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AUGUST 1977

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AUDIO SWEEP OSCILLATOR

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SOIL MOISTURE INDICATOR

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JULY 1977 Vol. 6 No. 7

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COVER The photograph of the camera on our front cover shows the Contax RTS and was kindly supplied by Photax

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news digest

WATCH THIS CALCULATOR

National Semiconductor have launched a new Scientific calculator watch module. The watch/calculator is based on two new chips, the MM58101 and MM58102 and probably represents the most powerful such combination on the market.

The Watch/Calculator (the name is longer than the module) uses a liquid crystal display to provide a continuous indication of hours - minutes - seconds, as well as a month/date calendar and AM indicator on demand.

In the calculator mode, it employs algebraic logic, has full scientific notation, trig. and log. functions, store and recall memory, pi, powers of numbers, register exchange and reciprocals.

The dual function keyboard, which has thirty six possible switch functions, is activated by a pen, pencil, or other small pointed object.

Unlike conventional digital watches there is no complicated procedure for setting time or date, since the keyboard may be used instead. For example, seconds can be added or subtracted from the display by pushing the plus or minus key followed by the desired number of seconds.

Another useful feature of this Calculator/ Watch module is its ability to store numeric information. A telephone number may, for example, be entered into memory where it will remain until altered by the user or the modules battery runs flat.

Other versions of the Watch/Calculator are also possible, such as financial, statistical or other scientic notations, all by simply re-programming the chip's ROM.

WOW – WHAT A METER

Pictured above is the new Wow and Flutter meter from Pye Unicam Ltd. The PM6307 is designed to allow service technicians to check and align audio and video cassette records and record decks to performance limits which could previously only be measured with laboratory equipment.

The meter consists of a high stability crystal controlled oscillator at 3k Hz or 3.15k Hz, a measurement section and two analogue meters showing DRIFT and FLUTTER to 3% each in three ranges.

The PM6307 should appeal to service technicians as it can differentiate between electrical and mechanical problems. Thus while excessive Wow and Flutter reading are indicative of mechanical wear, Drift is often associated with faulty electronic circuity. The technician can therefore by interpretation of the DRIFT and FLUTTER readings, locate the area of the fault.

A standard DIN input/output socket located on the front panel makes the unit easy to connect to most domestic tape recorders and record players which would be the majority of applications for the unit.

TEXAS STEP AHEAD (5,000 TIMES)

News concerning a new range of calculators has reached us from Fort Bedford.

The range includes two new programmable calculators which offer a significant advance in the provision of memory capability and programming flexibility when compared to the present generation of programmables.

These models, TI Prog. 58 and TI Prog. 59, differ in two respects. First in that the 58 is a key programmable machine whereas the 59 is a card programmable and secondly in their memory capacity. The 58 offers 480 program steps or 60 memory registers while the 59 offers 960 steps or up to 100 memory registers.

The flexibility offered by the capibility to partition memory between program steps and data store is a valuable feature. For every increase or decrease by 10 data memories 80 program steps can be added or taken away.

These calculators also feature plug in solid state software modules. These modules are prerecorded program libraries containing up to 5000 program steps. These program steps can be addressed from the calculator's keyboard or inserted as subroutines in programs developed by the user. They cannot be altered by the user.

Each calculator is supplied with a master library solid state software module containing 25 prewritten programs in the engineering, mathematics, statistics and financial fields. A number of other solid state software modules are available concerning specialist fields such as navigation and engineering.

Both models may be used with Texas' PC-100A print unit to provide program and data lisitings. The printer provides the capability to print 64 characters on 6.35 cm wide thermal paper.

The price for these calculators are expected to be £ 249 for the TI 59, £ 99.95 for the TI58 with the PC-100A at £ 209.00.

INJECTING INTEREST

Alcon Instruments have launched their Chinaglia USIJET Universal Signal Injector. The device incorporates a blocking oscillator as the main signal generator,giving a baic 500kHz which is modulated at 1kHz for identification and demodulation check purposes. The waveform contains harmonics up to 500MHz and is thus uselul in many servicing applications.

Power consumption from the unit 1.5V battery is 25 mA and the output at the probe tip is 20V peak-to-peak.

In use the fly-lead is connected to the earth line of the equipment under test and the probe tip touched to the point at which the signal is required.

The price complete with earthing lead and instructions, is £ 11.55 inc VAT.

Further details from Alcon Instruments Ltd., 19 Mulberry Walk, London SW3.

GI NOSE AHEAD

General Instruments have developed a single-chip LSI package containing a FET input, detector, voltage comparator, oscillator, trigger and C/MOS output. It just so happens that this is about all you need for a 'sensitive nose' to detect combastion or, more technically, an ionization smoke alarm.

The MEM 4962 can replace more than 30 discrete components now being used in alarms of this type, to provide a small, rugged and reliable smoke detector.

LSI DPM OK

The panel meter pictured is based on single chip LSI technology and offers major savings in size, cost and power consumption over earlier digital panel meters.

The units feature a 1999 count, autopolarity, auto ranging and an accuracy of 0.05%. Power may be derived from a wide range of voltages, including AC mains. Power consumption is about 500mW and meters covering ranges from 200mV to 200V are available from stock.

At a price of £ 26.00 each (1 off), these meters represent a practical alternative to analogue panel meters.

For further information contact OMB Electronics, Riverside, Eynsford, Kent, DA4 OAE.

WATCH THOSE TEXANS

Texas Instruments recently announced that they are to move into the LCD watch market. They are to introduce a range of models in a wide variety of slim line case styles.

The watches will be powered by a single silver oxide battery which will provide an average of 18 months use.

Prices are expected to start at £18 with top of the range models selling for about £30.

While moving into LCD production, Texas will continue their commitment to the LED market where the emphasis will be on the low cost 'impulse' market.

BALLY VIDEO GAMES

The Bally Manufacturing Corp. of America are to produce a programmable video game based on the powerful Z80 MPU.

The programmable video games unit, which includes a calculator as well as video games, is expected to sell for about £150.

Additional plug-in units, each carrying up to three video games, will also be available. These units will extend the range of the basic unit and are expected to retail at about £10.

THREE NEW EAGLES

Eagle have added three microphones to their range of audio products. The New models, PRO M70, PRO M80, and PRO M90, are rugged designs for use in stage and recording work.

The M90 is a dynamic cardioid mike with a frequency response from 40Hz - 16kHz and a 600 R impedence. The M70 is a capacitor mike while the M80 is dynamic, both are in the same body as the M90.

Prices are £43.90 for the M90, £37.60 for the M80 and £34.20 for the M70. All are backed by the usual two year guarantee.

TIME FOR THE FAX

The BBC has added a further time checking service to the many it already operates. The time is broadcast over the Corporation's CEEFAX service.

CEEFAX is the news and information service which is broadcast in the field blanking period of a television frame and can be displayed on a converted set (see page 17).

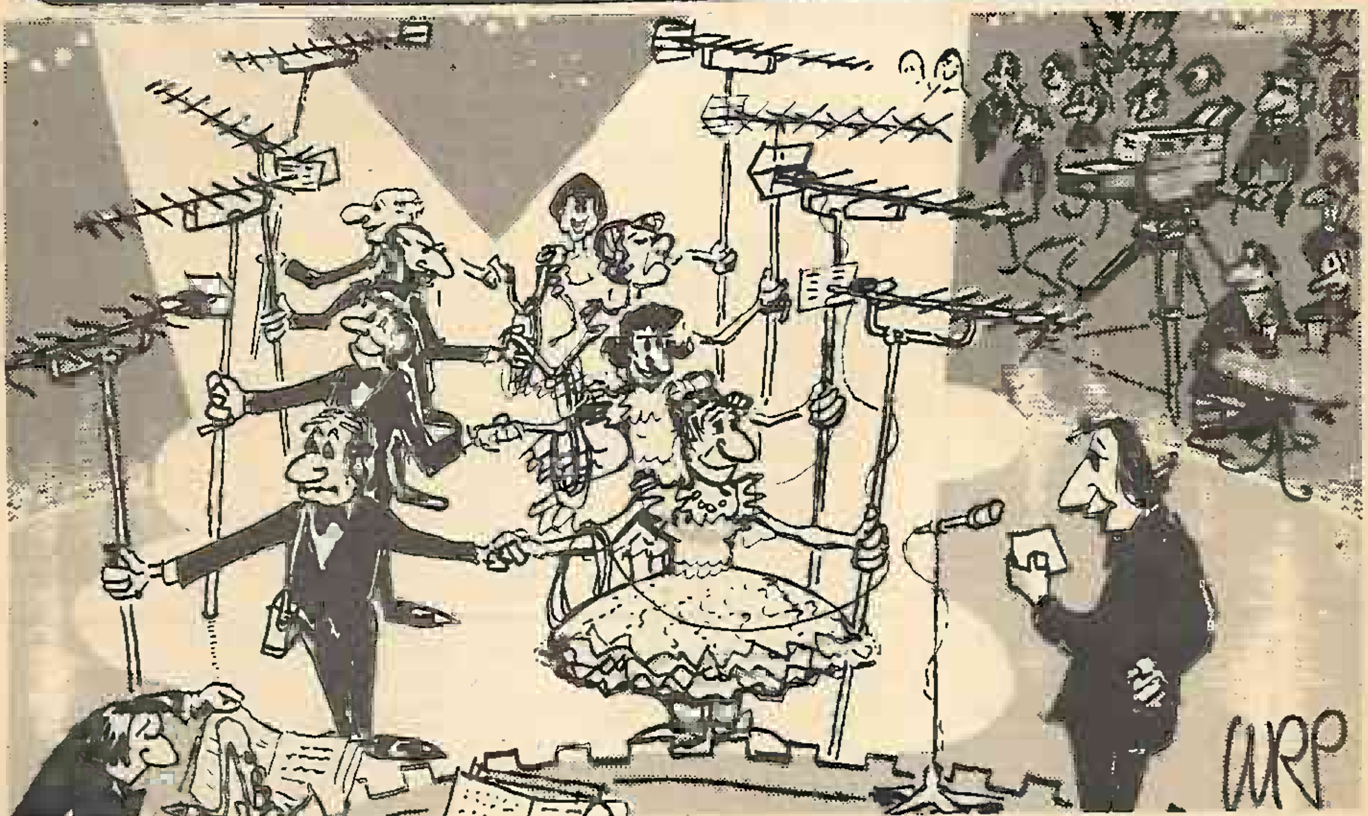
Although the BBC has transmitted day and date information since 1974 the service now offers a time display of seconds. The time is derived from the MSF Rugby signal, which is in turn checked against an atomic clock at the National Physical Laboratory.

Because it takes up to a quarter of a second to write a CEEFAX page, the system is limited in accuracy to this figure.

CORRECTIONS

Digital Frequency Meter, June 1977:-

Foil pattern of board B is not shown full size. A full size foil side PCB pattern can be obtained by sending us a S.A.E.



A warm welcome now for the southern area offbeat section champions — Cynthia Coggles Aerial Erectors Precision Formation Team!!

ETI PROJECT

SWEEP OSCILLATOR

Invaluable test unit at less than one fifth of the commercial cost!

By Tim Orr and P. Wielk

SWEEP OSCILLATORS are generally considered to be a rather fancy piece of test equipment and usually attract a fancy price. Units similar to the one to be described sell for around £200 to £300. It produces square and triangle waveforms from a voltage controllable oscillator, which can be internally swept by the machine's own ramp generator, (which is itself controllable), or it can be connected to an external control voltage source. Thus various frequency modulations can be performed, the most useful one being a wide range logarithmic sweep for resolving the frequency response of various networks and filters. To do this, a swept sinusoidal waveform must be synthesised. The triangle waveform is bent, by passing it through a diode function generator, until is closely resembles a sinewave.

Another waveform provided by the function generator is a tone burst output. This gates the sinewave signal on and off and thus generates a burst of sinewaves followed by a period of silence. Tone bursts are very useful for analysing the dynamic responses, (as opposed to the steady state responses), of networks such as filters, compressors, expanders, loudspeakers, etc. The last waveform provided is a square wave suitable for driving TTL circuits. This output uses a current sinking transistor, so that up to about 30 TTL unit loads can be driven by it.

Selecting IC's

The function generator needs fast op-amps to buffer the signals to the external world. These op-amps should also remain stable when connected to various reactive loads. Several devices were tried. The 741S, a fast version of the 741 made by Motorola; the 748, an uncompensated version of the 741; the CA3130 and the CA3140 made by RCA, both of which are fast CMOS devices. Also the LM318, a fast (50v/ μS) slew rate op-amp made by National Semiconductors; and the NE531v, another fast device made by Signetics. Not all of these proved successful, particularly when driving reactive loads. Also some of them require external frequency compensation and so the PCB was designed to accept various capacitors. You can use any of the op-amps, but I feel that the best will be obtained by using the suggested devices. In fact you can use the ordinary 741, but this will result in degraded waveforms. Recommended ICs are show on page 12

Using The Machine

Generally try to keep the load impedances presented to the machine as high as possible. The current driving capabilities of all the outputs are limited, particularly at high frequencies and so you may find that outputs become degraded as the frequency increases.

If you want to investigate the frequency response of a filter design, to get a non flickering display, you may have to use a fast sweep rate, say 20 times a second. This could result in a 'time-smeared' display due to the ringing time of the filter. The display will be a cross between the filters dynamic and steady state response. To overcome this problem, there are two possible solutions. One, use a slow sweep speed, if you have a storage scope then this will be OK. Two, frequency scale the filter up in frequency, so that say, a 100Hz bandpass filter becomes a 1kHz filter. You can then increase the sweep speed by a factor of times 10. However this is generally only possible when you are designing a filter and when you know that there is a sufficient bandwidth margin still available.

Construction

Even though this is electronically a complex project, construction is reasonably straightforward! Main points to note are as follows — first insert and solder all the wire links, followed by the presets. The link near RV1 is insulated. It's a good idea to use terminal pins for all the off board leads, saves trouble if you have to move a wire. Next the resistors, capacitors and diodes can be fitted. C3 only needs to be fitted if you can't get C2 on the board. Q7 needs its base lead bending underneath to fit the board. The only IC that really needs a socket is IC15, but sockets can save hours if used for all ICs — if a fault develops.

All off board connections should be soldered before inserting IC15 anyway. Screened wire should be used to the controls — but only the socket end should be earthed, otherwise nasty hum loops can develop. The external voltage control socket was mounted on the rear panel. The transformer specified has twin windings which are used in parallel. IC1 does not need any heat sink, as very little of its capacity is used. Last and by no means least, R16 and R34 are both mounted off the main board — good luck!

Setting Up And Alignment

Having built and tested the generator it now only remains for you to align the six presets. **RV1, frequency bias.** Set switch SW2 to manual and switch SW4 to the high frequency range. By turning the frequency control knob, the output of the machine should range from approximately 20Hz to 20kHz. However the transistors in the transistor array IC3 are only matched to within + or — 5mV

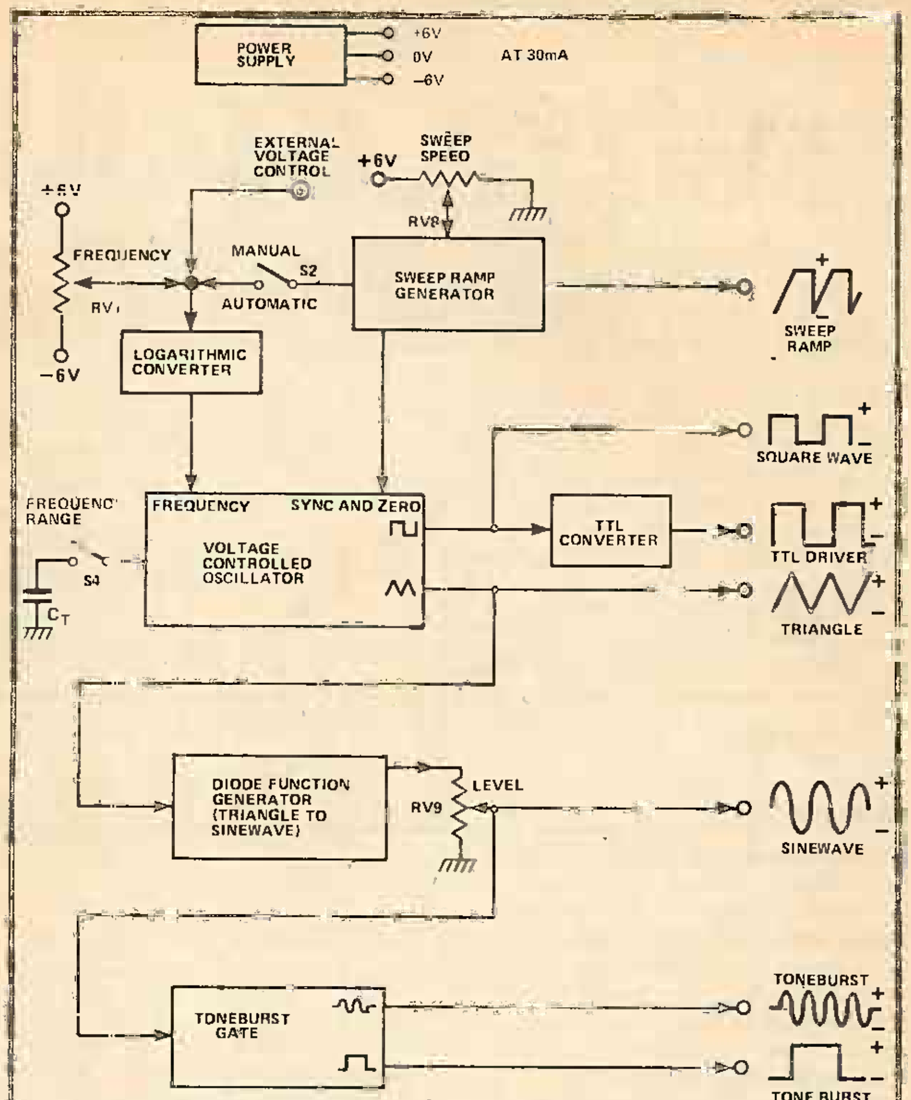


Fig 1 General System organization of the sweep oscillator.

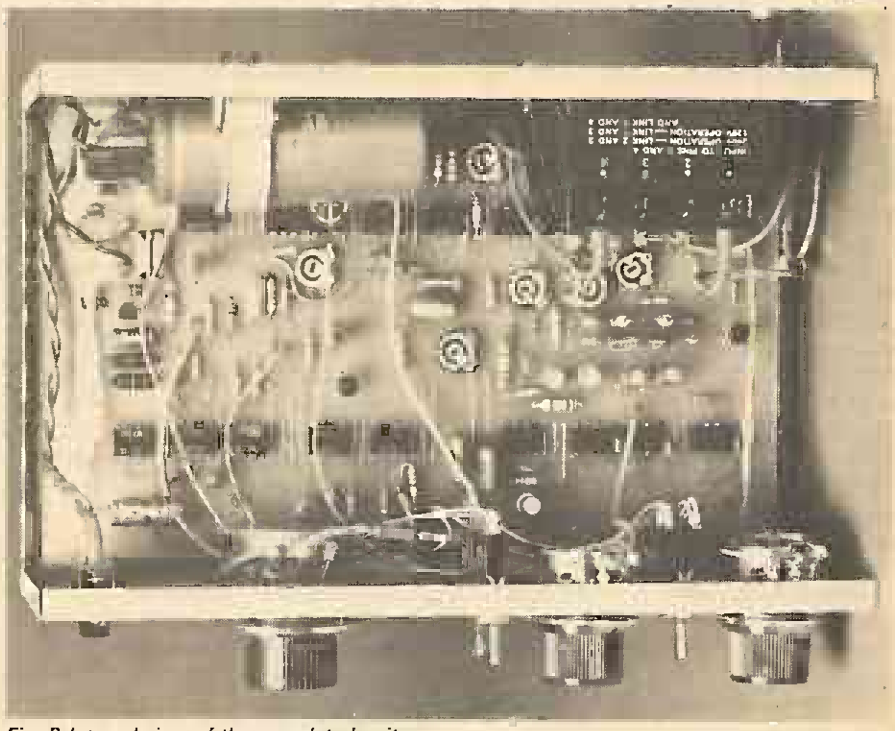


Fig. 2 Internal view of the completed unit.

and this can shift the generator's operating range. So to counteract this mismatch adjust RV1 until the manual operating range is as near to 20Hz to 20kHz as possible.

RV2, triangle time symmetry. The time symmetry of the triangle wave form may not be exactly 1 to 1, and if it is not then the sinewave will have a large THD. The root cause of any time symmetry is IC5, which is a CA3080. If the time symmetry varies significantly when the frequency is changed then IC5 will have to be changed until a suitable output is obtained. To align RV2, set the operating frequency to 1kHz, look at the triangle waveform and rotate RV2 until the best symmetry is obtained. This preset should be readjusted later on when the THD alignment is being performed. Move the frequency throughout its range and check that the symmetry is well maintained.

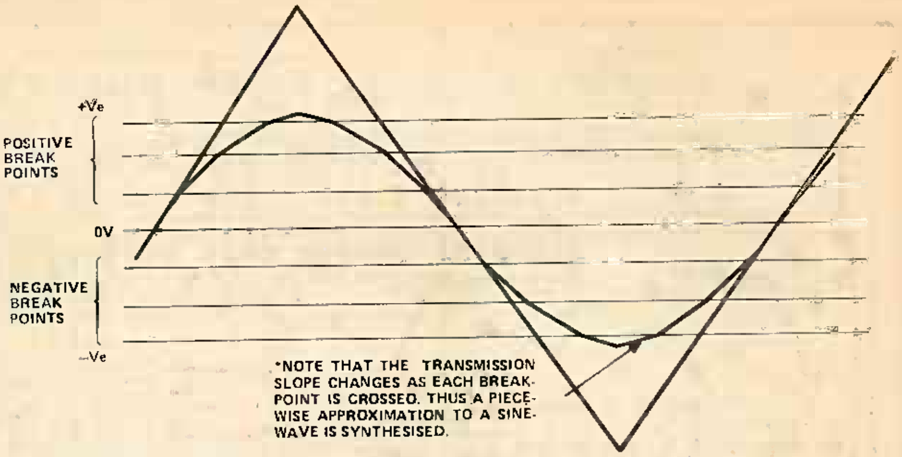


Fig. 3 Technique used to synthesise sine wave for triangle wave form

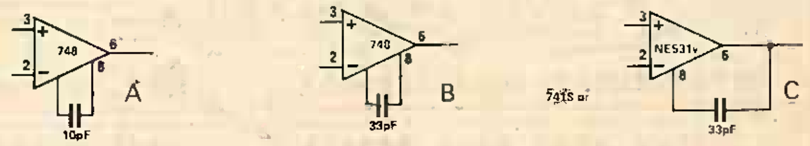


Fig. 4 Suggested ICs for IC11, 12, 13, 16 with correct equalization capacitors. IC11 is C, IC12 is A. IC13, 16 are B.

Ears and Things

THD minimisation RV3, 4, 5, 6. As it was not practical to use high tolerance components and matched diodes in this design, it is necessary to perform several alignments to produce the best possible sinewave. The way in which you align this generator depends on the equipment at your disposal. Here are four methods.

First, by ear. Your hearing apparatus is surprisingly accute to matters of frequency and harmonic structure. For instance if you listen to the square wave output on a good pair of headphones (high impedance preferably), then you can adjust the time symmetry (RV2) by ear with far more accuracy than you can with a direct visual display on an oscilloscope.

As RV2 is adjusted and the symmetry changes there comes a null point where all the even harmonics disappear, which can be distinctly heard. You can also try to align RV3, 4, 5, 6 by listening to the sinewave output at a frequency of say 400Hz. As you adjust each preset you should be able to minimise the harmonics and generally converge upon settings that give the purest tone.

Second, using an oscilloscope. Look at the sinewave (set to 1kHz) on the oscilloscope and adjust RV6 so that the waveform, whatever it looks like, is vertically symmetrical. RV6 merely compensates for any loss of DC offset that has occurred in the production of the triangle. Presets RV3, 4,5, can now be used to adjust the breakpoint slopes. By careful adjustment of them it is possible to converge upon a waveform that looks very nearly sinusoidal.

Third, using a distortion meter. This device is merely a tuneable notch filter. The sinewave is connected to this device and the fundamental is notched out leaving only the harmonics, which you can see and measure. The procedure is to set the frequency to 1kHz and adjust the distortion meter so that the 'sinewave' fundamental has been removed. Look at the residue with an oscilloscope and/or millivoltmeter and adjust RV3, 4, 5 until this residue is at a minimum.

If you don't happen to own a distortion meter you can construct a notch filter at about 1kHz, (see ETI, 'Active filters' and notch out the fundamental by altering the function generator's frequency.

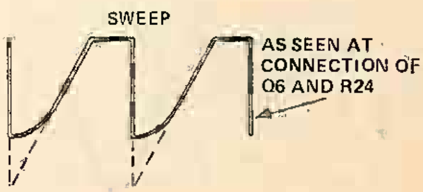
Lastly, using a real time spectrum analyser. These devices are quite cheap, usually about £7000 each. The analyser will display all the harmonics, and so the effect of adjusting RV2, 3, 4, 5, 6 will be instantaneously displayed.

Problems likely to be Encountered

The power supply can be a problem source. The 12V regulator can be responsible for many deviations from the predicted performance, due to the ±5% spread in output voltage. This could cause the sweep range to be larger or smaller, or it can effect the distortion of the sinewave. Here is a list of some common problems and their solutions.

Reduced frequency range. If the manual or swept frequency range is less than expected then increase R12 from 1k to 1k1. This will provide approximately an increase of one octave. If the range is too large then reduce R12 to 910 ohms

Clipped Triangle. This could be caused by a low power supply rail or a large Vp in Q3. Either change Q3 for a low Vp FET or reduce R17 to 470 ohms. Similarly, if the sweep output waveform (output 19) is bent on its negative end, change Q6 for a low Vp device or reduce R24 to 4k7



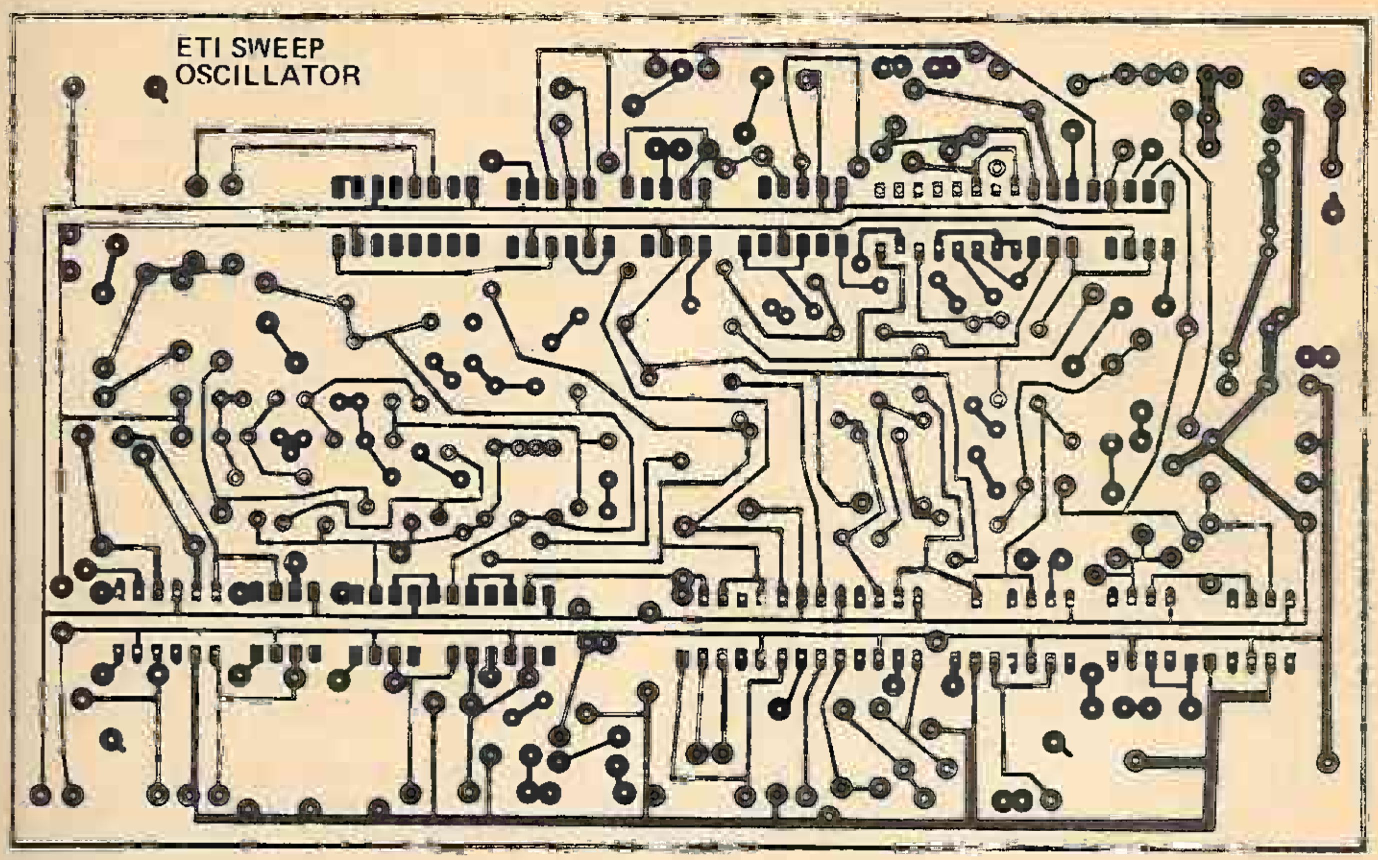
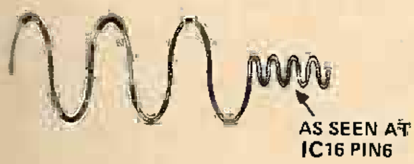


Fig. 5 Full size pattern for the PCB.

Tone burst does not shut off. This is because Q12 will not switch off. Change Q12 for a low Vp device.



Sine wave has a high THD. If the THD cannot be trimmed to about 1% then it is likely that the diode function generator has the wrong gain. If the sinewave looks more like a triangle(a), then increase R42 to 20k. If it has flattened ends(b), then decrease R42 to 16k. Note, very small changes in R42 have a large effect on the THD figure.

