

THIS MONTH'S COVER. A small package with big ideas is an apt description of the Calcumeter 4100. This month we took long look at the Calcumeter and what it can do. Read about it on page 27.



Fibre Optics And The Telephone

In late December Bell Canada completed placement of the first high capacity fibre optic cable in its Ontario and Quebec regions.

The company's Ontario Region engineering staff of its Technology Development Department will now add opto-electronic components to the eight kilometre cable joining the 20 Water St. switching centre with the microwave radio site on Mannheim Rd. west of Kitchener, and by mid-year will start performance monitoring tests of the optical transmission systems.

Transmission of the system will be at the DS-3 data rate of 44.736 megabits (44.7 million units of information) a second or 672 equivalent voice conversations on each pair of hair-thin glass fibres. With traditional transmission methods, one pair of copper wires can carry not more than two conversations at one time in the subscriber loop network and about 12 in the trunk network (interconnecting switching centres and other equipment sites.)

The Kitchener trial will be the first time optical fibre has been placed in Bell Canada as an entrance link, i.e. connecting the switched telephone network with the 8 gigahertz DRS-8 microwave radio system which later this spring will join Toronto and Calgary through the TransCanada Telephone System network.

The Kitchener system was designed by Bell-Northern Research and manufactured by Northern Telecom and uses all-Canadian assemblies. This type of system will be installed for actual network service in Sudbury, Kingston and Ottawa and parts of Quebec in 1981.

Two other lower capacity optical fibre systems are currently being tested by Bell Canada; a trunk network test in Montreal, and a subscriber loop network test in the Yorkville district of Toronto. Cable for two other trunk network tests has been laid in Montreal and Berthierville, Quebec for trial this year.

The Yorkville trial, when it was opened in December, 1978 was the first in the world to connect a telephone switching centre by optical fibre with actual telephone subscribers. Thirty-six households are currently receiving phone service in this system, and a demonstration centre in the same area is connected by 1.2 kilometres of optical fibre with the 15 Asquith switching centre to carry simultaneous two-way telephony and TV signals in both uni-directional (two fibres) and bi-directional (signals over one fibre) applications.

Optical fibre systems, like the one to be installed in Kitchener, comprise tiny light sources that convert voice and data signals into coded light pulses which are transmitted down the inside of very pure glass strands and re-converted in electrical signals by a light detector at the receiving end. The light sources in the Kitchener trial will be 4 tiny injection lasers, designed and developed by Bell-Northern Research, which pump out 5 milliwatt light pulses (about .02 per cent of the output of a 25 watt light bulb) some 44 million times a second. This is the first time that Bell Canada will use lasers in an operating communication systems and is a forerunner of the future when signals will be transmitted by lasers 30 to 50 kilometres without need of repeaters.

The cable in Kitchener is coated by an air-tight plastic sheath and contains six slots arranged around a plastic core which itself encloses a steel strength member. Four of these slots each contain three strands of fibre .000125 metres (5/1000ths of an inch) in diameter. The others will hold two pairs of copper wires used for pressure alarm cicuits and emergency voice communication during maintenance or restoration procedures.

Bell-Northern Research started work on optical fibre communication systems in 1972 and first installed a working system in 1974 for the Department of National Defence. First test by Bell of optical fibre in the operating network started during October, 1977 between two switching centres in Montreal. Early success of this trial led to development of the pioneering Yorkville trial.

Principal advantage of using glass fibre rather than copper pair as a transmission medium is the increase of capacity by hundreds of times and the efficiency and economy of sending light pulses up to 9 kilometres without the need of repeaters, compared with about 1.8 kilometres for copper. Moreover copper is a diminishing resource and becoming more expensive whereas optical fibre is made from one of the world's most abundant resources, silicon – commonly found in sand – and is expected to drop in price as manufacturing techniques improve and demand for it grows.

Bell Canada will make other trunk installations of optical fibre on a regular basis from 1981 and will start placing fibre in the subscriber loop network starting about 1986 in the densely-populated urban areas of eastern Canada.

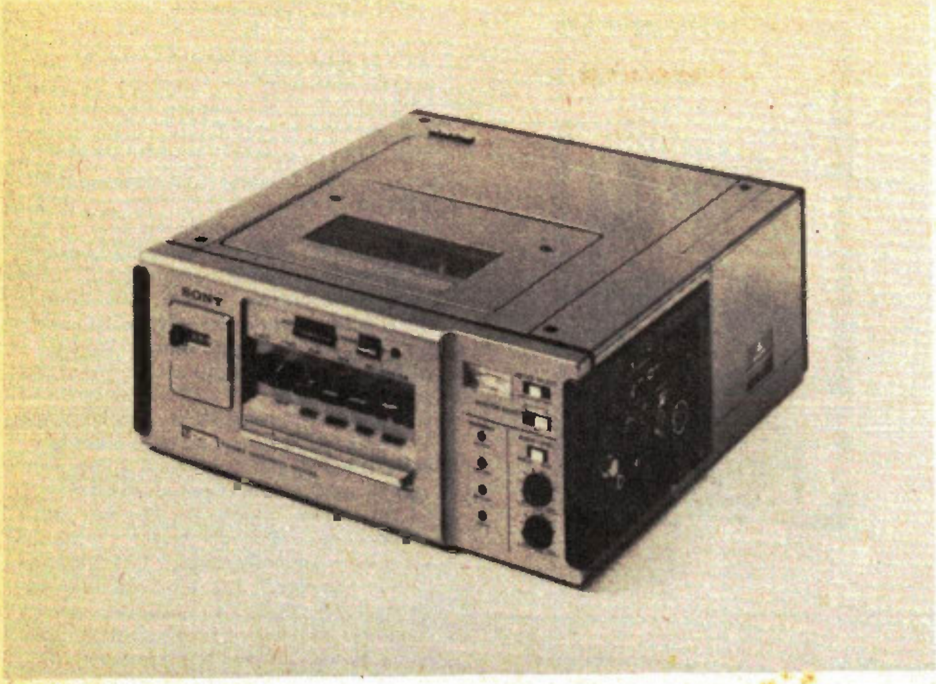
Since it permits simultaneous transmission of voice, TV and data signals, optical fibre has been suggested as the ideal medium for "wired city" communications in the future.

Want to know more? Write to: Douglas C. Peck, Supervisor-Technical Press, Public Affairs, 393 University Avenue, Floor 19, Toronto, Ontario M5G 1W9. (416) 599-6840.

Expose Yourself

News Digest is a regular feature of ETI Magazine. Manufacturers, dealers, clubs and government agencies are invited to submit news releases for possible inclusion. Submissions, or questions about material, should be sent to: News Digest, c/o ETI Magazine, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

Audio product news will be directed to Audio Today's product department, and similarly Shortwave news will appear in Shortwave World. Sorry, submissions cannot be returned.



'Nother Portable VCR

Readers of News Digest may remember we commented on RCA's VDP 150 portable video cassette recorder. It seems now that the market is just starting to open up.

Sony of Canada, Ltd. has introduced the VO-4800 portable U-matic videocassette recorder.

The compact recorder has built-in features such as field editing capability for smooth picture transitions, a three way power operation, warning lamps and relatively low-power consumption.

This self-contained unit also features an antigyroscopic mechanism that stabilizes mobile operation in either a vertical or horizontal position.

Used with Sony's new DXC-1640, portable Trinicon camera, users have a versatile 2-piece system that is ideal for EFP of ENG applications where portability is desired.

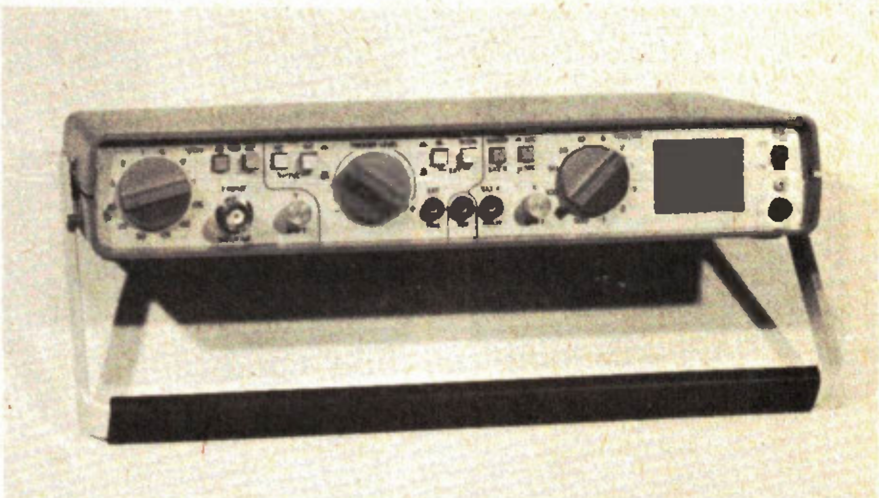
For more information write to: Sony of Canada, Ltd., Industrial Division, 411 Gordon Baker Road, Willowdale, Ontario. M2H 2S6.

Hams Take Note

Weekend Projects for the Radio Amateur is written for the electronics hobbyist interested in constructing low-cost Amateur Radio equipment while investing a minimum of time. Volume 1 in a series, Weekend Projects is a 60 page soft-bound book which supplies the builder with schematic diagrams and helpful suggestions for the construction of a pre-amplifier, noise blanker, transmatch, 160-meter converter, small transmitter, amplifier, external VFO, plus various test equipment and Amateur Radio accessories.

Weekend Projects for the Radio Amateur is available directly from the ARRL or local electronics dealers for $3.50 (sug.).

For more information contact: Ms. Bobbie Chamalian, Publication Sales Manager, ARRL, 225 Main Street, Newington, CT 06111.



A Really Small Scope

The SC110 is a truly portable professional oscilloscope. Priced at $499.00, it has many applications, including field service, laboratory bench use, technical education and amateur electronics.

Fitting easily into a briefcase or toolkit, weighing less than 2½ pounds, and offering performance of standard bench oscilloscope, the SC110 is perhaps one of the most flexible pieces of test equipment on the market.

The basic specification of the single trace, 10MHZ Bandwidth and 10mV Sensitivity, together with attractive styling, lightweight portability, low power consumption, clear bright display, and simple controls, adds up to a unique combination of features. The SC110, with a 12 month guarantee, and a range of optional accessories, is now available from Audiex Electronics distributors or write to Audiex at 1735 Avenue Road, Suite B, Toronto, Ontario M5M 3Y7.

PSST! Got A Secret?

Budding cryptologists will be interested in a new publication, The Code Book by Michael Marotta.

The book goes into considerable detail on codes, cypher, computer applications and how to successfully employ your secret code. In addition the author adds a good historical perspective to the subject.

The Code Book $6.95 + $1.25 shipping from Loompanics Unlimited, P.O. Box 264, Mason MI 48854. U.S.A.

NEWS DIGEST

New DVOM From Hickok

New from the Hickok Electrical Instrument Company is the latest in their LX Series of low cost hand-held DVOM's. The LX 304 features a ½ inch 3-½ digit L.C.D. display, automatic polarity, zero and over-range indication and other features.

Designed for convenient and economical bench and field use, Hickok LX Series multimeters are self-contained, with test leads that store in the removable, protective thermoplastic cover. Hickok claims they will withstand a four foot drop without loss of accuracy. A complete line of accessories extends their use into high voltage applications and temperature measurements beyond the capacity of comparably priced analog meters.

Contact H. Rogers, P.O. Box 310, 595 MacKenzie Avenue, Units 1 & 2, Ajax, Ont. L1S 3C5.

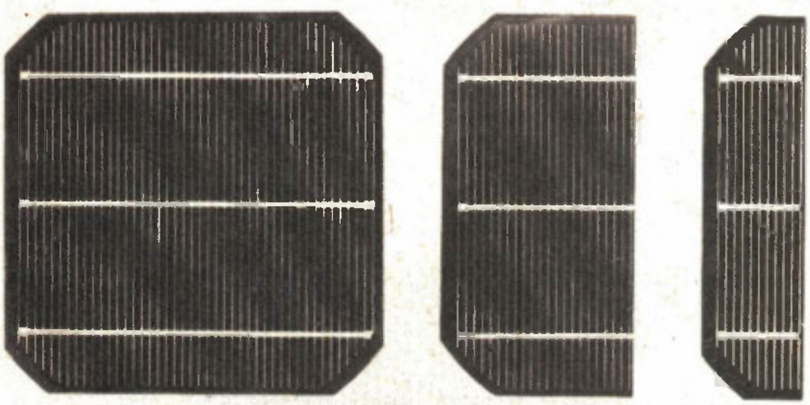
Low Cost Keyboards

Two professional quality keyboards suitable for demanding environments, the VP-601 with a 58-key typewriter format at $65. US and the VP-611 with the typewriter format plus a 16-key numeric keypad for fast data entry at $80. US have been announced by RCA. Both boards feature fully encoded, 128-character ASCII alphanumerics in a desk-top style package. They utilize flexible-membrane key switches requiring only a light, but positive, pressure for activation. Contact life is rated at greater than five million cycles per key. A finger-positioning overlay combined with the positive keypress action gives good operator "feel" and an on-board tone generator gives aural keypress feedback.

The keyboards operate from a single 5 volt DC supply and include and LED power-on indicator. The buffered seven-bit ASCII output is TTL compatible. The user may select either the full 128-character upper and lower case alphanumerics or 102-character "upper-case-only." The typewriter format also includes two user-definable keys (switch closures). Two-key-rollover circuitry, even parity bit and buffered KD (keydown), $\overline{\text{KD}}$, Strobe and $\overline{\text{Strobe}}$ handshake signals.

For further information contact RCA COSMAC VIP Marketing, New Holland Avenue, Lancaster, PA 17604.

MOTOROLA SQUARE SOLAR CELL



FULL CELL 1.25 W Typ — 1/2 CELL 0.6 W Typ — 1/4 CELL 0.3 W Typ

Solar Cells

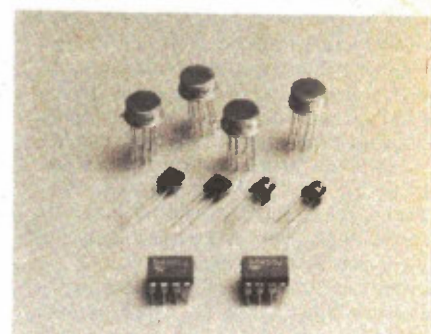
Utilizing its advanced solar cell technology, Motorola Solar Systems has announced the production of square solar cells for the direct conversion of sunlight to electricity.

The new square cells, 100 cm X 100 cm, offer 20% more density than round wafers. All square cells are now available in 33-cell modules, with full square cells giving 40 watts per module.

Applications of the new square cell photovoltaic products include village power systems, remote communications equipment, offshore and forestry equipment. Other applications in which such devices are in current use include cathodic protection for buried pipelines to prevent corrosion, electrical power on boats, for water pumping, and for microwave relays and navigational aids. Other uses are in emergency phones, portable equipment requiring electrical power and in remote refrigerators.

Other features of the new square cell module are: High reliability due to redundant interconnects; across-the-cell contacts eliminate potential power loss due to cracked cells; maintenance-free construction, with tempered glass superstrate and stainless steel frame; and low cell temperature.

Price of the MSP43A40, 40W panel is $476.00 US ($71.90 per W) in quantities of 100 and up. Additionally 10 and 20W Modules are available. Write to Motorola Semiconductor Products, P.O. Box 20912, Phoenix, Arizona 85036. Call Bob Hammond (602) 244-5459.



Precision Voltage Regulators

Teledyne Semiconductor is offering a set of three comprehensive data sheets on its new voltage reference product line. These data sheets supply detailed information on the 9491 (1.22V), 9495 (5.00V) and the 9496 (10.00V).

All three references use the band gap principle to achieve extremely tight regulation over a wide range of operating currents and temperature conditions.

Teledyne Semiconductor's references are ideally suited for use in such applications as: A/D converters, D/A converters, voltage regulators, VOM and VTVM's. They are available in both hermetic or plastic packages. Temperature ranges are 0°C to 70°C and -55°C to +125°C.

For a complete set of data sheets write to Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94043.

NEWS DIGEST

Using Bubbles

An eight-page brochure entitled "A Total System Solution to Magnetic Bubble Memory Applications" is now available from Intel Magnetics, Inc.

Included are discussions on: the concept of bubble memories; an examination of both the Intel 7110, and the one-megabit bubble memory; and the support electronic family which completes the system.

Copies of the "Total System Solution to Magnetic Bubble Memory Applications" may be obtained at no charge by writing to the Intel Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051.

Tiny Toolkit

Moody Tools, Inc., has introduced their Super Economy Tool Set, a precision subminiature 3 oz. tool package for field engineers, technicians and lab personnel.

More specifically, the Super Economy Set, stock no. 58-0154, contains a knurled, chuck-type, swivltop handle and the 27 interchangeable tools; six slotted drivers from .025" to .100", two Philips, no. 0 and no. 1, six Allen from .028" to .093", eight open-end wrenches from 5/64" to 5/16" and five socket wrenches/nut drivers from 5/64" to 5/32".

For complete information on the Moody Super Economy Lightweight write to Len Finkler Limited, 25 Toro Road, Downsview, Ontario M3J 2A6.

Circle No. 11 on Reader Service Card.

Audio Today

Developments in audio reviewed by Wally Parsons

THE VACUUM TUBE is a device in which current is controlled by the voltage applied to a control electrode. As such it is possible to produce a current flow pattern which is the counterpart of a voltage wave-form. If a resistance is placed in the external circuit, the varying current flow will result in a varying voltage drop across the resistance, and if the current variations are great enough and/or the resistance is of an appropriate value, the resulting variations in voltage drop may exceed the voltage variations on the control electrode. In other words, the AC output voltage will exceed the input voltage, and the stage behaves as a voltage amplifier.

We examined this mode of operation last month, using a triode tube as our example. One of the characteristics of all vacuum tubes is *plate resistance*, which is the resistance to the flow of electrons between plate and cathode. If a voltage is applied across the tube a current will flow whose magnitude can be determined by Ohm's law. Since current flow is also controlled by the voltage on the control grid, then it is possible to regard the tube as a variable resistance whose instantaneous internal resistance is controlled by the signal. This is illustrated in Fig. 1, in which Rv is the vacuum tube and R_L is the load. If R_L is made large as compared with Rv under zero signal, the current flow will be small, but large voltage swings can be produced at the junction (x).

Suppose, now, that we reduce the value of R_L to a value close to that of Rv. We can still swing the voltage at the junction (x) over a wide range, but now the current will not only be higher at zero signal, but the swing will be greater. This is shown in Fig. 2 which plots plate voltage against plate current for a variety of grid voltages. The line xy is a load line drawn for three different values of load resistance.

Since power is the product of current and voltage, it can be seen that a large increase in current with only a small reduction in voltage results in an increase in power dissipated in the entire circuit, and that if R_L and Rv are of equal value, half the power will be dissipated in each.

In real tubes, we connot always use this relationship, in part because we are more likely to be interested in maximizing the power in the load, and in part because this may not be the most linear mode of operation for the individual tube.

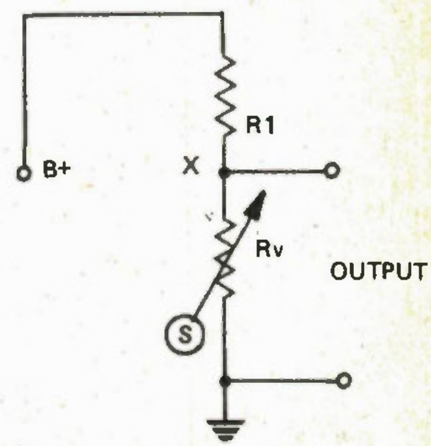
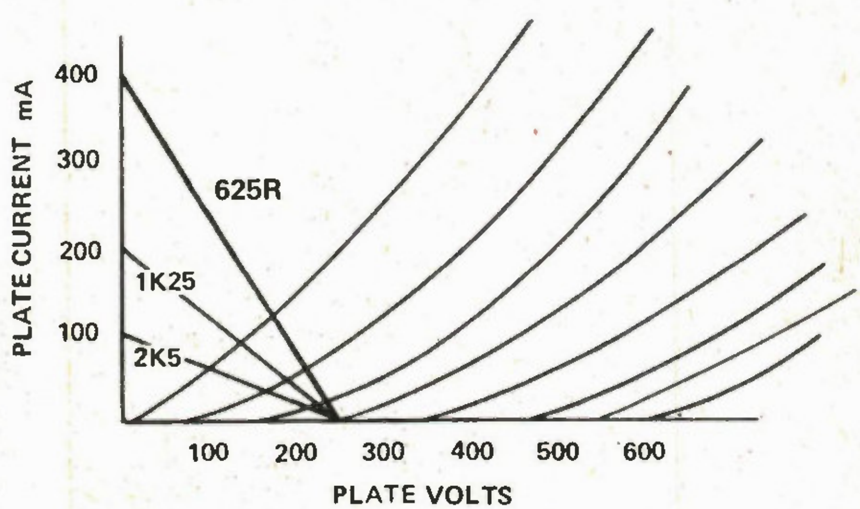


Fig. 1. Tube viewed as variable resistance.

Fig. 2. Triode characteristics.



A REAL LIFE CIRCUIT.

In Fig. 3 we have a power amplifier stage using a single triode, transformer loaded, with cathode bias, operating in Class A. By using a transformer in this manner, several benefits are achieved: very low DC resistance exists in the transformer, so amost full supply voltage is available, and very little power is dissipated as heat in the windings. The optimum load will turn out to be several thousand ohms, whereas, if we wish to use a loudspeaker, the load is only a few ohms. The transformer allows impedance matching. If a loudspeaker is used as the load, we want to keep DC out of the voice coil.

In the real world in which we live, there are very few real triodes designed for audio use. The usual practice is to connect a pentode as a triode by connecting the screen (more about this electrode later) to the plate, and that's how it's shown in Fig. 3.

The RCA Receiving tube manual lists the following characteristics for a type 6L6 tube connected as a single ended triode;

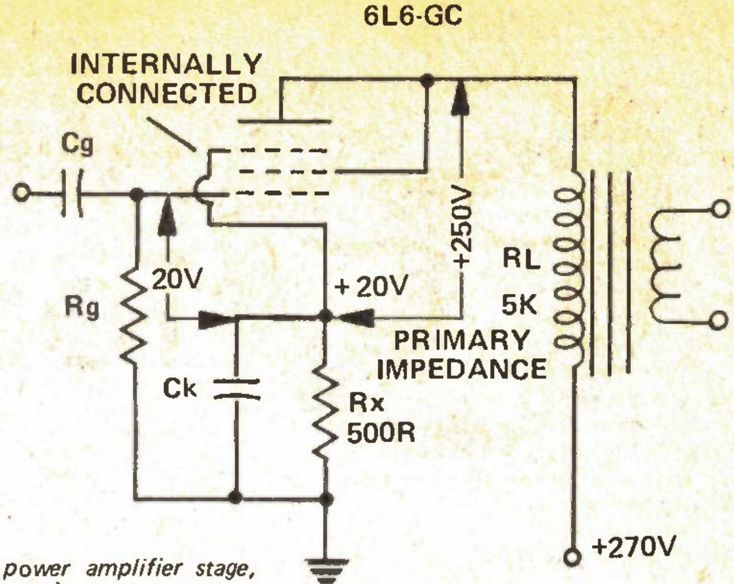


Fig. 3. Triode power amplifier stage, single ended, with cathode bias.

Plate Voltage;	250V
Grid No 1 Voltage;	–20V
Zero Signal Plate Current;	40mA
Maximum Signal Plate Current;	44mA
Plate Resistance; 1700 Ohms (approx.)	
Amplification Factor(u);	8
Transconductance;	4700umhos
Load Resistance;	5000 Ohms
Total Harmonic Dist.;	5%
Maximum Signal Power Output;	1.4 Watts

This is a convenient form for tabulating required information, but doesn't do much for us if we wish to operate with a supply voltage of up to 450 V and deliver proportionately more power. However, the manual does include a nomograph to allow conversion conveniently to different conditions.

Three important facts can be observed from this table; Power output is very low; the recommended load resistance is almost three times the plate resistance, resulting in low effiency, and accounting for the low output; there is a difference of 4 mA between zero-signal and maximum-signal plate current. One would think that since the average voltage on an AC sine wave is zero, that the average signal current would also be zero (averaged over 360^{o}). However, the tube is not completely linear, as indicated by the distortion figure of 5%, so that current swing is not equal on each half-cycle. The importance of this will become clearer as will the mechanism involved, when we deal with Class AB, and Class B Push-Pull circuits.

The only component value to be calculated is the value of the cathode resistor, R_k, which establishes bias, and the value of supply voltage.

The voltage on grid No. 1, the control grid, is specified as -20 Volts. As we saw last month, this voltage is with reference to the cathode, and it makes no difference if we make the gird negative with respect to ground, with the latter grounded, or the cathode positive with respect to the grid, with the latter at ground potential for DC. Since plate current flows through the cathode resistor, a voltage drop will appear across R_k which is equal to the current times the resistance. To find the required value of resistor, divide the desired voltage by the value fo plate current. The desired voltage drop is 20 V, and current is 40 mA, so the required resistance is 500 Ohms. Since the plate voltage is specified as 250 V, and this is measured between plate and cathode, and because we have dropped 20 V across R_k the required supply voltage is 250 + 20 = 270V, assuming negligible drop across the primary winding of the transformer. If the drop across this component is significant (ie. 10% or more of the supply voltage) the supply must also be increased by this amount. An even better idea is to use a better transformer whose primary DC resistance is low.

CURRENT VARIATIONS

At this point, it would be instructive to examine the effect of driving the stage to full output.

At full output, plate current rises to 44mA. Since this passes through R_k, or $2(44 \times 10^{-3})^2 \times 500 = 22V$. Also, the plate-to-cathode voltage now drops to 248V. Ordinarily, reduced voltage between plate and cathode requires a *reduction* in bias voltage, not an increase. This is the main reason for using such a high value of load resistance; a lower value would certainly allow greater output power, and, with most tubes, lower distortion, but as Fig. 2 illustrates, current swing is greater and will usually result in greater difference between zero and maximum current. Again, the significance of this becomes greater when we deal with Class B and Class AB stages.

R_k is bypassed by a capacitor, C_k. Because both the input signal and output signal appear across R_k, but in opposite phase, negative feedback occurs. This may be desireable because of the benefits of feedback, but for maximum gain C_k bypasses R_k at audio frequencies. It should be noted, however, that if the time constant is made long enough, the variations in bias between minimum and maximum output can be reduced. If, for example, $(RC)_k$ = 1 second, then bias will remain constant for peaks of less than one second duration.

INPUT

Finally, we come to C_g and R_g, the input coupling capacitor and grid leak resistor. In any tube, there is some gassing present due to the fact that no vacuum is actually complete. As a result, there is normally some grid current present. The grid leak resistor serves the function of providing for a ground return for this current, and a ground reference for the grid. This may be any value up to and including the maximum specified for the tube, which in the case of the 6L6 tube with cathode bias, is 500k.

However, this resistor is effectively in parallel with the load of the previous stage, and, if it's value is too small, may load it down, reducing both gain and maximum drive voltage. If we elect to use the maximum permissible value, then the value of C_g which couples the grid to the previous stage, while blocking the DC component of the latter, should be such that, at the lowest frequency to be reproduced, its reactance is equal to R_g in parallel with the series combination of the load resistance and plate resistance of the previous stage. Where this is not critical you can simply make it equal to the load of the previous stage, but if feedback is to be used around the amplifier, it will be necessary to control the response of each stage, and you can't approximate.

A great deal of space has been devoted to this simple little circuit, but doing so should save having to explain the same thing over and over again.

Next month we'll discuss that screen grid which we connected to the plate, and we'll do other things with it, as well as get into push-pull operation.

Audio Today Products

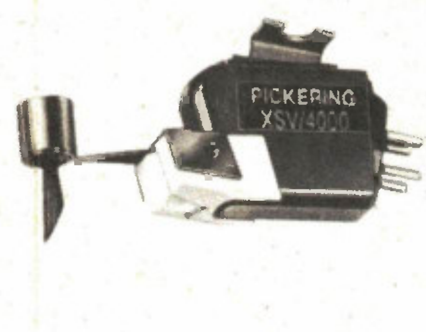
Audio developments reviewed by ETI's Contributing Audio Editor Wally Parsons.

PICKERING INTRODUCES THE XSV/4000

This is a new addition to the Pickering line, and uses the Stereohedron long contact stylus, a design described in previous issues.

The new design is a moving magnet system, a departure from previous moving iron designs. The change is due to the availability of samarium cobalt for use in the magnet structure, a material featuring a high ratio of mass to retentivity, allowing considerable reduction in the physical size and mass of the magnet with no loss of magnetic field strength and the attendant reduction in output. The result is a moving system with extremely low mass, permitting a claimed frequency response to 36 kHz, the ability to track high velocity modulations, and superior transient response.

Output is said to be 0.7mv/cm/sec within 2 dB, DC resistance is 900 Ohms, Inductance 510mH, and it works into a load of 47k in parallel with 275 p capacitance.



Pickering XSV/4000 Cartridge

Total mass, including brush, is 6.5 g, and recommended tracking force is from ¾ g to 1¼ g, with 1 g as the optimum. Also available as accessories are accessory stylii, one for Mono long play and another for 78 rpm discs.

Priced at $189.95 suggested retail, is distributed in Canada by E.S. Gould Marketing Co. Ltd., 109 Montee de Liesse, Montreal, Quebec, H4T 1S9. Telephone (514) 342-4441.

BLAUPUNKT STEREO CASSETTE DECK

Blaupunkt Electronic Tuning AM/FM Stereo Cassette Car Radio Model CR3001 features automatic and manual electronic scan, twelve station (6 AM and 6 FM) memory storage with digital display of time and frequency and 4 x 15 Watt IC power amplifier.

The cassette unit features sendust head and metal, chromium dioxide playback capability, plus Dolby on FM and tape. Radio scan and cassette programme selection can be remotely controlled, and dial lighting intensity is automatically controlled by a light sensitive cell.

Other features include Noise Suppression circuit for FM, built in four way fader, separate bass and treble controls, local/distance, stereo/mono, and balance control. The cassette unit has auto reverse, locking fast forward and rewind, and automatic cassette eject when ignition and radio power are off.

For price and other information, contact Robert Bosch (Canada) Ltd., 6811 Century Ave., Mississauga Ont., L5N 1R1, or phone (416) 826-6060.

Audio Today Events

The chap with the beard in the above picture is S.K. Pramanik, chief engineer of Bang and Olufsen of Denmark, and the brains behind one of the more successful approaches to long line stylus design. The occasion was a meeting for dealers and the press at the offices of B & O's Canadian distributor, BSR Canada Ltd., during which Pram discussed the rationale behind the stylus design which bears his name, as well as the general Bang and Olufson design philosophy, which includes one of the very few lines of receivers which actually looks as if it were designed for the home.

These pages will deal with the characteristics of various stylus geometries sometime in the future, so the meeting was most welcome.

Although it was not on the agenda, I was able to take part in one of the few meaningful speaker blind comparisons I've yet encountered, part of a salesman training programme set up by BSR for the benefit of dealers.

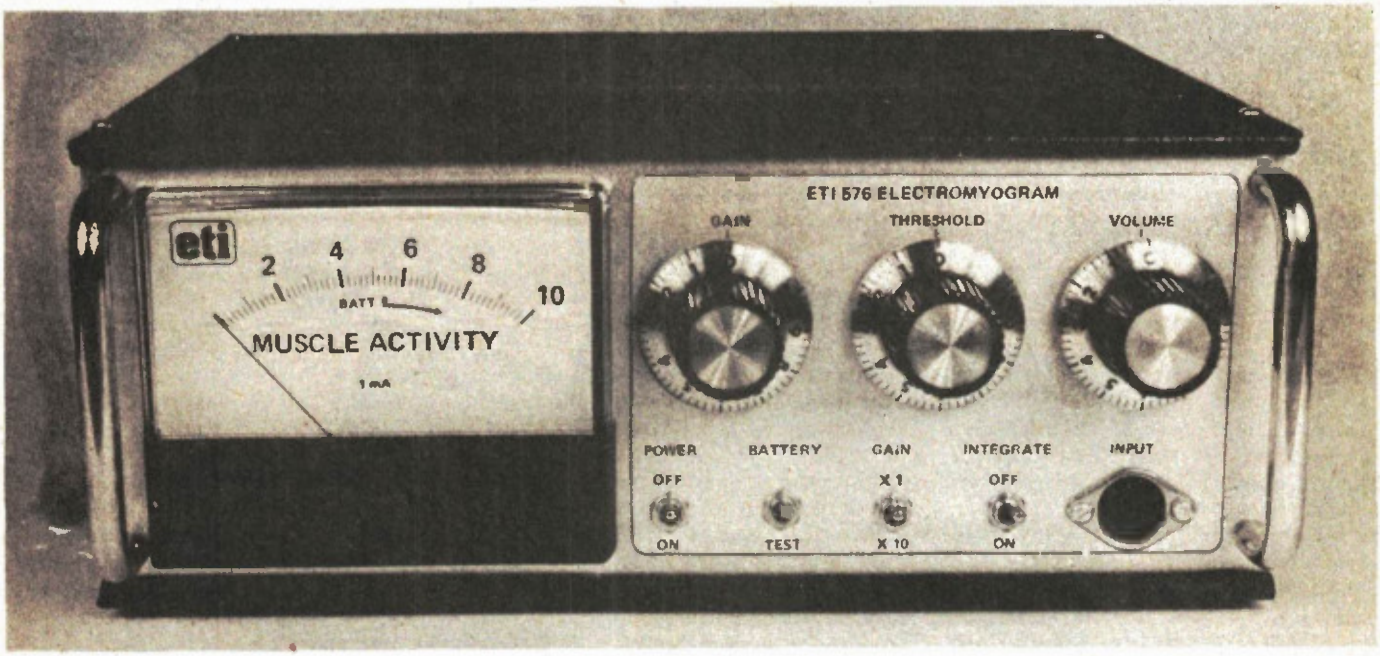
BSR can reached by writing to P.O. Box 7003, Stn. B, 26 Clairville Dr., Rexdale, Ont. M9V 4B3, phone (416) 675-2425

Dealers meet Bang & Olufsen chief engineer.

Electromyogram part I

David Tilbrook

This unit senses the tiny electrical impulses associated with muscle activity and provides an indication of this activity via a meter and a sound output. The latter is a series of pulses, the repetition rate increasing with increased muscle activity, decreasing as muscle activity declines. It may be used to 'train' particular muscles or to learn effective relaxation.



AT THE SUGGESTION of Tom Benjamin, author of the biofeedback feature on page 36 elsewhere in this issue. An electromyogram project was investigated to go hand in hand with the feature on the premise that it's frustrating to read about something that you can't follow up with some practical experiments!

