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MAY 1979

50p

Six Channel Fully Proportional

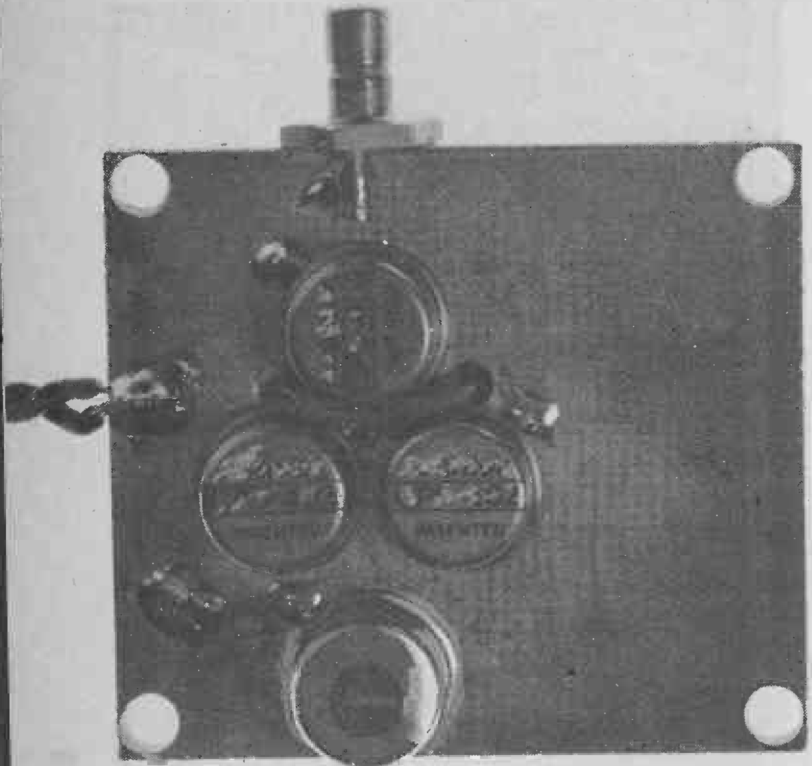
RADIO CONTROL SYSTEM

HEADPHONE AMPLIFIER

HOW IT WORKS ~ RADIO

STAR CHESS

... NEWS . . . . PROJECTS. . . . MICROPROCESSORS. . . . AUDIO . . .



Simplified Plessey IF filter, it would be difficult to reduce component count further.

devices can be produced to suit different applications, or in the case of TV filtering, for different systems (ie PAL, — SECAM, NTSC etc). If the electrodes are evenly spaced with a gap of λo between electrodes of the same polarity the frequency response of the filter would be sin x/x where the centre frequency is given by:

$$fo = \frac{\text{(velocity of wave propagation)}}{\lambda o}$$

The bandwidth (Δf) is given by:

$$\Delta f / fo = 2/N$$

Where N is the number of electrode pairs. Such a device would possess a linear phase response.

The central coupling grids consist of uniform strips of isolated electrodes, which effectively re-direct the surface wave to the output transducer.

The Future?

So far, SAW filters have been competing against conventional IF filters and are now recognised as being economic and technically advantageous. Already techniques are emerging from the development laboratory which will give even better response and cheaper filters. Parallel sound filters, which have separate outputs for sound and video signals are now in development. These will make possible TV sets with Hi-Fi quality sound. Professional SAW filters are now also being produced and these filters are very stable and can have response shapes which are almost impossible to produce any other way. For instance the CATV filter from Plessey in virtually square. It has an 8 MHz bandwidth which is flat ±0.2dB and then falls off almost vertically to sidelobes which are lower than 55 dB down. The filters have also made new types of pulse compression/expansion radar possible.

Our thanks to Peter Haywood of Plessey Semiconductors Ltd for his help in preparing this article and to Mullard Ltd for additional information.

ETI

"Good Morning Miss! You are privileged to be a participant in my new invention — 2-way broadcasting through mirrors. Would you care to say a few words?"

Take a

SO WHAT, YOU MAY ASK, is the advantage of an electronic dice over its conventional and inexpensive plastic (solid state?) counterpart? The answer is that, apart from looking better (and being a better conversation piece), the electronic die or dice is very fast: it can be 'thrown'' and read in a fraction of a second, compared to the several seconds needed for the mechanical item. That enables the rate of play of a game to be speeded up, and consequently makes most games more fun to play. The electric die-dice is a particular boon to the war-games enthusiast.

Our dice has a few unusual features. It has only two panel-mounted controls. One of these is a two-way switch that lets you select either a single die or a double die (dice) display: the displays are naturally presented in the conventional die format. The other control is a push-button that gives the roll-and-throw action. When the button is pressed the die are rolled and the display is blanked out. The die are thrown and displayed on release of the pushbutton. Once thrown, the die are displayed for about seven seconds, and then black out automatically. When using the device, you can roll-and-throw as fast as you like: you don't have to wait for an autoblanking phase between actions. The unit consumes negligible current when in the standby mode, so no on-off switch is required.

The ETI die-dice is designed around readily-available CMOS IC's. It is the most economically die-dice circuit that we've seen so far. It uses only five IC's and eight discrete components, apart from the 14 LED's and 8 limiting resistors associated with the actual display.

Construction

Not much to say here. All the electronics, except the LEDs, are mounted on a single PCB, so construction should present no problems. On our prototype we

gamble: DOUBLE DIE

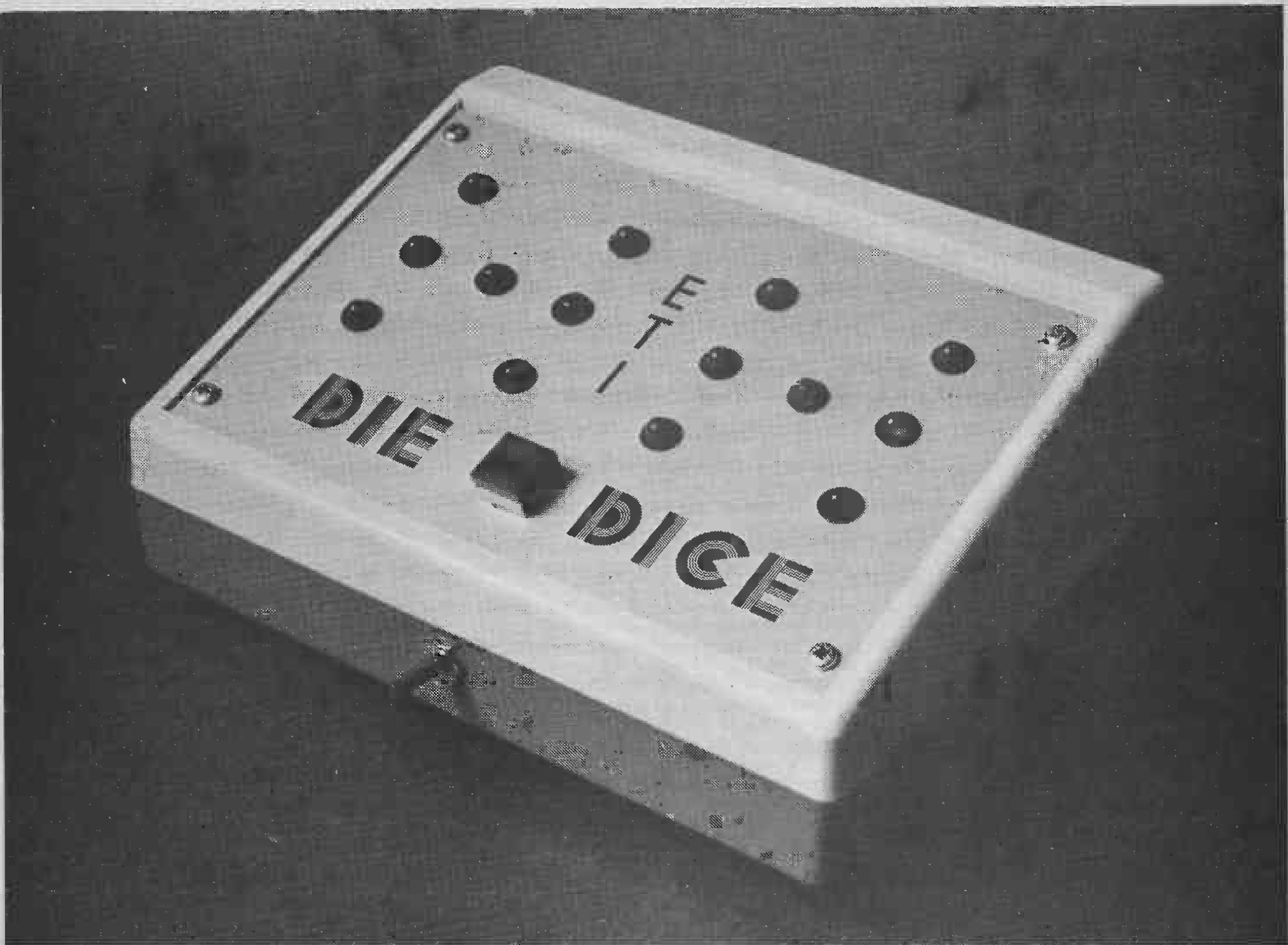
used red LEDs for the left-hand die display, and orange for the right. Not a good idea: the orange LEDs aren't contrasty enough, and are difficult to read. Our advice is use red LEDs for both displays.

Our prototype unit is housed in a sloping-front Verocase. The PCB is held in place by Sellotape sticky fixers. That's a good idea: it saves drilling holes in the case and the PCB. ▶

Fig. 1. The random element in Double Die is comparable to the mechanical version. The table on the right was compiled from extensive practical tests and as you can see it produces identical results to it's 'solid state' counterpart.

Double dice odds

COMBINATION	ODDS
any double number	1 in 6
a specified double	1 in 36
total of 2 or 12	1 in 36
total of 3 or 11	1 in 18
total of 4 or 10	1 in 12
total of 5 or 9	1 in 9
total of 6 or 8	1 in 7.2
seven	1 in 6
any two numbers	1 in 18



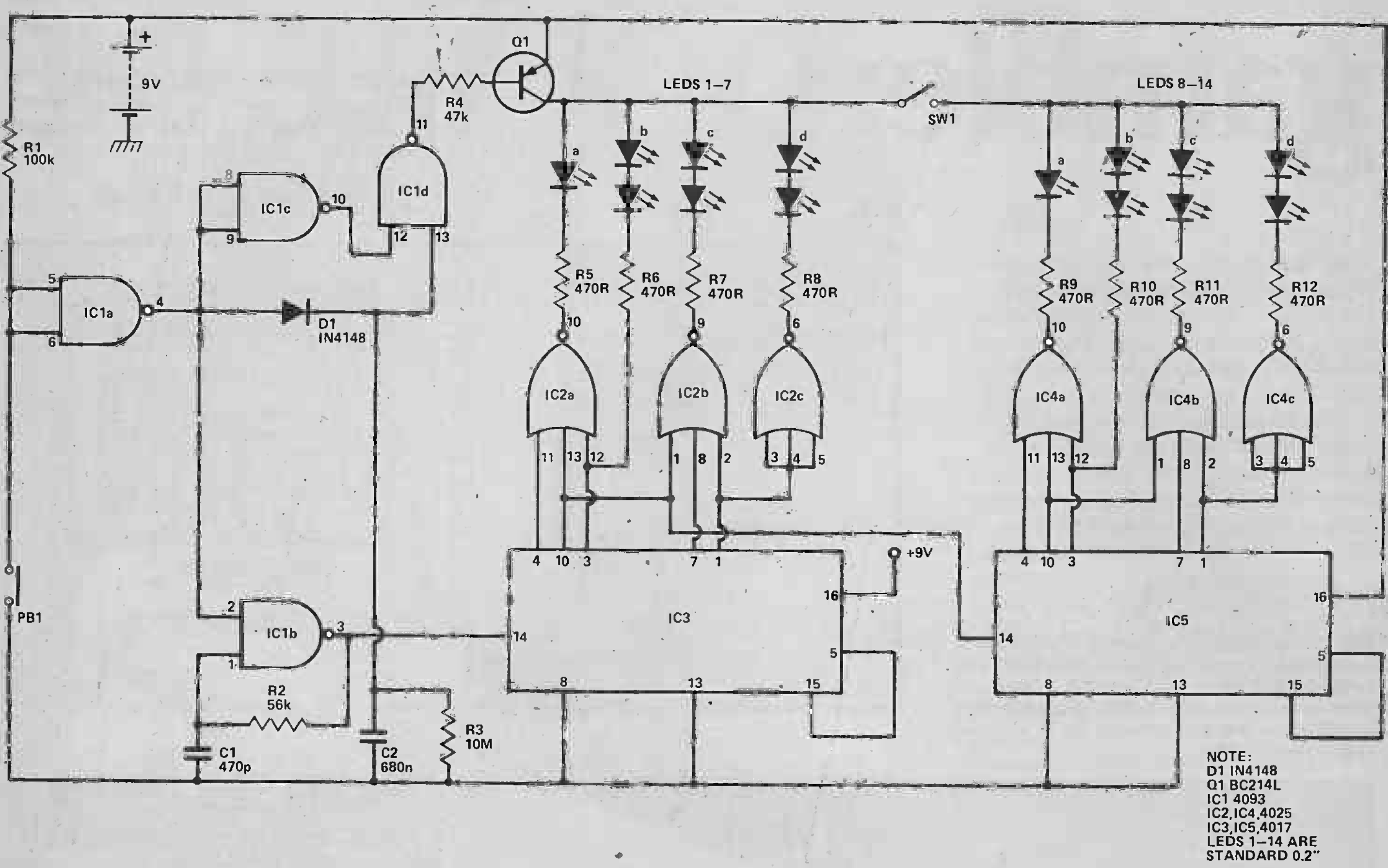


Fig. 2. The complete circuit diagram of Double Dice, as you can see the component count is significantly lower than any previously published design. ICs 3 and £ are 4017s arranged as divide by six, counter-dividers.

HOW IT WORKS

The circuit may be divided into three sections; the clock-control and two identical counter-decoder stages. IC1 handles the control fuction and generates the clock pulses to drive the 4017 counters IC3 and IC5. The output from these in then decoded to provide a conventional die display by IC2 and IC4.

When PB1 is depressed the output of IC1a goes high. This signal, inverted by IC1c, disables IC1d as long as the switch is closed and Q1 remains off so no LEDs are lit. During this time, C2 is charged to about 9 volts through D1 and the clock oscillator IC1b is enabled.

Clock pulses are input to IC3, a 4017 configured as a divide by 6 counter-decoder. This is achieved by connecting decoded output '6' to the rest input. As the outputs are numbered from zero, output '6' goes high on the seventh clock cycle resetting the counter and providing six decoded outputs which go high sequentially. The rest pulse generated is too short to reliably clock the second counter IC5 so one of the decoded outputs from IC3 is used.

When PB1 opens, IC3 and IC5 which have been cycling continuously will stop at a random position as clock oscillator IC1b is disabled. The output of IC1 a will go low again and this signal inverted by IC1c enables one input IC1d. The other input of IC1d will be at a high level as C2 is still charged and so its output will go low turning on Q1 and the LEDs until the charge on C2 leaks away through R3 after about six seconds when the LEDs will extinguish. One or both displays will be illuminated depending on the position of SW1. If you wish to replace PB1 by a touch contact, R1 may be increased to 4M7.

PARTS LIST

RESISTORS (5% all ¼-watt)

R1	100k
R2	56k
R3	10M
R4	47k
R5, 6, 7, 8, 9, 10, 11, 12,	470R

CAPACITORS

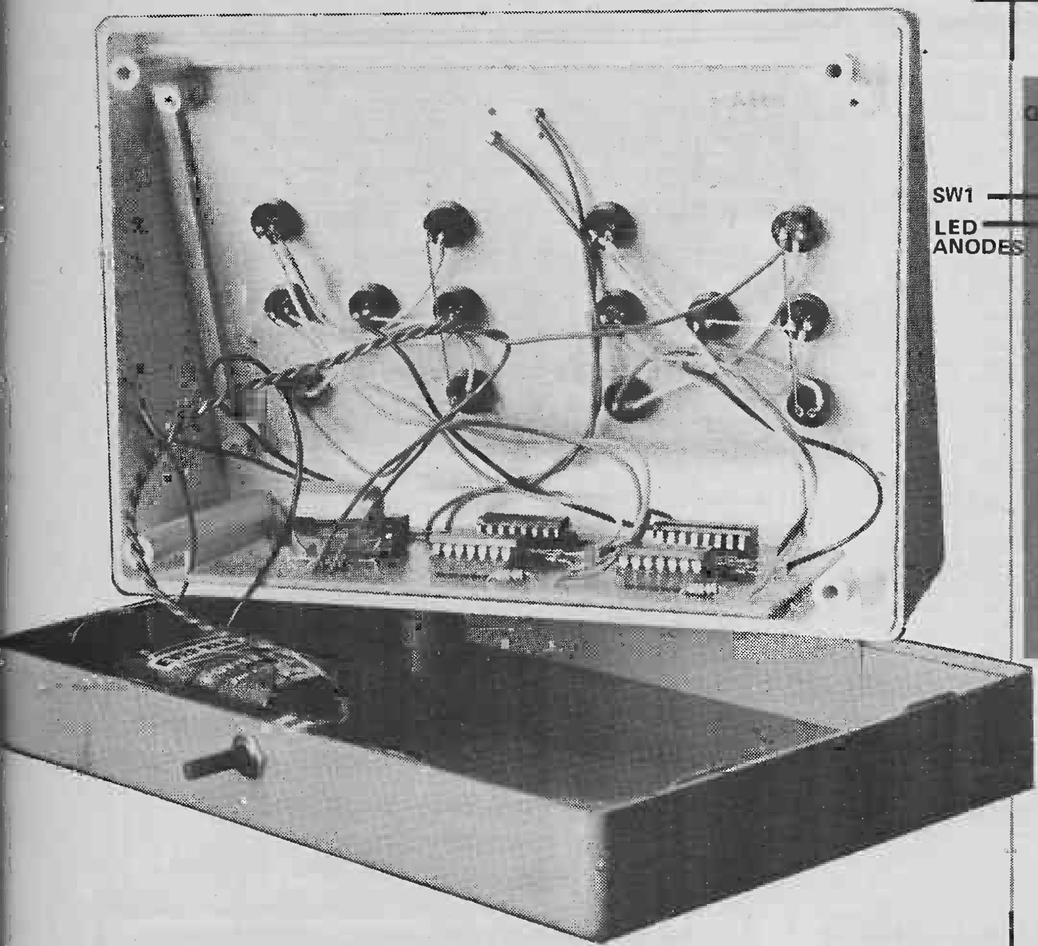
C1	470p
C2	680n

SEMICONDUCTORS

D1	IN4148
Q1	BC214L
IC1	4093
IC2, IC4	4025
IC3, IC5	4017

LEDs 1-7 red 8-14 yellow, standard 0.2"

MISCELLANEOUS
PB1 push-button SPST
SW1 SPST
P.C.B. Vero-case to suit.



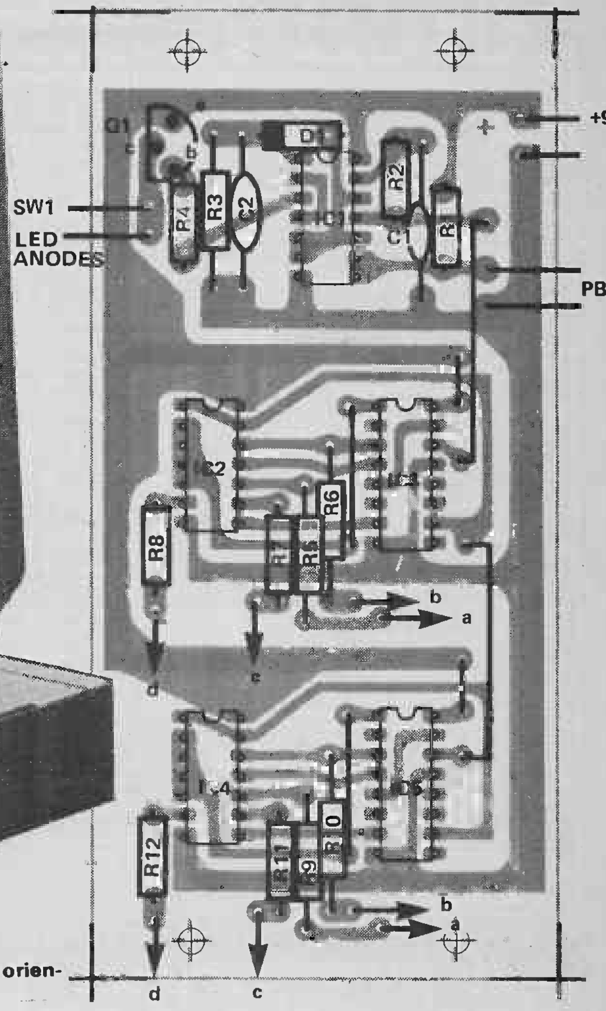
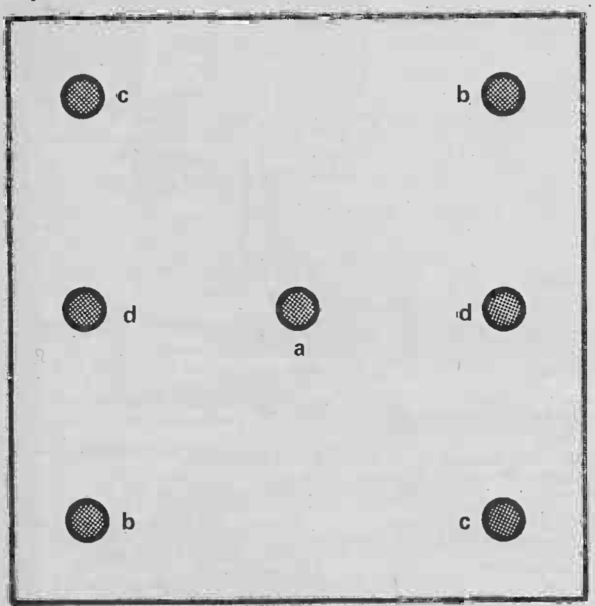


Fig. 3. Component overlay, note the orientation of the LCs.

Fig. 4. Layout for the LED display, two are required.



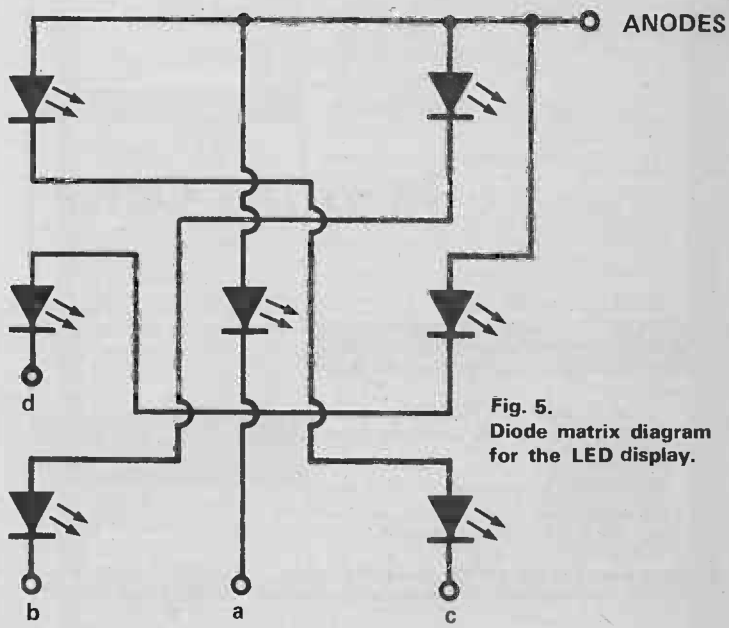


Fig. 5.
Diode matrix diagram for the LED display.

BUYLINES

There should be no problem in obtaining any of the components used in this project. The !Cs are common types available from most electronics hobby shops.

HOW IT WORKS AM & FM RADIO

Gordon King manages to dispell a few rumours about a very widely misunderstood subject, Radio. Such diverse subjects as Varicap Tuning and Stereo FM are clearly explained.

OF THE TWO sound broadcasting systems the AM (amplitude modulation) system is capable of far greater range of reception than the FM (frequency modulation) system. This has nothing to do with the type of the modulation but is related to the carrier frequencies involved. FM sound radio uses a part of the VHF (very high frequency) spectrum called Band II and covering approximately 88 to 108 MHz, though all of this is not yet used in the UK specifically for entertainment radio.

AM radio broadcasting occupies the long, medium and short wavebands which range respectively from about 50 kHz (6,000 metres) to 600 kHz (500 metres), 600 kHz to 1.5 MHz (200 metres), and 1.5 MHz to 300 MHz (1 metre). Conversion from frequency to wavelength merely involves dividing the propagation velocity (virtually 300 metres per microsecond) by the frequency, or from wavelength to frequency by dividing the velocity by the wavelength.

With increasing carrier frequency the waves tend more closely to follow the laws of light, and at VHF they emanate from the top of the transmitting aerial in rather the same way as light is radiated from the top of a lighthouse. They are less affected by obstructions, though, and are more prone to diffraction and refraction than light which to some extent allows them to pass round obstacles and penetrate walls, etc, but this accommodation is diminished at even higher frequencies. The reception distance of VHF waves, therefore, is limited to a little in advance of the 'line of sight' distance between the transmitting and receiving aerials, the extra being provided by atmospheric refraction and diffraction round the curved Earth.

On Reflection

However, VHF waves are less reflected back to Earth by the ionosphere, and most wave energy skyward-bound penetrates the ionosphere and vanishes into space — which is just as well for space communications! At the lower AM broadcast frequencies the ionosphere acts more like a 'mirror' to the signals, which not only prevents them getting into space but it also reflects them back to Earth over ranges far in advance of the 'line of sight' distance. World-wide reception is thus possible by the waves undergoing a number of 'hops' between ionosphere and Earth.

At certain frequencies ionospheric reflection is enhanced as night falls which means that signals well outside the basic reception range appear and are likely to cause interference with the signals from wanted local stations. To some extent this is avoided by an international agreement of wavelength spacing; but because there are so many medium-frequency stations to take account of the spacings cannot be very wide, so to reduce the effect of interference the bandwidth of AM receivers is restricted, as this attenuates or deletes the higher-order sidebands the quality of the reception is impaired. This is not necessary at FM because the stations can be adequately separated in Band II without the fear of distant stations producing signals which could interfere with those of the wanted signals. Moreover, FM has a far better immunity than AM so far as this sort of interference is concerned.

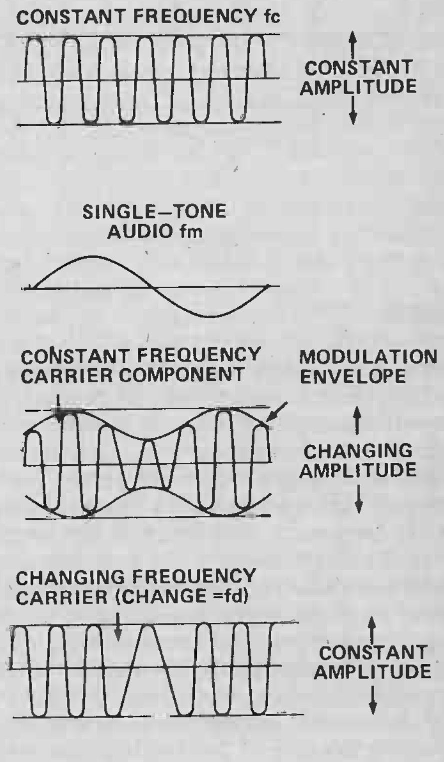


Fig. 1. Impressions of modulation (not to scale). (a) carrier wave, (b) single-tone modulation signal, (c) AM waveform, and (d) FM waveform.

The FM system, therefore, is capable of far better audio quality than the AM system as it is currently exploited. It also carries an additional channel of information for stereo reproduction and is thus a 'hi-fi' broadcasting system as will be explained.

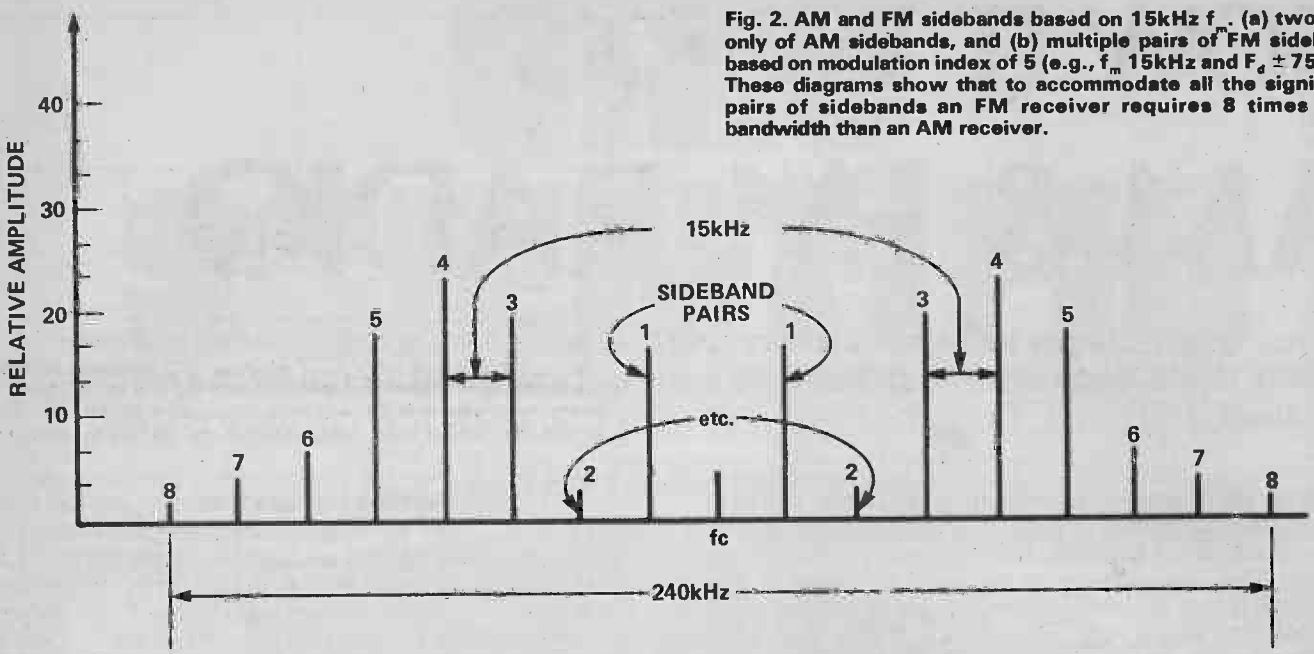


Fig. 2. AM and FM sidebands based on 15kHz f_m. (a) two pairs only of AM sidebands, and (b) multiple pairs of FM sidebands based on modulation index of 5 (e.g., f_m 15kHz and F_d ±75kHz). These diagrams show that to accommodate all the significant pairs of sidebands an FM receiver requires 8 times more bandwidth than an AM receiver.

Sidebands

Audio information at AM is carried by the carrier wave being caused to change in *amplitude* in sympathy with the sound. The stronger the sound, the greater the amplitude change; and the higher the audio frequency the faster the rate of amplitude change.

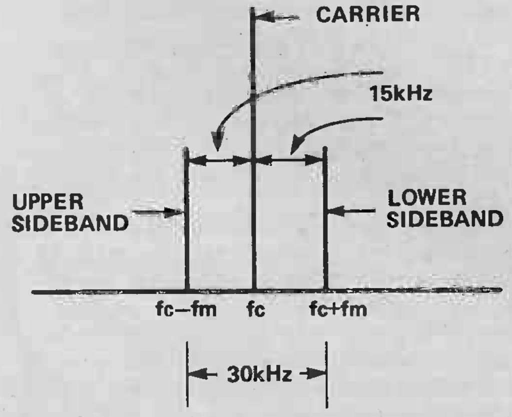
At FM it is the *frequency* of the carrier that is altered in sympathy with the sound. The stronger the sound, the greater the frequency change; and the higher the audio frequency the faster the rate of frequency change.

It is always instructive to look at a carrier wave modulated by a single-tone audio signal, as in Fig. 1, where at (a) we have the carrier, at (b) the modulation tone, at (c) the resulting AM signal and at (d) the resulting FM signal (not drawn to scale, of course!).

100% AM occurs when the carrier amplitude dissolves to zero at the troughs of the modulation envelope. If the modulation level is increased beyond this point very severe distortion sets in owing to the carrier holding at zero for a period of time. With FM sound broadcasting 100% modulation is said to occur when the change in carrier frequency is ± 75 kHz on audio signal peaks. This is called the deviation frequency (f_d). It is noteworthy that with 625-line TV sound, which is also FM, f_d is ± 50 kHz for 100% modulation. With stereo the total f_d includes both the mono and stereo information, the latter occupying approximately 10% of f_d, so that approximately ± 67.5 kHz is available for the mono part.

Modulation

When a carrier wave (f_c) is modulated sideband signals corresponding to every component frequency of the modulation signal (f_m) result. With AM and a pure single-tone f_m upper and lower sidebands at $f_c - f_m$ and $f_c + f_m$ occur, as shown at (a) in Fig. 2. With FM the resulting sideband structure per pure single-tone of f_m is far more complicated, as shown at (b). At 100% AM each of the sidebands is 50% greater in amplitude than that of the



unmodulated carrier; but with FM f_d as well as f_m determine both the amplitude and number of the sidebands. Ratio f_d/f_m is the *modulation index* which has a value of five at full deviation by the top audio frequency (15 kHz).

Fig. 2 (b) shows that FM yields a sideband structure which spreads out either side of the carrier over a far greater spectrum than AM, and for the least distortion all sideband pairs above 1% amplitude must be accommodated by the receiver. The multiple sidebands result from the change from sinusoidal form of the carrier as its frequency is changed by f_m, and Bessel functions are used to determine the sideband amplitudes and frequencies for any modulation index. It is not proposed to become involved in the deep mathematics of this, but it can be so proved that for top quality mono the bandwidth requirement is about 240 kHz, and a little greater than this for the best stereo.

Assuming a top modulation frequency of 15 kHz at AM, the total bandwidth requirement is a mere 30 kHz, some 8 times less than for FM. Sadly, 30 kHz spacing between stations just cannot be accommodated in the highly congested medium-frequency scene, and to avoid

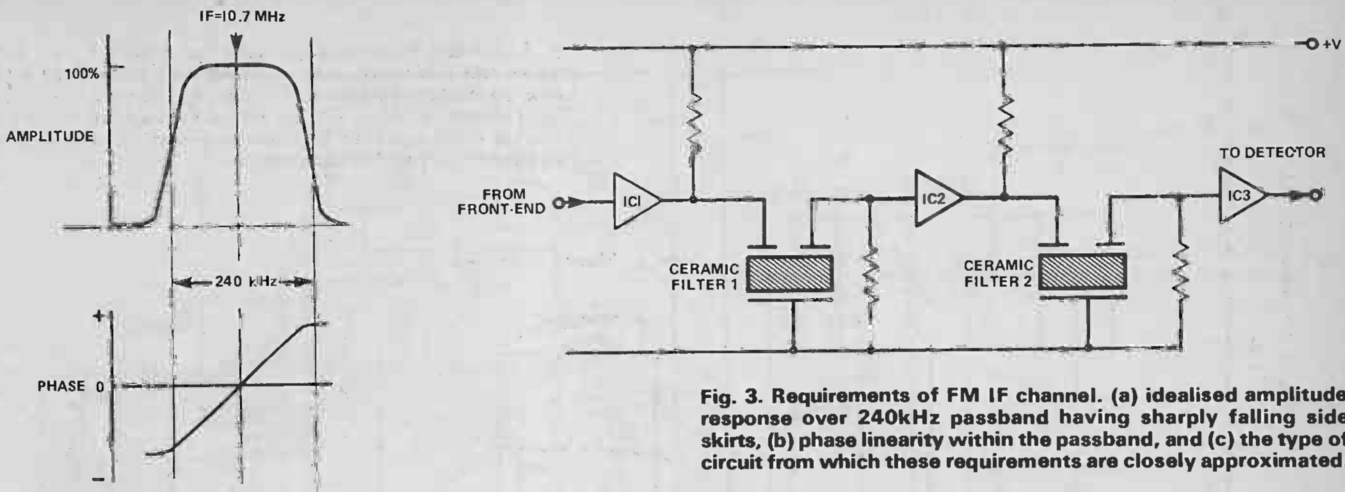


Fig. 3. Requirements of FM IF channel. (a) idealised amplitude response over 240kHz passband having sharply falling side skirts, (b) phase linearity within the passband, and (c) the type of circuit from which these requirements are closely approximated.

adjacent station interference the receiver bandwidth needs to be curtailed to 7 or 8 kHz at best with a consequent attenuation of the upper audio frequencies.