SINE WAVE (Variable 0-4V)	**THD < 1.5%**
TONE BURST (Variable 0-4V)	**16Hz on 48Hz off**
TRIANGLE (3V5 Fixed)	**Summetry ±2% (better than)**
SQUAREWAVE (3V5 Fixed)	**Markspace 1:1 ±2% (better than)**
TTL (5V, pulldown to zero)	**Markspace 1:1 ±2% (better than)**

TONEBURST GATE	**12V Fixed**
X SWEEP RAMP	**1V9 Fixed**
CONTROL INPUT	**+1V/Octave +3V3/Decade**
SWEEP RANGE (Logarithmic)	**1000:1**
RAMP RANGE (30Hz to 0.06Hz)	**500:1**
HIGH RANGE	**20Hz to 20kHz**
LOW RANGE	**0.2Hz to 200Hz**
(Manual or Automatic Sweep)	

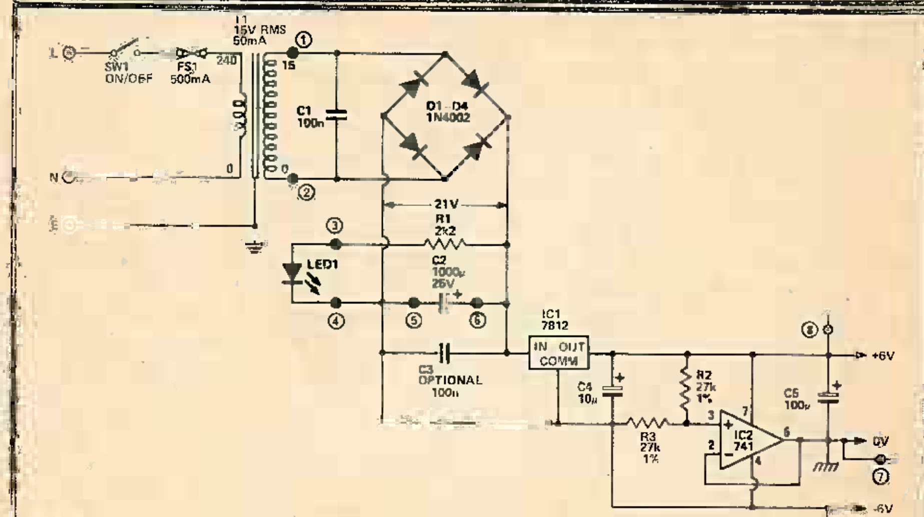


Fig. 6 Power supply circuit diagram.

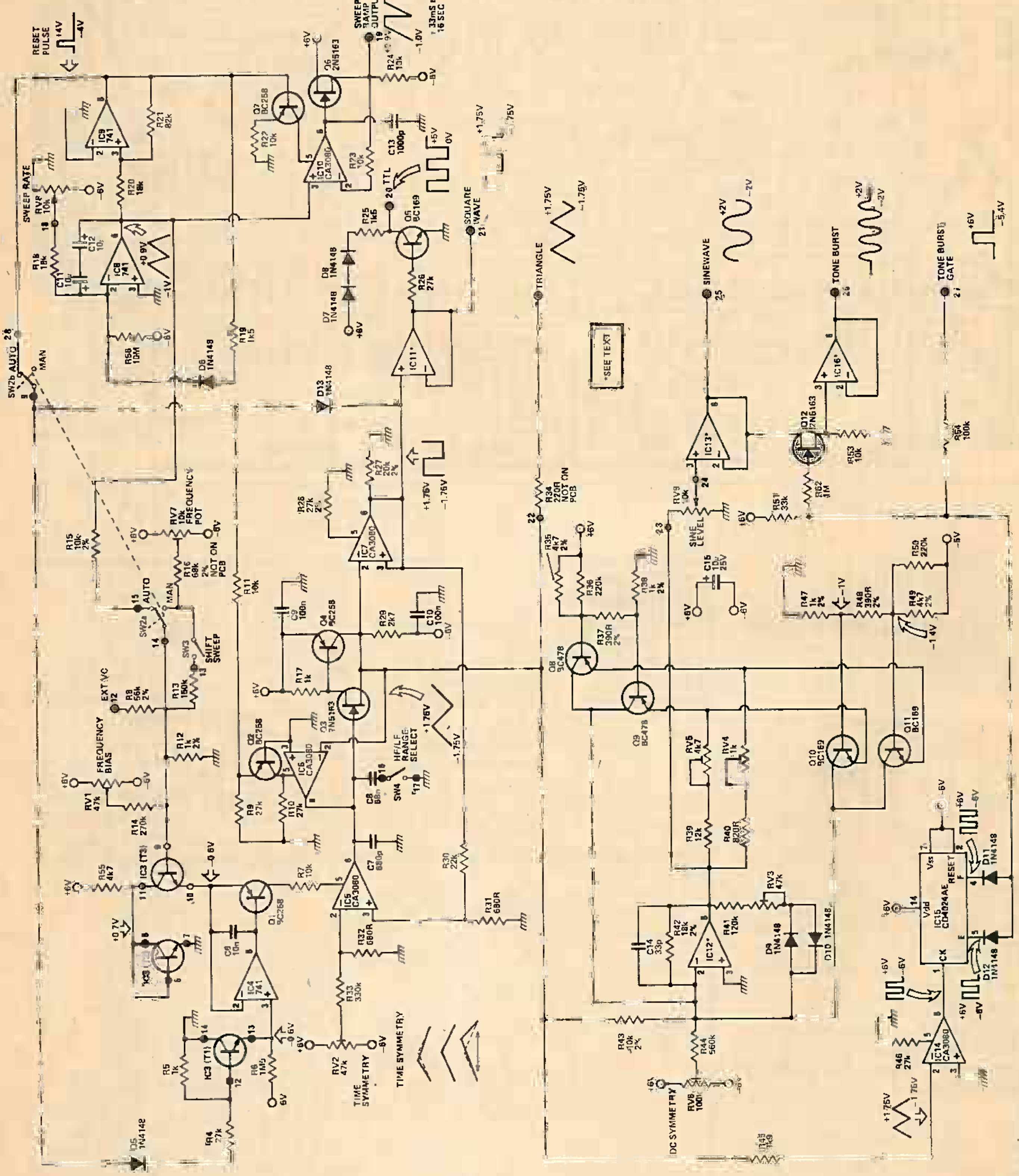


Fig. 7 Main circuit diagram, see page 12 for details of IC11, 12, 13, 16 and compensation capacitors.

The general system diagram is shown in Fig 1. The heart of the generator is the voltage controlled oscillator shown in more detail in Fig 3 and in the circuit diagram, fig 7. This is the well known triangle square wave oscillator made from an integrator and a schmitt trigger. A control current, (this determines the oscillating frequency), is fed into a current steering device IC5. When a positive voltage is applied to the non-inverting terminal, this control current comes out of IC5 and charges up the timing capacitors C7 and C8. When C8 is switched so that it is in parallel with C7, this selects the low frequency range of operation, (0.2Hz-200Hz). If the applied voltage is negative, then a current equal to the control current is 'sunk' into IC5 and the timing capacitors are discharged. Thus IC5 can either charge or discharge the capacitors, this being determined by the steering voltage.

The speed at which the capacitors charge or discharge is determined by the magnitude of the control current. If this current is constant then the capacitor voltage will increase or decrease linearly. The voltage on the timing capacitor is buffered by a high impedance buffer, Q3,Q4. The FETQ3, has such a high impedance that it hardly takes any current from the timing capacitor, so that it does not affect the charging or discharging operation. Q4 is arranged to drive Q3 at constant current, and the pair, (Q3, Q4), form a high input impedance voltage follower, with a DC shift caused by the FET characteristics. In fact it would be advisable to use low pinch off voltage FET's throughout so as to minimise the effects of these offset voltages.

The way in which oscillation occurs is as follows. Control current is injected into IC5 and the voltage on the timing capacitor rises. This voltage is buffered and presented to the schmitt trigger IC7. When this voltage reaches the upper hysterysis level, the schmitt flips over to its low state and thus the steering voltage becomes reversed. The timing capacitor voltage then ramps down until the lower hysterysis level is reached and then the schmitt flips back to its original state. Thus the timing capacitor voltage ramps up and down between these two hysterysis levels, the speed at which this occurs being determined by the control current. Switching in another capacitor C8, will reduce the ramp rate and hence the frequency of operation. This circuit produces triangles and square waves with a 1 to 1 time symmetry and symmetry about OV.

IC6 and Q2 are used to 'zero' the triangle output for the start of sweep. IC6 adjusts the voltage on the timing capacitor so that the triangle output is at OV. It does this only when Q2 supplies it with current.

The triangle output has a 220ohm resistor connected in series to prevent any damage caused by possible short circuits. The square wave output is buffered by A11 which has a fast slew rate. Q5 is the TTL driver stage. When switched on, it will pull down almost any load to a voltage near to OV. If a faster pull up is required the 1K5 resistor can be reduced.

Next the logarithmic converter. This device converts the sum of all the control voltages into a current, (the control current), to which it is logarithmically related. That means that for every IV increase of external control voltage the control current and hence the operating frequency will double. This logarithmic relationship is very useful for audio work, because when using a swept output, (displayed on an oscilloscope), the X axis is in octaves and decades rather than being linear. The circuit that does the conversion is known as an exponentiator and works in the following manner (see IC3, (T1,2,3.) IC4 and Q1).

IC3 is a CA3046 which is a transistor array providing us with a set of well matched devices at a low cost. Transistor IC3, (T1), has a current of 3.5μA passing through it and this produces a reference voltage of about −600mV at its emitter. IC4 and Q1 adjust themselves so that the emitter of IC3 (T3), is also held at this reference voltage. There are three control voltages, from the frequency pot wiper, the external control voltage terminal and the internal sweep ramp. These are resistively summed together and presented to the base of IC3, (T3). This transistor converts the control voltage into a current which flows out through the emitter, completely through Q1 and then to IC5. This is the control current. The voltage at the base of IC3 (T3) is logarithmically related to its emitter current. A voltage increase of about 18mV will double this current. However, this process is very sensitive to temperature changes which would result in drift in the function generators operating frequency, and so the arrangement of IC3 (T1) and IC3 (T3) has been used to provide temperature compensation. Also to keep self-heating effects to a minimum, IC3 (T2) is used to clamp the collector voltage of IC3 (T3) to +0.7v and thus reduce the power dissipated in the transistor array.

The next section to be discussed is the internal sweep ramp generator, (IC8,9,10,Q6,Q7). IC8, 9 form another triangle/square wave oscillator, having a controllable rise time and a fast reset time. IC8 is the integrator, IC9 the schmitt trigger. The output of IC8 ramps up at a rate largely determined by the sweep rate pot setting. When the upper hysterysis level is reached, IC9 output goes high, D6 becomes forward biased and the integrator ramps down very rapidly, reaches the lower hysterysis level, the schmitt trigger flips over and the process repeats itself. The ramp output is then used to drive the base of IC3 (T3), eventually sweeping the oscillator over a frequency range of 1000:1. This is approximately 10 octaves which requires a change in Vbe IC3 (T3) of about 180mV.

The ramp waveform can be used to drive the X axis on an oscilloscope but it needs some slight modifications to make it suitable. It needs to have a very fast reset of the order of a few microseconds to make the fly back invisible. This is achieved with the track and hold circuit Q6, 7, IC10. During the sweep the output of this circuit follows the input. However, during the reset period, IC10 is 'held' by virtue of the fact that no current is supplied to it. When the reset period is over, current returns to IC10 but its input has the 'start' ramp waveform presented to it, but its output has the stored value of the 'finish' ramp waveform. The output jumps as fast as it can, (within a few microseconds) to the input voltage and proceeds to track it. The process repeats itself. The reset voltage is used (in the sweep mode only), to perform three other tasks. One, it sets the schmitt trigger IC7 into a high state so that it always starts a new sweep with the same phase, (via the D13 route). This stops jitter on the display. Two, the reset is used to activate the zeroing switch mechanisms Q2 and IC6. Three, the control current is reduced during reset, due to the connection of D5. This helps the zeroing process. When switch SW2 (this is a double pole switch) is in the automatic position, both the sweep wave form and the reset pulse are routed to their respective sections of the circuit, and a logarithmically swept output is generated. The manual frequency control knob has no effect on the process, except when switch SW3 (the shift sweep), is closed.

This enables the sweep to be manually displaced up or down the frequency axis by a factor of about 5 times. That is if the sweep were between 20Hz to 20kHz it could be shifted up to 100Hz to 100kHz or down to 4Hz to 4kHz, thus enabling the useful range of the generator to be greatly extended. When switch SW2 is in the manual position, the sweep and reset signals are disconnected and so the generators output frequency is entirely determined by the manual control knob, plus any external control voltages and of course the position of the range switch SW4.

Next the diode function generator IC12, Q8, 9, 10, 11 and D9, 10. This circuit converts the triangle waveform into one that approximates a sinewave, see fig. 3. It is called a diode function generator, although four of these supposed diodes are transistors, Q8,9,10,11). The triangle is applied to an op-amp with several feedback routes, the purpose of which are to change the gain of the section, depending upon the instantaneous signal level. As the triangle waveform (which is symetrical about OV) goes positive, the output of IC12 goes negative. When it exceeds −0.6V, diode D9 begins to turn on and in doing so, the overall feedback resistance is reduced and so therefore the transmission slope is also reduced. This is known as the first break point. Transistors Q10,11 have their bases biased to voltages of −1.0v and −1.4v respectively. These transistors will provide further feed back routes when the output of IC12 exceeds −1.6v and 2.0v, and this extra feedback will decrease even more the transmission slope. Thus, the triangle waveform is gradually bent to resemble a sinewave in the negative excursion of IC12.

However there is also a complementary set of feedback routes for positive excursions via D10,Q9 and Q8 and so a complete sinewave is synthesised. This process is far from perfect and the best THD figure that can be obtained by careful adjustment of RV3, 4, 5, 6 is about 1.0% at 1kHz. This compares with a figure of about 0.2 to 0.5% THD for moderately expensive commercial function generators. These lower figures can only be obtained by having a precision regulated power supply, good tolerance resistors (0.5%) and a more elaborate set of MATCHED diodes. Also, some high quality equipment will be needed to make the final adjustments to the sinewave.

The sinewave from IC12 is passed through a manual level control and is buffered by the voltage follower IC13 to the output terminal. The sinewave also goes to the **toneburst** section. IC14, 15, 16 and Q12 FET Q12 is used as an analogue switch between the sinewave and the voltage follower/buffer IC16. This switch is turned on for 16 cycles of the sine wave and off for 48 cycles. The switching occurs synchronously as the waveform passes through OV. The control for the FET switch is generated by IC14 and 15. IC14 is used as a voltage comparator which determines whether the triangle waveform is positive or negative. It generates a square wave of + and −6V state as the triangle waveform passes through OV. This square wave is used to clock a seven stage CMOS counter, IC15. The divide by 32 and 64 outputs are AND'd together to generate the voltage control for the FET switch. This voltage is high (FET switch on) for 16 cycles and low (FET switch off) for 48 cycles and is used as an output (toneburst gate) to trigger, say, an oscilloscope.

The last piece of circuitry to be described is the power supply, IC1, 2. This delivers + and −6V at about 30mA. The transformer delivers 15V RMS which produces about 21V of unregulated supply. A 12VRMS transformer would be rather low and you might experience problems of the supply dropping out.

PARTS LIST

RESISTORS (all ¼ W 5% unless otherwise stated)

R1	2 k 2
R2,3	27 k 1%
R4,9,10,26,46	27 k
R5,17	1 k
R6	1 M 5
R7,11,22,23,24,53	10 k
R8	56 k 2%
R12,38,47	1 k 2%
R13	150 k
R14	270 k
R15,43	10 k 2%
R16	68 k 2%
R18,20	18 k
R19,25	1 k 5
R21	82 k
R27	20 k 2%
R28	27 k 2%
R29	2 k 7
R30	22 k
R31,32	680 R
R33	330 k
R34	220 R
R35,49	4 k 7 2%
R36,50	220 k
R37,48	390 R 2%
R39	12 k
R40	820 R
R41	120 k
R42	18 k 2%
R44	560 k
R45	3 k 9
R51	33 k
R52	1 M
R54	100 k
R55	4 k 7
R56	10 M

CAPACITORS

C1,3,9,10	100 n polyester
C2	1000 u 25 V tant.
C4,11,12,15	10 u 25 V tant.
C5	100 u 25 V tant.
C6	10 n polyester
C7	680 p polystyrene
C8	68 n polyester
C13	1 n polystyrene
C14	33 p ceramic

TRANSFORMER

T1	240 V, 0-15 + 0-15 V (3 VA per winding) (Doram 207-217)

CASE

Samos S7	(Doram 984-497)

MISCELLANEOUS

500 mA fuse, holder, single screened wire, stranded flex, pcb as per pattern, 3-core mains wire, 8 off 4 mm. red sockets, 2 off 4 mm. black sockets, pcb mountings, etc, instrument knobs.

POTENTIOMETERS

RV1,2,3	47 k Hor. min. trim
RV4	1 k " " "
RV5	4 k 7 " " "
RV6	100 k " " "
RV7	10 k lin. moulded track pot.
RV8,9	10 k log. carbon pot.

SWITCHES

SW1	off-on rocker etc. 3 A 250 V
SW2	D.P.D.T. toggle
SW3,4	S.P.S.T. Toggle

SEMICONDUCTORS

Q1,2,4,7,8,9	BC 258 or similar (BC 477,8,9)
Q3,6,12	2N 5163 or 2N 3819 (N type FET)
Q5,10,11	BC 169
D1-4	1N 4002
D5-13	1N 4148
LED1	.2" type
IC1	7812
IC2,4,8,9	741
IC3	CA 3046 or CA 3146
IC5,6,7,10,14	CA 3080
IC11,12,13,16	see text
IC15	CD4024AE

BUYLINES

Most of the components are easily available, if they are in stock! **Marshalls** are preparing various packs for this project to make construction easier. All resistors for **£1.50**, capacitors for **£1.60**, switches **£2.70** and a complete semiconductor pack (preferred ICs for IC11, 12, 13, 16) for **£16.75.** All prices include VAT but add **30p** per order for postage etc.

Total cost for the whole project should be under **£35.00.**

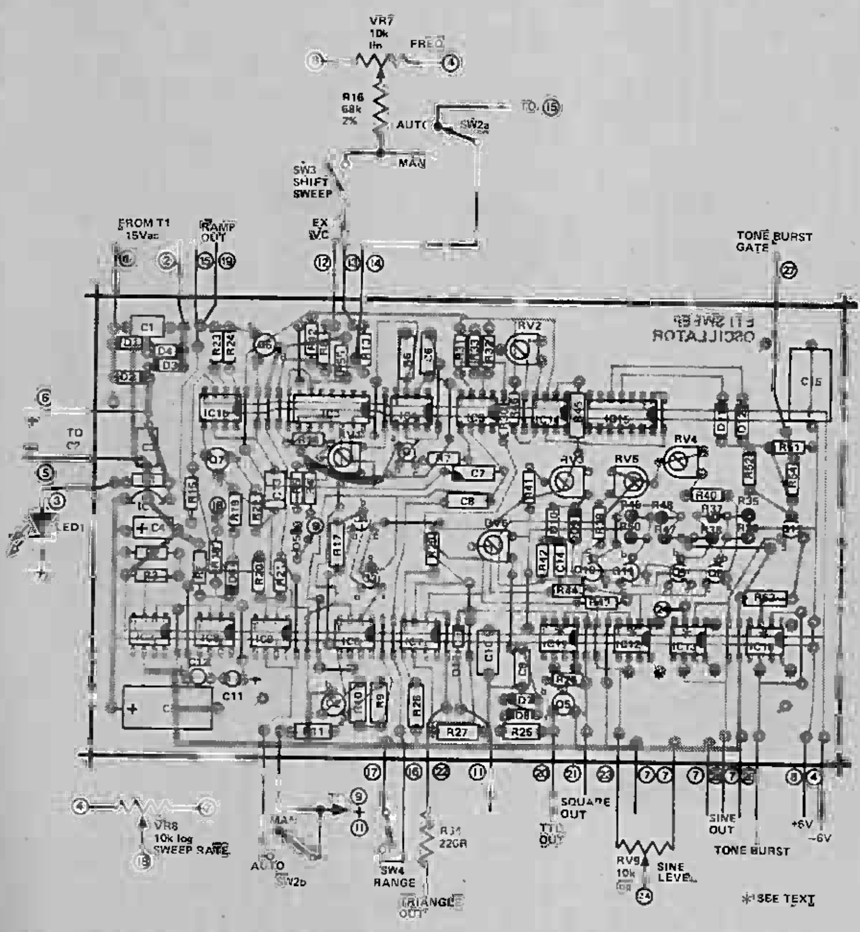


Fig. 8 Overlay and interconnection pattern.

Halvor Moorshead takes a look at Videocraft's

Teletext Kit

The Texas Instruments TIFAX module is now available to the amateur and a kit is available comprising everything you need to convert your colour TV (if it is a suitable model) for reception of Teletext.

IN THE JULY 1975 issue of ETI, we carried a main feature entitled 'Teletext Takes Off'. History has shown that our title was a mite premature!

This feature, and the forecast, was based on the announcement by Texas Instruments that they were going to produce a dedicated module which would bring down the cost of a Teletext capable TV set to the level of the mass market.

Now most readers will know what Teletext is, but due to the lack of publicity over the past year or so, some of you may be unfamiliar with this system.

What is Teletext?

In late 1972 the BBC announced a system called CEEFAX: this would be a series of 'pages' of written information which could be displayed on a suitably modified or designed TV set. The 'pages' would be broadcast during the frame blanking. The transmitted signals were (and are) a series of digital pulses which did not form a picture in themselves but programmed a character generator at the receiver to write the page.

The 'pages' are transmitted sequentially and to hold the display on the TV screen, memory was also necessary.

Not long after the BBC announced this system, the IBA announced ORACLE, technically a very similar system.

Sense prevailed and a committee of all interested parties got together and drew up a technical specification using the best of both CEEFAX and ORACLE. This new system is generally known as TELETEXT, though the BBC (who did invent the thing after all) seem reluctant to differentiate between the system and the service, both of which they call CEEFAX.

Progress report

In September 1974, the BBC started a full experimental service and although some of the information now broadcast is experimental in nature, it is fully operational.

Both BBC networks put out 100 pages on all 625-line transmitters and the information provided is real and properly updated.

The IBA until recently were transmitting ORACLE only from London and from programmes networked from the capital but at the time that we're putting this issue to bed, ORACLE is due to be transmitted over the country, irrespective of the programme origin.

It is to the eternal credit of both the BBC and the IBA that they are operating very full systems - there is nothing amateurish or slip-shod - the information is mostly up - to - date and there is enough of it to be useful.

Both services are also operated with a sense of fun and are not yet plagued with considerations of 'balance'. The receipes on ORACLE are accompanied by a delightful graphic of one of the 'Homepride' men; retail outlets who are displaying Teletext can still get their names mentioned on a page and birthday greetings for Teletext users are put out.

Now the problem, if that's not too strong a way of putting it, is that very, very few people can receive it. No one knows for sure how many TV sets are equipped but it's probably under 2,000 so we've got a fabulous system, fully operational put out over the entire country, but with only a handful of viewers.

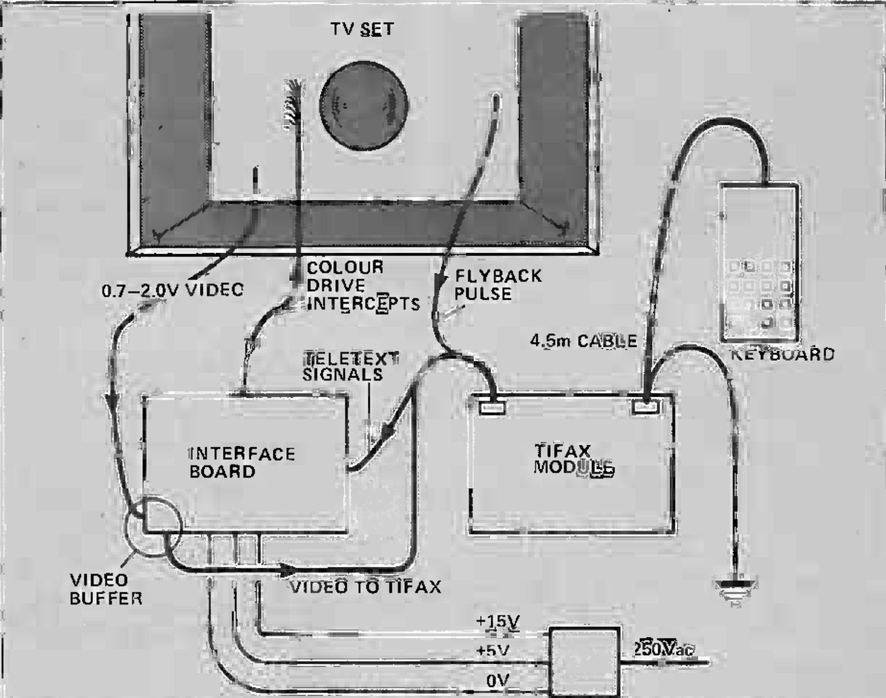
Perhaps the publicity given to it was a bit premature but now is the time to give the flag another wave because you can now buy a converted set or, if you're technical, you can modify your own set.

Kitfax

The long awaited TIFAX module is now available and one company, Videocraft of London, is supplying a conversion kit to the likes of us.

When we first heard about this we were very excited and arranged to try out a kit and convert one of our own TV's. In fact things didn't work out as we expected but we learned a lot about the kit and Teletext in general.

The kit comprises four main items: 1. Power supply, 2. Tifax module 3. Keyboard (very like a pocket calculator on a string) and 4. The Interface board.



The arrangement used to convert your colour TV receiver to get Teletext using the Kitfax from Videocraft. Connections to the Tifax module are made with Molex connectors. The connections you make to the set depend upon the chassis. The Video and flyback pulse signals are simple taps but the signal intercepts involve cutting the track of the PCB and connecting wires to both sides of the break. The screen of the keyboard cable is earthed in case it is broken and dangerous voltages have found their way in.

The keyboard and Tifax module need nothing doing to them, they're pre-assembled and even the connectors are prewired. The power supply needs building; all the components are supplied but there's no PCB or tag strip. The Interface board has to be built but this contains few enough components to be made up quickly in any one of two patterns to suit the particular TV to be converted. We'd rushed Videocraft a bit so we only got draft instructions which delayed matters a bit but we sorted out the problems O.K. Construction took about 3 hours and sorting out the connections to the TV and wiring it in took another 1½ hours. In theory the latter could take far, far less but you want to be careful.

The set we converted was an ITT 26in

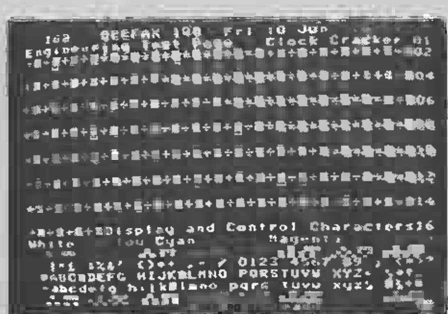
Photograph taken during the installation of the kit to the ITT CVC8 chassis.

Principle index page of ORACLE. There is now so much put out that the complete index will not fit onto one page.

We were experimenting at the time of the Jubilee as you can see. BBC-2 contains many such graphics.

Newsflashes are one of the main features of Teletext and are a fully operational part of the system. The IBA update theirs until 23.00Hrs.

Part of the fun aspect that pervades both CEEFAX and ORACLE at the moment is demonstrated here.



The 'Clock Cracker' page contains all the possible characters that can be displayed.

The weather map is just one example of a rolling page. Although always page 115, this page alternates between two displays, this is page B (may just be seen top right).

CVC8 chassis about three years old. Our problems arose because we found out after a heck of a time that this is not a suitable chassis for conversion! The other colour set we had for conversion uses the BRC 9000 chassis which is also a tricky one (we didn't try it, Videocraft told us in advance).

We feel that this was just bad luck. (We did get Teletext in brilliant colours and were able to operate it O.K. but had unbeatable troubles due to page rolling and hum). At Videocraft's workshops, which are really buzzing, they've modified a large number of sets which we've seen working so we know most sets work O.K.

This is not a beginner's kit by any stretch of the imagination - but it's not claimed to be. There is no casing as all the sections fit inside the TV - where there's always plenty of room - except for the keyboard and its wire to select TV, Teletext or the other facilities. You have to use some initiative but unless you've got some - and a measure of common sense - you shouldn't be dabbling inside the back of a TV set!

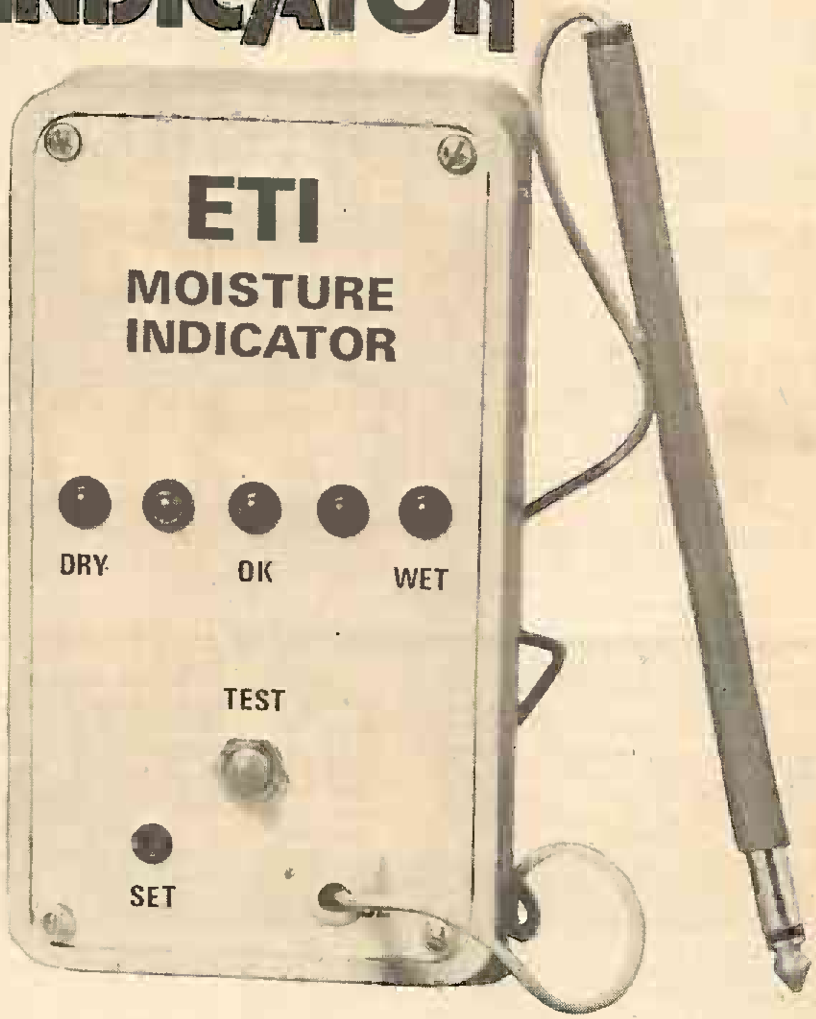
If you've got a TV which can be converted, it'll cost you £180 plus VAT and postage - well under half the price of any other method of converting.