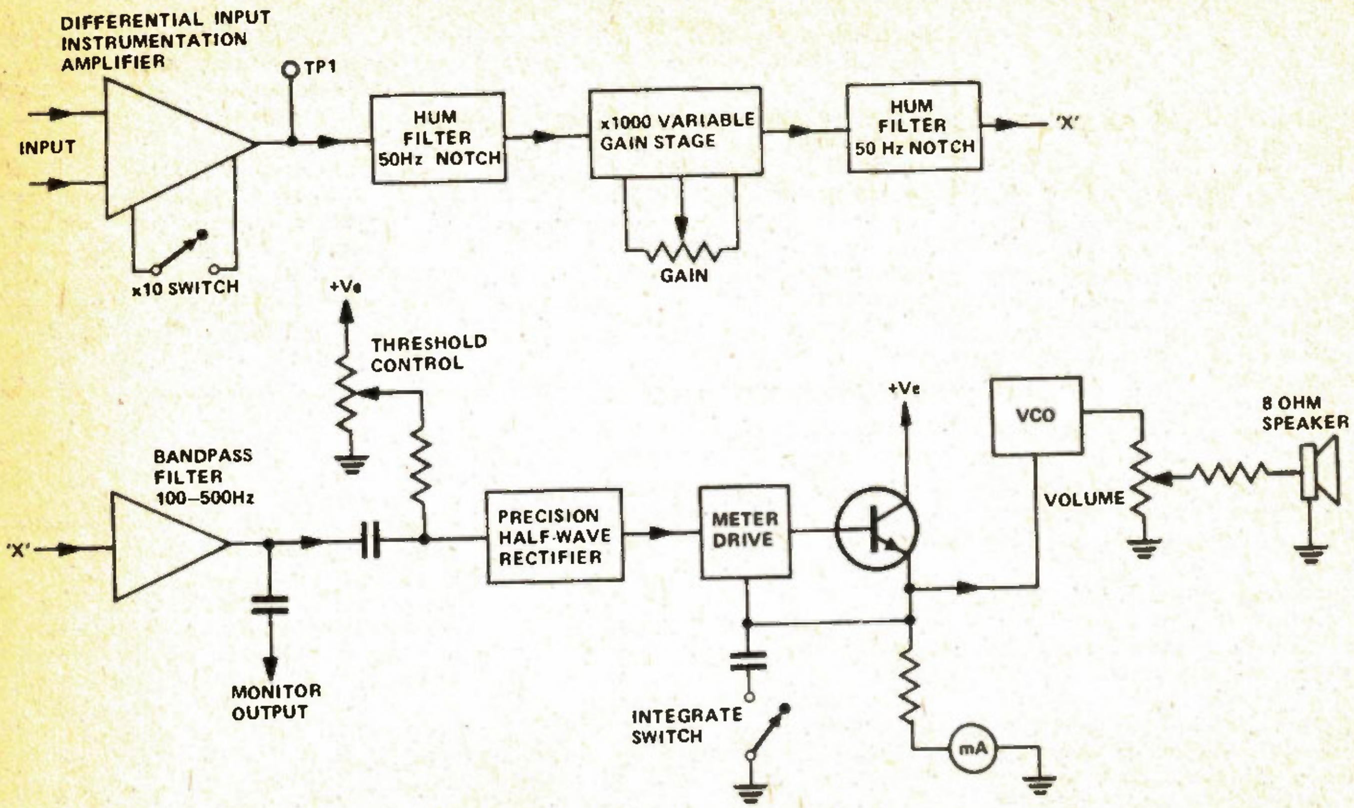
I tackled this project with some enthusiasm as it presented a range of interesting design problems as well as having some pretty tough specifications to meet if the unit was to be at all useful. There's nothing like a challenge to stimulate a little creativity!

Before going on to the construction and setting up of the instrument, you may be interested in seeing how this design evolved and why particular circuit techniques were used.

DESIGN PROBLEMS

The design and construction of an electromyogram presents some unique problems.

The object is to detect the minute electrical signals produced by the 'firing' of muscle fibres in a particular muscle. For our purpose metal electrodes of some sort are attached to the skin over the muscle(s) of interest. For a relaxed muscle, these signals are fractions of a microvolt in amplitude. That's a small



enough signal to detect on its own without having to find it amongst *volts* of 60 Hz hum that will be present in the body — induced from power and light wiring. Of course, you could do these measurements in the middle of the Gibson Desert but that's not always convenient! You only have to touch your finger to the input of an oscilloscope to get an idea of the magnitude of the hum induced onto the body.

When the body is grounded, this hum will drop to typically one volt peak-to-peak, but trying to see one microvolt in 1 volt of unwanted noise (60 Hz hum here) sure isn't easy.

The overall block diagram of the unit is shown in the drawing here.

Battery operation is essential as, with any device connected directly to the body, the possibility of accidental contact with line potential from a line-operated unit is very real— with lethal results.

Under no circumstances should this unit be used with any form of AC adaptor. Always restrict use to battery operation. The low electrode to skin resistance required will substantially reduce the potential that can cause shock and possible heart fibrillation.

The instrument is called upon to detect quite small signals in the presence of large amounts of noise. It should have variable gain control — adjustable by the user, a threshold control so that small variations of a large signal may be readily detected, a visual indication (a meter) and an audible output that follows the convention of rising pitch or pulse rate for increasing muscle activity, and vice versa. Tom Benjamin also mentions some form of bandpass filtering to sort out the predominant muscle signal which is in the 100 Hz to 500 Hz range. Selectable integration of the feedback response is also considered desirable.

First thing was to tackle the hum problem. To overcome this, a number of techniques have been employed. Firstly, I have used a differential amplifier for the input stage. This type of circuit has two input terminals. Signals on the inputs that are *out of phase* will be amplified and passed to the output, while signals that are *in phase* (called common mode signals) will be rejected. The amount of rejection is determined by the amplitude of each in-phase signal. As, in this application, the two inputs are connected to the skin, they will each receive hum signals in phase and of similar amplitude and thus be rejected to a large extent. The amount of rejection of a common mode signal is called the common mode rejection ratio (CMRR).

Most IC operational amplifiers are of the differential input type. A typical op-amp IC has a CMRR of about 90 dB — which means that any common-mode signal will be reduced by a factor of about 30,000. This is good in theory but, in practise, the use of 5% resistors in circuits results in a CMRR of around 60 dB, which is not good enough.

The differential input stage was the most difficult portion of the circuit to design as it was required to have a very high CMRR, a high input impedance and very low noise. Naturally, the home constructor should be able to reproduce the performance of our prototype, preferably without going to a lot of trouble selecting special components or through elaborate set-up procedures. I managed to achieve all these design goals — after discarding several circuits!

The need for a high input impedance is a much-debated subject. Some commercial EMG's boast input

ELECTROMYOGRAM SPECIFICATIONS

Equivalent input noise	150 nV (0.15 uV)
Minimum 60 Hz rejection	80 dB (irrespective of common mode rejection)
Common Mode Rejection Ratio	100 dB or better
Input impedance	220 k
Bandwidth	100 Hz to 500 Hz
Audio output	Variable repetition rate pulse output from inbuilt loud-speaker.
Power source	two 9 V batteries
Power consumption	20 mA per battery
Battery check	battery check switch indicates condition of batteries on meter

impedances as high as 1000 M! The reason is to reduce the effect of poor electrical contact between the electrodes and the skin. In a 1000 M input impedance a few thousand ohms difference between the electrode input impedances (that is, from each electrode to the instrument common or 'ground') goes unnoticed as it represents such a small percentage of the unit's input impedance. Input impedances in this order necessitate MOSFET devices which are relatively noisy in comparison with bipolar transistors at these frequencies.

I elected to use a much lower input impedance and to optimise the noise figure. This has the added advantage that readily available transistors could be used for the input stage.

The input impedance is limited by the base bias resistors of the input stage — in this case, 220 k for each input. At this input impedance, differences in electrode contact resistance with the skin are important, so care should be exercised to minimise this when attaching them.

Biasing the differential input stage is important and this is discussed in the "How it Works" section. One trimpot is used to set up the input stage for correct operation. Once set up, any of the component values may be varied by +/− 10% without affecting the CMRR.

Gain of the input stage is about 1000 (60 dB). Common mode signals will be reduced by the CMRR (about 100 dB, or better), the exact amount of reduction depending on the electrode attachment, as just mentioned, but the CMRR can be degraded quite a bit by this before it becomes a real problem. We experienced little difficulty attaching dry electrodes to dry skin on the forearm.

The choice of this type of first stage has resulted in a very low noise figure. The prototypes (we built two) had measured noise figures close to 150 nV (0.15 uV) at the input. This equals the performance of the best commerical units we have seen.

Immediately following the input stage is a 60 Hz notch filter to offset any increase in hum pickup due to contact resistance variations.

There are two hum filters, we'll get around to the second shortly.

From the first hum filter the signal goes to a variable gain stage. This employs a 741 op-amp, the gain of which is controlled by a potentiometer mounted on the front panel. Gain is variable between 10 and 1000. This stage is fairly straightforward, although the circuit is a little unusual. See "How it Works" for a complete description.

Following this stage is the second hum filter, immediately preceeding the bandpass filter. Signal levels at this stage are around one volt, excess hum on top of this can cause clipping and severe distortion in the succeeding stages.

The bandpass filter is centred at 250 Hz, around the middle of the frequency range of interest. Output from the firing muscle fibres consist of a broad 'noise' signal extending from a little below 100 Hz to about 1 kHz, although the largest amplitude portion of the muscle signal spectrum is between 100 Hz and 500 Hz. The bandpass filter attenuates noise and other signals outside the main area of interest, improving the signal to noise ratio of the instrument.

The output of the bandpass filter is available as a 'monitor output', via a coax socket on the rear panel of the instrument. This enables you to monitor the signal directly using an oscilloscope or via an audio amplifier.

To provide the required audible and visual feedback indications, the signals must undergo some processing to control the appropriate outputs.

From the bandpass filter the signal is mixed with a dc voltage that is varied by means of the Threshold control on the front panel, then fed to a precision half-wave rectifier. This stage tectifies any (ac) signal above the dc voltage set by the Threshold control. By setting the threshold just above the level of noise present, very small changes in muscle activity are made readily apparent. The output of this stage is a series of positive-going pulses from the muscle fibre signal.

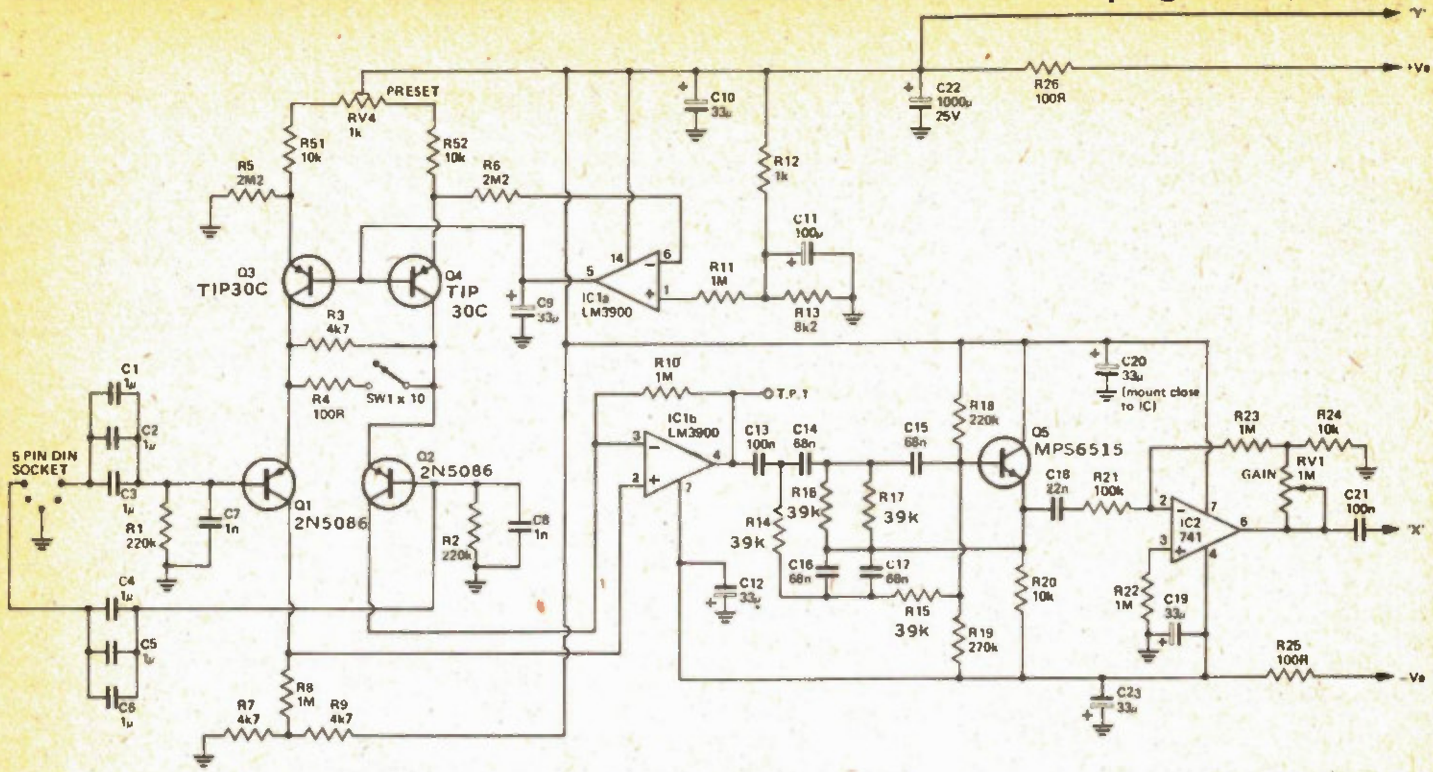
The meter drive stage follows the precision rectifier. This employs a 741 op-amp and an emitter follower stage with negative feedback from the emitter of the transistor. The positive-going pulses from the rectifier stage charge a capacitor, the voltage on this being a measure of the muscle activity as the signal varies above the threshold while the muscle is active.

To provide some integration of the muscle activity level, so that the meter and audible responses are not too rapid (as researchers have found undesirable in some instances), switched capacitors are provided at this point to provide integration times of about 0.5 second and 4 seconds — selected by a front panel switch.

The audible output is derived from the meter drive so that it corresponds with the visual feedback response provided by the meter. This consists of a voltage-conttolled oscillator (VCO) that provides a series of pulses to drive a speaker. The VCO employs a 555 timerIC.

Originally, it was intended to use a tone for the audio output. However, battery consumption on the prototype was almost 150 mA — at best! Battery life would be very limited at this consumption. A class A audio output stage is necessary to provide a tone output, and these are quite inefficient. Using a pulse output enabled me to reduce the total current consumption to 20 mA.

Construction details and how to use the machine will appear next issue . . . acts of God, gremlins and the fairies at the bottom of the darkroom permitting!



HOW IT WORKS

Since the circuit is fairly complex, a detailed analysis of its operation is best tackled by looking at the individual stages in turn, from input to output.

Differential input stage

Input signals from sensors on the body drive Q2 and Q1 which are arranged as a differential pair. Emitter current, and thus collector current, for Q1 and Q2 is derived from a precision constant-current source comprised of Q3, Q4 and IC1a. Transistors Q1 and Q2 share the current supplied by the constant-current source. If Q1 (for example) is driven harder, by an input signal, than Q2 then, while the collector current of Q1 increases, there will be a corresponding decrease in the collector current of Q2.

Now, the collectors of Q1 and Q2 are each connected to the input of IC1b, one amplifier in an LM3900 (a quad op-amp package). The amplifiers in the LM3900 package have the special feature that they amplify current differences applied to the inputs.

To ensure a high common-mode rejection ratio, the quiescent (no signal) collector currents of Q1 and Q2 must be held very close to a fixed amount. Hence, the precision constant-current source.

To derive this constant current source for Q1 and Q2 the two bases of Q3 and Q4 are driven by the output of IC1a. The non-inverting input (marked +) of IC1a is driven by a fixed voltage derived from a voltage divider (R12, R13) from the positive supply rail. C11 is a bypass capacitor to prevent supply rail variations modulating this reference voltage.

The inverting input (−) of IC1a is coupled to the emitter of Q4 placing this transistor in the feedback loop of IC1a. The op-amp (IC1a) will attempt to maintain the current flowing through its inputs at a constant level, thus maintaining the base-emitter current through Q4, and therefore the collector current, constant at nominally, 100 mA. Assuming Q3 has similar gain to Q4, its collector current will be the same. The 1k preset, RV4, allows adjustment of the two collector currents to offset any slight differences in gain.

The input stage gain is determined by the value of the resistance between the emitters of Q1 and Q2. The lower this resistance, the higher the gain. The 'x 10' switch simply connects a 100 ohm resistor in parallel with R3, increasing the gain.

Capacitors C7 and C8 ensure high frequency stability through bypassing the bases of Q1 and Q2 at frequencies above the range of interest.

To ensure good common-mode rejection ratio, it is essential that the bases of Q1 and Q2 each receive the *same* level of input signal. As the input is ac-coupled the characteristics of the input coupling capacitors must closely match each other. If stranded 10% capacitors are used the slightly different impedances of each will limit the common mode rejection. The solution we adopted was to use several capacitors in parallel so that the slight capacitance variations, and corresponding impedance variations, average out. It is important therefore that these six capacitors, C1-C6, are all the same type.

Supply rail decoupling for the input stages is provided by R25, R26 and C22, C23.

The hum filters

Two 60 Hz hum filters are employed, as can be seen in the block diagram, one immediately following the differential input stage, the other between the variable gain stage and the band-pass filter.

Both 60 Hz filters employ a 'twin-T' circuit.

In the first hum filter, Q5 is connected as an emitter follower, the twin-T components connected to provide feedback at 60 Hz. In order to obtain a high circuit Q and thus good rejection at 60 Hz, the value of the resistance formed by R16 and R17 (parallelled) must be as close as possible to half the value of R14 and R15. As the latter are 47k resistors, the best way to obtain a value of half that is to connect two 47 k resistors in parallel.

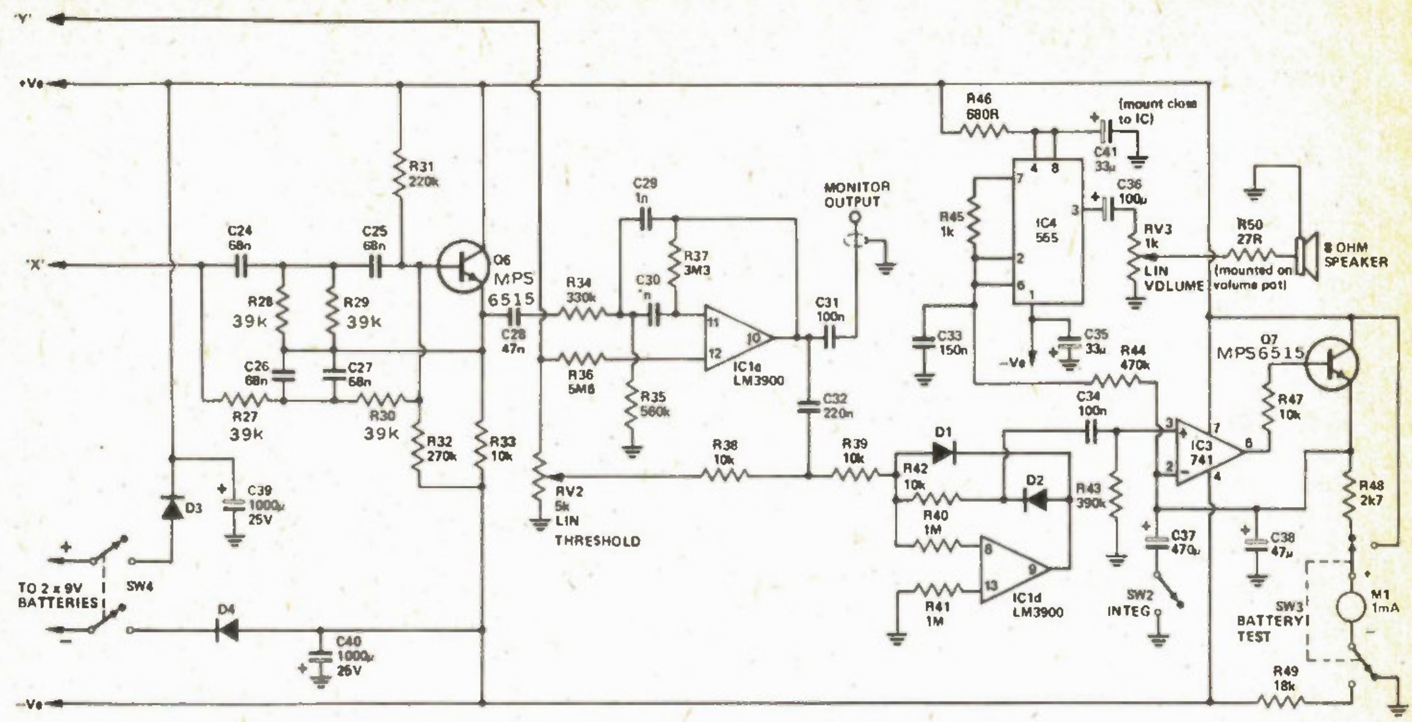
Similarly, for the second hum filter, Q6 is the active component and the filter consists of C24, 25, 26, 27 and R27, 28, 29 and 30. Resistors R28 and 29 form a resistance half that of R27 and 30 to provide good rejection at the notch frequency.

These stages provide a total of 20 dB rejection at 50 Hz.

Variable gain stage

Following the first hum filter is a variable gain stage employing a 741 op-amp. This is quite a conventional amplifier, gain variation being provided by RV1, a 1M potentiometer connected in the feedback path of the 741. RV1 is a front panel control. Gain is variable between 10 and 1000.

To avoid problems arising from large output offset voltages and unstable gain settings, the feedback for the 741 has been arranged via a voltage divider consisting of R23 and R24, the gain potentiometer being connected between the op-amp



output and the junction of these two resistors.

The gain of the circuits is given by the equation:

$$GAIN = \frac{R_{23} + \frac{R_{23}\,RV1}{R_{24}} + RV1}{R_{21}}$$

Bandpass filter

Signal levels at the output of the variable gain stage are around 1 V. Any hum exceeding this level could easily cause clipping in succeeding stages and the purpose of the second hum filter is to prevent this.

The bandpass filter employs one op-amp from the LM3900 package, IC1c. A filter network, consisting of R34, R35 and R37 and C29 and C30, is connected around a feedback path between the op-amp output and its inverting input. This provides a bandpass extending from 100 Hz to 500 Hz which encompasses the range of interest for the muscle fibre signals. At midband (250 Hz), the gain of this stage is roughly four.

A monitor output is taken from the output of IC1c so that the muscle activity waveforms (filtered) may be viewed on an oscilloscope if desired.

Threshold control

This consists of a precision rectifier that passes only the positive peaks of the signal that are greater than a preset dc voltage — determined by potentiometer, the threshold control on the front panel.

The output of the bandpass filter is mixed with a dc voltage derived via the positive supply rail by the potentiometer RV2. The resultant signal — the ac muscle activity signal superimposed on a dc voltage — is then applied to the input of the precision rectifier. This involves IC1d, D1 and D2 and resistors R39, 40, 41 and R42. The latter two resistors convert the current-differencing input of the LM3900 into a conventional voltage-input op-amp.

Positive-going signals of less than 0.6 V above the voltage present on the junction of R39 and R40 will be amplified by the full open-loop gain of IC1d. The output of this stage increases rapidly until D2 conducts, the stage then has only unity gain (x 1), determined by the ratio of R42 and R39.

Output from the precision rectifier is taken from the cathode of D2 and will consist of the amplified, positive-going part of the muscle fibre signals that are above the positive voltage set by the threshold potentiometer, RV2.

Diode D1 ensures that the gain of the stage remains at unity gain for the negative-going portions of the muscle fibre signals from the output of IC1c.

Meter drive

This consists of an op-amp (IC3) with an emitter-follower stage (Q7) connected in the negative feedback path. The emitter of Q7 drives the meter.

The threshold stage output is coupled to the input of IC3, a 741, via a 100n capacitor, C34. Resistor R47 limits the base current of Q7 to a safe value as the 741 will provide much more current than the transistor will stand! A signal from the output of the threshold circuit will be amplified by IC3, causing Q7 to turn on, charging C38. The meter is connected to 'read' the charge on C38, via R48. The more signal that appears above the threshold, the longer Q7 will be turned on, increasing the charge in C38, thus increasing the meter reading. The circuit will respond quickly to increasing input signals, showing a corresponding increase in the meter reading. As the signal decreases, with decreasing muscle activity, the meter reading decays at a rate depending on the capacitance between the emitter of Q7 and ground. This provides for some integration of the signal level variations.

The integrate switch, SW2, connects a 470 µF capacitor C37) in parallel with C38 (47 µF). With this in circuit (integrate switch 'on'), the meter takes some four seconds to drop from full scale to zero.

Voltage-controlled pulse generator

This provides an audio output, consisting of a series of pulses, the repetition rate being an indication of muscle activity.

The emitter of Q7 is coupled to IC4, a 555 timer, via R44. Current through this resistor charges C33 until the voltage on pin 6 of IC4 reaches 2/3 of the voltage on pins 4 and 8. At this point, pin 7 of the 555, previously appearing as an open circuit, will conduct discharging C33 via R45. Once the voltage on pin 2 drops below 1/3 of that on pins 4 and 8, pin 7 returns to an open circuit condition, allowing C33 to charge again. In this manner, the 555 oscillates providing pulses on pin 3 to the speaker, via RV1 which serve as a volume control. As the voltage at the emitter of Q7 varies according to the variation in muscle activity signals, the rate at which C33 charges will vary. This varies the pulse repetition rate of the 555 oscillator in sympathy with the variations in muscle activity.

Love-o-Meter

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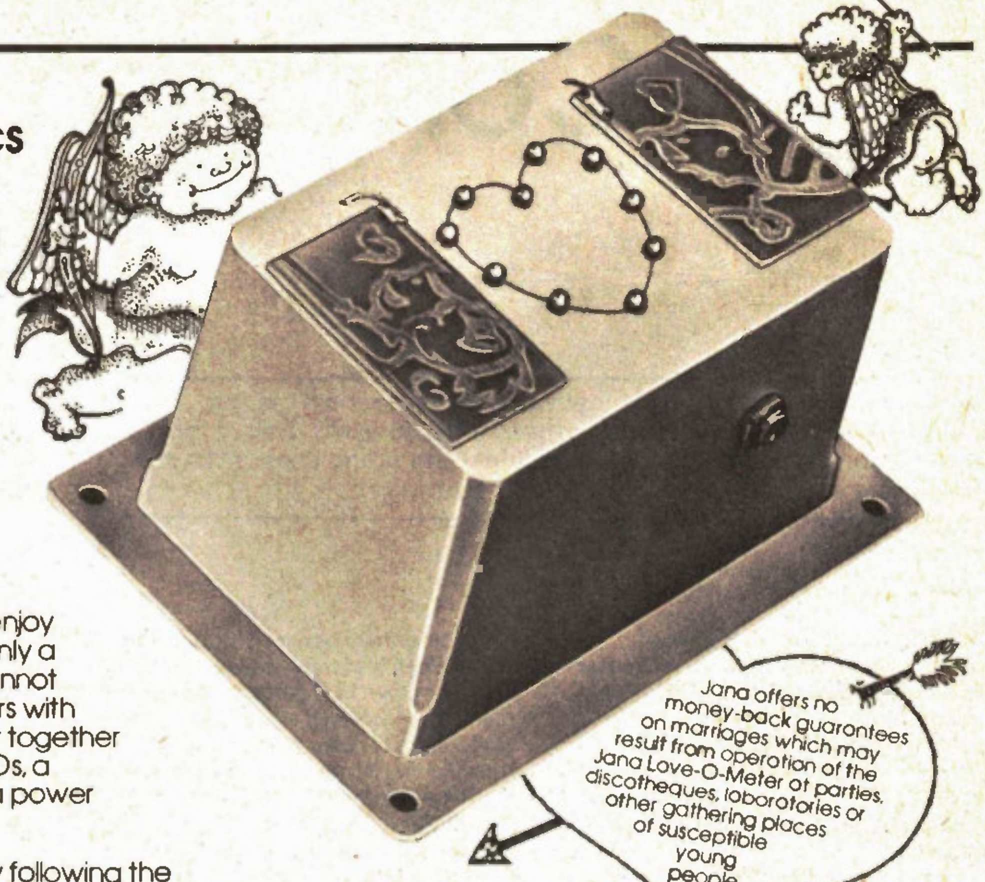

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INDUSTRIAL ELECTRONICS

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Battery Condition Indicator

Ever been caught by a battery that went flat at an embarrassing moment — like when you've just offered a friend a lift? The conversation goes a little flat when you're both riding the bus to work, 20 minutes late. Jonathan Scott found a solution . . .

THE OLD, RELIABLE lead-acid battery may be way ahead of what ever is in second place for vehicle electrical systems, but they do need a 'weather eye' kept on them. Particularly if they're out of warranty. The same applies to 'reconditioned' batteries, so often found in secondhand vehicles of some age.

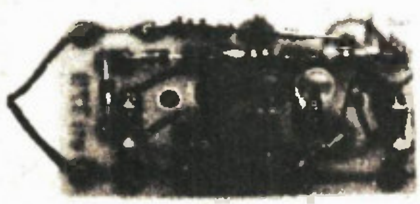
That's the problem with cars — running out of gas and running out of of battery produces the same heart-rending result. Immobility.

Most vehicles have a gas gauge. Few have an equivalent for the battery. Many 'older' cars included a 'charging current' meter. This told you something about the car's generator-regulator and required some interpretation to figure out whether the battery was in good health.

Probably the best way to check on the state of your battery is to use a hydrometer. However, hydrometers have a number of drawbacks. Being made of glass, they're fragile and can't be used while a car is in motion. The small amount of battery acid that remains on them presents a storage problem — the drips and fumes attack most metals and materials. They're okay for the corner garage but justifying their cost,for the occasional use they get in home workshops, is not always possible.

Another method of testing battery condition is by checking the voltage 'on load'. A lead-acid vehicle battery in a reasonable state of charge will have a terminal voltage under normal working load somewhere between 11.6 and 14.2 volts. When a battery shows a terminal voltage below 11.6 volts its capacity is markedly decreased and it will discharge fairly quickly. Like as not, it won't turn the starter motor for very long! On the other hand, if the voltage on load is above 14.5 volts then the battery is definitely fully charged! However, if it remains that way for any length of time while the car is on the road, the vehicle's alternator-regulator system is faulty and the battery may be damaged by overcharging.

Reading the battery voltage can be done in a number of ways. You could use a digital panel meter, set up as a voltmeter. Their drawback is that they cost nearly ten times as much as a hydrometer! The next best method is to use an 'expanded-scale voltmeter'. Reading the voltage range between 11 and 15 volts on a meter face calibrated 0-16 volts is a squint-and-peer exercise. On a 0-30 volts scale, as used on many modern multimeters, it's worse. A meter which reads between 11 volts at the low end of the scale and 16 volts at the high end is ideal. Hence, the term 'expanded-scale'.



HOW IT WORKS

This circuit depends for its operation upon the different voltage drops across different colour LEDs.

At 20 mA the voltage drops across red, yellow and green LEDs are typically 1.7, 3.0 and 2.3 volts respectively. When the vehicle battery voltage is too low to cause either ZD1/ZD2 or ZD3 to conduct, Q1 and Q2 are held off by R3 and R5. Under these conditions the yellow LED is forward biased and conducts via D1 producing a potential of about 3.7 volts at point A (see circuit diagram). When the supply rises above about 11.6 volts ZD3 conducts, biasing Q2 on. By virtue of its lower voltage requirements the green LED conducts, reducing the voltage at point A to approximately 2.6 volts. This is not enough to bias D1/LED3 on, so the yellow LED goes off. The green LED 'steals' the bias from the yellow LED. When the supply rises above about 14.2 volts, Q1 is biased on and the red LED 'steals' the bias from the green. The potential at point A falls to two volts and only the red LED conducts.

R1 limits the current through the LEDs. R2 and R4 limit the base currents into Q1 and Q2.

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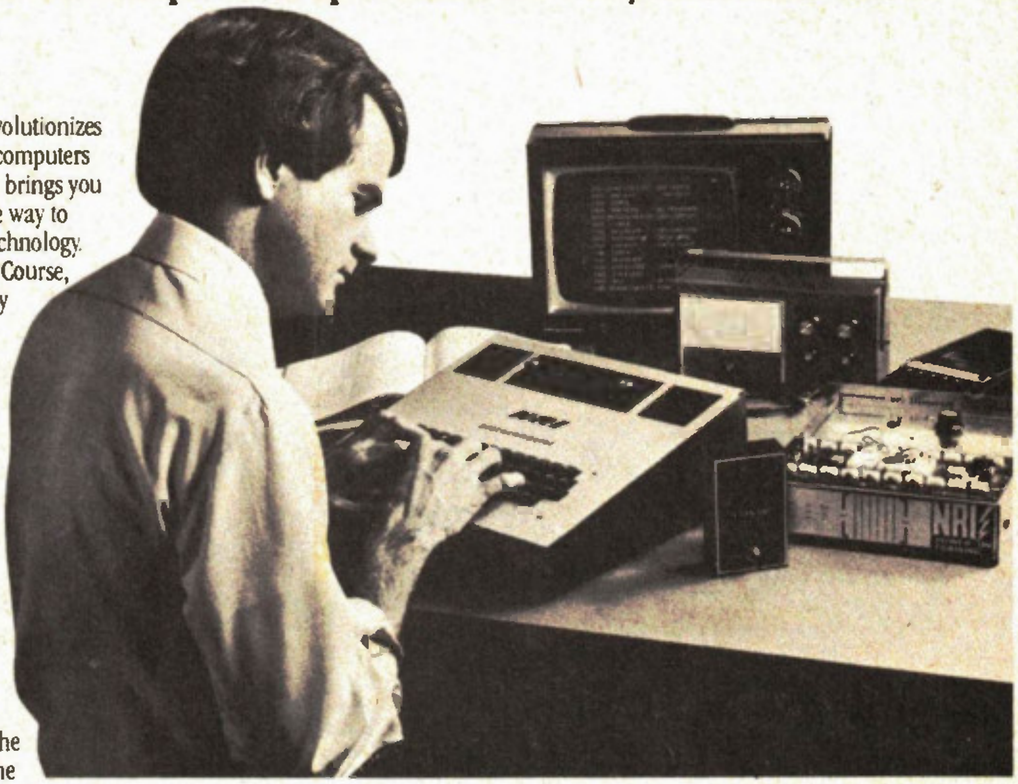

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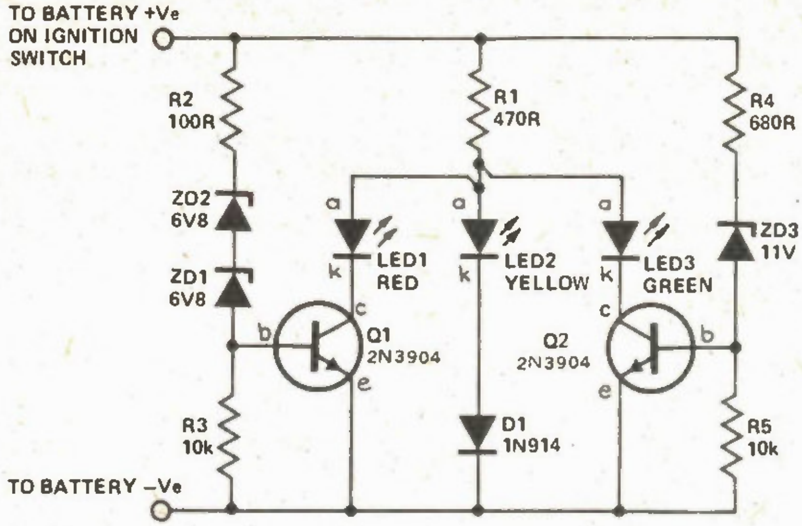
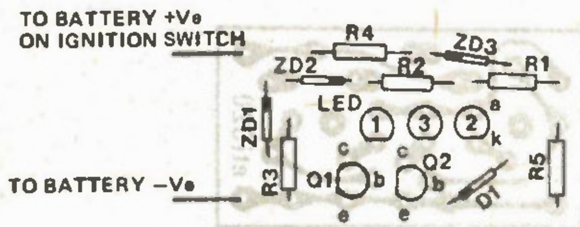
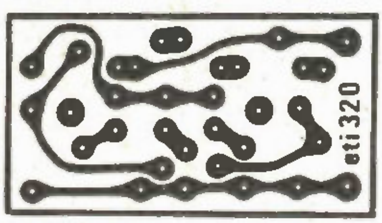


The circuit diagram and component overlay (below). During construction, make sure all of the diodes and LEDs are the right way round.