The Capture Effect

With FM channel spacing is 200 kHz (there is much more elbow room at VHF), and local station groups use far greater spacings between transmitters (2.2 MHz) so there is very little danger of interference. Moreover, FM exhibits what is called the *capture effect* which itself avoids interference provided the wanted signal is a little stronger than the unwanted one, even when the two stations have the same frequency! This results from the insensitivity of an FM receiver to amplitude variations of the carrier. When two signals interact one tends to amplitude modulate the other, which means that on AM the wanted signal needs to be very much stronger than the interfering one to give the same interference immunity as FM.

Receiver Requirements

From Fig. 2 it is dramatically apparent that an FM receiver requires much more bandwidth than an AM counterpart to do full justice to the high quality audio signal. The bandwidth needs to be reasonably phase-linear to ensure the least distortion at high modulation index and for the best stereo performance (channel separation, distortion, etc). Latter-day creations employ phase-linear quartz, ceramic and surface-wave acoustical filters to achieve these requirements, as distinct from the earlier LC transformer couplings, as shown in Fig. 3.

To help maintain a high S/N (signal-to-noise) ratio the VHF front-end must employ low noise-figure transistors, especially for the RF (radio-frequency) amplifier, and have a good coupling match to the VHF aerial. Most of the selectivity and response tailoring is undertaken in the IF (intermediate-frequency) channel at the standard IF of 10.7 MHz. Even so, a reasonable degree of front-end selectivity is desirable to restrict the amplitude of off-tune VHF signals arriving at the mixer from the aerial. A multiplicity of fairly strong signals here can generate intermodulation products of the 3rd-order variety and hence produce spuriae which might detract from the quality of the wanted signal. RFIM (radio-frequency intermodulation) immunity is achieved by using two or more variable-tuned circuits between the aerial and mixer and VHF transistors of good linearity (e.g., bipolars running at fairly high emitter current or FETs).

One important aspect of 3rd-order RFIM lies in the production of an interfering signal of $f_2+f_4-f_3$ where f_2, f_3 and f_4 correspond to Radios 2, 3 and 4. This interfering signal lies in the f_3 transmission and is perturbed by the modulation of any of the three transmissions. In bad cases of this interference (stemming from a receiver with a poor RFIM performance) the only solution lies in attenuating the aerial signal.

Most front-ends use an RF amplifier followed by the mixer which may generate its own local oscillator signal (f_o) or call for a separate oscillator stage. Whatever the arrangement, the mixer receives f_c and f_o and thus delivers $f_o \pm f_c$. The vast majority of FM front-ends use an f_o equal to f_c+IF, the IF thus corresponding to f_o-f_c, and it is this signal only which is accepted by the IF channel, as shown in Fig. 4.

Thus, if the aerial signal is, say, Radio 2 from Wrotham at 89.1 MHz, the local oscillator will be 10.7 MHz above this at 99.8 MHz, so that 99.8-89.1 equals the 10.7 MHz IF. Both additive and multiplicative mixing are used, the former generally when the mixer has just one input port, ▶

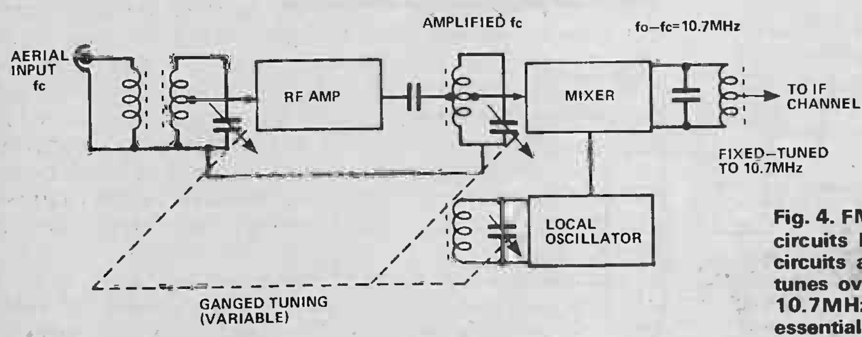


Fig. 4. FM front-end with RF amplifier using two variable-tuned circuits between aerial and mixer. The RF and mixer input circuits are tuned in step while the ganged oscillator tuning tunes over Band II so that the oscillator frequency is always 10.7MHz above the carrier frequency. Accurate tracking is essential to avoid a decrease in sensitivity over the tuning range. Some receivers have double bandpass tuning between the RF amplifier and mixing for further improvement in front-end selectivity.

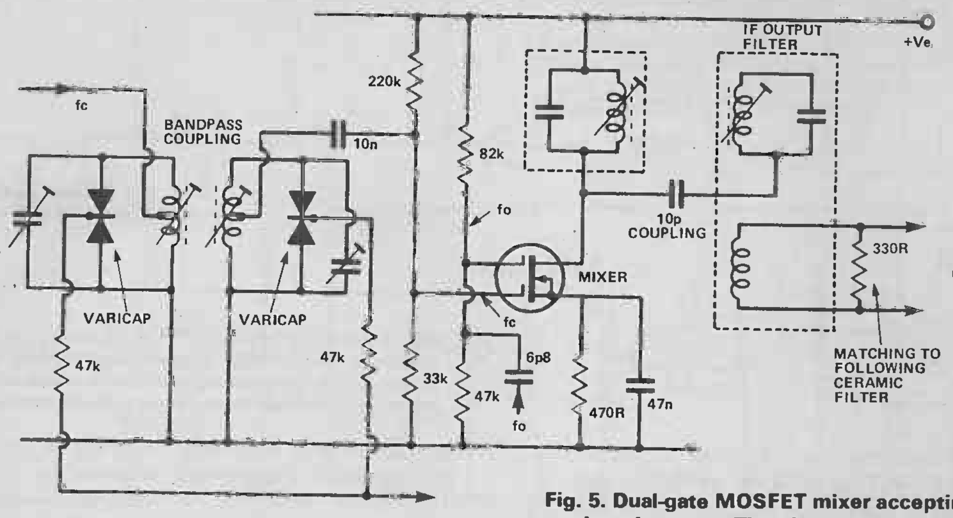


Fig. 5. Dual-gate MOSFET mixer accepting f_c on one gate and f_o on the other gate. The circuit also shows varicap tuning and a capacitively-coupled IF output filter.

and the latter when there are two inputs, such as with a dual-gate FET as shown in Fig. 5. This sort of FET (MOS) may also be used for the RF amplifier, with one gate accepting f_c and the other an AGC (automatic gain control) bias *via* an amplifier as shown in Fig. 6.

Varicap Tuning

Some contemporary receivers, especially of European origin, use varicaps (e.g., capacitor diodes) instead of a mechanical tuning gang. The bandpass section in front of the mixer in Fig. 5 is tuned in this way. The varicaps are diode pairs arranged to neutralise non-linearity which, when biased for reverse conduction, exhibit capacitance of value which decreases as the reverse bias is increased. For continuously variable tuning, therefore, it is necessary merely to bias the diodes together from a potentiometer which is mechanically coupled to the tuning system. To eliminate capacitance change and hence tuning drift the tuning voltage is derived from a stablizer or regulator. The scheme also lends itself to press-button station selection.

Also in Fig. 5 the IF signal is filtered out by a capacitively coupled circuit. The 330 ohm resistor matches the output to the following ceramic filter in the IF channel, as do the input and output filter resistors in Fig. 3. Unless this matching is correct the filters fail to provide the proper symmetry, selectivity and skirt sharpness.

Bandpass coupling at the output of the RF amplifier is also used in Fig. 6, but the tuning here is by a ganged mechanical capacitor.

Oscillator Stage

To avoid oscillator 'pulling' on strong carriers state-of-art FM receivers use a local oscillator followed by a 'buffer' stage, as shown in Fig. 7. Less elaborate models either use a separate oscillator coupled direct to the mixer or a self-oscillating mixer.

AM Front-Ends

Exactly the same principles apply to AM, but because f_c is that much lower the design of the front-end section is less critical. The IF is generally around 455 kHz and, as with FM, f_o is often the IF above f_c; but some models place f_o the IF *below* f_c, though this may reverse on some wavebands.

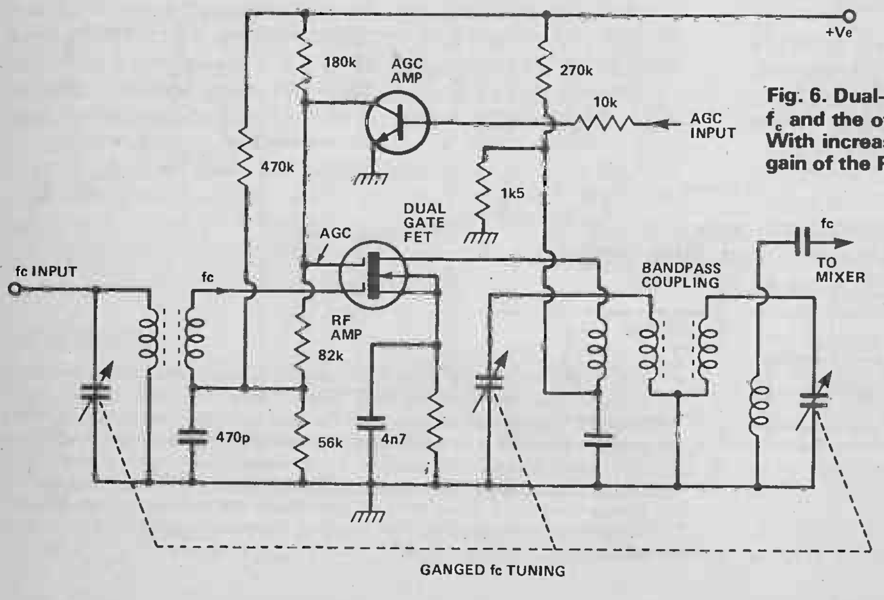


Fig. 6. Dual-gate MOSFET RF amplifier where one gate receives f_c and the other an AGC bias obtained from a bipolar amplifier. With increase in signal strength the bias increases so that the gain of the RF amplifier is diminished.

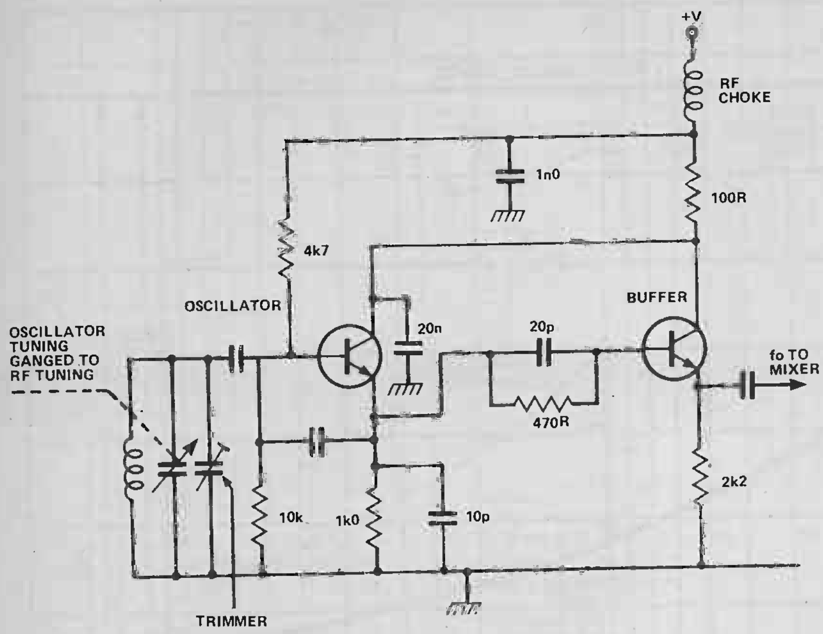


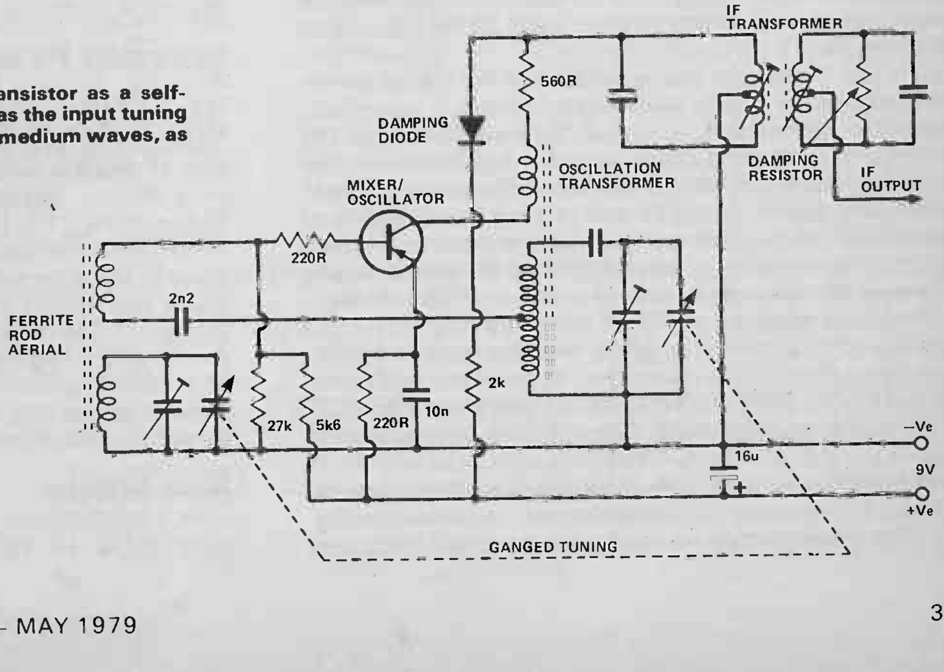
Fig. 7. FM local oscillator followed by buffer stage for feeding the mixer.

The majority of AM transistor portables employ a ferrite rod aerial which also serves as the input tuning. Only the more elaborate models boast an RF amplifier, and a self-oscillating mixer is commonly adopted, as shown in Fig. 8. Receivers with poor front-end selectivity are relatively prone to spurious responses at frequencies removed from the tuned frequency. A typical one is the 'image' or 'second channel'' response where the IF is produced from an input two times the IF above the tuned frequency when the oscillator is running at the IF *above* the signal frequency. For example, if the receiver is tuned to, say, 1,000 kHz the oscillator will be running at 1,455 kHz, so an incoming signal at 1,910 kHz (two times the IF above the tuned frequency) will heterodyne with the oscillator signal to yield the IF in terms of 1,910-1,455. When the front-end selectivity is sharp a signal two times the IF away from the tuned frequency would be well attenuated and not so likely to cause interference. Another is called the half-IF or 'repeat spot' response which falls half the IF away from the tuned frequency owing to the 2nd-harmonic of the oscillator heterodyning with the 2nd-harmonic of the off-tune signal from the RF stage and producing the IF again.

IF Channels

IF channels nowadays use ICs for the gain and resonant filters of the type already mentioned for the selectivity. FM IF channels employ amplitude limiting ICs or ICs deliberately arranged to limit above a certain signal amplitude. Although FM detectors are essentially insensitive to amplitude variations of the IF-converted carrier, especially ratio detectors, additional limiting is desirable in the IF channel further to enhance the AM rejection ratio and to help with the capture effect. A top-flight modern FM receiver will fail to rise in audio output level once the input cartier at the aerial has reached the 2 to 3 microvolt level, the effect then being a progressive improvement in S/N ratio with increasing level of aerial input, as shown by the curves in Fig. 9. Less exacting models will require an input of 100 microvolts or more before full limiting occurs. The ▶

Fig. 8. AM front-end using single bipolar transistor as a self-oscillating mixer. The ferrite rod aerial serves as the input tuning and may have switched windings for long and medium waves, as also the oscillator transformer.



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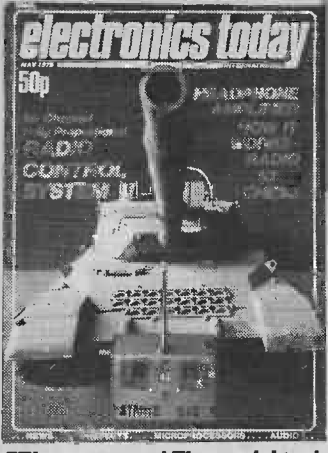

ETI goes to war! The model tank shown on our cover is a Tamiya 1/16th Leopard A4, kindly supplied by Richard Konstam Ltd who import the kits. See page 62 for marching orders.

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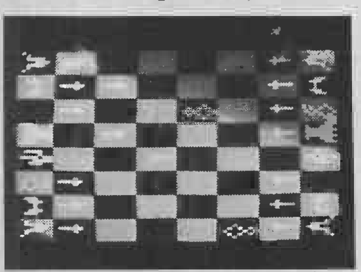

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NEXT MONTHS HE	**45**	Little sister, but she's growing fast.
MARKETPLACE	**58**	Good buys from the good guys.
ETI, NEXT MONTH	**69**	Warmongers special.
PANEL TRANSFERS	**85**	The finishing touch.
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PUBLISHED BY Modmags Ltd., 25-27 Oxford Street,
DISTRIBUTED BY Argus Distribution Ltd. (British Isles)
Gordon & Gotch Ltd. (Overseas)
PRINTED BY QB Limited, Colchester

Electronics Today International is normally published on the first Friday of the month prior to the cover date

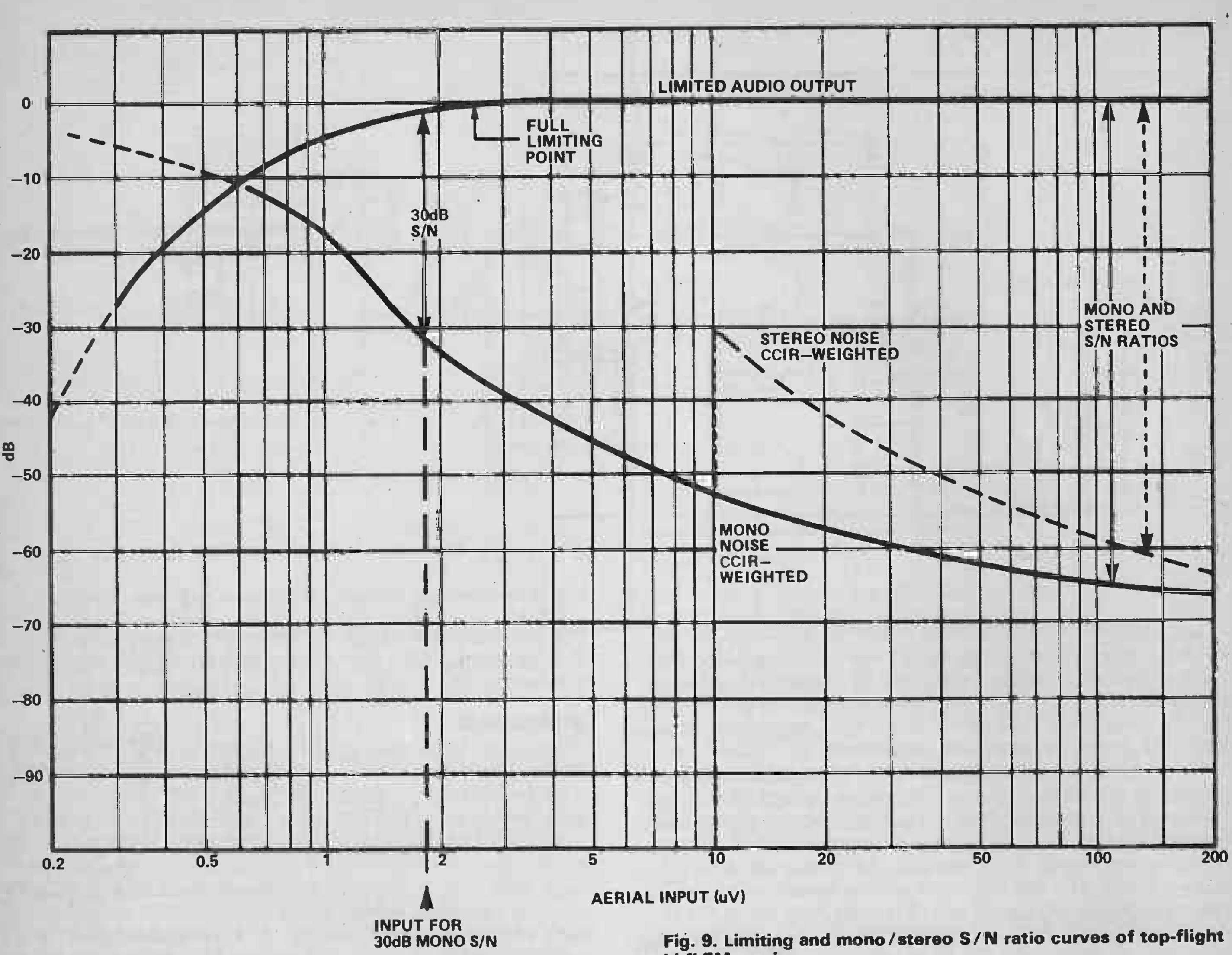


Fig. 9. Limiting and mono/stereo S/N ratio curves of top-flight hi-fi FM receiver.

action of the stereo decoder impairs the S/N ratio at the lower signal levels, catching up with though never reaching the mono ratio at higher inputs. There is always an ultimate S/N ratio impairment of about 2 dB on stereo with respect to mono owing to approximately 10% of the available deviation being used for the stereo information and the greater noise power bandwidth of the receiver in stereo mode.

The FM IF channel also provides the AGC bias for the front-end (when used), AFC control voltage (automatic frequency correction potential derived from the FM detector or separate discriminator for application to the oscillator varicap to hold the carrier at the centre of the IF passband), signal strength and tuning metering, and inter-station muting (where the audio output is disabled until the input reaches a predetermined level as a means of cutting the noise when tuning between FM stations).

The most complex of FM IF channels may employ a cascade of ICs (three or four) feeding into a bipolar transistor which in turn drives the FM detector. Additional ICs and bipolar transistors may be used for front-end AGC, AFC, muting and metering. The simplest adopts a complex IC, such as the CA3089E, which provides IF amplification, limiting, FM detection and audio preamplification for driving the stereo decoder, as shown in Fig. 10. The device contains no fewer than 80 transister integrations, and includes sections for delayed front-end AGC, AFC, signal strength meter drive, tuning indication and interstation muting. In the circuit the muting is operated by S5 and the threshold level set by RV7. S4 switches the AFC on and off, while coils L10 and L11 are concerned with the FM detection.

Quadrature FM Detector

The coils, in fact, are a part of a quadrature detector circuit, which is fast finding favour in FM receivers, facilitated by ICs, without which would demand a complex of discrete components. The arrangement is based on a 90-deg. phase shift and synchronous detector, as shown in Fig. 11. FM IF signal is amplified and heavily limited, and the resulting 'clipped' signal is passed to one input of the detector direct and to a second input *via* the phase shift, which is merely an LC circuit such as L10/11 in Fig. 10. The detector is essentially a 'multiplier' which combines the two inputs vectorially. Owing to the relative phase shift and the deviating FM signal the output consists of varying width rectangular pulses, and from these the audio signal is obtained by low-pass filtering.

Ratio Detector

This is another very popular FM detector whose circuit is given in Fig. 12. When the primary and secondary of the

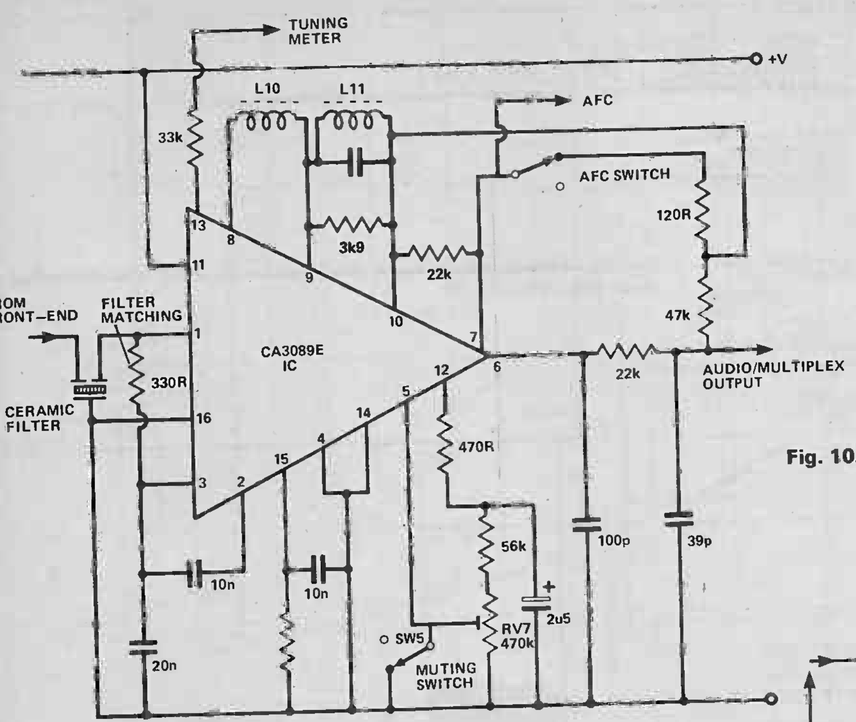


Fig. 10. FM limiting and detection by CA3089E IC (see text).

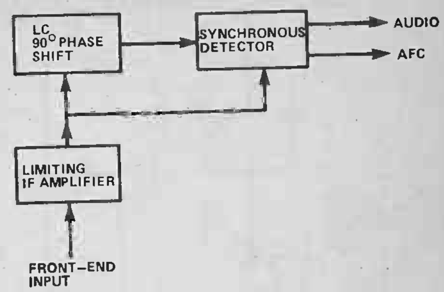
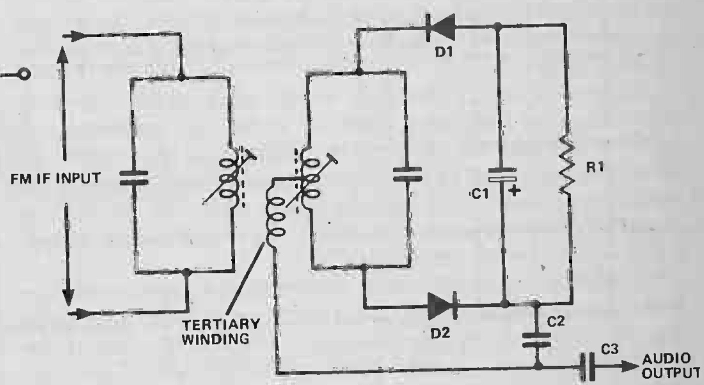


Fig. 11. Simplified quadrature detection.

Fig. 12. FM Ratio detector circuit.



steady-state potential across R1 is substantially unaffected by faster occurring amplitude changes of IF signal such as caused by electrical interference, etc. A value around 200 milliseconds is a fair compromise between poor limiting and sluggish tuning.

FM detectors generally have a bandwidth in advance of that of the IF channel to ensure that at maximum deviation the signal remains on the linear parts of the 'S' characteristic and as an aid to the capture effect.

AM Stages

The IF channel is far simplier in AM than FM receivers. Gain is given by a couple of bipolars or an IC and selectivity is introduced either by two tuned transformers or a ceramic filter (sometimes both). AM IF is around 455 kHz which, with the restricted bandwidth, makes it easier than FM to achieve the required gain with fewer devices.

Detection is invariably accomplished by a simple diode circuit as shown in Fig. 13. From the signal point of view this rectifies the AM waveform so that the average value varies in sympathy with the modulation. Subsequent filtering deletes the IF component. The rectified DC value of the carrier is commonly used as an AGC potential automatically to control the gain of the IF amplifier. At the front-end a damping diode may be used to reduce the mixer output on very strong aerial signals. Such a diode is shown in Fig. 8. This conducts and thus damps the IF output when the signal level rises above the value established by the biasing. Fig. 13 shows alternative biasing for this diode.

The tapped primary of the IF transformer ensures that the tuned circuit is not excessively damped by the output resistance of the transistor. This technique is also used in other sections as will be observed from the circuits.

FM Pre- and De-Emphasis

The S/N ratio of the FM system is further enhanced by the application of treble boost to the modulation signal at the transmitter (pre-emphasis) and compensating treble cut (de-emphasis) at the receiver. These are based on a time-constant which is 50 microseconds UK and 75 microseconds America. It thus refers to the 'turnover' frequency (that frequency where the boost or cut occurs) and is equal to $1/2\pi T$, where the frequency is in Hz and the time-constant (T) in seconds, which works out to about 3,184 Hz at 50 microseconds. The ultimate rate of boost or cut approximates 6 dB per octave (e.g., single-pole filter). FM produces a triangular noise output because the output from the detector is proportional to f_d. Because f_d max is $\pm$75 kHz and f_m max 15 kHz the noise content is significantly reduced and is reduced by a further 4 dB or so by the pre- and de-emphasis.

The de-emphasis consists of a simple RC time-constant at the detector output in the case of mono and at the decoder output in the case of stereo. It is not possible to apply de-emphasis at the detector when this is followed by a stereo decoder since the effect would be seriously to attenuate the complex stereo multiplex signal. The net result of the $\pm$75 kHz f_d and the pre- de-emphasis is a weighted S/N ratio of 75 dB or more mono and just over 70 dB stereo, depending on the noise figure and quality of design of the receiver.

Stereo Encoding

After separate pre-emphasis of the left (L) and right (R) audio channels at the transmitter the signals are fed to a combined adder and subtractor (matrix) which yields L+R mono information and L-R stereo information. The mono signal is passed to the transmitter in the usual way▶

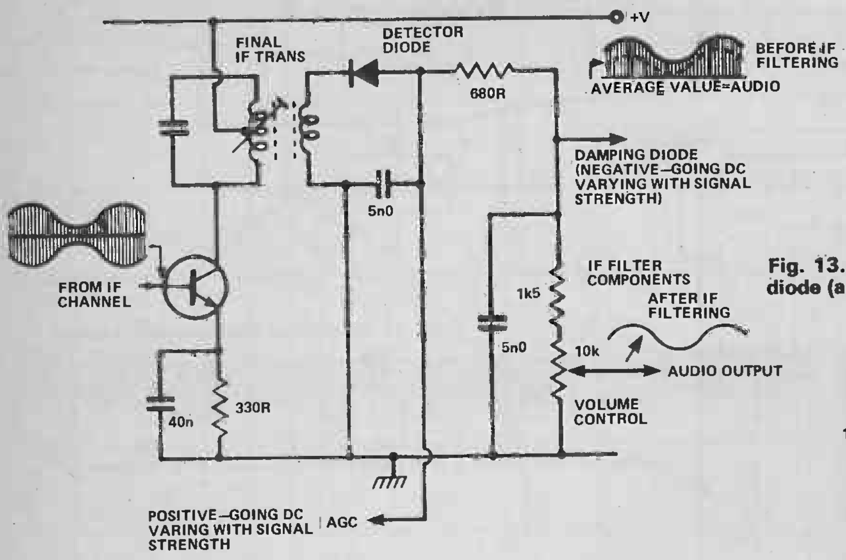


Fig. 13. AM detector circuit with feeds for AGC and damping diode (also see Fig. 8).

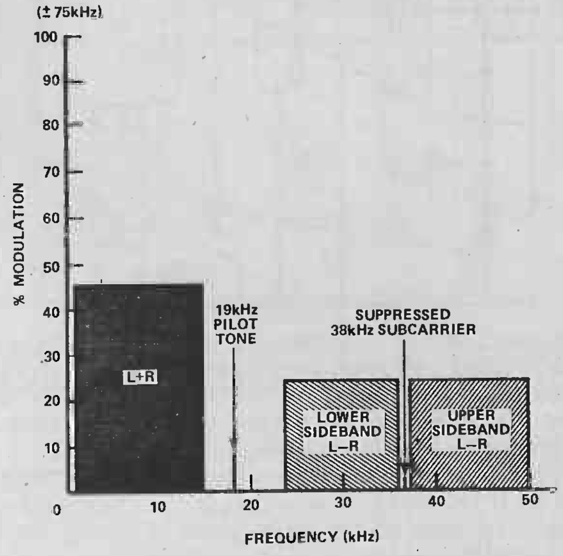


Fig. 14. Spectrum of multiplex signal at FM detector output on stereo signal when one channel only is modulated. See text for other modulation levels.

tuned transformer are resonated to the undeviated carrier the two diodes conduct equally and since the diodes are connected in series a potential is developed across R1 which charges C1.

When the input deviates either side of its nominal frequency the balanced phasing condition is destroyed and the diodes fail to conduct equally. This results in current flowing out of the circuit through the 'phasing' or tertiary winding, and because this external current is geared to the deviation the audio signal develops across C2, which is fed out through C3.

An advantage of the ratio detector compared with the Foster-Seeley detector or discriminator (which also uses two diodes but connected back-to-back and is without the tertiary winding) is that it yields amplitude limiting. Provided time-constant R1/C1 is large enough the (allowing receivers not equipped with a stereo decoder to work on the signal without undue loss, which is an aspect of system compatibility), while the stereo signal is separately processed and subsequently 'added' to the mono signal for transmission. It is applied to an *amplitude* modulator whose carrier frequency is 38 kHz but which is suppressed so that only the lower and upper *sidebands* of the stereo information remain (in practice the residual 38 kHz subcarrier accounts for no more than 1% of the maximum deviation — e.g., less than ± 750 Hz). The stereo information sidebands along with the mono information are then applied to the normal VHF modulator of the transmitter.

For the detection of suppressed carrier AM the carrier needs to be regenerated at the receiver (in the stereo decoder), and to facilitate this a 19 kHz pilot tone using up approximately 9% of the maximum deviation (e.g., about ± 6.75 kHz) is also applied to the VHF modulator. The total modulation signal thus applied to the VHF carrier has the spectrum shown in Fig. 14. The L+R mono signal occupies the normal audio range from about 30 Hz to 15 kHz, next comes the 19 kHz pilot tone and then the lower and upper stereo sidebands between which is the suppressed 38 kHz sub-carrier. At no time can the total deviation of all these signals exceed ± 75 kHz (e,g, 100% modulation). In Fig. 14 the total modulation consists of 45% L+R mono, 22.5% L-R stereo in each sideband (45% in all), 9% pilot tone and 1% residual subcarrier, adding up to 100%. This condition would obtain with an input only to one channel (e.g., L or R 1 unit and R or L zero). With both inputs receiving the same intensity of 'in phase' signal (e.g., stage-centre mono condition), the stereo information would be virtually zero so that a full 90% modulation capacity would be available for the L+R mono information (the remaining 10% being used by the pilot tone and residual subcarrier). With both inputs equal but in phase opposition (a very rare happening) all the information would be in the L-R stereo channel. Under normal music conditions, of course, the mono and stereo information is continuously changing, but the balance of 100% maximum is always maintained.

Stereo Decoding

The encoding system just described is based on the Zenith-GE developments which is universally adopted. Various schemes for decoding the signals back to the L and R channels for reproduction have been devised, the earlier ones using discrete components with valves and later transistors, and the latest ones using ICs specially developed for encoding. It is clearly outside the scope of this article to venture back into history, but a phase lock loop (PLL) IC decoder circuit used in many receivers is given in Fig. 15.