Some readers may well ask why the kit isn't arranged as a 'plug-in'. In fact, this makes a colour display impractical and would increase the cost considerably. Colour on Teletext may sound like a luxury but anyone who'se seen it in mono and colour wouldn't ask.

Teletext is here to stay and if you want to be a genuine pioneer and can indulge your enthusiasm to the tune of £196.90 , Videocraft's Kitfax could be what your'e looking for *if* you've got a set suitable for conversion.

Just think of inviting around the neighbours - you'll have something working that they've probably never heard of, let alone got and the punch line is, of course, "Oh, I did it myself in a few hours, the rental companies will be offering suitable sets soon". Then go out and change your name to Jones!

SOIL MOISTURE INDICATOR



TO A GREENHOUSE OWNER, or indeed to many indoor and outdoor gardeners the degree of moisture within a plant pot's soil or compost is important but relatively unknown. When pots were made of fired clay an expert could rap the pot with his knuckles and the 'ring' or 'thud' would show the need for watering! Nowadays however, the use of polythene sleeves and plastic containers gives too variable a sound for adequate guidance.

This circuit was developed to give an easy and accurate indication of the need for water or - just as important, very often - of a state of excess that tends to drown the roots of a plant.

Development

Ohmmeter measurements between probes in various soils and composts showed a surprising range of resistances, from about 3 kΩ to about 30 kΩ and further enquiry proved (as might have been expected) that soil acidity and probe dimensions also varied the readings; in particular the use of dissimilar metals for the probe tips gave enormous variations. Indeed some soil-probe combinations seemed to be trying to produce a reverse resistance reading when used in one way and then nearly full-scale - zero resistance - when the probe connections were reversed. The probe electrodes *must* be of the same metal, preferably solid and not plated.

Initial circuitry suggested that a fairly sensitive micro-ammeter would be needed, or at least an amplifier to drive a less sensitive instrument. A gardener could easily drop the completed apparatus and this could be an expensive accident; also, a pointer-type instrument led to queries about the 'needle is 2 mm further than last time', and 'not the same reading as last week' when (potted?) field trials were carried out in greenhouses. An LED display was therefore chosen as being cheaper, very robust and giving sufficiently repeatable results.

Construction

All the components with the exception of the LEDs, PB1, and SK1, which are mounted onto the front panel, are carried by the PCB. RV1, the sensitivity adjustment potentiometer, is made accessible via a hole drilled in the case.

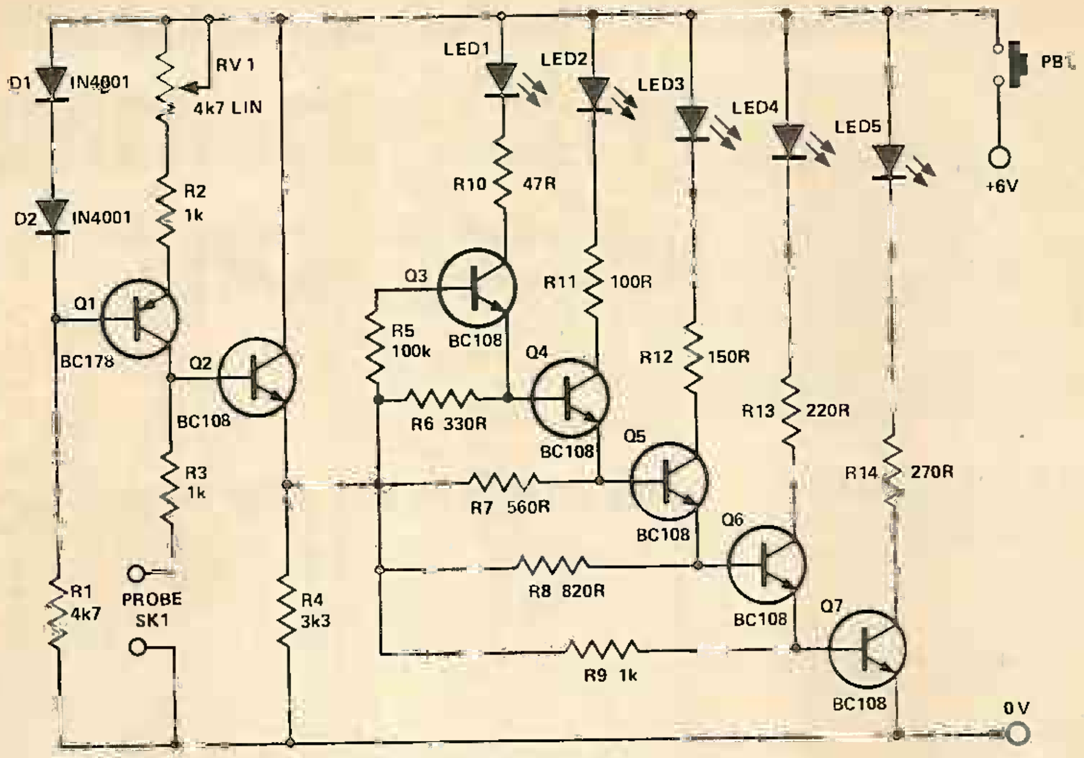
The most taxing part of constructing the device is the actual 'building up' of the probe. Ours was fabricated from a Japanese ¼" mono jack plug. Remove the cap, and upon inspecting the contents within, you will see that the tip contact is held in place by what appears to be a splayed rivet.

Take a file to this until the contact comes away freely. You can now remove the tip contact, earth contact and a spacing washer. However, we've not done yet. Hold the knurled 'body' of the plug in a vice or strong pliers, and physically pull the barrel out of it! (It may be necessary to make a small saw cut across the thread in order to achieve this.)

The barrel and tip portion is all you need for this job. A plastic sleeve is now visible over the central rod, and this too can be pulled out. Solder the probe lead to this as shown below, fixing the rod in a central position with some Araldite or similar adhesive.

Mounting the probe assembly is largely up to you, but we found that a 'Biro Minor' ballpoint, which is a cheap and universally available device, accepted the barrel like it was made for it.

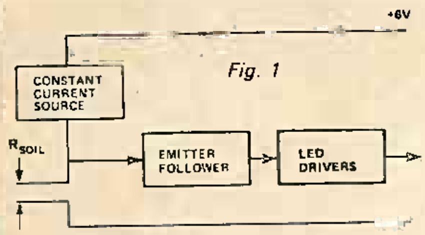
Wiring from the probe to the box should be strong but as flexible as possible, so that continued use does not take its toll and incorrectly monitored moisture drowns both your plant and reputation as a genius!



Circuit of the moisture indicator

HOW IT WORKS

Fig.1 is the basic diagram of the system. A constant current (preset to suit local soil conditions) through the probe tips, and the moist soil, produces a volt drop that is proportional to the resistance of the soil. This voltage then turns on an LED, which typically requires some 2 V at 15 mA for adequate brightness. A soil



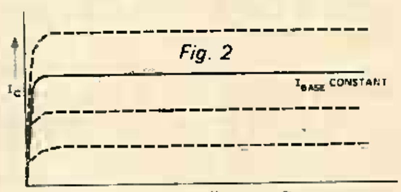
resistance that is higher or lower than that given by the correct moisture content should also be indicated, so five LEDs are incorporated to cover the range of 'too wet' to 'too dry'.

Using silicon transistors, an emitter-base voltage of about 0.6 V is sufficient to turn on the emitter-collector current of Q7 and further increase in voltage (or base current) then results in additional emitter-collector current flow if the load allows. By connecting Q6 emitter to Q7 base, Q6 base needs to be 0.6 V more positive than Q7 case, hence at about 1.2 V (at the base) Q6 as well as Q7 is conducting. Similarly Q5, 4, 3 will conduct at base voltages of 1.8, 2.4, and 3.0 V respectively.

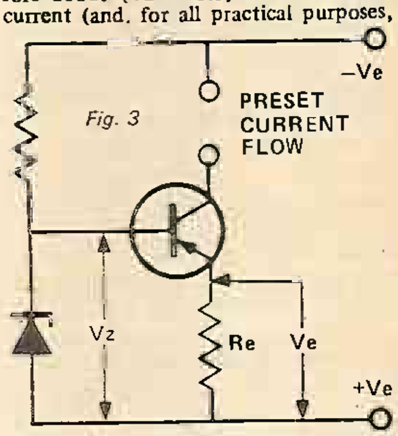
The current through an LED is limited to 15-20 mA by an additional series resistor (R10-14); the transistors Q3-7 are bottomed at this present collector current, a collector voltage then being only slightly more positive than its emitter when an LED is at full brilliance.

Resistors R5-9 are included to prevent the various base-emitter diodes from clamping the output of Q2 to a low value. The inclusion of these resistors and the required currents through them taken taken by the various bases means that the 0.6 V steps of voltage that should turn on Q3-7 are modified slightly. When the LEDs are illuminated the total base current drive for Q3-7 is in the order of 10-20 mA and this is supplied by Q2, an emitter follower.

A quick revision of theory reminds us that the collector characteristics of a transistor, Fig.2, shows a nearly constant-



current curve when the base is supplied with a steady value of current and voltage, this voltage being about 0.6 V. In Fig.3 the base voltage is clamped or set by a zener diode to a particular value, say Vz, and the emitter voltage is therefore about (Vz − 0.6) V. The emitter current (and, for all practical purposes,



the collector current too) is thus defined as Ie = Ve/Re and by selection of Re the value of Ie (or Ic) is determined. As long as there is about one volt between emitter and collector the collector current remains constant at this chosen value - or at least until a resistor or load of too large a voltage and so robs the collector of its working voltage.

With only a 6 V supply Vz must be as small as possible and once again the fact that a forward biased silicon diode drops about 0.6 V is used. The two series-connected diodes D1-2 maintain Q1 base at about −1.2 V and the voltage drop across R2-RV1 is about 0.6 V.

PARTS LIST

RESISTORS (all ¼ W 5%)

R1	4 k 7
R2,3,9	1 k
R4	3 k 3
R5,11	100 R
R6	330 R
R7	560 R
R8	820 R
R10	47 R
R12	150 R
R13	220 R
R14	270 R

POTENTIOMETER
RV1 4 k 7 hor. min. type

SEMICONDUCTORS

Q1	BC 178
Q2-7	BC 108
D1, 2	IN 4001
LED1-5	.2" type

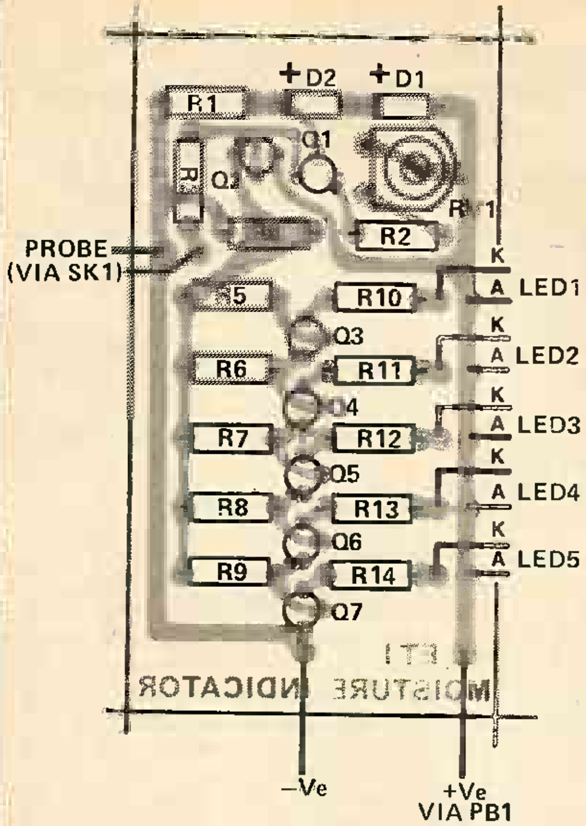
SWITCH
P.B.1 Push to test type

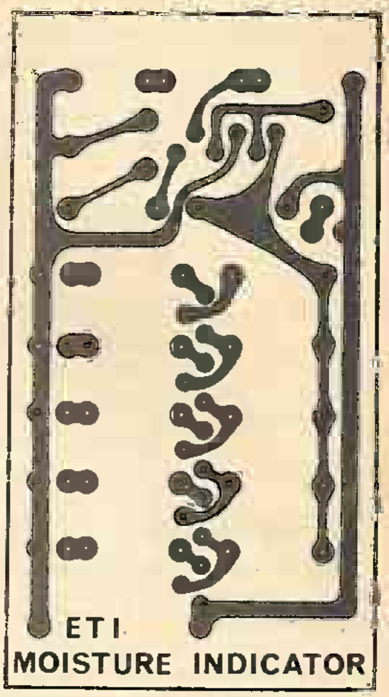
SOCKET
SK1 3.5 mm panel jack socket

PROBE
See text (¼" mono jap. type jack plug, Biro 'Minor' ball point pen)

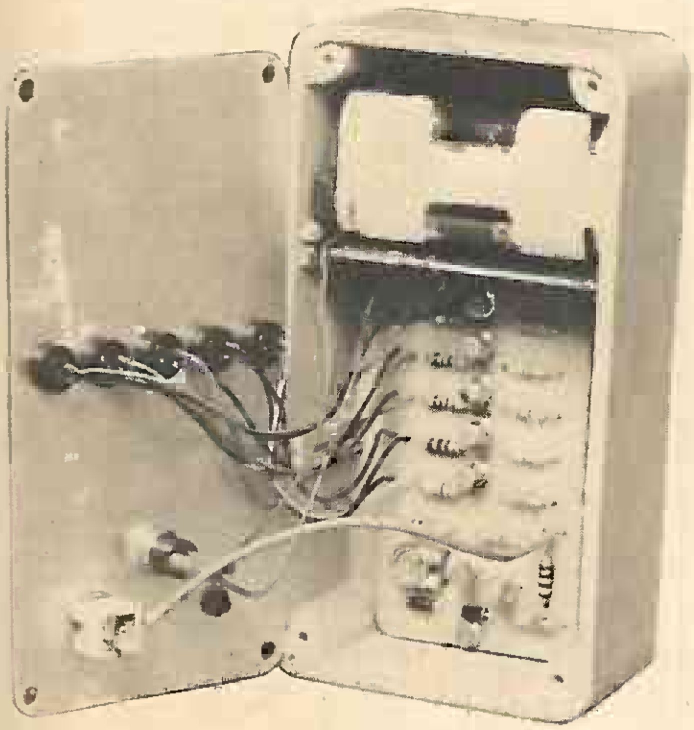
CASE
5¼" x 2⅞" x 1½" / 134 x 73 x 38 mm

MISCELLANEOUS
Battery holder (4 x HP7), battery clip, screened wire, wire, Araldite, 3.5 mm jack plug, pcb as pattern.

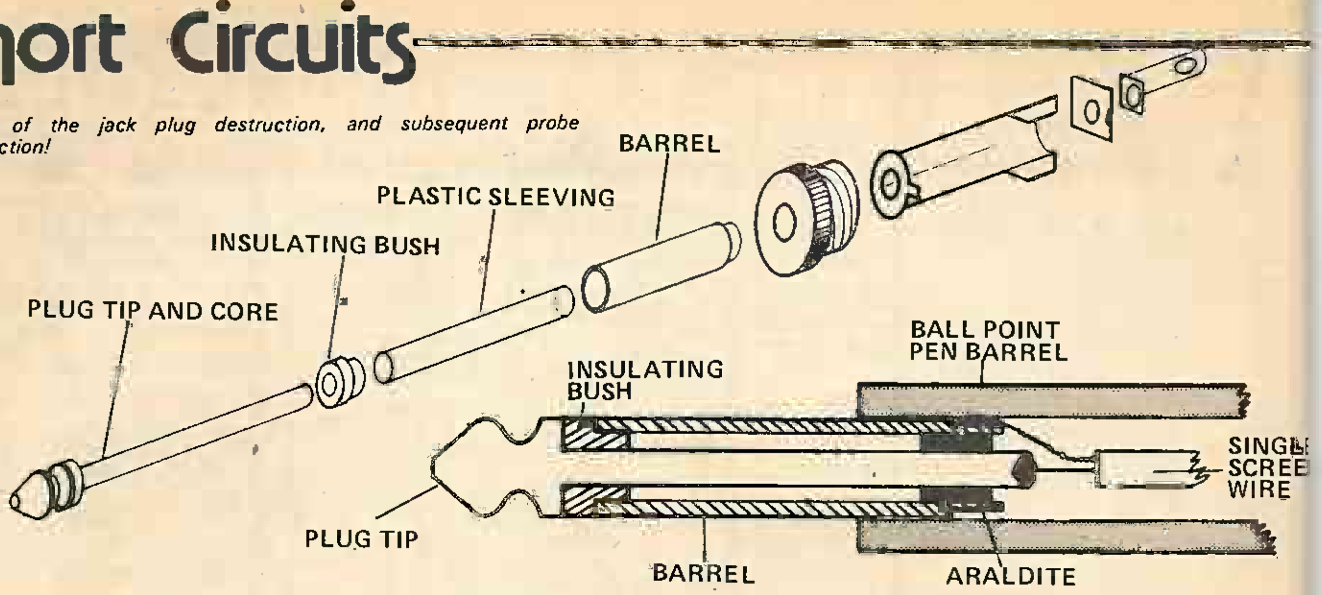




Above left: Component overlay for our Soil Moisture Indicator. The only thing to be careful of here is the orientation of the semiconductors.
Above right: Full size foil pattern for the PCB. This will be available from all the usual suppliers (see Mini-Ads) by the time you read this.
Below: Just to prove it works! A shot of the unit actually in use at the ETI Rubber Plant Department, being deftly weilded by our resident doddering old bearded gardener!



Details of the jack plug destruction, and subsequent probe construction!



Testing and Using

Before connecting the supply to the board, check carefully there are no 'bridges' present lest they lead you to troubled waters.

With the probe 'dry' all the LEDs should come on. With a short-circuit across it (i.e. VERY wet!) not one should be lit. Check the range of current in the probe, by short-circuiting with a milliammeter, to be about 0.1 mA to 0.6 mA approx.

Push the probe into soil of what you consider correct moisture, and adjust RV1 to light three LEDs. More moisture than this then lights *fewer* LEDs, whilst a drier soil lights more.

Perhaps one usage for this would be if you trotted off on holiday, leaving some willing person to take care of the plant-life while you sample the night-life. Once set the indicator could ensure that your instructions are carried out faithfully, and you don't return to see your favorite rubber plant impersonating a water-lily.

BUYLINES

The probe for this project was constructed from a ¼" Japanese mono jack plug, and a 'Biro-Minor' ballpoint pen available from most stationers. The case is a Norman F.B.1 fibre glass type available from H.L.Smith, 287 Edgware Road, London, W.2. at approximately £1.20 inc. VAT and p&p. All other components should be easily obtainable.

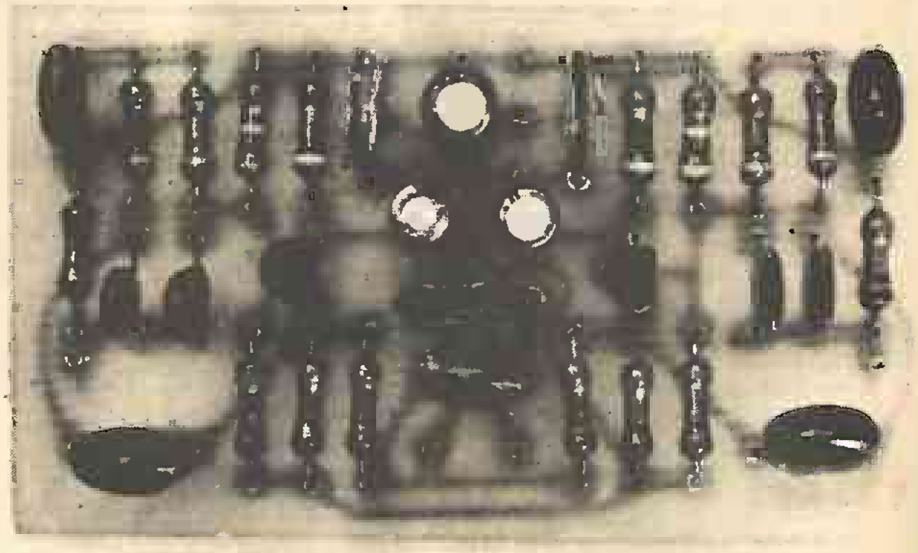
The approximate cost of construction, including box, is £6.50 inc. VAT.

ELECTRONIC BONGOS!

MANY musical instruments can be simulated with sometimes astonishing accuracy by electronic circuitry. Complex circuits in the form of electronics synthesizers, can reproduce virtually any sounds that one can imagine.

Regrettably though at the present state of technology even a basic music synthesizer is an expensive and complex undertaking, and is beyond the scope of a series such as this. Nevertheless providing one attempts only to simulate a limited range of sounds some extremely realistic effects can be obtained without too much complication.

This article shows how to build up a circuit which simulates the sound of bongo drums. The finished unit is played in basically the same manner by tapping one's fingers on a pair of plates — one for each 'drum'.



Construction

The touch plates may be made of any electrically conductive material — copper, brass, stainless steel, aluminium, etc. Size and shape is not critical — they need to be at least 50 mm across but they may be much larger than this if desired — and round, square, triangular or whatever you will!

The finished unit may be housed as you wish in a box — built into another instrument — or even made up as a full-size or miniature replica of a bongo drum. But if you use a metal case you must have the touch plates insulated from the case and spaced away from any metal surface by at least 25 mm.

Potentiometers RV1 and RV3 are used only in the initial setting up procedure — easy access is not essential. Potentiometer RV2 controls the level of sound output and is required if the unit is to drive an amplifier which has no built-in volume control. If desired this potentiometer may be omitted from the board and replaced by a larger rotary potentiometer located away from the circuit itself. If you do this you'll need a 50k half watt rotary device (logarithmic curve). Connect it as if you were using the original potentiometer — except that now you're doing it via three bits of wire.

When the unit is assembled check out all connections and check all tracks to ensure there are no solder 'bridges'.

Setting up

Connect the unit to a suitable amplifier and loudspeaker. Connect the battery and then switch on the amplifier — keeping the volume control at a low setting.

Rotate RV1 to minimum setting and RV2 to about mid-way. Transistor Q1 should now be oscillating and you should head a sound from the loudspeaker. Now turn RV1 until the oscillation just stops and touch the associated touch plate momentarily. This should cause the circuit to produce a 'bong' sound which then decays away. Continue to adjust RV1 until a realistic bongo sound is reproduced.

Now repeat the operation for the second oscillator by adjusting RV3. Turn the amplifier up loud and play away!

Extending the circuit

The components specified will result in frequencies of about 290 Hz and 400 Hz. These frequencies are determined by C1, C2 and C4 (for the left hand part of the circuit) and the corresponding C9, C10 and C11. The frequency produced is inversely proportional to the values of these capacitors. Thus doubling their value will halve the 'bong' frequency. If you change the frequency maintain the same approximate ratios between capacitor values.

If you are ingenious and/or have some knowledge of electronics it is quite possible to extend this circuit so that you have a whole series of oscillators of different frequencies. The circuit is totally symmetrical except for the capacitor values mentioned above, so all you do to build up 'half circuits' — all connected to the common battery — and with their outputs connected to the point on the circuit which is the junction of R8, R9 and R6.

It is also possible to build the circuit using a range of switched capacitors to provide the tonal range you require.

HOW IT WORKS

The circuit consists of two twin-T type sine-wave oscillators. Each is virtually identical - there is one per touch plate.

Each oscillator has a filter in the feedback loop. If the loop gain is greater than unity the circuit will oscillate. In this application the gain is adjusted to be just less than unity. Touching 'touch plate' force starts the oscillator but the moment one's finger is removed from the touch plate oscillations will die away. The rate of decay is of course a function of circuit gain and this is controlled by RV1 (and RV3).

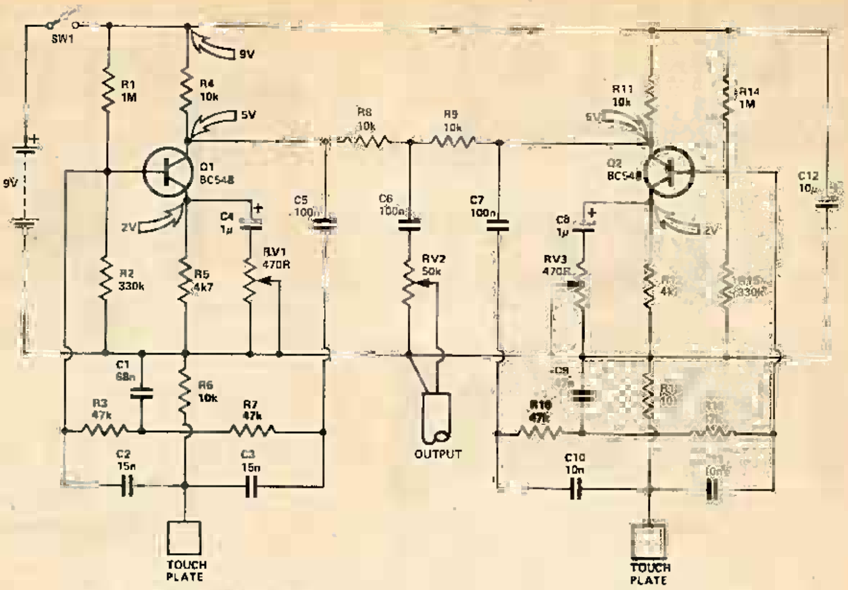
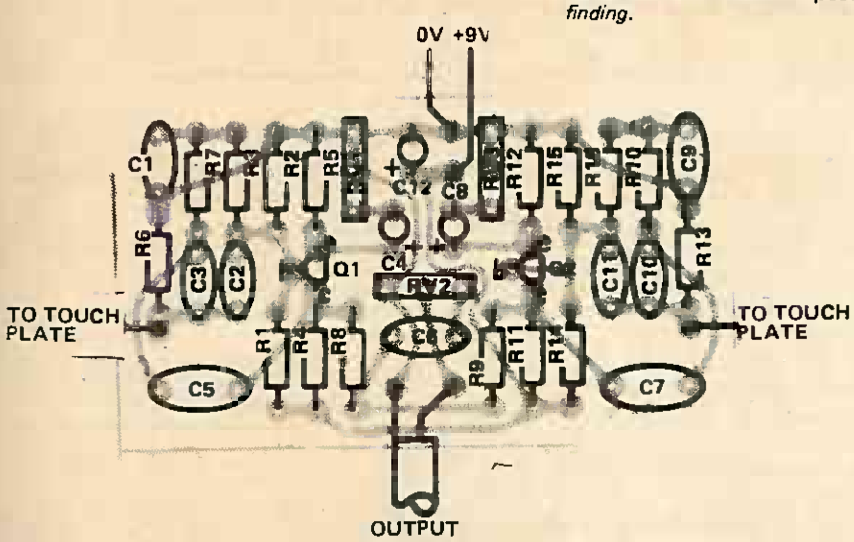
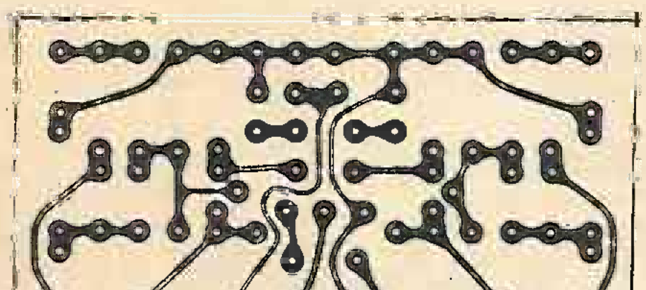


Fig. 1. Circuit diagram for the bongo circuit. Note that the voltages given around the circuit are all with respect to ground, and are intended as an aid to fault finding.



Above: The component overlay for the design. The board is symmetrical which may or may not make it easier to get working as there is a good chance one half will work first time! No case details are shown as the board will probably be built into something else.
Below: The foil pattern, shown full size.



PARTS LIST

RESISTORS (all ¼ W 5%)	
R1,14	1 M
R2,15	330 k
R3,7,10,16	47 k
R4,6,8,9,11,13	10 k
R5,12	4 k 7
CAPACITORS	
C1	68 n polyester
C2,3	15 n polyester
C4,8	1 u 16 V electrolytic
C5,6,7	100 n polyester
C9	47 n polyester
C10,11	10 n polyester
C12	10 u 16 V electrolytic
SEMICONDUCTORS	
Q1,2	BC 548 or BC 108
POTENTIOMETERS	
RV1,3	470 R vert. trim type
RV2	50 k vert. trim type
SWITCH	
SW1	off-on rocker or toggle
MISCELLANEOUS	
pcb as pattern, PP3 battery and clip, screened wire, metal for touch plates.	

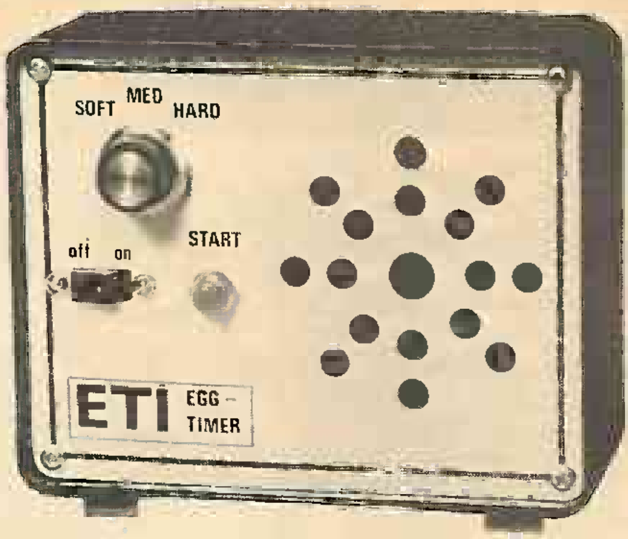
BUYLINES

All the components used here should be readily available; if the BC 548 cannot be purchased then the BC 108 will be o.k.