The printed circuit board pattern

PARTS LIST

RESISTORS all ¼W 5%

R1 . . . . . . 470R
R2 . . . . . . 100R
R3, R5 . . . . 10k
R4 . . . . . . 680R

SEMICONDUCTORS

D1 . . . . . . 1N914
ZD1, ZD2 . . 6V8 400 mW zener
ZD3. . . . . . 11V 400 mW zener
Q1, Q2 . . . . 2N3904 or common silicon NPN type

MISCELLANEOUS
pcb ETI 320

PROBLEMS? NEED PCBs? Before you write to us, read Project File through carefully. You may find the information you need and save time.

However, you don't want to be peering at a meter on the dash board when you're driving through traffic. The range of voltage over which your battery is healthy is some two volts. An indicator which simply requires the occasional glance, and needs no 'interpretation', is what is really needed.

With this project, that's exactly what we've done.

GO, CAUTION, STOP

We have devised a simple circuit that indicates as follows:

Yellow: battery 'low'
Green: battery okay
Red: battery overcharging

When the battery voltage is below 11.6 volts, a yellow indicator lights. This indicates the battery is most likely undercharged or a heavy load (such as high power driving lights) is drawing excess current. When it is between 11.7 and about 14.2 volts the green indicator lights, letting you know all is sweet. If the red indicator lights, as it will if the voltage rises above 14.2 volts, maybe the vehicle's voltage regulator needs adjusting or there is some other problem.

THE CIRCUIT

The circuit is ingeniously simple, having barely a handful of parts. Reliability should be excellent.

We actually started out with a somewhat complex circuit. It used only two indicators and required you to 'interpret' what was happening. In trying to convert that to a yellow-green-red style of indication it sort of grew like topsy. This circuit had four transistors, a dozen resistors etc and didn't look at all attractive as a simple project that the average hobbyist or even handyman could build one Saturday afternoon and get going immediately. A rival circuit was devised by another staff member using a common IC. This sparked a controversy as to which was the better! Certainly, both did the job required . . . but maybe there was a simpler method.

It was discovered that different coloured light emitting diodes (LEDs), which we had decided to use for the indicators in the project, had different voltage drops when run at the same current. Seizing on this idea, the original circuit (four transistors, a dozen resistors . . .) was modified to exploit this characteristic and the simple circuit you see here was the result.

CONSTRUCTION

Construction is straightforward. If you haven't soldered electronic components before — and this project was designed for the motorist/handyman as well as electronics enthusiasts — then we suggest you practice on something before tackling this project.

We recommend you use the printed circuit board designed for this project. The actual layout of the components themselves is not critical but a printed circuit board reduces the possibility of errors.

It is best to mount and solder the resistors first. Follow this by soldering in the diodes D1 and the zener diodes ZD1, ZD2 and ZD3. Carefully follow the accompanying component overlay making sure the diodes are all inserted the correct way around. Next, mount the transistors, again referring to the overlay, checking to see they are inserted correctly before soldering.

Finally, mount the light emitting diodes. These too may only be inserted one way. Check with the component overlay and connection diagrams. Make sure they are in the correct sequence. On the component overlay, LED 1 is the red LED, located at the left. The yellow LED is on the right, marked with a '2'. The green LED, marked '3' is between them.

The circuit could be tested at this stage if you have a variable power supply, or access to one. Simply vary the voltage across the range between 11 and 16 volts and note whether the LEDs light up in the correct sequence and close to the voltages indicated.

MOUNTING

As vehicles vary so much in dash panel layout, we can only make general suggestions.

Clearly, the indicator should be mounted such that the three LEDs are not in direct sunlight. A low part of the dash, but make sure it's readily visible from your normal driving position, will pretty well ensure the display may be easily read during the daytime. Alternatively, if you have an 'overhung' dash, or a portion which overhangs (usually where the instruments are mounted anyway), then a suitable position will generally suggest itself.

Exact mechanical details will have to be determined according to your particular situation. Two holes are provided in the pc board for mounting bolts. Alternatively, the whole assembly may be mounted from the LEDs. Three LED holders inserted through part of the dash panel, or an escutcheon plate mounted on the dash, will hold the LEDs quite securely. Providing the leads on the LEDs are fairly short, the pc board will place little strain on them and the assembly should be mechanically secure.

CONNECTION

The indicator may be installed in vehicles having positive or negative ground electrical systems.

The component overlay shows the connection for a negative ground vehicle. The 'battery+ve' lead goes to the ignition switch — the indicator only operates when the vehicle is being used — the battery negative lead should be taken to a good 'ground' point on the vehicle frame.

For a positive or negative ground vehicle, the lead marked 'battery —ve' goes to the ignition switch connection, while the 'battery +ve' lead goes to the vehicle frame.

PRB-1 DIGITAL LOGIC PROBE

- DC to > 50 MHZ
- 10 Nsec. pulse response
- 120 K Ω impedance
- Automatic pulse stretching to 50 Msec.
- Automatic resetting memory
- Open circuit detection
- Automatic threshold resetting
- Compatible with all logic families 4-15 VDC
- Range extended to 15-25 VDC with optional PA-1 adapter
- Supply O.V.P. to ± 70 VDC
- No switches/no calibration

PRB-1	DIGITAL LOGIC PROBE	$61.95

PROTOTYPE BOARD CM-100

TERMINALS 1,020 TEST POINTS 188 separate 5 point terminals plus 2 horizontal bus lines of 40 common test points each

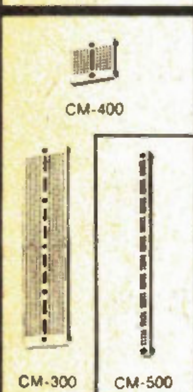
SIZE 6½" Wide 5" Long

CM-100	MODULAR PROTOTYPE BOARD	$43.45

PROTOTYPE BOARD CM-200

TERMINALS 630 TEST POINTS 94 separate 5 point terminals plus 4 bus lines of 40 common test points each SIZE 6" Wide 3½" Long

CM-200	MODULAR PROTOTYPE BOARD	$27.50


CM-400 CM-300 CM-500

PROTOTYPE BOARD CM-300, CM-400

CM-300 and CM-400 have two separated rows of five interconnected contacts each. Each pin of a DIP inserted in the strip will have four additional tie-points per pin to insert connecting wires. They accept leads and components up to .032 in. diameter. Interconnections are readily made with RW-50 Jumper Wire. All contact sockets are on a .100 in. square grid (1⅜ in. wide).

CM-300	MODULAR PROTOTYPE BOARD	$16.65
CM-400	MODULAR PROTOTYPE BOARD	$4.15

MODULAR BUS STRIP

CM-500 is a bus strip to be used in conjunction with CM-300 and CM-400 for distribution of power and common signed lines. Two separate rows of common terminals, grouped into clusters of five. All contact sockets are on a .100 in. square grid.

CM-500	MODULAR BUS STRIP	$3.29

JUMPER WIRES

50 Preformed wires, from 1½ to 4 inches, 20 AWG solid wire, white insulation.

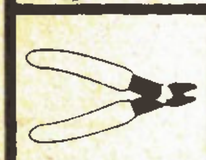
RW-50	JUMPER WIRES	$4.98

"CLIP AND STRIP" TOOL

For cutting and stripping 1 in. insulation from 30 AWG wire.

CAS-130	CLIP AND STRIP	$3.55

THE ABOVE CUT AND STRIP TOOL IS NOT APPLICABLE FOR MYLENE OR TEFLON INSULATION



MINI SHEAR

MS-10	MINI-SHEAR	$8.95

MINI SHEAR WITH SAFETY CLIP

MS-20	MINI-SHEAR WITH CLIP	$10.75

VACUUM VISE

ABS construction. 1½ in. wide jaws.

VV-1	VACUUM VISE	$5.85

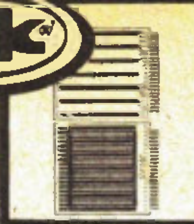
WIRE WRAPPING KITS WK-2, WK-3, WK-4

WK-2-B	WIRE-WRAPPING KIT (BLUE)	$20.95
WK-2-Y	WIRE-WRAPPING KIT (YELLOW)	$20.95
WK-2-W	WIRE-WRAPPING KIT (WHITE)	$20.95
WK-2-R	WIRE-WRAPPING KIT (RED)	$20.95
WK-3B (BLUE)	WIRE-WRAPPING KIT	$27.35
WK-4B (BLUE)	WIRE-WRAPPING KIT	$41.90

WIRE WRAPPING KIT WK-5

BW-630, WSU-30M, CON-1, EX-1, INS-1416, TRS-2, MS-20, 14, 16, 24 and 40 DIP sockets, WWT-1, WD-30-TR1, H-PCB-1.

WK-5	WIRE-WRAPPING KIT	$120.85



PC BOARD

4 x 4.5 x 1/16 in. board, glass coated EPOXY laminate, solder coated 1 oz. copper pads. The board has provision for a 22/44 two sided edge connector, .156 in. spacing. Edge contacts are non-dedicated for maximum flexibility.

The board contains a matrix of .040 in. diameter holes on .100 in. centers. Component side contains 76 two-hole pads.

Two independent bus systems are provided for voltage and ground on both sides of the board.

H-PCB-1	HOBBY BOARD	$9.00

TERMINAL BOARD

.062 thick glass coated epoxy laminate. Outside dimensions 6.3 in. x 3.94 in. Not plated.

A-PC-01	TERMINAL BOARD	$5.79

PC BOARD

Same specifications as A-PC-01 except matrix pattern is copper plated and solder coated on one side.

A-PC-02	PRINTED CIRCUIT BOARD	$9.95

PC BOARD

Same specifications as A-PC-01. Each line of holes is connected with copper plated and solder coated parallel strips on one side.

A-PC-03	PRINTED CIRCUIT BOARD	$9.95

PC BOARD

Same specifications as A-PC-01. One side has horizontal copper strips, solder coated. Second side has vertical parallel bars.

A-PC-04	PRINTED CIRCUIT BOARD	$13.30

PC BOARD

The A-PC-05 features numbered contacts for easy reference along with a numbered matrix for easy hole locations. Made of .062 in. thick epoxy laminate. 4.5 in. x 5 in. Edge Connector Board.

A-PC-05	PRINTED CIRCUIT BOARD	$9.15

Same as A-PC-05 except outside dimensions are 4.5 in. x 6.5 in. Edge Connector Board.

A-PC-06	PRINTED CIRCUIT BOARD	$11.65

Same as A-PC-05 except outside dimensions are 4.5 in. x 7 in. Edge Connector Board.

A-PC-07	PRINTED CIRCUIT BOARD	$14.99

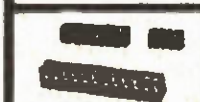
TERMINALS

WWT-1	SLOTTED TERMINAL	$5.39
WWT-2	SINGLE SIDED TERMINAL	$5.39
WWT-3	IC SOCKET TERMINAL	$7.20
WWT-4	DOUBLE SIDED TERMINAL	$3.59

TERMINAL INSERTING TOOL

For inserting WWT-1, -2, -3 and -4 terminals.

INS-1	INSERTING TOOL	$4.50



P.C.B. TERMINAL STRIPS

TS-4	4-POLE	$2.50
TS-8	8-POLE	$3.40
TS-12	12-POLE	$4.69

MODULAR TERMINAL STRIPS

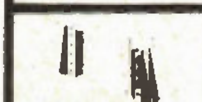
TS-6MO	2-POLE	$3.00

(3 per Package)

PC CARD GUIDES

TR-1	CARD GUIDES	$3.40

QUANTITY — ONE PAIR (2 PCS.)



PC CARD GUIDES & BRACKETS

TRS-2	GUIDES & BRACKETS	$6.85

QUANTITY — ONE SET (4 PCS.)

PC EDGE CONNECTOR

44 pin, dual read-out, .156 in. spacing, wire-wrapping.

CON-1	P.C. EDGE CONNECTOR	$6.35

Available at your nearest Electronics Parts Distributor   Write for complete OK Machine & Tool catalogue

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Circle No. 6 on Reader Service Card.

Wire Tracer

ETI's latest offering to the DIY person: a wire tracer that will find wires that other tracers cannot find.

IF YOU HAVE EVER done a complete or partial rewire of a house, or have found yourself lumbered with jobs like drilling holes or knocking masonry nails into interior walls, you'll appreciate just how useful and reassuring it can be to know exactly where live wiring is hidden beneath the wall plaster. ETI's wire tracer is designed to help give you that reassurance and will help you trace those hidden wires that most other 'seekers' can not find. No licence is needed to operate the device.

BFO TRACER

There are two basic types of line seeking device. The most common of these is the BFO metal-detecting type of unit. Fig. 1 shows the circuit diagram of one simple version of this type of device, which in this case is supposed to be used in conjunction with a hand-held pocket radio. The fig. 1 circuit is a simple L-C oscillator, tuned to about 120 kHz. Coil L1 is a long-wave aerial coil, wound on a ferrite rod.

In use, the fig. 1 circuit and the radio are both turned on and held close together. Their controls are then adjusted to obtain a beat note from the receiver. When any kind of metal comes near the end of the L1 ferrite rod it causes the inductance of the coil, and thus the frequency of the oscillator and the tone of the beat note, to change. Metal that is buried beneath plaster can thus be located by simply moving the above ferrite rod and radio slowly across the 'search' area of the plaster.

The BFO type of wire tracer is very good at locating old-style wiring that is shrouded in metal conduit, and old style metal plumbing, but is not very good at locating unshrouded cables or cables that are shrouded in modern plastic conduit. The wise handyman is never the less advised to build one of these simple units, but to build the new ETI wire tracer as well.

THE ETI WIRE TRACER

The theory behind the ETI wire tracer is quite elementary. All current-carrying wire generates a magnetic field about itself. Wiring that is carrying line current generates a magnetic field at line frequency and the intensity of the field is proportional to the magnitude of the current being carried. Line currents above a hundred milliamps or so generate quite significant magnetic fields, so live wiring can easily be traced by applying it to a load (switching on the lights, etc), and then using a field-detecting and indicating instrument to trace the

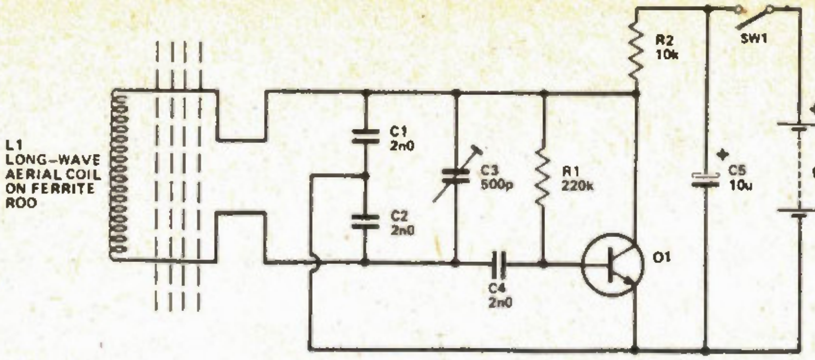


Fig.1. Circuit diagram of one simple version of a BFO metal detector.

HOW IT WORKS

THE ETI WIRE TRACER works by detecting the weak magnetic field of any current-carrying house wiring and amplifying this signal up to a level that is adequate for driving a magnetic earpiece. The unit uses a telephone pick-up coil to detect the magnetic field.

IC1 is a type-741 op-amp, biased for linear operation from a single-ended supply via potential divider R2-R4, which has its junction decoupled to AC via C1. The op-amp is configured as a variable-gain inverting amplifier, and directly drives the Q1-Q2 complementary emitter follower output stage which is used to drive a magnetic earpiece via limiting resistors R7 and R8 and via C2. Components R5, D1, D2 and R6 are used to bias Q1 and Q2 into the linear mode. Note that the Q1, 2 stage is incorporated in the negative feedback loop of the op-amp.

The input to pin 2 of the op-amp is derived from a telephone pick-up coil, which is highly sensitive to magnetic fields and typically has an impedance in the order of 1k to 5k. The overall voltage gain of the circuit is approximately equal to the ratio of this impedance to that of the R1-RV1 negative feedback network and typically can be varied from near unity to about 50 dB via RV1. This degree of gain is sufficient to produce strong audible signals in the earpiece even from quite weak magnetic fields in the vicinity of the pick-up coil.

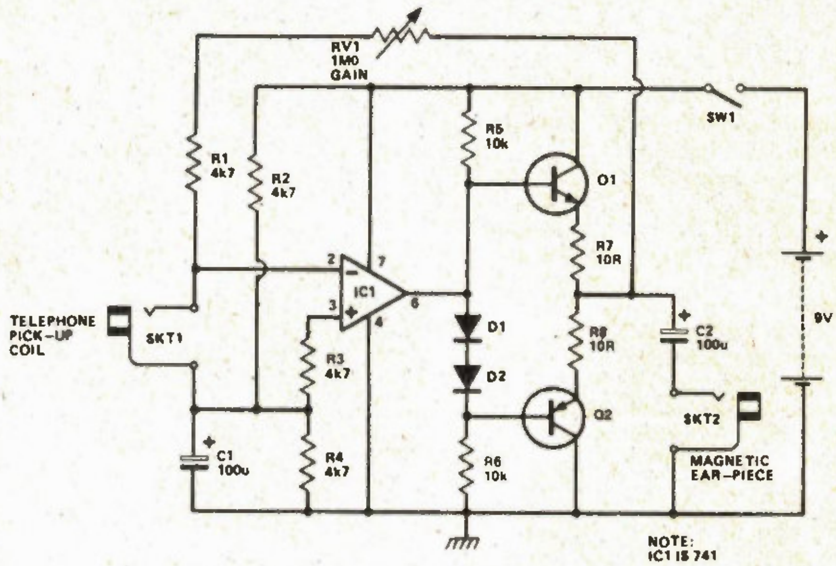
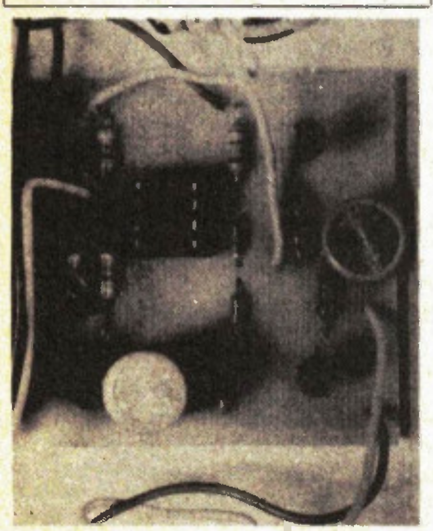


Fig.2. Circuit diagram of the ETI Wire Tracer.



PROBLEMS? NEED PCBs? Before you write to us, read Project File through carefully. You may find the information you need and save time.

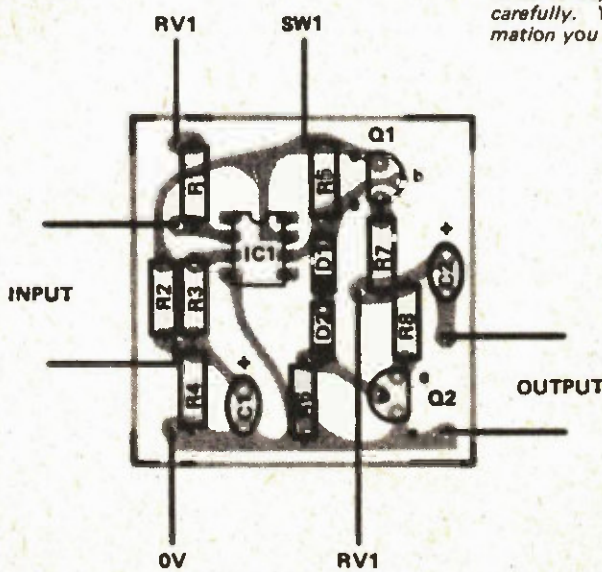


Fig.3. Component overlay.

PARTS LIST

RESISTORS

R1, 2, 3, 4	4k7
R5, 6	10k
R7, 8	10R

CAPACITORS

C1, 2	100p

POTENTIOMETERS

RV1	1M0 lin

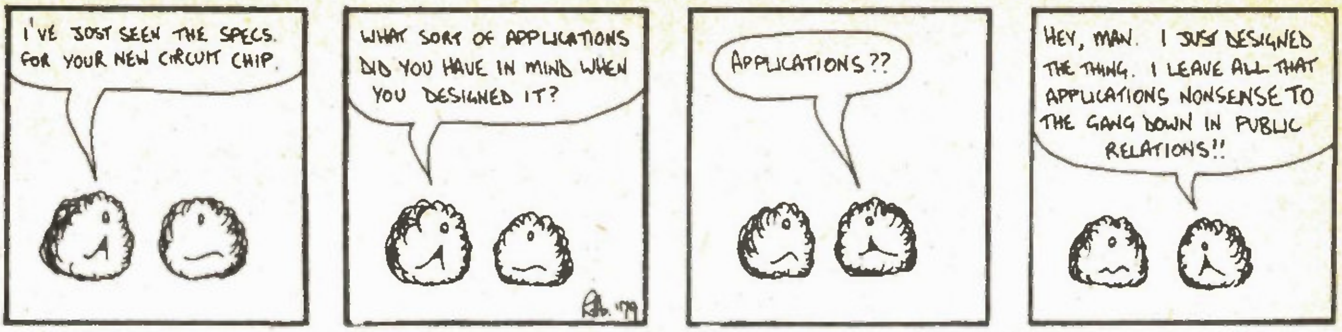
SEMICONDUCTORS

Q1	MPS 6515
Q2	2N3906
IC1	741
D1, 2	IN4148

MISCELLANEOUS

SW1	SPST
2	3.5mm jack sockets

Case to suit
telephone pick-up coil
personal earphone 8Ω



Wire Tracer

wiring route.

In the ETI wire tracer we use a standard telephone pick-up coil (as used with tape recorders) to detect the line frequency signal, which is then amplified and fed to a magnetic earpiece via a variable high-gain op-amp and transistor stage. The resulting instrument easily traces buried cables that are either unshrouded or are buried in plastic or non-ferrous conduit, or are hidden in non-ferrous metal channelling, but is not so good at tracing cables that are shrouded in old-style ferrous conduit. Circuits of the fig. 1 type are more suitable for the latter application.

CONSTRUCTION

Construction should present no problems at all, since the circuit uses relatively few components, most of which are mounted on the PCB.

We housed our prototype unit in a plastic case with outside dimensions of approximately 3 × 4½ × 1½ inches, but any roughly similar case is suitable. The pick-up coil and the earpiece are connected to the unit via jack sockets.

Calcumeter Review

This month, we present a truly fascinating piece of test gear. Electro Scientific's Calcumeter 4100 uses custom MOS technology to combine a digital multimeter and scientific calculator in one hand held instrument. John Van Lierde reports.

PERHAPS the most fundamental and significant facet of science and technology has been the measurement and interpretation of physical phenomena.

Essentially scientific measurement consists of the quantitative observation of known physical characteristic followed by the appropriate translation and scaling into meaningful and useful units. This is achieved, to a degree, in all measuring devices. A clock converts the period of swinging pendulum to hands rotating across a calibrated scale. Similarly a car speedometer converts angular velocity to an angular displacement across another calibrated scale. These instruments are rather inflexible in their range of application. For example, try recalibrating a glass fever thermometer from Fahrenheit to Celsius. A ticklish proposition at best.

To bring the point closer to this article, consider the ubiquitous VOM. An indispensible instrument, yet very few offer the facility to measure Siemens (mhos) directly. You could add your own scale calibrations directly to the meter face, but this is a tedious and unsatisfactory solution. Similarly, applying the output of a temperature sensor directly to a multimeter rarely produces direct reading. Some intermediate calculation is required.

It is with these thoughts in mind that we now turn our attention to the Calcumeter 4100.

WHAT IT IS.

As the name implies, the calcumeter is a combination scientific calculator and digital multimeter. All functions are accomplished by a dedicated MPU which accepts commands from the keyboard, initiates and interprets A/D conversions, and drives an LCD display directly.

The net effect is a calculator that accepts data entry from the digital multimeter section for calculation purposes. In addition there are several preprogrammed functions, to take advantage of this.

THE DMM

For measurement purposes, the Calcumeter is an Auto ranging 3½ digit DMM capable of measuring AC and DC voltage and current directly.

To make a measurement, one merely connects the probes and depresses either the HOLD or CONT button. In CONT mode the Calcumeter will continue to make measurements until HOLD is depressed. Depressing HOLD allows only one measurement cycle.

The Calcumeter actually has six measurement ranges. When a measurement is initiated, it cycles through each range until it finds the one with the best resolution. In CONT mode it remains in the same range during each subsequent measurement cycle. The autoranging function takes several seconds to cycle through all the ranges, and a fixed range function is available to save time for repeated measurements.

Electro Scientific promises one million measurements from single 9V battery. This is accomplished by turning off the analogue section after a measurement is complete and simply holding the reading on the display. Another nifty feature is a two speed CPU clock. The clock runs at slow speed (25 kHz) during idle periods and switches to a higher speed (300 kHz) for measurements and calculations. Another advantage of battery operation is the elimination of common mode errors.

The Calcumeter also incorporates a small piezo electric transducer to generate clicks and beeps. The clicks can be heard whenever the autorange is searching at the rate of one click per range. The Calcumeter will also beep for any type of error, whether on a measurement or a calculation. It's not a very impressive sound, in fact it would be lost in any kind of noisy enviroment, but it can be disabled if it becomes unbearable.

THE CALCULATOR

The calculator itself is similar in operation to any Hewlett Packard calculator in that it uses reverse polish notation. The only difference is the absence of a LAST X key. The calculator can store five numbers, one in memory and four in the stack. In addition you can perform all four arithmetic functions directly on memory.

Another feature is variable display formats. The user has a choice of fixed scientific or engineering notation. The display formatting applies to both measurements and calculations. It should be noted that while the calculator will work with eight digits, the multimeter only produces 3½, an important consideration when calculating on measurements. Taking a measurement has essentially the same effect as using the keyboard, the numerical value is placed in the X register (which is where you want it, for you non-RPN users).

ESI did produce a really novel innovation, specifically a 2π key, which is great for reactance calculations (I usually end up keeping a 2π in memory if I'm doing any kind of AC analysis). This was definitely incorporated with engineers and technicians in mind.

One major beef, though, there's no SIN, COS or TAN key. This is understandable, since the Calcumeter was probably primarily intended as a lab and industrial instrument, but is sure would have been nice for power factor calculations. I found this disappointing as I had originally envisaged the Calcumeter as an engineer's right hand. The Calcumeter is more at home in the lab than at the drawing board.

PUTTING IT TOGETHER

The true worth of the Calcumeter, however, does not become apparent until you consider the preprogrammed functions it offers. In all, there are six such functions, they are; a scaling ability (mx + b), averaging, limits, inversion, percent deviation and decibel voltage.

The scaling function is probably the most useful. In effect, it allows you to multiply theDMM reading by a constant (m) to produce a direct reading in whatever units you choose. In addition you can introduce an additive constant (b) to cancel any offsets. This is useful for thermocouples in that you can take accurate temperature measurements directly from the display. For example the ESI Model 4120 Temperature probe has a temperature coefficient of 0.5 mV/°C (m) and requires an offset of -279°C (b). This function could also be used for strain gauges (display Newtons), photocells (candellas/m^2), or a small DC motor (RPM).

Sometimes one is required to make measurements of a noisy or unreliable source, such as perhaps a gasoline generator. Use of the averaging mode produces a reading with the effect of noise fluctuations greatly reduced. The Calcumeter will take any number of measurements (stored in memory) before displaying the final result. Measurements are made at the rate of two per second. Some caution is required in using this feature. The amount of noise removed is proportional to the square root of the number of measurements. Consequently 100 measurements adds one more digit of accuracy and one minute to the measuring period. Ten thousand measurements adds two digits at the expense of an hour and a half of measurement time.

The inverse function allows direct measurement of conductance (Siemens) by directly inverting resistance measurements. I suppose if you tried hard enough you could find a case for inverse Volts or Amperes.

The decibel voltage function is particulary useful for measuring amplifier or filter response. The reading is referenced to a predetermined input value

SPECIFICATIONS

DC Volts	
RANGE	
Full scale	
Accuracy	±(0.25% of reading + count + 50uV)
Input impedance	10M
Normal mode rejection ratio 50Hz and 60Hz	40dB
Common mode rejection ratio 1k = Rs	100dB
Overvoltage protection	1000V peak
AC Volts	
RANGE	
RANGE	
Full scale	
Accuracy	±(1% + 2 counts + 1mV at 400Hz >1% harmonic distortion) Response ±1dB from 40Hz to 10kHz
Input impedance	10M shunted with >50pF
Overvoltage protection	1000V peak
DC Current	
RANGE	
Full scale	
Accuracy	±(0.36% of reading + 1count +50uA)
Input impedance	(~ 1R6)
Overcurrent protection	0.5A (fused)
AC Current	
RANGE	
RANGE	
Full scale	
Accuracy	±(1.2% of reading + 2 count + 1mA)
Resistance	
RANGE	
Full scale	
Accuracy	±(0.30% of reading + 1 count + 0R6)
GENERAL	
Battery life, typical	160 to 3000 Hours (depends upon measurement mode)
Battery life, indicator	Display reads Error.... for battery low
Weight	400 grams (14 ounces) with battery
Dimensions	21.6cm X 8.0cm X 4.0 cm (8.5" X 3.2" X 1.5") MAX.

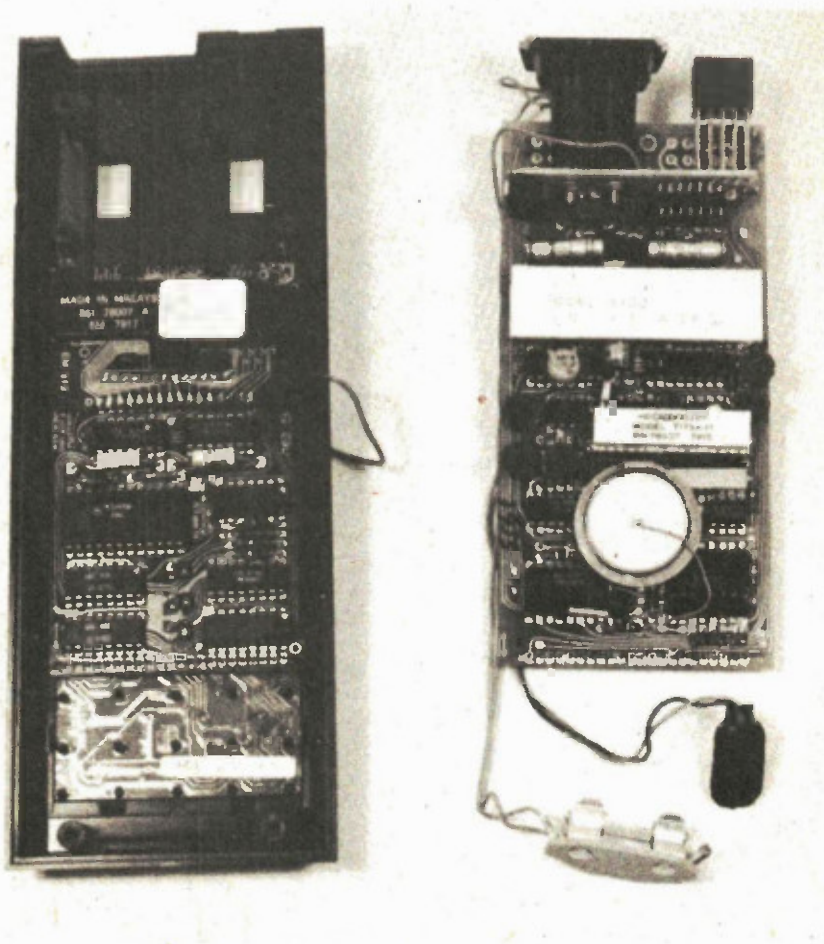


Fig. 3. Inside the Calcumeter one finds two PC boards. The one in the case carries the microprocessor and I/O interfacing and the one on the right, the A/D convertor. The round disk in the middle of the A/D board is the sound transducer. The socket at top right is the I/O interface socket.

stored in memory. With this feature you can make adjustments to an amplifier while continuously monitoring the gain (this assuming you do not change the input signal).

The final two functions, percent deviation and limits are particularly useful for comparing similar quantities.

Of the two, percent deviation is the more obvious in function. Upon taking a measurement, the display will give a percentage difference from a nominal reference stored in memory.

The limits function is the most intriguing to use. After being given nominal upper and lower bounds the Calcumeter will yield a graph like display for a given measured value (Fig. 4), the position of the bar being equivalent to the values located within the boundaries. (Pressing the DSP key, normally used for formatting, will cause the Calcumeter to temporarily display the true measured value). If the value lies outside the limits, the display will read ERROR and the beeper will sound, the latter is handy if you can't look at the Calcumeter. This function is probably the most valuable in small factories where it can be used to quickly check components to specifications and tolerances.

USING IT

The first thing one notices upon turning on the Calcumeter is total gibberish on the display. This is easily cleared up when the Shift key is pressed, but it seems odd that the machine can't initialize and clear itself upon powering up. No matter, though.

The calculator is simple and easy to use, if you know RPN. The keys click upon actuation and have a good positive feel to them.

As with the calculator, there is little one can say about the multimeter section. The clicking that accompanies the range search is useful in that it tells the Calcumeter is working (which is handy when nothing else seems to). The range setting feature is also a useful time-saving characteristic for multiple measurements.

The oddest part of getting to know the Calcumeter is having to initialize a measurement using HOLD or CONT. This is especially inconvenient if you need both hands to make a measurement. One can leave it in CONT so that it measures continuously, but this puts a larger drain on battery power (there is a way around this. ESI makes a foot switch).

While not exactly pocket size, (21.5 X 8.0 X 4.0 cm, it would stick out alot) the Calcumeter is a good size to hold in one hand. The HOLD is positioned on the left, easily reached with the left thumb.

The Owners Handbook is one of the best I've seen. Using a profusion of keyboard and display diagrams, it walks the user through all functions without being too elementary.

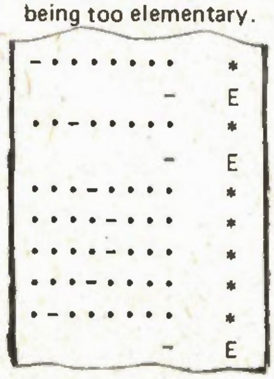


Fig.4. Printer output of the limits function. Note that the values outside limits cause error reading. The LCD display is similar.