Multiplex signal (of Fig. 14 spectral form) is fed to pin 1 input *via* Q1. Inside the IC the PLL is formed by a 76 kHz voltage controlled oscillator (VCO), two divided-by-two stages yielding first 38 kHz and then 19 kHz, a 19 kHz

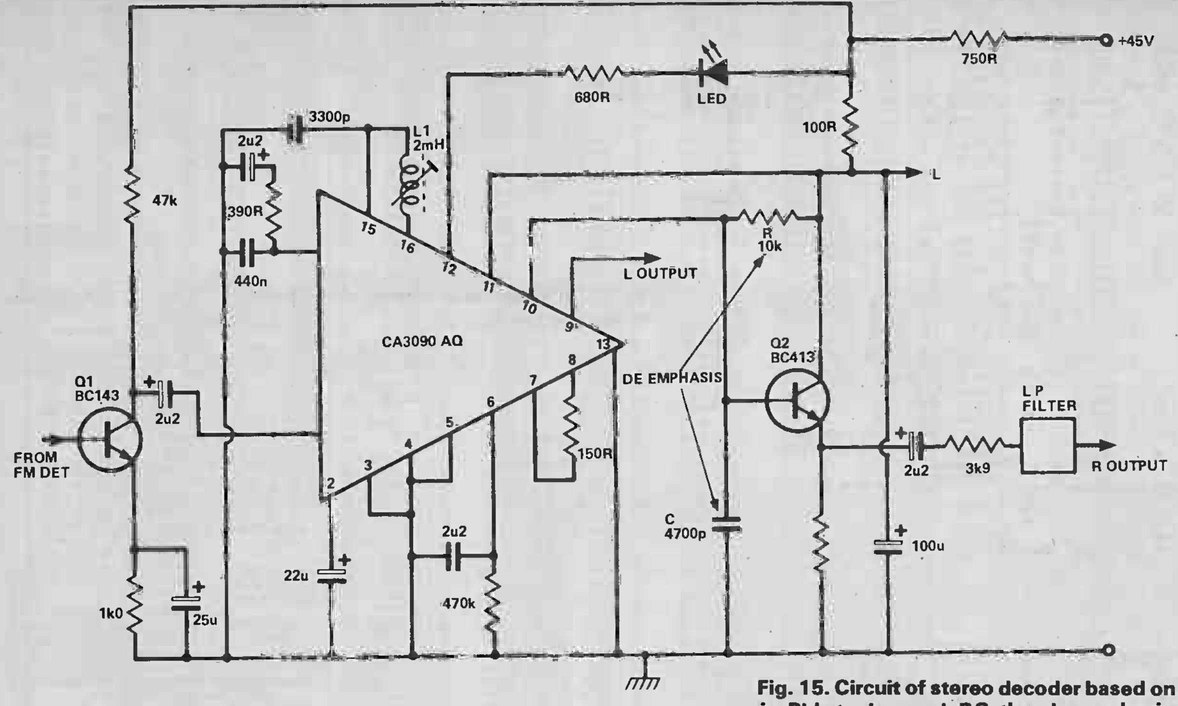


Fig. 15. Circuit of stereo decoder based on the CA3090AQ IC. L1 is PLL tuning and RC the de-emphasis. One channel only is shown; the other channel is similar.

phase comparator, low-pass filter and DC amplifier whose output is fed back to the VCO for control, as shown in Fig. 16.

The multiplex signal is first buffered and then fed to the phase comparator where the pilot tone component is compared with the loop-derived 19 kHz signal. The loop is thus locked and the 38 kHz signal from the first divider constitutes the reclaimed subcarrier which, along with the multiplex direct, is applied to the decoder section. This can be regarded as an 'inverse' of the encode matrix which, after AM demodulation, yields the L audio from (L+R)+L—R) and the R audio from (L+R)—(L—R). Each output is subjected to de-emphasis before being applied to the L and R audio amplifiers for driving the loudspeakers.

The IC is also equipped with automatic stereo switching so that on a non-stereo signal the two outputs deliver mono signal, and a stereo indicator switch which lights a small bulb or light emitting diode (LED) when stereo information (pilot tone) is detected. The circuit connections involved are shown in Fig. 15. The VCO locking is achieved by L1 which is a 2 millihenry inductor. Audio from each channel is 'buffered' by Q2 (same for the other channel though not shown) and passed through a low-pass filter for attenuating residual pilot tone and subchannel spuriae before arriving at the audio stages of the receiver. Some of the very recent ICs incorporate a pilot tone cancelling circuit so avoiding the need for low-pass filtering and maintaining an excellent response to 15 kHz or more.

Of course, all stereo receivers have two separate audio channels for the L and R signals. Hi-fi receivers employ the latest technology in this area, some models yielding 60W per channel or more at remarkably low distortion. Less exacting receivers have relatively simple audio stages based on push-pull transistor pairs or hybrid power ICs.

There is no doubt that latter-day hi-fi receivers operating from off-air stereo signals (particularly when these correspond to 'live' transmissions) are capable of extremely high audio quality, on par with the best of most other programme sources. ETI

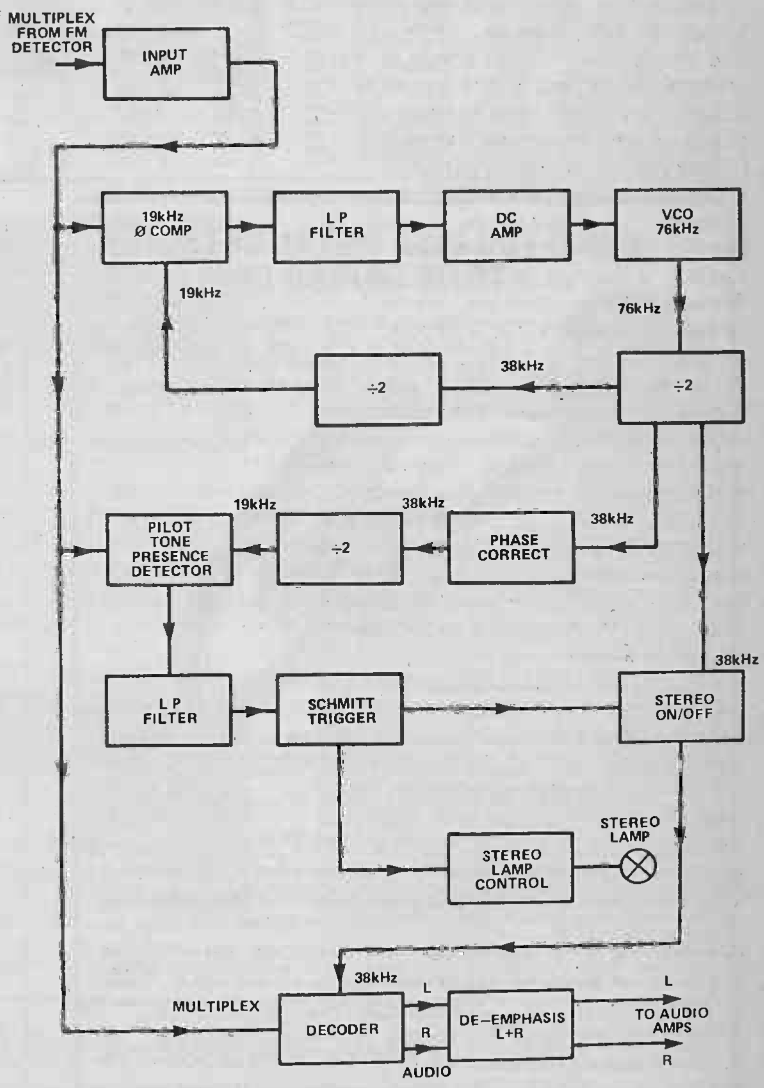


Fig. 16. Block diagram of PLL stereo decoder IC.

AMBUSH! PART 2

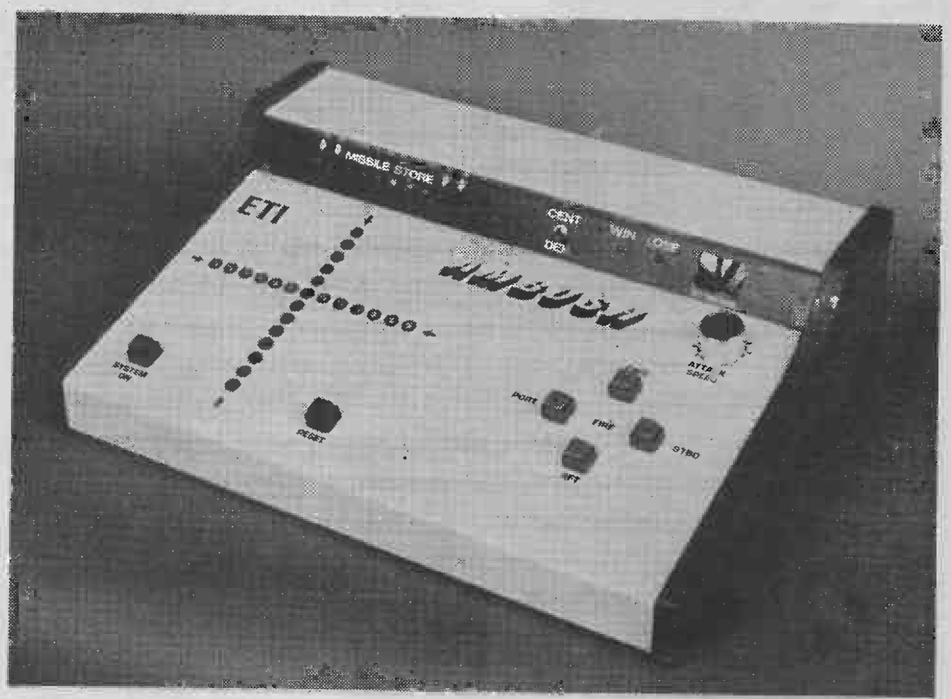
At last the second and final part of our very own space game Ambush. Red blood sweat and tears have gone into the production of the game and we beleive it's all been worthwhile. Virtually guaranteed to provide hours of excitement, not one of those games you easily tire of. So switch it on and prepare to do battle with the forces of evil.

THE MAJOR part of the Ambush circuitry, other than the LED displays, is wired up on a set of three PCB's. Considerable care should be taken over the construction, due to the difficulty that will occur in trouble-shooting the circuitry if it does not work correctly first time. Take special care to ensure that all diodes are fitted in the correct polarity, and that all IC's are correctly located.

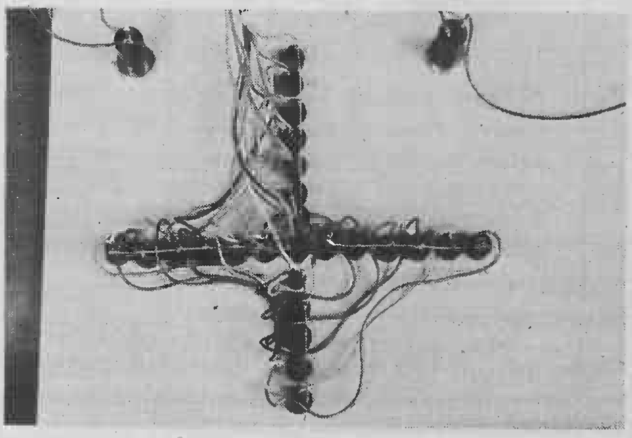
On our prototype unit we mounted all IC's in holders. We used Wafercon connectors on each board, rather than solder pins, to facilitate the interwiring. Take great care over the interwiring.

When it comes to fitting the LED's for the Main Display and for the Missile Store indicators, take the precaution of testing each LED individually to confirm its polarity and functioning before finally wiring it in place. Note that silicon diodes D22 to D25 are mounted directly on the Main Display matrix.

Our own Ambush game is mounted in an attractive but rather expensive case that we obtained from Boss Industries. The same company produces an 'economy' range of similarly shaped sloping front cabinets. We have powered our unit from a set of eight HP2 batteries, fitted in two 4-section holders. Our Attack counter is mounted on a 20mm x 60mm 0.1 inch matrix Vero board that is epoxy-glued into position on the front panel of the case.



The finished AMBUSH prototype, it really does look good in its case. The staff of ETI have had great fun over the past few weeks playing with the game. A case similar (or the same) to ours is highly recommended and would look good almost anywhere.



Inside the front panel of Ambush showing the display layout. All of the wiring on the prototype was completed before final assembly to allow for flexibility in arranging the PCBs within the case.

SCENARIO

Like all good wargames 'Ambush' has a scenario to go with it. This is it. The scout cruiser Eatyeigh is on a vital war mission to the planet Tora. An enemy fleet (Yappanies) is detected closing in on it by long range hyper radar. A message is flashed ahead to the cruiser's captain. The communications officer, white-faced, takes it to the control room wherein the crew are gathered to hear the news. . . .

The Captain read the message he had been handed. A worried frown briefly creased his brow. He looked up again and spoke. "Men, I have just received a message from Command Headquarters. Our intelligence units report that the Yappanies know of our mission. They are determined to stop us at any cost, and will probably attack us with a suicide fleet somewhere in space sector seventeen. We will reach that sector in just over three hours. All units will maintain Battle stations until further notice. Message ends." The screen flickered, and went blank.

Joe Reader sat back thoughtfully in his chair. He glanced at his three fellow gunners. He spoke reassuringly to they. "Don't worry, mates. The Yappanies haven't got a chance against us. We've got masses of Phanton missiles on board, enough to fight off an entire suicide fleet each. All you've got to do is sit there and wait for the little devils to appear on your sector screens, then press your Phanton FIRE buttons and blast 'em to hell." His three companions laughed. One of them made a rude sign.

Three hours later Joe Reader was sitting in the data viewing room, adjacent to the Fire Control centre, reading up on Yappanie battle techniques. A terrible explosion suddenly blasted through the ship. He was thrown to the floor by the blast. The ships starboard engine had ripped itself apart and hurled great chunks of white hot metal through the hull. The ships self-repair system immediately set to work, sealing the damaged hull. Joe raised himself from the floor, forced open a connecting door, and staggered into the Fire Control centre. A ghastly sight met his eyes.

The control centre was a shambles. His three companions were clearly dead. Blood was spattered on the walls and across the floor. Three of the four Phanton missile magazines had disappeared, blasted into space before the hull had resealed itself. Joe's mind raced. The ship was about to enter space sector seventeen. The Yappanie attack was about to start. Joe would have to fight off the attack alone. Feverishly, he started to patch all four quadrant fire control switches into his own control console. A damage control report could be heard echoing through the ship. All external attack sensors were damaged. Attack warnings would be minimal.

A few moments later the battle attack sirens screamed through the ship. Joe knew that the Yappanies would attack with either a full Century of one-man Kamanzi suicide craft, or a Dekuron of ten heavily armoured Sutzma battle cruisers. Ten fire units of Phanton missiles were needed to destroy a single Sutzma cruiser, whereas a single unit would destroy a Kamanzi. Joe checked the ammunition register, and made a quick calculation. He had just enough ammunition, in the form of Phanton missiles, to destroy either type of attack, so long as he fought off the attacks with fire bursts of no more than one hundred milliseconds each.

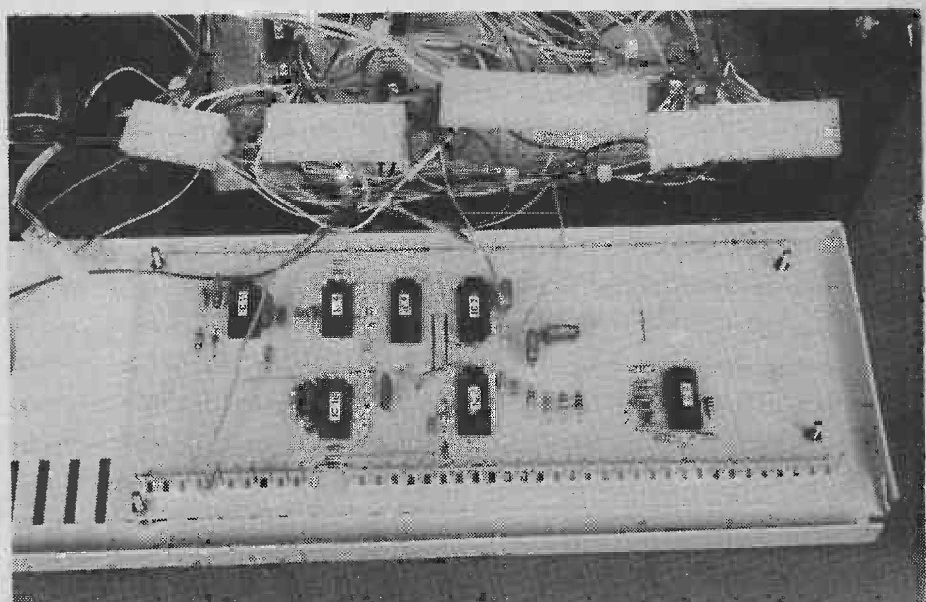
Joe knew how the attacks would be delivered. The Yappanies always attacked one at a time, at random intervals and from random directions, until they had either won the battle, or had been totally destroyed. He switched on the attack indicator unit. A cross formation appeared on the screen in front of him, each arm of the cross indicating a possible quadrant of attack. At the centre of the cross a red indicator gleamed, representing the starship Eatyigh. He switched on the attack simulation computer, to check the extent of the sensor damage. The ships sensor system projected a continuous beam that reflected back from the hull of any attacking vessel, and was modulated by the vessel's hull vibrations in the process. The reflected beams were then demodulated to give a visual output of range and an audible output of engine noises.

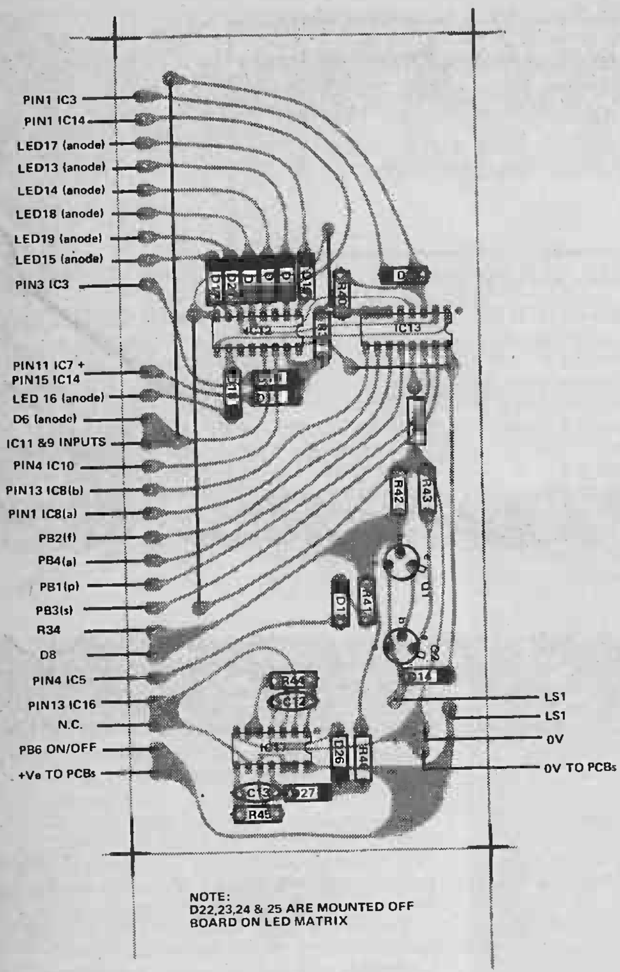
The computer showed that the Forward sensor was inoperative on sound, and gave only 250 milliseconds of range warning at normal battle speed. Port and Starboard sensors were operating at half strength on sound, and gave 300 milliseconds of range warning. The Aft sensor was fully operational on sound, and gave 350 milliseconds of range warning.

The Commander's voice boomed through the ship again. "All units at Red Alert. A Yappanie century of Kamanzi suicide craft has been detected, closing at high speed. Out." Joe threw the attack mode switch to the CENT position, and the fire control computer automatically adjusted the Phanton missiles into packets suitable for fighting a Kamanzi attack. Almost instantly, the first Kamanzi craft appeared as a rapidly moving spot of light at the bottom of the attack indicator screen, and the staccato sound of the crafts engine burst from the audio simulator. Joe stabbed his finger at the AFT fire button, heard the screech of a Phanton missile pack leaving its silo, and instantly saw the Kamanzi craft obliterated from his screen. Without hesitation, another attack started in the starboard quadrant, and was rapidly stopped by another pack of missiles. A pause of five seconds, then another attack from the aft quadrant.

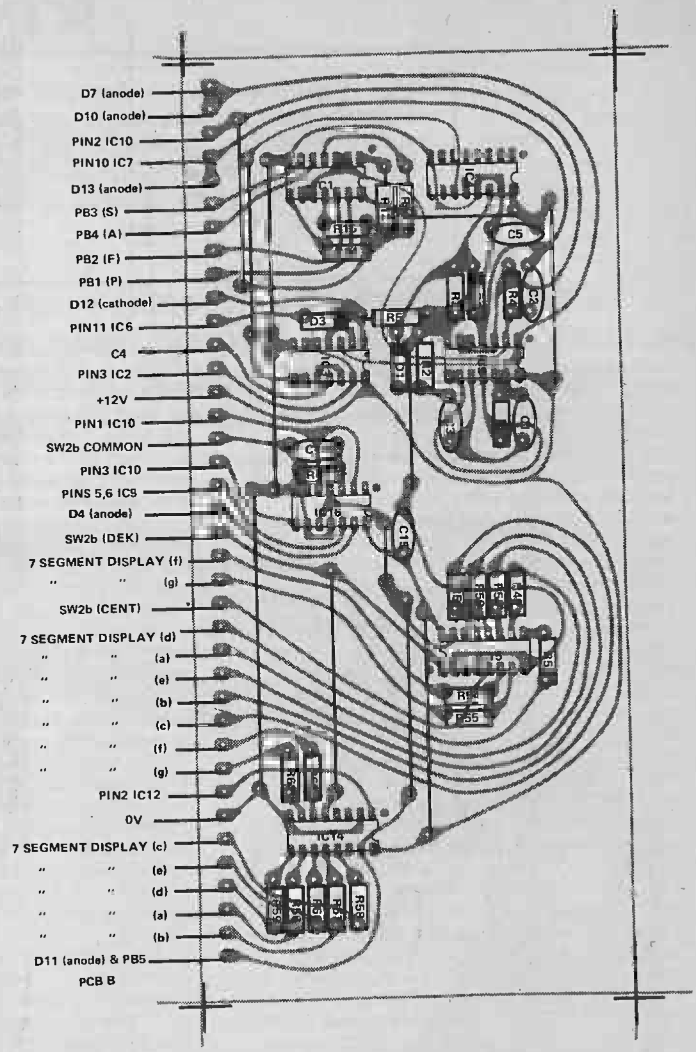
The attacks continued relentlessly. Sixty attacks were clocked up on the attack counter within the first five minutes. Joe glanced at the ammunition state indicator. Nearly seventy per cent of his ammo was used up. If he was to survive, he must reduce the fire time on each attack. He glanced back at the screen and saw an attack rushing in silently on the forward quadrant. He groped frantically for the Forward fire button, and hit three buttons at once. Three packets of Phantons screamed from the silo. The attacking craft disappeared from the screen. The ammo store indicator lurched downwards. An attack from the stern. Fire! A three-second pause. A port attack. Fire! Instantly, another attack in the same quadrant. Fire again. The attacks continued.

Part way through the seventh minute Joe noticed that the attack register recorded ninety-five, and that the ammo register was only a notch above the EMPTY state. He wondered if he could ward off the final five attacks. The crew of Eatyigh were depending entirely on him. "It's up to you now, Reader," he thought. Another attack came rushing in on the starboard quarter. . . .





PCB, C. The display drive and sound output sections.



PCB, B. Most of the display functions are carried out on this panel.

PARTS LIST

R1	6M8
R2	390k
R3, 8, 9, 10, 11, 31, 40, 48	22k
R4	10M
R5, 26, 28, 29, 30, 39	47k
R6, 16-25, 36, 37, 47	1k
R7, 12, 13, 14, 15	100k
R27	330k
R32	6k8
R33	680k
R34, 41, 42, 46	10k
R35	2M2
R38	270R
R43	33R
R44, 45	1M5
R49-62	470R
POTENTIOMETER	
RV1	1MO
CAPACITORS	
C1, 5, 6, 7, 8, 11, 14, 15	100n
C2, 3, 4, 10, 12, 13	10n
C9	150n

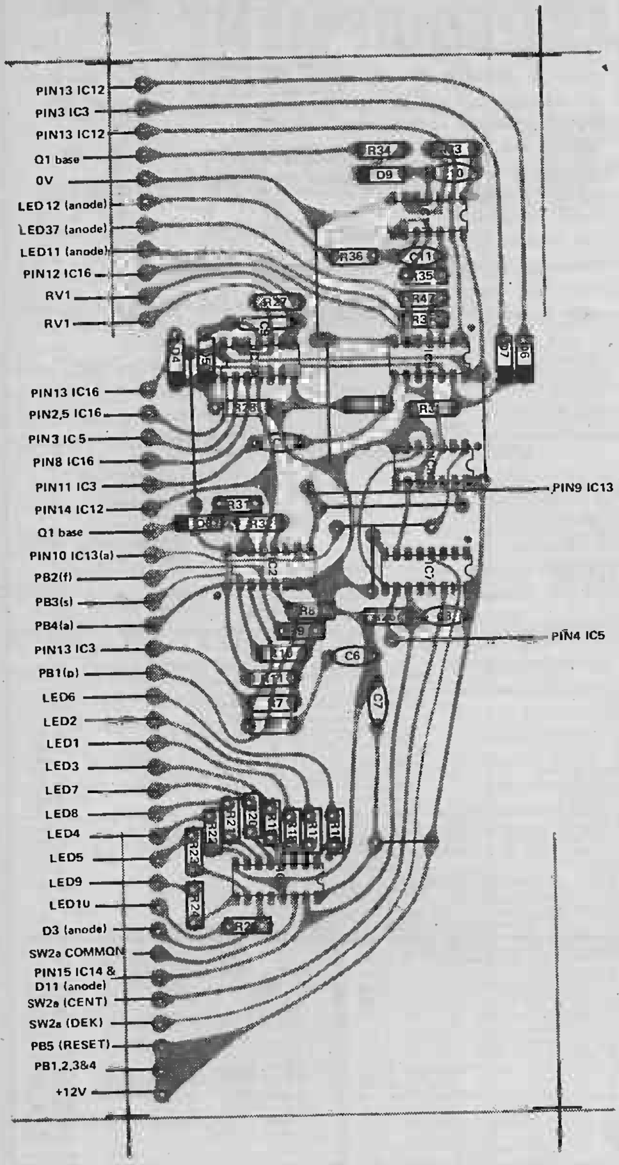
SEMICONDUCTOR	
IC1	4016
IC2, 13	4052
IC3, 9, 10	4001
IC4, 6, 12	4017
IC5, 17, 11	4011
IC7	4940
IC8, 16	4026
IC14, 15	4013
NOTE. All CMOS devices are B Series.	
Q1	BC109
Q2	BFY50
D14	1N4001
All other diodes are	1N4148
LED 1-37 are standard 0.2in dia.	
LED 7 segment displays are common cathode 0.3in	

MISCELLANEOUS
LS1 2in 40R
5 off SPST push buttons
1 off SPST latching push button
1 off DPDT min. toggle
8 off HP11
2 off 4 section battery holders
case to suit

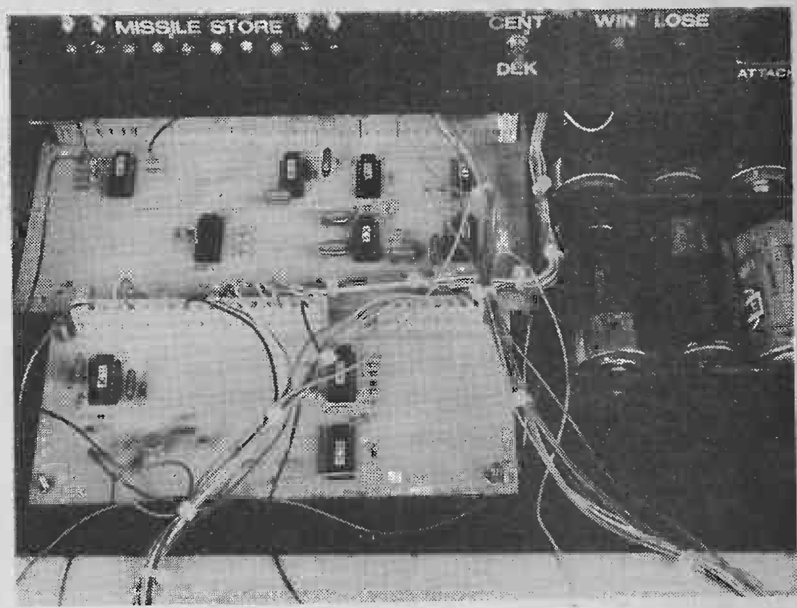
BUYLINES

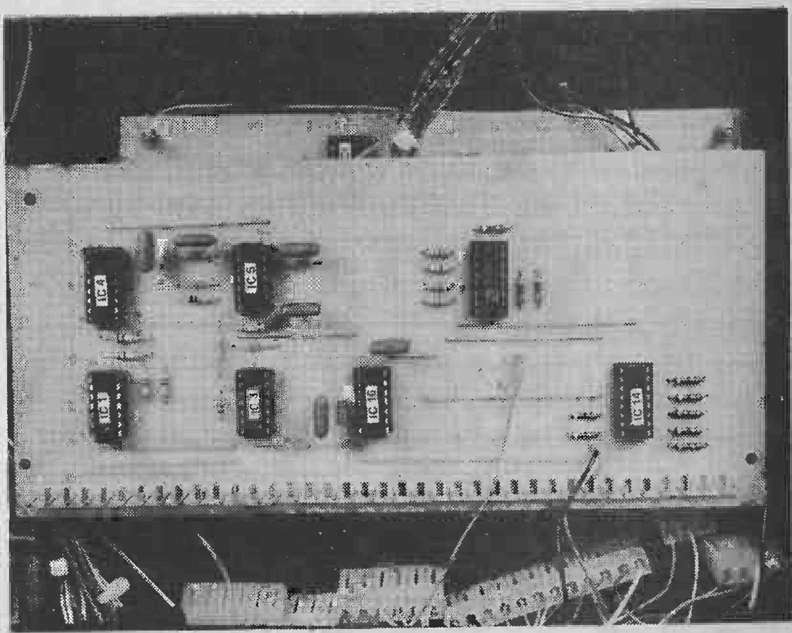
The case we used for the Ambush project is available from Boss Industries. Since panel layout is not critical, inventive ETI readers may be able to come up with their own hardware designs. All the ICs are common types, available from most component mail order firms.

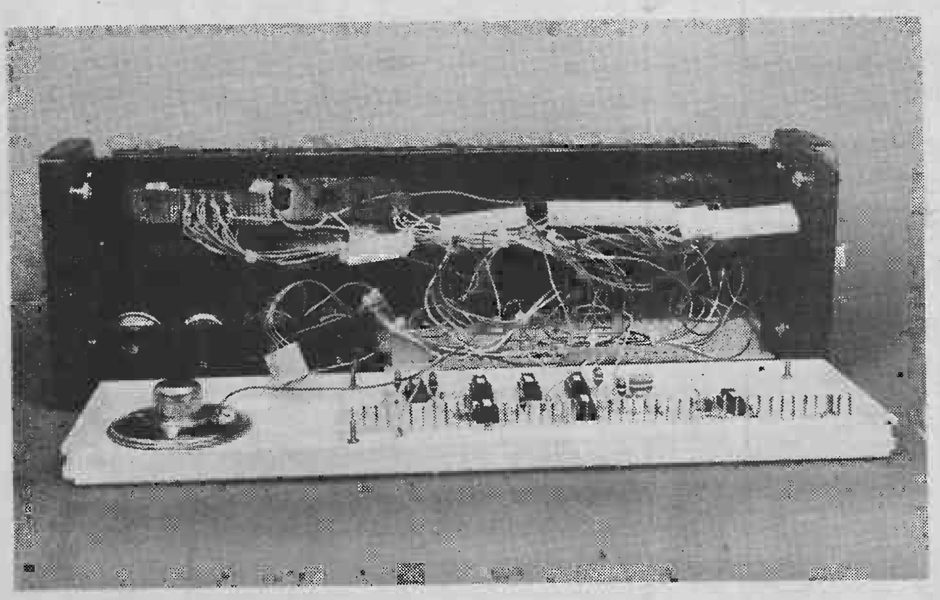
If you think you are likely to spend every waking hour zapping the starfleet, it's worthwhile investing in a mains adaptor, available from your local Tranny shop.



PCB, A. This panel holds the ammo register, random multiplex cock generater and most of the amplex switching functions.



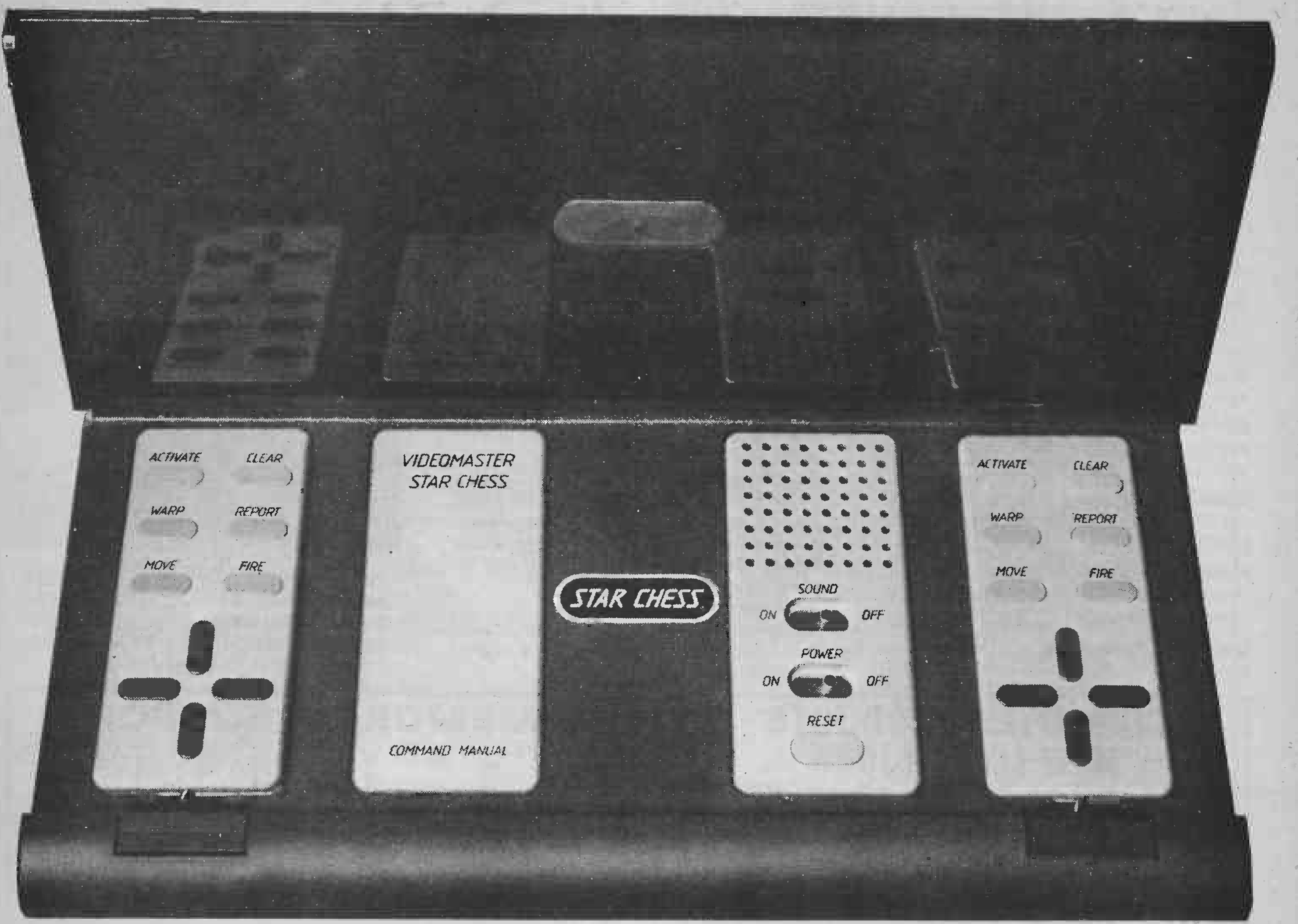




Above. Internal view of ambush with top panel removed. The PCBs are mounted within the case on stand-off pillars.