The total cost of the project, excluding a box should be about £3.00 inc. VAT.

Get to work on our

EGG TIMER



This design uses two integrated circuit chips to provide a versatile and accurate timer for your kitchen

THE ANALOGUE MINERAL egg timer that has been used in the kitchen until now has a number of serious drawbacks. The main one being that when it has finished "doing its thing" it does nothing to draw attention to the fact. Instead it sits quietly on your shelf while your attention is elsewhere and your egg is becoming decidedly hardboiled.

Our egg timer gets over this problem by giving you a shout when it feels that your breakfast is ready.

Getting it together

Construction is made easier if our PCB layout is used, pay particular attention to the orientation of the integrated circuits and electrolytic capacitors during assembly. When the board is finished, make a quick check of the soldered joints, also check that there are no solder bridges.

Our pictures show how we mounted the PCB board and the layout of our front panel.

As you like it

The preset resistors, RV1, 2, 3, can be adjusted to provide the following range of times depending on the position of SW2:

Soft	2½ — 3 mins
Medium	3½ — 4 mins
Hard	4 — 5 mins

To use the timer, switch on SW1 and press PB1. The timer will operate after the period selected by SW2 has elapsed.

The unit uses very little current in its timing mode but a lot more when it is producing the tone. So, for long battery life, do not leave the unit switched on and producing a noise for too long.

BUY LINES

The project was based on readily available components obtainable from most stockists. SW2 was a 2 pole 3 way type using only one half. LS1 is the Eagle TP26G (80 R) and the case came from Doram.

The cost of construction, including VAT, should be approximately £6.00.

HOW IT WORKS

The timer is based on the 741 op amp, IC1. R1 and R2 hold the inverting input at half supply voltage. Pin 3, the non-inverting input, is connected to the junction of C1, PB1 and SW2.

SW2 selects one of three resistor and potentiometer combinations, the value of this combination determines the timing period.

Upon operating PB1, to discharge C1, the voltage on C1 will increase towards the supply rail at a rate determined by the resistors selected by SW2.

When the voltage on C1 reaches half supply voltage the output of the 741 will swing from nearly 0 V to near to positive supply rail.

The time taken for the 741 to change O/P state is approximately 0.7 CR seconds where C is in Farads and R in Ohms.

The second IC is a 555 connected as an astable oscillator which a frequency of about 800 Hz.

When the O/P of the 741 is near 0 V the transistor Q1 is biased off and the 555 has no power applied to it. When the 741 changes state, Q1 turns on, allowing the 555 to oscillate and the tone is produced.

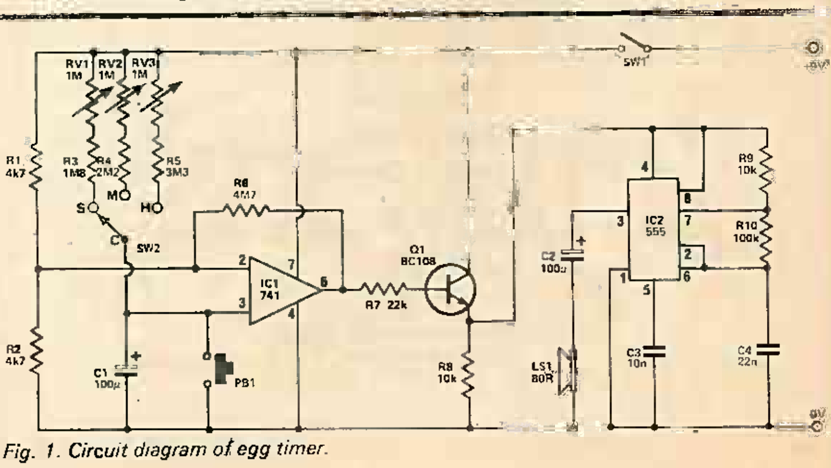


Fig. 1. Circuit diagram of egg timer.

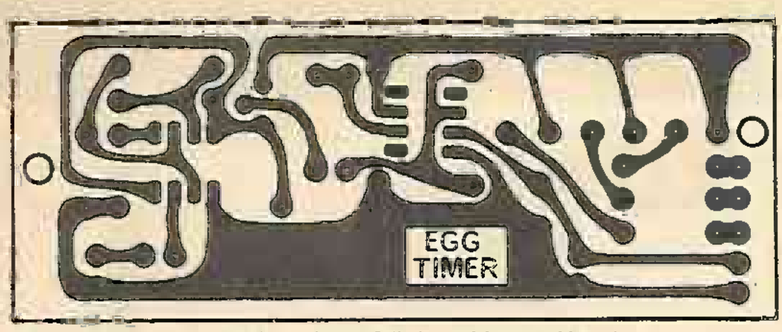


Fig. 2. Foil pattern of egg timer shown full size (100mm x 40mm).

PARTS LIST

RESISTORS (¼ W 5%)

R1,2	4 k 7
R3	1 M 8
R4	2 M 2
R5	3 M 3
R6	4 M 7
R7	22 k
R8,9	10 k
R10	100 k

CAPACITORS

C1	100 u 10 V tantalum electrolytic
C2	100 u 16 V electrolytic
C3	10 n polyester
C4	22 n polyester

POTENTIOMETERS

RV1-3 1 M min. hor. trim type

SEMICONDUCTORS

Q1	BC 108
IC1	741
IC2	555

SWITCHES

PB 1	push to test type
SW1	off-on rocker or slide
SW2	1 pole 3 way rotary

LOUDSPEAKER

LS1 80 R type (Eagle TP 26 G)

CASE

DORAM type M3 (984-526)

MISCELLANEOUS

pcb as pattern, PP6 battery and clip, knob, rubber feet, wire, etc.

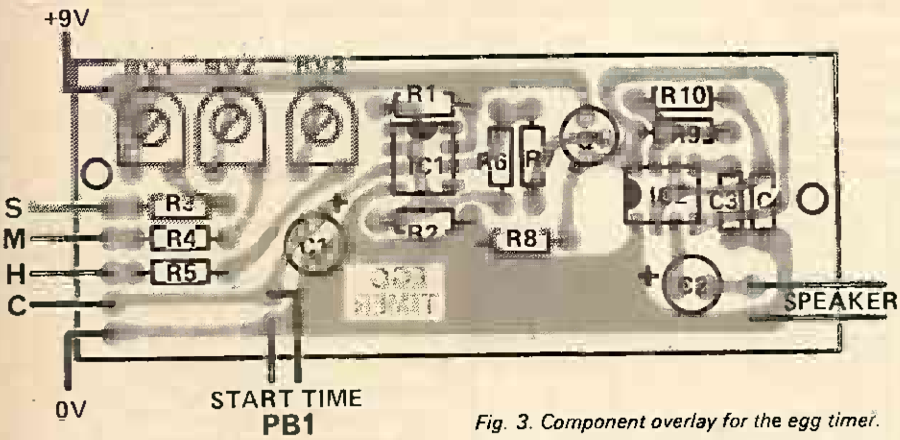


Fig. 3. Component overlay for the egg timer.

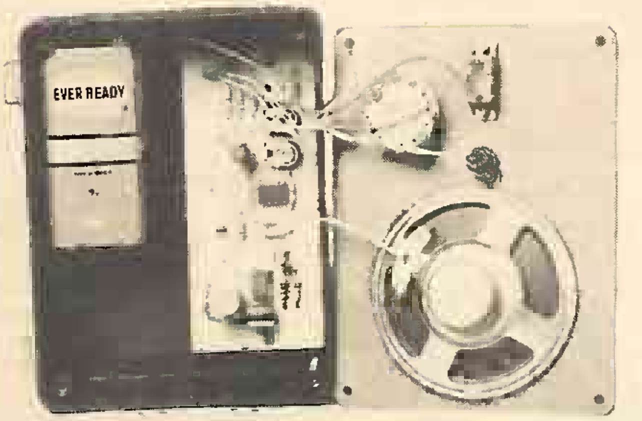
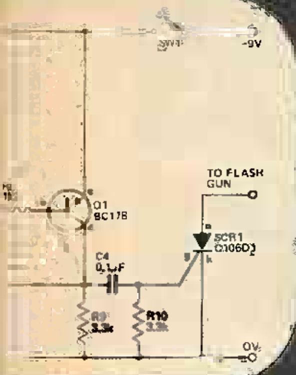
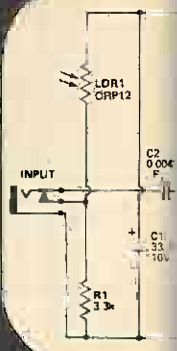


Fig. 4. View of the interior of the egg timer showing the location of the major components.



ELECTRONICS IN PHOTOGRAPHY



BY IAN SINCLAIR

FOR SOME CONSIDERABLE time now, there have been close links between electronics and photography. Glancing through past issues of ETI, for example, we find a fair number of projects of particular interest to keen photographers, and a look through past copies of "Amateur Photographer" shows the appreciation of the role of electronics shown by our photographic kindred. This article sets out to describe how electronics is involved in photography today, as it affects the keen amateur and the professional.

Electronics circuits, ranging from the very elementary to the extremely complex, become involved with photography at almost every step in the photographic process; at the camera itself, in the darkroom, and in slide and cine projection. Some of the electronic circuits that are used will be familiar, others less so, and we assume that the readers of this magazine are much more familiar with the electronic circuits than with the photographic processes.

Exposure Control

One of the earliest applications of simple electronics to the camera was exposure metering and, later, control. The amount of darkening of a given photographic film is decided both by the intensity of the light that reaches the film, and the duration for which the film is exposed. The intensity of light (luminous flux) reaching the film is regulated by the iris of the camera, a variable opening placed close to the lens, or built into the lens by placing it between the elements (separate glass pieces making up the lens). The timing is decided by the open time of another aperture, the shutter, which opens when the shutter release is pressed, and closes a preset time later. From fairly early days, shutter timings were obtained by using clockwork mechanisms that were reliable and robust. Today with smaller cameras in use, and more objects of interest moving, the range of shutter speeds has had to be increased to cope, and the regulation of the light level by an iris is used to a greater extent; the shutter speed is set to a value capable of "freezing" movement (of object or photographer) and the iris is used to set the light level for the correct exposure. This is why camera electronics are so devoted to controlling the iris, leaving shutter control in a lesser rôle.

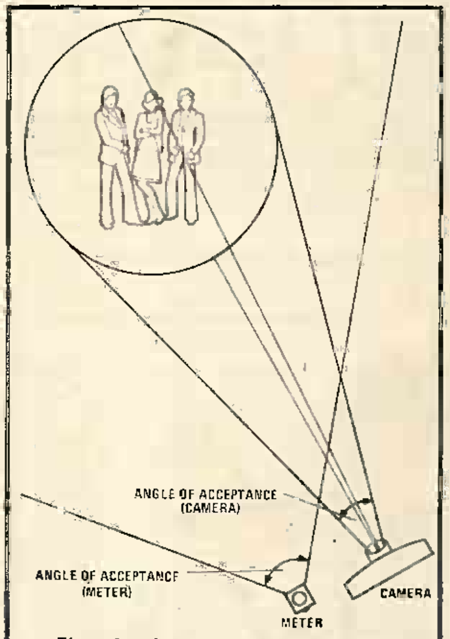


Fig. 1. Acceptance angles. The amount of light passing through a camera lens is not usually the same as the amount passing through the window of a separate exposure meter. This problem is more apparent when a telephoto lens is in use.

The first efforts concerned metering rather than control; consisting of exposure meters, using selenium cells driving moving-coil meters. The problem of these meters, which can produce excellent results if used properly, is that the light reaching the meter may not be proportional to the light reaching the lens (Fig. 1). The problem becomes more apparent when telephoto lenses are used, since there will be little relationship between the light entering the lens and the light entering the meter. One partial solution, still used, is the "incident light" reading, in which the meter, fitted with a diffusing cone, is pointed at the light source and the resulting reading used in setting the camera aperture.

The combination of colour slide film, which needs fairly exact exposure, with interchangeable lenses and the single-lens reflex system called for some improvements in light metering systems. Single lens reflex cameras use a mirror at 45° to the light path to divert the light path to

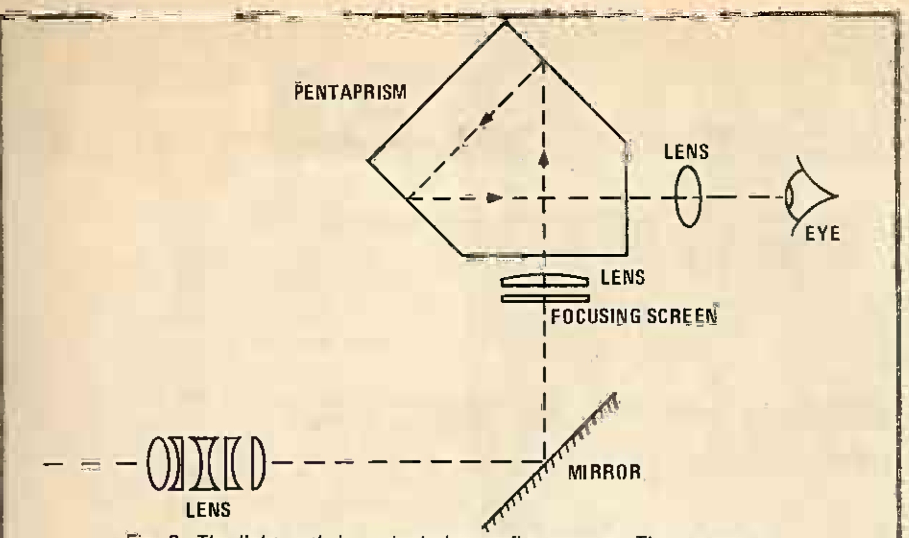


Fig. 2. The light path in a single-lens reflex camera. These cameras use a mirror at 45° to the light path to divert light to the viewfinder which therefore shows an image identical to the one that will appear on the film.

the viewfinder (Fig. 2), which therefore shows an image identical to the one that will appear on the film. Since the viewing is done through the lens, there is no parallax problem caused when close-ups are taken, as there would be if a separate viewfinder were used and specialised work such as photomicrography becomes possible.

TTL Metering

The next logical step is to place the exposure meter somewhere in this reflex viewing system, so that the light coming through the lens also operates the exposure meter. Right away we come up against a problem that still divides good quality cameras into two groups — shall this light reading be taken at one point in the image (a **spot** reading) or should the photocell be affected by the total amount of light entering the lens (an **average** reading). If the reading is a spot one, we must be certain that the spot is located on a piece of the picture we most need to be correctly exposed, so that we can take this reading. If the reading is an average one, we must be sure that the exposure will not be faulty because of a misleading average.

The use of TTL (Through The Lens) metering, whether spot or average, demands the use of cells much more sensitive than the old selenium type. Cadmium sulphide cells have been used for some time; since they are photoresistive, not photovoltaic, they need a battery. They are also much more sensitive to red and infra-red than the eye or the usual run of films so that some light filtering must be used to correct the balance of the light reaching them.

Indication

The first types of TTL cameras used the cells to indicate correct exposure, which had then to be set by the user after taking the meter reading. Very soon, this developed to a system still used today in which the setting can be done while the image is viewed in the finder. The needle of the exposure meter appears in the viewfinder along with a marker coupled to the iris control. Aligning the marker and the needle by opening or closing the iris control sets the iris to the opening called for by the metering, but the photographer can, from experience of the type of subject and lighting, modify the setting as needed. A more "electronic" modification of this method, pioneered by Yashica, uses two LED displays (Fig. 3 c,d,e), one shaped as a U, the other as a ∩. A U displayed means that the iris is set for underexposure, an ∩ indicates overexposure, and a complete oval indicates correct exposure, for average light reading. Once again, the experienced user can modify the setting.

These systems, though simple, still demand considerable design expertise. The exposure indication is controlled by four quantities: film speed, shutter speed, iris setting and subject illumination, so that variation of any of these quantities will affect the readings. Since the resistance of the cell is determined by the amount of light reaching it, the compensation for film speed and shutter speed must be made by altering other parts of the system, either electrically by potentiometers in the current path, or optical, by neutral density filters in the light path.

With film speed set according to the type of film in use and the shutter speed set for coping with the motion of the subject or camera, the object is viewed and the meter needle position matched by the marker ganged to the iris opening. This scheme has the disadvantage that the image in the viewfinder might be very difficult to see if the iris is at a small aperture

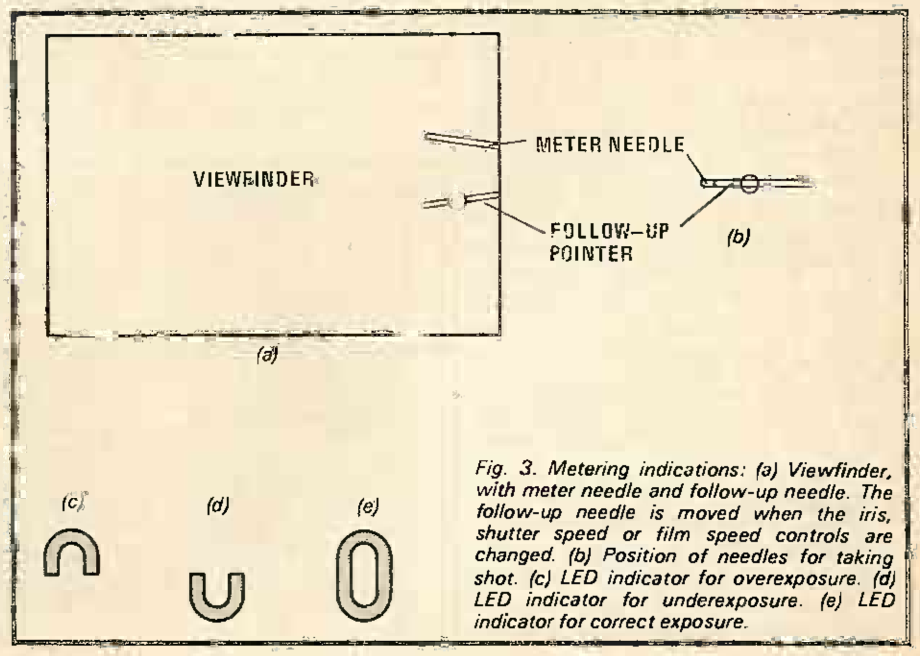


Fig. 3. Metering indications: (a) Viewfinder, with meter needle and follow-up needle. The follow-up needle is moved when the iris, shutter speed or film speed controls are changed. (b) Position of needles for taking shot. (c) LED indicator for overexposure. (d) LED indicator for underexposure. (e) LED indicator for correct exposure.

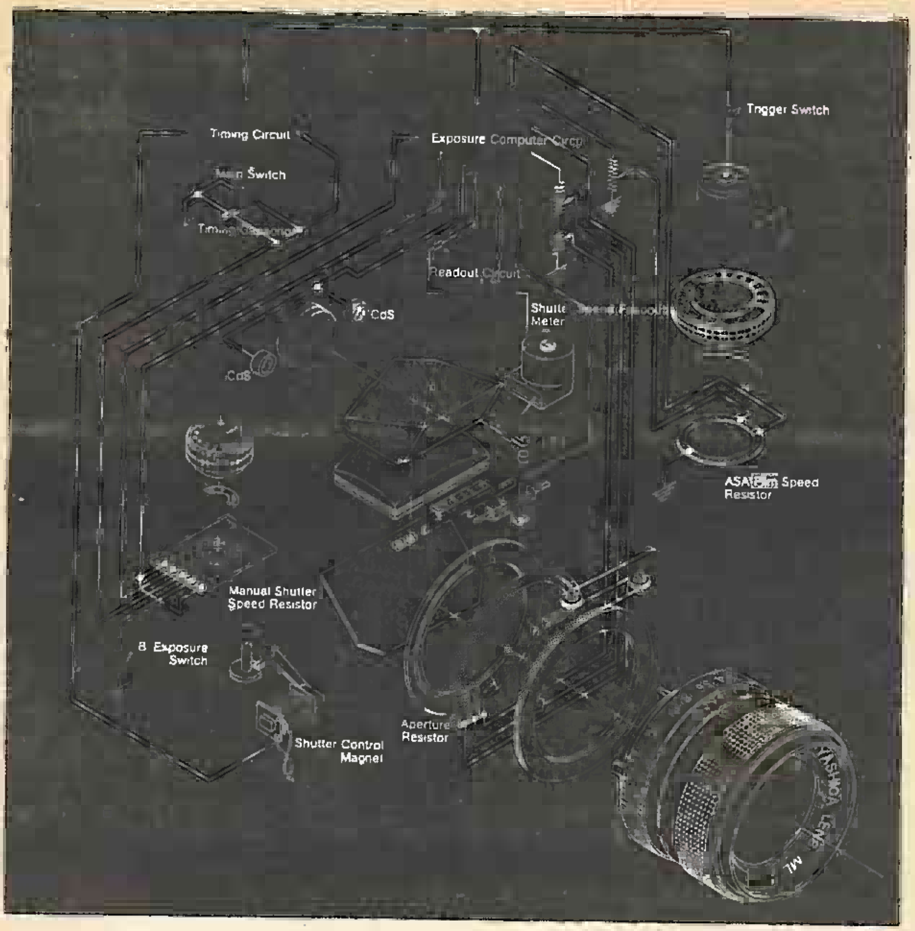


Fig. 4. Yashica FXI open aperture control system.

(stopped down) so that the next design step was full-aperture finding. This comes in two types, full aperture viewing or full-aperture metering. In each case, the iris can be fully open until the shutter release is pressed; the aperture is then changed to a preset value just before the shutter opens. In full aperture metering, the iris control ring affects the meter sensitivity and presets the iris control without changing the setting of the iris, which remains at full aperture, hence the name, for a bright display in the viewfinder. When the release is pressed, the iris is set, and the shutter operates. In simpler types of camera, viewing for focusing is done at full aperture (and cannot easily be done at reduced aperture) but the iris is stopped down when the metering system is switched in. With this system, the metering can be switched in momentarily to set the iris; if left in place, the system can reset after the release has been pressed.

Automatic Camera Systems

The final step in this progression is to use the photocell(s) to control the iris directly, with an over-ride to enable the photographer to adjust the exposure if he wants to. A block diagram of the system used in the Yashica FX1 is shown in Fig. 5. The IC in this system has been developed for Yashica, and comprises a set of comparators into which information on film speed, shutter speed, and iris setting is fed, along with the input from the cells. Since d.c. amplification is easily carried out using ICs, cadmium sulphide cells have now given way to silicon cells which, though less sensitive, can be made much smaller and have a colour response that matches the films (whether colour or black and white) much better.

Time Control

For many years, the Compur shutter was the ultimate in timing. Pressing the shutter release opened a set of interlocking shutter blades situated between the lens elements and started a clockwork timer that closed the blades again after the preset time. With additional spring assistance, times of 3 ms or less were obtainable. The demand for interchangeable lenses and faster times led to the development of the focal plane shutter, the first types of which resembled a miniature roller blind with a slit of the same width as the film. This roller blind is set parallel to the film, and when the shutter release is operated, the slit is drawn rapidly across, exposing the film.

The modern focal plane shutter consists of two blades operated electromagnetically rather than by clockwork. This makes the release action smoother, and enables the camera to be operated by remote electrical contacts. The principle used is that pressing the shutter release button activates a solenoid that pulls the blades of the shutter apart, and also starts charging a capacitor through a resistor. At a set level of voltage on the capacitor, the current through the solenoid is switched off, and the blades are closed by a spring or by another solenoid. The timing here is achieved by capacitor charging, a familiar electronic principle, rather than by mechanical gearing, so that the speed is infinitely variable as compared to the set speeds obtainable with mechanical action. To conserve battery charge,

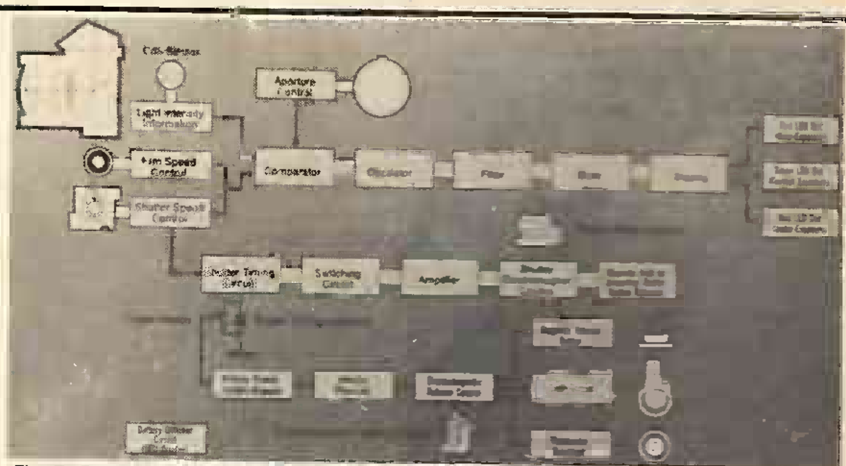


Fig. 5. Complete Yashica FR systems block diagram.

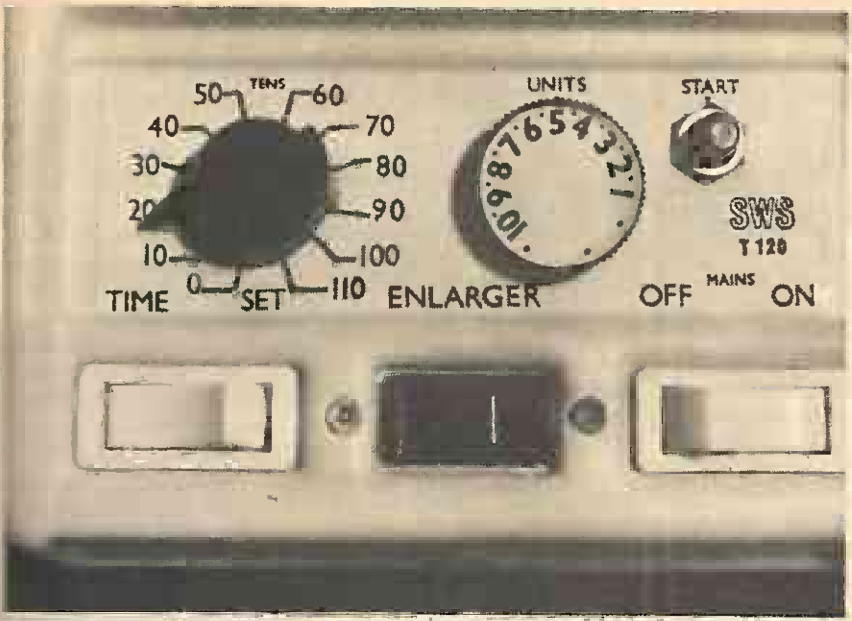


Fig. 6. Photograph of author's enlarger timer

However, the slower speeds are usually of set values obtained by mechanical operation, electrically triggered; this also avoids the problems of very long time constants, which would call for large capacitance and resistance values.

Darkroom Electronics — light readings

The design and construction of electronic devices for the darkroom is simpler than the corresponding work in cameras, because there are practically no restrictions on size or power supply. Whereas camera electronics must be fitted into the space available on a camera, and operate at the low voltage and current obtainable from small long-life cells such as the manganese alkali or silver oxide types, darkroom electronics equipment can be of any reasonable size and shape and can also be mains operated. The darkroom operations of interest to us are measurements of enlarger light values and the timing of enlargements, possibly along with electronic control of the temperature of chemical baths, and voltage stabilisation of enlarger lamps. The requirements for colour printing are much more stringent than those for black/white printing, so that electronic aids, though very useful for B/W work, are of more use when a large amount of colour printing is done.

With the small format (36 mm x 24 mm) negatives used for so much work nowadays, nearly every print produced is an enlargement.

The enlarger is a high-quality projector arranged vertically so that the photographic enlarging paper (bromide paper) can be laid flat on a base-board and the negative, held in a carrier, used to project an enlarged image on to the paper. The amount of enlargement may be fairly small, such as to the "enprint" size, or very large. In each case, however, the amount of exposure time for the combination of negative and paper size must be determined.

The use of electronic exposure meters simplifies problems of exposure and colour correction considerably. For B/W work, the use of an enlarger exposure meter is most valuable when technical phtography (such as photographing circuits for ETI!) is carried out, since the density of negatives, the contrast range, and the amount of enlargement may vary much more than those of the family snaps. The simplest types of B/W enlarger exposure meters use ORP12 cadmium sulphide photoresistive cells operating moving coil meters or other indicators. The setting of the speed of the paper, which must be done using a test-strip, since manufacturers do not quote paper speeds for most materials.

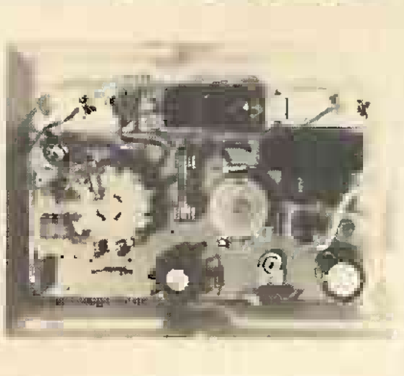


Fig. 7. Interior of unit shown above

For colour adjustment, much more elaborate meters are needed, preferably using silicon cells with amplification. The problem now is not simply that of exposure, but of adjusting the colour of the light in terms of three primary colours (red, green, blue) or their complementary colours, cyan, magenta, yellow. This requires three light readings, one for each colour, and the outputs should be in the form of colour correcting factors that can be supplied in the form of filters. In the simpler types of enlarger, a "filter drawer" is used between the condenser lens (used to make the light from the lamp converge into the projecting lens) and the main lens, and the readings on the colour meter are used to help select the correct filters. On the more expensive enlargers, the correcting filters are built in the form of a "colour head," controlled by three dials on the lamphousing. These are set to correspond with the meter readings, so carrying out the colour correction. Another reading taken from all three sensing cells is then used to determine the exposure time needed.

For the occasional colour print (and the cost in money and work will ensure that the prints will be occasional) the high cost of a colour analyser is quite prohibitive, matching the price of a good oscilloscope, but for regular colour work, particularly when very expensive materials are used, such as in the Cibachrome process, the cost is comparable with the price of the type of enlarger that will have to be used anyway, and can be justified if really excellent results must be attained.