The table of contents is very complete, and one can reference any function with very little trouble. In addition there is an excellent block description of the analog circuitry as well as schematics (the circuit description only goes up to the I/O interface, no description of keyboard, interfacing, mpu or the display is given).

ACCESSORIES

The Calcumeter itself comes complete with test probes, alligator clips and rubber case. The case (Fig. 5) is composed of two shells of moulded resilient rubber (Fig.5.) which would probably do an excellent job of protecting the Calcumeter except there is no fastener to keep it together (I used a heavy rubber band). The bottom half of the case also serves as a stand and storage for test leads, spare battery and fuse. Very few multimeters or calculators have that degree of protection and convenience in their cases. Other accessories include RF probe, temperature probe, battery adapter, 20 Amp current shunt, AC Clamp-on Current probe and so on.

A particularly useful accessory is the foot switch. Essentially it allows you to operate the HOLD button with your foot. Obviously it's really only suitable for bench work, but it's invaluable when your digging around the guts of some complicated piece of equipment.

Another useful adjunct is the Model 4142 Data Logging Printer (Fig.6.). The Printer does more than just print any Calcumeter reading, it can be set to initialize and print measurements at present intervals up to over 3 hours in length. Data is printed on standard 3½ inch adding machine paper in a 12 column format. In addition to printing numbers, the printer also has a limited character capability in that it can print units (dB, V, A, etc) along the right margin. Characters and time intervals are selected by DIP switches located on the bottom.

The printer plugs into an interface socket at the 'top-end' of the Calcumeter. This socket allows external control of the Calcumeter, direct input to the A/D convertor, and has a serial ASCII output. The latter is a significant

Fig. 6. The Model 4142 Data Logging Printer can be used for automatic monitoring over long periods of time (its MPU controlled too).

Fig. 5. Even the case is well thought out. It provides storage for test leads, spare fuse and battery and protects against drops (we didn't test that feature though).

feature. ESI is planning a RS232 ASCII and IEEE interface. These probably aren't necessary since it should be feasible to interface the Calcumeter directly to any Microcomputer. What can you say about a autoranging, fully protected A/D convertor that can convert and process Ohms, Volts and Amperes?

FINALLY

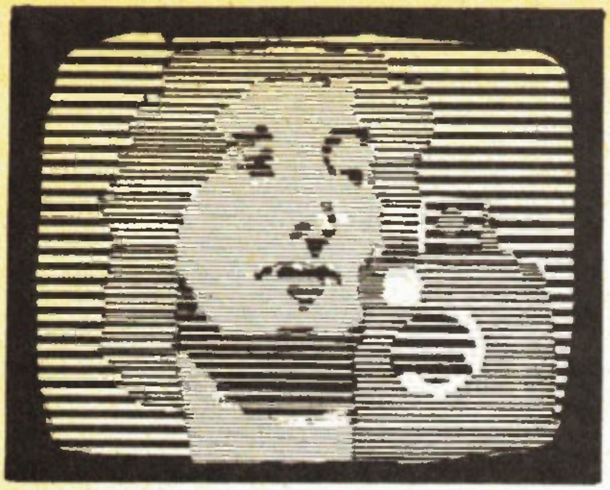
For the price, the Calcumeter isn't a feasible instrument for the hobbyist or bench technician but it is such in industry and laboratory situations where significant amounts of numerical interpretation of results is required. I would suspect that in these applications the Calcumeter could be very cost effective.

The Calcumeter itself is an incredibly well thought out and well built piece of equipment. There are some features that I feel have been passed over, but they are relatively insignificant.

The most exciting aspect of the Calcumeter is what the future promises. With any sort of luck, Calcumeter prices will start to drop, (remember digital watches?) bringing them within range of more people. Hopefully some will eventually come out with programmable ability, allowing the user greater control and telemetry capability. The Calcumeter 4100 is only the beginning.

The Calcumeter is available from Webster Instruments, Ltd., 1200 Aerowood Drive, Unit 28, Mossissauga, Ont, L4W 2S7. Price, $545.00 (CDN.) for the calcumeter itself, $434.00 for the printer, and the foot switch is a mere $59.00.

Our special thanks to Mr. Roger Webster for making a review model available to us.



WHAT'S ON

Want to get into directing but don't have a lot of money for production? Steve Rimmer tell you how to use pre producted material.

MORRIS' LAST MEAL

OUR STORY OPENS, as it has on so many previous occasions, with a dazzling full frontal shot of Morris. Now, we all know that the real Morris is actually dead; he bit the dust about a year ago. However, the animal shelters of Southern California have been mercilessly scoured and, eventually, it seems, someone did come up with another tan coloured, grossly overfed house cat, so the illusion remains. In this episode, Morris is perched upon a plush cushion in a polystyrene kitty bed looking, as always, like the director has been dabbing hash oil on his nose. From out of the ether comes a sparkling female voice, late of the dish washing soap scene. "Morris! Dindin time." Do people really talk like that?

A slightly effeminate, deeper voice intones "I think I'll be finicky." Oh, really. Like, this is supposed to be the cat talking, but I suspect it's a fake. His lips never move.

"But Morris . It's Nine Lives."

"Oh, God help me", bemoans the cat, still without actually saying much. "The last time she served that stuff it took three of mine."

"Don't be finicky, Morris, Honey", coes the lady off camera.

"I'm not home."

"Look, Morris. A nice twelve gauge double barrel shotgun." The barrel of which prods the cat in the side. I don't remember these script changes.

Cut to a clone in a suit, grasping a bottle of detergent. "Ever wasted an annoying pet with light artillery? In the living room? It can get a little messy. All that dried blood on the paint. You probably thought it would never come off. Well, here's good news. New, improved Pine Sol, with fifty percent more plasma dissolvers..."

Never seen this particular commercial on the tube? You just haven't been tuning into the right networks.

CUTTIN' N' SPLICIN'

As much creative expression can be had in editing tape as in shooting it. In fact, TV being such a rich medium, with quite a multitude of images already committed to the video format, just in terms of commercial broadcasting, a lot can be done without ever turning a camera on at all. The Saran Wrap like nature of network programming does, of course, lend itself to satire...it may be regarded as one in completeness just as it rolls off the tube...but much can be done in other genres as well. In many cases, veritable phosphor Mono Lisas can be created by doing nothing more cases, veritable phosphor Mono Lisas can be created by doing nothing more than rearranging the order of a few scenes. Soap operas, for instance, are great for this. With relatively little effort, it is possible to distil a week's worth of the Edge Of Night into a completely new melodrama. Some overdubbing of voices might prove

necessary, although real artists at this sort of thing can usually get along without it.

Imagine creating your own K-Tel commercials. "Now, for the first time ever, forty of your favourite election lies on one low priced album." Recreate the CTV National News, with Lloyd Robertson and Harvey Kirk...telling dirty jokes. Have the Ayatollah host Saturday Night Live. The possibilities are endless, not to mention probably illegal if shown in public.

Cutting *film*, to get scenes in order, is not very complicated, and most people with average eye-hand coordination can master it in a few hours. Cutting video tape, in much the same manner, is not a great deal more difficult, and most basement videophiles try it sooner or later. The main difficulty comes in watching what results.

The first problem which we encounter in editing tape is that the physical distribution of the signal on a piece of video tape is not, as in the case of film, perpendicular to the long axis. If one considers the operation of a helical scan VTR, it will become apparent that the video tracks are layed down at some angle, running diagonally across the tape. In fact, depending upon a number of variables, a single frame of the TV image may be spread out over more than six inches of longitudinal tape travel. Thus, a simple razor blade cut across the tape will pare not one but many frames, and unless the human wielding the knife is most extraordinarily lucky, the resulting union will find the overall picture, at the point of the splice, rather abysmal.

Even with the very sophisticated equipment used by studios today, "bad" tape edits are not unheard of. This is not so much sloppiness on anyone's part, but, rather, the very critical nature of the signals involved. The actual video which presents itself on the screen can be quite miserable before we'll notice it, especially if the misery is short lived, or if we're watching Mork and Mindy and thus do not notice it. (On second thought, you watch Mork and Mindy by yourself.) However, the sync information associated with said video is most fiendishly touchy. It wants to run along just so, with no sudden changes in frequency or phase, because, even though we speak of having television sets with built-in automatic frequency controls for the synced oscillators, these have extremely limited compensatory abilities when faced with abrupt disruptions. If a cheery train of pulses is coming along, triggering an oscillator and generally getting the picture together, and that train is suddenly modified, even minutely, the AFC circuitry will have to spend quite a while hunting around for a new lock. In the meantime, the screen will be rolling and guffawing in the raptures of severe picture breakup.

If one is editing together a series of four second scenes, it will be shortly observed that this can be a trifle annoying.

The key to editing video, then, is to do so with supreme concern for the preservation of a mellow and undisturbed karma about the sync pulses in the vicinity. This is not all that easy to accomplish, and a lot of ingenuity has been laid down in pursuit of a fast, clean edit.

There are two ways to edit. The first is physical editing, actually chopping tape up with a razor blade and sticking it back together with adhesive plastic stuff. The other is electronic editing, in which signals are dubbed from recorder to recorder. The former is all but unheard of in the present day, but, as might be imagined, is the precursor of contemporary electronic techniques. It also illustrates an important fundamental in the makeup of a recorded video signal.

Bedsides which, it's a good thing to know if you tape breaks.

A complete recorded video signal consists of at least three tracks. Central of these, as one migh expect, is the video information, which occupies most of the tape surface in a wide track down the middle. On either side of this lies an audio track, one carrying the sound associated with the picture, and the other carrying a control signal which provides a reference for the video head drum servos when playing back. This latter track is a genus of sync pulses, just as are the ones actually associated with the video signal. In other words, if they become disrupted during the editing process, the picture will break up too, although the cause will be the upsetting of the drum servos in the playback machine as opposed to the sync oscillators in the TV.

When making a physical edit, the prime rule is to cut between the sync pulses. However, if you hold a piece of tape up to the light, you may notice that it isn't all that easy to discern the location of said pulses. This is due to several peculiar characteristics of magnetic recording, not the least of which is that the tracks are invisible to the naked orb. In order to nail down the little trolls, it is necessary to coat the area of the area of the tape where an incision is contemplated with the solution of suspended metallic particles, which goes by the name of Edisol. Once having done this, it will be observed that the pulses are rendered marginally viewable and extremely small. Physical editing is thus performed beneath a microscope.

Having found the pulses, one can now decide which of two types of edits is called for. If a vertical cut is made so as to fall between two of the control track pulses, the resulting edit will take the form of a downward moving vertical wipe, taking a little less than two seconds, the exact time being variable from machine to machine This type of cut is relatively easy to to do, but gets to be boring after a while. on the other hand, a diagonal cut can be made so as to fall between two video tracks, and if this is properly done, if will be found that the several control tracks, line up upon splicing. The result will be an instantaneous cut between scenes. However, this type of edit is quite difficult to perform, the actual splice being a good half foot long.

The actual splice used in editing video tape is, whichever of the above techniques is involved, is quite critical. The process is no different than that which is employed with audio, except that the tape is, of course, somewhat wider. The two sections are butted together and the appropiate width of splicing material is applied to the back of the tape. However, it is essential that the two edges match perfectly, and that none of the adhesive shows through. If the video head is allowed to run over the sticky surface of the splicing tape, it will roll up its little eyes and check out permanently.

THE ELECTRONIC EQUIVALENT

Physical editing is a supreme pain.

It's deadly dull, very time consuming, and involves putting the blade to $60 rolls of tape, something I've never been too fond of. Furthermore, while it is potentially more accurate, and cleaner, than electronic techniques, considerable practice is required to be able to achieve consistently good edits. In the interim, bad physical edits are worse than no edits at all.

The alternative to the physical editing process is electronically synchronized dubbing. One can simply dub the scenes one wishes to splice thgether in the correct sequence on a second recorder. Now, in the simplest sense, this won't yield anything like clean edits, because the random blocks of video so deposited will be just askew as if they randomly spliced together. However, it must be kept in mind that while the signal source, such as a VTR playing back, is fixed, in terms of phase, the recorder which is recording the signal can modify the phase of what it is putting down on the tape with respect to the tape. If the recorder knows the phase of what is already on tape, and has the capacity to shift that phase, it can bring itself into line with an incoming signal. Confused so far?

The simplest form of electronic editing is called assembly. To make an assembly edit, on a machine equipped to do so, of course, the first scene is laid down on the tape. When it is complete the tape is wound back slightly, and the machine put into play. At the same time, the recoder having the second scene on it is also put into play, again slightly before the point where the edit is to be made. Timing is everything, and it will take some practice to get an edit just when one wants it. As the two machines are rolling, the recorder on which the finished productions is to be assembled, the recording recorder compares the phase of the signal it's playing back with that of the signal being fed into it, and juggles its head drum servos to get them to sync. Thus, when the recording recorder switches into the record mode, there will be a clean cut between scenes, with no picture breakup, because both signals were, however artifically, synchronized.

Most VTRs having assembly editing functions are also usually equipped with a second type of editing system, called insertion. Insertion is just what it sounds like; it permits dropping a new scene into the middle of an existing, longer scene without breakup either at the beginning or end of the insert.

FURTHER MOOD MODIFIERS

Now, the cosmic headspace expantion of the karmic imperceptability of the psychic flotsam that is network television broadcasting into the multi-dimensional meta-reality of your own individual spacial and temporal perception with the external oneness of electronic editing is by no means a complete entity within its limited sphere. Which is to say, you can render far more interesting modifications upon the trash on the tube than just cuttin' an' splicin'. If you can dig directing the galactic transposition of your individual polychromatic aura further into the multi-faceted orbness of the astral plane of your non-finite psyche will be expanded further toward the ever receding limitless cosmo of absolute comprehension. In other words, here's a couple of other things you can get into.

One of the very useful headspace expanders you might want to check out when fooling around with broadcast video is the capability of taking pictures of the TV screen with a videocon camera, should you happen to have one. This would permit, for instance, throwing a scene out of focus, doing some marginal cropping and exposure control and interposing silhoueted objects, such as the shotgun in the bit at the beginning of this column, between the tube and the camera.

With a bit of practice, this last technique can yield surprisingly good results. The most obivious way to go about this would seem simply to be simply aiming the camera at the TV. Sometimes this works, the only noticable result being a slight loss of resolution. Other times, such attempts are plagued with frame and retrace lines, due to the scan of the camera being out of phase with that of the broadcasted image.

For reliably decent results at this, an additional bit of hardware is required. Don't worry though. It's nothing atomic. In order to lock the camera onto the scan of the TV set, the video from the TV is fed into a "sync box", a circuit not much different from the sync separators used in TV receivers. This device strips the sync pulses from the video, cleans them up, and sends them onto to trigger the scan in the camera. The nuts and bolts involved are not excessively complicated, and we'll have a look at some circuitry in a future column.

The other thing you might want to add it titling. The generation of titles can be most easily achieved with a TV typewritter or minicomputer, should you be so endowed. If you can restict your titles to a small handful of chracters at any one time, a fairly simple, single line generator can be put together for about fifty dollars. A good start for this is the On Screen Time Generator in the September '74 issue of Radio-Electronics.

The simplest way to get titles into a production is simply to edit them in, as if they were a scene. The only severe limitation involved with this is that one cannot have them sitting over a scene. . . at least, not without further circuitry. This time, it is the timebase of the character generator which must be synchronized to whatever is producing the image to be placed under the titles. In addition to this, a circuit is required to mix the two video sources together. Once again, due to limitations of space. this will have to be dealt with sometime in the dark and distant future.

THE BIT AT THE END

Creating kamakazi video of this sort can be a lot of fun. It can also provide a small modicum of revenge for all those incessantly interrupted movies and banal situation comedies. Its single shining feature is that the worse television gets, the greater the expanding vistas of potential that will appear before anyone with a VTR and sufficient inclination... promising some really splendid material in the next few years. You can do a really poetic trip, here, about vanquishing the enemy with his own sword.

For all the satelite freaks, excuse me, phreaks, out there, there will be another bit on this fascinatingly expensive topic as soon as some data can be amassed. There has been considerable mail, much of it with postage due, requesting information on satelites of late. One of these came from a persona calling himself K. R. Daniel, PhD, which could very well be his real name, although you meet very few people with last names PhD. In any case, fictional or not, this fellow would like to contact anyone currently engaged in building a TVRO downlink. Anyone so emcumbered can contact him at the Psychology Department, Brandon University, Brandon, Manitoba R7A 6A9.

I should also mention that there was a small, however tiny error in the January video camera column. It stated that Cosmicar iris-less lenses are not supplied with any production TV cameras. In fact, it turns out that there are two super-econo surveilance cameras from the mysterious East which can be ordered with these optics. A hearty much obliged to Mark Salusbery of TeleTech for this one.

Next issue, a test pattern generator. Maybe.

If the spacial infudibulation that is the undifferentiated meta-galactic fug of karmic destiny burns the incense of the eternal guru of beneficent fate within the finite plane of your aura, *(come on Steve, give us a break, ed.)* you can catch this column here next month, same time, same station. Until then, avoid using pachouli oil for salad dressing, and stay tuned.

Circle No. 5 on Reader Service Card.

TECH TIPS

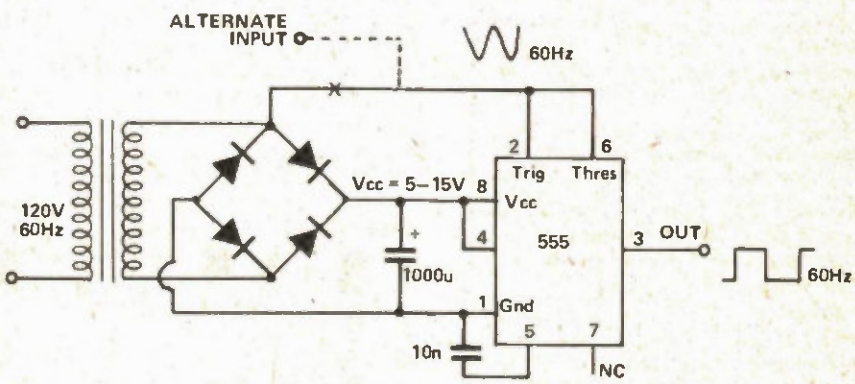
Circuits from our readers.

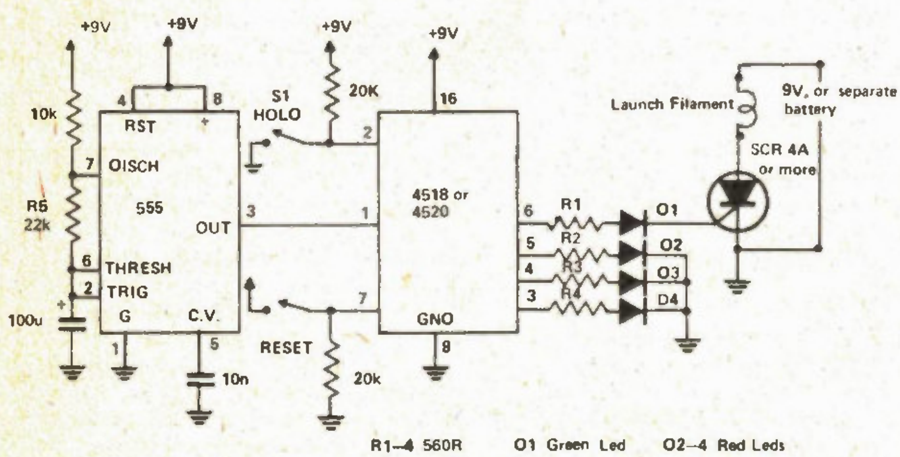
Tech Tips is an ideas forum and is not aimed at the beginner. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible, and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI Tech Tips, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1

Continued on page 46.

SINE SQUARER
Robert Maxwell, Ont.

Here is yet another use for the 555 timer IC. In the configuration show, the 555 behaves very satisfactorily as a Schmitt trigger. It is extremely useful for squaring up the 60 Hz sinewave from the AC line. On the falling portion of the sine wave, the output of the 555 goes high as the voltage reaches 1/3 Vcc at pin 2, the 'trigger' pin. When the rising portion of the input wave reaches 2/3 Vcc, pin 6 assumes that the capacitor normally present is charged, and the output goes low. The circuit is most handy for IC gates that need a fast risetime or falltime, but the project needs only one or two Schmitt triggers.





BINARY ROCKET LAUNCHER
Ray Hill, Manitoba.

This 8 second Binary Rocket Launcher is an eye catcher, simple and cheap to make. Since CMOS is used, a 5V regulated supply is not needed and low current drain allowed the prototype to run all weekend on a shelf from a 9V battery too pooped to power a small transistor radio.

Launch occurs on the eighth second as the green LED light (on the seventh second, all three reds are lit). Some change in the value of R5 may be required to obtain an exact 1 second period if desired. The circuit will run off Ve if connected via SW3.

If the 4520 is used, the period may be extended beyond 8 seconds to 16, 32 etc.

Biofeedback

Machines to aid human motor functions, or to replace functions lost through birth defects or accidents, are now able to be linked to the brain using electronic biofeedback techniques — chief among being the electromyogram, a sensor of the tiny bio-electrical impulses controling muscle activity.

"Why should we offer you a pilot's job?", asked the interviewer.
"In addition to my considerable private experience, I have superior reflexes", replied Geoff.
"But surely a desk job would be more suited to your . . . uh . . . capabilities."
"My 'handicap', you mean? . . . perhaps an old trick could help me make my point. Would you mind placing your thumb and finger on either side of this card? . . . Now see if you can catch it when I drop it . . . before it slips through . . . Ready?
Without warning, Geoff then dropped the card . . . the interviewer's fingers closed on empty space.
"Now you try it," said Geoff.
The interviewer dropped the card without warning . . . it fell about 10mm before Geoff caught it.
"Following my accident," said Geoff dispassionately, "the surgeons put me back together again . . . the engineers made some improvements . . . this is one of them. There are others . . ."

THE short story above, imaginary though it is, may very well represent a real-life situation in the not too distant future.

Geoff, the bionic pilot, isn't flying yet but our minds have been prepared for his appearance years in advance thanks to 'The Six Million Dollar Man' and 'The Bionic Woman' — souped-up, sexed-up versions of last century's Frankenstein's Monster.

BIONICS: *The emulation of biological components, 'body parts', with electro-mechanical ones with the object of their ultimate replacement.*

Today's handicapped person may sometimes feel like a "Six Dollar Man" compared with TV's Steve Austin. However, the stigma attached to prosthetic devices such as electric wheelchairs, artifical legs, and hearing aids may someday give way to the sort of intrigue and admiration we feel toward TV's growing bionic community.

From another direction, we have been increasingly prepared for the appearance of more human-like robots (see ETI January 1979). The 'droids' of *Star Wars* are the only characters beside the noble Ben who show a selfless compassion — as when C3PO offers to lend his own components to his comrade R2D2.

Thus, the media has looked at the bridge between man and machine from both ends. The engineer who builds a more human 'droid' and the biologist who creates machine-like capabilities for the human are each working towards a new species. A quite believable example from *2001: A Space Odyssey* was the Jupiter space craft complex, with its combination of human crew and HAL, the computer, vying for control of the mission. An alien spacetraveller might well have had difficulty in figuring out "Who's in charge here?" in a close encounter with this craft.

CURRENT PROGRESS IN BIONICS

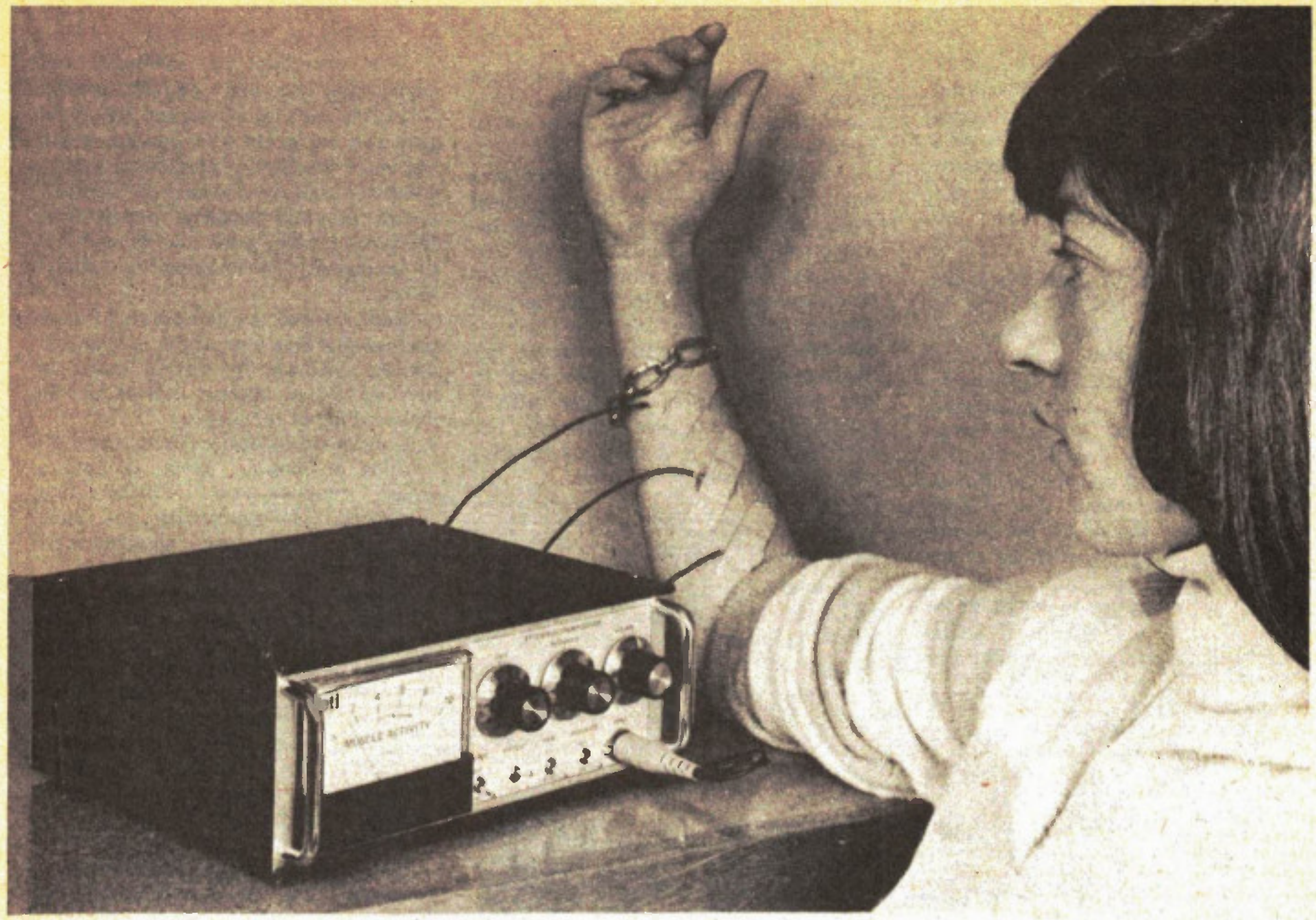
In November 1978, Dr. G. Shannon, of Queensland University, published an account of a "myoelectrically controlled hand" capable of providing sensory feedback about the strength of grip applied by its electric motor — possibly the first of its kind accepted and used for any length of time by its recipient.

The mechanism used for providing a sense of "touch" was a pair of strain gauges attached to the mechanical fingers to register the slight bend which occurs when grasping. The sense of "force" was provided by an electromyograph (EMG) which amplifies the electrical activity of a muscle's nerves, converting this to a signal capable of controlling the motor. The EMG was attached to the forearm between the elbow and the patient's amputated stump. The muscles measured in this case normally control movement of the fingers — now they control an electric motor in an artificial hand.

The brain is regarded as "the last defence perimeter" of a person's identity. Fears of electrical stimulation and control of the brain have been expressed in such works as *Brave New World* and *The Terminal Man*. However, it seems likely that many severely handicapped persons will gladly trade some amount of personal identity and privacy for increased abilities with which to contact and manipulate the outside world.

Today's multiply-handicapped person — quadraplegic or brain-damaged, can look forward to a pretty sedentary life. A number of complex switching circuits can put such amenities as a typewriter, TV, and intercom at the person's disposal. Currently, these circuits interface via a blow-tube on/off switch or, more recently, via a matrix system switched by photocells activated by a beam mounted on the head. Neither of these systems can provide the multi-channel, simultaneous, analogue type of control required for complex movement and manipulation. A more direct interface is required.

In addition to artificial hands, there



Illustrating muscle relaxation training using our owm electromyogram project. This project design is based on criteria given by the author of this article and compares very well with commercially made machines. Learning to relax is Jan Collins. . . note the calm expression, unfurrowed brow and general aura of peace!

are a variety of aids being perfected to replace and assist the eyes, ears, and legs of those who are denied their use, either by birth or accident. Implantations in the visual cortex of an electronic grid which produces light sensations have brought artificial vision closer to reality than dream. Similar experiments with the auditory cortex have shown promise, although the frequency range perceived has thus far been limited.

BIOFEEDBACK

In 1901 the psychologist, J.H. Blair, sought to shed light upon "the nature of the will" by observing how subjects learned to direct muscles to serve a mental command. He taught his subjects to wiggle their ears by observing their efforts amplified via a system of pressure-filled drums onto a kymograph

MAN VERSUS MACHINE: A COMPARISON

What are some of the strengths and weaknesses that each brings to an interface between man and machine? The space programmes and the nuclear arms race have forced a perhaps premature look at these issues. The age of cloning and bionics may well force a further look. A shopper for bionic and cloned components might keep the following shopping list:

SPECIFICATIONS AND FEATURES

MAN	MACHINE
on-line processing and data reduction of multi-sensory input	reliance upon external sensors
large CPU capacity (10^{20} bits) relative to size	limited CPU dependent upon size
delicate components require an artificial environment	capable of operation in extremely hostile environments
reliability through redundancy; multiple back-up systems	reliability through strength of components
learning capability	very limited learning capability
direct interface difficult due to the body's rejection systems	modular construction allows limitless interface
indirect opto/mechanical interface with outputs	direct amplification of outputs
complex manipulative ability	strong but clumsy manipulative ability
flexibility in short-distance locomotion over rough terrain	capable of fast, extended travel over large distances — land, sea, air, space
low energy consumption: $<$ 100 W	high energy requirements
low energy output: $<$ 400W	high energy output
must be protected	disposable
must be maintained alive	can be switched off indefinitely

(early chart recorder). A notched lever fitted to the wall of a drum transmitted small ear movements as pressure changes to a second drum to which was affixed a chart-pen. The subjects made efforts to wiggle these long-disused muscles and were rewarded by feedback from the pen tracing.

In the early '60s, Dr. John Basmajian investigated the ability of persons to control the 'motor units', which are responsible for muscle contraction, using EMG biofeedback. He used needle electrodes 25 μm in diameter, inserted beneath the skin to contact a large number of the tiny motor units. The oscilloscope tracings of the combined rhythms of the motor unit firings resemble a noise signal. To the person observing the tracing, however, the effect is like that of an orchestra. From the assembled patterns, the traces of single rhythms could be discerned. With practise, Basmajian's subjects learned to be able to recognise and control single motor unit firings — *voluntary control over the action of a single body cell in isolation*!

The significance of the discovery was not lost upon orthotists, biomechanical engineers, and doctors. The electromyograph had been in use since the '20s as an expensive laboratory tool capable of measuring the activity of the nervous system in controlling the body's movements. By the '60s, however, the devices had become cigarette pack in size and capable of interface with a variety of electronic devices. The myo-electrically (muscle-electrically) controlled prosthesis was born.

FROM LABORATORY TO REHABILITATION CENTRE

The human body is notorious for its ability to reject as "foreign matter" the finest creations of the best-intending implanter. The problems encountered in the kidney have long plagued pioneers in transplant and pacemaker research.


Current prosthetic hand 'replacements' are capable of quite a range of manipulative movement. With improved materials and electromechanical controls employing biofeedback, such prosthetics will improve markedly in appearance and performance.

The courtship of medicine and engineering has been equally stormy. Outsiders such as physicists, psychologists and engineers who operate within the inner sanctum of medical care often complain publicly about their 'sidekick' status, minimal financial return from the great health 'pork barrel', and lack of reciprocity in learning the other's secrets.

Even granted the smoothest of inter-professional relations, there is a lengthy process involved in fitting even the simplest of prosthetic devices to the most willing of recipients:

1. Construction: devices used in real life must be durable, simple to operate by someone not concentrating, "normal" in appearance, and cheap enough for the disadvantaged recipient to afford.
2. Fitting: an orthotic team must ensure that the device is precisely mated to the person's height, weight, shape of limb, and cosmetic needs.
3. Training: a team of physiotherapists and occupational therapists must put the recipient through a graduated series of tasks to allow practise in mastering the device. EMG biofeedback provides a bridge between the trainee and his new addition.

The myoelectronic prosthesis is currently only in experimental use. Many of the needs of the handicapped are better served with simpler mechanical limbs, spring-soled shoes and, of course, the ubiquitous wheelchair. But the day may not be far off when the first handicapped person opts for a myoelectric device which gives him abilities he lacked before his accident.

THE ELECTROMYOGRAM (EMG)

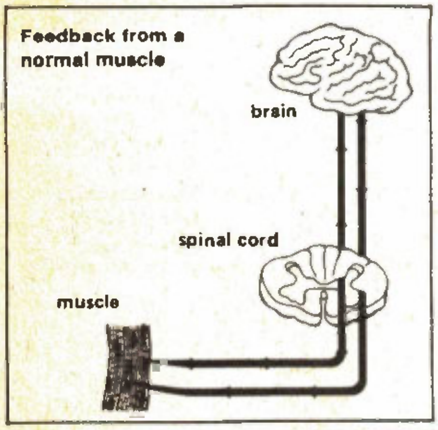
The electrical output of a muscle derives from the *motor units* which entwine the contracting fibres of the muscles. As a number of motor units fire to contract a muscle, their asynchronous firings resemble a noise signal, modulated in amplitude. Numerous studies have attempted to describe the statistical properties of the complex EMG signal. It may be regarded for practical purposes as:

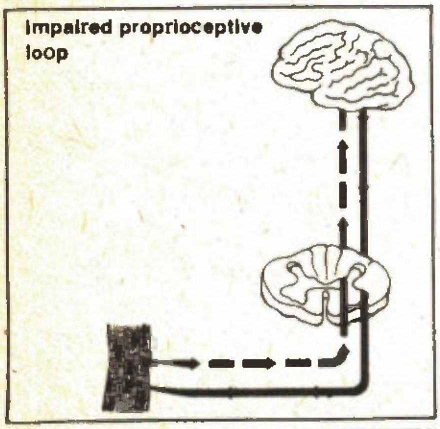
- amplitude modulation
- a weighted sum of the potentials of the motor units
- a function of the number of units, their rate of activation, and the quality of electrical contact

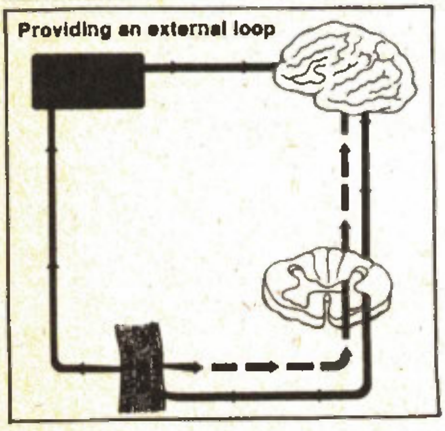
Amplification of the EMG signal presents problems to the amateur constructor. The output of a relaxed muscle is of the order of one or two microvolts peak to peak. To tap this signal from the skin is no mean feat. The skin is itself a source of electrical activity, whose surface resistance changes with mood (see ETI – 546 galvanic skin response meter, June '77), and a source of a dc potential which can dwarf the feeble EMG signal from beneath.