Centre. PCB, B showing the interconnecting plugs removed, the use of plugs or PCB connecting pins makes troubleshooting (we hope you don't have to) simple.

Left. Inside Ambush from the rear, the speaker can be clearly seen, note also the battery pack on the base panel.



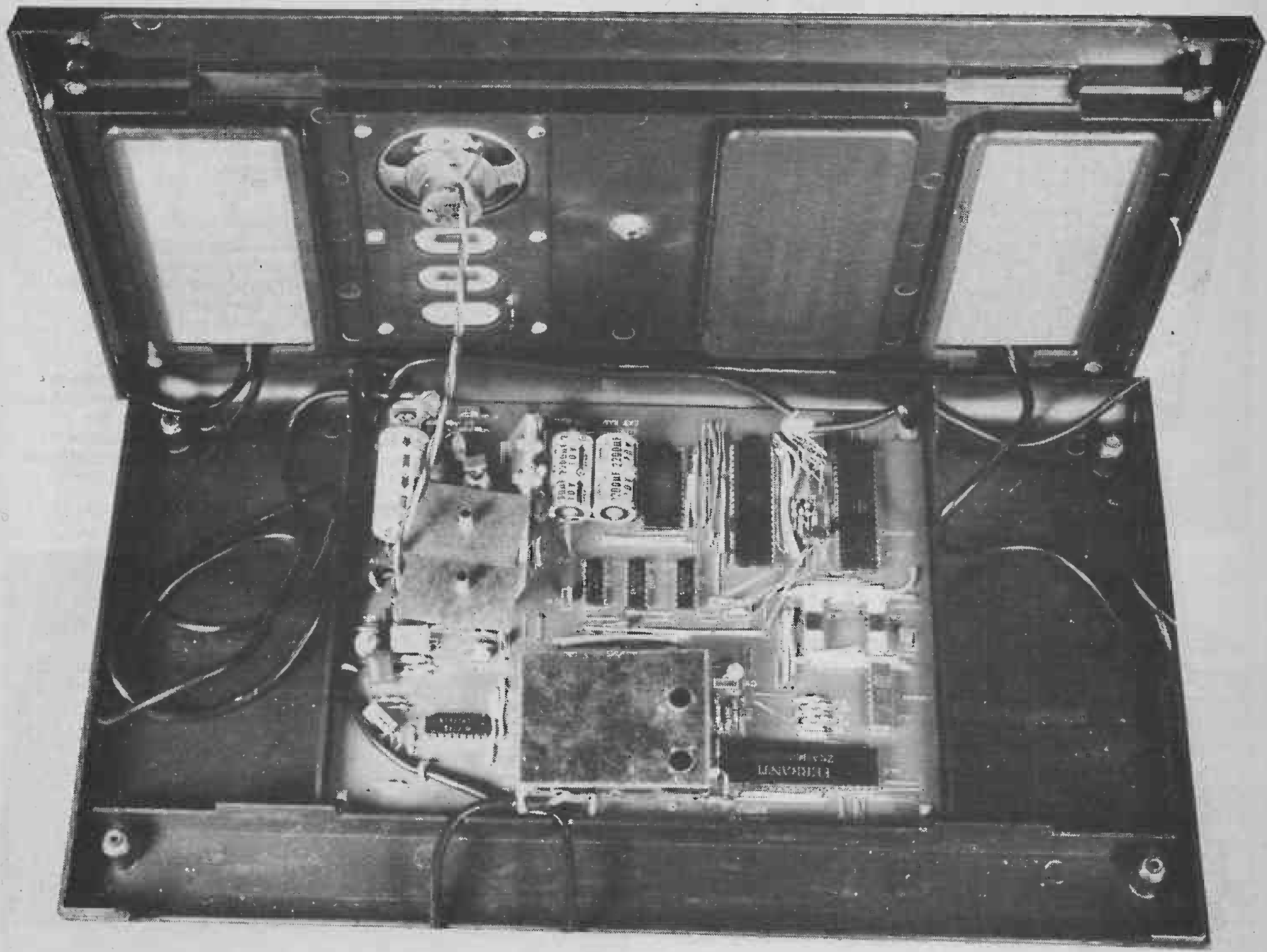
STAR CHESS

MOST OF YOU probably think that people who work on electronic magazines spend their days burrowing through mounds of exotic electronic equipment sent into us by eager manufacturers. Well to an extent that's true, we do get to see a fair amount of new stuff but how enthusiastic can you get over a 20 amp power supply or yet another revolutionary device that indicates 'heads or tails' at the flip of a switch?

Perhaps we're being a little unfair, the odd calculator or TV game does catch our jaded eyes but is usually followed by "Oh yeah and how many games does this one play?" It's true that we see more TV games than most people, so it's got to be good to get any kind of reaction, and such a game crept unceremoniously into the ETI offices last week. It had all the odds stacked against it from the beginning, for one thing it only had a one game repertoire, not a very good start for something costing almost sixty quid. It almost didn't get switched on! Perhaps it would have been better if it hadn't because ETI came to a virtual standstill for nearly three days.

Button boxes

Called STARCHESS it boasts a fine pedigree, coming as it does from Videomaster (now owned by Waddingtons). The game is housed in a fairly un-imposing black/grey box, looking like so many other TV games. The remote control boxes seemed to have more than their fair share of buttons but we're so used to a plethora of 'reset' and 'serve' knobs we didn't think much of it. Duly connected up to the power and TV set, it was switched on. Our ears were immediately assaulted by a shrill warbling sound punctuated by what can only be described as a noise like someone treading on a cat's tail — coming from the built-in speaker. A touch of the re-set



Chess games seem to be a growth area in the electronic games market, so find a mate and switch on the TV — Rick Maybury tells what to expect then . . . .

and clear buttons soon cured that.

A quick fiddle with the TV's tuner brought in a sharp well defined chess board (in full colour) with some rather unconventional looking pieces lined up on the back ranks. A lengthy study of the instruction manual (more of that later) is highly recommended before any play commences.

At this point it must be said that you've got to be able to play chess but that hurdle over you can forget any ideas you may have about playing ordinary chess with this machine, that's about as likely as the editor of ETI becoming the next Prime Minister. After a game or two it soon becomes abundantly clear that what this game has that others seem to lack is the need to think, rather than a question of who can twiddle their knobs fastest?

A typical game is both noisy and exciting, the manufacturers have seen fit to include as many variables as possible but without making it cumbersome. We take our hats off to the software engineers who wrote the game.

A lovely mover

Each piece is moved by shifting a cursor with a set of four positional buttons arranged in a cross, when the cursor is over the piece to be moved the 'move' button is pressed, then the cursor is placed on the square to be occupied and the 'activate' button pushed. Every action is accompanied by a virtual symphony of 'squarks, warbles' and other equally strange noises, adding tremendously to the fun of the game. All of the pieces except the 'pawns' move exactly as ordinary chess. The main feature of the game, however, is the ability of each piece to 'fire' missiles in the direction it would normally move, so instead of taking an opponent's man you can take a pot-shot at it, although you're not guaranteed a ▶

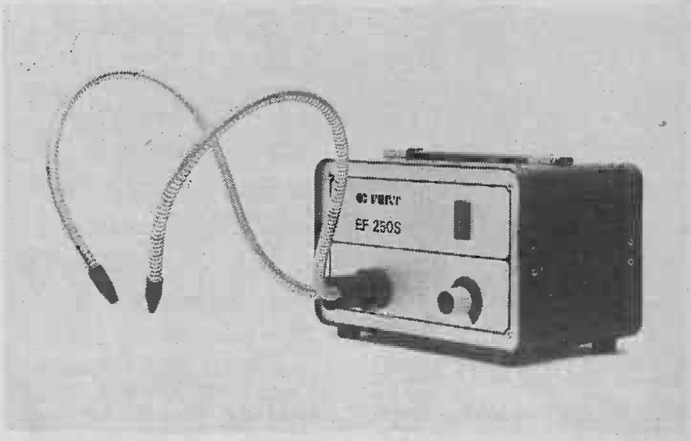
news digest..................

BYTE SIZED CHUNKS

Some new expansion kits for the three most popular MPU systems have been announced by Ithaca Audio Ltd. Each pack contains eight 16K Rams, packed in anti-static foam and are all 100% guaranteed. The kits are intended for the TRS 80, Apple 11, and Exidy Sorcerer. UK price and availablility are yet to be announced but for those who can't wait you could contact Ithaca Audio at:- Box 91, New York, 14850.

PUTTING OUT THE FEELERS

Pointing the way with their new 'cold' light-source boxes Optronic Fort Ltd are introducing a new design incorporating fibre-optic techniques. The Flexible or semi-rigid light guides can be obtained in a choice of thicknesses, and up to 1800 mm long. Because the light is 'cold' it would be ideal for illuminating areas sensitive to heat, particularly microscopic work. The light sources are available in a variety of ratings, from 50 to 250 Watts. The boxes will work on an AC supply of 110-240V (selectable) 50/60 Hz. The Tungsten-Halogen lamps are fully adjustable for brightness and are cooled by fan to prevent over-heating. Prices for the light sources start at around £145, call Optronic Fort Ltd at Cambridge Science Parl, Cambridge CB44BH for more information.

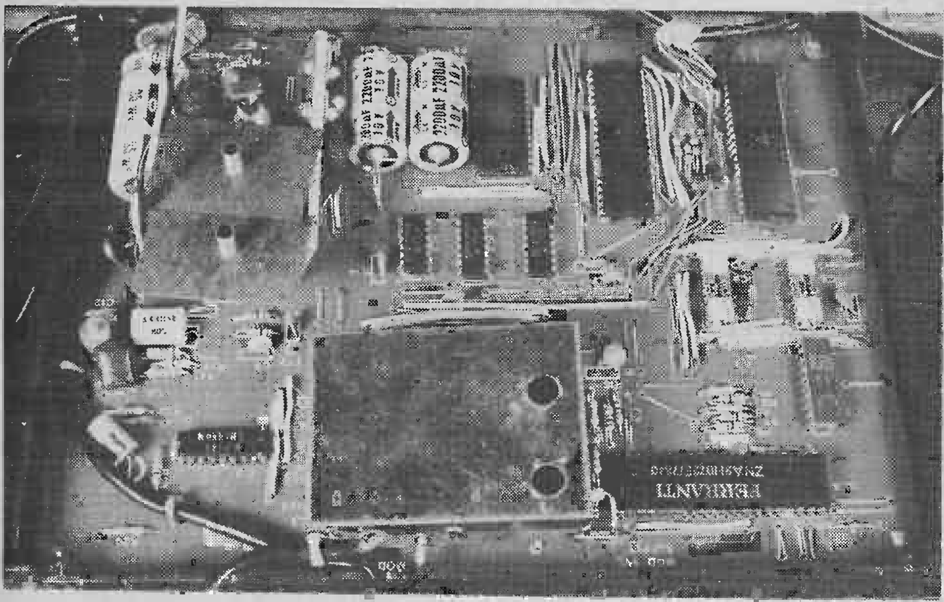


FRED'S BIG BILLS

Another Electricity Board first; 'Fred' is an electronic spokesman and will give advice on how to save energy by using more economical appliances. Using only 5KW, it is hoped to supply every home that has a 'white meter' with their own 'Fred.'

TROUBLE LOOMING? . . .

Anyone who has ever had to build up, or fault find a wiring loom will realise how useful the Vero Cablehound promises to be. It works by connecting one end of the loom to the unit and a wrist strap from the Cablehound to the operator. Particular wires can be identified simply by touching each wire in turn. Another feature is the inclusion of a digital readout to further identify individual wires. Two or more Cable-Hounds can be connected together to increase the loom identification size from 100 to 10 000 separate wires (or more if further units are added). Vero Systems Ltd will be only too pleased to supply any more details, contact them at 362 Spring Road, Sholing, Southampton, Hampshire.



(1)

Starchess, naked to the world. It has a surprising amount of parts for a 'dedicated' game, many of the ICs are unknown to us. The modulator deserves a mention: it produces one of the most stable and clear pictures of any TV game we've come across.

(2)

The preliminary stages of a game, the pieces may look rather unusual, particularly the 'queen' which looks a little like the 'Starship Enterprise.'

(3)

It's a bit confusing showing a game in black and white, there is an explosion on the screen (square C4). In fact the explosion is in red and accompanied by some very 'Star Wars' like sound effects.

hit, in fact you take a chance of hitting one of your own men if they are too close.

Each direct hit will destroy one of your enemy's 'shields' which can number from two (pawns) to seven for the King and Queen, and the amount of ammunition each man has is similarly limited. The pieces, however can replenish their ammunition by returning to the 'starbase' which is the squares occupied by the king and queen. When an opponent's shields have all been destroyed a further hit will produce a satisfying 'double explosion' (in red) and obliterate the piece completely.

Warped ideas

The second major feature is the ability to 'warp' any of your pieces from the board, the only danger in doing this is that the piece will return after a random period (from a few seconds to several minutes) and will reappear anywhere on the board, even on top of one of your own men (or your opponent's). The piece coming out of 'warp' makes a banshee like wail and slowly materialises (just like the transporter on the Starship Enterprise), but this is an extremely useful feature lending itself to risky but worthwhile tactics.

Yet another feature is the 'report' facility which apparently gives a readout of shield and weapon status but we found we rarely used it as it counted as one move.

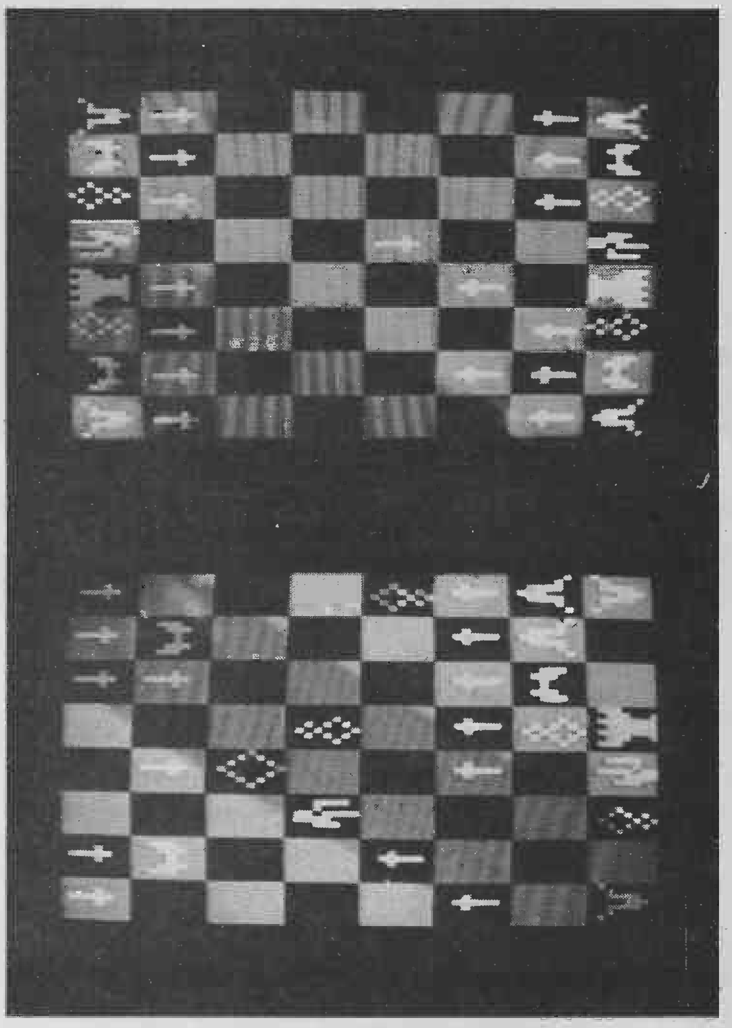
All of the pieces are given alternative names which is just as well, because none of them look even remotely like ordinary chessmen, the rook for instance is a star-cruiser. The final objective of the game is to destroy your opponent's King, although it can't be taken on its Starbase, it can still be fired upon.

We did find we had one or two small niggles with the machine, it would have been a good idea for it to play ordinary chess, especially when most of the hardware is already there, and the power supply could have been located inside the case.

Taken overall, however it's without doubt the best 'dedicated' game we've ever come across and recommend it highly. By the way ETI Starchess team confidently challenges all comers to a shootout!

Any takers?

ETI



Our thanks to N.I.C. Models for lending us an example of Starchess, just hope they don't want it back. But just in case they do it will cost us (and you) £59.95.

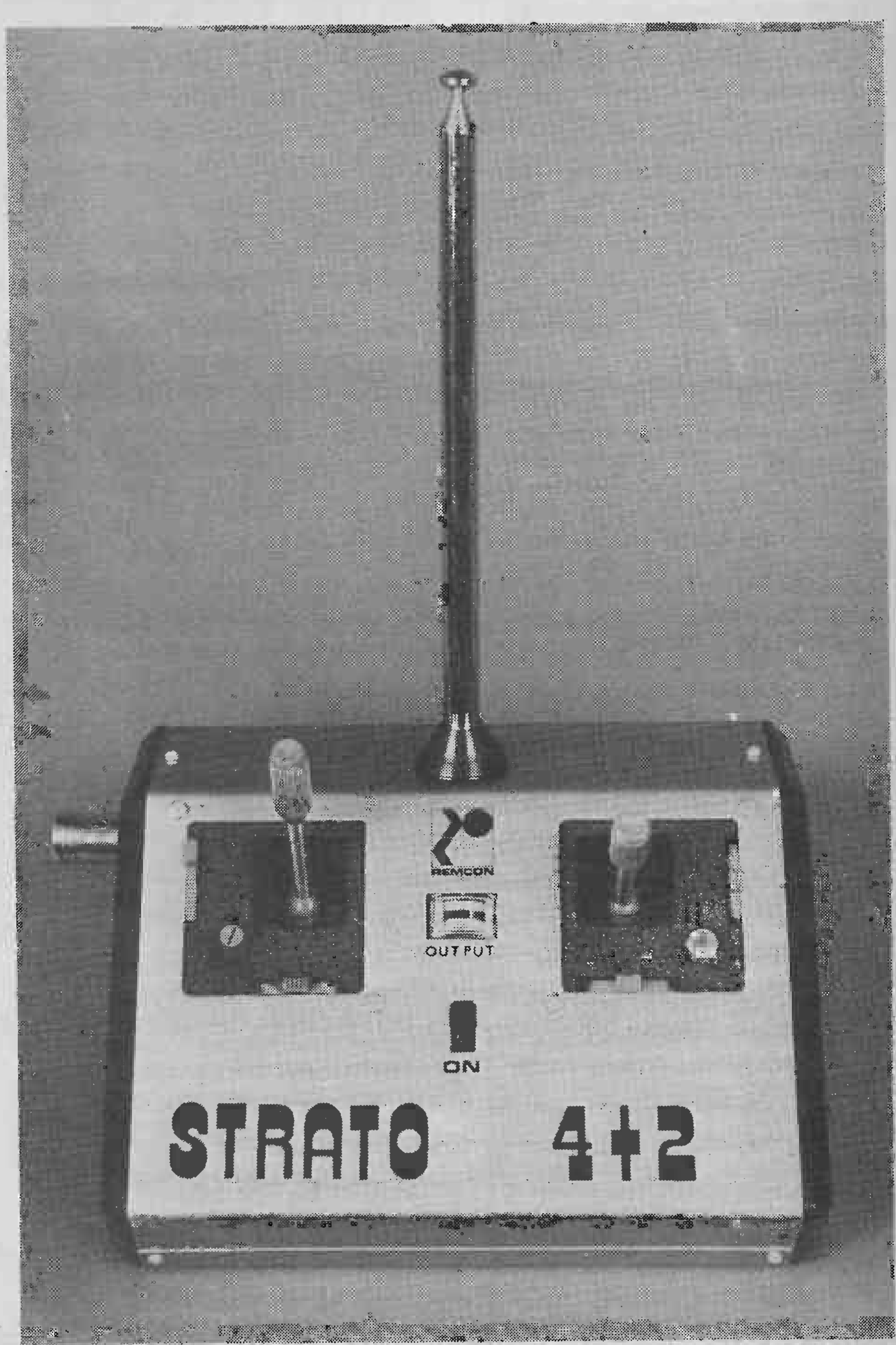
RADIO CONTROL SYSTEM
PART 1: TRANSMITTER

THERE WERE SEVERAL criteria we considered important in any radio control system before this project came up, and these have been perhaps the main reason for ETI keeping out of this field thus far.

However Rencoms design, presented here, satisfys our requirements perfectly and fulfills a few we hadn't thought of. Firstly it is easily constructed and easy to set up — too many systems are marred by their requirements for expensive test gear in the alignment procedures. All that is needed here is a simple voltmeter.

Secondly the transmitter produces a 'clean' output which does not interfere with adjacent channels to any degree worth mentioning. This is an essential requirement since the receiver can handle 10kHz channel spacing, and interference would render this unusable. In any case this is now a legal requirement in many countries.

The charger for both transmitters and receiver can be built into the transmitter case itself, which any enthusiast will recognise as a decided convenience a five pin socket fitted to the case allows access to the charger circuit for this facility, and the same socket holds the transmitter crystal (normally encased within a DIN plug). This means channels can be changed quickly — or the set disabled — simply by removing the plug.



Tune In

The Strato system can be built as either a four or six channel unit, and is suitable for any kind of model from airplane to boat. Choice of servo will be made according to the vehicle to be controlled. ▶

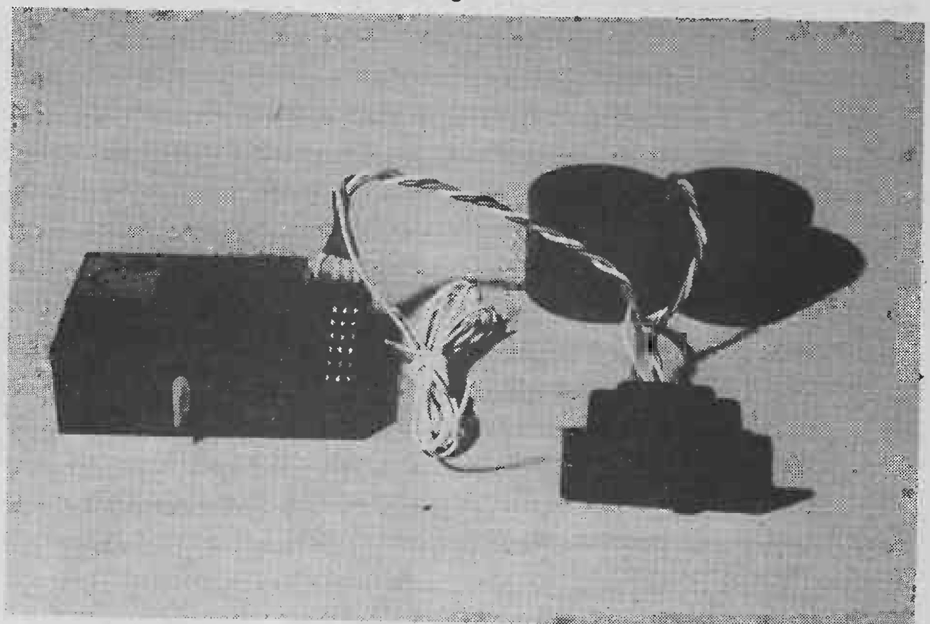
Publication of the system will be in two parts, transmitters first. Next month there will be full details of the receiver unit along with some hints on installing the radio control. There will also be a follow up article later designed to give some ideas of what can be achieved with a system of this versatility.

We chose an armoured vehicle as the example upon which to base our articles, as this is more general in principle than most and allows easier illustration. The model we used was the excellent Tamiya 1/16th Leopard kit. This gives a splendid model of the W. German tank with Tamiyas usual superb moulding detail and a drive system designed for radio control through an ingenious twin clutch system.

It is an expensive kit, but in our opinion is well worth it, and includes everything right down to the servo rods.

Above: the Tamiya tank upon which the system is based

Below: the receiver with its DEAC and charger switch



A Case For It

The transmitter case is designed for four channels to be controlled by joystick and two by either pot or simple switch. The latter could be useful for aircraft undercarriage and the like.

The angled aerial produces a radiation pattern that reduces the risk of an aircraft (in particular) getting itself into an area of low strength and thus passing beyond operator control.

The meter on the front panel is a form of field strength meter and is used initally for setting the only tuning control in the TX circuitry, and thereafter indicates RF output as a check upon performance.

Construction

Building the Tx should pose no problems to the average constructor, but when fitting the joystick and case, follow the photographs carefully otherwise it could cause unnecessary problems.

Assemble the PCB first, and check carefully the polarity of semiconductors etc. Fit the aerial and other sockets initially, then the passives and leave the transistors until last. Note the inductors are labelled.

The small PCB fits aback the meter and carries the components for the FSM.

Solder the output wires to the board at this stage as fitting the control pots later will be tricky else. Follow the installation drawings carefully and there should be no trouble. Check everything carefully though.

Power To The Aerial

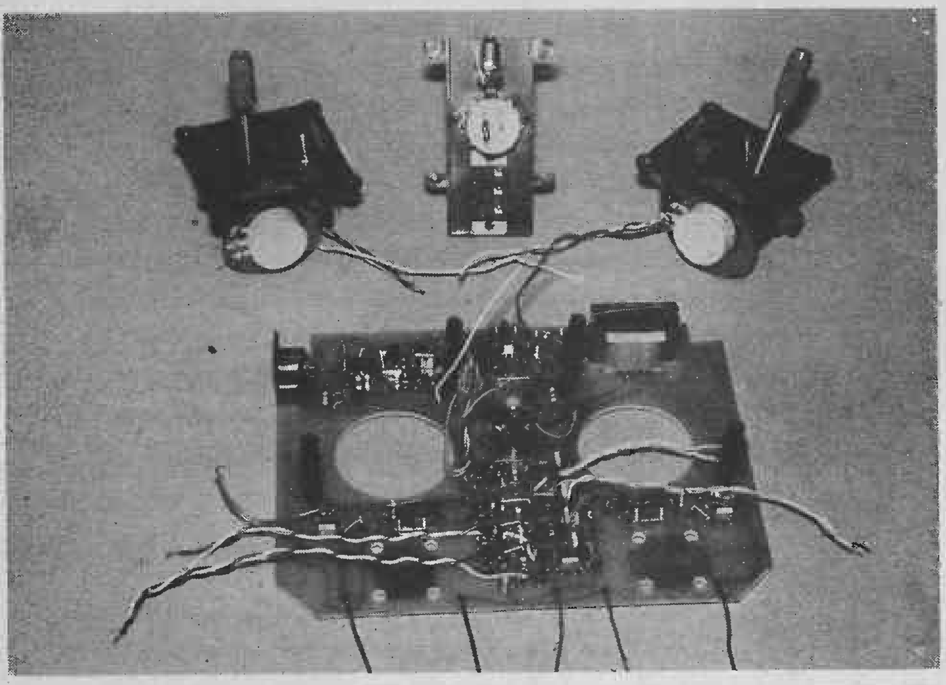
Once the board is complete and the sticks wired fit the rechargeable cells, screw in the aerial (telescoped) and plug in your crystal. Switch on.

The meter should show a reading. Rotate CI using a small insulated screwdriver or better yet a plastic control trimmer the reading will rise and fall as CI is rotated.

Extend the aerial fully and rotate CI to get a maximum meter reading. It helps during this operation to keep a finger on the —ve of the cells to provide an earth load.

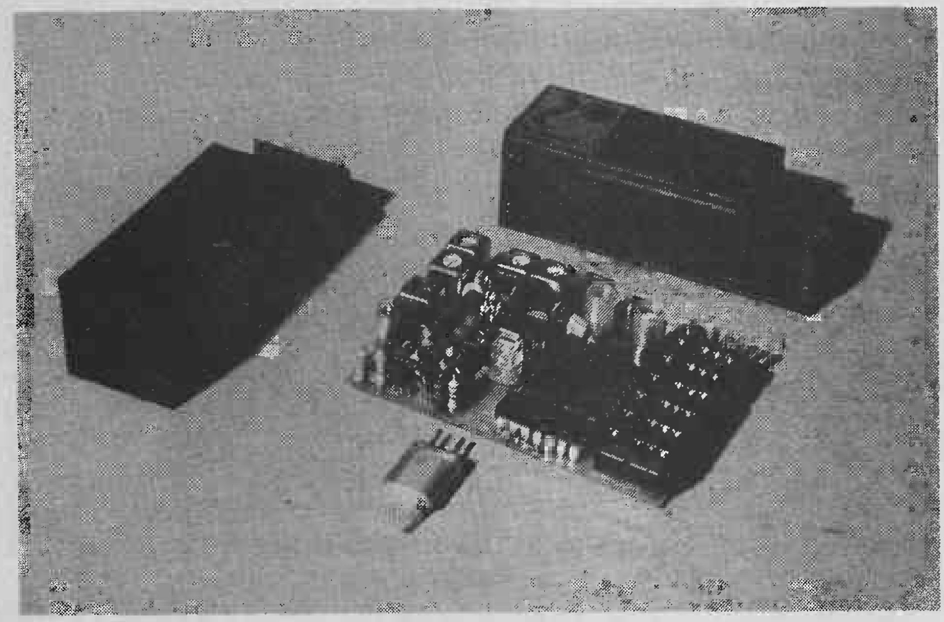
The reading should be about 80-90% of FSD so move the FSM aerial around slightly to obtain this.

The transmitter is now tuned. Presets PRI-6 are used to set the centres of servo operation and do not interfere with RF output at all.



Above: a denuded transmitter unit. The joysticks mount above the board.

Below: the receiver removed from its case. Note the crystal.



Fit the completed assembly to the case, lining up the aerial bush with the plastic grommet on the case top. For those not fitting the internal charger, cover the holes in the back of the case with some tape or card.

Charge

Remember that the cells used will take 14 hours to charge from flat, and the bulb will light quite brightly at first and then dim as charging progresses. To charge the Tx batteries alone fit the DIN plug with R32 across pins 1 and 2 and plug in the mains lead to the rear socket.

That same DIN socket is utilised many ways. Pins 4 and 5 are the connections for the Tx crystal. Pins 1 (+ve) and pin 2 (—ve) allow charging of both the Tx and Rx cells together. Pins 2 and 3 if strapped together can switch on the Tx so that when removed 'locks off' the unit. Makes unauthorised use a little difficult! Pins 2 (+ve) and pin 5 (—ve) connect an external charger to the Tx cells. 50mA maximum please.

Crystal Clear

By changing crystal you change channel, and the colour can be used ▶

BUYLINES

With a project of this type the metalwork is more important than for our usual endeavours. For the transmitter in particular, with the joysticks and aerial to be mounted, we cannot imagine anybody enjoying filing away for hours. In consequence we strongly recommend use of the hardware packs offered by the designers, Remcon. Our photographs and text employ these.

Ambit are marketing the components for this project, so between the two a complete kit is to be had. We estimate that, including four servos, the project will cost about £130 in total, which is approximately £60 less than a commercial set-up of approximately equal performance would cost.

The model we intend to base our installation on is the Tamiya Leopard A4 in 1/16th scale, which is designed for radio control. The kit is superb in all respects, both as a model and as a vehicle for radio control, and cannot be recommended highly enough. Beatties chain of stores stock the kit and it will cost around £90 including the gearbox/clutch/motor assembly for direction control.

Component details:
From Remcon.

Manual for system (worthwhile step-by-step constructional details) £2.75

£1.00 refundable against purchase of packs over £25

Transmitter hardware pack (everything except components and batteries):
4 channel £39.95
6 channel £45.00

All components available separately. SAE to Remcon for details.

Receiver hardware pack complete (six channels) £18.50

All components available separately.

From Ambit —

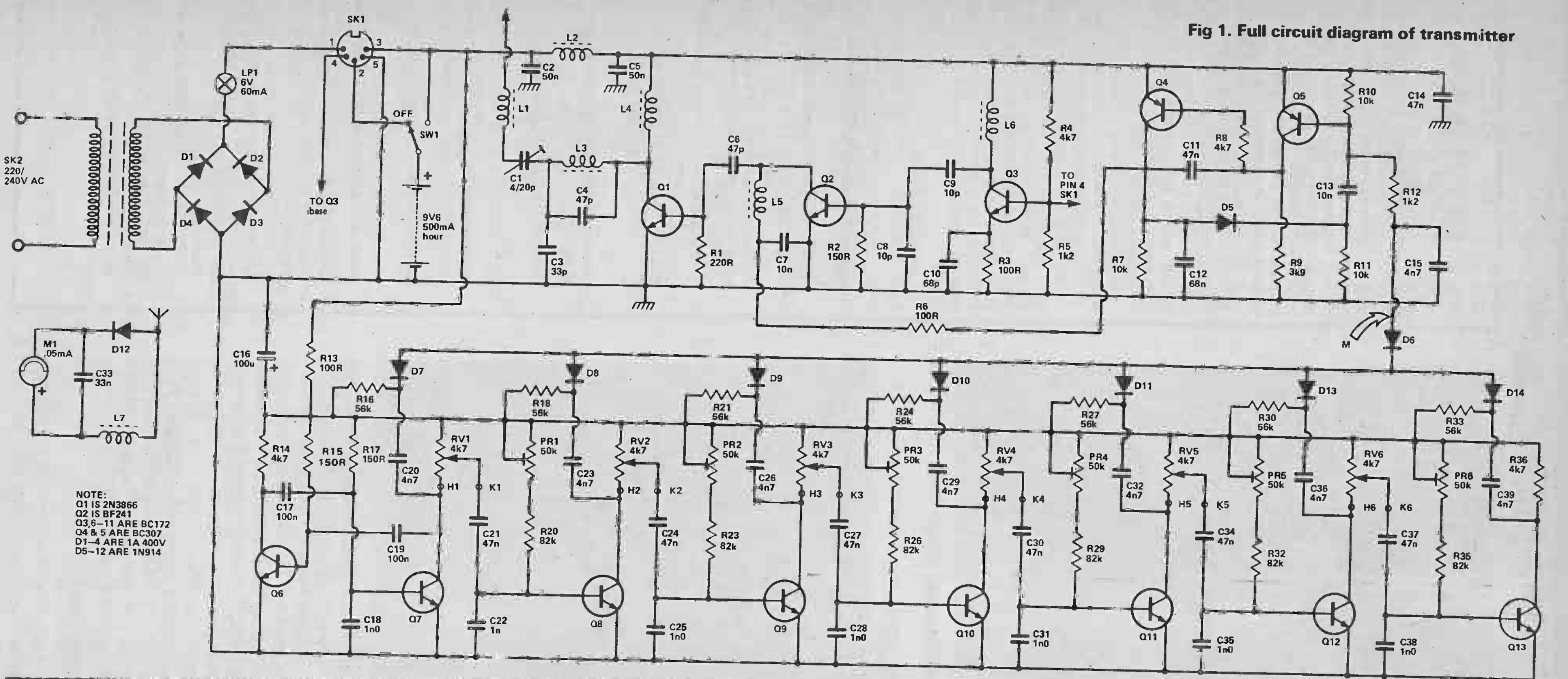
Transmitter components £10.95
Two PCB DIN plugs and charging resistors £1.60
Matched crystals (2) and DIN plug £4.00
Five-pin plug DIN (options) £0.75
Receiver components (complete) £8.95

All components available separately. Rechargeable batteries also available. SAE for details.

Any servo will operate with the Strato system. Next month we will give wiring details for the different types.

Addresses:
Ambit International, 2 Gresham Road, Brentwood, Essex.
Remcon Electronics, 1 Church Road, Bexleyheath, Kent.
Add 12½% VAT to all prices except manual.