Before leaving the darkroom, we should note that for colour processing, the temperatures of several of the solutions, notably the first developer and colour developer, are critical, needing control to within 0.25 C. This can be done by keeping all the bottles, along with the developing tank or drum, in a water bath, and the maintenance of the bath temperature is much easier if thermostatic control can be used. Conventional bimetalic thermostats have much too great a difference between switch-on and switch-off temperatures (differential), but an electronic type using a thermistor to sense temperature and a triac to control heating current can easily provide the amount of control that is needed.

Other Applications

Outside the darkroom, the applications of electronics mainly concern projectors, flashguns, and cine equipment. The capacitor-discharge flash gun, using a transistor inverter circuit to provide a few hundred volts to charge the capacitor, is well established. With the flash gun connected to the camera shutter contacts, the capacitor is discharged through a thyristor when the shutter is wide open, and the current flows through a tube containing Argon and Xenon gases at low pressure. The time of the flash is short, about 100 µs or less, which is very short compared to the shutter speed, and the usual arrangement is to have a fixed delay built into the camera, so that the shutter speed must be set to 1/60s, or to a part of the shutter speed dial marked with the letter X. The timing of the exposure is then entirely due to the flash, though complications can arise if the long exposure time allows some exposure in conditions of partial darkness.

A recent development is the triggered shut-off flash (or "computer" flash, as the advertisements dub it). In this system, a silicon cell detects the light reflected back from the subject in the first microsecond or so of the flash, and this cell then charges a second capacitor feeding a comparator. At a fixed value of voltage, the comparator fires a second thyristor that short-circuits the main capacitor, stopping the flash very rapidly. In this way, the camera can be left at a fixed setting and flash photos taken without the usual need to pace out distances and set the aperture of the camera each time. Other flash developments more familiar to the electronics constructor are light-triggered flash used to synchronise one flash gun to the flash of another, so filling in shadows, and sound-triggered flash, used for some "frozen-action" shots where the speed of sound can be used to provide a variable delay.

Projection

Slide projectors of the semi-automatic type, using a magazine of slides advanced by a remote-control that incorporates motor-driven focus, have become popular within the last few years now that reasonably-priced models have become available. A more recent development is the fully-automatic projector, with the automatic focus (also featured now on some enlargers). This is based on the principle that the light reflected back from a projection screen is greatest in intensity when the image is correctly focused. A photocell mounted at the front of the projector picks up the reflected light, and the output of the photocell is taken through a d.c. amplifier to a servo-system operating the focus screw of the lens. Because the photocell is part of a negative feedback loop, the system will settle with the lens in the position giving maximum reflected light, therefore in focus. The system is disabled during slide changing or in the absence of a slide in the carrier, to avoid having the servo-system hunt about for an impossible focus.

Another application of electronics to slide projectors of the automatic or semi-automatic types is the synchronised tape-slide show. To achieve this, using an ordinary reel-to-reel tape recorder, a synchroniser unit is needed. This consists of an additional tape head over which the tape is led on its way from the playback head to the take-up spool. The sound commentary is recorded on one track of the tape, and synchronising pulses via the additional (sync.) head on another track. On playback, each sync pulse at the sync-head is picked up and amplified to generate a pulse of sufficient amplitude to operate the slide-change switch. In this way, the slide changing can be synchronised exactly to the commentary providing that the order of slides in the magazine is unchanged. The pulses are placed on the track by setting up the equipment for recording, and changing the slides at the appropriate times. The pulse at the projector socket is now used to generate the sync signal, and this is recorded on to the tape at the sync head.

Fig. 8. A modern flash gun, with automatic flash cut off. The small silicon cell that detects the reflected light can be seen in this view.

Finally, the closest marriage between photography and electronics occurs in modern cine sound. This is such a specialised field that even to start on cine sound systems would take up much more space than can be justified here, and we can only note that the use of Dolby noise reduction looks like making the optical sound system, in which the sound is recorded in the form of light-and-dark bands on the film, a very serious rival for the magnetic tape stripe systems that have dominated cine sound for years. The important advantage of optical sound is "lip-sync," meaning that the synchronisation of sound and picture is close enough to permit views of people speaking, without the nonsense mouthing words that are not these being heard.

Looking to the future, it seems that the applications of electronics to photography will surely increase. At the time of writing, new colour printing systems are being announced at almost monthly intervals, new cameras appear with still more advanced electronics systems, and elegant applications of electronics appear in instruments that previously used only optical or mechanical techniques. One outstanding possibility for the future is a more electronic image formation process — we are still using the silver halide process for images (along with dye coupling for colours) that was being used over 100 years ago. In these days of electrostatic copiers, could we be at last heading for a film that will wean us away from silver? ●

VOCODERS!

THE EMS VOCODER (VOice CODER) is a machine that can change the age or sex of a talker, compress or expand the speech in time without varying the pitch and make normally inanimate objects speak!

For instance, an electronic organ or guitar could be made to speak or sing! Other tricks include that of freezing a sound in midword, making a single voice sound like a chorus, producing synthetic speech at constant or varying pitch, and many others. Several well-known artists and organisations have used or own Vocoders. These include the BBC Radiophonic Workshop, The Pink Floyd, The Who, Stevie Wonder, Kraftwerk, Tangerine Dream, all of whom have used them to produce dramatic effects on records, radio and television, as well as live on stage.

History

One of the first speaking machines that we know of was designed by a man called Kratzenstein back in 1779. He had a bit of trouble getting hold of ICs and so he designed his machine with bellows, vibrating reeds and acoustic resonators. His machine was capable of generating vowel sounds, but not much else.

In the late 1800s, Alexander Graham Bell had a bash at constructing a speaking machine, which again was mechanical and could only produce very poor quality speech. However he claims to have 'taught' his dog (a Skye terrier) to say "How are you Grandmamma?". This was done by making the dog growl and then manipulating its vocal tract by hand.

Other mechanical speakers were constructed but it wasn't until the advent of electronics that speaking machines became really practical. One type of machine that emerged was the Channel Vocoder, invented by Dudley (1939). This Vocoder was used to compress the band width necessary to send intelligible speech down, say, a telephone line.

Interesting Effects

However, as EMS has proven, the Vocoder can be used to do a whole lot of other interesting things. The Channel Vocoder operation is as follows, (fig. 1), speech is analysed into 22 frequency bands throughout the audio spectrum. The time varying energy levels in each channel is extracted by an envelope follower. This is in fact a real time spectrum analysis of the speech.

Another signal, the excitation, is introduced into the Vocoder. This is the signal that we will make talk. That is, if the excitation signal is a chord from an organ, we will end up with a talking chord. The excitation signal is also analysed into 22 frequency bands throughout the audio spectrum. However, the signal that is presented to each band is multiplied by a control voltage, which is the envelope signal from the speech channels. Thus the time varying spectrum of the speech is imposed upon the excitation signal, that is the excitation is filtered in a way entirely prescribed by the speech signal.

Realism

If realistic synthetic speech is required, the excitation used is a voltage controlled oscillator and a noise source. The oscillator is controlled in pitch by a pitch extractor and is used to synthesise the 'voiced' portions of speech. The 'unvoiced' portions, sounds like 's'

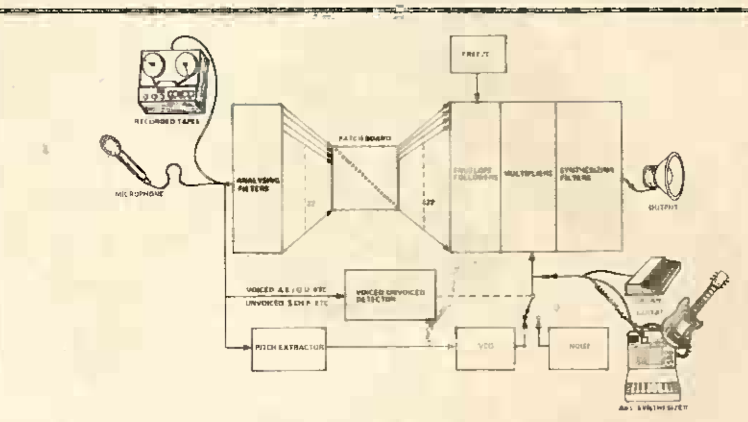


Fig. 1 Block diagram of the big Vocoder model (not illustrated). The model 2000 works in the same way but is simplified for stage (live) useage.

'f', 'th', are synthesised with the noise source. The synthesised speech can be modified by, say, shifting the pitch of the oscillator and shifting up the interconnection between analysing and synthesising channels. This will change a man's voice into one of a woman or a child. If the original voice and the synthesised voice are then mixed together, a 'double tracking' or chorus' effect is heard.

The first EMS Vocoder was designed by Tim Orr for West German Radio (Cologne). Since then he has designed two other types of unit (see photos), the larger one being for studio work, the smaller one, by virtue of its reduced size and portability, for live work.

So next time you hear something strange on the record, radio or TV, then maybe it's a, it's on the tip of my tongue, it's a V . . . . . .!

Two Vocoders are produced by EMS a big 22 channel one (as in schematic) which is yours for only £10 500 plus VAT. Possibly more within the reach of our readers is the illustrated Vocoder 2000 which is £2 500 plus VAT.

Further details from Electronic Music Studios Ltd, The Priory, Great Milton, Oxford.

"Fascinating feedback effects were readily produced even in these early Vocoder experiments involving larynx manipulation."

DESIGNING & USING ACTIVE FILTERS PART 2

CONTINUING TIM ORR'S INSTRUCTIVE SERIES DESIGNED TO HELP THE HOME CONSTRUCTOR EMPLOY ONE OF THE MOST USEFUL CIRCUIT BLOCKS AVAILABLE

The following section contains all the information needed to be able to build low and high pass filters, of first, second, third and fourth order to Bessel, Butterworth and Chebyshev characteristics.

Low pass

Figure 1 shows a first order low pass filter. In all the examples to follow the filters have been designed for 1kHz operation. Equal component value 'Sallen and Key' filters have been used as the basic building blocks. If operation at a frequency other than 1kHz is required, then the resistor/s Rf should be scaled accordingly, (the Rd resistors are not altered). For example, if operation is required at 250Hz, then the Rf in the chart must be multiplied by

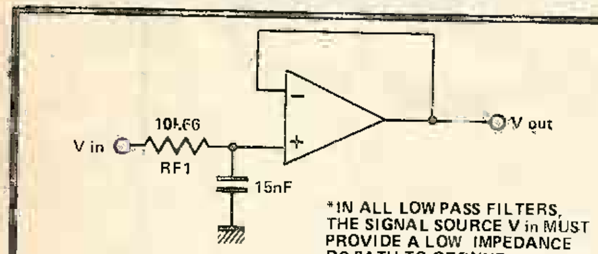
$$\frac{1000}{250}$$

which is

$$\frac{\text{(Normalised 1kHz)}}{\text{Required frequency of operation)}} = 4.$$

Figure 2 shows second, third and fourth order filters. The design procedure is as follows: –

1. Decide which type of filter is required, high, low, bandpass or notch.
2. In the case of high or low pass, decide which type of response is required, Bessel, Butterworth or Chebyshev.
3. Next, what filter order is needed. This will lead you to a particular order filter with components designed for 1kHz operation.
4. Scale the Rf components so that the filter will operate at the required frequency.
5. Build and test the filter.

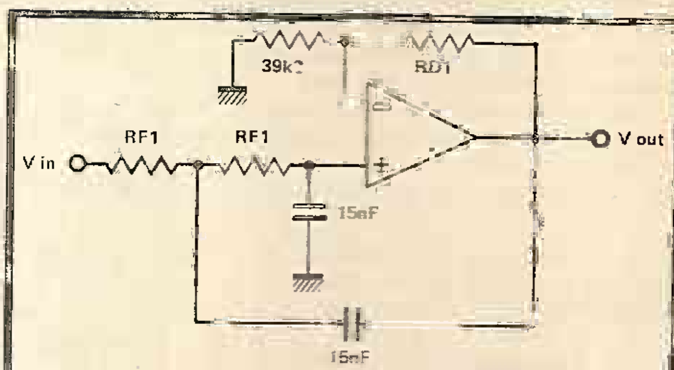


*IN ALL LOW PASS FILTERS, THE SIGNAL SOURCE V in MUST PROVIDE A LOW IMPEDANCE DC PATH TO GROUND.

	RF1	GAIN IN dB	COMPONENT TOLERANCES
BESSEL	10k66	0	10%
BUTTERWORTH	10k66	0	10%
CHEBYSHEV	10k66	0	10%

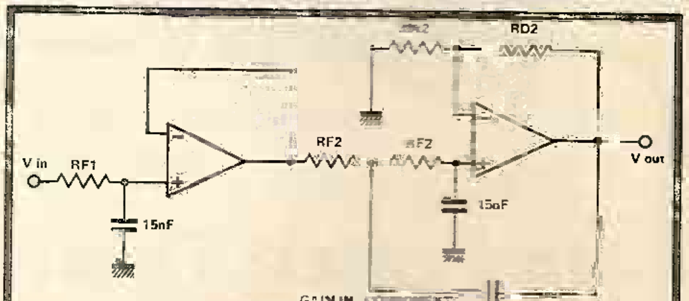
ALL THE RESPONSES ARE THE SAME FOR A FIRST ORDER FILTER

Fig. 1. A general circuit for a first order low pass filter.



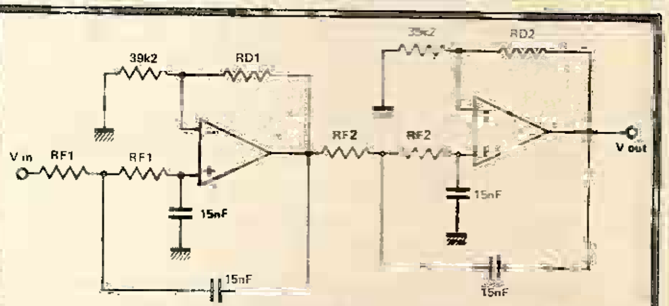
	RF1	RD1	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	8k39	10k5	2.3	10%
BUTTERWORTH	10k66	22k6	4.1	10%
CHEBYSHEV	12k6	48k7	6.8	5%

Fig. 2a Second Order low pass filter design break frequency = 1kHz.



	RF1	RF2	RD2	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	8k	7k26	21k5	4.1	10%
BUTTERWORTH	10k66	10k66	39k2	6.0	10%
CHEBYSHEV	35k41	11k73	66k5	8.6	2%

Fig. 2b Third Order low-pass filter. To alter break frequency (here 1kHz) scale resistors accordingly



	RF1	RD1	RF2	RD2	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	7k45	3k24	6k60	29k4	5.6	10%
BUTTERWORTH	10k66	5k9	10k66	48k7	8.3	6%
CHEBYSHEV	24k11	42k2	11k20	71k5	15.3	1%

Fig. 2c Fourth Order Low Pass Filter.

There are of course some problems which may occur. One is that these filters have a voltage gain in their passband. So you might find that although you have got the required frequency response there is an unexpected signal gain.

This may cause some problems with op-amp bandwidth. As a rule of thumb, the op amps should have 10 to 100 times more bandwidth than the product of the filters maximum operating frequency times the individual stage gain of each section. If the op amp runs out of bandwidth or introduces a phase shift then the filter is not going to work properly. For the examples given, if you use a 741 as the op amp then a frequency limit of approximately 10kHz should be imposed. (If an LM318 is used then the limit can go to 200kHz). Another problem is one of range of values of Rf. If Rf is made too small then large currents have to flow from the Op amp and this may effect the performance of the filter. If Rf is too large there may be hum pick-up problems and DC offset voltage problems due to bias currents. Therefore, keep Rf between 1k and 100k. If Rf needs to exceed this range, scale the capacitor as well.

Charting examples

As an example of using the design tables, let us solve the following problem. Design an audio 'scratch' filter, having a break frequency of 7.5kHz and an attenuation at 15kHz of more than 20dB. The first decision to be made is what type of response do we want? A roll off of more than 20dB/octave is quite steep and so the Bessel filter is ruled out. The Chebyshev filter has a poor transient response and at 7.5kHz we would hear it ringing. Therefore a Butterworth response should be used. Next, the filter order. Third order gives us — 18dB/octave which is not sufficient, fourth order gives —24dB/octave. Hence what is needed is a fourth order Butterworth design (fig. 2c).

The break frequency is 7.5kHz and so the resistors Rf1 and Rf2 have to be *divided* by 7.5. This gives Rf1 = 1k42, Rf2 = 1k42, Rd1 = 5k9, Rd2 = 48k7, C=15nF, and the component tolerance is 5%. Now we must fit preferred values to the resistors.

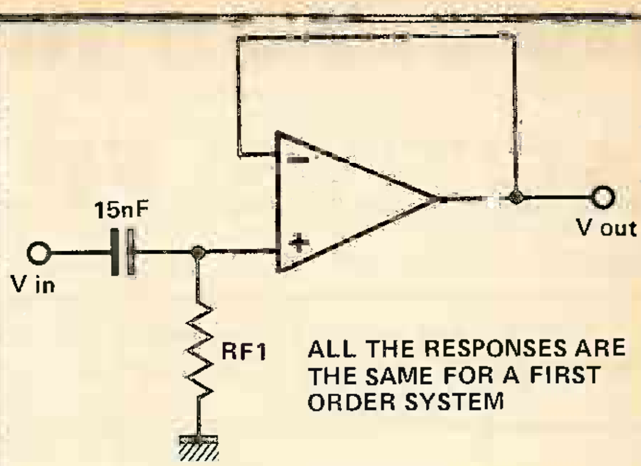
Rd2 becomes 47k, Rd1 becomes 6k2 (this is just over the limit of tolerance) Rf1 and Rf2 are a problem. Even when taken to the nearest E24 value they are outside the component tolerance allowed. There are two solutions; use the nearest E96 1% resistor or use 1k5. This will lower the break frequency by about 6%, but as this is only an audio filter no one will probably be any the wiser!

High Pass

Figure 3 gives the design tables for high pass filters. The design procedure is exactly the same as that for low pass filters.

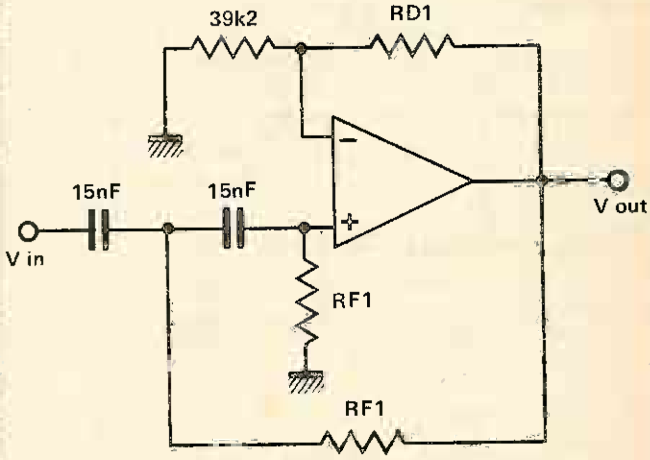
Band Pass

Several second order band pass filters can be cascaded to produce a different response shape which, like those discussed earlier for the low and high pass filters, can be optimised to give maximum roll off, or maximum pass band 'flatness'. However, these tend to get rather difficult to design and so only second order filters will be discussed.

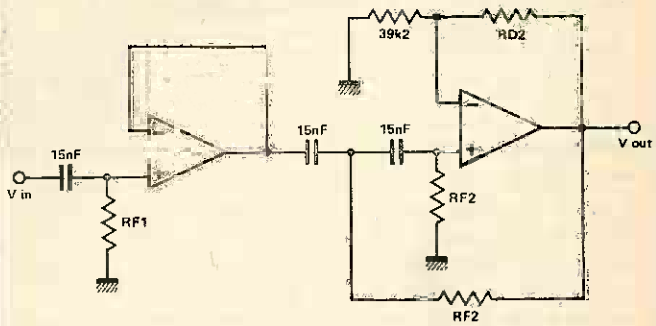


ALL THE RESPONSES ARE THE SAME FOR A FIRST ORDER SYSTEM

	RF1	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	10k66	0	10%
BUTTERWORTH	10k66	0	10%
CHEBYSHEV	10k66	0	10%



	RF1	RD1	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	13k55	10k5	1.3	10%
BUTTERWORTH	10k66	22k6	1.6	10%
CHEBYSHEV	9k01	48k7	2.2	5%



	RF1	RF2	RD2	GAIN IN dB	COMPONENT TOLERANCE
BESSEL	14k19	15k68	21k5	4.1	10%
BUTTERWORTH	10k66	10k66	39k2	6.0	10%
CHEBYSHEV	3k21	9k70	66k5	8.6	2%

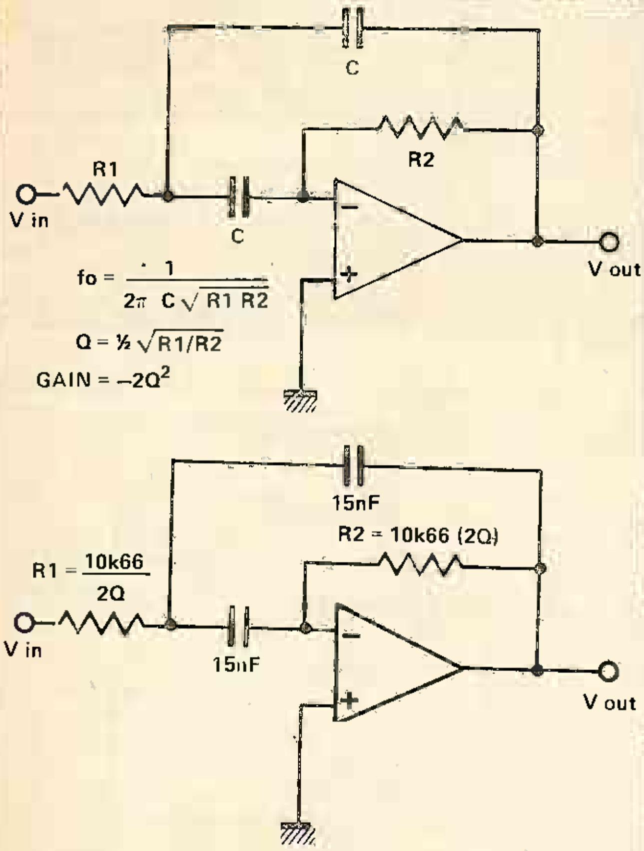
Fig. 3. From the top! First, second and third order high pass filters, break point 1kHz. Final roll off is 6, 12 and 18 dB/octave respectively.

ACTIVE FILTERS

Figure 4 shows a simple bandpass filter known as a multiple feedback circuit. This circuit can only provide low values of Q up to about 5. It will probably oscillate if it is designed to give a higher Q. Note that a high Q implies a large gain at the centre frequency. Therefore care must be taken to ensure the op amp has enough bandwidth to cope with the situation. Fig. 4 gives a design chart, normalised for 1kHz operation. First, choose a Q factor and then perform the frequency scaling. For instance, if the centre is 250Hz, then multiply *both* R1 and R2 by a factor of 4. If a high Q is required, then a multiple op amp circuit must be used. The 'state variable' and the 'Bi-Quad' are two such circuits and Q's as high as 500 may be obtained with them.

Figure 5 shows a state variable filter. It has three major features which are

1. It can provide a stable high Q performance.
2. It is easily tuned.
3. It is versatile, providing bandpass, lowpass and highpass outputs simultaneously.



Q	R1	R2	GAIN IN dB
1	5k33	21k32	6 dB
2	2k66	42k66	18.1dB
3	1k77	60k40	25.1 dB
4	1k33	85k33	30.1 dB
5	1k06	106k66	34.0 dB

Fig. 4. A multiple feedback bandpass filter. The centre circuit is normalised for 1kHz. The table is the design table for this circuit. To change the centre frequency change R_1 and R_2 by an equal factor.

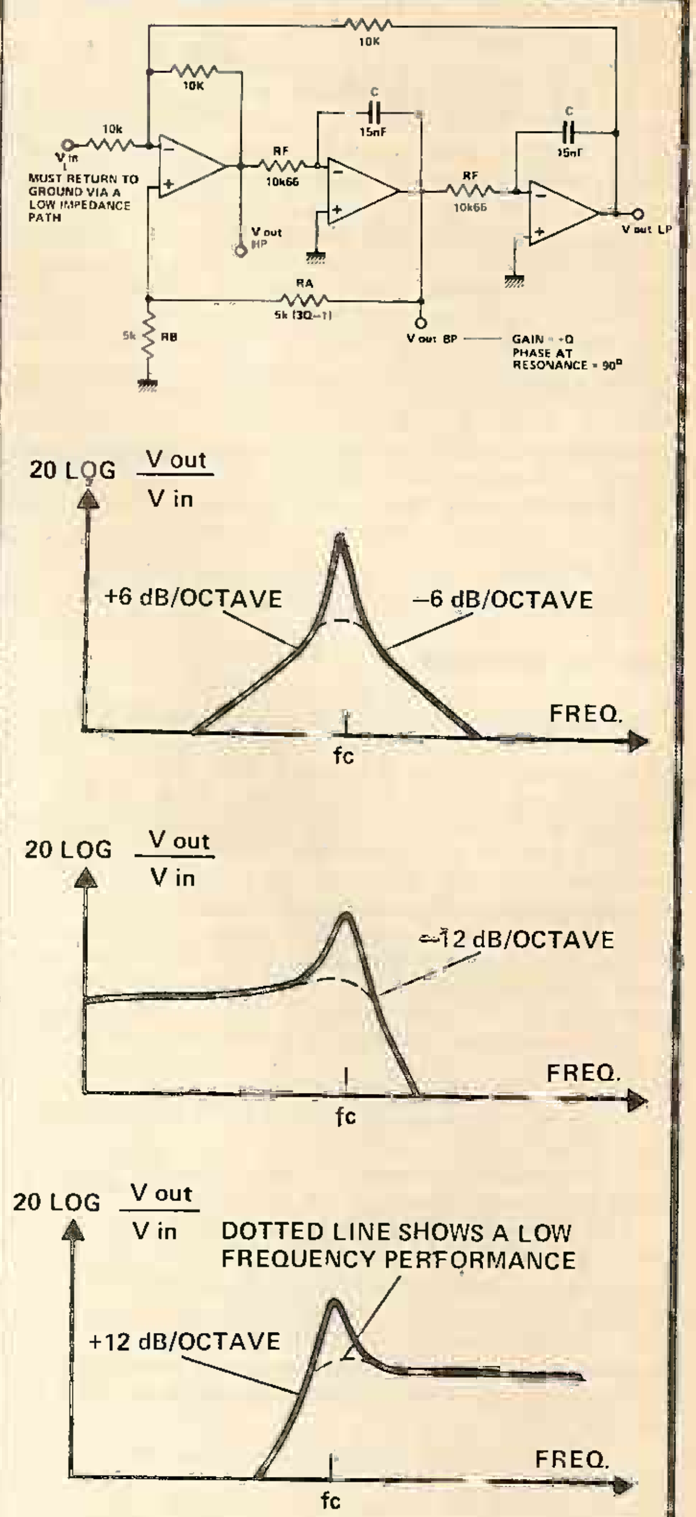


Fig. 5 The state variable filter is called a universal filter because it can give bandpass, low and high pass outputs — as shown above. Note that all these responses are second order in nature.

The Q is determined by the ratio of two resistors; RA and RB, where RA/RB = 3Q−1). The resonant frequency fc =

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

Note that there are two C's and two Rf's in the circuit, and so if the filter is to be tuneable, then both Rf's should change by an equal amount (the Rf's can be a stereo pot).

You will note that Q and fc are independent of each other, and so as the resonant frequency is changed, Q remains constant, and visa versa.

Op amps

The requirements placed upon the op amps in the filter, Fig. 5, are less than that for the multiple feedback circuit. The op amps need only have an open loop gain of 3Q at the resonant frequency. Say we have a Q of 100 and an fc of 10kHz. Therefore the open loop gain is 300, the frequency is 10kHz and so the gain bandwidth product needed is 3MHz. When using a high Q, care must be taken with signal levels. The gain of the filter is +Q at resonance, and so if you are filtering a 1V signal with a Q of 100 then you could expect to get a 100V output signal!

National Semiconductors manufacture an active filter integrated circuit, which is a four amp network that can be used to realise state variable filters with Q's up to 500, and frequencies up to 10kHz. The device is called AF100.

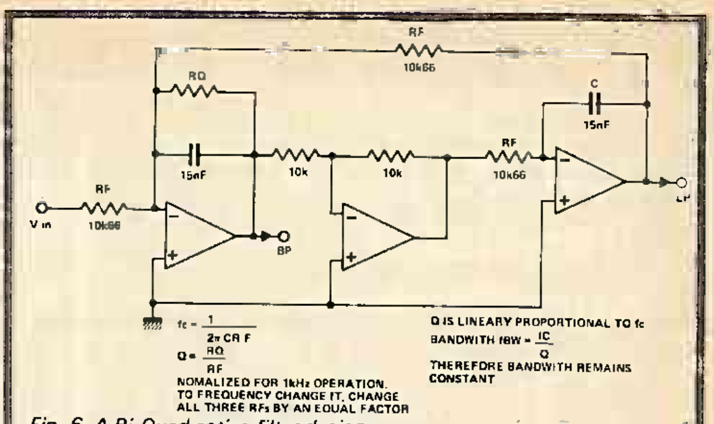


Fig. 6. A Bi-Quad active filter design.

Figure 6 shows a Bi-Quad active filter. It looks very similar to the state variable filter, but the small changes make it behave quite differently. It only has a bandpass and a low pass output. The resonant frequency is given by

$$f_c = \frac{1}{2\pi C R_f}$$

Next month: Comb filters, delay lines and some practical circuits to build up.