An amplifier which meets the strict demands of electromyography will probably have some of the following specification:

- common mode rejection of greater than 70 dB
- noise level less than 1 µV p-p
- sensitivity of at least 2 µV p-p
- linearity over the range 1 µV to 10 mV







obtained through a combination of the following features:

- ac coupling,
- a high input impedance (100 K) or 'bootstrapped' differential pre-amp.
- a threshold for amplitude which chops the midportion of the signal, giving greater contrast to small changes in input.
- Filtering for line radio and heart-beat frequencies.
- a narrow bandwidth, centred around 200 Hz say 100 Hz to 500 Hz.
- provision for both direct and time-integrated readings to capture both transients and average levels of activity.
- audio and visual output for feedback.

For practical use there are mechanical considerations as well. The electrodes are, of necessity, attached at some point in the system by flexible cable to allow movement by the user. But cable, however well shielded, presents its own problems of noise. One solution is to mount the electrodes, together with a compact preamplifier stage, into a single assembly worn directly on the user. The amplifier, integration, power, switching and output functions, built into a larger box, can then be connected by cable to this tiny system which rides on the body.

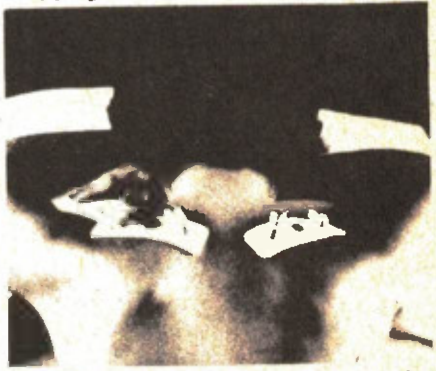
USES OF EMG

The object of training with an EMG is to begin to recognise the subtle sensations within the body which correspond to tiny variations in muscle activity level. One application is in learning to relax: the subject attempts to "switch off" his central nervous system from movement and sensation in specific areas of the body. This technique has shown promise with a variety of anxiety-based disorders and may benefit Yogi's and athletes who are learning to conserve their energy. At the other end of the spectrum is the need of the physically-handicapped to use the EMG as a sort of 'strength-ometer' for re-training weakened muscles.

Typically, the user applies a conductive gel to the electrode, tapes it to the skin and adjusts the sensitivity of the device, checking the noise level. A popular and practical training procedure is as follows:

1. Connection to forearm – flex the fingers and note the electrical activity which corresponds to fine movements; relax the arm by picking it up at the wrist and dropping it, allowing it to flop lifelessly onto the lap; note the sensations as the arm is allowed to become more and more "numb" and "heavy"

2. Connection to forehead – raise and lower the eyebrows, frown, squeeze the eyes shut, bite hard: note how all of the facial muscles interconnect; close the eyes and allow the face to become "smooth", listening to the audio feedback as the muscles lose their tightness.
3. Connection to neck (cervical or trapezius) – shrug the shoulders, move the head from side to side: note the postures in which the muscle output becomes lowest – slightly drooped shoulders, head balanced vertically; lose that tight feeling in the neck which often accompanies typing or driving.



Having practised the above, the trainee can then strive for more complete mastery of the nervous system: causing tinier and tinier voluntary flickers of movement while remaining relaxed; relaxing quickly after muscular strain; relaxing one portion of the body while tensing another.

Biofeedback is an educational and athletic discipline – there are no unbreakable records, no unbeatable performances, no lack of goals and challenges. No matter how powerful and sophisticated a man's bionic body may become, the challenge of mastery will remain.

Biofeedback will continue to form a bridge between man's mind and his body.

Gain Control

To conclude his survey of electronic gain control methods. Tim Orr presents us with more circuits which vary from a light bulb compressor to a markspace modulated universal filter unit, and a noise gate/expander.

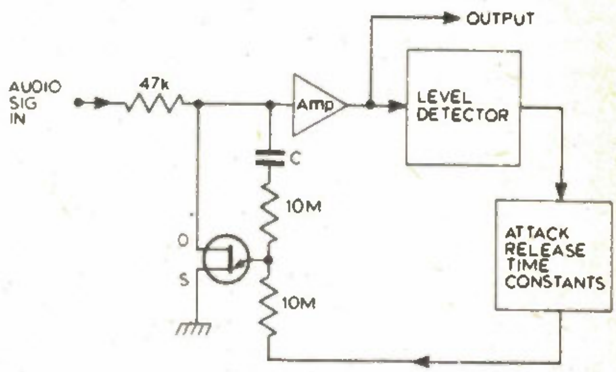
Basic Limiter Circuit

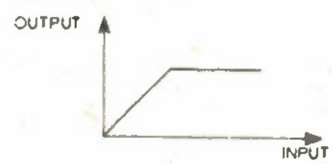
Most professional limiter circuits use a FET as the variable gain element. Relatively low distortion with a reasonable signal to noise ratio can be obtained. A basic limiter circuit is shown this being no different to previous circuits except for the variable gain element.

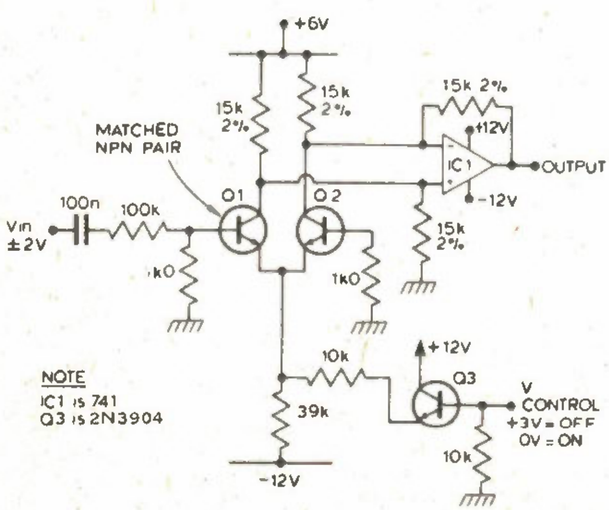
When a relatively small voltage (20 mV) is applied to the drain source of a FET, it acts like a fairly linear resistor. As the gate source voltage is varied, this resistor (RDS) also varies.

In fact the channel resistance RDS is inversely proportional to gate source voltage V_{GS}. When V_{GS} is OV, then RDS is at its generally minimum resistance (R_{ON}) which can be as low as 5R, but it is generally more like 100R. When V_{GS} exceeds the pinch off voltage (Vp or V_{GS} off) the channel resistance goes up to several hundred megohms. So a junction FET can be used as a voltage controlled resistor, except that R_{ON} and V_{GS} (OFF) tend to vary widely from device to device. However with a bit of perseverance suitable devices can be selected and made to work.

One circuit trick that greatly reduces distortion is shown here. Half of the audio signal at the drain of the FET is presented to the gate. This is superimposed on top of the control voltage and produces a distortion cancelling effect. Distortion levels below 0.1% can be achieved using this technique.

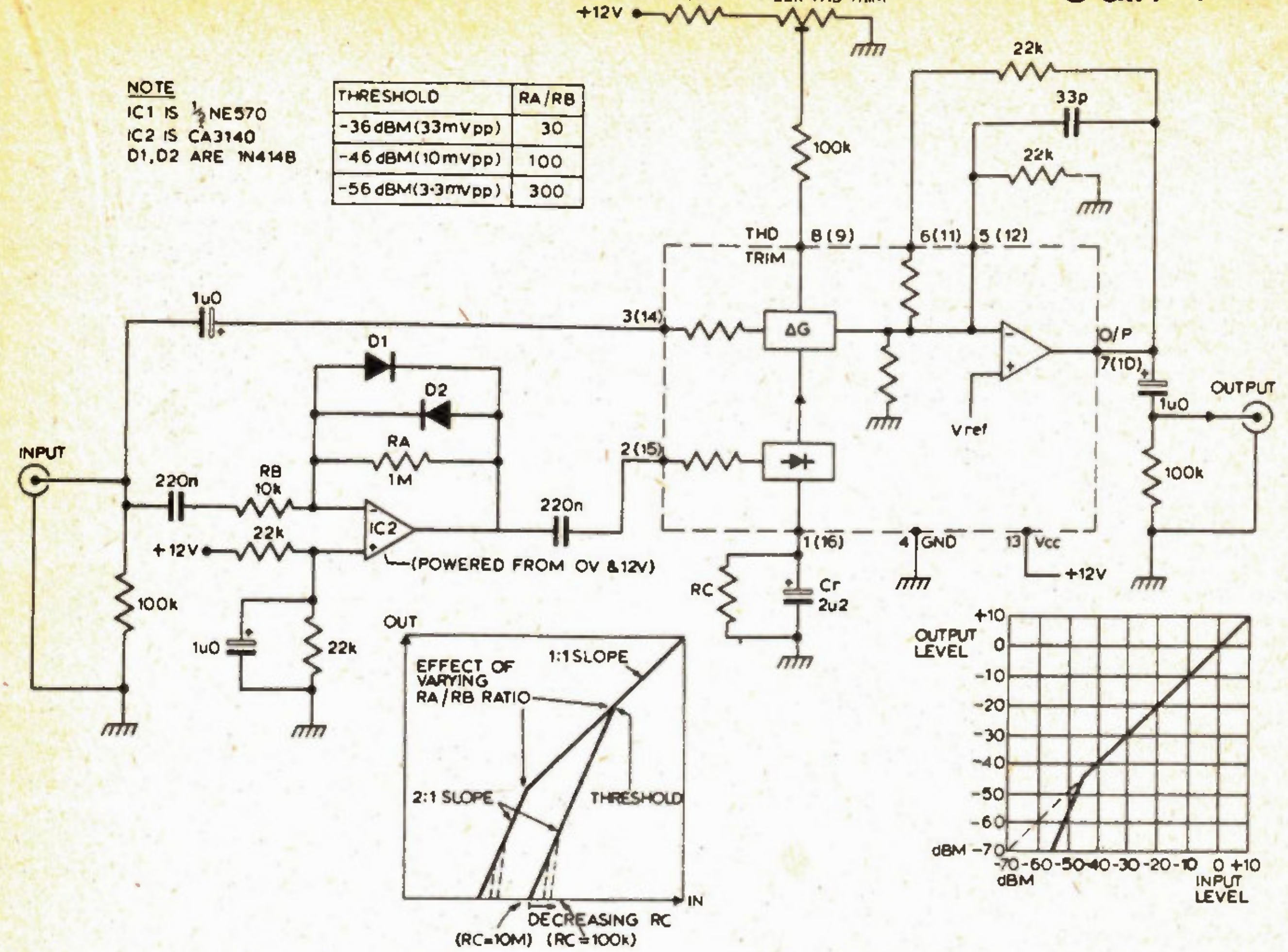






Transistor VCA

A circuit similar in operation to a CA3080 can be constructed with a matched pair of transistors and an op amp. Transistors Q1, 2 form a differential transistor pair which is used to steer whatever current is available between the two collectors, just as in the CA3080. The difference between the collector currents is equal to the product of the input voltage times the current I_{EE} times a constant. This difference is extracted by the differential amplifier IC1. The current I_{EE} is controlled by Q3. As the control voltage goes positive, Q3 robs most of the current flowing down the 39k resistor, and hence I_{EE} and the output of IC1 decrease.



THRESHOLD	RA/RB
-36 dBM (33mVpp)	30
-46 dBM (10mVpp)	100
-56 dBM (3·3mVpp)	300

Two Channel Low Level Expander/Noise Gate

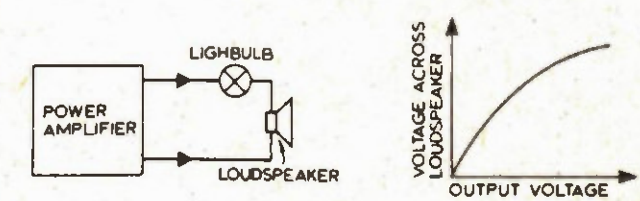
It is often required that a rather noisy signal be cleaned up a bit. This is not possible to do continuously, but it is possible to clean up noise in what was initially the gaps. The results of this cleaning up process can quite often be heard when telephone conversations from "foreign correspondents" are broadcast.

By turning down the signal level in the gaps, (by performing a low level expansion) the perceived sound quality improves dramatically.

The circuit performs just such an expansion. The inputs signal passes through the variable gain cell and then appears at the op amp output. The gain of the gain cell is controlled by the signal coming from IC2. This is a high gain amplifier with diode clamping, so that the output swing is limited to about 1VO ptp. Therefore for input signals of 10 mV pp to 10 V pp, the output of IC2 remains at about 1 VO ptp to 1V2 ptp.

So, for this range of input voltages the gain of the gain cell remains roughly static. Now when the input level drops below 10 mV, the output of IC2 will start to fall and so will the gain of the gain cell. This produces a 2:1 downwards expansion curve, which means that the output then gets quieter at a rate faster than the input. To accentuate this effect, a bleed resistor can be placed in parallel with Cr.

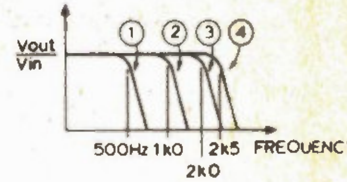
The resistor robs some of the current that would have otherwise gone to the gain cell and causes the input/output curve to roll off much more rapidly at low signal levels. Also, by varying the resistor ratio of RZ/RB, the expansion threshold level can be altered.



Incredibly Simple Compressor

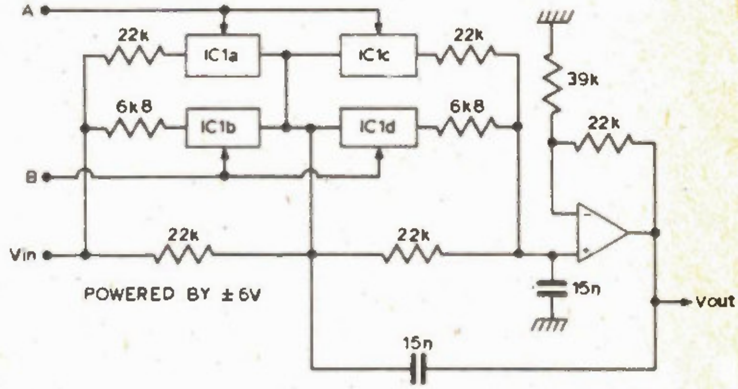
Not all gain control systems need to be complicated or indeed active. One product which I saw advertised was a compressor to help prevent loudspeaker/overloads. All it was was a lightbulb in series with the loudspeaker. When the power exceeds a certain level, the lamp will turn on, glow, its resistance increase dramatically and hence a bigger percentage of the power output is dissipated in the lamp. A nice, simple solution, but I think it would require some experimentation to find the right sort of car headlamp bulb!

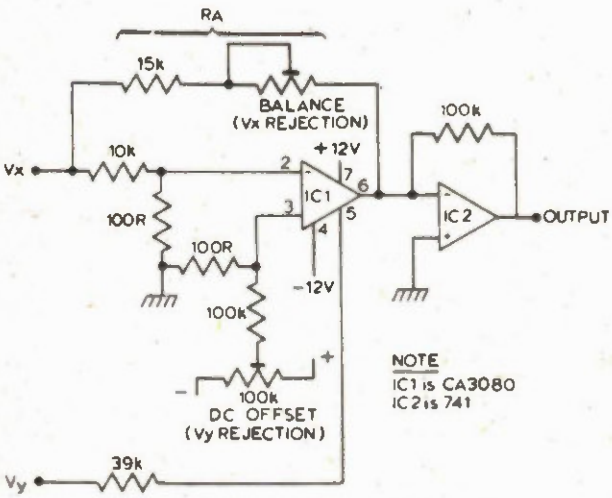
	1	2	3	4
A	OFF	ON	OFF	ON
B	OFF	OFF	ON	ON
Fc	500Hz	1kHz	2kHz	2.5kHz

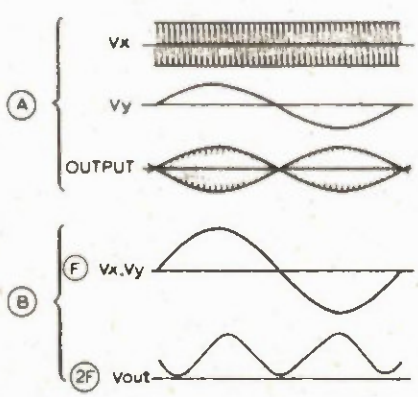


Switched Frequency Low Pass Filter

In this example the effective resistance is switched by using 4016 gates. The filter is a lowpass Butterworth and by turning gates A or B ON or OFF the cut off frequency can be altered. This allows the filter control to be physically remote or even to be computer controlled. Mark Space modulation of A and B would enable continuous control over the cut off frequency.





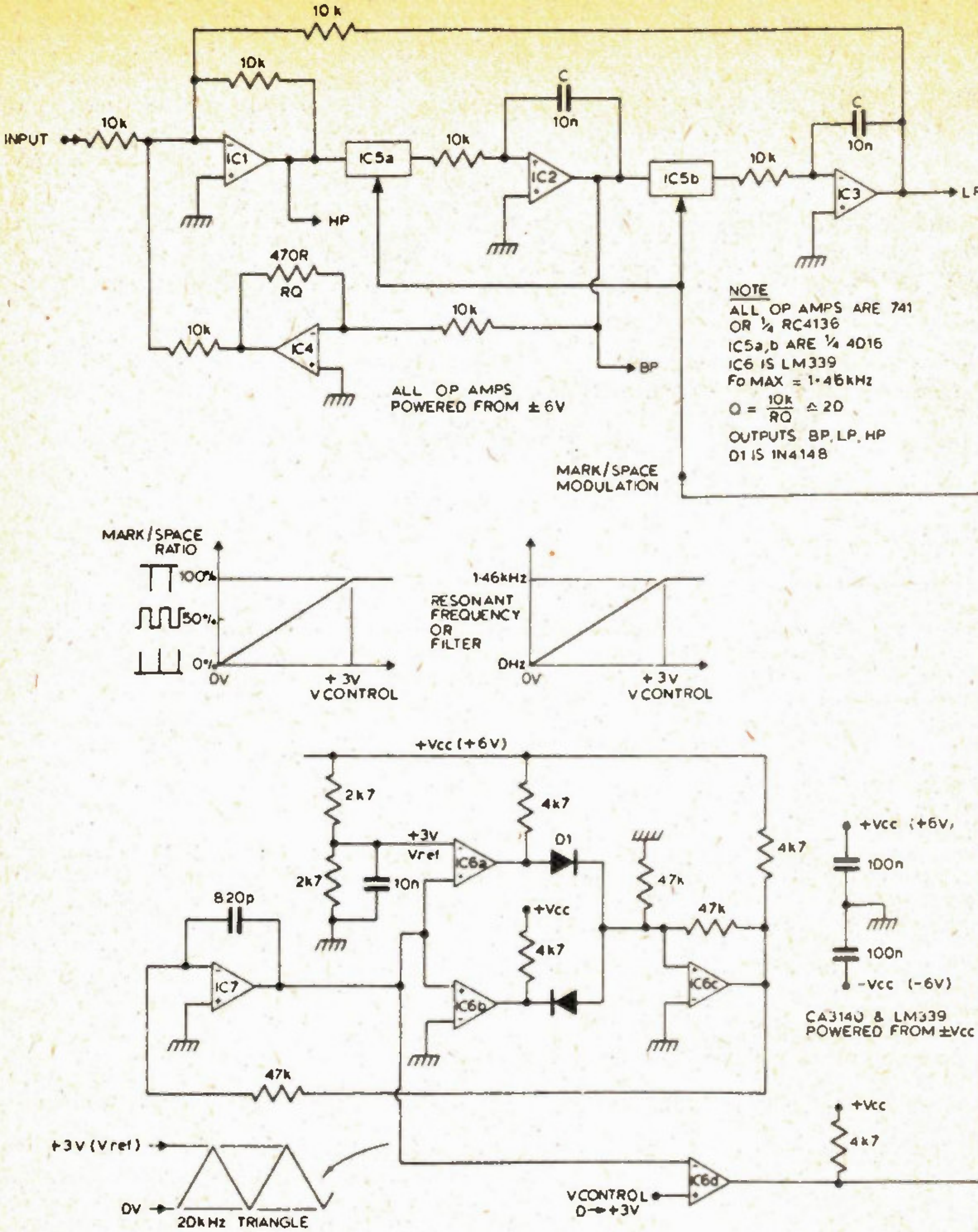


Four Quadrant Multiplication

By using a few circuit tricks, the CA3080 can be made to perform 4 quadrant multiplication. In fact the CA3080 performs 2 quadrant multiplication and the trick is to move the axis on the multiplying graph. If we ignore the RA resistor chain then we have a 2 quadrant multiplier circuit similar to that shown previously. Imagine that V_x is a 1kHz sine wave. 1 Vptp and V_y is a 0V. The output of IC2 is a sine wave of fixed amplitude. Now if we connect RA , and adjust the balance control, it will be possible to cancel out the output, because the signal coming from IC1 is out of phase with that from the RA resistor chain. So with V_y set at 0 V there is no output for IC2. If V_y goes + ve, the output of IC1 will become greater than the current via the RA chain and the output if IC2 will grow.

If V_y goes—ve the current through the RA chain will exceed that from IC1 and the output of IC2 will grow, the phase being opposite to that when V_y was a sinewave from an oscillator, then this circuit could be used to generate ring modulation effects.

When V_x is set at OV there may be some V_y breakthrough and this can be minimised by adjusting the V_y rejection preset.



Markspace Modulated Universal Filter

It is possible to change the gain of an amplifier by effectively altering the input resistor. This can be done by markspace modulating a voltage controlled switch in series with the resistor.

When the markspace ratio is low, the switch is 'off' most of the time and the effective resistance is large. When the markspace ratio is high the switch is 'on' most of the time and the effective resistance approaches that of the series resistor.

Having generated a markspace control waveform, it is possible to gang together literally hundreds of voltage controlled switches. This allows the control of large numbers of variables simultaneously.

The circuit consists of a modulated universal filter (ICs 1 to 5) and a markspace generator (ICs 6 and 7).

ICs 7 and 6a to 6c form a triangle/square wave oscillator. IC7 is the integrator whose output ramps up and down between 0V and +3V. IC6a and 6b are fast comparators which detect the end of the inegrator travel and switch the schmitt trigger IC6c, which in turn controls the integrator. The output frequency of the oscillator is about 20 kHz.

It is important that the frequency of the oscillator be relatively high. As a rule of thumb it should be 2½ times the highest frequency components of the signal you wish to process. The triangle output is fed into IC6d's inverting input, the control voltage being fed into the non-inverting one. The output of IC6d is the markspace modulation which is used to drive the switches IC5a and b. The filter's resonant frequency is directly proportional to the markspace ratio of the signal that drives the switches and thus is proportional to the control voltage.

The Middle East, Listening with the World

NEAR & MIDDLE EAST LISTENING

IN THE SEPTEMBER, 1979 issue of ETI we had a list of stations broadcasting from the Far East. We will continue this month with some interesting stations in the Near and Middle East countries. All times mentioned are in GMT (EST plus five hours) and frequencies are given in kilohertz. Of course, as I have mentioned previously, stations often change frequencies so some of these stations may change. Most of the frequencies, however, should be in use until May, at least, when most of the stations make their seasonal changes. Now onto the stations in alphabetical order:

AFGHANISTAN - The external service from Radio Afghanistan in Kabul has English to South Asia at 1530 to 1600 on 4775 kHz and English to Europe between 1900-1930 on 15075. They also transmit in Urdu, Russian, Arabic, German and Pushtu/Dari languages. Their domestic service also broadcasts in local languages on 15289, 11900, 7200, 6230, and 4775 kHz at various times during the day.

CYPRUS - The International service of the Cyprus Broadcasting Corporation is sometimes heard here in Greek to the United Kingdom on 6155, 7190 or 9695 on Friday, Saturday and Sunday between 2215 and 2230.

The BBC also operate a relay station from the island of Cyprus on a number of frequencies. A few that you might try include the following: 21660 at 0900-1130; 11735 from 0030-0145 and 0230-0330; 9530 from 0000-0230; 7140 from 0000-0145 and 0230-0330; 15420 from 0500-0730. They also use many other frequencies and times from this East Mediterranean relay.

Radio Bayrak, the Turkish-Cypriot State Radio, has been observed in the Turkish language on the variable frequency of 6141 until their sign-off at 2000.

IRAN - Broadcasting from this troubled country has been somewhat erratic since the overthrow of the Shah. The name of the international broadcasting station was changed at that time from the Voice of Iran to the Voice of the Iranian Islamic Republic. English is usually heard between 1930 and 2000 on 9022. French may be heard one-half hour earlier. They also broadcast in several other languages.

IRAQ - The foreign service from Radio Baghdad in Iraq is often heard here quite well in English between 2130 and 2230 on 9745 and between 0300 and 0400 on 11925. French may be heard on 9745 between 1930 and 2030. They also broadcast in Arabic, German, Hebrew, Persian, Russian, Turkish and Urdu languages.

ISRAEL - The foreign service of the Israel Broadcasting Authority (IBA) is now called "Kol Israel". This is probably the easiest station to hear from this area of the globe. They broadcast in English at the following times and frequencies: 0500 to 0515 on 21500, 15300, 15105, 11637 and 9815 kHz; from 1200 to 1230 on 25640, 21495, 17605 or 17615, 17560 and 11620 kHz; from 2000 to 2030 on 17685, 11655, 9815, 9425, 9009 and 7412 kHz; and from 2230 to 2300 on 17685, 15300, 11655, 11637, 9815 and 7412 kHz. You will notice from the above English schedule for Kol Israel that they do not broadcast to the North American continent during the prime evening hours. This is something that they want to rectify and had hoped to be on the air during evening hours here last fall, but that was postponed temporarily. Because of a union agreement, technicians will not work beyond midnight, Israeli time. Hopefully this problem will soon be resolved and we will be able to listen to this popular station at a more convenient time. Kol Israel also broadcast in twelve other languages.

JORDAN - Radio Jordan is often heard here in North America although they are not one the the powerhouses. Try for them in English between 0900 and 1200 on 7155 and from 1500 to 1730 on 9560. They also have many Arabic language programs.

KUWAIT - This is another popular station here. From Radio Kuwait you may hear many of the latest American tunes. Try the following frequencies from 0500 to 0800 on 21545 and 9650 and from 1800 to 2100 on 11690 and 9650 kHz. They have also been reported lately on 15345 at 1930 GMT.

LEBANON- This is another troubled country whose broadcasting is erratic. Radio Lebanon has been heard in recent months on 6550 in English at 1640 and on 15440 at 0242 GMT. The latest Schedule I have from Lebanon also shows English at the following times and frequencies: 1830-1900 on 21610; 0230-0300 on 15285.

OMAN - This can't be classified among the more popular shortwave stations in the Near and Middle East however the BBC have a relay station here which is frequently heard. This is their Eastern relay station. Some of the times and frequencies that the BBC use are: 17770 from 0900-1245; 15310 from 0900-1515; 11955 from 0230-0330; 7250 from 1700-1830; 6195 from 0230-0330; 6140 from 0000-0030 along with many other times and frequencies.

Radio Oman may sometimes be heard in English between 0900 and 1100 on 11890 kHz. They also broadcast in Arabic on 11890 from 0345-0800 and from 1100 to 1315 and also on 6174 between 1349 and 2010.

QATAR - The Qatar Broadcasting station operates from 0300-2100 in Arabic on the frequency of 9570. It

isn't heard here very often but keep trying.

SAUDI ARABIA - The Broadcasting Service of the Kingdom of Saudi Arabia operate their external service in English on 11855 from 1100 to 1300 and from 1900 to 2200 GMT. They broadcast in French on the same frequency from 0500 to 0700 and from 1700 to 1900. These broadcasts are beamed to Northeast and Central Africa but are often heard in North America. They also broadcast in Turkish, Indonesian, Urdu, Persian, Swahili and Somali.

Their home service in Arabic may be heard on a number of frequencies throughout the day.

SYRIA - Shortwave broadcasting from Syria had been off the air for some time but has recently returned on the frequency of 7145 carrying the Western/Turkish programming with French from 0800-0900, English from 0900-1000 and West Music with an Arabic introduction from 1000 to 1100.

TURKEY - The Voice of Turkey is quite well heard here throughout the year. Their English service operates from 1200 to 1300 on 15125 and also from 2130 to 2255 on 6185, 7170, 9515 and 11955. French is aired from 2100 to 2130 on 11955. They also broadcast in Arabic, Bulgarian, German, Greek, Persian, Romanian, Serbo-Croat and Urdu as well as Turkish. I had the pleasure of meeting Mr Ekber Menemencioglu of the Voice of Turkey last summer and he mentioned at that time how important radio is to the developing countries to help them get their message across to world-wide audience. He also indicated that the Voice of Turkey appreciate all reception reports that they recieve.

UNITED ARAB EMIRATES - This one will be rather tough to get but give it a try now and then. Their home service in Arabic is carried on 9695 between 0900 and 2100. To help you identify them they make the following announcement, "Sout all Emirat al Arabiyah al'Mutahidah min Abu Dhabi".

YEMEN ARAB REPUBLIC - This is another station which only broadcasts in Arabic. They are on 4853 from 0300-0700, 1100-2110 and on Friday only from 0710-1100; on 6050 at the same times as above; and on 9780 from 0300-0700 and 1100-2110. Their identifying announcement is "Idha'at al Jumhuriyah al Arabiyah al Yamaniyah".

PEOPLES'S DEMOCRATIC REPUBLIC OF YEMEN - Like its neighbour, this is another Arabic broadcaster. They are on the air from 0300-0530 and 1100-2200 (Friday 0300-2200) on 5060, 5970 and 7190; also on 11770 from 1200 to 2200. They announce "Idha'at al Jumhuriyah Al'Yemen Al-Dimucratia Ash-Shabeya Min Aden".

So there you have sixteen countries from this exciting part of the world. Most of these stations are reported to club bulletins quite reqularly so you shouldn't have too much difficulty hearing them. To help you obtain QSLs from these stations a list of addresses follows:

RADIO AFGHANISTAN, P.O. Box 544, Kabul, Afghanistan

BBC, Box 76, Bush House, WC2B 4PH London, England (for the Cyprus and Oman relays).

CYPRUS BROADCASTING CORPORATION, P.O. Box 1834, Nicosia, Cyprus

RADIO BAYRAK, Ataturk Square, Nicosia, Cyprus (Turkish Federated State of Cyprus).

RADIO IRAN, National Iranian Radio & Television, P.D. Box 41-3456, Foreign Relations Department, Tehran, Islamic Rapublic of Iran

RADIO BAGHDAD, Directorate General of Broadcasting, Salithiya, Baghdad, Iraq

KOL ISRAEL, Israel Broadcasting Authority, P.O. Box 1082, 91-000 Jerusalem, Israel

RADIO AMMAN (Broadcasting Service of the Hashemite Kingdom of Jordan), Box 909, Amman Jordan

RADIO KUWAIT, Kuwait Broadcasting and Television Service, P.O. Box 397, Kuwait, Kuwait

RADIO LEBANDN, Ministry of Information, Beirut, Lebanon

RADIO OMAN, Ministry of Information and Culture, P.O. Box 397, Muscat, Oman

QATAR BROADCASTING SERVICE, Director of Broadcasting, P.O. Box 1414, Doha, Qatar

BROADCASTING SERVICE OF THE KINGDOM OF SAUDI ARABIA, Ministry of Information, Engineering Department, Riyadh, Saudi Arabia

RADIO DAMASCUS, Omayad Square, Bamascus, Syria

TURKISH RADIO-TELEVISIDN CDRPORATIDN, TRT Turkiye Radyo Televizyon Kurumu, Nevzat Tandogan Caddesi 2, Kavaklidere, Ankara, Turkey

VOICE OF THE ARAB EMIRATES, P.O. Box 637, Abu Dhati, United Arab Emirates

RADIO SA'NA, Sa'na, Yemen Arab Republic

YEMEN BROADCASTING SERVICE, P.O. Box 1264, GPO Aden, People's Democratic Republic of Yemen

WARC '79

The World Radio Administrative Conference (WARC) held sessions for about ten weeks last fall in Geneva, Switzerland. All users of the radio spectrum were present to discuss changes to frequency spectrum. Because of the crowded conditions in the shortwave bands, international broadcasters were naturally looking for more space to help them to avoid interference. Additional portions of the high frequency spectrum were approved for international shortwave broadcasting above 9 Megahertz. To implment these expansions a High Frequency Broadcast Planning conference will be held in 1982 or 1983. The first session will consider technical aspects such as single side band (SSB) broadcasting. The actual planning for the use of the new band allocations by the various countries will take place in the second session of this conference. Since there

are presently other fixed services operating in the expanded portions of the bands, these will have to be moved and transfer procedures will be set up for this purpose. Therefore it looks as though it will be at least ten years before we will be into expansion for the international broadcasters.

According to George Jackson, head of Radio Canada International's Engineering Services and a member of

Canada's delegation to WARC '79, the Canadian delegation was quite satisfied with the results of the conference except for the crowded 7 MHz band where no expansion was approved. Canada took a final protocol on the conference expressing their views in this area.

All approved expansions took place above 9 Megahertz. Here are the new expanded bands with the present frequency ranges in parenthesis:

Up to 9 MHz - no change
9500 to 9900 (9500 to 9775)
an increase of 125 kilohertz
11650 to 12050 (11700 to 11975)
an increase of 125 kilohertz
13600 to 13800 (a new band)
an increase of 150 kilohertz
15100 to 15600 (15100 to 15450)
an increase of 150 kilohertz
17550 to 17900 (17700 to 17900)
an increase of 150 kilohertz
21450 to 21850 (21450 to 21750)
an increase of 100 kilohertz

As you can see from the above there will be an additional 850 kilohertz of frequency spectrum available for shortwave broadcasting. Canada's

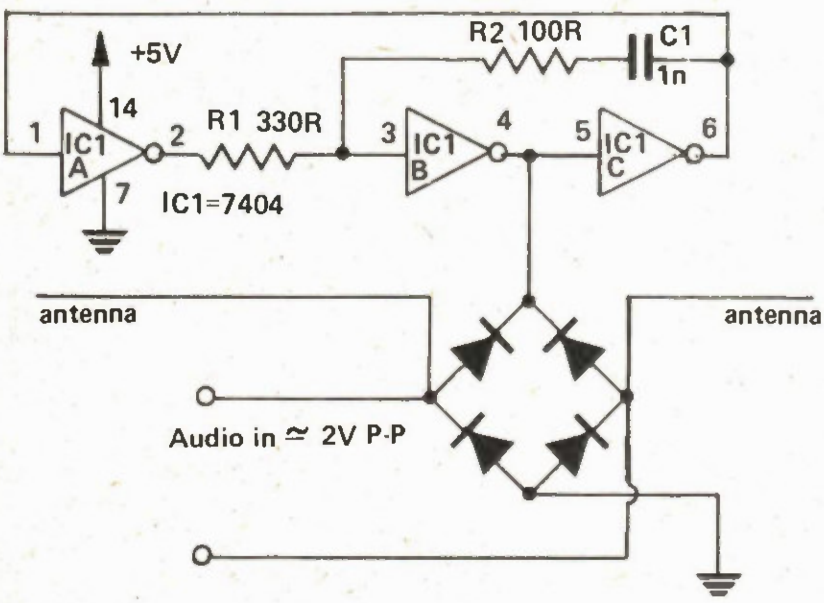
for WARC '79 ironically called for an expansion of the bands by 850 kilohertz, although the Canadian proposal had been broken down differently by bands.