Fig 1. Full circuit diagram of transmitter



HOW IT WORKS

This has been designed to meet the stringent requirements of continental post offices in respect of harmonic radiation and sidebands and has adequate power output to ensure out-of-sight range for model aircraft.

Referring to the transmitter circuit Q6, 7 R14-17, RV1, C16-19 comprise a conventional astable mutivibrator of unity M/S ratio, and period approximately 20mS. This is the system clock. If we look for a moment at Q8-11 it will be seen that these initially have their collectors close to the - ve rail potential due to their base bias. Now when the collector of Q7 goes to logic 0, the step change in voltage at the slider of channel 1 control potentiometer RV1, is passed via C21 to the base of Q8, cutting off its collector current. The collector of Q8 therefore goes to logic 1. The base potential of Q8 slowly rises on a time constant C21 (R19+R20) until the base/emitter diode again becomes forward biassed At this point the collector goes to logic 0 once again. When this happens, the -ve going stage voltage at the channel 2 control. potentiometer RV2 cuts off Q9, followed by the same pattern of events as detailed for Q8. This sequence is followed by Q10 and Q11. Potentiometers RV1-4 are the operator controls, and R19, 22, 25, 28 permitsetting of the pulse width with the channel controls centred. These adjustments are carried out to set the mid-travel position of the servos.

The encoding process is completed by the C,R and diode network at the collectors of Q7-11. Taking as an example, C26, C21, D9, capacitor C26 is normally charged to a potential approximately that on C16, When Q9 is cut-off by the pulse from Q8, C26 discharges on a time constant C26 (R21+RV3), which is much less than the 1ms minimum duration of channel data. When Q9 is again turned on, D9 and D6 are forward biassed by the current through R12 turns on Q5 which is part of the monostable which modulates the buffer stage Q2. Before triggering, Q5 to cut-off, and Q4 therefore turned on by base bise current through R9, R6. When triggered by an encoder pulse via D6, Q5 conducts turns off Q4, which reverse biasses D5. C13 then charges through R11, maintaining Q5 in its turned on state for a period determined by C13, R11. Since this occurs when Q7-11 collector go to logic 0 then five absolutely identical pulses will be generated by Q4 and Q5 in every 20 mS frame of data.

The RF section is one of elegant simplicity, having only one adjustment, C1, Q3 is the crystal oscillator using 27 MHz 3rd overtone crystal base to -ve rail 27 MHz output is coupled to the base of buffer/modulator stage Q12 via C9. As we mentioned in the description of the encoder, Q4 is normally conducting, which means that collector voltage is applied to Q2 via R6 and L5. The amplified RF from Q2 collector passes to the power amplifier Q1 via C6. Impedance matching from Q1 collector to the power amplifier Q1 via C6. Impedance matching from Q1 collector to the aerial is effected by pre- coupler C3, L3 C4, and base loading by the adjustable network L1, C1. A simple RF meter circuit is included, comprising the meter, C33, L7, D12, it is used to peak the aerial matching adjustments during initial setting up. Thereafter it constantly indicates the carrier strength.

Before leaving the transmitter it is perhaps worth mentioning C2, L2, C5, C11, C14, C15, C18, C22, C25, C28, C31. They are all there to prevent R.F. from reaching unauthorised, and sensitive parts of the circuit!

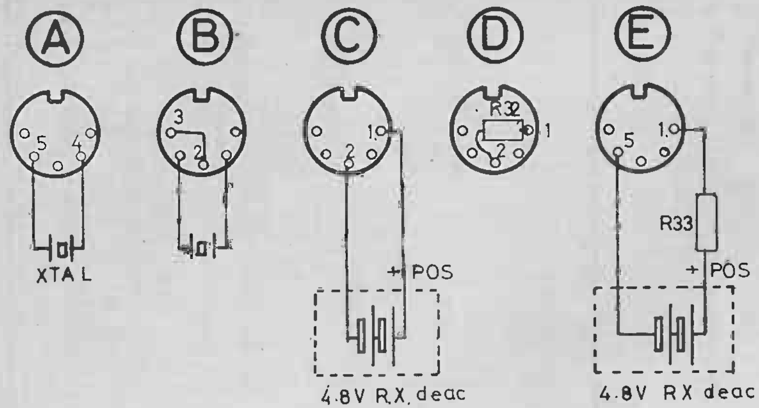
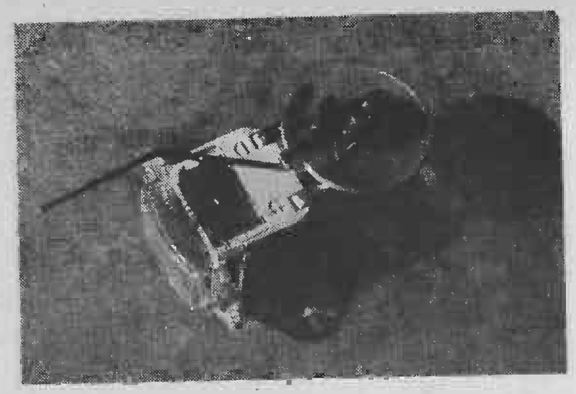
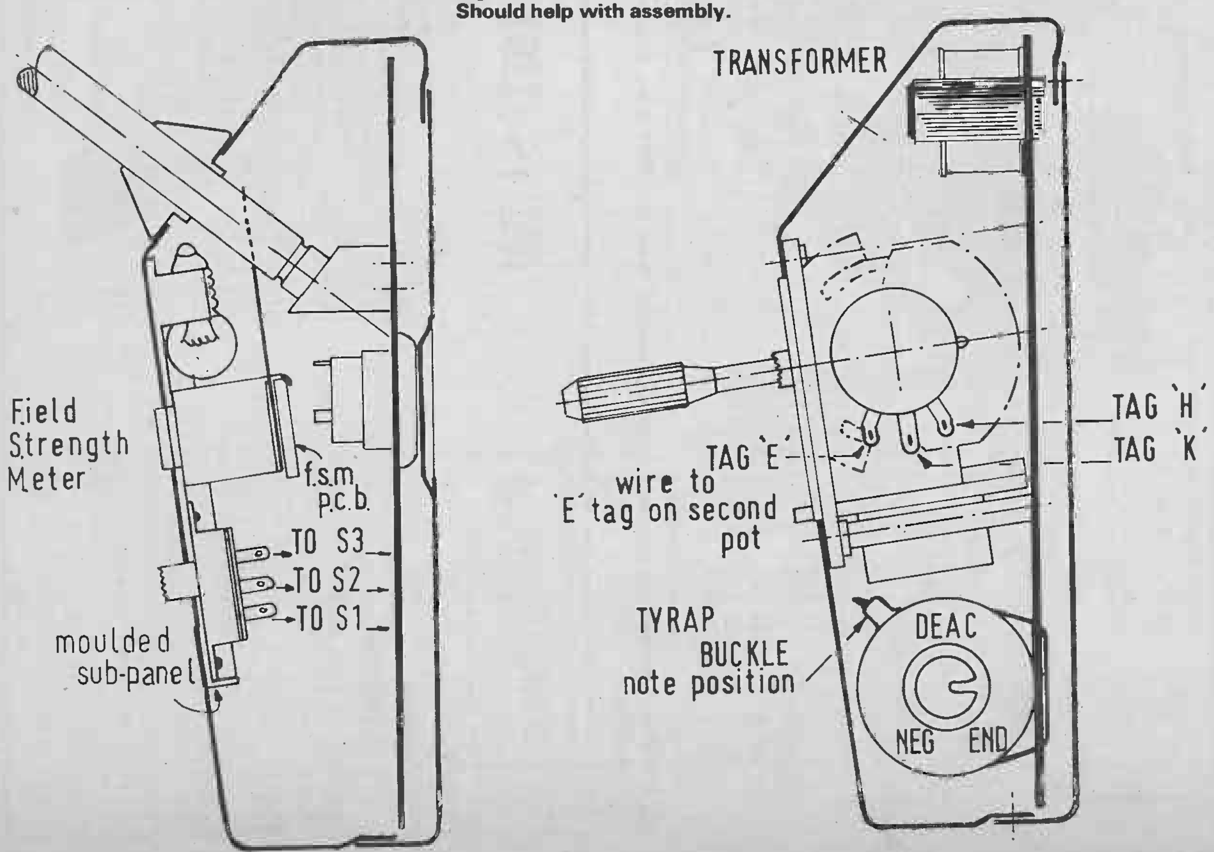


Fig 2. All the possible DIN plug configurations. See text for uses.

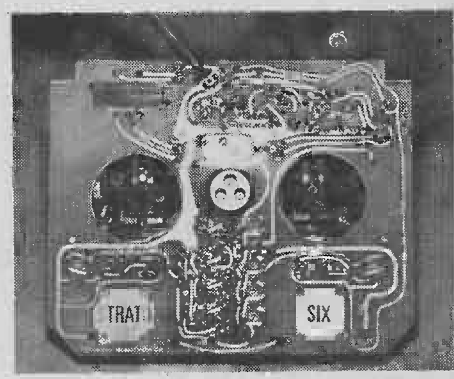


The field strength meter, with PCB ready for bending at the meter tabs.

Fig 3. Section through transmitter case. Should help with assembly.



The complete Tx excluding case.



Copper side of PCB. Note earth bush.

The field strength meter with pCB bent over for fixing.

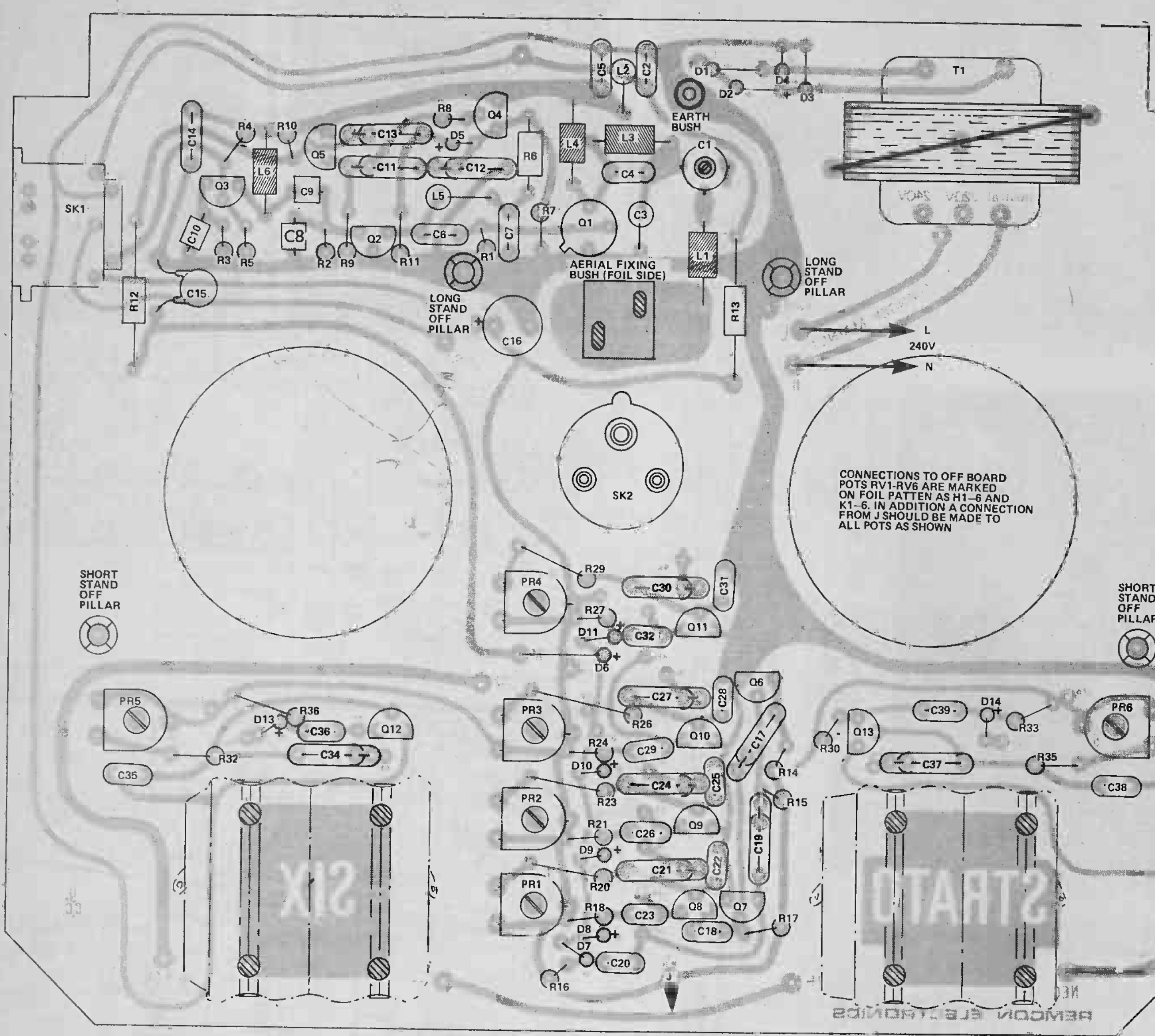


Fig 4. the main component overlay for the transmitter. Note that PR1-6 are 50k in value.

PARTS LIST

RESISTORS (all ¼W 5%)

R1	220R
R2,15,17	150R
R3,6,13	100R
R4,8,14,36	4k7
R5,12	1k2
R7,10,11	10k
R9	3k9
R18,21,24,27,30, 33,16	56k
R20,23,26,29,32, 35	82k

Note that R19,22,25,28,31,34 are annotated as PRI-6 to correspond to channel number

POTENTIOMETERS

RV1-RV6	4k7

CAPACITORS

C1	4-20p trimmer
C2,5	50n polystyrene
C3	33p polystyrene
C4,6	47p polystyrene
C7	10n polyester 5%
C8,9	10p polystyrene
C10	68p polystyrene
C11,14	47n ceramic
C12	68n polyester 5%
C13	10n ceramic
C15,20,23,26,29, 32,36,39	4n7 ceramic
C16	100u electrolytic 25V
C17,19	100n polyester 5%
C18,22,25,28,31, 35,38	1n0 ceramic
C21,24,27,30,34, 37	47n ceramic
C33	33n ceramic

INDUCTORS

L1,2	4u7
L3	220n
L4	22u
L5	680n
L6	1u5
L7	10u

SEMICONDUCTORS

Q1	2N3866
Q2	BF241
Q3, 6-11	BC172
Q4,5	BC307
D1-D4	ITT 2002 or equivalent
D5-D12	1N914

MISCELLANEOUS (for charger version)
Mains skt, 6V 60mA bulb, 20V 1A secondary transformer, meter 200uA FSD, 5 pin DIN skt, metalwork (see Buylines), aerial — 1.4m long.

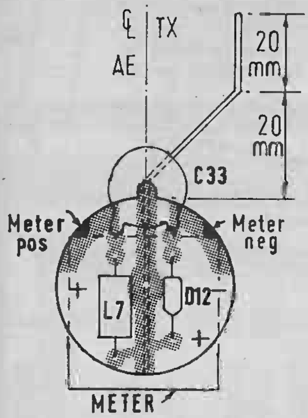
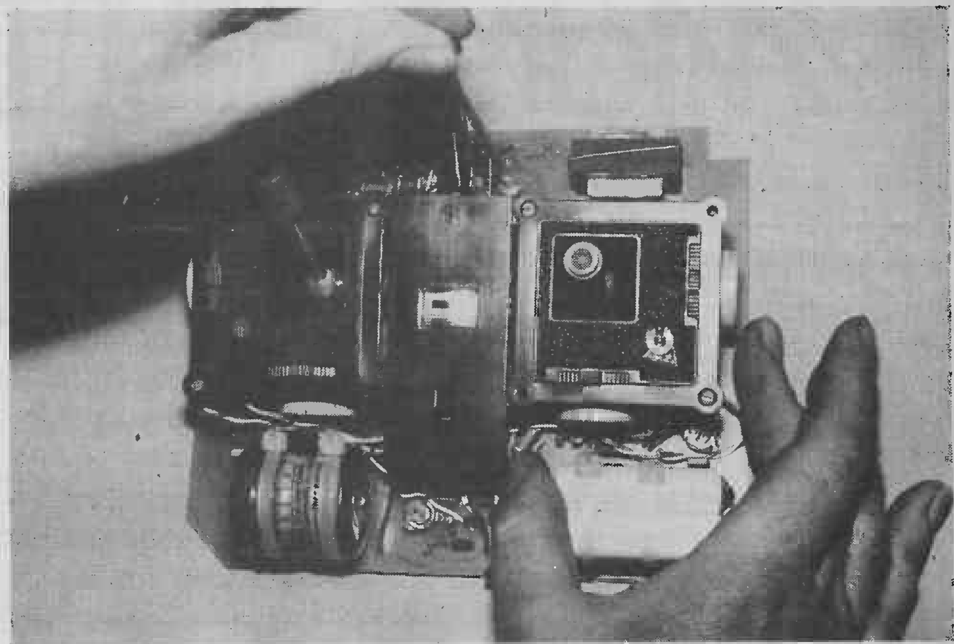
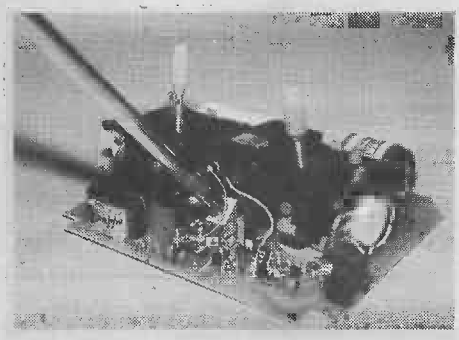


Fig 5. (Above) the overlay for the meter PCB. This mounts stop the meter itself



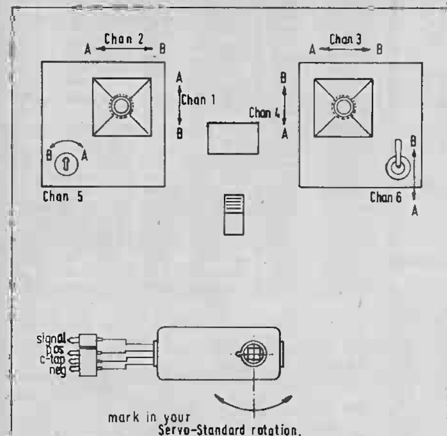
Tuning involves one adjustment only one note thumb on battery earth.

The top of the PCB slips under the flange at the top of the case.

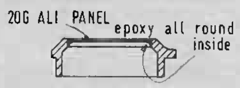


The Rf end of the PCB.

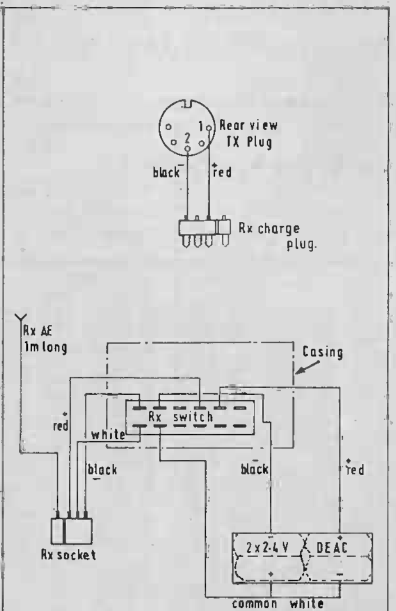
Fig 6. (Below) Plug wiring for servos and channel line-up.



Channel allocation & direction of servo travel



Section thro case end moulding



Wiring — charge plugs switch & battery.

to identify operation easily. The standard system of coding is:—

Tx	Rx	Colour
26.995	26.54	Brown
27.045	26.59	Red
27.095	26.64	Orange
27.145	26.69	Yellow
27.195	26.74	Green
27.255	26.80	Blue

Conclusion

So that's about it for the transmitter, except to remind you that to run a radio control system you NEED A LICENCE. This costs £2.80 for five years and obtained from:—
The Home Office
Radio Regulatory Dept
Waterloo Bridge House
London
SE1 8UA.

Next month we will be giving full details of the receiver and installation of the system into a model. In the meanwhile for the fleet of soldering iron, or just plain impatient, Remcons manual contains full constructional details of the complete system and will be available shortly.

data sheet

TDA 1008 **MULLARD**

Introduction

The TDA1008 integrated circuit provides frequency-dividing and gating functions for tone signal generation in electronic organs and other electronic musical instruments. An increasing variety of electronic organs has become available in recent years, their popularity having been enhanced by the rapid expansion of the home entertainments market. To provide effects such as sustain, percussion, and fifth coupling, the organ designer has usually needed to add special electronic circuits to the basic organ design, increasing overall cost. However, in a system based on TDA1008 ICs, these and many other effects can be easily provided without significantly adding to circuit complexity. The reduction in component count and number of key contacts compared with conventional systems results in a significant saving in cost, greater reliability, and easier servicing. With simplified circuits and fewer components, organ designs using TDA1008 ICs are also ideal for the home constructor.

The main features of the TDA1008 are given below.

The IC is a monolithic bipolar device using I^2L logic, and therefore requires no special handling techniques.

Only a single set of contacts is required for each key, because the TDA1008 provides five octave-related output signals when each of five key inputs is activated. Thus, in a typical system, only one busbar is required for each manual.

An outstanding feature of the TDA1008 is that the tone-output signals are symmetrical about a fixed DC level, and so no DC jump occurs in the outputs when the keys are operated. Thus 'plopping and scratching' sounds are eliminated from the audio output without the need for the usual additional suppression components.

The amplitudes of the five output signals from the IC are proportional to the DC voltage applied to each key input, and because the nominal impedance of these inputs is high, sustain and percussion effects can be added by using simple RC networks in conjunction with the key circuits.

The rate of attack and decay can be adjusted simply by varying a DC voltage applied to a 'sustain control' pin on the IC.

Description of TDA1008

The circuit of the TDA1008 IC with basic peripheral components is shown in Fig. 1. The IC comprises eight divide-by-two circuits and a matrix of gate circuits.

As shown in Fig. 1, the TDA1008 can be driven directly from a top-octave synthesiser, because only one input signal applied to pin 15 is required to produce nine octave-related notes within the IC. The minimum impedance at pin 15 is 28 k ohm.

Up to five keys can be connected to pins 8 to 12. When a DC voltage is applied to one of these inputs, five of the nine octave-related notes are routed by the matrix circuit to the five tone outputs, as shown in the truth table. Although the maximum input frequency of the TDA1008 is 100 kHz, as can be seen from the truth table the frequency chosen would normally be within the audio range to give the full range of audible tones. If more than one key input is activated, then the signal from each tone output will comprise the sum of all the tones for the activated inputs.

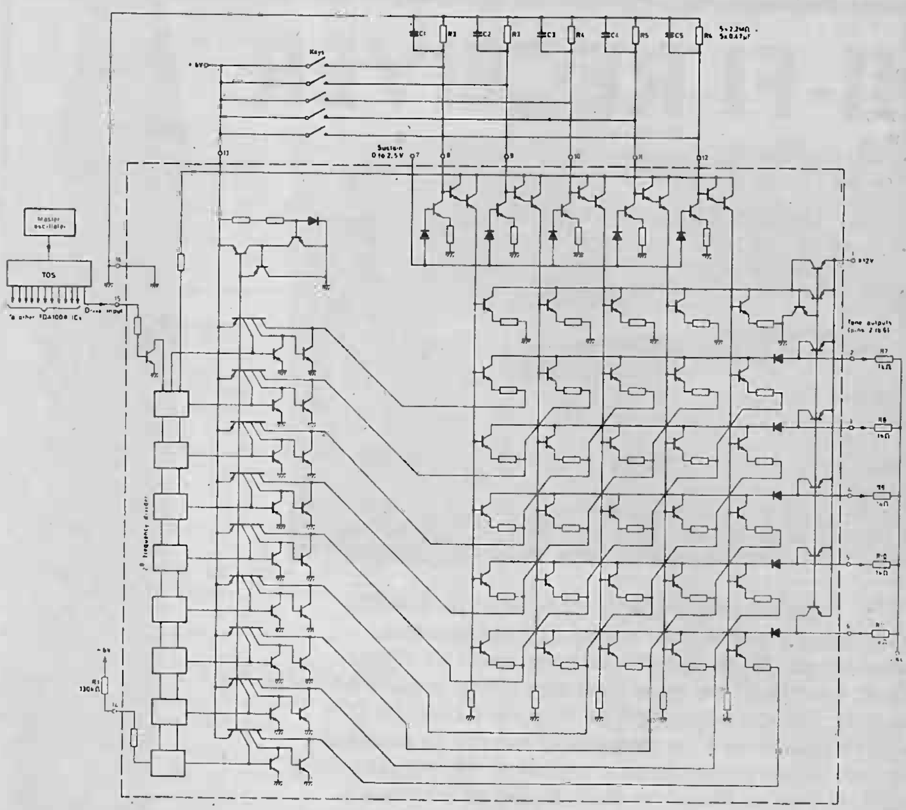


Fig. 1. TDA1008 and basic peripheral circuit.

The signal amplitude at each tone output (pins 2 to 6) is proportional to the DC voltage applied to each key input. Sustain and percussion effects can, therefore, be obtained by connecting simple RC networks to the key inputs. Some practical networks are described later. The networks shown in Fig. 1 (resistors R_2 to R_6 and capacitors C_1 to C_5) provide a simple sustain effect. The impedance of the key inputs, and hence the rate of discharge of C_1 to C_5, is determined by the DC voltage applied to pin 7 of the IC. With pin 7 at 0 V, the impedance of each key input is greater than 8 M ohms. When this voltage is increased towards 2.5 V DC, the impedance of each input falls accordingly. Thus the decay of the output waveforms at pins 2 to 6 can be adjusted continuously by simply varying the sustain control voltage at pin 7. The impedance of the tone outputs is determined mainly by the values of the load resistors R_7 to R_{11} (1 k ohms in the circuit shown).

The ungated output from the last divider stage is provided at pin 14. This output is used when the IC is tested during manufacture, but it can also be used by the organ manufacturer for a quick operational check of each TDA1008. (An output signal from pin 14 when an input signal is applied to pin 15 indicates that all the divider stages are operating correctly.) During normal operation, pin 14 should be connected through a resistor to the +6 V supply so that a current of 20 µA is drawn. In a practical circuit, this can be achieved by connecting a 330 k ohms resistor (R_1 in Fig. 4) between pins 14 and 13.

It is possible to derive a low-frequency output signal for a pedal board from pin 14. Provided that the current drain of 20 µA is maintained, a transistor can be used to amplify the low-frequency signal from this pin.

Practical Circuits for Organs Using TDA1008 ICs

The number of TDA1008 ICs required for a particular system depends on the number of octaves required by the organ designer. Normally, a minimum of twelve of these ICs would be required for subdivision of the twelve top-octave notes. For example, a master oscillator, a top-octave synthesiser IC, and twelve TDA1008 ICs would be required for a five-octave single-manual organ. All the ICs, together with the peripheral components, can be mounted on a single compact printed-wiring board.

A brief description of a variety of practical circuits for use with TDA1008 ICs is given below. The five-octave organ has been chosen as a practical example of a system using these circuits.

Master oscillator

The Hartley oscillator is a popular choice for electronic organs because of its inherent high stability. The sinewave output signal from this oscillator must be shaped by a Schmitt trigger to provide a squarewave with the correct slew rate for driving the TOS, as shown in Fig. 2. For TOS circuits that require two input signals of opposite phase, these can be provided as shown.

However, because the TDA1008 IC requires a stabilised supply, use can be made of this supply to simplify the oscillator circuit greatly, as shown in Fig. 3. Only four NAND gates contained in a single HEF4011P IC, three resistors (one variable), and a capacitor, are required to produce an output signal of the correct shape for the TOS. One of the gates can be used as shown to provide an output signal of opposite phase.

Switching and envelope-shaping circuits

The TDA1008 IC can be connected as shown in Fig. 4, and will provide five octave-related tones at pins 2 to 6 by operation of a single key contact connected to each key input (pins 8 to 12). The signal obtained from each output, relative to the three supply voltages, is shown in Fig. 5. The amplitude of this signal is dependent on the voltage applied to the key inputs. If any of the output pins remain unused, these pins should be connected to the +9 V supply to avoid intermodulation between the output signals.

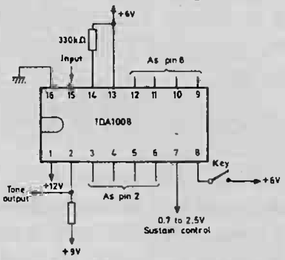


Fig. 4. Simplified connection diagram for TDA1008.

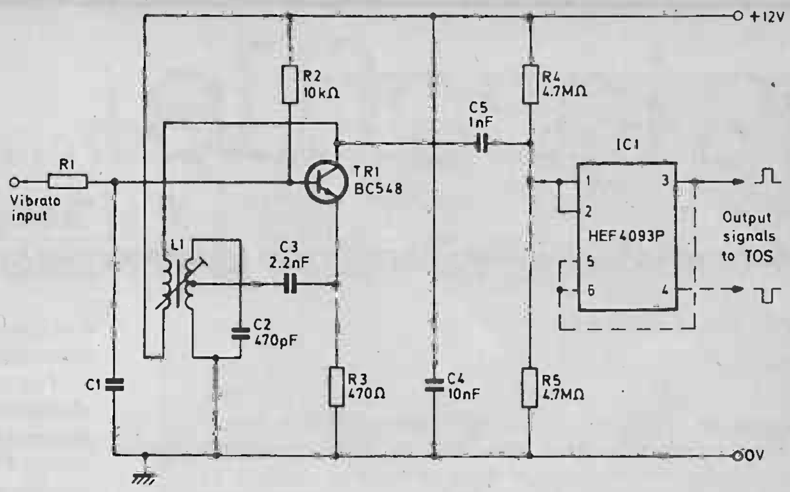


Fig. 2. Hartley oscillator and Wave- Shaping circuit.

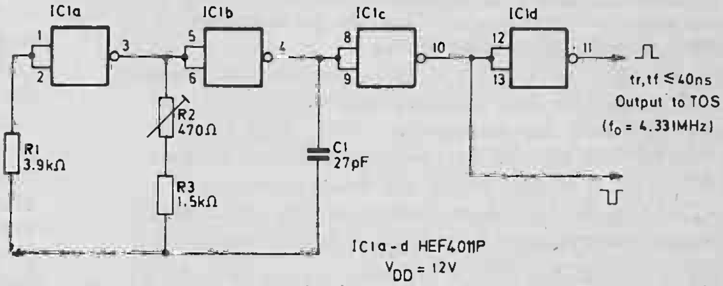


Fig. 3. Master oscillator using NAND gates.

Sustain

The sustain effect, the continuation of a note or notes for a predetermined period after a key has been released, can be easily obtained in an organ system using TDA1008 ICs.

To apply sustain to the five tone-output signals simultaneously, it is only necessary to connect a capacitor between each key input of the TDA1008 and earth, as shown in Fig. 6. With pin 7 either open-circuit or at a low DC voltage, the impedance of each key input is high (≥8M ohms). This impedance, combined with capacitor C_1, provides a time-constant which gives the maximum sustain period (about 4s with the value shown for C_1). Resistor R_2 is included to reduce this maximum period to a practical value, determined mainly by the time-constant of R_2 and C_1. The time-constant is given by:

$$t = C_1R_2,$$

where t is in seconds.

For more details of the device contact Mullard Ltd, at: Mullard House, Torrington Place, London WC1E 7HD.

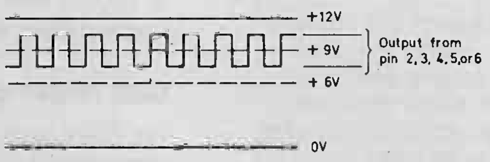


Fig. 5. Output signal from pin 2, 3, 4, 5 or 6.

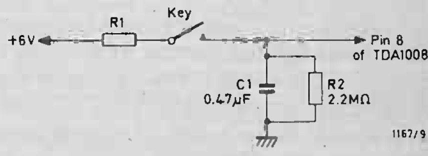
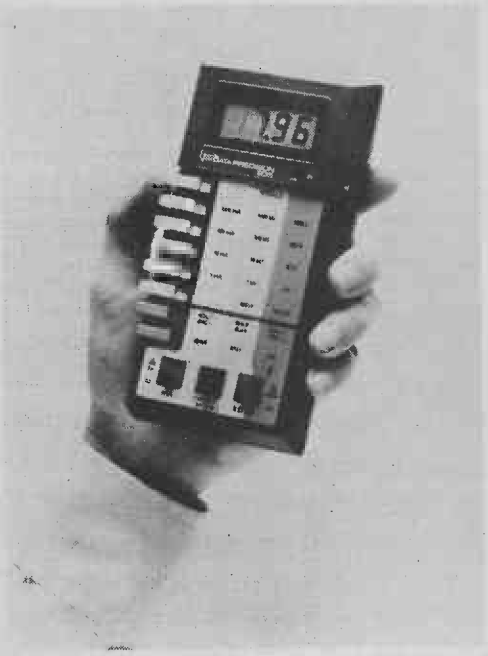


Fig. 6. Sustain circuit.

Tone output pin	Key input pin 8	9	10	11	12
2	f_{in}	$f_{in}/2$	$f_{in}/4$	$f_{in}/8$	$f_{in}/16$
3	$f_{in}/2$	$f_{in}/4$	$f_{in}/8$	$f_{in}/16$	$f_{in}/32$
4	$f_{in}/4$	$f_{in}/8$	$f_{in}/16$	$f_{in}/32$	$f_{in}/64$
5	$f_{in}/8$	$f_{in}/16$	$f_{in}/32$	$f_{in}/64$	$f_{in}/128$
6	$f_{in}/16$	$f_{in}/32$	$f_{in}/64$	$f_{in}/128$	$f_{in}/256$

TDA1008 Truth Table.

........news digest.......



LCD MULTIMETER

It's a fair bet that 1979 will see the digital multimeter make it's long awaited debut into the amateur market. It's true that one or two examples have appeared in the low price bracket, but have rarely been as good as an analogue meter of the same price. Data Precision hope to change all that with the introduction of their model 935. It features a 3½ digit LCD display with a claimed 0.1% basic accuracy. The unit has 29 ranges selectable by what the manufacturers call 'ergonomically designed' push-button switches. The device is fully protected over current and voltage and short duration high viltage transients. A standard 9V alkaline battery (PP9) should give over 200 hours of useful life, battery and over current fuses are accessible through a removable hatch, a replacement fuse is also located under the hatch.

Optional extras include high voltage, current and temperature probes, the case is claimed to be virtually unbreakable and it's small size puts it into the truely 'pocket size' class. Price is around the £99 plus VAT mark and includes leads, battery and instruction manual. If you're interested Franell International Instruments Ltd at Dandbeck Way, Wetherby, West Yorkshire, should be able to help.

BOOK CORNER

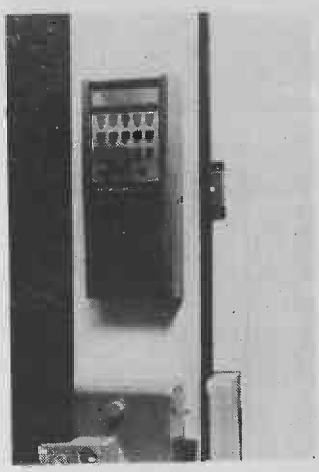
A couple of new books from Babani have just arrived, the first is called Practical Electronic Calculations and Formulae. Just crammed with all those obscure and elusive equations you'll probably only need once, but can never find (it's got plenty of the more mundane ones too). Definitely one for the workshop bookshelf. Order number is: BP 53 and it costs £2.25.

The second new publication is 'Your Electronic Calculator and your Money', the book, although well written (both books are written by F. A. Wilson) is just a trifle outdated, especially in these days of pre-packaged software for MPU systems. But for the confirmed calculator addict, particularly one who can't afford an MPU this book is a veritable mine of information. It shows in detail calculations for mortgages, profit and loss etc, all of which can be carried out on the most rudimentary of machines. Order code is BP 54 and it will retail for £1.35.