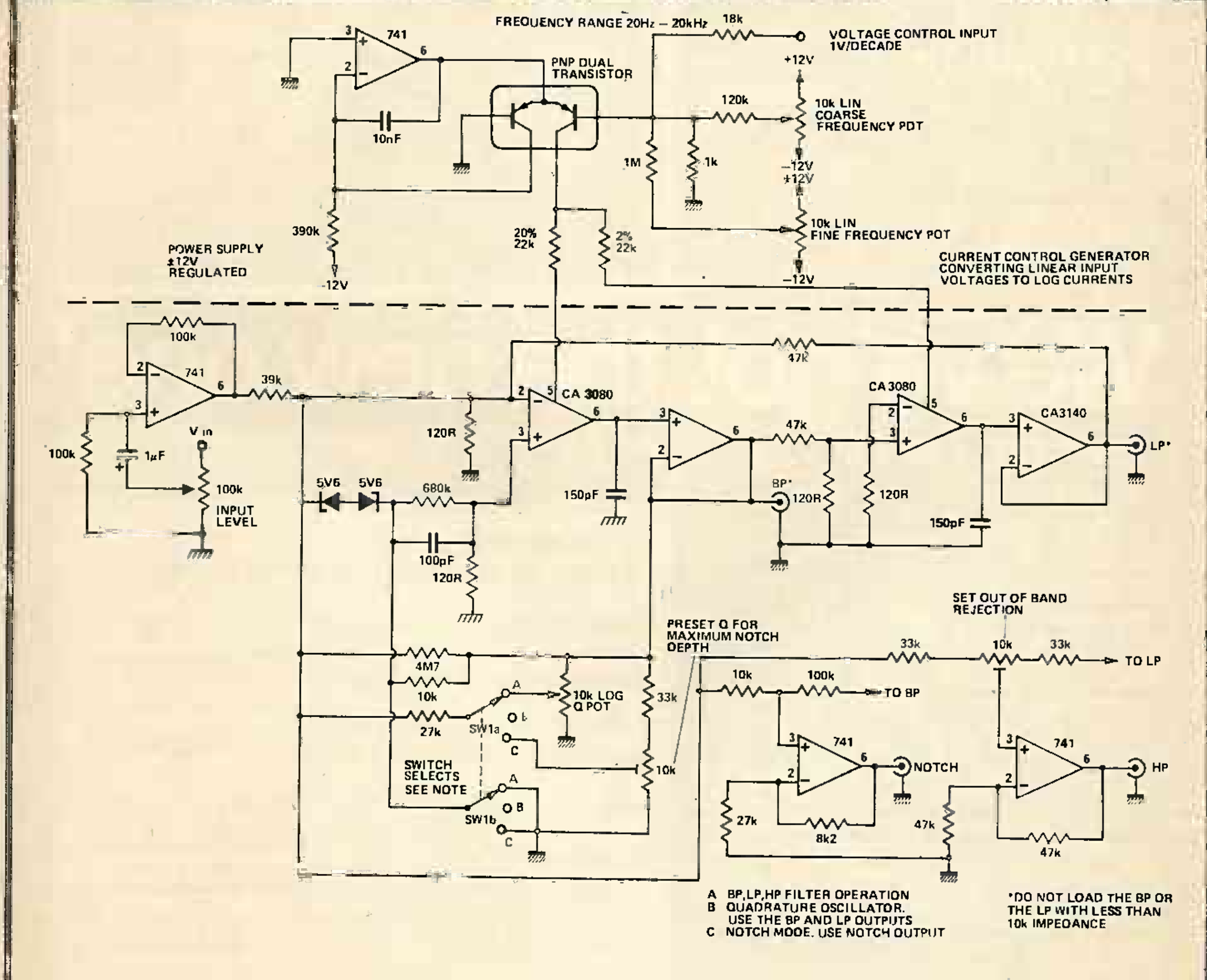


Fig. 7 The state variable filter can also be made to oscillate (as above). It has a variable resonant frequency, it becomes a variable frequency oscillator. This circuit produces two low distortion sineusoids in phase quadrature: ie, sine and cosine waveforms at low distortion.

SYSTEM BUS & VDU INTERFACING

Described by John Miller-Kirkpatrick

THERE ARE SEVERAL "standard" methods of interconnecting PCBs in an MPU system, these are known as different 'Bus Structures'. Probably the first of these is the one now known as the 'IMSAI' or S-100 Bus, developed for use with the Altair and Imsai computer systems which were the first popular 8080 microcomputer systems in the USA.

Most of the semiconductor manufacturers have chosen to ignore this standard in producing development kits and as other kit manufacturers copy or base their designs on the development kits so the hopes of a real standard dwindle. There are several groups now trying to set up another set of bus structures for the UK. Apart from the IMSAI BUS, SWTC BUS, etc, most of the others are based on the idea of using the DIN standard 'Eurocard' format of card size. This allows the smallest card to be 100 x 160 mm with double and quad Eurocards being multiples of the basic size. In System 68 we have decided to adopt the small single Eurocard as the basic card size, thus allowing the use of standard casing and connector systems.

The connector which we intend to use whenever possible is a 31-way DIN standard plug and socket system. There is no fixed parallel bus structure as 31-way severely limits the number of signal lines which can be included on every card.

The basic System 68 is based on a 4K block which most people will want to extend not long after getting the basic system operational. The logical extension to make is to add on more program memory in the form of PROM or RAM, a logical size to allow for in each expansion card is 4K. A 4K RAM card would require 2 or perhaps 3 power supply lines, 8 data lines, 12 address lines, read and write strobes and a "CARD ENABLE" line. Thus we have already allocated 26 of our possible 31 ways leaving 5 lines uncommitted, we could of course parallel the top 4 address bits as well as the lower 12 but this would leave only a couple of lines spare (CARD ENABLE would not be required).

System 68 backplane connections

PIN No.	VDU CARD	PREFERRED FORMAT
1	+5v	GND
2	GND	U/C
3	U/C	U/C
4	NWDS	U/C
5	Address bit 9	NWDS
6	Address bit 8	NRDS
7	Address bit 7	U/C
8	Address bit 6	U/C
9	Address bit 5	U/C
10	Address bit 4	Data bit 7
11	Address bit 3	Data bit 6
12	Address bit 2	Data bit 5
13	Address bit 1	Data bit 4
14	Address bit 0	Data bit 3
15	VDU ENABLE	Data bit 2
16	KBD ENABLE	Data bit 1
17	NRDS	Data bit 0
18	Data bit 0	Address bit 11
19	Data bit 1	Address bit 10
20	Data bit 2	Address bit 9
21	Data bit 3	Address bit 8
22	Data bit 4	Address bit 7
23	Data bit 5	Address bit 6
24	Data bit 6	Address bit 5
25	Data bit 7	Address bit 4
26	−12V	Address bit 3
27	INT/KBD STROBE	Address bit 2
28	RESET	Address bit 1
29	U/C	Address bit 0
30	U/C	−12V
31	U/C	+5V

U/C = Uncommitted

Note. On the PCB layout for VDU board B the pin numbers are marked from the wrong end.

From our definition of the requirements for a 4K RAM card we can lay down a 'preferred' bus structure on which System 68 cards should be designed wherever possible. Now the eagle-eyed amongst you will notice that the VDU cards do not fit this 'preferred' structure and the reason is that the VDU is an example of available space being a more important consideration than conforming to the 'preferred' bus. As the card sockets have to be wired to each other it is a simple matter to change from one layout to another. This makes System 68 a lot more flexible than most of the other micros on the market.

When wiring up the backplane connectors be neat, using different coloured wires for each signal and connecting them with as little excess wire as possible will help you and the MPU.

Using the VDU

The VDU system described in the past two months is of the 'Direct Access' type of VDU rather than the 'Serial' or pseudo-teletype type. The main advantages of the System 68 VDU over the TTY compatible units are speed and Read/Write facilities. Speed is very different because the direct access VDU has RAM which is shared with the MPU and thus the speed of writing a character or page of characters relies only on the speed of the MPU and the efficiency of the program.

Carriage Return?

The term Carriage Return / Line Feed otherwise known as CR / LF comes from TTY printer systems where at the logical or physical end of each line the printer carriage which holds the paper must be returned to its start position and the paper advanced one line by a line feed instruction.

In the case of the TTY VDUs the hardware is worked out to reset the character counter per line to zero (CR) and to cause the VDU to address the next line down (LF).

In the case of the System 68 VDU we do not have any hardware commands whatsoever and so all commands of this type must be decoded by a software routine which is driven by the main program and which in turn is solely in command of the VDU.

Carriage Routine

In its simplest form this routine will be passed the character to be output by the main program via a register, a stack or Working Storage RAM. The routine will test the character and decide whether it is an ASCII control character or a printable character. If the character is to be 'printed' then it is placed in the next available VDU RAM location and will thus be displayed by the VDU on the next page scan, as this happens every 20mS the change on the VDU can be considered to be instant. The routine will now increment the 'next available VDU location' register and store this address in RAM and then pass control back to the main calling program.

If the output character is found to be an ASCII control character the routine must go through a sequence of operations which will have the same effect as the control character would have on a TTY printer.

If it is a CR then what we need the MPU to do is to write spaces up to the end of the current line and then jump back into the normal end of routine which will update the 'next location' register and store it. Thus next time the main program wishes to output a character that character will be placed in the location following the previous end of line which just happens to be the first location on the next line. The interesting thing is that in most MPUs which I have looked at this simple form of VDU control takes up about the same amount of software

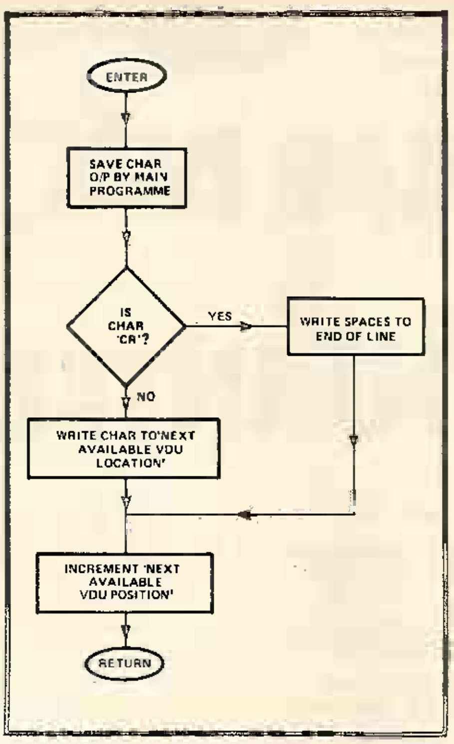


Fig. 1 Flow chart showing routine to implement writing to VDU. With this routine the only allowable ASCII control character is CR.

(program) as a software TTY routine, about 40-50 bytes. An example of this will be given when we discuss the software for System 68 in a couple of months' time, in the meantime those of you with MPUs who want to use System 68 VDU should be able to grasp the basic program requirements.

MPU + VDU = AOK

Connecting the System 68 VDU to an MPU is a reasonably simple matter as the shared RAM concept makes it almost as easy as adding RAM. For a start the 8 bit data bus from the VDU is connected to the MPU data bus (with buffering if required), similarly the basic 10 bit VDU address bus is connected to the lower 10 bits of the MPU address bus.

Ignoring the keyboard control signals for the time being we are left with only three signal lines — VDU ENABLE, NWDS and NRDS. The VDU ENABLE line is effectively the same as the chip select line on a 1K RAM, it must be taken to a logical low status at the same time as the address is set up on the bus. It is hardware decoded from the upper bits of the MPU address bus to define a 1K byte block starting address, in a small 4K system this might well be X'800' and thus the VDU ENABLE line will go low if the upper address bus indicates an address in the range X'800' to X'BFF' inclusive. As far as the MPU is concerned this RAM is now available for it to use as it wishes and it is the job of the VDU sub-routine to use it as a VDU.

The two other signals are NWDS (Not Write Data Strobe) and NRDS (Not Read Data Strobe), NWDS goes low whenever data is available on the data bus and a valid address is available on the address bus and a WRITE to RAM condition is required. NRDS is similar except that it is available if a READ operation is required, these are standard signals which must be available in any MPU system which uses RAM. By studying last month's circuit you should be able to see the effects of these signals on the VDU RAM and thus on the screen.

Key to Success

The keyboard control signals on the System 68 VDU board B are similar to the controls for the VDU and thus the DATA, and NRDS strobes are shared with those of the VDU (NWDS makes no sense with

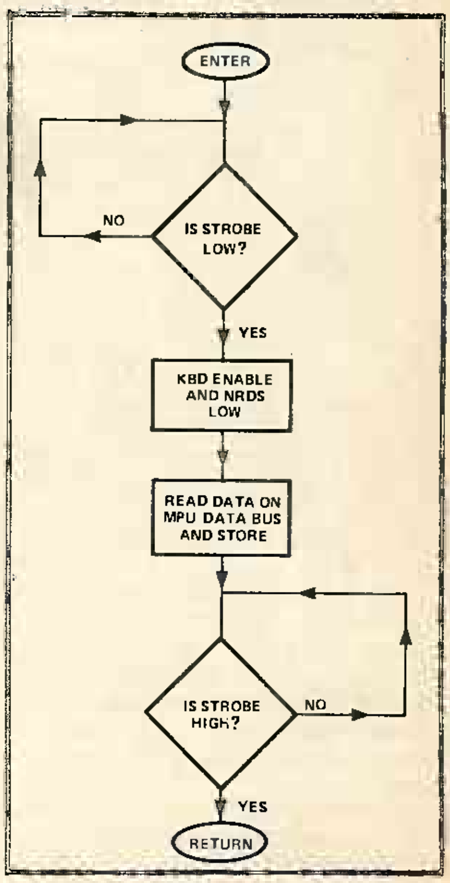


Fig. 2 Flow chart showing routine to implement a read from keyboard operation.

most keyboards). The additional control signals are 'INT' or strobe, RESET and three reserves. 'INT' is the negative going strobe signal produced by most ASCII keyboards and can be connected to the MPU interrupt or other sense input or can be connected as the eighth input bit from the keyboard. RESET is to be connected to allow resetting of the MPU from the keyboard rather than or in addition to the front panel, it should be connected to the MPU RESET pin. The three Reserves are intended for user applications for keyboard option switches or to allow the MPU to drive lamps, buzzers, relays, etc, on the keyboard, note that although only three lines are available these could be encoded or decoded by a 3 to 8 multiplexing chip.

Key to the Sub

The software required for examining the keyboard is very simple and again let us assume that it is a sub-routine called by the main program. The subroutine could have been called by the interrupt system in which case we know that the strobe line is already low and thus valid data is available at the keyboard buffer. Alternatively we have to enter a loop which continually tests the strobe signal and branch out of the loop when this signal goes low. In both cases we can now put the KBD ENABLE line low in a manner similar to that used for VDU ENABLE. At the same time we must put NRDS low to indicate that we wish to read the data at that location and the combination of both signals will enable the outputs of the KBD buffer and place the keyboard data on the MPU data bus. Our subroutine does all of this by executing a READ instruction and then saves the character data input in RAM. In order to fully debounce the keyboard the routine will now enter another loop to await the release of a key and thus the change to logic '1' of the strobe pulse. Command is now passed back to the main calling program with the input character in RAM or a register.

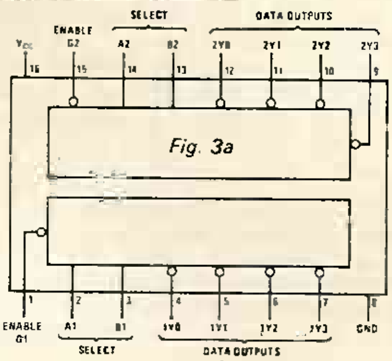
Device address decoding

This concept can be one of the most daunting to new MPU users — but have no fear, System 68 is here! Most MPUs claim to be able to access 64Kilobytes (65,536 bytes) but do not say what they are accessing. Others claim to have bolt-on goodies like I/O PORTS or PIAs and ACIAs, these are all ways of kidding the MPU that it is addressing one of the 64K locations available to it.

In the case of the 6800 the first instruction (effectively) is fetched from location X'FFFE' after a RESET or Power-up. The data in this location cannot be random and thus it has to be previously defined as ROM or switches and then has to be uniquely accessed by the MPU address bus so that the data at that location *only* can be loaded onto the MPU data bus.

Consider the standard (not ITT) 74LS139, this is a dual 2 to 4 line decoder in a sixteen pin package. If we wish to break up our 4K into four 1K blocks we can ignore the lower 10 bits of the address bus and use the next two as inputs to one of the 2 to 4 line decoders. These two address lines can be in any of 4 live (ie not TRI-STATE) states defined by logic levels 00, 01, 10, 11. The 74LS139 uses these to enable one of four outputs which can then in turn be used to enable a block of 1K bytes (eg VDU ENABLE). Similarly we can break down one of these blocks into four 256 byte blocks by using the other half of the 74LS139 and use one of the outputs as KBD ENABLE. We can also use another output from the 74LS139 (second half) to define an area of 256 bytes of RAM for use as a stack or Working Storage RAM. A RAM chip such as the 2112 is presented as 256 locations each with 4 bits, thus two of these chips would give 256 x 8 bits or 256 bytes. These chips are internally decoded to access each of the 256 locations uniquely and all they require is the lower 8 bits of the address bus plus a device address (usually called CHIP ENABLE) which in our example is output from the 74LS139.

By using further similar decoding techniques it is not difficult to work out how to access X''FFFE' uniquely without having to use a ton of TTL decoders.



INPUTS			OUTPUTS			
ENABLE	SELECT					
G	B	A	Y0	Y1	Y2	Y3
H	X	X	H	H	H	H
L	L	L	L	H	H	H
L	L	H	H	L	H	H
L	H	L	H	H	L	H
L	H	H	H	H	H	L

H = high level, L = low level, X = don't care

Fig. 3b

Fig. 3 Chip pin-out for 74139 is shown in (a) above; (b) shows the truth table for this IC

Tri-State Buffers, etc

MPUs introduced a new concept to digital electronics, that of a third output state of a logic gate. This can be very difficult to comprehend especially as most explanations are in the form of technical language.

We can however consider a TRI-STATE thus as two lots of 8 two position switches so that the first 8 switches are either open circuit or connected to the wipers of the other 8 switches and in turn these switches are connected to either logic '1' or '0'. It is assumed that all of the second batch of switches are preselected with the required logic states and that the first set of switches are all in the open circuit state. By closing all 8 of these switches at once the 8 outputs will change from open circuit to the preselected logic states. If you control all 8 of the output switches with a solenoid driven from a relay which in turn is driven by a logic '0' signal then you have just built an 8 bit TRI-STATE port! Most IC manufacturers have put all of this into ICs in the form of 4, 6 or 8 bit buffers, for example the 8095,6,7,8 6 bit buffers or the 8195,6,7,8 8 bit buffers as used in System 68 VDU.

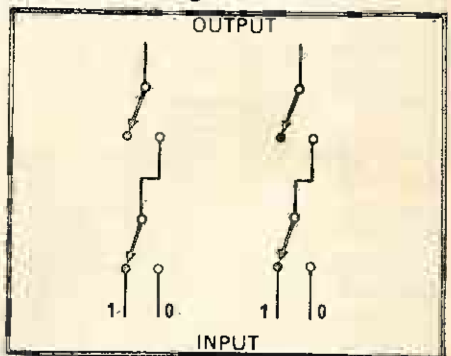


Fig. 4 A TRI-STATE gate may be represented by switches as shown above.

Next month

The 6800 MPU board

MICROFILE

Our micro man, Gary Evans, takes a look at a new system of large scale software distribution and at some new items of hardware.

THE PATTERNS THAT are shown at the top of this page are beginning to appear on a wide range of products, from paperback books to tins of baked beans. They are typical of the optical bar codes that can be used to record digitally encoded information.

The advantage of storing information in this way is that the data may be quickly and accurately read into a POS (Point Of Sale) terminal, stock control computer etc., thus making sophisticated stock control procedures and easy handling of invoices possible.

An example of use would be at a supermarket checkout. Each product would have a code printed on its label which would be read with the aid of a simple bar code reader. The POS terminal would decode the product information and access a "look up" table to determine the unit price. This amount would then be added to the invoice total. The terminal could also modify the stock level of that product enabling accurate, up to the minute stock levels to be maintained.

The increased flexibility of systems such as this together with the falling costs of the hardware involved means that many people are beginning to adopt systems based on these bar codes.

START HERE, SCAN DOWN PAGE

FRAME IDENTIFICATIONS

Fig. 1a

```
                 ****************************************************
                 *
                 *            S T A R T   O F   L I S T I N G        *
                 *                                                    *
                 ****************************************************
(0000)                     ORG   0000
(0000)  7E  00  00         JMP   MAIN        PGM ENTRY POINT IS AT 0000
(0003)             ERORSW  RMB   1           ERROR SWITCH
(0004)  20         MOD     FCB   $20                              ITEMS        *
(0005)             NAME    RMB   4                                BLANKED FOR  *
(0009)  20         SIGN    FCB   $20                              EACH         *
(000A)  20  20     BLNK    FCB   $20,$20                          COMMAND      *
(000C)  00  00     ADD1    FCB   $00,        GENERAL ADDRESS VARIABLE
(000E)             SAVADR  RMB   2           SAVE ADDRESS
(0010)             ALPHA   RMB   1           ALPHA OPERAND SWITCH
(0011)             ANSW    RMB   1           STRING COMPARE ANSWER
(0012)  2A  20  20 ASTK    FCC   *,          FOR COMPARE WITH *
(0015)  20
(0016)             BYTOUT  RMB   1           BYTE OUT
```

Fig. b.

1(a) above is an extract from the bar coder version of J F Emmerichs M6800 Assembler. This comes complete with a program listing. 1(b) above shows part of this listing, hexadecimal object code listing and notes on assembler structure. With this information the assembler can be inplemented on any 6800 based system.

More Bars Please

Let's turn now to a problem faced in the home computer field — namely that of low cost software distribution on a large scale.

Software, be it in the form of high level language statements, assembly language statements or as an object code, can be stored and transported in a wide variety of forms. In this country at the moment it seems that there is no standard method of software exchange media, instead, the first method that comes to mind is used.

These methods include dumping the program to PROM, to paper or cassette tape, or indeed, as a teletype print out.

None of the above methods meet the ideal requirements of a software exchange medium, namely that it be of low cost and of high reliability.

These two requirements should be met by both the encoding and decoding operations. Thus while a paper tape reader may be cheap to produce, the production of paper tape requires a large amount of mechanical devices, slowing the process and adding to the cost. On the other hand, while software trading via a paper print out is cheap it does not meet the requirement of high reliability, depending as it does on manual loading into a system.

It's about now that the relevance of our first few paragraphs becomes apparent. Why not encode our software in the form of a bar code?

Software in this form could be produced reasonably cheaply on high speed printing machines, perhaps as part of a magazine. The data may also be easily loaded into a home computer system. With a simple light pen reader, consisting of a light source and photo-sensitive element, not costing a great deal, this system meets our two basic requirements.

It may not surprise you to know that this has already been done in America. A number of software packages have been published, including a nice 4K Assembler for any M6800 based system.

Hard Time For Soft Pirates

The low cost of distributing software by means such as bar coding also has an incidental advantage. It kills off the "Software Pirates" that were begining to operate in this area.

These "pirates" would operate in much the same fashion as record bootleggers. They would produce low grade copies of any new software offered on the market, usually in the form of a CUTS encoded tape.

These copies being of very inferior quality, contained many bugs. They were supplied without any documentation i.e. source listing, flow charts, and so often proved impossible to debug (Have you ever tried to debug an object code program without good documentation and retained your sanity?)

With the major suppliers able to offer software cheaply and with adequate additional information it is

MICROFILE

hoped that the "pirates" will find no room in our lobby as they benefit nobody but themselves.

2716 Is FAMOS

Intel have recently developed a 16K EPROM which has a number of new features which make it one of the easiest to use EPROMS that we have come across. Apart from being the largest device of this type commercially available, the 2716 has programming requirements that are far easier to meet than many of the earlier types.

When programming the 2716, the 26V supply required does not have to be externally switched during the program cycle. Instead the necessary switching is incorporated on the chip enabling each address to be selected and programmed with a single pulse.

The chip uses FAMOS transistors as the storage elements and makes use of passive oxide isolation to reduce the space between the transistors of the memory array.

It is interesting to compare the 2716 with the 2708 (at 8K the largest EPROM to date)

The 2716 is four times as dense as the 2708, consumes 20% less power while retaining the same access time. It also incorporates a low power standby mode which does not degrade its access time.

While not for the amateur yet, it will not be long before we are able to get our hands on goodies like this.

National COPS Out

National Semiconductor recently launched their COPS (Calculator Orientated Processor Systems) family of 4-bit microprocessors. They are aimed at filling the gap between general-purpose micros, which are often too powerful, and dedicated systems which take too long to develop.

The range consists of the MM 5781 and MM5782, a two chip set, together with two single chip controllers, the MM5799 and the MM57140. Each chip has the same basic architecture but they differ in the amount of ROM, RAM and number and type of I/O ports they provide.

These chips should prove ideal for applications from basic industrial control situations to sophisticated POS (Point Of Sale) terminals. The MM5799 has already found a home in Sinclair's new Programmable Calculator.

COPS chips should also be able to provide a nice fast "number cruncher" board for your microcomputer system.

Daz-ling Chip

Glancing through an ITT semiconductor catalogue the other day, we came across a device which we found quite interesting.

The pin-out of the 28 pin package is quite different from those that we usually see. Pins marked — 15V and OV are familiar enough, but pins marked BIO, RINSE HOLD and FAST WASH?

The chip is in fact the ITT7150 which is typical of the dedicated micros that are beginning to appear in consumer goods. The 7150 spends its life controlling washing machines, hence the pin designations above. It provides a comprehensive range of control functions, and when used with a few interface circuits, it can replace the mechanical wonders that have appeared in washing machines until now.

With micros finding their way into dish washers, microwave overs and freezing systems in the near future we wonder what chip pin-outs of the future will look like. ●

POTENTIOMETERS

PART 12 OF OUR COMPONENT SERIES LOOKS AT THE VARIOUS POTENTIOMETER TYPES THAT ARE IN COMMON USE TODAY

POTENTIOMETERS ARE MADE in such a bewildering array of sizes, shapes, styles, and combinations that it is difficult to sort out what best suits a particular situation and what alternatives there may be. Apart from that, they come in a variety of wattage ratings, voltage ratings, resistance variation 'laws', etc — and how are you going to sort through that lot?

Potentiometers perform some control function by varying a resistance element or by tapping off a voltage from a fixed resistance. The variable resistor may need to be varied continuously so that some control function is performed, or it may be a 'preset' control which is only required for some calibrating or 'trimming' function. Preset potentiometers are generally called 'trimpots'.

So, potentiometers are generally split into two broad categories — continuously variable types, which are equipped with a shaft for the attachment of a knob, and trimpots which are generally equipped with a screwdriver slot.

Types

There are five basic types of potentiometer, classified according to the type of resistance element employed:

(1) Carbon composition
(2) Carbon Film
(3) Hot-Moulded Carbon
(4) Cermet
(5) Wirewound

Carbon composition pots have a composition element moulded to the required size and shape and generally employ a metallic spring-wiper. They are generally quite inexpensive but have the disadvantage that they become noisy after use. Carbon film pots consist of a resistive film that is sprayed or screened onto a phenolic former of the required size and shape. A metallic spring-wiper is also generally used in this type of pot, and the element will withstand many more rotations than a composition type before noise problems. Carbon film pots are also inexpensive and are the commonest types in use, along with Hot Moulded Carbon types. Carbon film pots have a good degree of resolution whereas the composition types are poor in this respect.

Hot Moulded Carbon potentiometers are manufactured by a process wherein the resistive element, insulating base, and terminations are moulded into one integral part. A carbon wiper contact is usually employed. They have a high wattage rating on a size-to-size basis and a high degree of conformity between units. This factor, together with their very high resolution, has led them to be increasingly used as precision controls. They exhibit low noise levels in operation compared with carbon film and wirewound types.

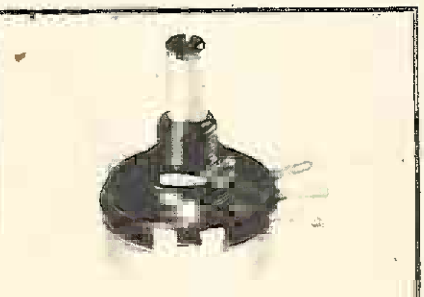


Fig. 1. The common, basic style of potentiometer. It has a threaded bushing and nut for panel mounting through a single hole and standard solder lug terminals.

Cermet potentiometers find wide application in precision controls, as trimpots and in many stringent applications (the element is rugged, exhibits low noise levels in use, and has good resolution). Wattage ratings are similar to those for hot moulded carbon pots of a similar size. They are generally somewhat more expensive. A metallic wiper is usually employed.

Wirewound potentiometers consist of a resistance wire would on a former with a metallic wiper, although a graphite wiper contact is sometimes used on low value, high wattage types. They have the disadvantage of being noisy, the resistance changes in small 'steps' as the wiper passes over the turns of wire, and they are usually more bulky than other types of equivalent value. However, they can be made in very low resistance values and they are able to dissipate much more power than other types of equivalent value.

Styles

The most common, basic style of potentiometer is illustrated in Figure 1.

In some applications, 'Tandem' or 'Ganged' potentiometers are required (for example for stereo tone and balance controls). They consist of several potentiometers all connected to the one shaft and stacked one behind the other, as illustrated in Figure 2. 'Dual-Concentric' potentiometers appear similar to the dual-ganged pot on the left in Figure 2. However, in this case, each pot is separately controlled by means of two concentric shafts. Dual-concentric pots are often used where there is limited space (e.g., for the RF and audio gain controls on a communications receiver).

The assembly illustrated in Figure 3 consists of four potentiometers mounted on the four sides of a metal box and connected by means of a special linkage to the lever which may be moved in any direction. These assemblies are used for complex control functions such as quadrophonic 'balance' controls, radio controlled models etc.

Switches are often mounted on the rear of potentiometer assemblies and connected (mechanically) to the control shaft so that the one control knob may serve several functions. There are three basic types of switches generally used: the rotary type, the push-pull type and push-push type. A rotary style of switch is often employed as a mains-power switch on a control, such as a volume control. It has the advantage that when the switch is moved to the ON position the control is at minimum. But, it has the disadvantage that anything up to the first 15% or 20% of the control cannot be used. On many controls this is of

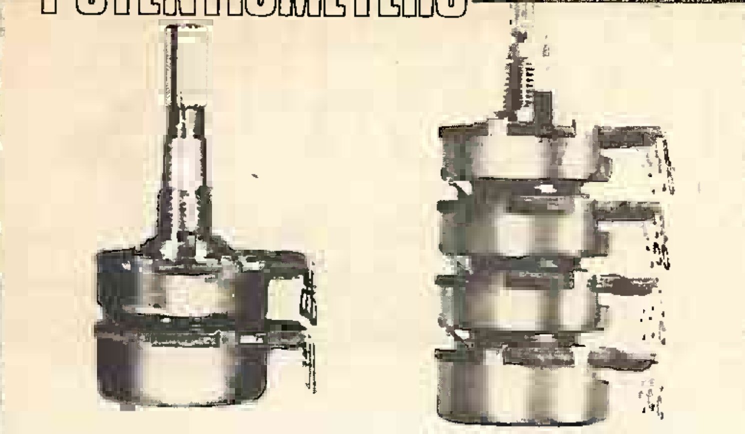


Fig. 2 'Tandem' or 'ganged' potentiometers consist of several potentiometers controlled by one shaft. 'Dual-concentric' type are similar to the one on the left except that they are separately controlled by concentric shafts, one inside the other – the inner, shaft controlling the 'back' pot and the outer shaft controlling the 'front' pot.