One of Canada's proposals was for an additional world-wide broadcasting band between 3950 and 4000 which would help the CBC Northern Service to reach Canada's far north. This proposal was rejected by the conference. However a foot-note was added to the frequency tables allowing Canada to broadcast to the north in this band. This will be a great help for the listeners of the Northern Service.

A transcript of a half hour talk with George Jackson and Ian McFarland of RCI's DX Digest about WARC '79 appeared in the January issue of CANDX, the monthly bulletin of Canadian S-W-L International. Copies of this article may be obtained from Canadian S-W-L International, P.O. Box 142, Thunder Bay, Ontario, P7C 4V5. Please include 50 cents to cover postage.

Until next month all the best and good listening.

Continued from page 35.



CB TRANSMITTER
Ken Higginson, Cobourg, Ont.

While not outstanding in performance (15 m can be considered DX), this transmitter is useful for control applications. Note that the audio source cannot share a common ground with the rest of the circuit. Frequency can be adjusted by altering C1. There is very little room for improvment in the basic circuit other than experimenting with resistor & capacitor values. Using germanium diodes should reduce crossover distortion somewhat.

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UPC 1026C	$2.55

TOSHIBA

2SC 784	$0.30
2SC 403 C (Sony)	$0.35

MATSUSHITA/PANASONIC

2SA 699	$0.45
2SA 564	$0.30
2SB 512A	$0.80
2SC 1226A	$0.40
2SC 1567	$0.60

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MES	11-5	Equiv. à/to ECG 115	$0.40
MES	15-9P	Equiv. à/to ECG 159P	$0.40
MES	17-6	Equiv. à/to ECG 176	$1.75
MES	18-0	Equiv. à/to ECG 180	$4.95
MES	18-1	Equiv. à/to ECG 181	$4.85
MES	18-4	Equiv. à/to ECG 184	$1.18
MES	18-5	Equiv. à/to ECG 185	$1.28
MES	18-6A	Equiv. à/to ECG 186A	$1.08
MES	18-7A	Equiv. à/to ECG 187A	$1.18
MES	21-9	Equiv. à/to ECG 219	$2.50
MES	23-4	Equiv. à/to ECG 234	$0.65
MES	26-8	Equiv. à/to ECG 268	$1.25
MES	26-9	Equiv. à/to ECG 269	$1.35
MES	70-6	Equiv. à/to ECG 706	$2.45
MES	71-2	Equiv. à/to ECG 712	$2.25
MES	72-8	Equiv. à/to ECG 728	$4.75
MES	74-4	Equiv. à/to ECG 744	$4.55
MES	79-8	Equiv. à/to ECG 798	$4.65

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This month a friend takes over for a friend. Some reminiscences from David Van Ihinger.

WHEN DICK CARTWRIGHT approached me a few weeks ago to ask if I would take over (for a while) writing this column, I did not feel that I had any choice other than to say "yes". Dick and I have been following each other around for a long time.

In 1953 I met Dick when he opened a store within a block of mine and we started off by sharing tough dogs (remember Crosley and Addision?). Later we took turns at the helm of R.E.T.A., memoirs of which I hope to examine in forthcoming articles. When M.T.T.S.A. (Metropolitan Toronto Television Service Association), now known as O.T.E.A. (Ontario Television Electronics Association) was formed, who else than Dick persuaded me to join. After enjoying his light-hearted, timely and well-written column for the past year or so, I find myself again obligated to my old friend, whose act is going to be tough to follow.

In all the years I have known him, Dick has always been a fervent promoter of the television electronic technicians and has constantly championed licensing and certification.

In April, after decrying the lack of compulsory legislation in Ontario with regard to certificates of proficiency in television and electronics repairs Dick appealed to "technicians or associations across Canada" to advise him regarding "rules and regulations pertaining to their particular province."

In August he'd received an answer sent in by Mr. Bob Collins of Stettler, Alberta stating that in that province "anyone found to be servicing domestic electronic equipment without a license faces very stiff penalties."

In the same article he also stated that 95% of the people to whom he had spoken on the subject, were "still adamant in saying that certification is necessary, and they would like to see the Government take action forthwith, if only to protect those technicians who have spent so much time and money in furthering their skills and at this moment have absolutely no protection at all."

In May he reported on a meeting of O.T.E.A. where Frank Drea, Ontario's Minister of Consumer and Commercial Relations, had given an address, offering the green light to O.T.E.A. to go ahead and draft a resolution dealing with the subject of regulation, such regulations to be carried out by the association with the blessing of this government.

Mr. Drea made it quite clear, however, that lacking such action, his government could readily institute its own regulatory laws relieving O.T.E.A. of the bother. Rather, he advised that if O.T.E.A. wished to take up the challenge, it should first increase its membership across the province.

And in June, Dick came on quite

strongly with "Make it a point to invest in your future by becoming a member of your Provincial Association."

It is quite obvious from the foregoing that Dick has never relented in his crusade for government recognition and I intend to take up the same theme, and I hope the reader who can, will follow suit, in more than just words.

I am publishing again, the list of such associations:

Appliance Service Association of British Columbia
860 Kingsway, Vancouver, B.C.
V5V 3C3
Mr. D. W. Loughran, Secretary

Electronic Guild of B.C.
735 Sixth Street,
New Westminster, B.C. V3L 3C6
Mr. George Quan, President

Professional Electronic Guild of Alberta
P.O. Box 784, Stony Plain, Alta.
Mr. R. A. Hopkins, President

Manitoba Electronics Service Assoc.
297 St. Mary's Road,
St. Boniface, Manitoba
Mr. M. Wrublowshy, President

New Brunswick Electronic Technicians Association
247 Dundonald St.,
Frederiction, N.B.
Mr. Glen Smith, President

Ontario Television Electronics Assoc.
1245 Ellesmere Road,
Scarborough, Ontario
Mr. Hank Steenhuysen, President

If you feel that you qualify for membership, simply mail your name and address to the one in your province so you can add *your* support which is so vitally needed. Even if you cannot attend meetings, or make a personal commitment to the group, your money is needed. The membership fee is a small price to pay for the recognition that has eluded this industry for so long.

Ontario Television Electrical Association Annual Provincial Convention. Three days in Toronto at the Prince Hotel (don Mills and York Mills). May 30, 31 and June 1 (Friday, Saturday and Sunday). Contact Len Longman, Vice President and Convention Chairman. 36 Fenelon Drive, Don Mills, Ontario. M3A 3K6. Phone: (416) 444-9219 or 447-3295.

Watch this column for announcements. As they arrive I'll put them down.

David Van Ihinger.

Power Supply

One more from Tim Orr. This time he takes us through a series of different methods for powering up circuits. On the way he explains the theory behind each.

THE JOB OF producing stable regulated power rails has been much simplified by the introduction (about seven years ago), of three terminal fixed voltage regulators. These devices can make the power supply design problem relatively simple, but even so the designer must be fully aware of a lot of other important details that can cause poor results. Firstly, consider a simple unregulated power supply, fig. 1.

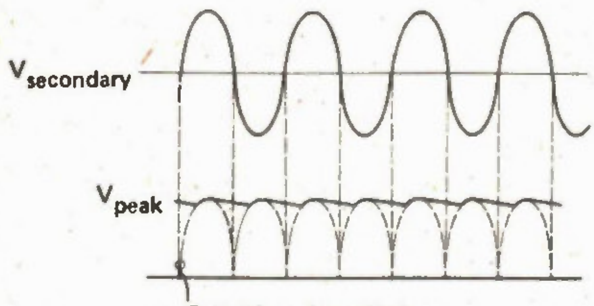


Figure 1. Below: an unregulated power supply. Above: The output (with a load resistor).

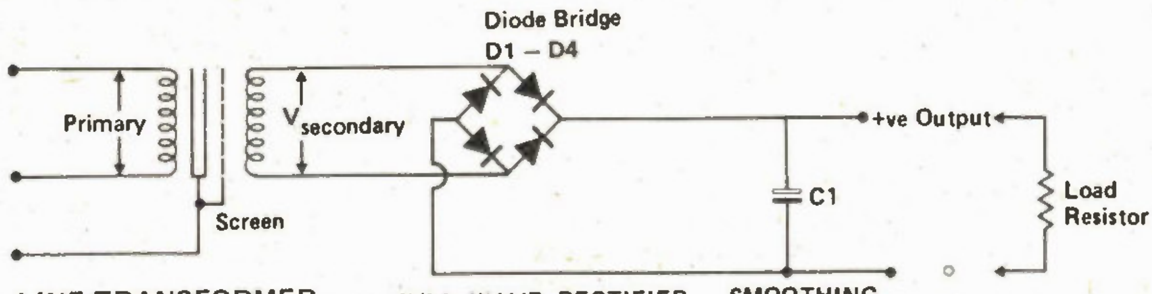
The function of a line isolating transformer is to physically separate the user end of a piece of equipment from the ' potentially ' (!) lethal line voltage. The transformer also provides a suitable voltage which can be rectified and smoothed and connected to a voltage regulator. This is the secondary voltage of a transformer and it is measured in VRMS at a particular loading.

That is, if the transformer is rated at 15V at 10VA, then the output voltage will be 15V when the load upon the transformer secondary is 10VA (10 watts).

If the load is removed the output voltage will rise. The percentage change from load to no load is known as the TRANSFORMER REGULATION and is typically of the order of 20%.

To convert the V_{RMS} voltage to a DC voltage it must be multiplied by 1.4142. Thus a 15VRMS (loaded) transformer secondary will generate 21V2 DC when full wave rectified and smoothed, which will rise to 25V45 DC when the load is removed (assuming 20% regulation see Fig. 1).

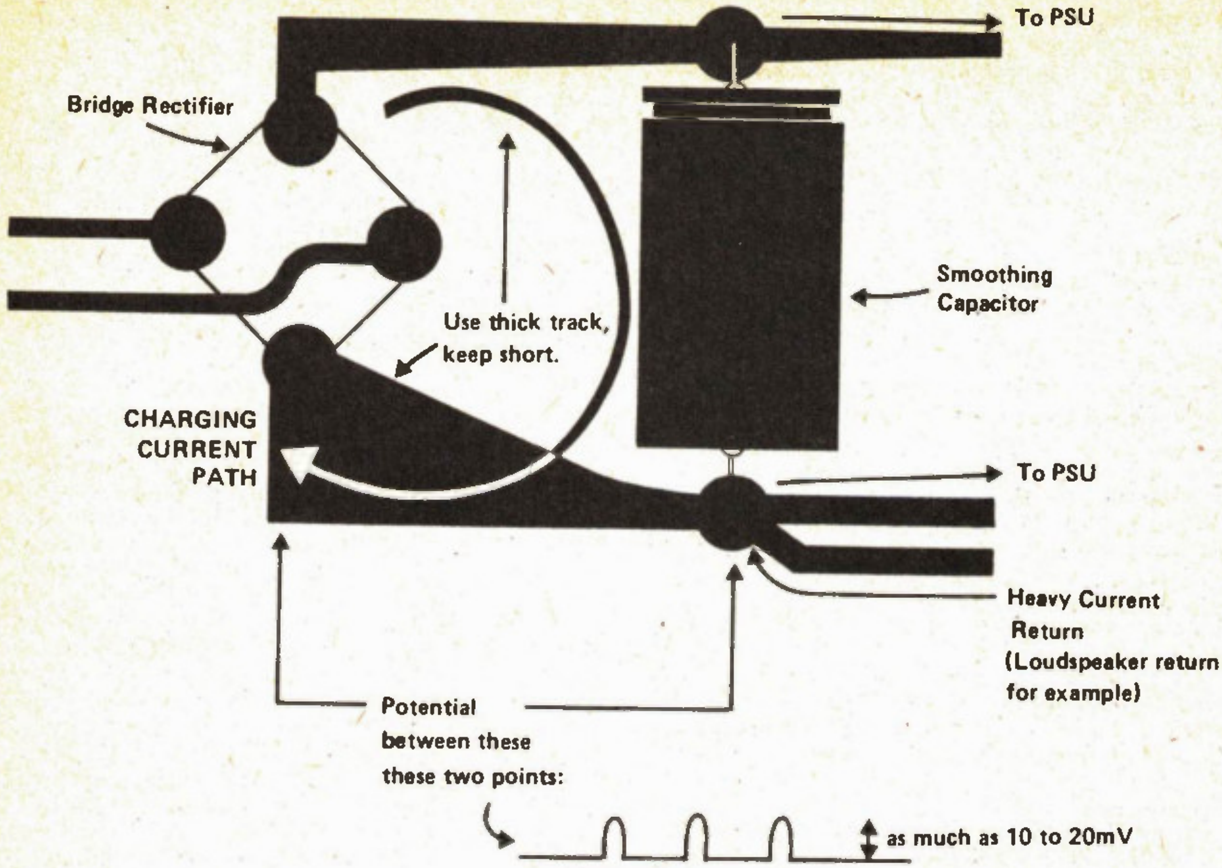
Thus care has to be taken when selecting a transformer such that the smoothing capacitor working voltage is not exceeded. Also, make certain that the polarity on this capacitor is correct, they can LITERALLY explode if wired up backwards!



This piece of hardware has three sections, a step down, isolating transformer, a diode bridge and a smoothing capacitor. The transformer is driven from the lines, the voltage of which varies depending on where you live (it's 120 RMS in Ottawa). Some transformers have got a copper screen which isolates the primary winding from the secondary windings. For the purpose of safety this should be connected to ground.

Also, for maximum safety, connect the 110/117/120 tapping to line LIVE. Another type of line transformer uses what is known as split bobbin, the primary is wound on one bobbin, the secondary on another. Thus the two windings are inherently physically isolated, and so no safety screen is included. These two transformer types are generally constructed on what is known as an 'E' core; take one to bits and you will find that it is constructed out of lots of 'E' shaped laminations. These 'E' laminations are butted into 'I' laminations, and clamped together. This butting together of the laminations can cause magnetic field problems. The wider the gap between the 'E' and 'I' laminations, the larger the magnetic field around the transformer.

The magnetic field generates a significant amount of induced hum in nearby electronics, this can be overcome by using a low leakage torroidal transformer which is constructed from circular laminations. The primary and secondary windings are wound through the centre of the torroid (see if you can imagine how). The torroidal transformer, by virtue of its 'continuous' laminations results in a low stray field and a low profile design, making it ideally suited for audio amplifier applications.



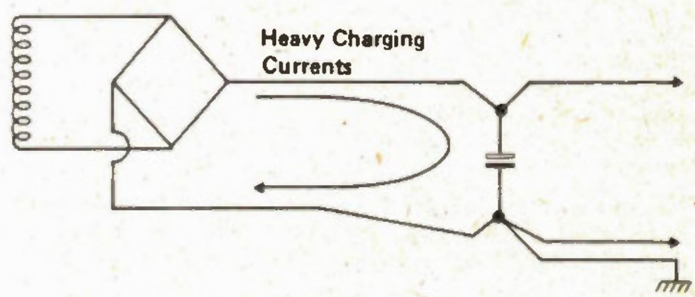
When a load is placed upon the power supply shown above, the output voltage appears as a DC voltage on top of which is a ripple voltage. This can be thought of as two separate periods, a charge period where the capacitor is charged up by the power supply and a discharge period where the load discharges the capacitor.

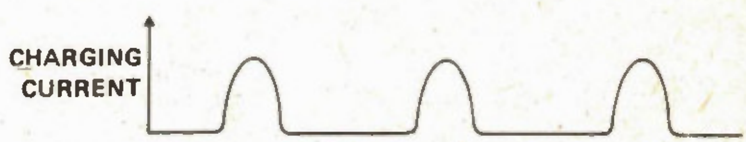
This charging and discharging generates a ripple voltage which has a period of 8 ms (120Hz). a load current of 100 mA, and a 100u capacitor will result in a ripple voltage (Vpp) of about V7.

As a rule of thumb I usually allow 1 to 1V5 maximum ripple if a voltage regulator is being used. This will generally result in an output ripple of less than 1 mV. If this ripple were to be obtained by just using a larger capacitor, then a 700,000u-capacitor would be required!

Generally the discharge period is much longer than the charge period. This means that the transformer is only supplying power for short periods, in fact during the charge period. During these periods the smoothing capacitor is rapidly charged, and it is quite common for these current surges to exceed several amps. This can cause lines BUZZ problems when laying out printed circuit board designs for power supplies.

The correct layout is shown below the circuit. If the current surge is 1 A and the track resistance is 200 milliohms then the voltage developed will be 20 m Vpp.





VOLTAGE REGULATORS

A voltage regulator takes a varying unregulated input voltage and produces a fixed regulated output voltage. There is a wide range of fixed voltage three terminal regulators to choose from, with a choice of maximum current handling, output voltage and positive or negative operation. The data sheets for these devices contain lots of seemingly complex pieces of information and so a glossary of terms is now included.

Ripple Rejection
The ratio of the ripple voltage at the regulator input to that at the output, generally expressed in dB. Typically of the order of 60 dB (1000 to 1), that is 1 Vpp of ripple at the input ends up as 1 mVpp at the output.

Temperature Coefficient
The output voltage change for a change in regulator temperature, expressed in mV/°C.

Input Voltage range
The range of voltages over which the regulator will function normally. For example, a 12V regulator may work from 14V5 to 30V. At 14V5 the regulator will 'drop out' and lose its regulation. Regulators generally need 2 to 2V5 in excess of their output voltage. At 30V the regulator will go 'pop' (time to buy a new one).

Output voltage
The voltage at the output terminal with respect to ground. Generally within ± 5% of stated value.

Line Regulation
The ratio of the change in the output voltage caused by a change in the input voltage, typically of the order of 0.2%.

Load Regulation
The output voltage change for a specific change in output load current.

Short Circuit Current
The output current when the output is shorted to ground.

Output Noise Voltage
The RMS noise voltage measured at the regulators output, not Including any ripple.

Power Dissipation
The maximum power that the regulator can safely generate on a particular heatsink.

As a rule of thumb the regulator case should not exceed about 80°C (which is hot to touch). However, always run the device at as low a temperature as possible. It is thermal ageing that eventually kills electronic devices and for higher temperatures the ageing process is disproportionally faster.

Some applications of voltage regulators are given below.

The table below relates the secondary voltage of a transformer to the peak voltage at rated load and the off load voltage, which will be considerably higher.

TABLE ONE

V secondary at rated load	V peak at rated load	V peak off load transformer regulation 20%
5 VRMS	7V07	8V48
6 VRMS	8V48	10V18
9 VRMS	12V72	15V26
10 VRMS	14V14	16V97
12 VRMS	16V97	20V36
15 VRMS	21V21	25V45
20 VRMS	28V28	33V93
25 VRMS	35V35	42V42
30 VRMS	42V43	50V92
35 VRMS	49V50	59V40
40 VRMS	56V57	67V88

TO92
plastic

or

TO5
metal

(100mA rating)

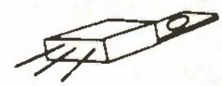
TO5
metal

or

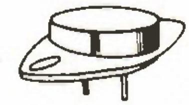
TO202
plastic
power

(200mA rating)

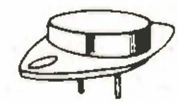
TO202
TO220
(500mA)

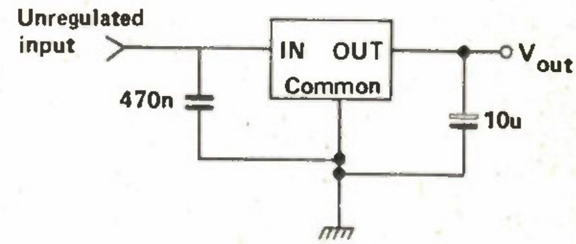


TO3
metal
(2A)

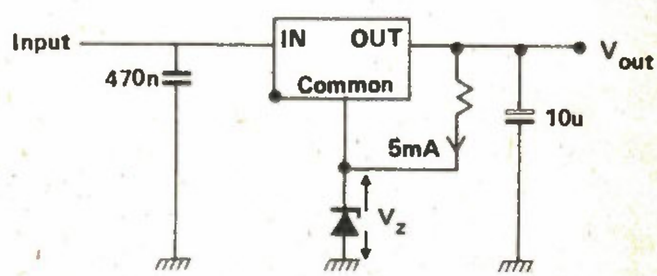


TO3
metal
(3A)

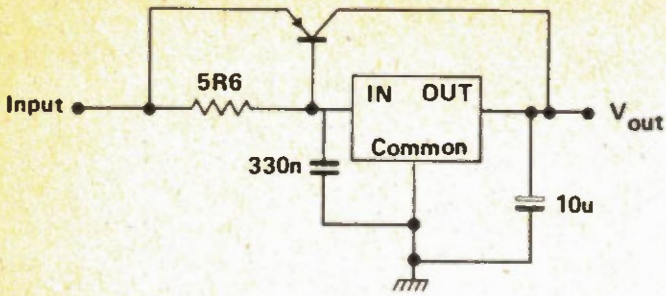




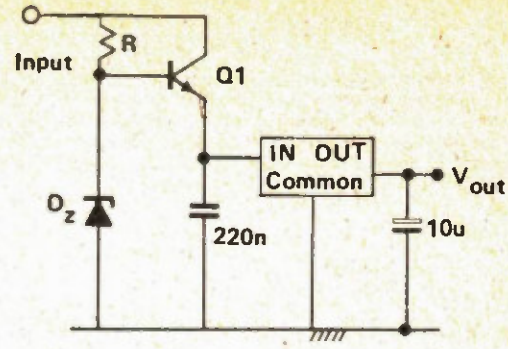
A)
This circuit shows a conventional arrangement of a three terminal device. It is advisable to use a decoupling capacitor connected close to the input terminals. This prevents high frequency instability. If this capacitor is left out then regulation can sometimes be greatly reduced. The decoupling capacitor on the output helps reduce the impedance at high frequencies, where the regulator loses its performance. For best results use a tantalum capacitor.



B)
The output voltage of a regulator can be increased by applying a voltage to the common terminal. This can be done by using a zener diode.



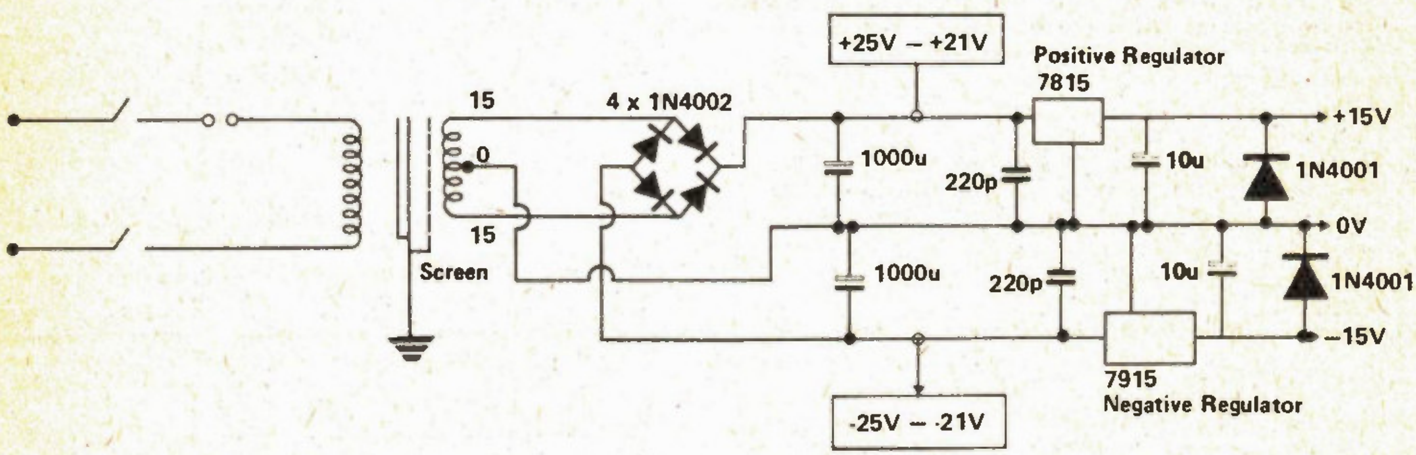
C)
The output current can be increased by using a bypass transistor. When the current flowing through the voltage regulator exceeds 100 mA (the voltage across the 5R6 being 560 mV), the bypass transistor begins to turn on. This transistor takes all currents in excess of 100 mA and yet the output still remains regulated. However a few extra components are needed to get current limiting in the transistor path.



D)
A high voltage unregulated supply can cause problems when using regulators. It may at times exceed the maximum voltage rating of the regulator. A simple voltage regulator D_z and Q1 can be used to overcome this problem. D_z should be chosen so that it is about 6V greater than the regulator output voltage. This technique has the added advantage that the power dissipated in the regulator is less (the rest being dissipated in Q1), and the regulator is presented with a semiregulated voltage, so the output will have less ripple.

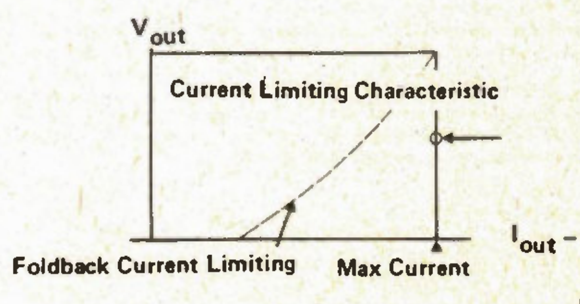
DUAL POWER SUPPLY

The circuit shows a complete regulated dual power supply. The unregulated rails are obtained from a split secondary transformer, a bridge rectifier and two smoothing capacitors. A positive and a negative regulator have been used to generate the + and — rails. These regulators should be mounted on heat sinks and they should be insulated. The pin out of the negative regulator is different to that of the positive regulator. The two diodes at the output prevent latching up situations (on load) whereby one side starts up faster than the other and forcibly reverse biases it, preventing it from operating.

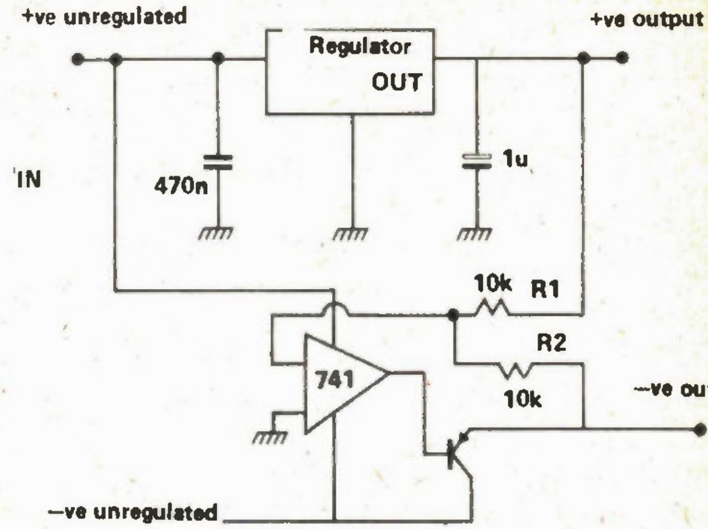


TRACKING REGULATOR

Instead of using a negative voltage regulator to obtain the negative rail, an op amp and a power transistor can be used. The resistor ratio, R1, R2 determines the negative rail voltage. The negative rail is not, however, current limited. The internal current limiting of the regulator is shown. When the load current exceeds the current limit, the output voltage drops to almost 0V. This makes the regulator short circuit protected. Another type of current protection is known as 'FOLD BACK' current limiting (shown dotted). This serves to reduce the short circuit current. These devices protect the power supply from abuse. Another type of protection device is the overvoltage clamp, which



protects the 'non-power supply electronics' from an increase in the power supply voltage. These are two terminal heavy current devices which are placed across the power supply. When the supply voltage exceeds a certain level a thyristor is triggered on and clamps the rail to ground. This is intended to pop a fuse and so disconnect the faulty power supply.

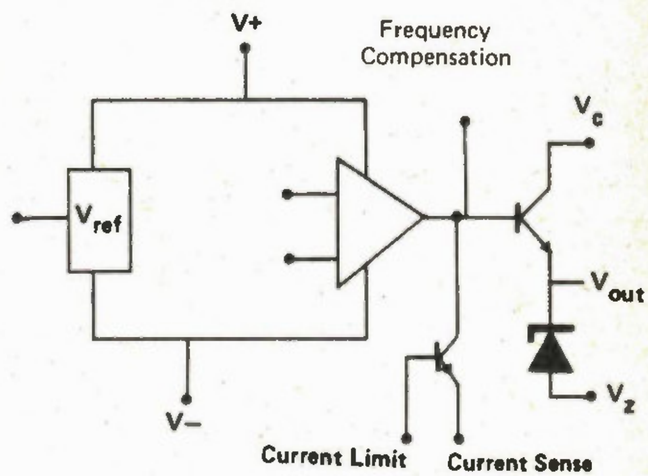


—ve output = —(+ve output × R2/R1)

With foldback the short circuit power dissapated in the regulator is less than that with current limiting.

723 VOLTAGE REGULATOR

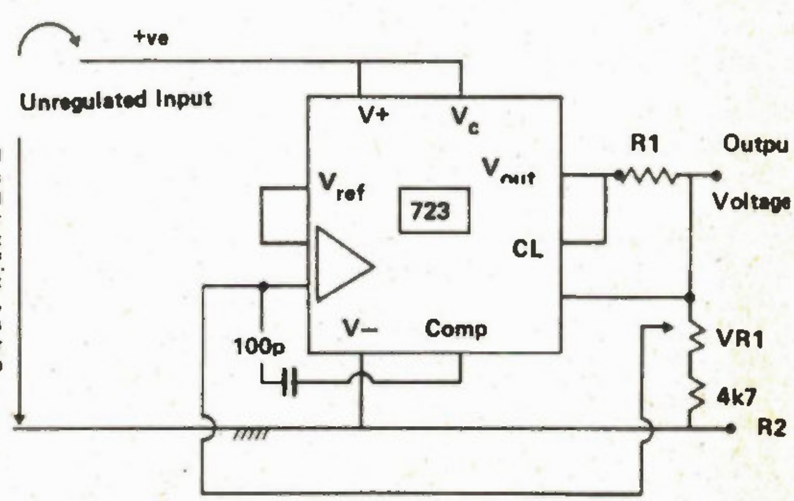
The 723 is an industry 'standard' device. Many manufacturers produce it and the device itself is versatile. It comes in a 10 pin TO5 can or a 14 DIL pack. The device contains a precision voltage reference, with a temperature coefficient of 50ppm/°C, an error amplifier, an internal transistor capable of handling 100 mA and a current limiting mechanism. By using a few external resitors, a capacitor and maybe an external power transistor, a wide variety of regulator designs can be realised.



Left is shown the block diagram of the 723 regulator. As pinouts vary depending upon package, no pin numbers are shown.

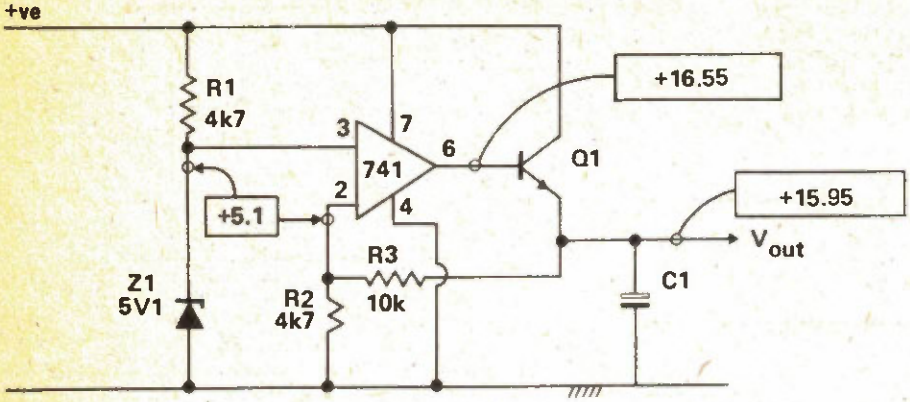
ADJUSTABLE POSITIVE VOLTAGE REGULATOR

By using a variable feedback path (RVI), a variable regulated output voltage can be generated. The voltage reference is connected to the non-inverting input of the error amplifier and the output voltage (via RVI), to the inverting input. The error amplifier drives the output transistor and hence the output voltage is controlled by the feedback voltage from VR1. A 100pf capacitor is used to stabilise the device. R1 is used as a current limit control. When the current through R1 (the load current), exceeds 100 mA a voltage of 560 mV is set up across it. This is just about sufficient to turn on the current limiting transistor which in turn shorts out the regulating transistor, causing the output voltage to collapse towards 0V.



REGULATED POWER SUPPLY

Sometimes it is necessary to make a simple power supply using discrete components when a non-standard voltage is required.



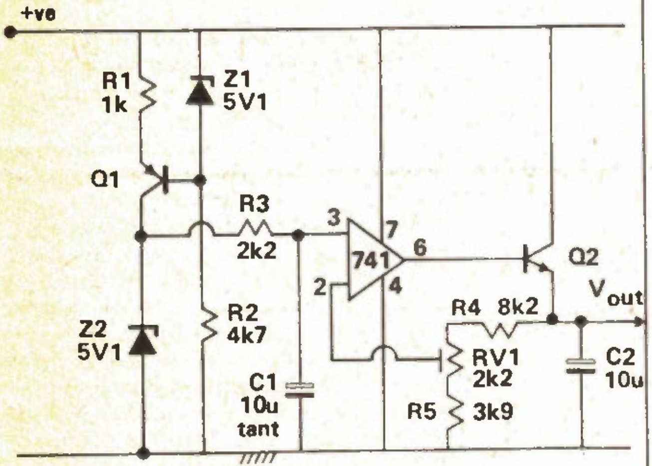
Left: Circuit diagram of discrete component PSU. Voltage measurements are taken with high impedance voltmeter.

The circuit shown uses all the basic elements of a voltage regulator, that is, a reference voltage Z1, an error amplifier and a series control Transistor Q1. The zener diode, Z1 sets up a reference voltage of 5V1. This diode has a temperature coefficient of —1.2mV/°C (a 5V6 zener is best at —0.2mV/°C). The resistor ratio of R3 and R2 sets the output voltage and the op amp provides the error correction (the regulation).

C1 is used to reduce the output impedance at high frequencies. The zener diode has a slope resistance of 76Ω, and so any fluctuations in the unregulated rail will be attenuated by the ratio of 76:7: 0.016
R1 4700
Therefore a 1 Vpp ripple will end up as 16 mVpp, but will be multiplied by the gain of the R3, R2 network to nearly 50mV.

IMPROVED POWER SUPPLY

This power supply has various improvements over that shown. The reference zener Z2 is run at almost constant current by the R12, Q1 Z1 network. This makes Z2 much less sensitive to ripple and unregulated supply fluctuations. The filter R3 C1 (7 HZ low pass), further reduces any ripple voltage and noise from the zener diode. The preset VR1 allows the output voltage to be varied.