GATES ON YOUR DOORS

Two interesting devices to grace your front door have been announced by Optimisation Ltd (45 South Street, Bishops Stortford, Herts). The first is the 'Door Guard', a calculator sized, fifteen digit keyboard. A caller is required to enter a three digit number whereupon a chime will sound. Should an incorrect number be pressed a piercing 96 dB siren will start, enough to deter even the most determined intruder. There are 2730 user pre-settable combinations, so the chances of a 'lucky guess' are almost negligable.

Another useful feature is the possibility of using the Door Guard for signalling departures, a good idea if there are children about. The device should be on sale by the time you read this, asking price — £14.95, installation should take only minutes and is powered by a 9V alkaline battery, with average use it will last for over one year.



COMP-U-LOCK

The second piece of equipment rejoices under the name of COMP-U-LOCK. As it's name suggests this is a digital door lock, requiring a four digit combination to be entered on a small waterproof key-pad strategically placed on your front door. Included in the kit is an electric door latch, a transformer for mains operation and a battery pack for back-up in the case of a power cut. We just hope that potential users do not forget their combinations, (numbers we hasten to add) because there are over 10 000 possible sequences to try if you are locked out.

YOUR FLEXIBLE FRIEND

Flexible printed circuit boards have been around for some years now, so what's new? Well the one shown is the first to meet stringent new British Standard specifications. Welwyn the resistor people are the first British company to meet with BS 9765 approval. Flexible PCBs offer several advantages over conventional SRBP or glass fibre boards, they are lighter, smaller and allow better heat dissipation and are particularly suitable for wiring loom applications.

microfile

Microfile this month has been taken over by Henry Budget, (editorial assistant of Computing Today) during Gary Evans absence.

A slight case of sunstroke

COMMODORE, THOSE WONDERFUL people who gave you a PET, have just taken a great step forward in the true American tradition. Rather than going to the moon they have headed for the Sun. A new solar powered industrial complex has been built in Silicon Valley at Santa Clara and they are moving in. The building was constructed with the help of the United States ERDA and is the first to get a 'solar grant.' The design was chosen out of 80 applications from 35 states.

In the 60 000 sq ft Commodore will house their headquarters, the LED and LCD production line, Pet and KIM assembly and warehousing space. The boffins reckon that 90% of all heating requirements will be met by the 6000 sq ft of roof mounted solar panels and a further 3000 sq ft of passive collectors. By using this little lot as a giant heatsink the building will be kept cool in summer and warm in winter . . .

Two views of the new Commodore plant in Silicon Valley. The picture on the right shows some of the roof-top solar panels used for heating.

Also from Commodore I have just heard the current UK sales figures for the PET. They are selling at 200 a week, with about 10% going to the hobby end of the market — that's about 13000 quid a week. (Who said hobbyists were poor?) Commodore reckon that they are holding up well against the competition as well . . .

The Videomaster Chess Champion, the level of play can be altered to suit your prowess, but be prepared for some slow games on the high levels.

We had a new chess player through the office last week micro based of course, and it nearly bored one of our staff to death. He decided to play it on level 5 and the machine took nearly six hours to make four moves. The device is the new Chess Champion from Videomaster and can cater for up to six levels so we may never see our colleague again if he tries that one . . .

The machine actually plays a very good game of chess and the response time is a good indication of the amount of thought that the program is putting in to each move. For the average player Level 1 or 2 will provide a reasonable game, Level 6 is strictly for the budding Grand Master . . .

Teletext comes home at last

On the subject of micro's — the faithful old 6800 is about to appear in a new home machine, with an added plus. The Liverpool based firm of Technalogics is producing a system that includes full Teletext decoding, allowing you to store information off-line and also to use the full graphics capabilities when running your own programs. The unit is configured for easy expansion and they hope to gain PO approval to connect to Prestel in the not too distant future. The cost of all this is only about £450 for a basic system and I hope to go and see one in the next couple of weeks. A full report will be published in Computing Today if I can get my hands on one.

Is it, will it . . .?

BUZZ! Down the grapevine came some news of the long awaited Texas micro. Allegedly it will be a 16 bit machine running PASCAL as the main language and a possible date of arrival is June. The last time I spoke to anyone from Texas the reply was 'No Comment' so we will just have to wait and see . . .

Club round-up

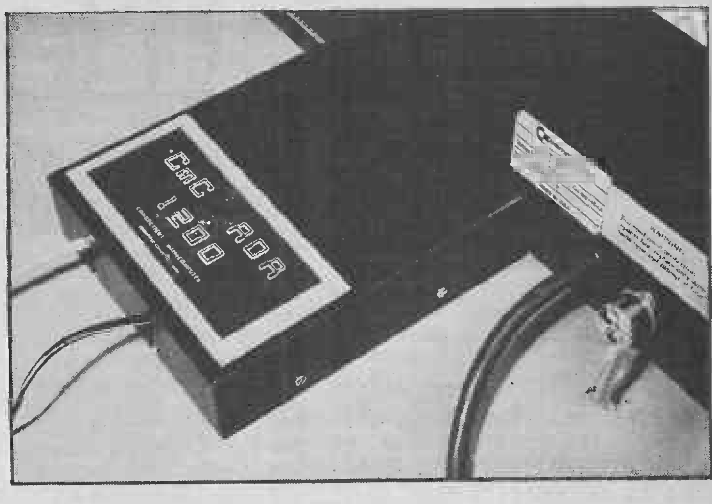
We have been getting news from around the country about computing clubs. A couple of recently formed ones have asked me to give a quick plug. This is a service we delight in performing so please keep the information coming in.

The Bristol Computing Club now meets regularly on the third Wednesday of each month and further information may be obtained from the Chairman, Mr L. Wallace, 6 Kilbernie Road, Bridge Farm Estate, Bristol BS14 0HY. Another new club is the Hull and District TRS 80 Users club. They will be meeting on the second Tuesday of each month and you can write for further information to the Chairman, Mr F. Brown, 421 Endike Lane, Hull, Yorkshire HU6 8AG.

Many thanks to the East London Branch of the ACC for the notice about their third meeting. They meet at the Harrow Green Library in Cathall Road, Leytonstone on the third Tuesday of each month between 7 and 10pm. Your contact here is Jim Turner at 63 Millais Road, London E11. Please note that when you write to these or any other club we may have mentioned in the past it will greatly help them if you enclose an SAE.

Connect your pet to better things

I've just received an interface adapter for the PET that should provide a solution to the problem of getting printout. The device is a CMC ADA 1200, such a lovely name, and has been announced by Petsoft in conjunction with their CMC Word Processor. It arrives in a small case that plugs directly onto the IEEE-488 bus port and will drive any RS232 device such as a printer. The unit comes complete with an encapsulated power supply and can be preset to any Baud rate from 110 to 9600 which makes it suitable for any printer around. The parity and stop bits are settable on a DIL switch to your own needs. The output port can be called direct from BASIC to give program listings or result output from calculations etc. The main use however is that it is directly accessed from the word processor package and will give you the basis of a small office package to handle letters and documents. The cost of the Word Processor program is £25 and the interface adaptor is going to set you back about £90 . . .



Another odd-on for PET, this time an interface adapter for a printer.

The BBC and ETI show.

We've had more than our fair share of dealings with the Beeb this month. First the bad bit, we wish to categorically state that the so-called spelling error shown on 'Thats Life,' was deliberate. Honest. Did you see that recent episode of 'Blakes Seven', our old friend Tolinka, the chess displaying MPU based devices was used for a game of speed-chess. The BBC recently got in touch with us with a view to using yet another of our past projects Twonky, the musical MPU as the basis for some theme music for a new childrens series. Alack and alas the programme was hit by industrial action, so Twonkys golden moment will have to wait. ETI

HEADPHONE AMPLIFIER

Here's a project for the true hi-fi enthusiast, or for the guy who simply likes to 'listen in silence'.

A HEADPHONE AMPLIFIER is a gadget for the true hi-fi stereo enthusiast. It is a low-distortion wide-band low-power amplifier, without built-in tone controls. It lets its owner hear signals virtually 'as recorded', with none of the usual problems from 'processing' distortion, or from room acoustics. Equally important, it lets its owner listen to recordings at full orchestral levels without upsetting the neighbours or causing the pet budgie to shed its feathers.

The ETI headphone amplifier has a couple of special features. It has a low-noise RIAA-equalised preamplifier built into each channel, so it can accept input signals directly from a phono pick-up. It can switch-select either phono, tape, or tuner inputs, and can drive up to four sets of 8 ohm headsets simultaneously at total power levels up to a few hundred milliwatts. The unit can thus be used for both individual and group listening.

Each 'phone output channel of the amplifier has a source impedance of 10 ohms. This impedance provides each 'phone with good damping and transient response, and at the same time makes each output immune to short-circuit damage. The available power at each output is sufficient to drive the ear drums of a 'phone user to the threshold of pain when using a decent 8 ohm headset; you can't ask more than that.

Construction

All of the units electronics components, including the mains transformer, are mounted on a single PCB. The layout is quite compact, so extra care needs to be taken over the construction, particularly with regard to the polarities of semiconductor devices and electrolytic capacitors.

We fitted our prototype unit in a fairly tight-fitting Verobox, and used a 6-way DIN connector for the inputs, rather than the six individual connectors shown in the circuit diagram. Note that screened lead must be used to connect the two phono inputs to the input of the preamplifiers.

When construction is complete, set RV2 and RV3 to minimum resistance, insert a DC current meter in series with the test point of the Right channel, and switch the unit on. Check that the unit is functional, and then adjust RV2 so that the meter reads a quiescent current of 15 mA. Repeat the procedure for the Left channel, using RV3 to set the 15 mA quiescent current, and remembering to fit links across the test points after the meter is removed. The unit is then complete and ready for use. Good listening. ▶

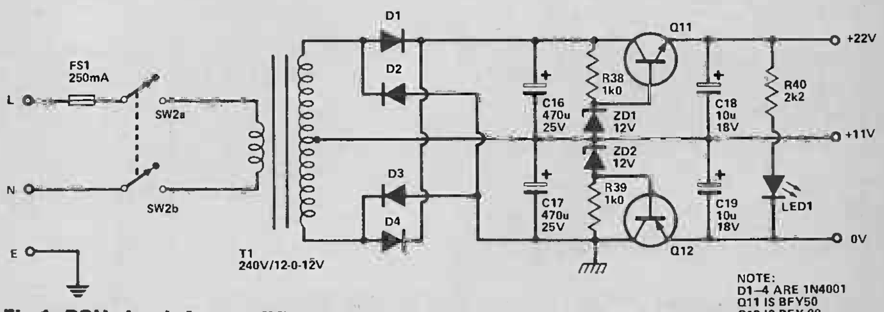


Fig 1. PSU circuit for amplifier.

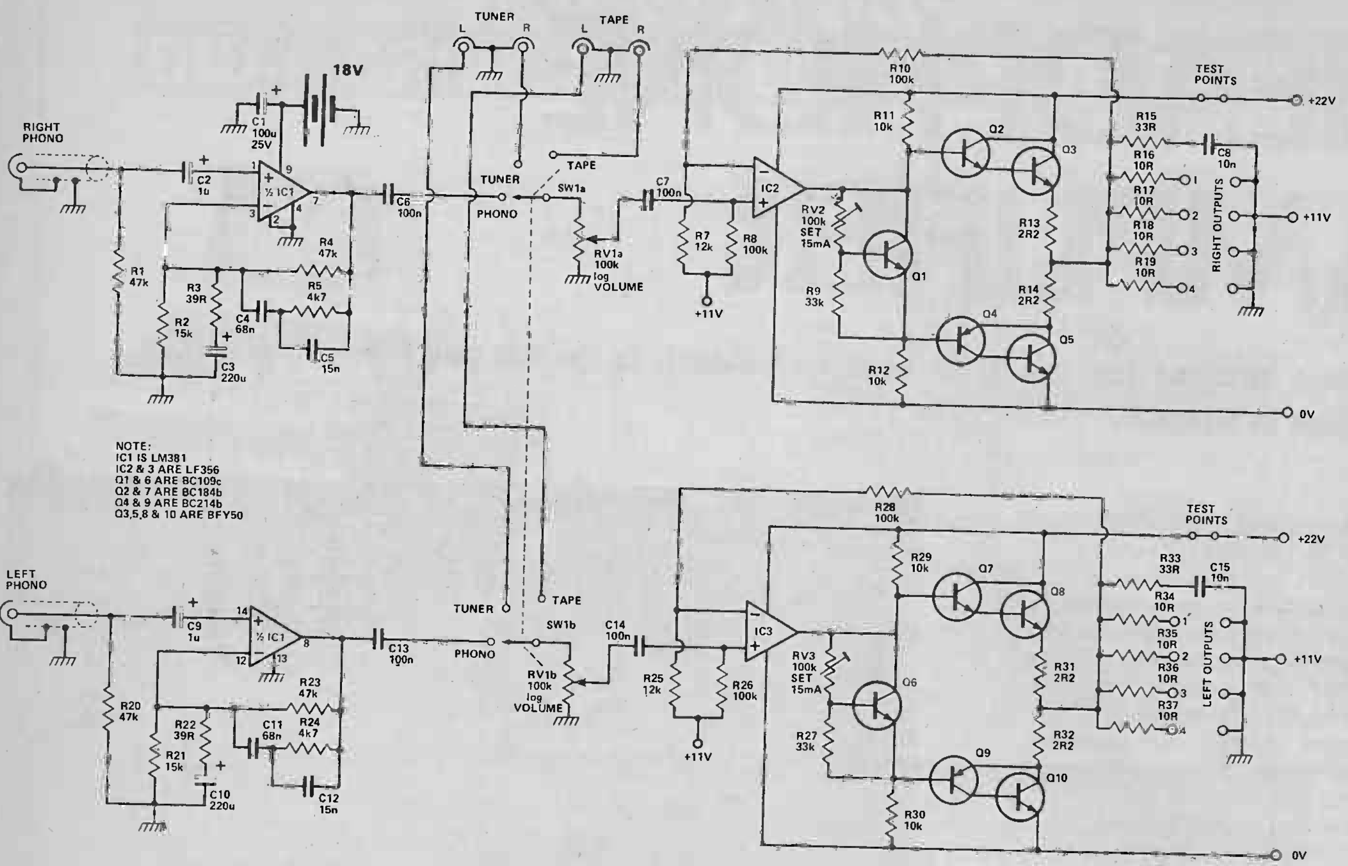


Fig 2. Main circuit. Note that R6 replaces the 18V battery if the pre-amp is mains powered.

HOW IT WORKS

The ETI Headphone Amplifier uses two identical amplifier channels, each comprising an RIAA-equalised preamplifier, an input-selection switch and a volume control, and a main amplifier stage. The design uses two mains-derived stabilised power lines, which are fed to each of the two channels.

Each pre amplifier stage is designed around one half of an LM381 low-noise dual preamplifier IC. In the Right channel, R1 matches the preamp input impedance to that of a standard magnetic pick-up, R2 and R4 set the quiescent output of the pre amplifier at approximately half-supply voltage, and R3 to R5 and C3 to C5 serve as the RIAA equalisation network. The preamplifier stage has a voltage gain of about 41 dB at 1 kHz, and gives an output of about 600 mV from a 5 mV input at this frequency.

Input signals to the main amplifier stage are derived from either the preamplifier output or the tape or tuner inputs via switch SW1 and volume control RV1. The amplifiers are standard class-AB types, with voltage gains of about ten. In the Right channel, the voltage gain is determined by R7 and R10. The quiescent current of the output transistor stages (Q3 and Q5) are controlled by 'amplified diode' transistor Q1, and are adjustable via RV2. Outputs are fed to each channel of each headset via a 10 ohm limiting resistor: R15 and C8 act as a Zobel network across the output, and enhance circuit stability.

Note that the op-amp used in each main amplifier stage is an LF356 high slew-rate type, which enables the amplifier to give a good high-frequency performance. Also note that the input and outputs of the amplifier are referenced to the 11 volt 'half supply' power line, and not to the zero volts grounded line.

The two power supply lines are derived from the mains via 12 V — 0 — 12 V step-down transformer T1. Each output is controlled by a series-pass transistor and zener diode regulator network. The nominal output voltages of the lines are 11 V and 22 V. The zero-volts line is grounded.

BUYLINES

The only component that may be difficult to find is the LF356 FET op-amp.

Marshall's can supply this IC.

PARTS LIST

RESISTORS

R1,4,20,23	47k
R2,21	15k
R3,22	39R
R5,24	4k7
R6	390R
R7,25	12k
R8,10,26,28	100k
R9,27	33k
R11,12,29,30	10k
R13,14,31,32	2R2
R15,33	33R
R16,17,18,19, 34,35,36,37	10R
R38,39	1k
R40	2k2

POTENTIOMETER

RV1	dual 100k
RV2,3	100k sub-min preset

CAPACITORS

C1	100μ, 25V
C2,9	1μ

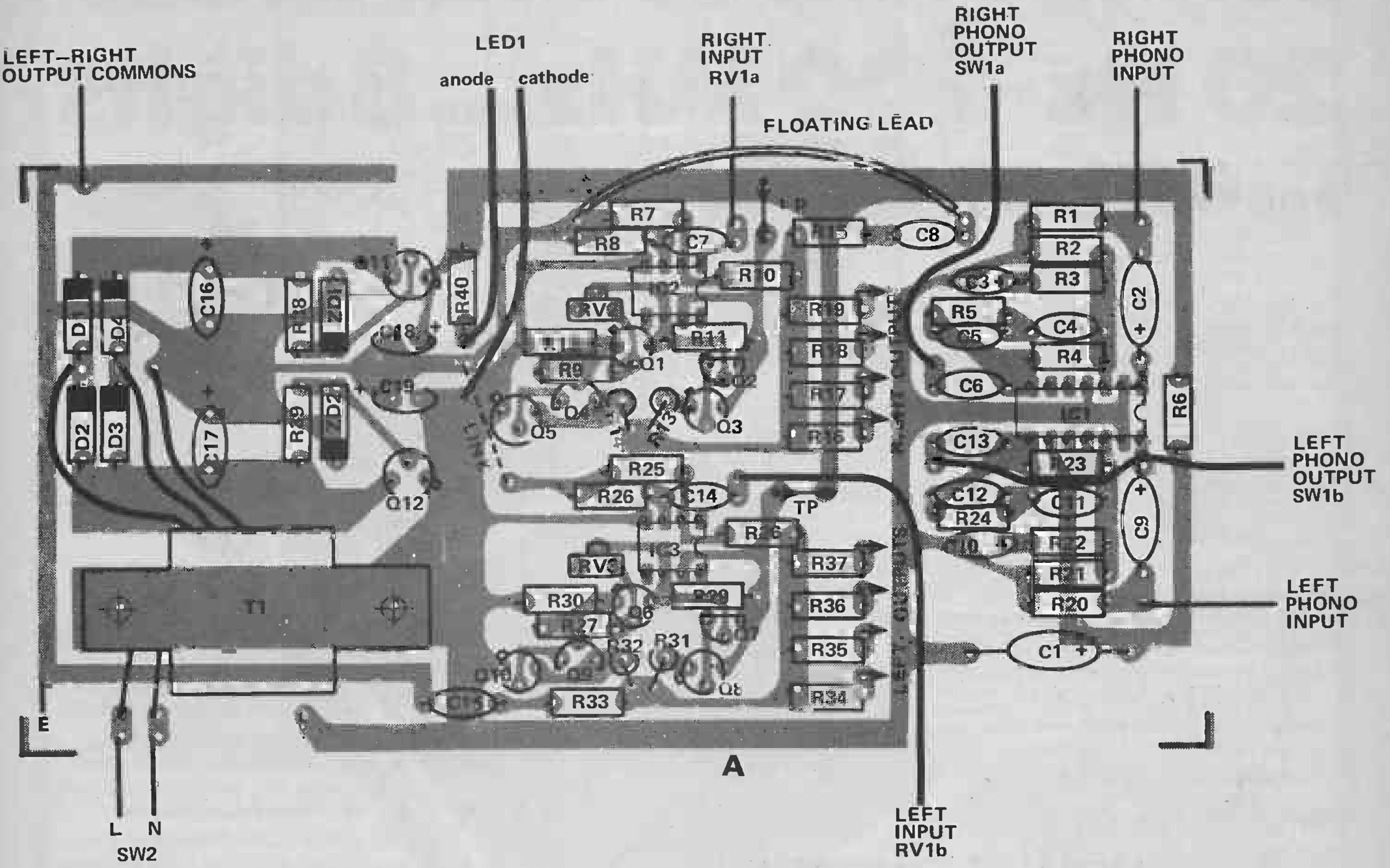
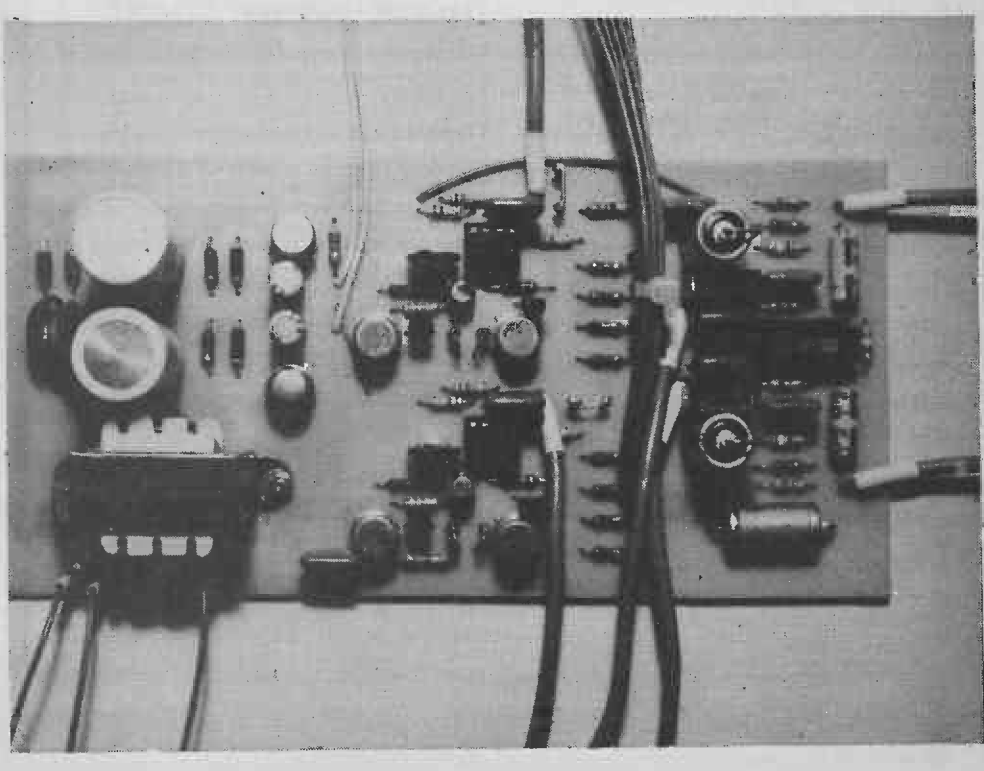


Fig 3. Component Overlay for the headphone amplifier with R6 in place to mains power the pre-amp. A lower noise figure can be obtained by battery powering the pre-amp. Connect the battery as shown in the circuit, and break the track at point A, Remove R6 from overlay.

C3,10	220µ
C4,11	68n
C5,12	15n
C6,7,13,14	100n
C8,15	10n
C16,17	470µ, 25V
C18,19	10µ, 18V
SEMICONDUCTORS	
IC1	LM381
IC2,3	LF356
Q1,6	BC109C
Q2,7	BC184B
Q4,9	BC214B
Q3,5,8,10,11	BFY50
Q12	BFX88
D1,2,3,4	IN4001
ZD1,2	12V zener
LED1	standard 0.2"
MISCELLANEOUS	
SW1	2-pole 3-way
SW2	DPDT
T1	12-0-12V, 100mA

Fuseholder and 250mA fuse connectors and case to suit.



STANDING WAVES

A standing wave has nothing to do with goodbyes on railway stations, but they could just be responsible for the poor quality of 'Crossroads'.

YOU KEEP COMING across that phrase, don't you, and it seems a bit daft. Waves wave, after all, they don't stand about. Or do they? Depends how you look at it and what you're looking at.

Pick a wave, any wave, radiating off an aerial into space. When this happens, the wave is radiating out from the aerial in all directions. The wave is an electromagnetic wave but since we only usually detect the electric part we can forget about the magnetic part for the moment. Let's just remind ourselves of what a wave like this is and does.

Equating With The Problem

A radiated wave of this type is a travelling wave. If we intercept it with an aerial attached to a sensitive oscilloscope what we would see on the screen (Fig. 1) would be the familiar sine wave trace, so that we could measure the time between peaks of the wave. This time between peaks is called the period or periodic time (T) of the wave, and is the quantity we measure by making use of the calibrated time base of the oscilloscope. This time period is related to the frequency of the wave: f=1/T with T in uS frequency f is in MHz. For example: if the period is 0.4 uS, then the frequency is 1/0.4 =2.5 MHz.

The wave is travelling, though, so that places a distance apart will get a different phase of wave. In the drawing, of Fig. 2, A will receive a peak of the wave earlier than B, simply because A is nearer the transmitter. The distance between two places which receive peaks which are just 360° out of phase is the distance we call the wavelength.

In the time of one complete cycle, the wavelength is the distance that a wavepeak travels, so that the speed of the wave is simply frequency wavelength. For an electromagnetic wave (radio wave) in space, the speed is a constant 300 million metres per second (3×10^8m/S), so that this is the quantity equal to frequency × wavelength. For a 1 MHz wave, the wavelength is $3\times10^8/1\times10^6=300$m.

For a 1000 MHz wave, though, the wavelength is just $3\times10^8/10^9=0.3$m — hence the alternative title of 300 mm wave. This frequency × wavelength business applies also to sound waves, incidentally, except that sound waves crawl along a lot slower, about 330 m/S. A 1 kHz sound

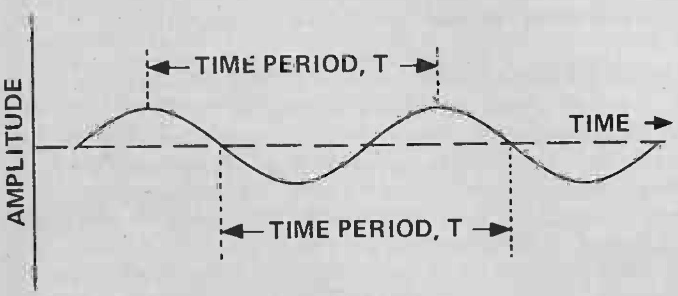


Fig. 1. Time period. This can be measured between neighbouring peaks or from one zero-crossing to the next-but-one, as shown.

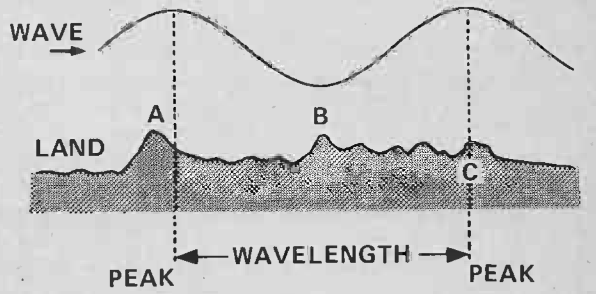


Fig. 2. Wavelength. Imagine the wavepeaks moving from left to right. At the instant shown, a peak is at point A, and a trough at point B, but the previous peak has reached point C. The distance between points A and C is one wavelength of this wave.

has a wavelength of 330/1000 metres, which is only 330 mm, almost the same as a 1000 MHz radio wave.

If we're in the business of beaming waves into space or testing loudspeakers in open fields, this is as much as we need to know about waves, but we find nearly always that there's some reflections around. Now the effect of a wave reflection meeting a wave is the same as the effect of two waves meeting each other — if the wave and the reflection are in phase, then the result is a large amplitude wave, if they are out of phase the result is a reduced wave. We can expect to find some variations in wave amplitude, then, if a wave meets its own reflection.

Reflecting On The Problem

The easiest example to sort out is when a wave meets a reflection of the same size travelling in the opposite direction. Now the mathematicians can do this without drawings, simply by fiddling with equations, and those of us who play with programmable calculators can sort it out that way — the fortunate owners of computers can watch the whole thing — play it out in slow motion. We have to do it the hard way — using imagination with the help of a few drawings. Fig. 3a shows a forward moving wave meeting a reflection — it's a diagram frozen at an instant in time because what is plotted is wave amplitude against *distance*. Fig. 3b shows the same picture an instant later, both waves have moved an identical distance in their opposite directions. A few more stills from this exclusive movie, and we begin to see glimmerings of something interesting. The combination of the forward wave and its reflection travelling in the opposite direction has produced a new wave pattern. At some points along this pattern, there is always complete cancellation — the forward wave and the reflected wave are always in antiphase so that there is no signal at this place — ever. At other places there are varying amounts of signal right up to a whopping great peak whose amplitude is about twice as much as either of the travelling waves. This pattern is what we call a standing wave (Fig. 4) — there is still a wave present, because a graph of voltage ▶

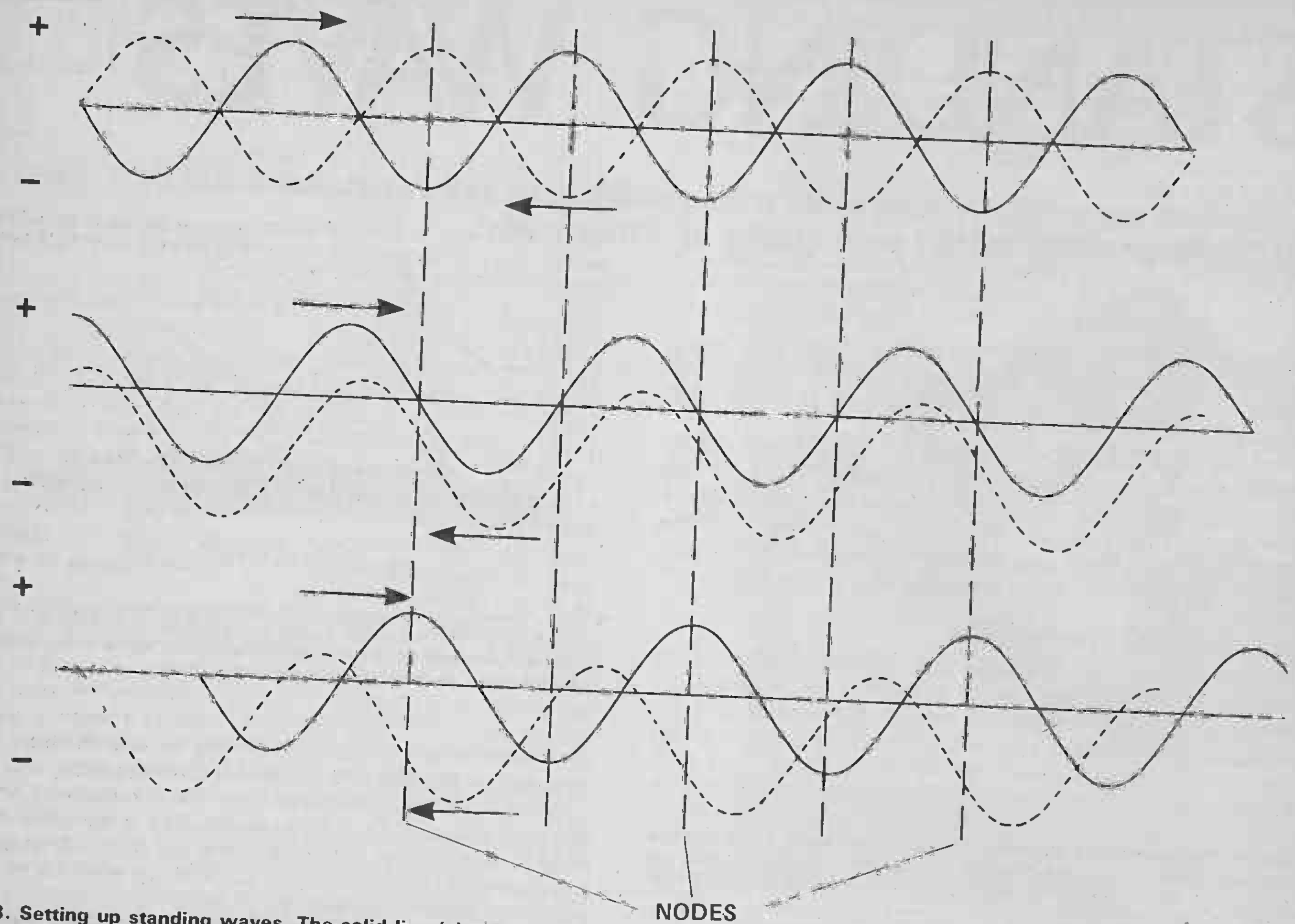


Fig. 3. Setting up standing waves. The solid line (a) represents a wave moving from left to right, the dotted line represents its reflection moving in the opposite direction. At (b), each wave has moved about ¼ cycle, and at (c) ½ cycle along in its own direction. The positions where the waves cancel (because they are equal and opposite, or both zero) remain fixed though. These positions are called nodes.

plotted against time shows a wave, but there's no movement of phase. In any standing (or stationary) wave like this there will be nodes — places where there's no wave signal at all — which are half a wavelength apart and antinodes — where there's a maximum wave signal — which are also half a wavelength apart but out of phase with the nodes.

The Effect On You

What's in it for us? Quite a lot, whether you dabble with high frequency signals or with loudspeaker cabinets. Standing waves have a lot of influence whenever a wave can be reflected. For example, there are places where UHF TV reception is terrible. Shifting the aerial slightly, though, makes the world of difference. Why? Because we're sitting in the middle of a standing wave pattern, that's why. Place your aerial at a node and you can forget about Kojak. Shift it by just half a wavelength, and yours is the strongest signal around. At 500 MHz, half a wavelength is just 300mm — not very far to shift.

How To Find Them

Standing waves can exist on a wire as well. One of the old classic methods of measuring the wavelength of a high-frequency radio oscillator is called Lecher Lines. The Lecher lines are two parallel metal bars of thick wires which are connected to the oscillator output. A shorting bar is fitted with a detector, which might be a neon lamp (for high voltage signals) a small lamp-bulb (for low voltage signals) or a diode/meter circuit Sliding the bar along the lines (Fig. 5) results in the detector indicating points of no signal, the nodes; and points of maximum signal, the antinodes. The distance between two neighbouring nodes, or two neighbouring antinodes, can be measured — this distance is half a wavelength.

The wavelength of a sound wave can be measured in the same way. One classic method of measuring the wavelength of a sound along a pipe was to sprinkle powder on the pipe. When the sound wave set up standing waves, the powder would gather into piles at the nodes of the standing waves, and spray away from the antinodes, so that the half-wave distance between nodes could be measured. It's equally easy to measure the wavelength of standing waves in a room by moving a microphone attached to an AC voltmeter and noting the position of nodes — once again the distance between two neighbouring nodes is equal to half a wavelength.

Leaving Loose Ends

If a length of coaxial cables connected to a circuit is left either open circuit or short circuit, standing waves can be set up in it, with a node at the short circuit or an antinode at the open circuit end. If the length of the cable is just right, that's fine. If it's not, then signals will reflect to and from along the cable, arriving at the circuit and with a time delay equal to the time taken to travel along the cable and back. Because of this effect, we seldom cut cables to a length which will permit standing waves — instead we terminate each end of the cable in a resistance value which will prevent reflections — this value of resistance has to be equal to a quantity called the characteristic impedance of the cable (calculated from the inductance and capacitance per metre of cable). With an open or shorted cable, on your telly, you can expect to see 'ghost' images — several edges to each object.