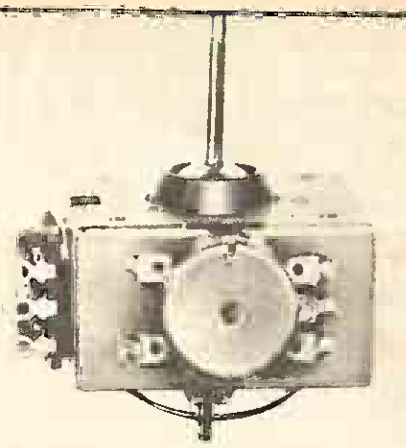


Fig. 3 Lever-controlled 'quad' pot assembly. These assemblies are used for complex control functions such as quadrophonic sound 'balance' and in model control applications etc.

little consequence. Push-Push and push-pull switches have the advantage that the control may be left in a certain position and switch operation does not disturb it. With a volume control however, this may be disastrous as the equipment may be turned on while the volume control is at a high setting, or worse still, full on!

While solder-lug terminals are commonly found, potentiometers are also manufactured with terminals suitable for printed circuit board mounting,

Power Ratings

With the exception of wirewound types the majority of standard potentiometers are obtainable in ratings of 0.1, 0.2, 0.25, 0.5 and 1 watt. Potentiometers are derated in much the same manner as fixed resistors. If this information is desired it is best to consult the manufacturer's literature.

Wirewound potentiometers are obtainable in ratings up to 100 watts (!!) but more usually they are available in ratings (depending somewhat on their resistance value) of 0.5, 1, 2, 5, 10, 15 and 20 watts. The higher power ones are usually quite bulky. Cermet and hot moulded carbon types are generally the smallest size for a given rating.

Resistance Law

The resistance 'law' of a potentiometer refers to the manner in which the resistance changes (as measured between as end terminal and the wiper terminal) with rotation of the shaft. There are a considerable number of different 'laws' in common use. The main ones however are: linear, logarithmic, and 'S' law. These are illustrated in Figure 4. Note that various log laws are used, the 20% log law is the more common one however. The laws for both clockwise (CW) and counter-clockwise (CCW) log are illustrated, as the potentiometer may be connected to operate in reverse fashion if desired. The various common laws are given a letter code which is stamped or marked on the body of the assembly along with the resistance value. The code is quite straightforward, as follows:

A = linear law
B = logarithmic law
C = reverse logarithmic (or anti-log)
S = 'S' law.

A pot may be marked 25kA, which is a 25k ohm, linear law potentiometer. Another may be marked 1M/C, which is a one megohm, reverse logarithmic pot.

The linear law control varies resistance in direct proportion to the rotation of the shaft. This type of pot is commonly used in voltage control applications, on tone controls and other applications which require a straightforward resistance variation.

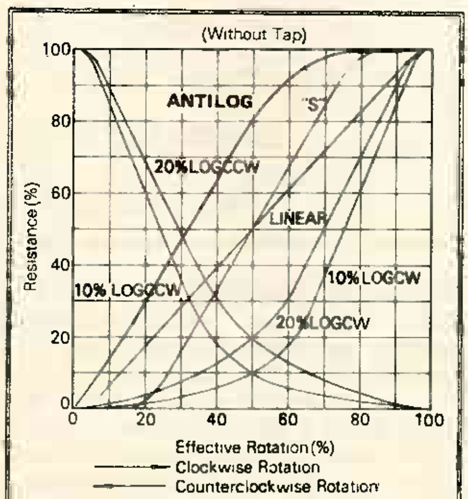


Fig. 4. The common resistance-versus-rotation 'laws' as 'tapers' for potentiometers.

With a log law control, the resistance increases very gradually during the initial rotation of the shaft, most of the resistance change occurring in the last 20-30% of the rotation. This type of law approximates the natural sensation of loudness as our ears follow a logarithmic law in their sensitivity to sound amplitude. Consequently, such controls are frequently used as volume controls so that they produce an apparent linear increase in sound output as the shaft is rotated. If a linear control were used, the greatest change in perceived volume would occur within the first 10-20° of shaft rotation.

Anti-log laws provide the reverse the greatest change in resistance takes place in the early portion of the shaft rotation, the least change occurs in the last 30-40% of shaft rotation.

The 'S' law provides only a small change in resistance for the initial and final 20% of shaft rotation and provides a linear variation between these extremes.

Other laws include semi-log and linear-tapered. These have curves that lie between the log and linear curves on the graph in Figure 4. The semi-log law provides a somewhat greater change of resistance-versus rotation over the first 40% of shaft rotation than with the log curve. The linear-taper provides a nearly logarithmic variation over the first 50% of shaft rotation and a linear variation thereafter.

Resistance Ranges

Most types of carbon element potentiometers are made in values ranging from 50 ohms up to 2 M. Some older types were made in values as high as 500 M. Cermet potentiometers are made in values ranging from 10 ohms to 10 M.

Some manufacturers make their pots to values in the standard E6 (20%) series (i.e.: 47 ohms to 2 M for carbon types). However, many pots are made with values according to the following decade series: 10,15,20,25,50 & 100. i.e: 2 k5, 5 k, 10 k, 15 k, 20 k, 25 k, 50 k, 100 k etc . . .
Some (typically of US make) include 75 in the value range.

Wirewound potentiometers are made in values ranging from 10 Ω to 100 k.

Slide Pots

These are pots having a linear element rather than a circular element as in standard pots. They are available generally with a carbon element having slider ranges of typically 50 mm, 75 mm, and 100 mm in the various laws as previously illustrated.

Slide pots have particular advantages of their own. One being that it is easier to see the proportional position of the control at a glance than with standard potentiometers. In some circumstances the slide pot provides a much more convenient form of control, for example in multi-channel audio mixer applications.

Trimpots

Trimpots are usually 'preset' controls. That is, they are only adjusted occasionally to set certain circuit parameters or conditions, for calibration purposes etc. Consequently they are generally adjustable by means of a screwdriver slot on the control shaft, although some have an integral knob to allow finger adjustment.

Trimpots are made in a wide variety of styles and sizes, as illustrated in Figure 5. Some types are enclosed to prevent the ingress of dust etc which can cause the control to become noisy in operation. Many types are only single-turn controls with the wiper covering only 180° in some cases, while others cover the more conventional 270-280° of rotation. Other trimpots are made for more critical applications and have a multi-turn control which allows a much finer and more accurate adjustment.

Manufacturers make trimpots in values ranging from 50 ohms to 5 M for carbon element types, and typically up to 30 M for Cermet types. Wirewound types are made in values typically ranging from 100 ohms to 5 k. Wattage ratings for the various types are typically 0.1, 0.2, 0.25, 0.5 up to 1 W. Trimpots are available in the same range of laws as are standard potentiometers, although most common styles have a linear law. Other characteristics are the same as for the type of element employed.

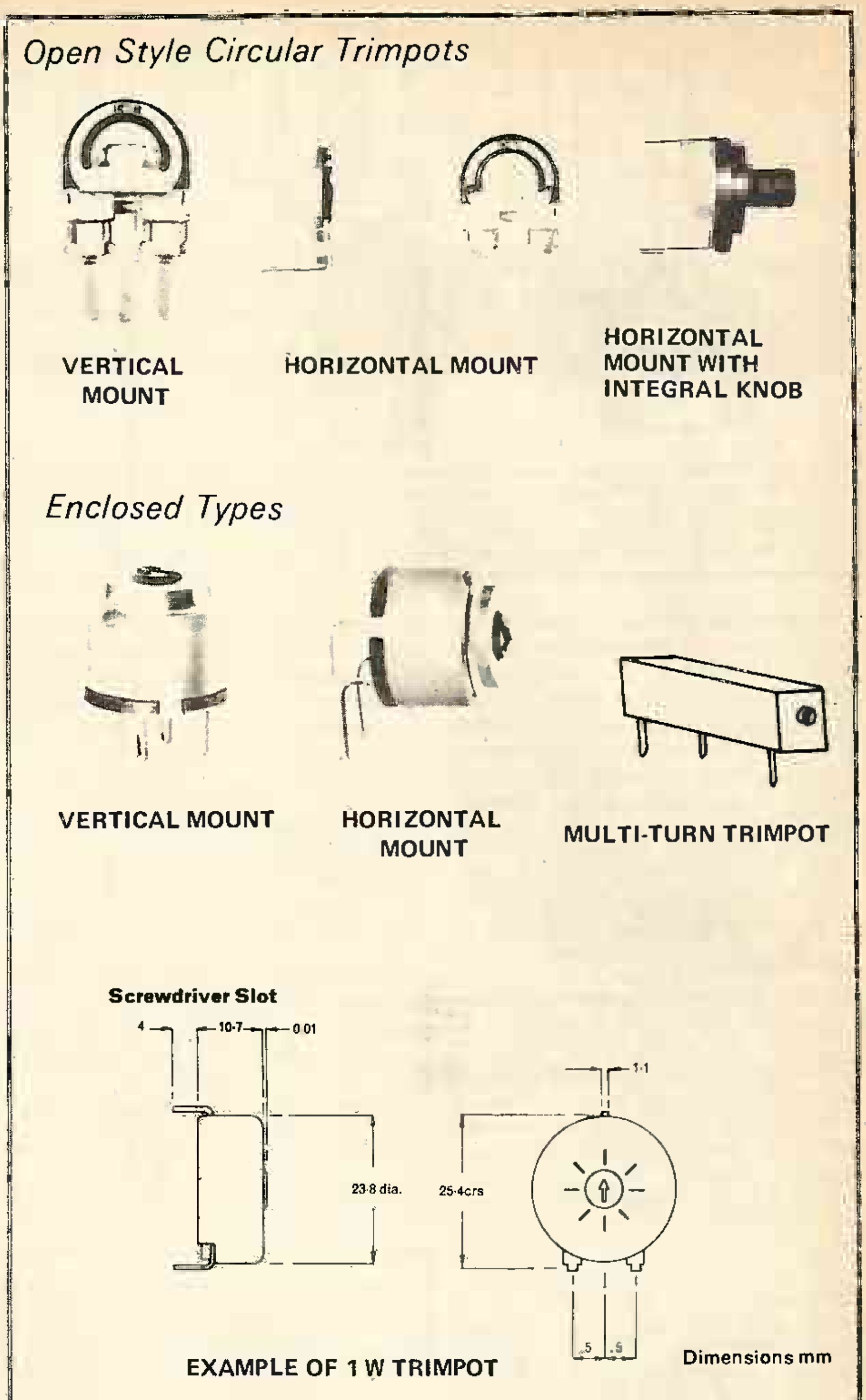


Fig. 5. Examples of various styles of trimpots.

Connecting Potentiometers

One thing that baffles electronic project constructors is the 'correct' way to connect a potentiometer.

The best way to illustrate how to do it is by example. The most common application of a potentiometer is that where it is required to vary a quantity (signal, voltage, etc) so that an increase occurs when the control shaft is rotated *clockwise*. The best example of this is a volume control.

In Figure 6 a pot is illustrated typically as you would see it when you come to make the connections. The arrow indicates the direction in which the control shaft will be turned to increase the output. THE TERMINAL IN THE CENTRE IS ALWAYS THE WIPER CONNECTION. So, terminal 1 (on the left as you view it to wire it up), connects to 'ground' or minimum. Terminal 2 (the wiper) connects to the output (in some cases it can also be the input terminal; operation of the pot still remains the same). Terminal 3 (the one on the right) connects to the input (or the output if the input is connected to the wiper).

Try it out for yourself. Get a 1 k (linear is best) pot and a battery (anything from 1.5 V to 9 V will do), hook up the battery with the positive to terminal 3, and the negative, to terminal 1. Connect a voltmeter with the negative to terminal 1 and the positive lead to terminal 2. Commence with the control shaft at the fully anti-clockwise position (hard left!). As you slowly rotate the shaft clockwise, the reading on the voltmeter will rise. True! It's easier to do it than it is to read about it. The wiper, in this case, commences at terminal 1 and moves towards terminal 3.

Some applications require the pot to work in the reverse fashion. For example, as a frequency or pulse rate control in an oscillator or multivibrator. In such cases, an increasing effect occurs as the wiper traverses towards the 'minimum resistance' end of the control. The pot is simply connected so that terminal 1 is the 'maximum resistance' end of the control and terminal 3 the minimum.

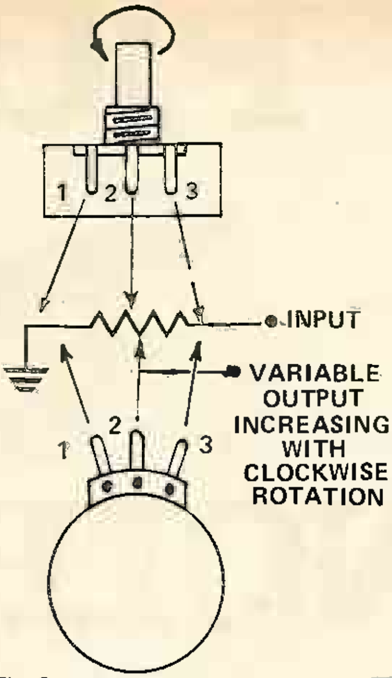


Fig. 6. Connecting a pot as a simple 'increase clockwise' control (e.g. volume).

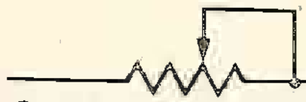
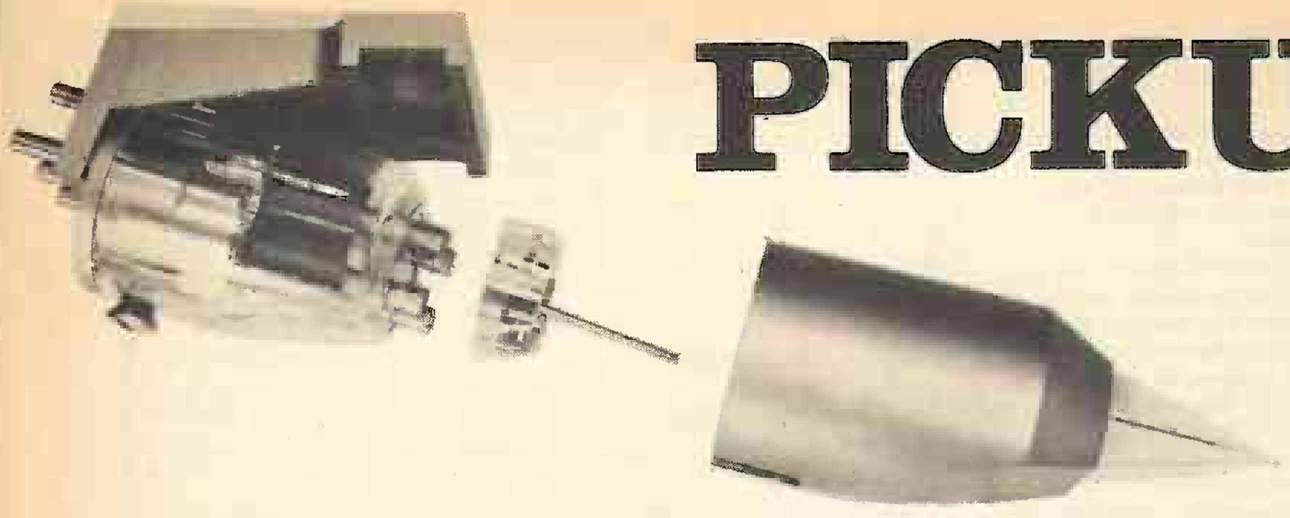


Fig. 7. Pots in some applications require only a variation in resistance. Which terminals are connected together depends on the circuit effect.

In some applications the circuit shows that the wiper is shorted to one of the 'end' terminals. But which one? Terminal 1, or 3? In such cases it depends on whether the 'maximum effect' occurs at minimum or maximum resistance. Look at Figure 7. The circuit shows that as the wiper traverses the element it shorts out the section of the track it has just traversed, decreasing the resistance as it moves towards the terminal which is not connected to the wiper. Leaving one 'end' terminal unconnected achieves the same purpose.

If the *maximum* effect (from the circuit in which the pot is to be connected) occurs at *minimum* resistance then terminals 1 and 2 are connected together. Maximum resistance (and thus minimum effect) occur at fully anti-clockwise rotation (hard left!). The effect increases as the control is rotated clockwise.

On the other hand, if the *maximum* effect occurs at *maximum* resistance then terminals 2 and 3 are connected together. Thus, as the control is rotated clockwise from the fully anti-clockwise position the resistance, and thus the effect, increases.



PICKUP PRINCIPLES

Ron Harris explains the workings of Hi-Fi's smallest black box

FOR ALL THE continuing sophisti--cation within the electronics of the hi-fi chain, no viable method has been offered up to extract the mechanical information from the good old L.P. other than the trusty electro-mechanical cartridge.

This in itself generates an order of magnitude more distortion than any hi-fi component, but for some as yet unexplained reason, people seem more ready to accept some quite quirky behaviour from cartridges than from anything else.

After all if a particular brand of amplifier needed its wires cleaning before every usage, its sales would remain nicely static at zero.

The term electro-mechanical can be seen to excuse a multitude of sins.

INDUCTION

Most pickups owe thier existance to Mr Faraday and his laws of induction. If you move a wire relative to a magnet within its field, you will generate an emf across that wire. It matters little whether you move the magnet or the coil of wire.

Various methods and variations have of course been evolved to utilise this principle to obtain an amplifiable voltage from the ups and downs of the vinyl.

Not all cartridges operate on this principle, just 90% of them! Ceramic devices are the main exception but these have completely faded from hi-fi usage, as the quality is no longer of comparitively high enough standard for the enthusiast.

The most common types are;

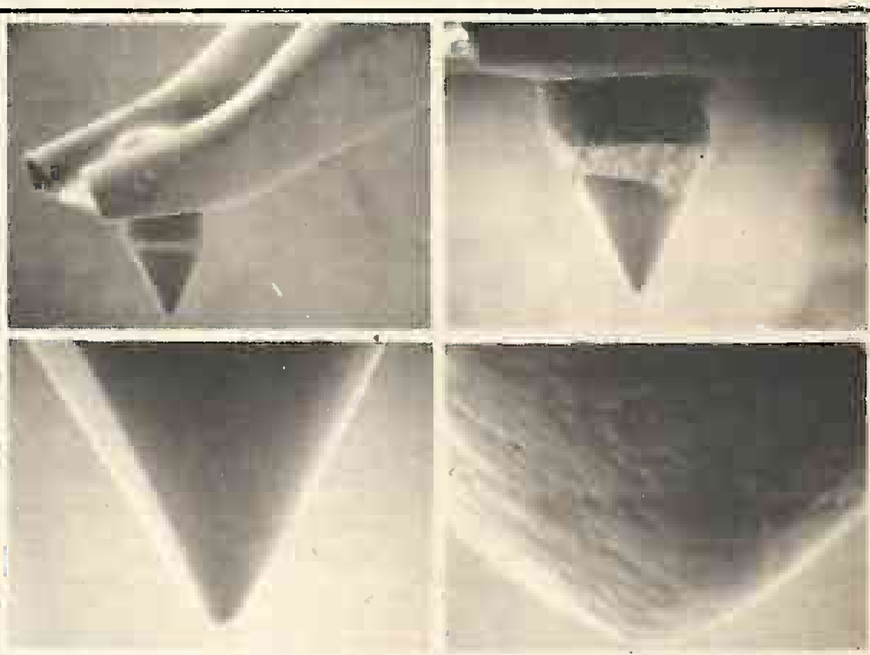
(i) Moving magnet
(ii) Moving coil
(iii) Moving iron Induced magnet
(iv) Electret

We shall be considering each type in turn.

No reference is made in this article to such universal parameters as tip mass compliance of cantilever, arm resonance, output level etc etc

Such things are of paramount importance, but have little to do with the operating principles behind the cartridges themselves.

We mention them lest you think we had forgotten, or worse still were ignorant of them!



Every home should have one! Every cartridge does, but not this size. Shown here are four extreme magnification shots of a Stanton stylus. From top, left to right, 50X, 100X, and on the bottom 400X and 2000X.
And you thought that diamond was smooth eh?

MOVING MAGNET

By far the most common method. Fig I shows the basic operation of a Phillips 412 super M pickup, which can be considered typical of the bar magnet variety.

The pole pieces PL and PR are composed of mu-metal. When the stylus moves following the groove wall at say the left channel signal, the magnet will follow a similar path such that movement takes place parallel to PR, varying the distance relative to PL. This causes an emf to be set up across the left channel coils. Since that movement takes place parallel to the right channel coil, no emf is generated across that coil.

Since the coils are detecting minute changes in flux, sheilding from external influences must be good so that these are not registered as signals. Transformers must be kept well away from all pickup cartridges, which is why your deck will invariably work better on one side of your amplifier than on another!

A variation on this theme has been penned by Audio Technica, who use one magnet for each channel, set at 45o to the record surface which makes them perpendicular to the groove walls. This does imitate the return of the cutting head pretty closely. The magnets are much smaller than usual, being around 25% of the mass normally utilised.

Since each channel was a totally separate motor assembly, stereo separation cannot help but be enhansed. Perhaps the most famous sons of the moving magnet are Shure, led by the VI5 111. This flagship design uses a laminated core structure, increasing the efficiency.

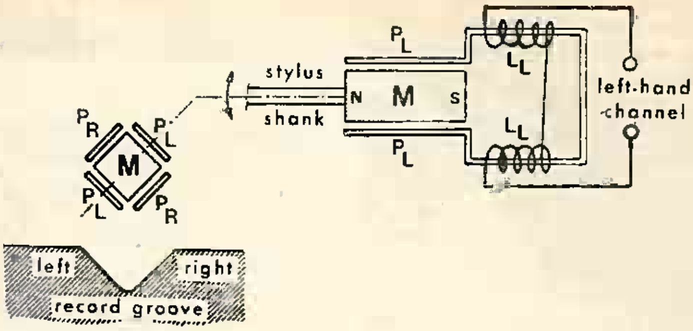
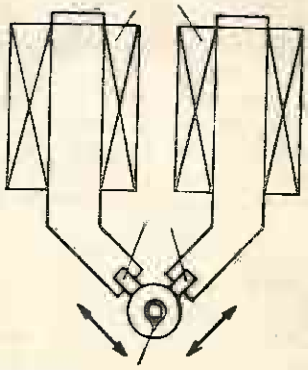
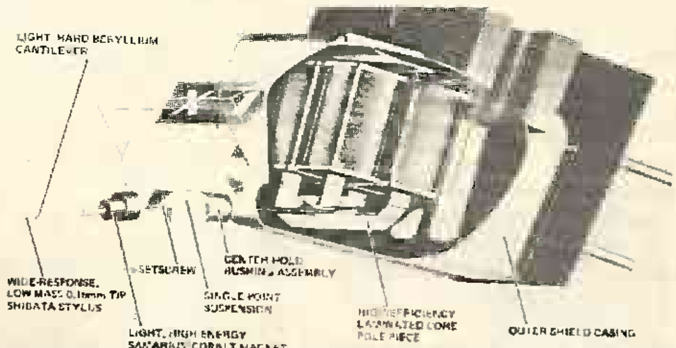


Figure 1. The workings of a moving magnet cartridge, which in this case is a Philips 412. The bar magnet is marked 'M', and PL and PR are the pole pieces for each channel.



Audio Technica's dual magnet system. On the left an actual stylus assembly, and on the right how that bit in the circle operates, copying the cutting head movements.



A cutaway drawing of the JVC XI cartridge. This device has an extended h.f. response to allow it to produce CD4 records, a task for which it has become the standard machine!

Surely this needs no introduction? The Shure V15 Mk3, probably the most famous moving magnet cartridge and arguably the most transparent in reproduction.

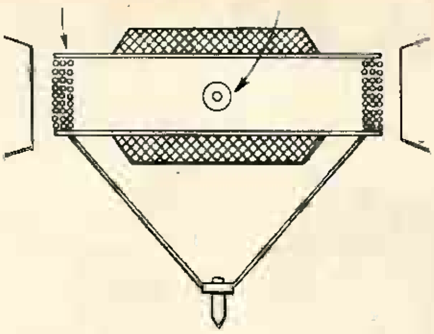
A Phillps 422 Super M. Very under-rated device this, people tend to only use them in Philips decks! The diagram in Fig 1 refers to this cartridge.

MOVING COIL

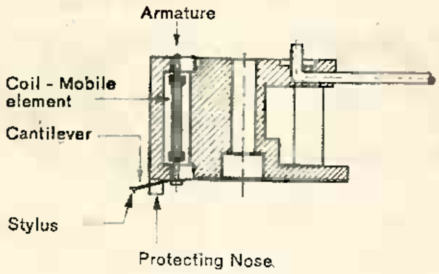
The oldest form of pickup cartridge. Originally developed by Ortofon, and now carried on by such adherents as Satin, Fidelity Research (and even Sony!).

The principle is extremely simple. The magnets are held in a fixed position within the cartridge body, and the coils for each channel are attached to the stylus assembly. The basic design is shown below. As the stylus follows the groove, the coils are forced to move next to the relevant magnets, thus inducing an emf in each.

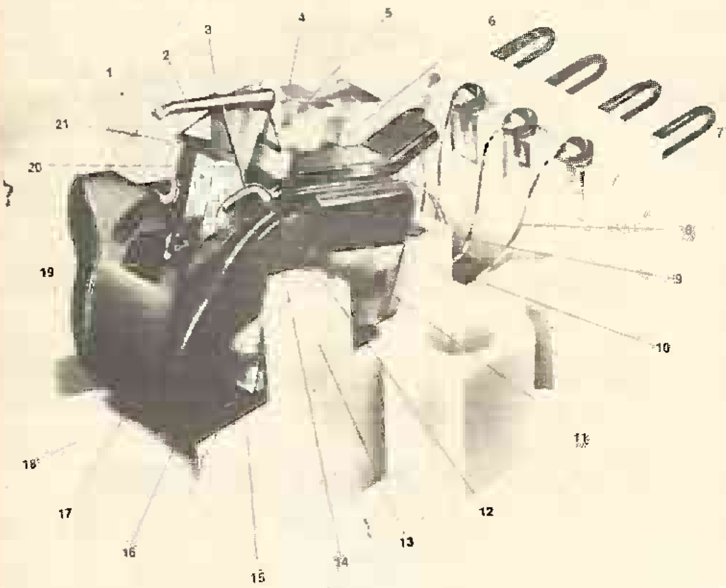
The main drawback is the low output, roughly 0.5 mV, as compared to 2 - 5 mV for the moving magnet designs. There are exceptions, notably Satin and Ultimo which produce outputs around 2mV. In order to raise this low level to one which can be fed to a normal input, a transformer or booster amp is required between cartridge and amplifier. However a tiny, but increasing number of amplifiers are now incorporating moving coil input to negate this requirement.



A highly simplified model of how a moving coil cartridge works. The blocks to either side represent the magnets, and the little flocks of circles are the coils.



Cutaway drawing of an early Ortofon moving coil device. An interesting feature is the vertical armature mounting. Note the protective nose mounted to safeguard the stylus!



1. Stylus tip
2. Cantilever
3. Stylus housing
4. Tension wire
5. Plate spring
6. Stylus mounting magnet
7. Output terminals
8. Connecting wire
9. Oscillating block resonance damper
10. Oscillating block restriction wall
11. Magnet
12. Pole piece
13. Oscillating block restriction wall
14. Magnetic gap
15. Gap spacer
16. Yoke
17. Moving coil
18. Cartridge main housing
19. Armature positioning pin
20. Armature support
21. Pantograph-type armature

Above is an internal peek at a Satin moving coil pickup. This is one of the high-output cartridges which does not need a transformer or booster amp to be used with normal amplifiers.

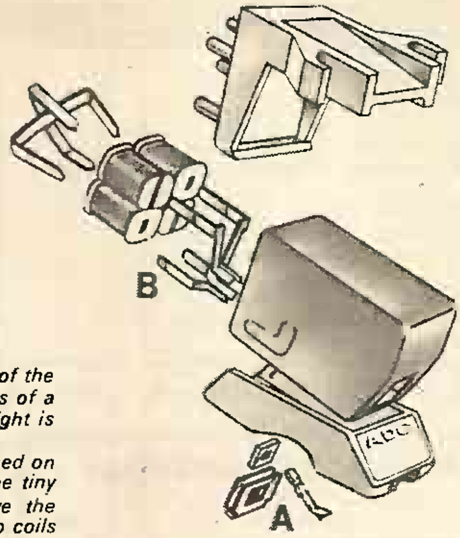
If you're setting up a hi-fi system based on a moving coil cartridge, check out the Yamaha 1010 amplifier, it already possesses a high quality moving coil pre amp!

And in the right corner . . . a Fidelity Research device with its booster transformer. This Japanese device has picked up quite a few followers in its short but glorious career in Britain.

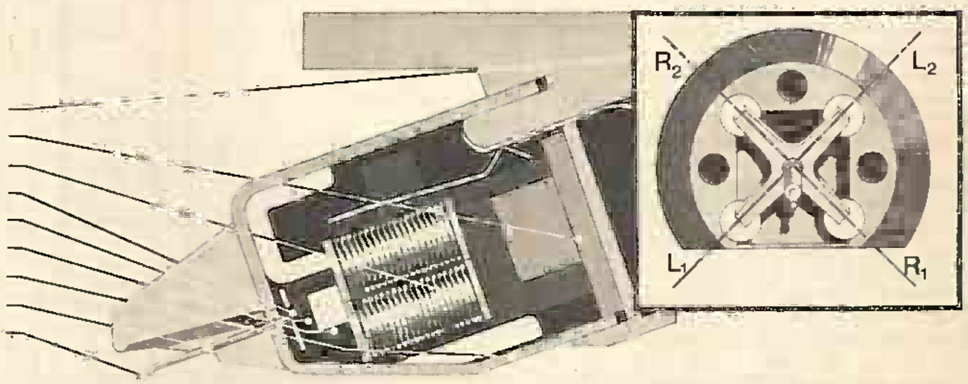
INDUCED MAGNET OR MOVING IRON

Replacing the moving magnets is a single high permeability armature which itself moves with the stylus within the field of the (fixed) magnets. As there is no mechanical linkage the mass of the stylus is reduced. ADC are the prophets of this system.