If a precision power supply is required then a precision voltage reference should be used. These can be obtained with temperature coefficients as low as 10ppm/°C. When using this level of stability, high stability resistors (TC = 10ppm/°C), and a low drift op amp should be used.

See page 71 of this issue.

Self Resonant Capacitors

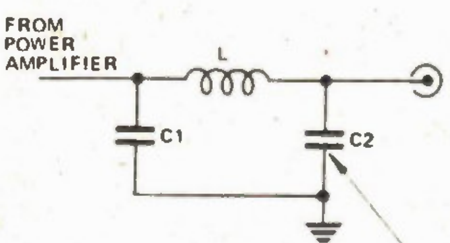
Roger Harrison has been plotting again — this time it's self-resonant frequency versus lead length of ceramic capacitors!

THE LEADS AND CONSTRUCTION of all capacitors form an inductance which is effectively in series with the capacitance of the component. The combined effect forms a series resonant tuned circuit, the frequency of which (the self-resonant frequency) is mainly dependant on the length of the connecting leads, the construction of the capacitor and the way it is mounted.

The impedance of an ideal capacitor decreases with increasing frequency. But in a real capacitor the series inductance of the leads and construction causes the impedance of the capacitor to increase above the self-resonant frequency. Within a range of 0.7 to 1.4 times this frequency the impedance will be equal to, or better than, the reactance of the pure capacitance.

One can make use of this characteristic in bypass applications by using a capacitor of appropriate value and lead length so that its series resonant frequency is at, or close to, the frequency in use. Series resonant bypasses do a better job.

Alternatively, when selecting a bypass capacitor, always ensure that, for the value chosen, its series resonant frequency is above the highest frequency likely to be encountered in the circuit. This ensures that the impedance is always low over the frequency range of interest.



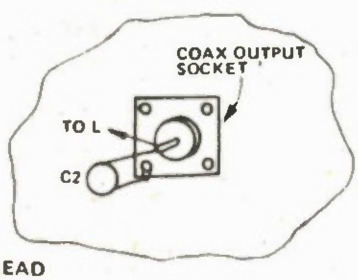


Fig. 1. Pi-network.

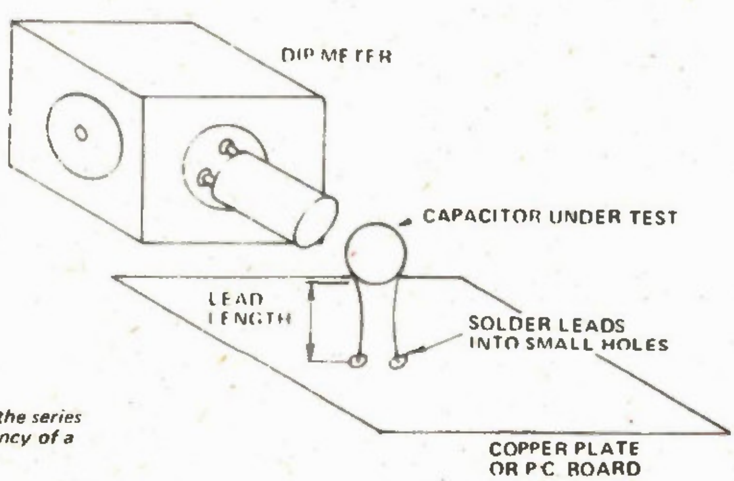


Fig. 2. Finding the series resonant frequency of a capacitor.

There are other ways in which the series resonance of a capacitor can be utilized. A pi-network, as is frequently used in the output stages of transmitters, is shown in Fig. 1. The output capacitor, C2, will have a value that depends on the frequency and the input/output impedances. The leads of this capacitor can be cut to length before installation so that the series resonant frequency of the capacitor falls on the second harmonic transmitter frequency. Thus it acts as a trap of very low impedance at this frequency.

If the second and third harmonics are to be suppressed, two capacitors may be connected in parallel (their added values to equal the value of C2), and resonated at the frequencies of the two harmonics. Other frequencies (such as spurious mixing products) may be suppressed in the same fashion provided each frequency is sufficiently separated.

In interstage coupling applications, the coupling capacitor may be resonated to the frequency used. Mounting a bypass capacitor flat against a groundplane (i.e. metal chassis or printed circuit board ground plane) increases its series resonant frequency by about 5%-10%. Adding 2 mm or 3 mm wide copper strips along the length of the wire leads of a capacitor can increase its series resonant frequency by 30%-40%.

The series resonant frequency of a capacitor may be measured by soldering

TABLE 1. SERIES RESONANT FREQUENCIES OF VARIOUS CAPACITOR STYLES

		Lead Lengths & Resonant Frequencies					
Value	Style & Size	25 mm	20 mm	12 mm	5 mm	1 mm	Bandwidth
100pF	Hi-K disc ceramic, 5mm dia	80 MHz	—	135 MHz	165 MHz	200 MHz	Broad
100pF	NPO disc ceramic, 20 mm dia	75 MHz	—	105 MHz	130 MHz	—	Narrow
100pF	NPO tubular ceramic, 20 x 3 mm	69 MHz	—	99 MHz	122 MHz	—	Narrow
100pF	Stacked mica	60 MHz	—	95 MHz	120 MHz	—	Narrow
470pF	Lo K disc ceramic, 5 mm dia.	—	—	65 MHz	80 MHz	140 MHz	Narrow
470pF	Hi-K disc ceramic, 7 mm dia.	40 MHz	—	60 MHz	—	—	Broad
680pF	Hi-K disc ceramic, 5 mm dia.	—	40 MHz	53 MHz	74 MHz	92 MHz	Narrow
1000pF	Hi-K disc ceramic, 5 mm dia.	34 MHz	37 MHz	45 MHz	58 MHz	84 MHz	Narrow
1000pF	Hi-K disc ceramic, 20 mm dia.	25 MHz	—	35 MHz	46 MHz	—	Sharp
1000pF	Plastic Film 'Greencap'	28 MHz	31 MHz	39 MHz	50 MHz	65 MHz	Sharp to Broad
4.7nF	Hi-K disc ceramic, 7 mm dia.	—	—	18 MHz	22 MHz	—	Broad
4.7nF	Hi-K disc ceramic, 'Red cap', 5 mm	18 MHz	21 MHz	25 MHz	33 MHz	—	Sharp to Broad
4.7nF	Plastic Film 'Greencap'	13 MHz	15 MHz	18 MHz	26 MHz	—	Sharp
.01μF	Hi-K tubular ceramic, 10 x 3 mm	8 MHz	—	11 MHz	14 MHz	—	Broad
.01μF	Hi-K disc ceramic, 10 mm dia.	—	—	13 MHz	15 MHz	—	Broad
.01μF	Hi-K disc ceramic 'Redcap', 5 mm	10.3 MHz	11.7 MHz	16 MHz	21 MHz	34 MHz	Sharp to Broad
.01μF	Plastic Film 'Greencap'	9.3 MHz	10.8 MHz	13.5 MHz	18 MHz	22 MHz	Sharp to Broad
1000pF	Resin-sealed Button Mica, 10 mm dia.	—	—	—	500 MHz	—	Broad
1000pF	Gold-sealed Button Mica, 10 mm dia.	—	—	—	800 MHz	—	Broad
1000pF	Solder-in Ceramic Feedthrough	—	—	—	400 MHz	—	Broad
1000pF	Screw-mount ceramic Feedthrough	—	—	—	250 MHz	—	Broad
.082μF	Resin-sealed Button Mica, 10 mm	—	—	—	100 MHz	—	Narrow

the leads to a relatively large copper plate or piece of p.c. board, as shown in Fig.2, and finding the resonance with a grid-dip meter (gate-dip meter, or base-dip meter for modern instruments).

Table 1 lists the series resonant frequencies of a variety of values, styles and sizes of capacitors. The lead lengths noted are the lengths of each lead (refer Fig.2), the disc ceramic is obviously a good choice for bypass applications into the middle VHF region. For applications to 60 MHz or so the common, plastic film 'greencap' is quite good along with various styles of ceramic capacitors. For stringent applications in the VHF-UHF region or for effective bypassing over wide bandwidths, the button mica capacitor or ceramic feedthroughs are necessary. Button ceramics exhibit similar characteristics. Note the high self-resonant frequency of the 0.082μF button mica.

The self-resonant frequency of disc ceramics is dependent largely on its diameter and lead length. The graph in Fig. 3 illustrates this for a variety of disc ceramics and a stacked mica capacitor for comparison.

Fig. 3. Self-resonant frequency versus lead length for various diameter ceramic disc capacitors (after J. Bork, 'A note on the self-resonance of ceramic capacitors: proc. I.R.E. (Aust) May 1957).

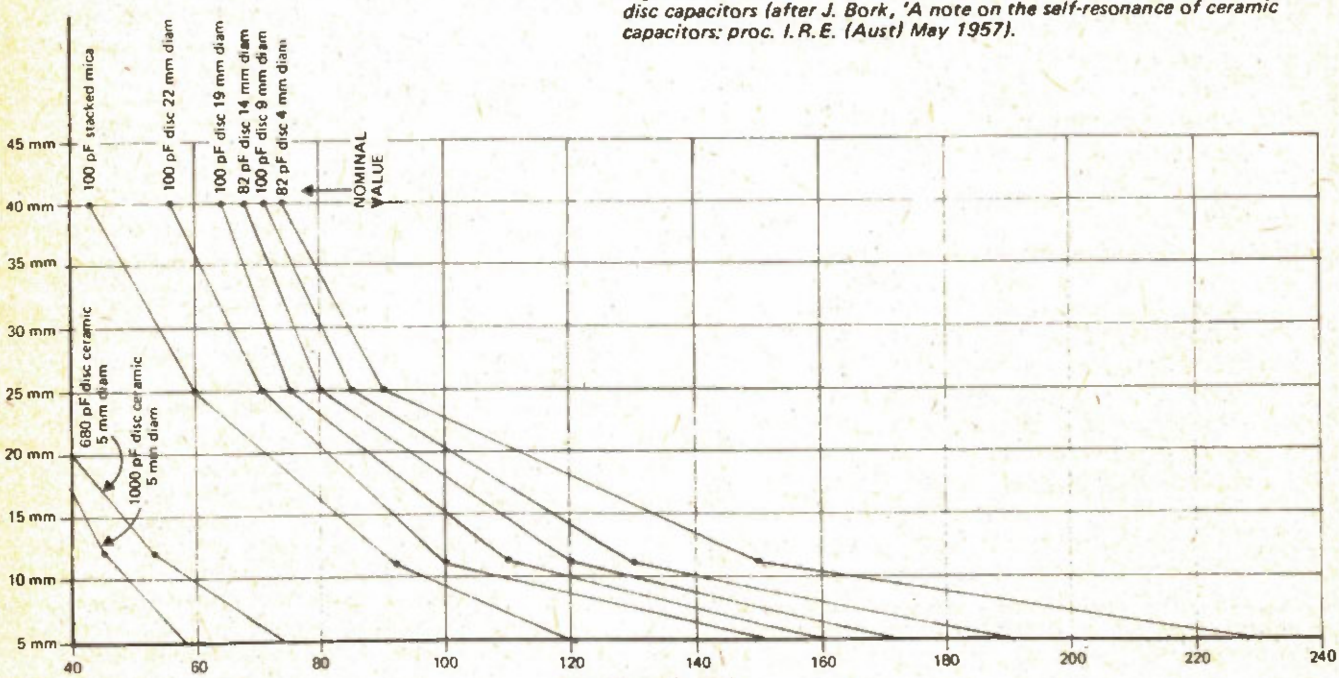


FIG 3

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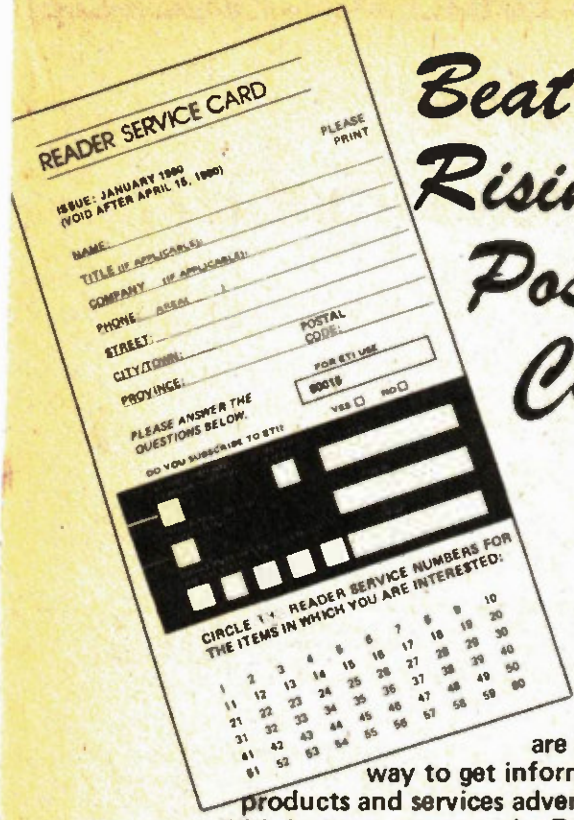

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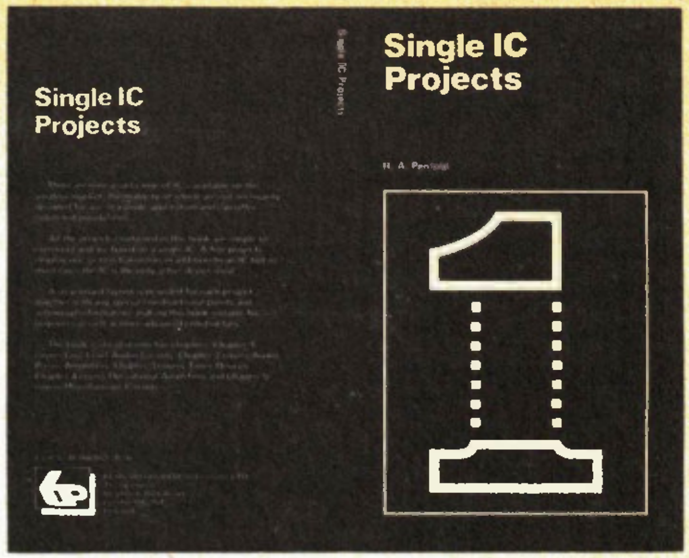

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QRM QRM QRM

In view of todays modern communications techniques morse code may seem as useful as the cat's whisker. Bill Johnson thinks otherwise.

WHAT IS IT that justifies our existence as amateur radio operators? Is it the public services that we perform at times like the Mississauga Rail Disaster (QRM January), the contribution to the state-of-the-art, or maybe the self-training in communications that is useful in time of national emergency or war? In both world wars, amateurs have been a prime resource for signallers and communications technicians. Our national EMO largely uses people who are amateurs to man their stations, so it seems that the only thing left to question is advances in the state-of-the-art.

It might seem paradoxical that amateurs the world over still use, and strongly support the continuance of the use of morse code for their transmissions. Such techniques have not been used by the other services for years now, having largely given way to high-speed data transmission and other highly-sophisticated modes.

The fact of the matter is that amateur radio is largely oriented towards building equipment and carrying out experiments. It is not the use of the equipment that is all the fun, but the building of it. Commercial communications, on the other hand, is concerned with the transmission of as much data as possible, be it voice or digital data such as telegrams, etc., as reliably as possible. Let's take the example of a ship at sea. While they still employ brass pounding radio operators, a large amount of the telegraphy traffic, such as passenger radiograms, weather bulletins, etc., is carried by teletype. The 'sparks' job is largely one of technician on the bigger ships. If a teletype machine fails, it can be replaced with a spare, communications maintained, and the spare repaired on board or at the next port of call. Thus the data still gets through, at a price.

Amateurs are communicating more and more by digital techniques. At the RSO convention in October last year, a complete packet station was demonstrated using a packet repeater. Data were sent from one side of the room to the other via a repeater some 20km distant. Amateurs all over the country have micro-computers in their shacks. At the moment, they are largely under-used, as their owners get used to them and try different programs and techniques. But they will be used, and they will be used very much in the years to come. Packet techniques will be expanded to voice communication and what we now see as a new-born baby will be an ever-present adult in the years to come. It is hard for us to envisage now, and our difficulties of foresight have not been unknown before. Take FM, for example. When FM was invented, it was thought that it would never be used in amateur communications, because it took up too much spectrum space, and amateurs are traditionally spectrum-thrifty. But all you have to do is take one look at any city's two metre spectrum and you will see that FM has become one of the more popular modes for local chatter. So, we can't rule out digital voice communication for the future because it appears at the outset to be wasteful of spectrum space. FM is supposed to be wasteful too, but it has many redeeming qualities.

Amateurs, while they can fill their basements with sophisticated equipment, cannot offer the reliability of commercial communications systems, because they cannot afford to buy complete spare systems. So, while amateurs can provide message service through repeaters and teletype stations, such service, offered to the public at no charge, cannot be guaranteed to be available at all times. However, one distinct advantage is still possessed by the amateur service, we can always get through with morse code, no matter how badly-off our super-sophisticated computer or teletype equipment is. This reliability will always be built into the amateur service, as long as we keep code a requirement for examination to be a ham.

The subject of dropping the morse requirement has reared its head at successive world administrative radio conferences since time immemorial. The old argument was that amateurs must know morse code so that they would not inadvertently interfere with a distress communication in morse. The validity of the argument has lost some weight in light of recent disuse of morse by ships, but it must be remembered that, despite all the sophisticated equipment on board ship, morse can and will continue to be a last resort means of communication where life is at stake.

A perfect example of the need for morse qualification in amateurs occurred in Northern Manitoba last year. An aircraft was down and rescuers were on the way. The people on the downed aircraft, knowing help was coming, started stripping all the valuable equipment out of the plane, leaving only the basic communications radio. When they realised that the search was concentrated fifty km away from their position, clearly given in the Mayday, they tried calling again and correcting the position being searched. The reply from the search party was that they had no audio, just dead carrier. The pilot, being a ham, realised that he must have damaged a mike connection while removing the equipment, and started giving his position in morse code. Great method, but nobody on the search party could read morse! He ended up sending slowly enough that they could look up what he was saying, one letter at a time!

Send your letters to;
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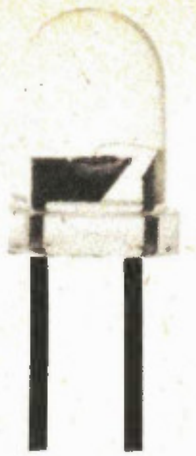
73 til next month,
Bill VE3APZ



Teachers' Topics

Some of us have trouble translating a circuit which we can understand into a practical layout of components. K.T. Wilson holds our hand to guide us over this difficult step.

EVERYONE WHO'S ANYONE publishes interesting circuits. Seen our "Tech Tips"? That's the sort of circuit that arouses the greatest interest and there's no doubt that many readers try them out, perhaps making their own modifications. Despite this, there are countless readers who find that circuit layout is a chore, a task that needs painful planning and lots of second thoughts. If you've never learned how to lay out a circuit properly easily, instantly — stay tuned — what follows is electronics-by-numbers; circuit layout with no sketches or plans, just the circuit diagram and a few scribbles.

THINK JUNCTION

There's no wizardry involved in instant circuit layout, but you have to be able to identify what is called a *circuit junction*. That's not the same as a semiconductor junction, but it's certainly a place where things join. At a circuit junction components join to each other, or to a negative or positive line, or to an input or output. Circuits consist of circuit junctions with components strung between them.

Figure 1 should make this idea of circuit junctions a bit clearer. The circuit is a straightforward one, a couple of transistors connected as an amplifier stage with DC feedback. In this circuit there are eight circuit junctions. Where are they? Well, one is at the input, because we have to take a signal to one lead or C1. Wherever there are connections, there's a circuit junction. We can mark it with a pencilled ring on the circuit diagram. There will be another similar junction at the output, and we can ring that one too.

Getting the idea? Each of these junctions is where components are connected together, and when you build a circuit you will need one line of a matrix board (like Veroboard) for each circuit junction. Have a look at the other junctions we have ringed in the circuit of Fig. 1 and see what you think of the show so far.

Now for the instant circuit layout. The circuit has eight junctions, so number your ringed junctions from one to eight. As easy as that!

Yes, it is, if all of the components have reasonably long leads, but if the transistors have short leads you will have to arrange your numbering so that the junctions where transistor leads are connected have consecutive or near-consecutive numbers. You don't, for example, want to have the collector of a transistor on junction number 1 and its emitter on junction 8. Fig. 2 shows a suggested numbering, one of many that are equally possible.

MATRIX BOARD

Now to build the circuit all you need is a piece of matrix board, the stuff with conducting lines of copper laid on a non-conducting board. Next, get yourself a bottle of liquid

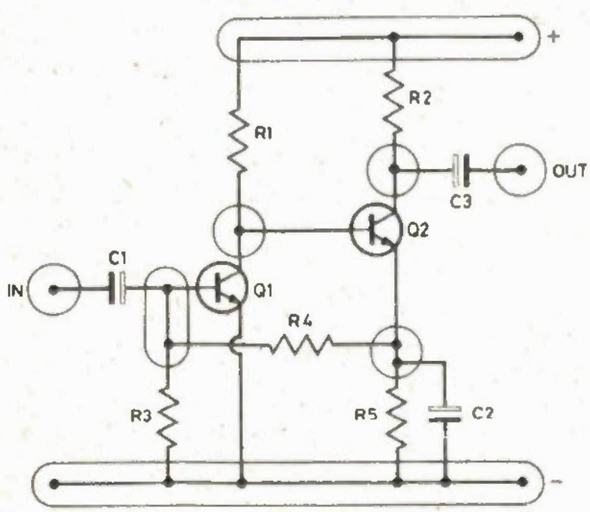


Fig. 1. Marking out circuit junctions.

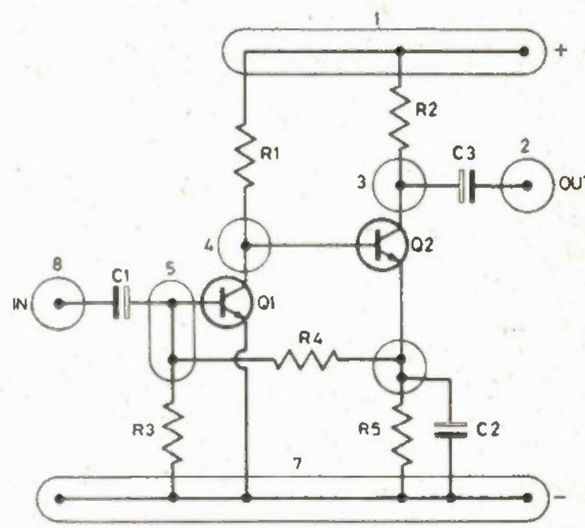


Fig. 2. Numbering the junctions.

paper or similar correction fluid. This is a quick drying liquid that sets matt-white, and it is used by sloppy typist (like me) to obliterate mistakes — it dries as white as paper and you can write on it . (You can also make it go a lot further by thinning it with any dry-cleaning fluid). paint a stripe of this — there's a brush provided on the cap of the bottle — down the side of the veroboard on each side, and let it dry for a minute (and I mean just a minute). Then you can number the strips of the vero-board on each side — but make quite sure that each strip has the same number on each side!

What are you waiting for? You can build the circuit straight away now, because the position of each lead of each component is indicated on the diagram, Fig. 2.C1, for example, is connected between strip 5 and strip 8, with the positive end on strip 5.Q1 is connected with its emitter on strip 7, its base on strip 5 and its collector in strip 4. R1 is connected between strips 4 and 1, and so on.

With your circuit built, look how easy it is to check your connections. Instead of going through the circuit bit by bit, all you need to do is to check that each component is connected between the correct strips. Couldn't be easier. You'll find, incidentally, that a remarkable number of "Tech Tips" can be built on boards of up to 14 strips.

WHAT IF. . . .

Now for the what-if department. What if your circuit needs more strips than you've got, what if the layout turns out awkward, what if you want to use ICs? We've thought about all these points, and here's how.

To start with, if your circuit is long rather than short, there are several things you can do. One is to break the circuit up into bits that will fit onto whatever number of strips you have on each board, and then connect several boards together. This after all is what everybody has to do with a realy large strip, a television isn't built on one board, after all (well, not usually).

The other dodge is just to cut the strips so that you double the number of strips on the board. You don't have to cut all the strips, in fact, because it's most likely that you'll want to keep the + and — supply lines uncut. A 14-track board cut in this way, and leaving two uncut lines, will give you 26 lines to play with, and that's enough for a pretty large chunk of circuit. If that's not enough for you, there's no law to stop you making another lot of cuts. The important thing, of course, is to identify each piece of track.

THE AWKWARD SQUAD

Now for the awkward squad. There are several types of circuits, particularly the multivibrator family of circuits (astable, monostable, bistable) which are awkward to lay out on any sort of matrix boards, particularly if the transistors have short leads. There's a nice simple solution to this problem, and that is to use a mirror-image layout. Never heard of it? Look and learn, then.

In a mirror-image layout, the negative line, or wherever the emitters of the multivib transistors are connected to, is made the centre track of the board, and the outer tracks (1 and 14, for example, when a 14-track board is used) are connected together by a wire lead and used for the positive supply. If you're using PNP, reverse all that, of course. One transistor will have its emitter connected to the centre line, and the supply end of its collector load resistor to line 1. The other transistor of the pair will have its emitter connected to the centre track and the supply end of its collector load resistor to track 14, or whatever the outer track is numbered. Not clear? Take a look at the numbered junction diagram of Fig. 3, and the board layout alongside it, and you'll see what we mean. This is a particularly simple form of construction, and it adapts well to strings of multivib type

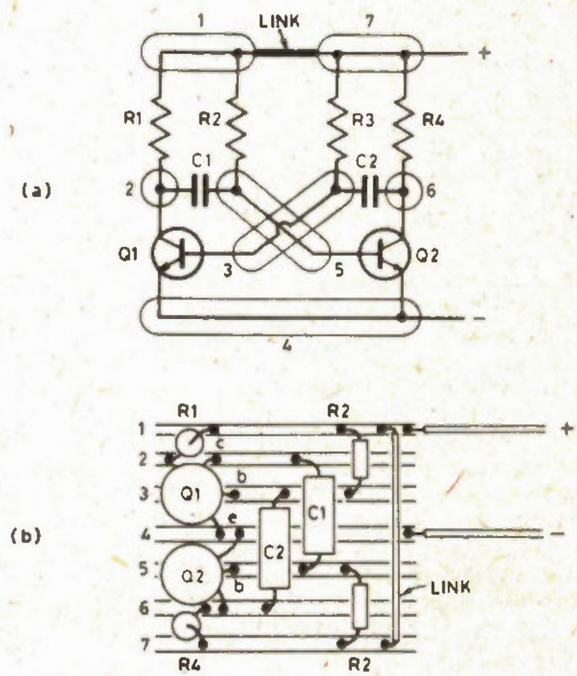


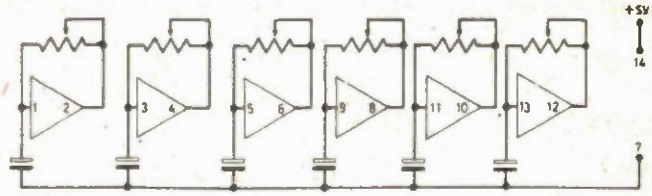
Fig. 3. Mirror-image layouts (A) Marked-out circuit (B) Board layout.

circuits, such as when a slow astable switches a faster one, or for bistable counters, or for long-tailed pair circuits all in a row. Short pulse generator circuits, consisting of an astable driving a bistable are also particularly easy to build this way.

INTEGRATED CIRCUITS

Now for these ICs. There's no doubt about it folks, lots of people don't like constructing IC circuits. As we'll show, though, Instant Circuit Layout makes IC circuits even easier to construct than discrete circuits. The key to it all, once again, is the numbering of the tracks on the board. Most IC circuits, particularly digital circuits, don't call for all that much in the way of other components. In addition, most of the components that are needed are strung either between one pin of the IC and the positive or negative lines, or between IC pins. This means that the number of circuit junctions we have to use is very often just equal to the number of IC pins.

Let's take an example. Fig. 4. shows a circuit for generating 6 different audio frequencies from a single TTL IC, a 7414. Just ignore the circuit for the moment. The IC is a 14-pin type and it will have to be mounted on



(a)

(b)

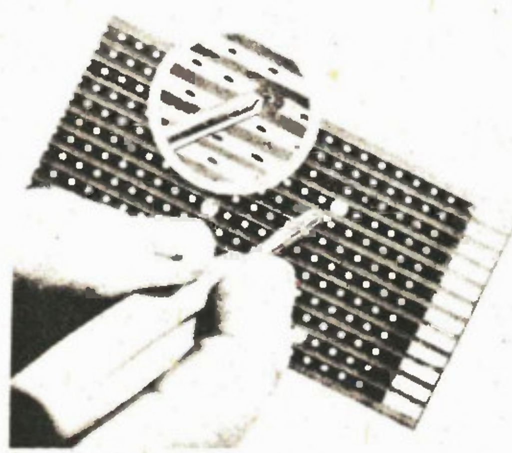
Fig. 4. Sample IC circuit (a), and 0·1in Vero cut-out diagram (b).

Conventional 0.1in Vero board will have to be cut as shown in figure 4b, and the tracks numbered. There is however, a Verostrip and a DIP board which the cuts ready-made, so that only numbering is needed. O.K. so far? You should have in front of you a circuit diagram showing the IC pin numbers and a piece of board with numbered tracks. All you have to do now is to make these numbering systems agree!

Using DIP board? Then make your track numbering agree with the IC pin numbers and connecting up is equally easy; there's no need to change the numbers on the circuit diagram if you're using just one IC. If you're using several ICs, then letter them A, B, C, and so on, and letter your bits of track as well.

Vero makes a spot face cutter for breaking Vero Track for about $5.00. Order tool No. 22-0239G.

There are fourteen Vero distributors in Canada, too numerous to list here. You can find out about them, as well as catalogues and pricing, from Electronic Packaging Systems Ltd., PO Box 481, Kingston, Ontario K7L 4W5.



Using a Vero tool to break up copper tracks.

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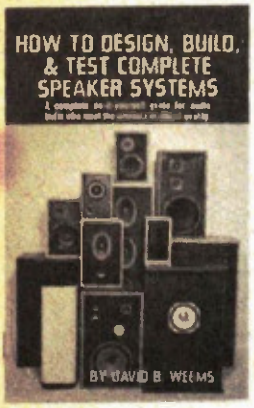

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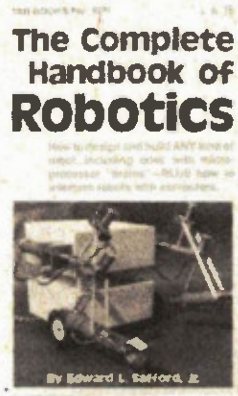

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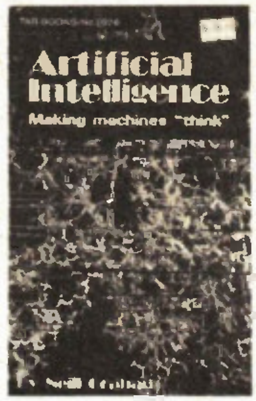

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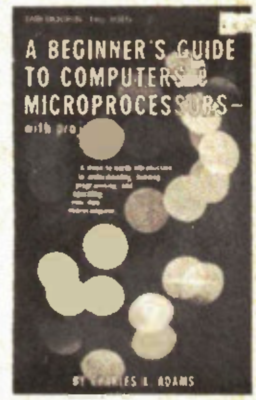

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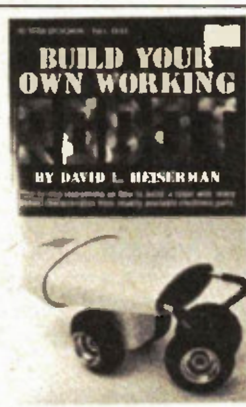

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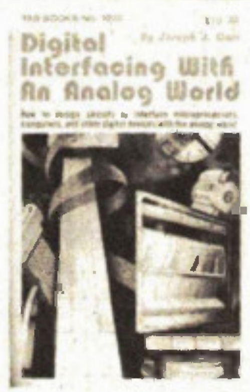

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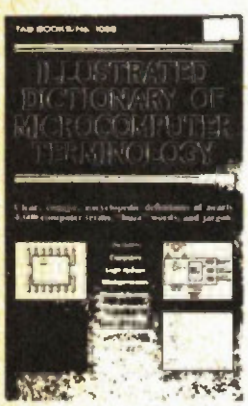

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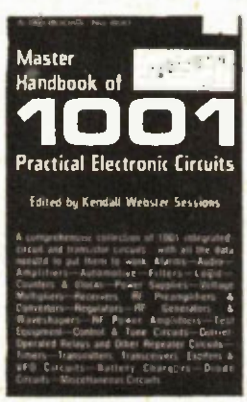

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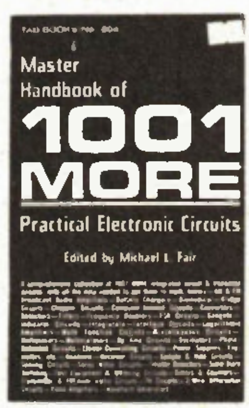

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FEEDBACK

Questions about our 60W Amplifier and a remark on our first attempts at French text.

Letters from our readers. This month; working projects, supply problems and a little bit more on police radar.

May I take some time to comment on your "Project 408" amplifier and CMOS switched preamp. I finished building this project some months ago, and must say I was suprised at how well it worked. I didn't know magazine projects could turn out so well.

Your magazine is tremendous. Keep up the good work and good improvements

Johnson DuPlessis
St. Laurent, Quebec

Frankly Johnson you've got us stumped. However you might try putting a few ICs in backwards. This should degrade performance sufficiently to give you something to worry about.

I am a student of Ladysmith Senior Secondary School. I have been working on your project, the Add-On FM Tuner from the May 1978 issue. I am half-way through completion and there is one part, the LP1186 FM Tuner module that I can not get a hold of. I would appreciate any information of where I could obtain an LP1186 FM Tuner module.

Bob Scyrup
Box 1146
Ladysmith, B.C.
V0R 2E0

Bob, I've got some bad news for you. Mullard stopped making the LP1186 about a year ago. Philips stock ran out some time later (probably due to our article). You should have checked availability before you started.

Perhaps someone out there bought a module and has since decided not to use it. If so, drop Bob a line.

In your article "Jobs for Professionals", News Digest, December 1979 issue, you mentioned a Technical Service Council. Are they an employment agency? How would I get a job with them?

Ron Ho
Crowell, N.S.

P.S. Your News Digest is great! A little bit like 'Science Fiction'. Keep up the very good work.

Fiction! Ron, please we like to call it reality. (How's that for pomposity). Glad you like it though.

Write to the Technical Service Council, 931 Yonge Street, Suite 401, Toronto, Ont. M4W 2H8. Or contact, (Toronto) N.A. Macdougall (416) 966-5030, (Montreal) C. Labrecque (514) 866-2807, (Edmonton) C.H. Humble (403) 482-7116, (Vancouver) A.G. Tinker (604) 682-8888.

The excellent article on police radar omits one quite obvious way of avoiding detection - bear in mind that the whole purpose is not to get caught.