Advantages And Disadvantages

We do, however, encourage standing waves in aerials. TV and FM aerials are cut to a total of half a wavelength so that a standing wave is set up on them. This allows us to do two things which would not otherwise be possible. One is to extract the maximum energy from the signal — the aerial responds like a tuned circuit to the correct wavelength; the other is to match the aerial to its cable. At one end of a half wave aerial we have an antinode — maximum wave amplitude. At this point we have maximum voltage, but no current. At the centre of the aerial there is a node — zero voltage but maximum current. We can select a point along the aerial to connect the cable so that the ratio of voltage to current is just right — 75 ohms for most coaxial cables, and

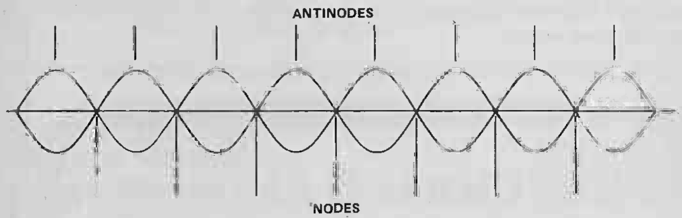


Fig. 4. Representing a standing wave. The standing wave has the same wavelength as the moving waves which cause it, but the nodes and antinodes are at fixed points, quarter of a wavelength apart from one another.

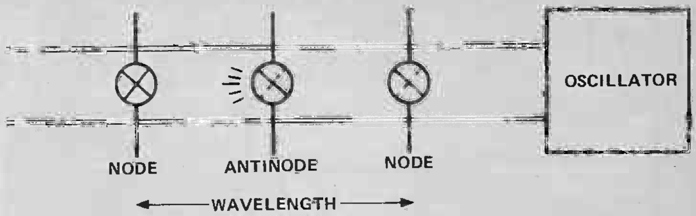


Fig. 5. Using Lecher lines. A high-frequency oscillator attached to parallel wires can display standing waves, using a small light bulb to detect the positions of nodes and antinodes.

in this position there will be the maximum transfer of signal from the aerial to the cable.

At the tuner, standing waves create another sort of problem — the problem of how to earth conductors. Earth one point of a conductor and there will be a node at that point — but there will also be an antinode (maximum signal) just ¼ wavelength away. The result is that earthing, a conductor may have just the opposite of the effect you expect unless you earth at just the right place. Move any of the conductors in a tuner, and you disturb the standing wave pattern — even a dent in the metal case of a UHF tuner can make a difference.

It's not always such a happy story. The greatest difficulties with standing waves arise when we try to design a loudspeaker cabinet. Each solid surface and cracks or gaps will behave as a short circuit or an open circuit respectively. A loudspeaker cabinet will be a mess of standing waves, therefore, unless we do something to absorb them. The room we use for listening will also have standing waves at some frequencies (depending on its dimensions) and in some directions — this is particularly noticeable in an empty room stripped of all its furniture. All in all, standing waves are all around us — we have to live with them! ETI

CAR IMMOBILISER

Here's a low-cost project that gives your car good protection against joy riders and a drunken driver.

THE ETI AUTOMATIC Immobiliser is an inexpensive but highly original car protection device. It has been designed to prevent a car being driven away by the 'joy rider' type of thief, or by a drunken owner-driver. Major features of the design are lack of circuit complexity, low building costs, and simple installation of the unit in any vehicle.

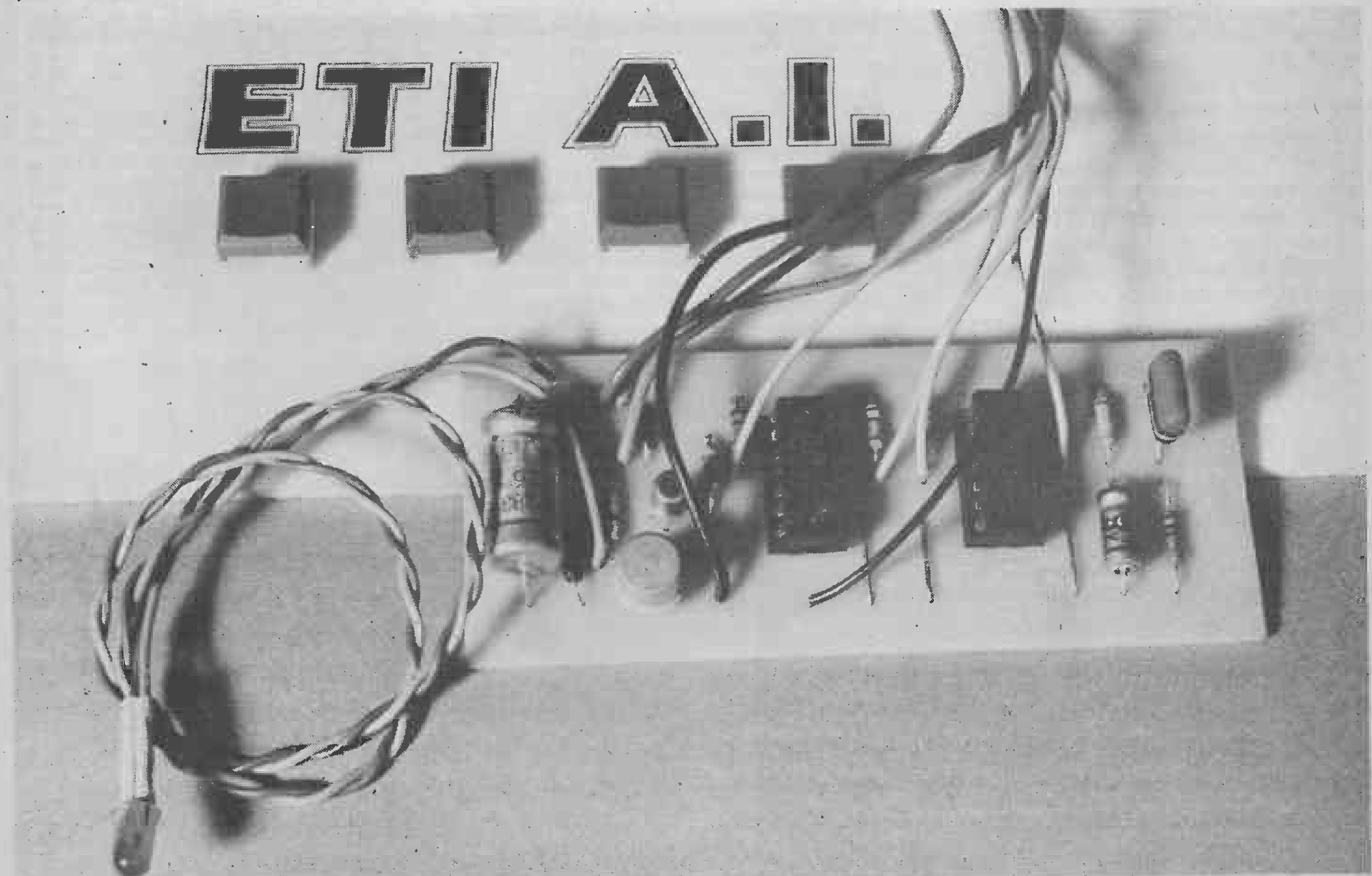
The circuit is designed to immobilise a vehicle's ignition system, by shorting out its contact-breaker points via a pair of relay contacts, as soon as the ignition is turned on. The owner then has five seconds to turn the immobiliser off by sequentially operating a set of four push buttons. If the four buttons are not correctly operated within the five second period, the ignition system remains immobilised and the vehicle's engine cannot be started. The automatic immobiliser timing sequence restarts each time the ignition is turned on.

There are four basic concepts behind the ETI Automatic Immobiliser system. The first of these is that, since the immobiliser activates automatically as soon as the vehicle's ignition is turned on, the vehicle is given a good degree of protection against the drive-away car thief, even if the owner leaves the car doors open and leaves the ignition key in its lock.

The second concept is that a thief entering the vehicle will have no idea of the purpose of the four push-button switches associated with the immobiliser, so these switches can be quite openly displayed on the vehicle's instrument panel, together with a LED that tells its legitimate owner the immobiliser circuit state.

Thirdly, because only five seconds are available to de-activate the immobiliser via the four sequentially-operated switches after first turning the ignition on, the system gives a good deal of protection against the fumble-fingered drunken owner-driver.

The final concept is that, because of the three factors already outlined above, the final circuit does not need to be super-sophisticated or to have an unbreakable 'key' sequence network in order to be highly effective in its functioning. Simplicity and effectiveness are thus the key features in the design of this ETI Automatic Immobiliser unit. ▶



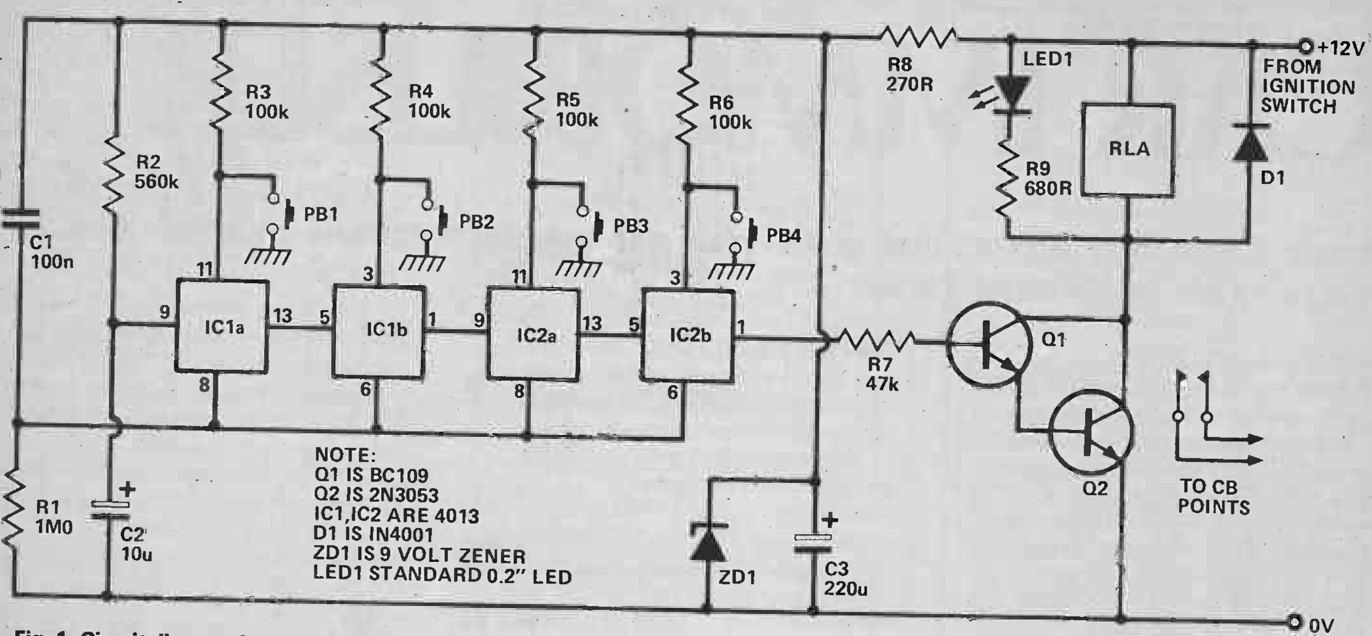


Fig. 1. Circuit diagram for immobiliser.

Construction

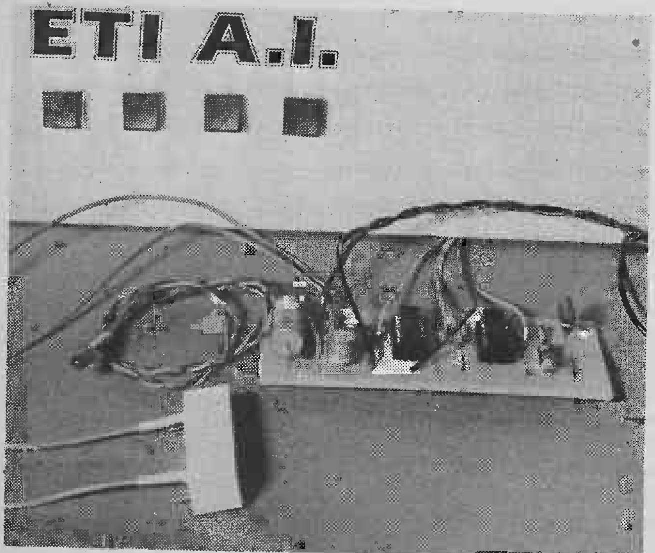
There should be no problems here. The relay can be any 12-volt type with a coil resistance greater than 100 ohms, and with one or more sets of normally-open contacts. The PCB and relay can be fitted in a metal box, or can be simply mounted on an aluminium plate that is screwed to the rear of the vehicle's instrument panel.

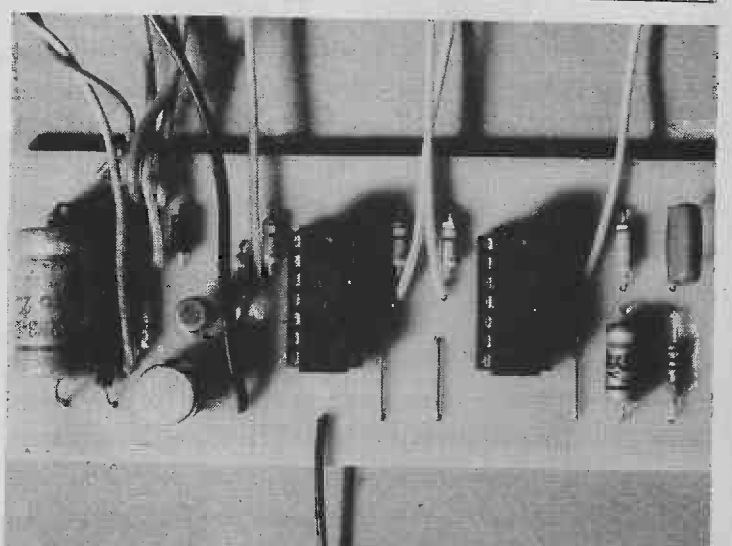
The unit's 12-volt rails must be connected to the vehicle's supply via the ignition switch. The normally-open relay contacts should be connected across the vehicle's contact breaker points. The LED and the four push-buttons can be mounted on the vehicle's instrument panel, either directly or via a screw-on panel. ETI

HOW IT WORKS

The circuit is designed around the 4013 D type flip-flop. It derives its power from the car battery via R8 with stabilization provided by ZD1, C3. The chip features direct set and clear inputs and complementary outputs. Data at the D input is transferred to the outputs on the positive going edge of the clock. The clear inputs are not used in this design and are tied to ground, the set inputs are connected together to the junction of R1, C1. This ensures that on switch-on the flip-flops will start up in the same state and a high level, logic 1, will be present at the output of IC2b. This voltage is fed to the base of Q1 via R7 and will cause the relay to turn on, disabling the car. Q1 and Q2 are connected as a super-alpha pair which effectively produces a super high gain transistor whose gain equals that of Q1 multiplied by Q2. D1 protects the transistors against the back EMF of the relay. System status is indicated by LED1.

To re-enable the system and start the car a logic 'O' must be present at the output of IC2b. This is produced by passing it down the line from the input of IC1a by depressing PB1, 2, 3 and 4 in turn. A novel feature is introduced here. At switch-on C2 is discharged and IC1a will see a low level logic 'O' at its input. This must be transferred to the output by depressing PB1 before the voltage rises above the transition level of the D input as C2 charges via R2. If PB1 is not depressed until about five seconds after switch-on then the junction of R2, C2 will present a logic '1' disabling the system until power is removed and re-applied. To make the system really difficult to beat, resistor, capacitor networks could be inserted between stages.





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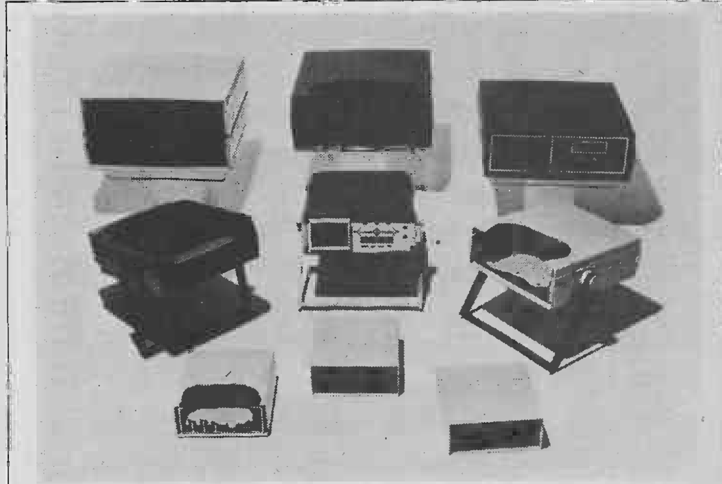
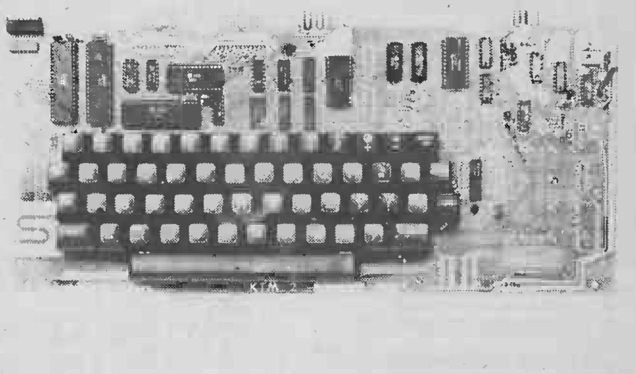


A CASE FOR TREATMENT

Some good looking new boxes from the OK Machine & Tool (UK) Ltd., there are over 25 sizes available with numerous variations to accommodate printers, terminals, clocks etc. Moulded from tough ABS plastic they are all dust and splash-proof. All the cases come in a choice of 3 colours, black, blue, or beige. The range is called 'Pac Tec' and is denoted the C series. OK will be delighted to help you. They live at 48a The Avenue, Southampton, Hants, SO1 2SY.

KEY BAUD?

A new Keyboard Terminal module has just come to our attention, it features all the currently favoured features and will interface with any RS232 computer (SYM-1 etc) up to 9600 Baud. The terminal boasts 128 graphic characters on a 40 character by 24 line format, each character having an 8x8 dot matrix. At £218 it's got to be the bargain of the month as the postage is free. Rostra Electronics can help with any queries — they can be found at: 275-281 aking Street, Hammersmith, London W6.



PARTS LIST

RESISTORS all ¼ watt 5%

R1	1M0
R2	560k
R3, R4, R5, R6	100k
R7	47k
R8	270R
R9	680R

CAPACITORS

C1	100n
C2	10u 16V electrolytic
C3	220u 16V electrolytic

SEMICONDUCTORS

Q1	BC109
Q2	2N3053
IC1, IC2	4013
D1	IN4001
ZD1	BZY88 C9V1 400mW 9 volt zener

MISCELLANEOUS

PB1, PB2, PB3, PB4	push to make pushbutton switches
RLA	12v relay (see text)

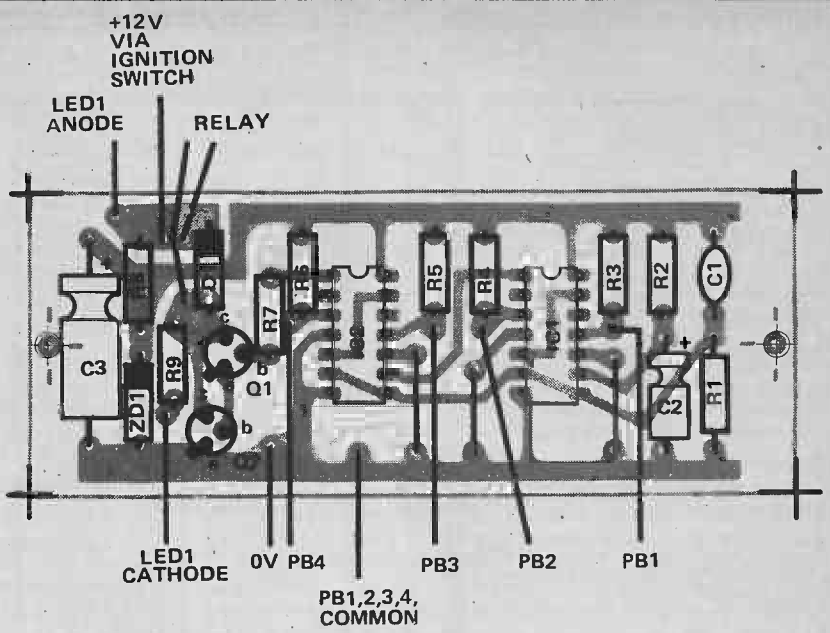


Fig. 2. Component overlay.

BUYLINES

No problems whatsoever with any of the parts for the Car Immobiliser, Maplin and Watford should be able to supply all the parts. The case is very much up to the individual, a strong watertight case however is essential to prevent any 'false alarms' due to ingress of water.

audiophile....................

Not strictly news this month. Views. Readers views. Most of the letters to Audiophile are 'upgrading' enquiries. Most but not all — some of the more interesting appear below, presided over by Ron Harris.

THIS MONTH IT'S over to you. With all the letters that have come in to Audiophile since it began I thought it was about time some of them saw the light of print. The selection is taken over about three months, and I hasten to add that all have been answered prior to this public pondering.

As you can see we get quite a varied mailbag to put it mildly, but still not enough of you are writing (to ETI in general) for our liking. Let's have more feedback please. Mind you the two gentlemen who wrote in to ask who this Felicity Kendal is anyway have *not* been answered. After the sedatives had calmed my outrage, and the expletives died from the air, it was somehow still not possible for me to compose a reply within Home Office rules.

Time has passed, however, and has healed the wounds in passing. (And wounded the heels I hope.). So gentlemen, let me state the obvious in as calm a manner as possible. Felicity Kendal is quite simply the most beautiful woman in the universe. Write it out 1000 times before one more copy of ETI reaches your unworthy hand.

Anyway onto more sonic matters . . . .

BAD START?

Dear Sir,

I own a hi-fi system comprising a Garrard SP25 Mk.5, Goldring G800, and 'home brew' amp and speakers. The loudspeakers are comprised of twin-coned Fane bass units and a pair of EMI drivers for mid and top.

I should like to upgrade this system, and wonder what would be the first thing you'd do?

J. WATERS
FAVERSHAM

Sell It.

●

STEAM VALVE

Dear Sir,

Some time you (ETI) published a series of articles on the subject of valve sound in amplifiers. A friend recently brought these to my notice and it surprised me that an otherwise modern magazine like what ETI is known for should be backing this old-fashioned nostalgic rubbish. Do you really believe that valves sound better than transistors? Of course they can't! Why did we ever change if they do?

I suggest you set yourselves a listening test and then have the courage to publish the results!

W. WITHERS, M.Eng.
PERTH

Hold it a minute mush.
Somewhere amid the prejudices I think you express the opinion that ETI is pro-valve. If this is indeed the message, then it is mistaken. To condemn a whole technology in such sweeping terms, be it valve or transistor, is akin to running down football because the All Blacks beat Liverpool at hockey. (Think about it.)

My own opinion is that the best of the solid state designs give a more accurate representation of the signal than do the top vacuum tube units. Beyond that yer pays yer money and takes yer choice

●

BARK DISTORTION

Dear Sir,

I am writing to tell you (and your readers if you should choose to print this) and the great fun we used to have in the 'Old Days' of hi-fi. My very first gramophone used to use wooden needles, pine I think, which wore out very quickly, but gave (to me) amazing tone. Somehow nowadays it never sounds as good as I remember it being then. Are there any of your "more mature" readers who'd care to correspond with this old'un about the early days? Anyone remember shellac?

F. NEWTON
MANCHESTER

I *can't* resist this:— the pitch in pine sounded fine eh? In apology for that, if any readers care to write to Mr Newton via Audiophile, I will pass on the epistles.

●

EAT YOUR HEART OUT

Dear Sir,

ETI hi-fi reviews!?! How come? Not a bad idea but stop ignoring the budget end of the business. We also play records who stand and drool (at SME's) you know.

Also let's see yer credentials Mr Harris — wots yer reference system? Reveal all and get rid of these evil thoughts telling me it's a wind-up job from Woolies! Keep up the reviews but more radio? It still exists you know.

D. ALEXANDER
LONDON

You keep your hands off my credentials, they've never hurt anyone and are certainly not to be revealed within the pages of ETI. I didn't get where I am today going

around revealing me credentials.

As for reference system that consists of:— Technics SL150 Mk.2, SME 3009 Mk.3, Goldring G900SE Mk.2, Shure V15 Mk.4, Lecson AC1 and AP3 Mk.2, Pioneer TX9500 Mk.2, Celestion Ditton 66 loudspeakers and Sony EL7 Elcaset (for as long as they let me hang onto it!) Occasional use is also made of Ultimo 20 and Coral 777EX moving coil cartridges. The Technics is fitted with a GA Audio glass turntable mat, and for headphones I use Koss Pro 4AAs or ESP10s as the occasion demands. My budgie has a green beak and my plants all died last week.

Revealing enough?

●

QUADRUPLE QUERY

Dear Sir,

Please could you explain some terms I keep reading in hi-fi magazines (including yours) and that no one has ever explained? These are 1) Selectivity 2) Modulus 3) Dynamic Range 4) Musicality.

Also I wish to upgrade my Quad 33/303 set up for more power and would welcome suggestions. Thank you.

H. COHEN
STOKE

Easy ones first. A new amplifier to replace a Quad. Since you give very little information as to speakers, cartridge, room size etc etc I'm gonna have to assume that all you seek is a more powerful version of the same thing! In which case why not try the Quad 405 as a starting point? If this fails to appeal, and funds allow, cast an ear over units by Lecson, Meridian and maybe the Sony VFET designs.

Now to the definitions you requested. Quite a mixed bag this little lot. Ah well here goes:—

1) Selectivity (of tuners):—the ability of the machine to discriminate against signals on adjacent channels (± 200kHz) to the one you're trying to tune to. Good selectivity is a must with sensitive tuners.

2) Modulus:—Presumably you spotted this lying next to the word impedance. Otherwise it must have been a maths book. In literal terms modulus means "size of", ignoring positive and negative aspects. Phase differences can make impedance (resistance to passing a signal) difficult to express simply. Non-mathematically it is best just to regard modulus as meaning 'magnitude of' but remember there is more to it!

Mathematicians please don't write in — $z=x+iy=r\ (\cos\theta+i\sin\theta)$ mod $z=/z/=r=\sqrt{x^2+y^2}$ OK?

3) Dynamic Range:—the difference, in dB, between the softest and loudest sounds reproducible by the hi-fi under discussion. For example a cassette with 20dB of tape noise, and on which compression sets in at 70dB, has a dynamic range of 50dB.

4) Musicality:—oh what a lovely word! Whichever gnomic intellect invented it has my congratulations. The really nice thing about it is that NO-ONE knows what it means! Currently it is employed (I think) to express the amount of 'information retrieval' a system is capable of. Earlier in its history it was simply a word reviewers used to mean 'nice' with exactly the same amount of precision as the word implies. Next week it could be describing how satisfying a crunch is generated in the destruction of a piece of toast. Musical Mothers Pride?

EH?

Dear Sir,

I strongly feel that transient intermodulation distortion and slew rate limiting together with uneven harmonic distribution are the total reason for the so-called 'transistor sound' in modem amplifiers. Do you agree?

M. DAWES
SWANSEA

My answer lies entirely within the negative quadrant of the sphere of communication.

●

ALL AT SEA

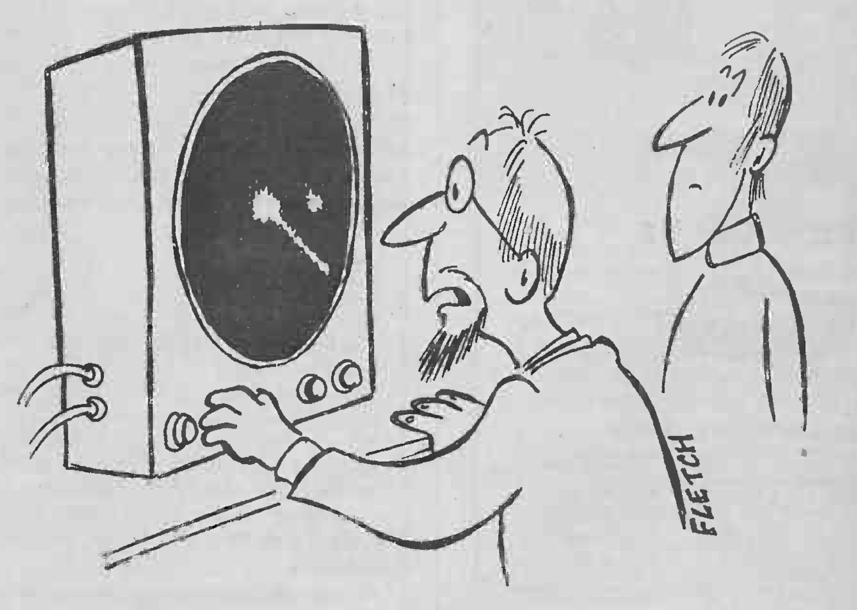
Dear Sir,

As a regular subscriber to ETI, I am writing to express my protest at ETI's hi-fi content. If I wanted to read about hi-fi I would buy hi-fi magazines, God knows there are enough of them.

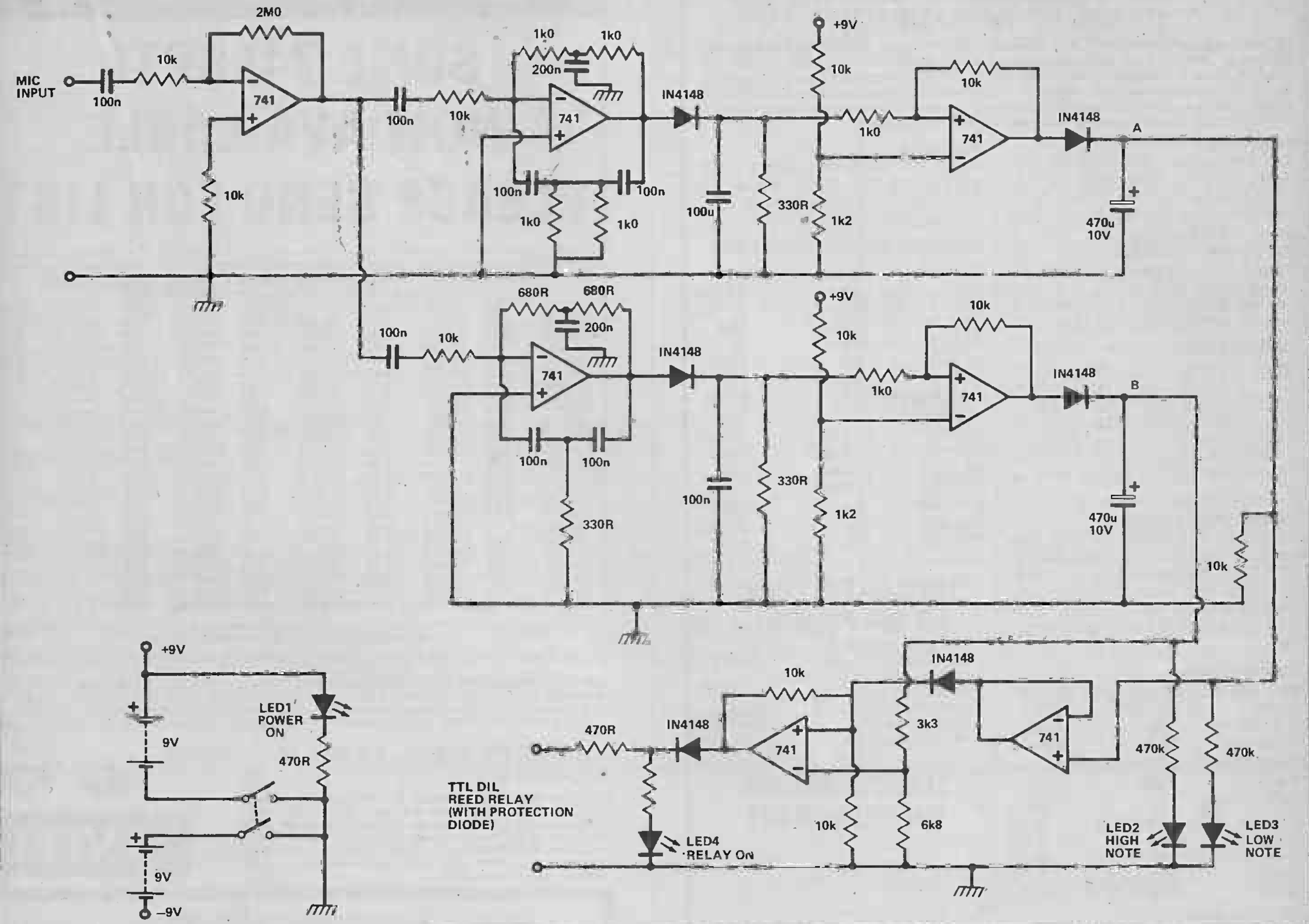
What ETI should be doing is more articles explaining how circuits work, so that your readers can design them themselves. And how about more circuits for us boating enthusiasts?

S. McGREGOR
LONDON

How did you get on this page?



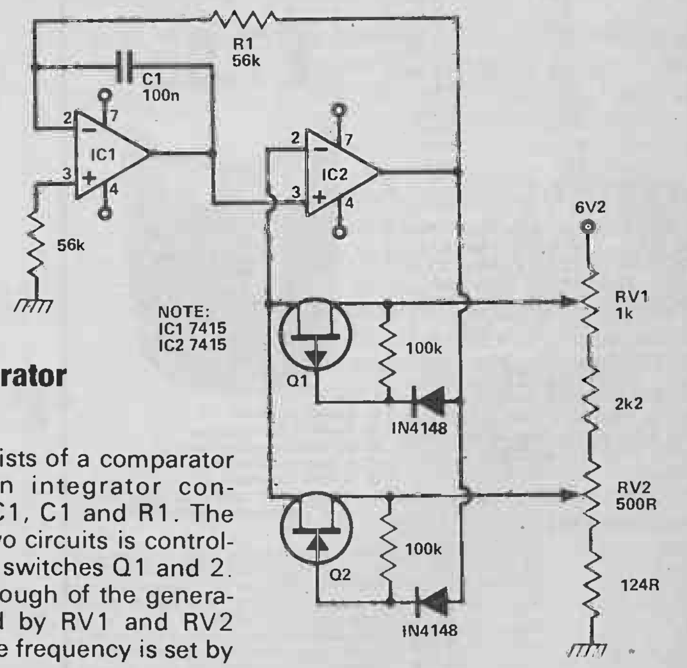
"According to this, there's a submarine approaching through the living room!?"



Whistling Switch
R. C. W. Gate

The circuit acts as a remote control switch, activated by whistling a high note and reset by a low note.

The input from the microphone is amplified by IC1 and then processed by two notch filters. The outputs of these are rectified and smoothed and used to fire the Schmitt trigger constructed from two operational amplifiers, IC's 6 and 7. The output points A and B can be used separately to drive other logic functions provided that if high impedance logic is used a 10 k resistor is placed in parallel with the 470 uF capacitor at these points.

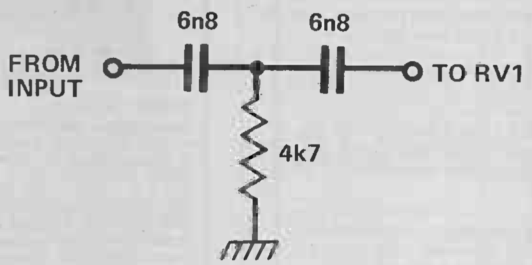


Triangle Generator
R. I. Harrison

The circuit consists of a comparator IC2 driving an integrator constructed from IC1, C1 and R1. The output of the two circuits is controlled by the JFET switches Q1 and 2. The peak and trough of the generator is controlled by RV1 and RV2 respectively. The frequency is set by C1 and R1.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

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, Electronics Today International, 25-27 Oxford St., London W1R 1RF.