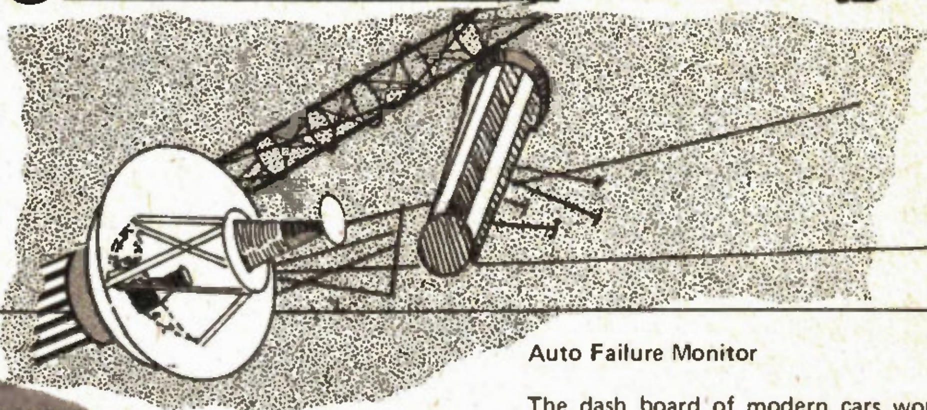
So just arrange a simple electro-mechanical catapult which tosses a hand grenade into the hedge as soon as a detector picks up a transmission from a radar. The fuzz will be so busy rushing towards the resultant explosion that you can roar around everywhere at 100 mph with impunity.

There are a few minor problems in towns.

Collyn Rivers
Managing Editor
ETI Australia

NEXT MONTH

APRIL 1980 IN ETI



Deep Space Tracking

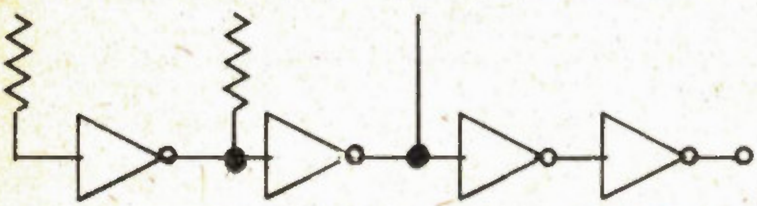
As unmanned probes travel further and further from mother Earth the problem of maintaining reliable communications becomes critical. Brian Dance reports.

Auto Failure Monitor

The dash board of modern cars would look like a Christmas tree if all the idiot lights were to come on. The Auto Failure Monitor will beep insistently if any vital function of your car fails. What's more, it doesn't burn out like dash lights do.

Electromyogram, Part II

Concluding portion of this two part feature includes constructional details, parts lists and hints on using it.

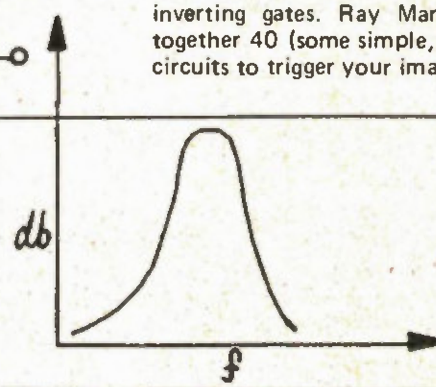


40 CMOS Clocks

A variety of timing and clocking functions are possible with just two inverting gates. Ray Marston has put together 40 (some simple, some unique) circuits to trigger your imagination.

Surface Acoustic Wave Filters

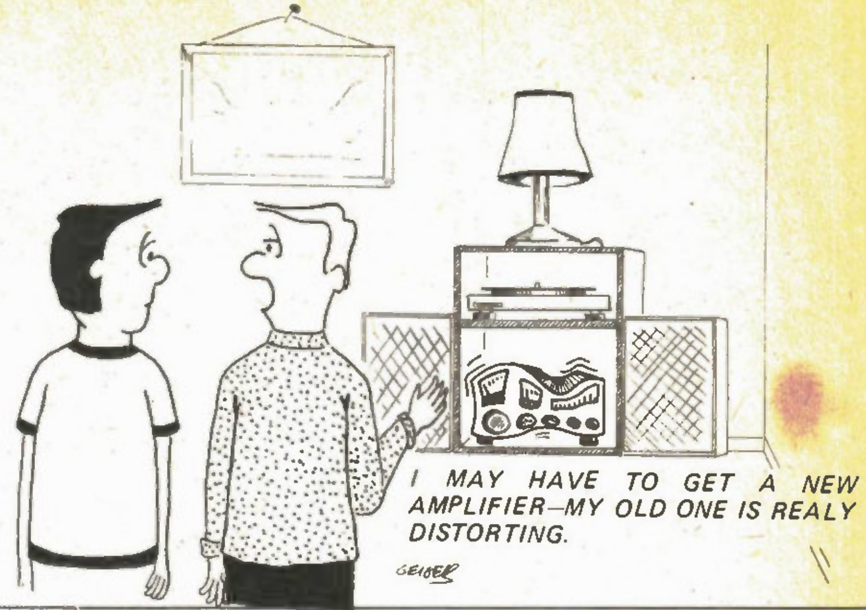
A major consideration in the design of a radio or television receiver is the use of filters to improve selectivity. SAWFs offer numerous advantages when compared to conventional IF strips.

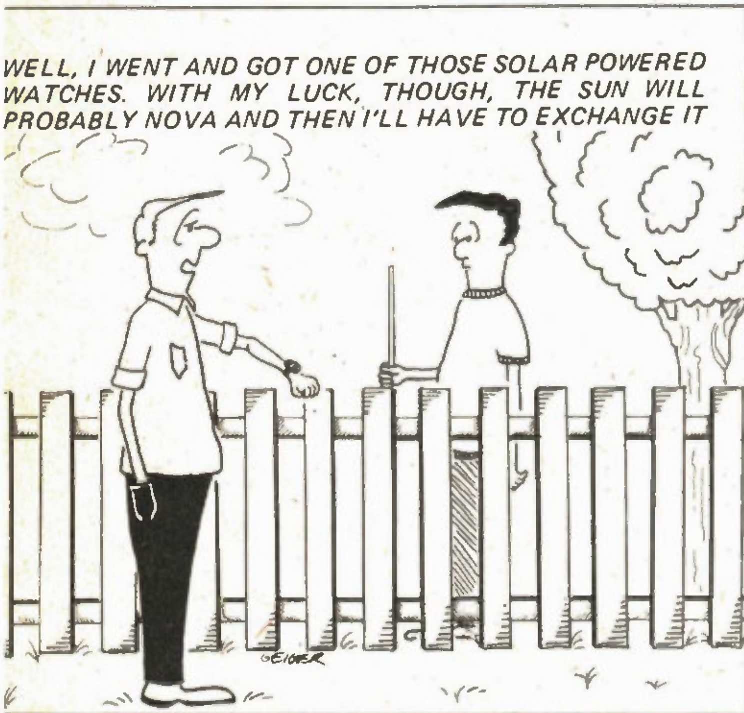


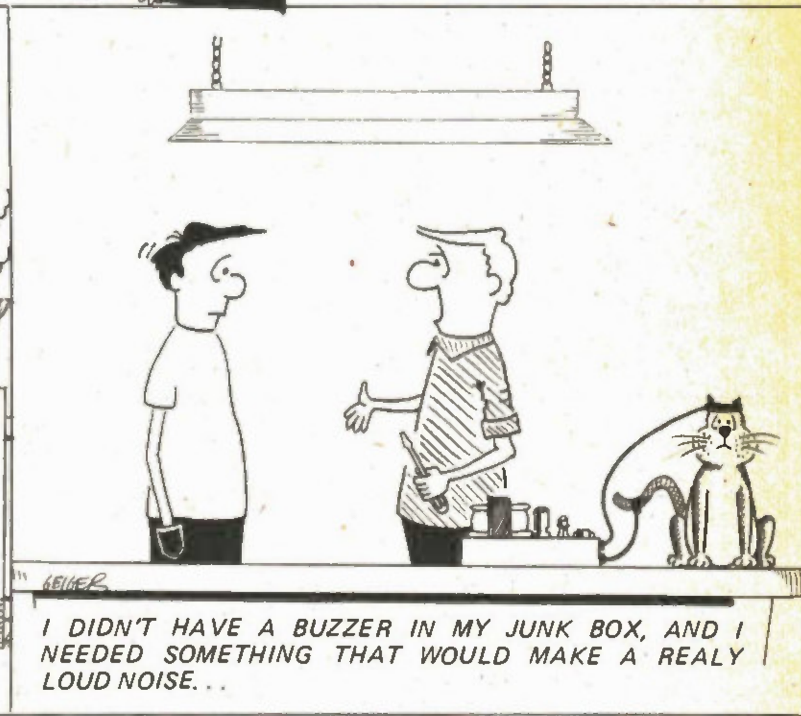
Complex Sound Generator.

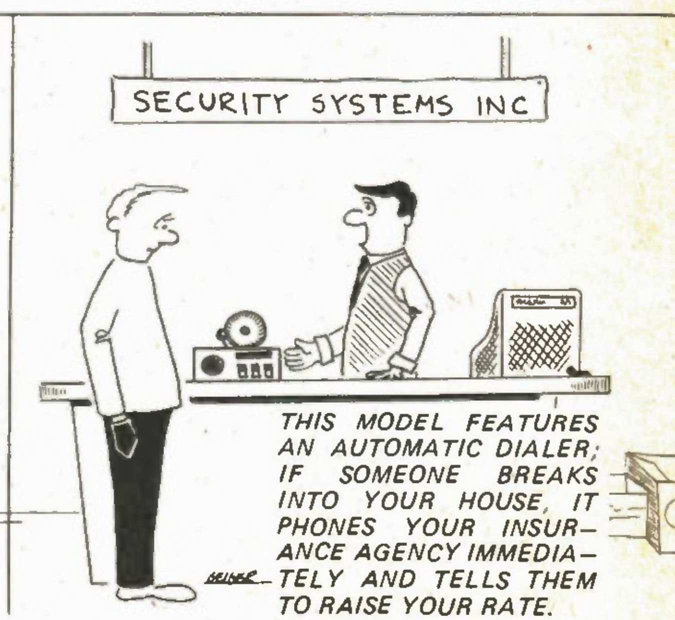
Actually we don't quite know what to call it. It's more than a toy organ but doesn't quite make it as a synthesizer. Essentially, our Minisynth makes full use of a TI-SN76477 sound generator IC's abilities. Another in a series of ETI noise makers.

The Fun of Electronics









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WHAT DO YOU DO?

Send us your typewritten or clearly printed words, your permanent address and telephone number, and your money (no cash please). Make your cheque or money order payable to 'ETI Magazine'. We're at Unit 6, 25 Overlea Blvd., Toronto, Ontario M4H 1B1.

WHAT DO WE DO?

We typeset your words (and put the first word and your company name in bold capital letters).

If we get your message by the 14th of the month, it will appear in ETI 1½ months later. For example, if we receive it by November 14th, you (and thousands more) will see it in the January issue.

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ETI Project File

PLEASE NOTE: WE CANNOT ANSWER PROJECT QUERIES BY TELEPHONE.

Updates, news, information, ETI gives you project support

PROJECT FILE is our department dealing with information regarding ETI Projects. Each month we will publish the Project Chart, any Project Notes which arise, general Project Constructor's Information, and some Reader's Letters and Questions relating to projects.

PROJECT NOTES

Since this magazine is largely put together by humans, the occasional error manages to slip by us into print. In addition variations in component characteristics and availability occur, and many readers write to us about their experiences in building our projects. This gives us information which could be helpful to other readers. Such information will be published in Project File under Project Notes. (Prior to May 78 it was to be found at the end of News Digest.)

To find out if there are project notes for a project you are interested in, simply refer to Project Chart (see below). If there are project notes listed, they will have appeared in Project File (note, prior to May 78, project notes appeared at the end of News Digest.)

Project notes can be ordered one of two ways. You can order the complete back issue, or you can order a photocopy from the appropriate issue. In either case consult General Information For Readers. If you order a copy of a construction article, specify the issue where the project note can be found and we will include them at no cost. You must specify from which issue those project notes can be found.

PROJECT CHART

This chart is an index to all information available relating to each project we have published in the preceding year. It guides you to where you will find the article itself, and keeps you informed on any notes that come up on a particular project you are interested in. It also gives you an idea of the importance of the notes, in case you do not have the issue refered to on hand.

COMPONENT NOTATIONS AND UNITS

We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used sooner or later. ETI has opted for sooner!

Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF= 5p6, 0.5pF = 0p5.

Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is 56k, 4.7k ohms is 4k7, 100 ohms is 100R, 5.6 ohms is 5R6.

KITS, PCBS, AND PARTS

We do not supply parts for our projects, these must be obtained from component suppliers. However, in order to make things easier we cooperate with various companies to enable them to promptly supply kits, printed circuit boards and unusual or hard-to-find parts. Prospective builders should consult the advertisements in ETI for suppliers for current and past projects.

Any company interested in participating in the supply of kits, pcbs or parts should write to us on their letterhead for complete information.

READER'S LETTERS AND QUESTIONS

We obviously cannot troubleshoot the individual reader's projects, by letter or in person, so if you have a query we can only answer it to the extent of clearing up ambiguities, and providing Project Notes where appropriate. If you desire a reply to your letter it must be accompained by a self addressed stamped envelope.

ETI Project Chart

ISSUE DATE	ARTICLE
Feb 79	Phasemeter & Neg
Feb 79	SW Radio
Feb 79	Light chaser & Neg
Mar 79	Tape-Slide Synch
Mar 79	Synth. Sequ.
Mar 79	Dual Dice
Apr 79	Solar Control
Apr 79	Audio Compressor
Apr 79	Wheel of Fortune
May 79	Light Controller
May 79	AM Tuner
May 79	VHF Amt.
June 79	Easy Colour Organ
June 79	LCD Thermometer
June 79	Light Show Seq.
June 79	VHF ant. 2
June 79	Bip Beacon
July 79	Note C
July 79	STAC Timer
July 79	Two Octave Organ
July 79	Light Act Tacho
Aug 79	Audio Power Meter
Aug 79	Two Octave Organs
Aug 79	Shootout.
Sept 79	Field Strength Meter
Sept 79	Sound Effects Unit
Sept 79	Digital Wind Meter
Feb 80	Note S
Sept 79	Up/Down Counter
Oct 79	Simple Graphic Eq.
Oct 79	Digital Dial
Oct 79	Variwipe
Oct 79	Cable Tester
Nov 79	60W Amp
Feb 80	Note U
Mar 80	Note S, U
Nov 79	Model Train Controller
Nov 79	Curve Tracer
Dec 79	High Performance Stereo Preamp
Dec 79	Development Timer
Dec 79	Logic Trigger
Mar 80	Note C
Jan 80	Logic Probe
Jan 80	Guitar Effects Unit
Jan 80	Series 4000 Stereo Amp
Jan 80	Logic Probe
Feb 80	Series 4000 Moving Coil Preamp
Feb 80	Egg Timer
Feb 80	General Power Supply
Feb 80	RTTY 1

PROJECT CHART

This chart is an index to all information available relating to each project we have published in the preceding year. It guides you to where you will find the article itself, and keeps you informed on any notes that come up on a particular project you are interested in. It also gives you an idea of the importance of the notes, in case you do not have the issue refered to on hand.

Canadian Projects Book

Audio Limiter
5W Stereo
Notes N, D May 79
Overled
Bass Enhancer
Modular Disco
G P Preamp
Bal. Mic. Preamp
Ceramic Cartridge Preamp
Mixer & PSU
VU Meter Circuit
Headphone Amp
50W-100W Amp
Note N May 79
Metal Locator
Heart-Rate Monitor
GSR Monitor
Phaser
Fuzz Box
Touch Organ
Mastermind
Double Dice
Reaction Tester
Sound-Light Flash
Burglar Alarm
Injector-Tracer
Digital Voltmeter

Key to Project Notes

C:- PCB or component layout
D:- Circuit diagram
N:- Parts Numbers, Specs
Neg:- Negative of PCB pattern printed
O:- Other
S:- Parts Supply
T:- Text
U:- Update, Improvement, Mods

PCB SUPPLIERS

The following companies currently actively supplying all or some PCBs for ETI projects. Write for complete ordering information.

- B & R Electronics, P.O. Box 6326F, Hamilton, Ontario L9C 6L9
- Spectrum Electronics, P.O. Box 4166, Stn. 'D', Hamilton, Ontario L8V 4L5.
- Wentworth Electronics, RR 1, Waterdown, Ontario L0R 2H0.
- Danocinths Inc., P.O. Box 261, Westland, MI 48185, USA.

Project Notes

Series 4000 Amplifier Jan 80

Unfortunately we neglected to include the pcb for the 472 power supply. It is included here.

Simple 60W Power Amplifier Nov 79

Most people haven't had problems with their 470 module, but inevitably there are some who do. From calls and letters we have identified five areas of trouble

1) The ground rail on the amplifier must be returned to the OV rail on the power supply. If this is not done the input transistors and their current source (Q1-Q5) will be destroyed.

2) It can be seen from the overlay that the base lead of Q5 must be slightly bent to fit the pc board. the transistor can easily be inserted the wrong way round. Watch this.

3) The darlington output transistors must have an adequate heatsink. Always make sure the thermal contact between the transistor and the heatsink is good. Use a thermal compound (such as GC No. 81095), but not too much — Just a smear on either side of the mica washer. Use a metel, rather than a nylon screw with an insulated bush to fasten the transistor — a nylon one will stretch under tension. Make sure the heatsink is smooth and flat, curved or sandblasted heatsinks will not make a good thermal contact with the transistor body.

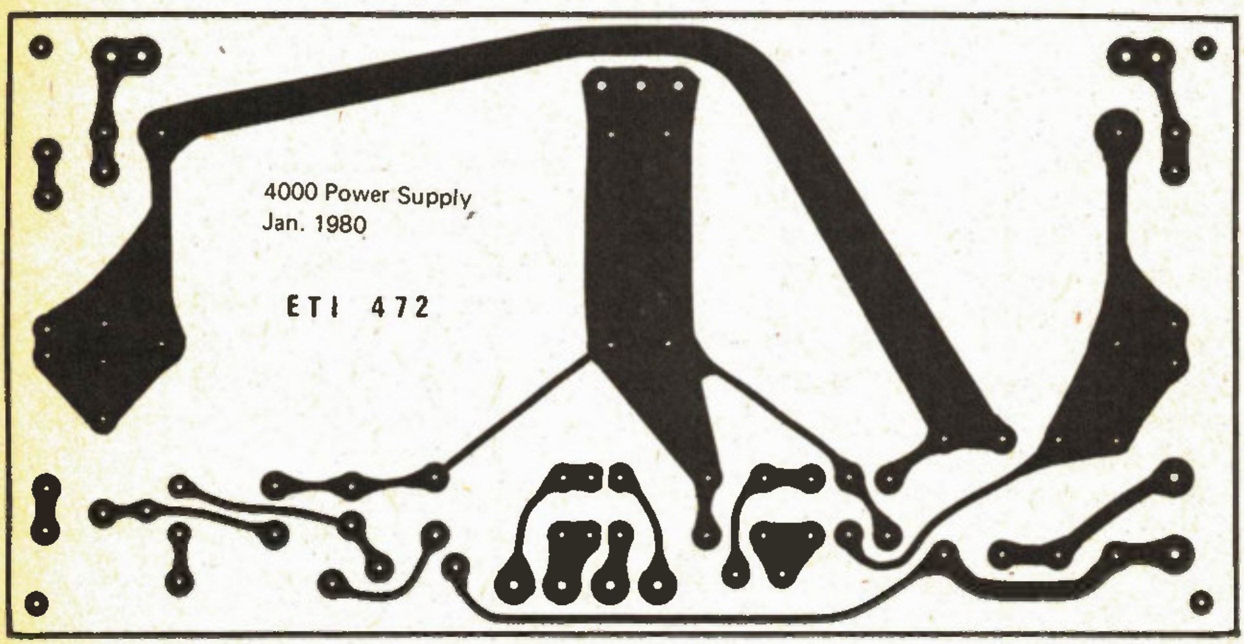
4) Make sure that the transistor Q8 has a good thermal contact to the heatsink. It must be on the same heatsink as the output transistors.

5) Never, never run the amp without a heatsink, even if only to the set the bias.

Overheating of the output devices due to poor heatsinking will result in thermal run away which will blow the fuses, but will probably not damage the output transistors provided the two amp fuses are in circuit. Faults where the amplifier operates correctly for a while then blows fuses, will probably be due to poor heatsinking.

Most transistors in the amplifier are designed to run quite warm in normal operation.

6) Additionally we have been informed that the 2N4920 and the 2N4923 transistors are available from Future Electronics (Active Components Sales, see ad in this issue for address), even though they're not listed in the catalogue.



General Information For Readers

Editorial Queries

Written queries can only be answered when accompanied by a self-addressed, stamped envelope, and the reply can take up to three weeks. These must relate to recent articles and not involve ETI staff in any research. Mark your letter ETI Query.

Projects, Components, Notation

For information on these subjects please see our Project File section.

Sell ETI

ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components. Readers having trouble getting their copy of ETI could suggest to their component store manager that he should stock the magazine.

Back Issues and Photocopies

Previous issues of ETI-Canada are available direct from our office for $2.00 each. Please specify issue by the month, not by the features you require. The following back issues are still available for sale.

We can supply photocopies of any article published in ETI-Canada, for which the charge is $1.00 per article, regardless of length. Please specify issue and article. (A special consideration applies to errata for projects, see Project File.)

1977
February
May
[redacted]
July
[redacted]

1978
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1979
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December

1980
January
February
March

LIABILITY: Whilst every effort has been made to ensure that all constructional projects referred to in this edition will operate as indicated efficiently and properly and that all necessary components to manufacture the same will be available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate effectively or at all whether due to any fault in design or otherwise and no responsibility is accepted for the failure to obtain any component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in the design of any such project as aforesaid.

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Select from this collection of fascinating pocket books.

IC 555 Projects — BP44

■ Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device.
■ It was first manufactured by Signetics, but is now manufactured by almost every semiconductor manufacturer and is inexpensive and very easily obtainable.
■ Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.
■ An invaluable addition to the library of all those interested in Electronics.

$6.50 plus 30c postage and handling.

52 Projects Using IC741 — BP24

■ IC741 is one of the most popular, inexpensive and easily obtainable devices available to the home constructor. It is also extremely versatile and can be used in a great number of various applications.
■ This unique book, originally published in Germany, shows fifty-two different projects that can be simply constructed using only the IC741 and a few discrete components.
■ An invaluable addition to the library of all those interested in electronics.

$3.95 plus 30c postage and handling.

Mobile Discotheque Handbook — BP47

■ The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.
■ The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.
■ The approach adopted is to assume the reader has no knowledge and starts with the fundamentals, hopefully the explanations given are simplified enough for almost anyone to understand but please not that this is by no means the full story.
■ The book is divided into six parts: — Basic Electricity, Audio, Ancillary Equipment, Cables and Plugs, Loudspeakers, Lighting Equipment and the information has been considerably sub-divided for quick and easy reference.

$4.95 plus 30c postage and handling.

28 Tested Transistor Projects — No.221

■ Mr. Richard Torrins is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book.
■ Some of the circuits are completely new and, to the best knowledge of the author, unlike anything previously published while others many bear similarity to more familiar designs.
■ The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.
■ Most of the circuits are very economical on the use of components and in many cases the semiconductors employed are non-critical, commonly available and inexpensive types.

$4.50 plus 30c postage and handling.

First Book of Transistor Equivalents and Substitutes — BP1

■ Shows alternatives and equivalents to many popular transistors made in Great Britain, U.S.A., Europe, Japan and Hong Kong etc.
■ Companion Volume to BP14 — SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES
■ An invaluable addition to the library of all those interested in Electronics be they amateur or professional.

$2.50 plus 30c postage and handling.

Second Book of Transistor Equivalents and Substitutes — BP14

■ Shows alternatives and equivalents to many popular transistors made in Gt. Britain, U.S.A., Europe, Japan and Hong Kong etc.
■ Companion Volume to BP1 — FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES
■ All invaluable addition to the library of all those interested in Electronics be they amateur or professional.

$4.50 plus 30c postage and handling.

Radio Circuits Using IC's — BP46

■ This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, whilst the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception of local v.h.f. stations possibly with stereo (and even quadrophony at some future date). Stereo decoder circuits and the devices available at present for quadrophonic circuits are discussed. Voltage regulator devices are also covered because they are so convenient in all varicap tuned receivers and because they have so many applications in all types of circuit.
■ Brian Dance is a highly experienced author who regularly contributes to many of the popular electronic magazines that are available both in the U.K. and overseas.
■ An extremely valuable addition to the library of all Electronics enthusiasts.

$4.95 plus 30c postage and handling.

50 (FET) Field Effect Transistor Projects — BP39

■ Field effect transistors (F.E.T.'s) find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.
■ It will be found that in general the actual F.E.T. used is not critical and many suitable types will perform satisfactorily. The F.E.T. is a low-noise, high gain device with many uses, and the dual gate F.E.T. is of particular use for mixer and other applications.
■ This book contains something of particular interest for every class of enthusiast — shortwave listener, radio amateur, experimenter or audio devotee.
■ A valuable addition to the library of all electronic enthusiasts.

$4.50 plus 30c postage and handling.

Popular Electronic Projects — BP49

■ Included in this book are a collection of the most popular types of projects which, we feel sure, will provide many designs to interest all electronics enthusiasts.
■ All the circuits utilise modern, inexpensive and freely available components.
■ The 27 projects selected cover a very wide range and are divided into four basic areas: Radio Projects, Audio Projects, Household Projects and Test Instruments.
■ An interesting addition to the library of both the beginner and more advanced constructor.

$5.50 plus 30c postage and handling.

Electronic Music and Creative Tape Recording — BP51

■ Electronic Music is the new music of the 20th Century. It plays a large part in "Pop" and "Rock" music and, in fact, there is scarcely a group without some sort of electronic synthesiser or other effects generator.

It is possible with relatively simple apparatus to create complete compositions using electronic and sometimes non-electronic musical sources.

■ This book sets out to show how Electronic Music can be made at home with the simplest and most inexpensive equipment. It describes how the sounds are generated and how these may be recorded to build up the final composition.
■ With the constructor in mind, several ideas are given to enable a small studio to be built including a mixer and various sound affect units.

Circuits are included for VCOs, VCAs, Envelope Shapers, VCFs, Active and Passive Mixers, Fuzz, Noise Generators, Metronomes and a 10-Note Programmable Sequencer etc.

All the units shown have been successfully built and used by the author and most of the projects can be built by the beginner.

■ An unusual, fascinating and highly rewarding application of electronics.

$4.50 plus 30c postage and handling.

IC LM3900 Projects — BP50

■ The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and Hobbyist. It provides the groundwork for both simple and more advanced uses and is considerable more than just a collection of simple circuits or projects.
■ The LM3900 is different from conventional 'Op-Amps', it can be used for many of the usual applications as well as many new ones. It is one of the most versatile, inexpensive and freely available devices on the market today.
■ The book is divided into six basic sections: —

Introduction
Audio Applications
Simple Linear Applications
Simple Digital Applications
Signal Generator Circuits
Special Applications

■ The LM3900 can do much more than is shown here — this is just an introduction, imagination is the only limitation with this useful device, but first the reader must know the basics and that is what this book is all about.

$4.95 plus 30c postage and handling.

1st Book of Hi-Fi Loudspeaker Enclosures — No.205

■ Contains 26 practical designs and over 40 drawings to enable the enthusiast to construct his own Hi-Fi Loudspeaker enclosures.
■ Includes the following types of enclosures: —
Corner Reflex, Bass Reflex, Exponential Horn, Folded Horn, Tuned Port, Klipschorn Labyrinth, Tuned Column, Loaded Port, Multispeaker Panoramic etc.
■ Also covers general construction hints and embellishing of cabinets as well as a considerable amount of other useful information.
■ A must for the library of all audio enthusiasts.

$2.95 plus 30c postage and handling.

50 Simple L.E.D. Circuits — BP42

■ The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.).
■ Also includes circuits for the 707 Common Anode Display.
■ A useful book for the library of both beginner and more advanced enthusiast alike.
■ Companion volume to book No. BP36 — 50 CIRCUITS USING GERMANIUM, SILICON & ZENER DIODES by the same author.

$2.95 plus 30c postage and handling.

Handbook of IC Audio Preamplifier & Power Amplifier Construction — BP35

■ Shows what audio IC's are, as well as how to use them.
■ Includes practical constructional details of various IC and Hybrid IC/Transistor designs of about 250mW to 100W output.
■ This book is written by the very experienced and popular author Mr. F.G. Rayer who deals with the subject in four parts:
Part I Understanding Audio IC's
Part II Preamplifiers, Mixers and Tone Controls
Part III Power Amplifiers and Supplies
Part IV Hybrid Circuits
■ An ideal book for both beginner and advanced enthusiast alike.

$4.50 plus 30c postage and handling.

50 Projects Using Relays SCR's & Triacs — BP37

■ Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. These may extend over the whole field of motor control, dimming and heat control, delayed, timing and light sensitive circuits and include warning devices, various novelties, light modulators, priority indicators, excess voltage breakers etc.
■ In this book, the very experienced and popular author — Mr. F.G. Rayer — has given tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct.
■ In most circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaption of them to individual needs.
■ An ideal book for both beginner and advanced enthusiast alike.

$4.50 plus 30c postage and handling.

50 Projects Using IC CA3130 — No.223

■ The CA3130 is currently one of the more advanced operational amplifiers that is available to the home constructor. This means that it is often capable of a higher level of performance than many other devices and that it often needs fewer ancillary components.
■ In this book Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into five general categories:
I Audio Projects
II R.F. Projects
III Test Equipment
IV Household Projects
V Miscellaneous Projects
■ An ideal book for both the beginner and more advanced enthusiast alike.

$4.50 plus 30c postage and handling.

Electronic Projects for Beginners — BP48

■ In this book the newcomer to electronics will find a wide range of easily made projects, many complete with actual component and wiring layouts. Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.
■ This book which is written by the very experienced author Mr. F.G. Rayer is divided into four sections: —
1. "No Soldering" Projects
2. Miscellaneous Devices
3. Radio and Audio Frequency
4. Power Supplies
■ An absolute 'must' for all beginners in electronics.

$4.95 plus 30c postage and handling.

50 CMOS IC Projects — No.224

■ C.M.O.S. IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinarily wide range of applications and are now also some of the most inexpensive and easily available types of I.C.
■ In this book Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories:
I Multivibrators
II Amplifiers and Oscillators
III Trigger Devices
IV Special Devices
■ An ideal book for both the beginner and more advanced enthusiasts alike.

$3.95 plus 30c postage and handling.

Electronic Calculator Users Handbook — BP33

■ An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators.
■ Presents formulae, data, methods of calculation, conversion factors etc. with the calculator user especially in mind, often illustrated with simple examples.
Includes:
■ The way to calculate, using only a simple four function calculator:
Trigonometric functions (sin, cos, tan)
Hyperbolic functions (sinh, cosh, tanh)
Logarithms, square roots and powers.
■ A comprehensive section of conversion factors covering such common conversions as length, area, volume and weight etc. through to more specialised conversions such as viscosity, illumination, and cargo shipping measures etc.
■ Formulae and data for VAT, discounts and mark up, currency conversion, interest, solutions of equations, binary and octal numbers, areas and volumes, statistics and mathematics etc.

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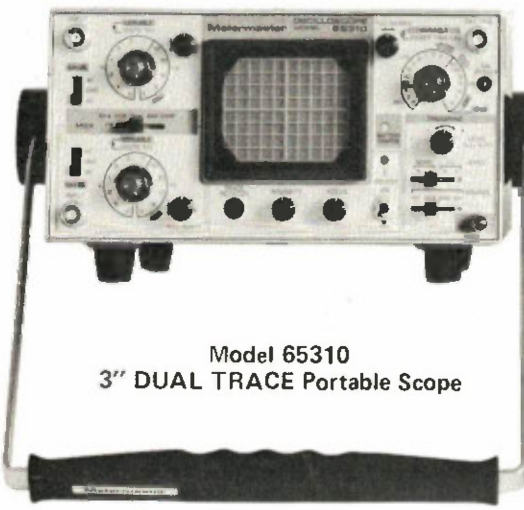
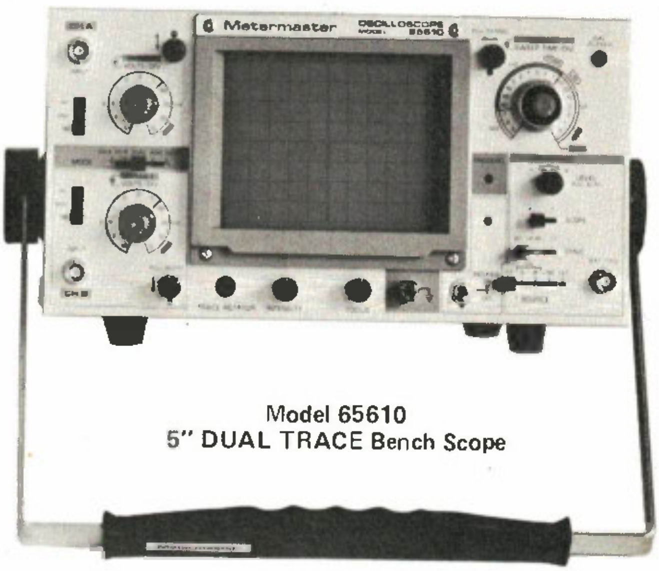


Model 65310
3" DUAL TRACE Portable Scope



Model 65610
5" DUAL TRACE Bench Scope

The Model 65310 is a truly portable, dual trace, 15MHz scope offering battery operation as a standard feature. This is an ideal oscilloscope for the service - man who needs a combination bench and portable instrument. This scope is packed with features:

* Operates from 3 power sources:
  1) Rechargeable NiCad batteries
  2) 120VAC line (also charges batteries)
  3) 11 – 30VDC
* 3" High Brilliance CRT
* Fully Automatic Triggering
* Built-in Calibration Source
* Trace Rotator
* 2mV Vertical Sensitivity
* Operating Modes CH-A, CH-B, Dual, Add/Sub Chop, and X-Y

WEIGHT: 13.5 lbs.
OPTIONAL ACCESSORIES: Combination 1:1 and 10:1 switchable probes(compensated). Priced at $39.00 F.S.T. included.
Vinyl carrying case for Model 65310 only, priced at $62.00 F.S.T. included.

The New METERMASTER Model 65610 scope employs an extremely bright 5" rectangular CRT with internal graticule. External DC operation permits floating measurements. Take a look at the features this scope has to offer:

* Operates from 2 power sources:
  1) 120VAC line
  2) 11.5 – 30 VDC
* Frequency Response 15MHz(-3dB)
* Fully Automatic Triggering
* Built-in Calibration Source
* Trace Rotator
* HF Rejection
* 5mV Vertical Sensitivity
* Operating Modes CH-A, CH-B, Dual, Add/Sub Chop, X-Y, and Z modulation.

WEIGHT: 16 lbs.
OPTIONAL ACCESSORIES: Combination 1:1 and 10:1 switchable probes(compensated) Priced at $39.00 F.S.T. included.

Call one of our offices (below) for a no obligation, free of charge evaluation.

Metermaster

R.H. NICHOLS

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