Modification to Tape Noise Limiter Feb '79

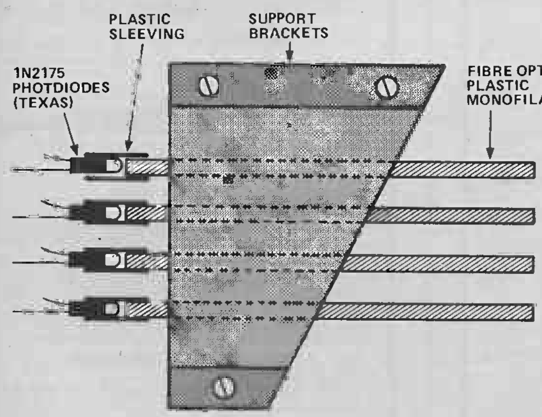
P. Burns

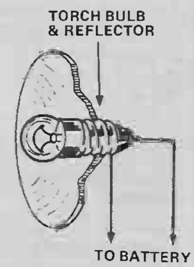
The performance of this unit may be greatly improved by this simple modification. The original circuit assumes that a high level music signal will mask background noise. In reality a high level bass signal will trigger the filter, giving an audible 'whoosh' of noise. This can be alleviated by adding a simple high pass filter to the control circuit. The filter removes signals below 5 kHz, resulting in a cleaner, less breathy, sound. It should be noted that the input impedance of this circuit is only about 3 k and it may be advisable to precede this circuit with an emitter follower.

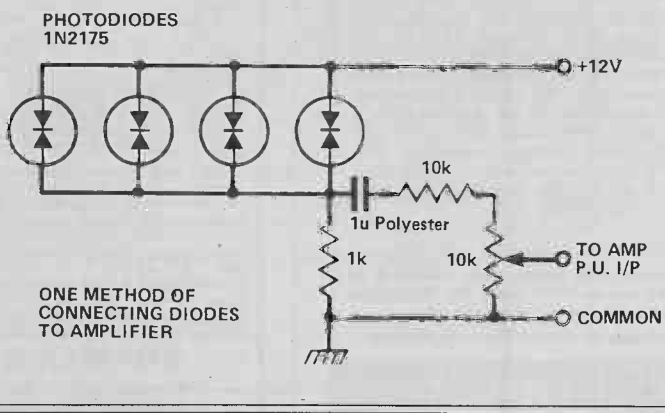
Upgrading Valve Tuners

R. N. Soar

Older valve tuners often use an ECC85 type valve as the RF amplifier-mixer amplifier. The performance of these tuners can be permanently upgraded by using a solid state replacement such as a Fetron. A typical example is the TS12AT7, a plug in replacement for the ECC81/12AT7 range of valves but the performance is almost the same as the ECC85, only the heater connections are different and this does not apply to solid state. The advantages of replacement are that gain never falls off, thermal drift does not occur and performance is generally better. The only disadvantage is that the Fetrons cost several pounds but can be obtained from East Cornwall Components Ltd.





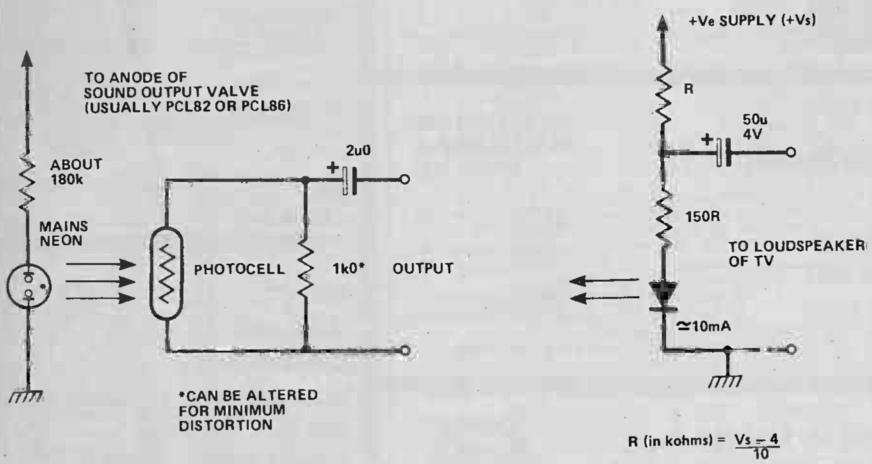


ONE METHOD OF CONNECTING DIODES TO AMPLIFIER

Fibre Optic Bass Guitar

J. Smith.

This item is in effect a simple musical instrument. It consists of a number of short lengths of plastic monofilament fibre optic material arranged in such a way that when a fibre is touched then released it vibrates at its own natural resonant frequency (like a ruler twanged on the edge of a desk). When in a light beam supplied from a torch battery the vibrating end sends sine wave impulsed along the fibre, at the fixed end there is a photodiode which with suitable circuitry feeds a signal to a normal audio amplifier. The sound produced is similar to that obtained using a tea chest, piece of string and Broom handle, remember those days? Thickness of the fibres and length are not critical and it is best to experiment to obtain the sound that pleases the constructor. The fibres need be no longer than about 60m/m. Remember the shorter they are the higher the note produced.



Television Optoisolator

A. P. Hiley

The problem of how to connect a tape recorder, or amplifier, to a television set is not an easy one to solve, because most televisions, having no mains transformer, have the chassis connected directly to the mains. The easiest, and simplest solution is to incorporate some form of optoisolation between the television and the external equipment. This particular design is simple, has a very low noise level, and introduces negligible distortion.

The LED or neon is brightness modulated by the output of the television sound channel. The light is picked up by a small, cheap silicon photocell, placed a fraction of an inch away. A small current is produced, proportional to light intensity, which produces a PD across the load resistor, which is a replica of the original signal.

Telephone Amplifier

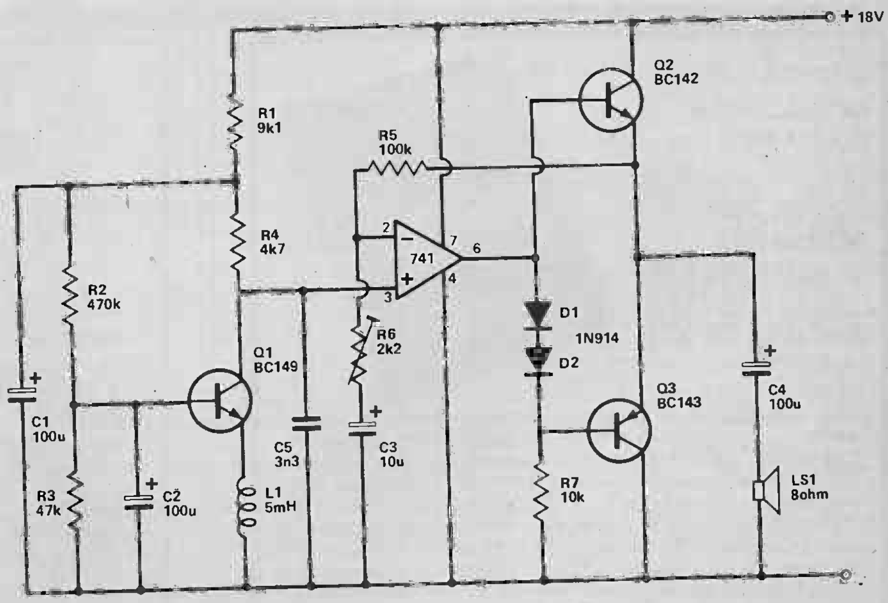
J. P. Macaulay

One of the most frustrating things in life must be to wait in line whilst one's wife converses (nags?) on the phone. What makes the matter worse is that only one side of the conversation is heard. The circuit here will at least enable you to hear what's going on at the other end of the line.

The signals are picked up by the coil L1, a 5 mH RF choke taped to the side of the set. Q1 operates in the common base mode with the output signal appearing across the collector resistor, R4. The output stage consists of two complementary transistors fed from the output of IC1 and included in it's feedback loop.

The gain provided by the IC is made variable by the inclusion of R6 and this should be adjusted for a comfortable output level. D1, D2 in conjunction with R7 provides the small but necessary bias required by the output pair.

The interstage capacitor provides a 13db point in the bass end at 300Hz.

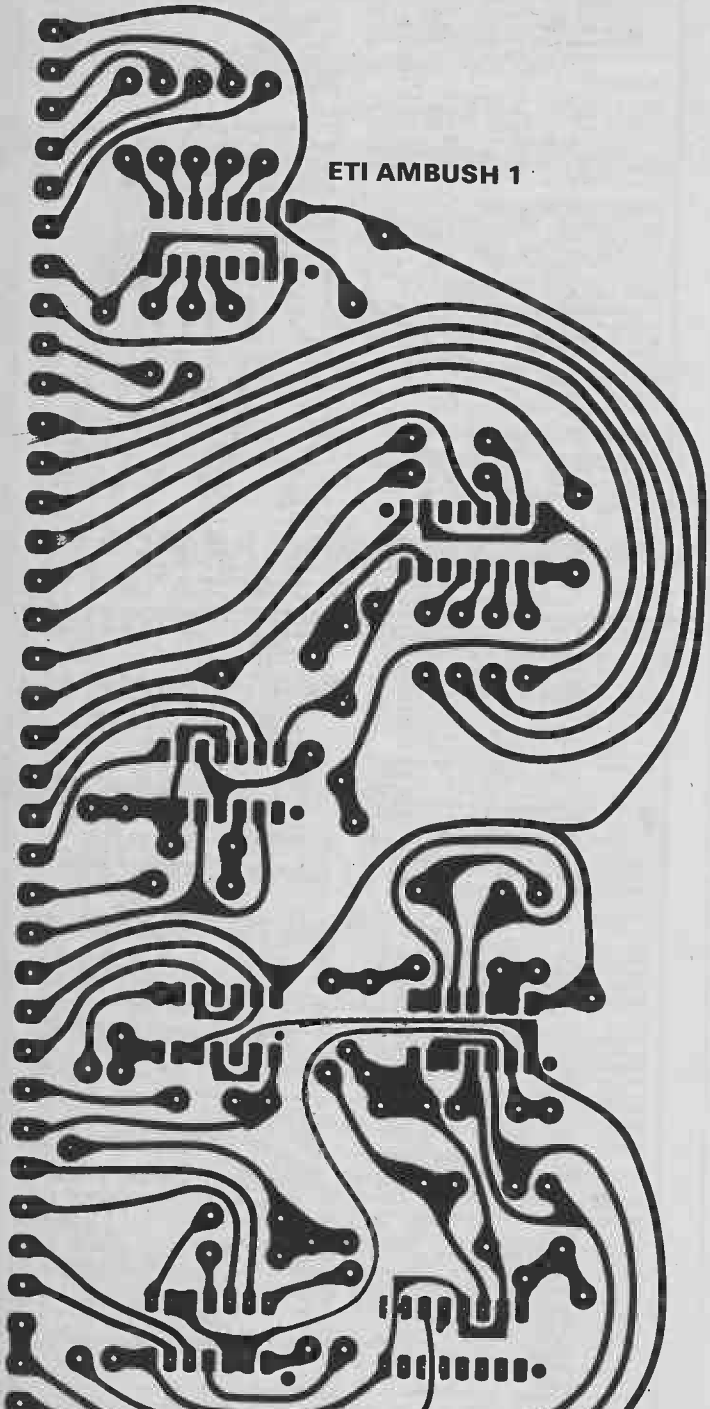


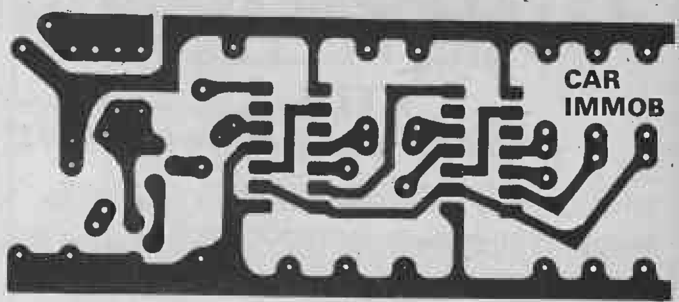
C5 defines the upper frequency limit of the circuit at 3 khz, the best bandwidth for maximum intelligibility.

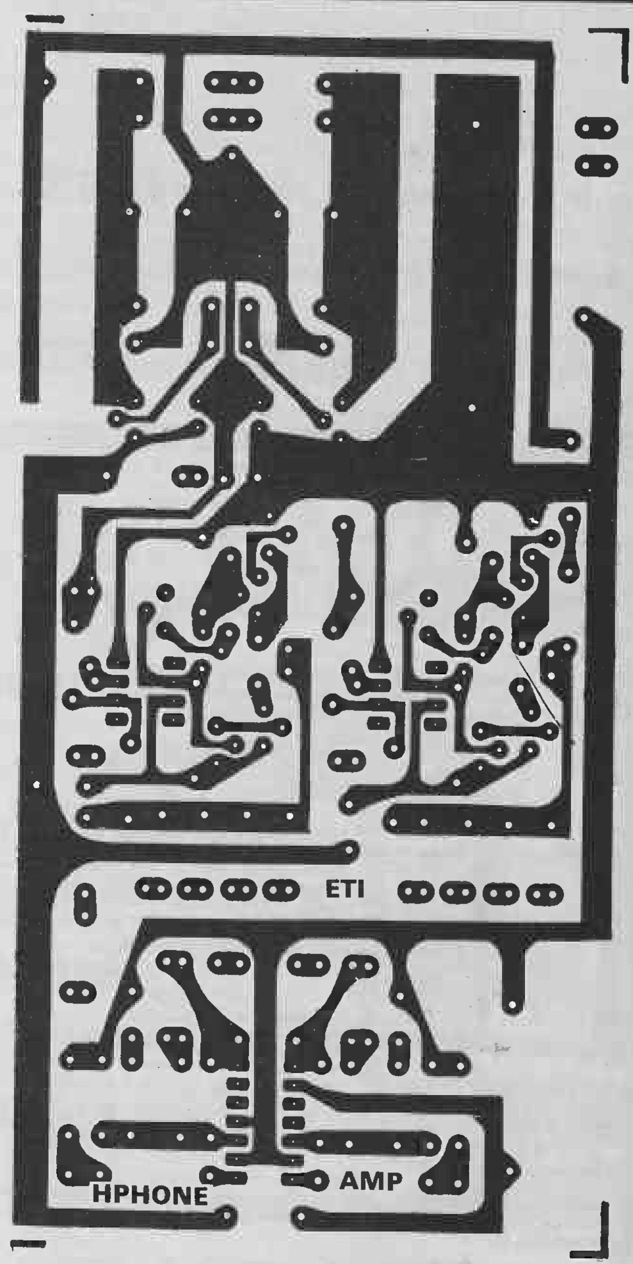
Quiescert current consumption is less than 5 mA so the circuit can be easily run from a pair of PP3's in series.

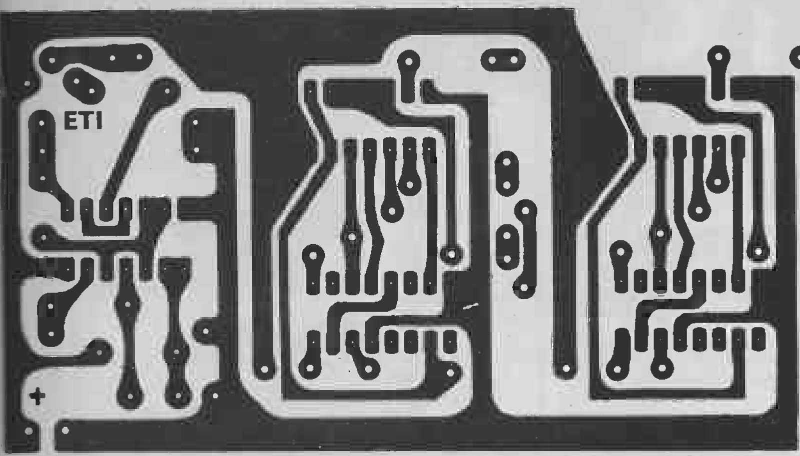
PCB FOIL PATTERNS

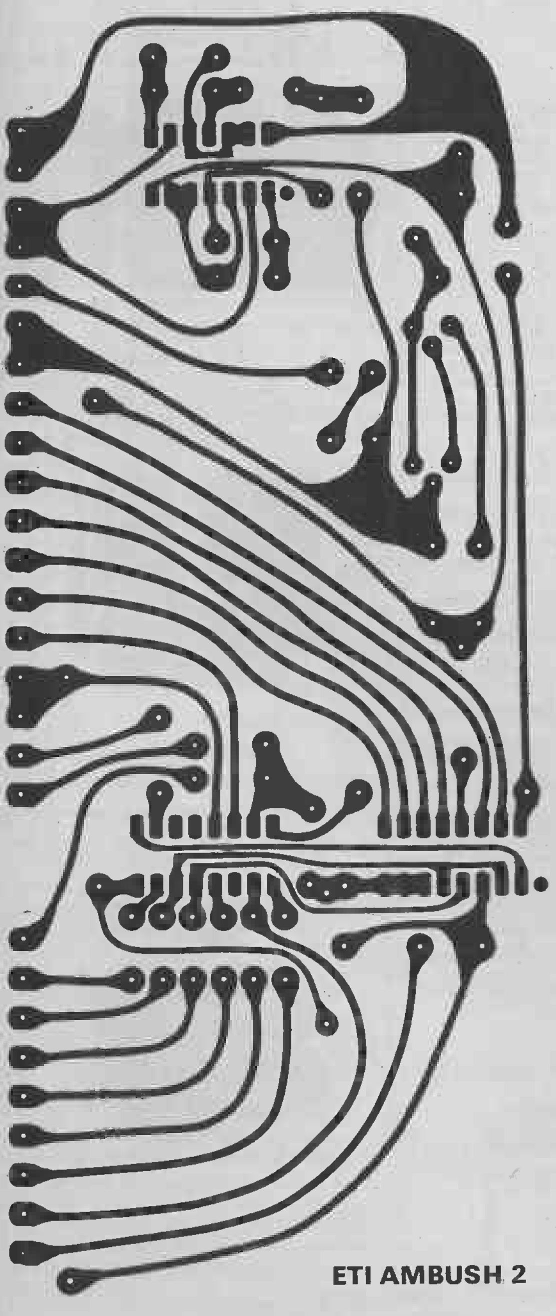
This months project boards. Note that the radio control transmitter PCB is copyright Rencom and hence is not shown here.



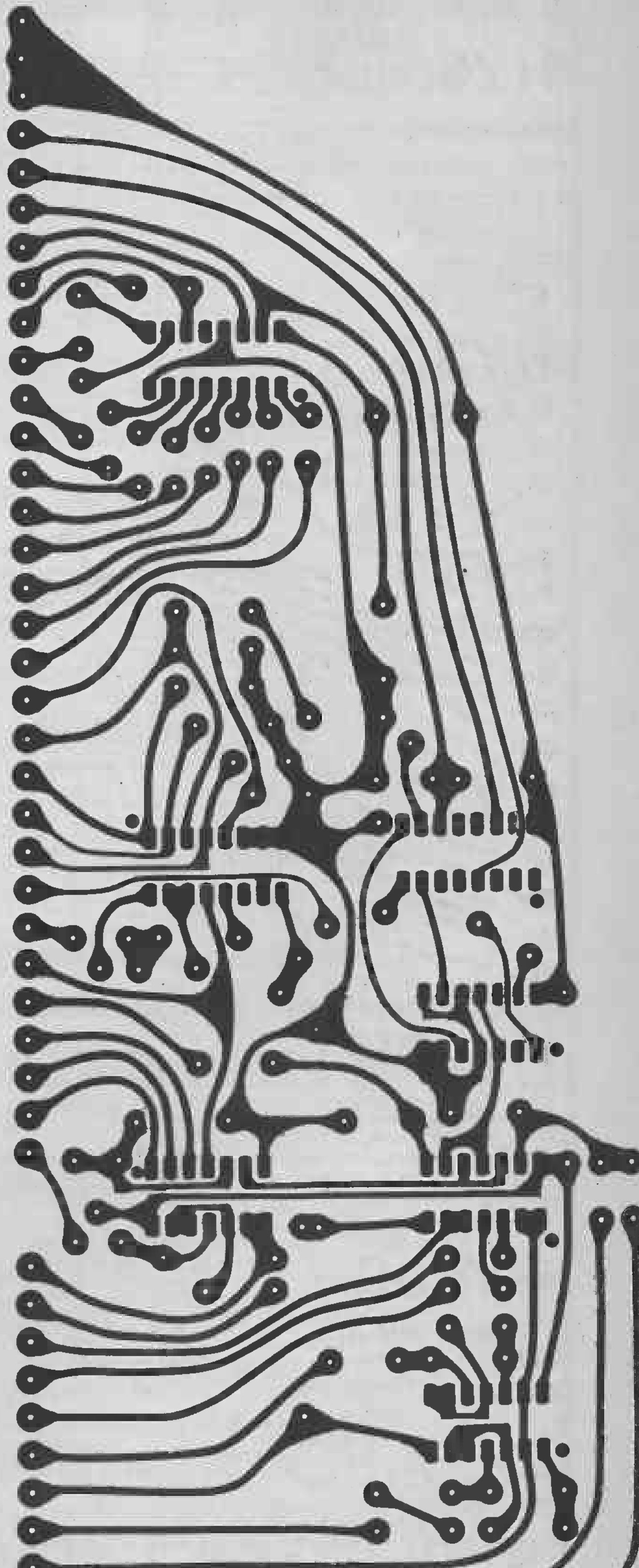






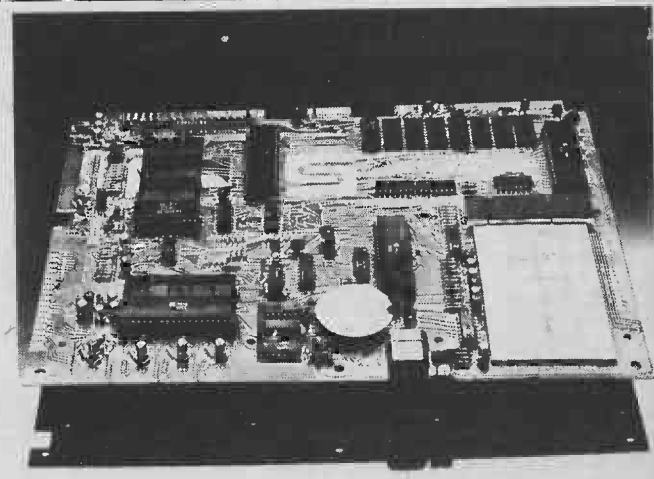


ETI AMBUSH 2



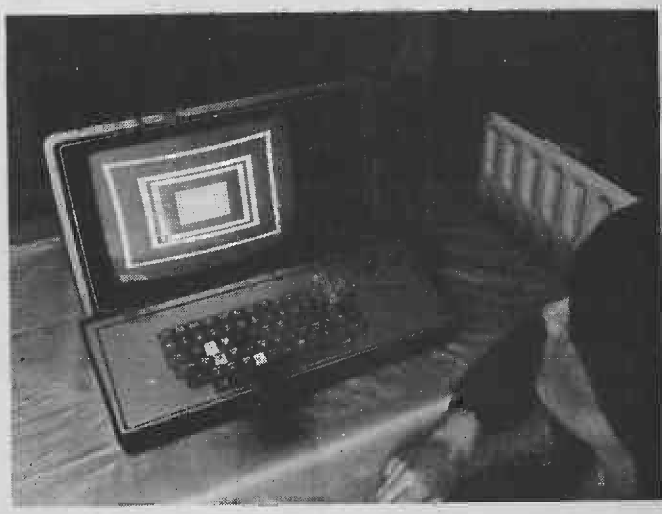
ETI AMBUSH 3

.... news digest.......



SYM-1

AN ideal companion to the keyboard terminal (see key Baud) is the new SYM-1. MPU system. Intended clearly for the development market it should appeal to both engineers and hobbyists. The board is complete and ready to go, needing only the addition of a 5 V DC supply. The unit has 4K on-board software and 1k of static RAM. Full access is available to important busses and ports. The SYM uses the popular 6502 MPU already a firm favourite with TV games manufacturers, price is £175, post free. See Rastra Electronics for details.



UNCLE SAMS LATEST

Good to see the American built 'Compucolor II' is at last available in the UK. For £1,390 you get a very comprehensive system indeed. The integral VDU (8 colour) and Mini-Floppy Disk drive support the on-board 8K RAM which works in Basic. Abacus Computers Ltd will be importing the machines and examples can be seen at the Byte Shop and Trans Am of Chapel Street, London.

SURFACE ACOUSTIC WAVES

Surface Acoustic Wave Filters (SAWFs) are a comparatively recent newcomer to the electronics scene. They promise to revolutionise entire sections of colour TV manufacture. Richard Maybury and Peter Haywood* take a look into the workings of SAWFs.

THE SUPERHETRODYNE RECEIVER has been with us for around 50 years now (although opinions vary as to its exact age). In that time the basic concept has altered very little. With the advent of semiconductors came Varicap front ends, bringing with it the demise of the mechanical tuner (well almost). As ICs began to appear another bulky section of the superhet shrank dramatically — the audio stage. One stage, however, seems to have resisted any great change, the good old IF, indeed many a radio engineer of the thirties and forties would still recognise a contemporary IF stage, possibly even feel quite at home with it.

A quick re-cap on the operation of the IF would not come amiss at this point, as most of you will realise the superhet works by mixing the incoming RF (from the aerial through a series of RF amplifiers) with an internally generated oscillator (the 'local' oscillator usually runs at a higher frequency to that of the incoming RF, around 465 or 470 kHz in the case of an AM receiver and 10.7 MHz for FM). The oscillator 'tracks' with the RF when the tuner dial is altered the local oscillators frequency will change accordingly. The result of mixing these two frequencies is to produce a product, sum and difference output. The IF stage will reject all but the difference output, hence it is really nothing more than a highly accurate 'notch' filter, tuned in the case of AM to 465 (or 470) kHz.

* **(Plessey Semiconductors Ltd)**

Early Days

Development work on SAWFs first began in the late sixties — the theory, however, was known as early as 1940. The SAWF is perhaps unusual in that it uses no silicon in it's construction, instead it relies on a substance called Lithium Niobate, which has very predictable piezo-electric properties. Simply explained that means it has the ability to convert electrical energy into mechanical energy and vice-versa. An electrical signal applied to the inter-leved Aluminium fingers (see Fig. 1.) of the input transducer sends an 'acoustic' wave across the surface of the filter and is converted back into electrical energy by a similar transducer at the other end of the device. Because the signal *is* acoustic it will travel slower than an equivalent electrical signal, so there is a significant delay between the input and output transducers.

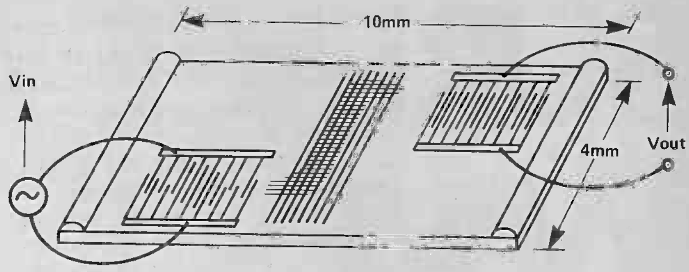


Fig. 1

Typical SAWF construction, the ridges at the two ends of the substrate act as acoustic absorbers for unwanted signals. The central electrodes serve to guide the acoustic wave from the input transducer to the output transducer.

A Notch In Time

Regarding the IF just as a filter can be somewhat misleading, because the accuracy and stability of an IF stage is of a very high order, and up to now could only have been achieved with a series of highly accurate LC networks. The main drawback apart from sheer physical bulk has always been the setting up needed for a conventional IF strip, often involving up to six or more separate tuning operations on sophisticated pieces of test equipment, (wobbulators or sweep-generators). With all these constraints it's not surprising that a search (mostly fruitless) has been going on for many years to find a suitable alternative; the most likely candidate looks like being the Surface Acoustic Wave Filter or SAWF for short.

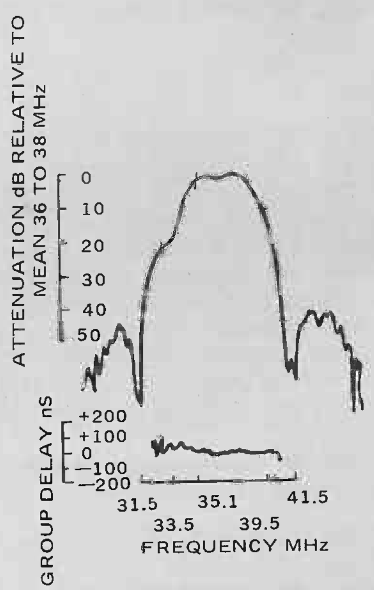


Fig. 2.

Typical response curve for a TV IF filter (Plessey), note the almost 'square' response, this kind of accuracy is nearly impossible to duplicate by conventional means.

Pioneering Plessey

Most of the early development work was carried out by Plessey Semiconductors Ltd at their Caswell plant about a decade ago, and in fact within three months of the research department being set up they had a working prototype. This early success led to the department being given a brief to produce a viable TV IF filter, demonstrating what had previously been possible only theoretically.

Early efforts to market SAWFs met with a slow response. This was not so much because of technical performance but because a comparison of costs showed little, if any, cost advantage of the SAWF version at that time over the conventional coil-type of IF most UK TV companies were committed to. Many TV manufacturers had invested a lot of money in coil-winding equipment and were naturally reluctant to scrap such expensive machinery.

The breakthrough came when Spain and Italy started colour TV transmissions. Because the IF is one of the most difficult areas of a TV set to design and build. (Colour TV demands a particularly high standard of IF design), the Spanish and Italian TV setmakers were saved from a difficult design problem by the use of SAWFs and sales of Plessey filters rocketed to around 70 000 a month. This naturally led to a rapid reduction in prices and gave Plessey confidence to invest further capital in setting up a high volume SAWF production plant capable of producing 10 million devices per annum.

Filtering Through

Technical refinement, and acceptance by the TV setmakers, enabled Plessey to penetrate some of the traditionally difficult markets. In the UK all but one of the TV manufacturers will be in full production with SAWFs by the end of 1979.

Although most of the initial arguments against the use of SAWF's were on economic grounds. The advantages found by users when in production are very wide ranging.

Perhaps the most commonly cited advantages are the consistently good performance, the simplicity from a production viewpoint due to the lack of adjustments and the small number of components on the IF board. Other advantages are the flexibility to change from UK standard sets to any other standard by changing the SAW filter and a few other components, and the improved reliability since the SAW filter is a robust passive component.

Construction

Basically a Surface Acoustic Wave Filter consists of Two transducers (see Fig 1) on a piezo-electric substrate. An electrical signal (V in) applied to the input transducer causes an acoustic wave (proportional to V in) to be propagated bilaterally along the surface of the substrate. The transducer generates a wave symmetrically across it's surface producing an unwanted output to the left of it's body, this is absorbed by a raised wedge to prevent any spurious reflections crossing the 'chip'. The wave to the right of the transducer is re-directed by the central coupling grid to the output transducer where it is reconverted into an electrical signal (V out). The time taken for the wave to cross the device is typically 1.6 microseconds. The input transducer generates a further unwanted signal called a Bulk Wave this, not being a surface component passes under the central coupler and misses the output transducer.

Material

The substrate material commonly used for SAWF devices is Lithium Niobate (LiNbo3) which has a very high piezo-electric coupling factor, this results in filters with a low insertion loss. Being relatively cheap and having a low temperature co-efficient make it a practical choice, although much research is being carried out at the moment into alternative materials.

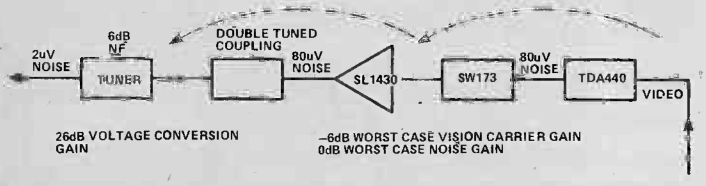


Fig. 3.

Block diagram showing diagram of SAWF within receiver design, noise levels are shown. The SL1430 is a purpose-designed SAWF pre-amplifier (Plessey) for use in TV IF filtering.

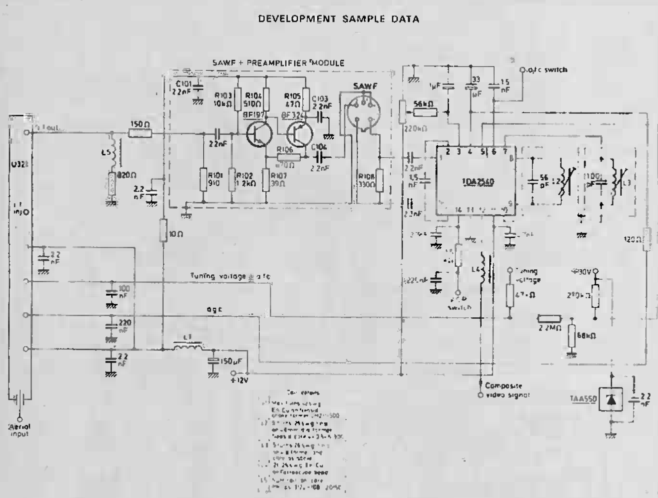
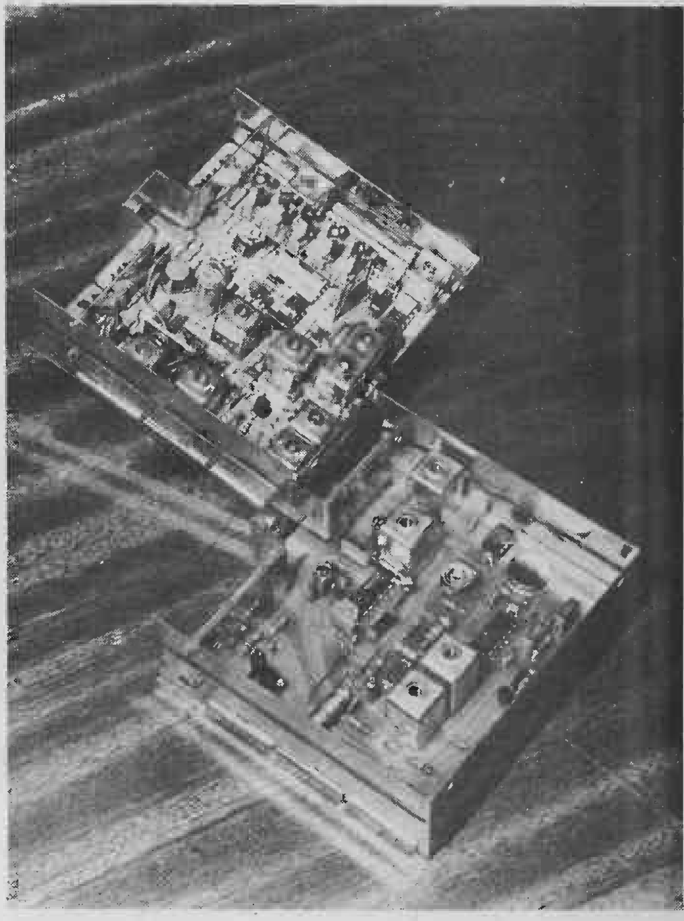


Fig. 4.
Complete Tuner/IF circuit using a Mullard SAWF, the component count is around a quarter that of a conventional IF (Diagram courtesy Mullard Ltd).



Pre-assembled Plessey IF/Tuner units. With the introduction of SAWFs these modules can be made substantially smaller than current IF and Tuner modules.

Transducers

The Transducers consist of interdigital grids or fingers of electrodes formed from Aluminium. Each grid is around 200 Angstroms thick and 10 micro Meters wide.

Practical Considerations

In practice several other features are incorporated into SAWF design, the use of an acoustic absorber on the back face of the substrate is used to isolate the transducers from any mechanical interference (it also serves to mount the substrate on to the package or encapsulation). The edges of the substrate are 'cut' at an angle to steer any reflections away from the input and output transducers. Double thickness electrodes are also used to further reduce spurious reflections.

Bandwidth

The 'geometry' of the transducers dictates the effective frequency response (fo) and bandwidth of the device. By 'tailoring the shape and sizes of the electrodes a variety of ▶