Bang and Olufsen have an innovation on the market in the form of the MMC range. Here a small 'cross' is attached to the armature and this influences the 4 induction coils, to obtain that emf.



Right: ADC are the main exponents of the art of the induced magnet. The drawing shows the vitals of a Q36 pickup following this doctrine. Further right is how it looks when in use and in one piece.
Below: Bang and Olufsen MMC is heavily based on the moving iron principle, but incorporates the tiny little cross (shown as an insert) to improve the transfer from armature to coils. Note that two coils per channel are used

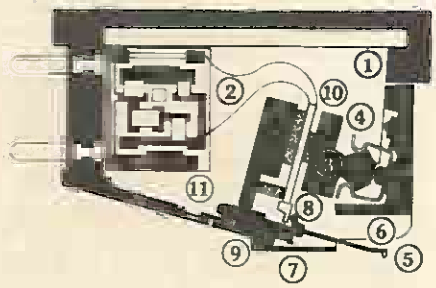


ELECTRET

Just as a quartz crystal is capable of producing an output under stress so are some semiconductor substances. An 'electret' is a permanently polarized block of material which, when stressed, produces an output voltage directly proportional to the force causing the stress.

In the Micro-Acoustics QDC 1E cartridge, a conventional stylus assembly joins with a pyramid shaped chunk of material which is pivoted in the centre of the base, and supported by two elastomer blocks, at each corner, where the actual electret contacts the pyramid.

Output impedence is around 8K, which shunts the usual 47K of amplifier inputs down. Micro claim this engenders their cartridges with lower noise figures. Phase shift characteristics should certainly be good, since the output impedence will be almost pure resistance, with very little capacitance present, and no inductance. The signs are that this system will be used increasingly as time goes on.



The drawing shows the insides of a Micro Acoustics 2002 electret cartridge. This is the cheaper version of the QDC 1E referred to in the text. To explain the numbers: 1, Total device possesses a mass of 4.0 grams; 2, Internal connecting wires to the matching circuit; 3, Dampers (mechanical); 4, Retainer spring for the stylus assembly; 5, Stylus assembly; 6, Beryllium cantilever; 7, Bearings and resolver; 8, Stylus to electret coupling; 9, User replaceable stylus assembly; 10, The actual electret transducer; 11, Passive matching circuit (matching to phono inputs).

ETI DATA SHEET

LM 2907, LM 2917 FREQUENCY TO VOLTAGE CONVERTORS — NATIONAL

The LM2907, LM2917 series are monolithic frequency to voltage converters with a high gain op amp/comparator designed to operate a relay, lamp, or other load when the input frequency reaches or exceeds a selected rate. The tachometer uses a charge pump technique and offers frequency doubling for low ripple, full input protection in two versions (LM2907-8, LM2917-8) and its output swings to ground for a zero frequency input.

Features

The op amp/comparator is fully compatible with the tachometer and has a floating transistor as its output. This feature allows either a ground or supply referred load of up to 50 mA. The collector may be taken above V_{CC} up to a maximum V_{CE} of 28V.

The two basic configurations offered include an 8-pin device with a *ground referenced tachometer* input and an internal connection between the tachometer output and the op and amp non-inverting input. This version is well suited for single speed or frequency switching or fully buffered frequency to voltage conversion applications.

The more versatile configurations provide differential tachometer input and uncommitted op amp inputs. With this version the tachometer input may be floated and the op amp becomes suitable for active filter conditioning of the tachometer output.

Both of these configurations are available with an active shunt regulator connected across the power leads. The regulator clamps the supply such that stable frequency to voltage and frequently to current operations are possible with any supply voltage and a suitable resistor.

Applications

The LM2907 series of tachometer circuits is designed for minimum external part count applications and maximum versatility. In order to fully exploit its features and advantages let's examine its theory of operation. The first stage of operation is a differential amplifier driving a positive feedback flip-flop circuit.

The input threshold voltage is the amount of differential input voltage at which the output of this stage changes state. Two options (LM2907-8, LM2917-8) have one input intermally grounded so that an input signal must swing above and below ground and exceed the input thresholds to produce an output. This is offered specifically for magnetic variable reluctance pickups which typically provide a single-ended ac output. This single output is also fully protected against voltage swings to ±28V, which are easily attained with these types of pickups.

Following the input stage is the charge pump where the input frequency is converted to a dc voltage. To do this requires one timing capacitor, one output resistor, and an integrating or filter capacitor. When the input stage changes state (due to a suitable zero crossing or differential voltage on the input) the timing capacitor is either charged or discharged linearily between two voltages whose difference is $V_{CC}/2$. Then in one half cycle of the input frequency or a time equal to $1/2\ f_{IN}$ the change in charge on the timing capacitor is equal to $V_{CC}/2 \times C1$. The average amount of current pumped into or out of the capacitor then is: $= V_{cc} \times f_{IN}$

The output circuit mirrors this current very accurately into the load resistor R1, connected to ground, such that if the pulses of current are integrated with a filter capacitor, then $V_o = i_c \times R1$, and the total conversion equation becomes:

$$V_O = V_{CC} \times f_{IN} \times C1 \times R1 \times K$$

Where K is the gain constant — typically 1.0.

Applications

- Over/under speed sensing
- Frequency to voltage conversion (tachometer)
- Speedometers
- Breaker point dwell meters
- Hand-held tachometer
- Speed governors
- Cruise control
- Automotive door lock control
- Clutch control
- Horn control
- Touch or sound switches

Absolute Maximum Ratings

Supply Voltage	28V
Supply Current (Zener Options)	25 mA
Collector Voltage	28V
Differential Input Voltage	
Tachometer	28V
Op Amp/Comparator	28V
Input Voltage Range	
Tachometer	LM2907-8,
LM2917-8	±28V
LM2907, LM2917	0.0V to +28V
Op Amp/Comparator	0.0V to +28V
Power Dissipation	500 mW

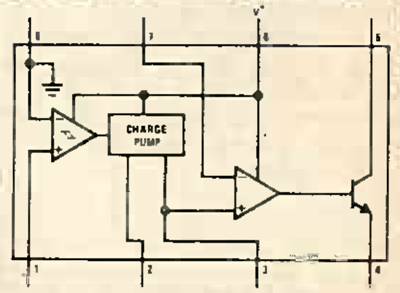
Choosing R1 and C1

There are some limitations on the choice of R1 and C1 which should be considered for optimum performance. The timing capacitor also provides internal compensation for the charge pump and should be kept larger than 100 pF for very accurate operation. Smaller values can cause an error current on R1, especially at low temperatures. Several considerations must be met when choosing R1. The output current at pin 3 is internally fixed and therefore $V_o/R1$ must be less than or equal to this value. If R1 is too large, it can become a significant fraction of the output impedance at pin 3 which degrades linearity.

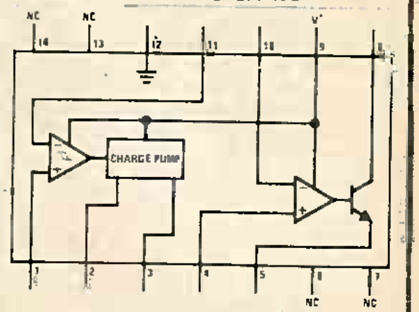
It appears R1 can be chosen independent of ripple, however response time, or the time it takes V_{OUT} to stabilize at a new voltage increases as the size of C2 increases so a compromise between ripple, response time, and linearity must be chosen carefully.

As a final consideration, the maximum attainable input frequency is determined by V_{CC}, C1 and I_2:

$$f_{MAX} = \frac{I_2}{C1 \times V_{CC}}$$



Order Number LM2907N-8



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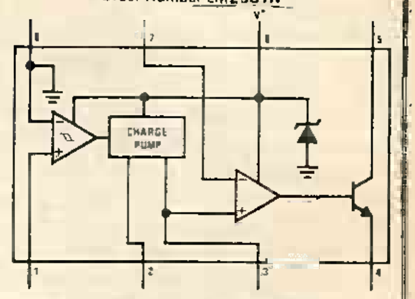
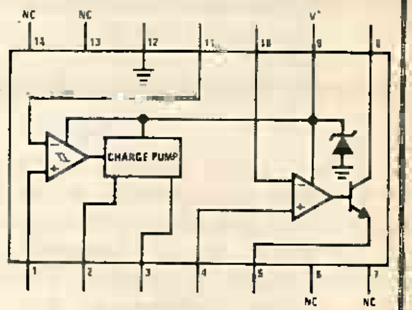


Order Number LM2917N



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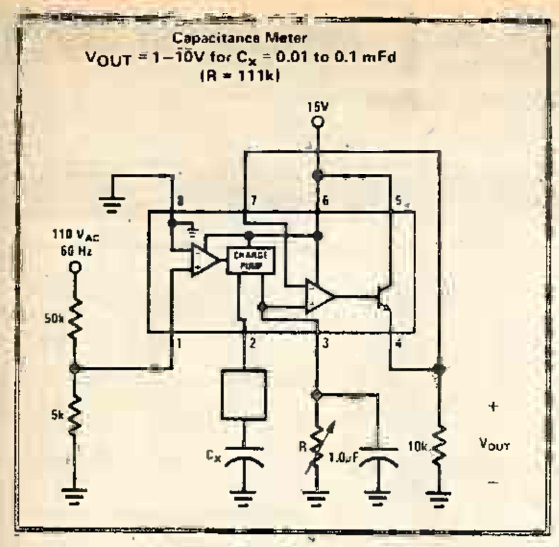
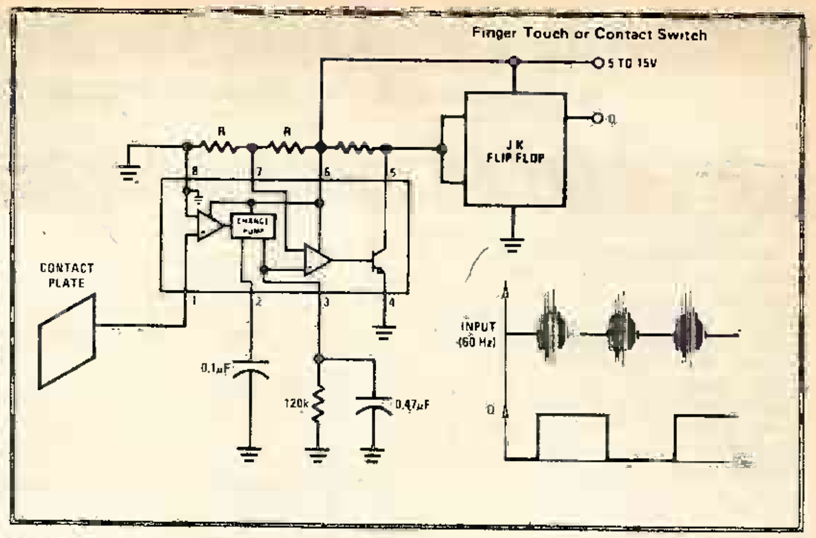
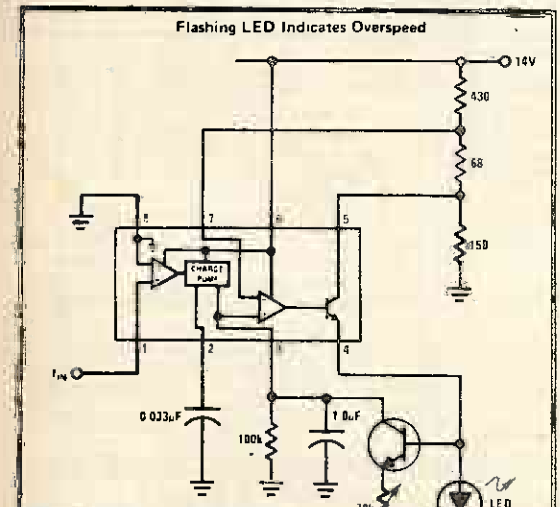
Using Zener Options

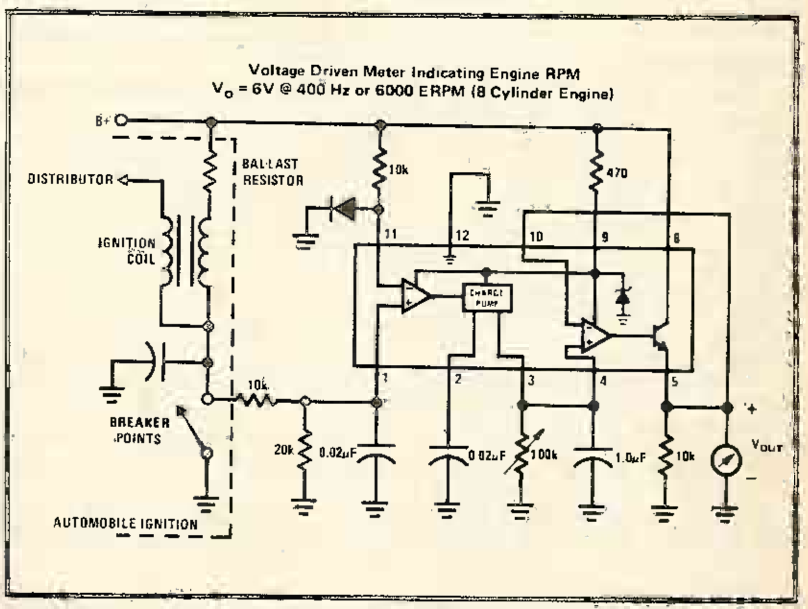
For those applications where an output voltage or current must be obtained independent of supply voltage variations, the

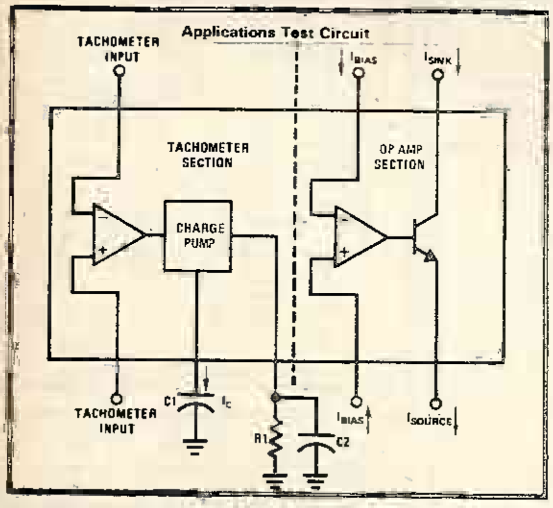


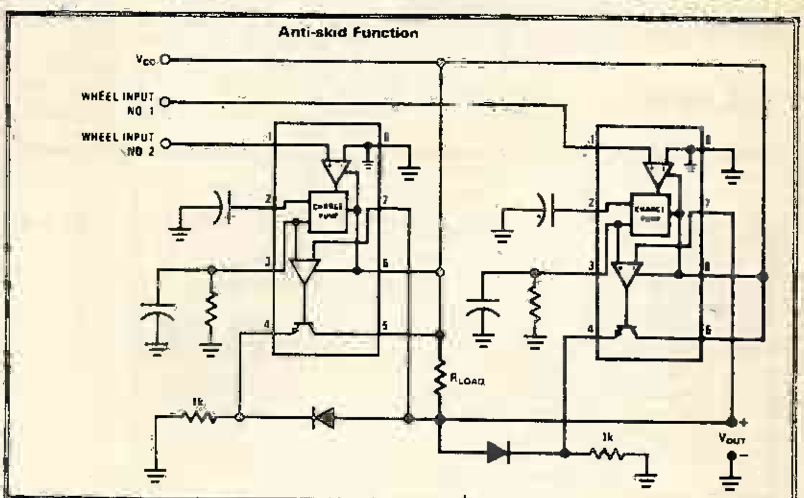




Flashing begins when $f_{IN} \geq 100$ Hz.
Flash rate increases with input frequency increase beyond trip point.

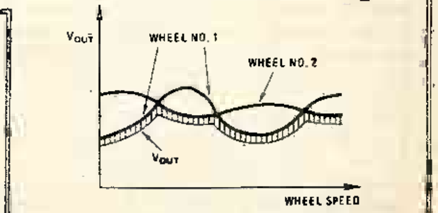






LM2917 is offered. The most important consideration in choosing a dropping resistor from the unregulated supply to the device is that the tachometer and op amp circuitry alone require about 3 mA at the voltage level provided by the zener. At low supply voltages there must be some current flowing in the resistor above the 3 mA circuit current to operate the regulator. As an example, if the raw supply varies from 9 to 16V, a resistance of 470Ω will minimize the zener voltage variation to 160 mV. If the resistance goes under 400Ω or over 600Ω the zener variation quickly rises above 200 mV for the same input variation.

The LM2907-8 and LM2917-8 are both available from **A. Marshall (London) Ltd** price is **£1.78** each plus **30p** postage per order.



V_{OUT} is proportional to the lower of the two input wheel speeds.

The LM 1830 is a monolithic bipolar integrated circuit designed for use in fluid detection systems. The circuit is ideal for detecting the presence, absence or level of water, or other polar liquids. An AC signal is passed through two probes within the fluid. A detector determines the presence or absence of the fluid by comparing the resistance of the fluid between the probes with the resistance internal to the integrated circuit. An AC signal is used to overcome plating problems incurred by using a DC source. A pin is available for connecting an external resistance in cases where the fluid impedance is of a different magnitude than that of the internal resistor. When the probe resistance increases above the preset value, the oscillator signal is coupled to the base of the open-collector output transistor. In a typical application, the output could be used to drive a LED, loud speaker or a low current relay.

Applications

The LM 1830 requires only an external capacitor to complete the oscillator circuit. The frequency of oscillation is inversely proportional to the external capacitor value. Using 0.001 μF capacitor, the output frequency is approximately 6 kHz. The output from the oscillator is available at pin 5. In normal applications, the output is taken from pin 13 so that the internal 13k resistor can be used to compare with the probe resistance. Pin 13 is coupled to the probe by a blocking capacitor so that there is no net DC on the probe.

Since the output amplitude from the oscillator is approximately 4 V_{BE}, the detector (which is an emitter base junction) will be turned "ON" when the probe resistance to ground is equal to the internal 13kΩ resistor. An internal diode across the detector emitter base junction provides symmetrical limiting of the detector input signal so that the probe is excited with $\pm 2\ V_{BE}$ from a 13k source. In cases where the 13k resistor is not compatible with the probe resistance range, an external resistor may be added by coupling the probe to pin 5 through the external resistor as shown in Fig. 2. The collector of the detecting transistor is brought out to pin 9 enabling a filter capacitor to be connected so that the output will switch "ON" or "OFF" depending on the probe resistance. If this capacitor is omitted, the output will be switched at approximately 50% duty cycle when the probe resistance exceeds the reference resistance. This can be useful when an audio output is required and the output transistor can be used to directly drive a loud speaker. In addition, LED indicators do not require DC excitation. Therefore, the cost of a capacitor for filtering can be saved.

Features

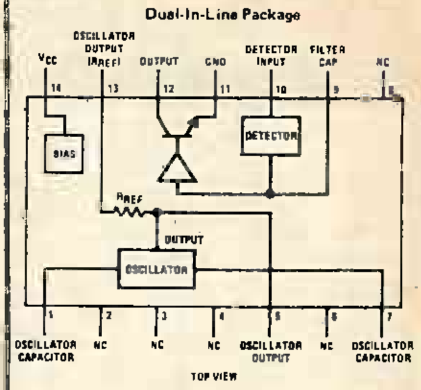
- Low external parts count
- Wide supply operating range
- One side of probe input can be grounded
- AC coupling to probe to prevent plating
- Internally regulated supply
- AC or DC output

Applications

- Beverage dispensers
- Water softeners
- Irrigation
- Sump pumps
- Aquaria
- Radiators
- Washing machines
- Reservoirs
- Boilers

Absolute Maximum Ratings

Supply Voltage	28V
Power Dissipation	300mW
Output Sink Current	20mA



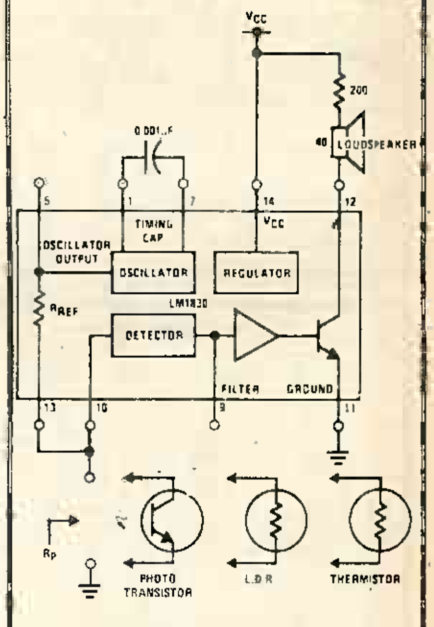
Order Number LM1830N

Fig. 1 Pinouts

Probes

In a typical application where the device is employed for sensing low water level in a tank, a simple steel probe may be inserted in the top of the tank with the tank grounded. Then when the water level drops below the tip of the probe, the resistance will rise between the probe and the tank and the alarm will be operated. This is illustrated in Fig. 3. In situations where a non-conductive container is used, the probe may be designed in a number of ways. In some cases a simple phono plug can be employed. Other probe designs include conductive parallel strips on printed circuit boards.

In automotive and other applications where the power source is known to contain significant transient voltages, the internal regulator on the LM 1830 allows protection to be provided by the simple means of using a series resistor in the power supply line as illustrated in Fig 4. If the output load is required to be returned directly to the power supply because of the high current required, it will be necessary to provide protection for the output transistor if the voltages are expected to exceed the data sheet limits.



Output is activated when $R_p \gtrsim 1/3\ R_{REF}$

FIGURE 4. Direct Coupled Applications

Although the LM 1830 is designed primarily for use in sensing conductive fluids, it can be used with any variable resistance device, such as light dependent resistor or thermistor or resistor or resistive position transducer.

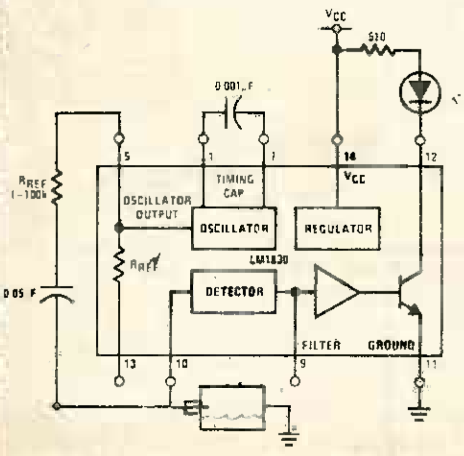


FIGURE 2. Application Using External Reference Resistor

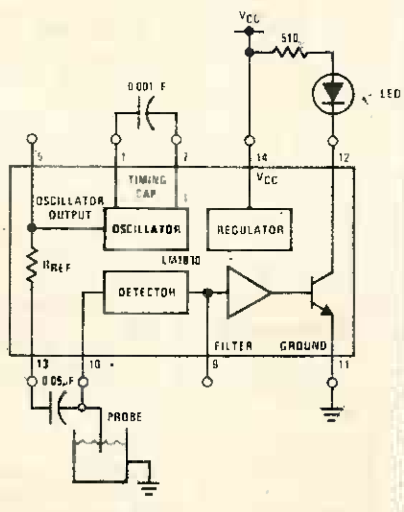


FIGURE 3. Basic Low Level Warning Device

The LM 1830 is available from **A. Marshall (London) Ltd., 42 Cricklewood Broadway, London NW2 3ET.** Price for one off is **£1.86** plus **30p** per order post and packing.

ELECTRONICS —it's easy! PART 42

Chart recorders

IN GENERAL, chart recorders are designed to accept electrical voltage signals as these constitute the majority of signals produced by sensing equipment. Occasionally the chart recorder is more appropriately connected to a mechanical output without electrical signals being involved: in some circumstances there is no need for electrical circuitry.

Chart recorders are, therefore, electronic system units which accept a voltage signal converting it to an equivalent graphical representation on paper. The recorder can be put to use in any application where an electrical signal is produced. Examples are measurement of fluctuations of the power mains voltage, records of body currents in medical diagnosis and changes in temperature in a process plant. The earliest chart recorder was probably Lord Kelvin's 19th century paper-tape siphon-recorder used to record electric telegraph signals. Because of the large and varied demand for chart recorders, manufacturers have developed numerous alternatives. Figure 1 shows a number of recorders installed to monitor an oil rig.

In fundamental terms chart-recorders are electro-mechanical converters — electrical signals are changed into equivalent mechanical ones which are used to make a permanent record on a paper-chart. For this reason there are two aspects to a chart recorder — its mechanical design and its electrical design. For convenience we look at each more or less separately but in designing and operating the recorder the two are so closely related that the response depends on adjustment of both disciplines of thought.

Fig. 1. Chart recorders are used in many varied applications. The panels of this control room contain a number that are used by the operators to see how the process is behaving.

Chart Recorder Formats:— Chart recorders are designed to display a signal in a graphical form that is convenient to the user. There are two basic types: those which record one or more variables with respect to time (commonly called x-t recorders) and those which plot one variable against the other (x-y recorders).

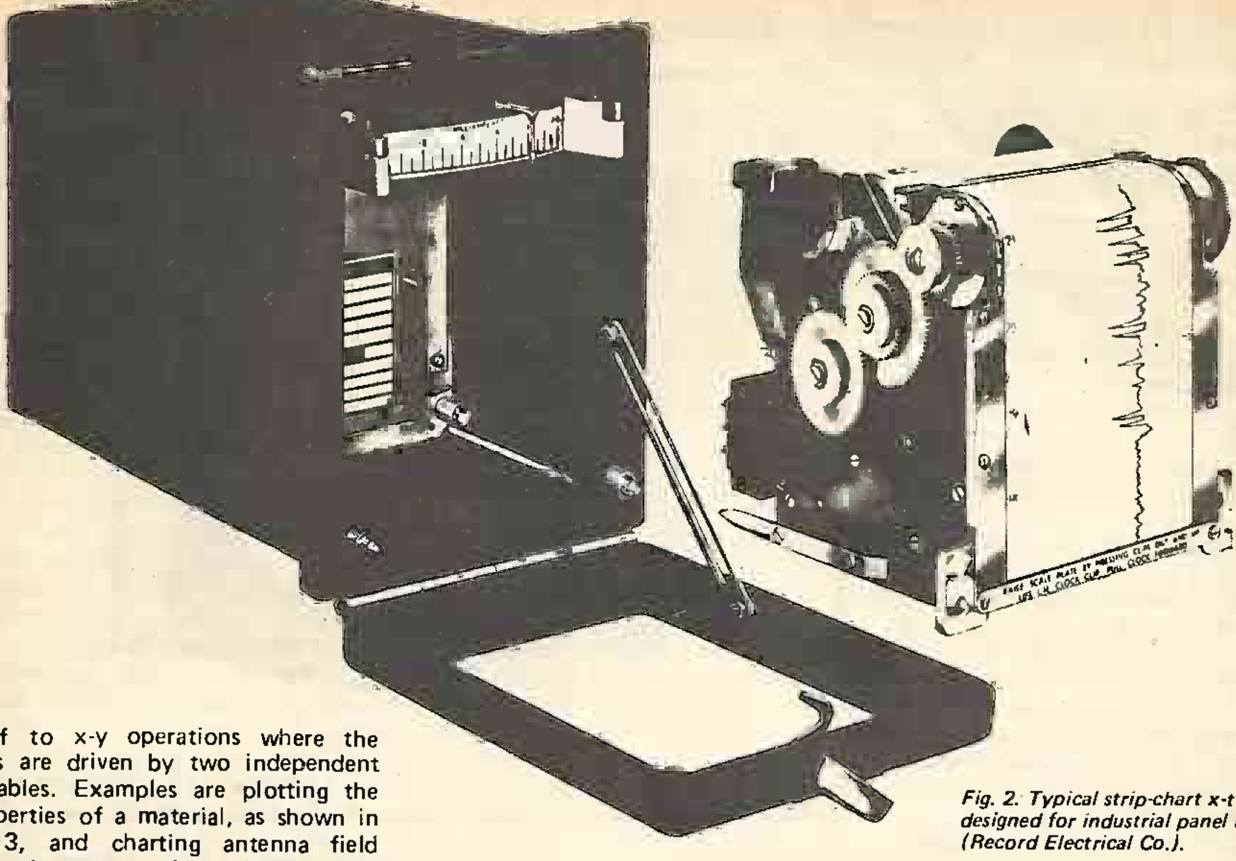
Strip-chart:— In these recorders a continuous roll of suitably scaled paper is motor driven at constant speed past the marking head. The paper drive is usually driven by a synchronous or stepping motor as this ensures accurate paper-speed. Where mains supply is not available dc governed-motors and clockwork alternatives can be used. Chart speed changes are commonly obtained by altering gear ratios. Figure 2 shows the construction of a typical panel mounted strip-chart x-t recorder. The module shown withdrawn from the housing is the paper drive unit, the housing contains the electronic amplifier driving the pen which contacts the top of the paper when the drive unit is plugged in.

Strip chart recorders for bench top use are also common - Figure 3. Some strip chart recorders take up the used paper by rolling it or by folding it in a concertina. The latter, known as z-fold, is very convenient when the need to refer to the record arises.

Chart speeds vary widely - from metres per second in fast-writing recorders used to capture kilohertz bandwidth transients, down to millimetres per hour for industrial process and slow-scientific phenomenon recording. It is not usual, however, to find a range as wide as this in the one unit.

Process industry strip-chart recorders generally run at one speed only; units for scientific use usually have switched speed capability. The choice is decided by matching the resolution required with the amount of paper consumed.

Paper sheet:— The flat-bed style lends



itself to x-y operations where the axes are driven by two independent variables. Examples are plotting the properties of a material, as shown in Fig. 3, and charting antenna field strength versus position. In this style the recording paper is a single sheet which is attached to the platen. The pen moves both in the x and y directions. The paper may be held by clips or by electrostatic attraction. If the x axis input (horizontal) is fed with voltage that rises linearly with time (a ramp function) the x axis will move across the chart with time making the unit an x-t format recorder. Plug-ins generating appropriate ramps are often provided as an accessory — one is illustrated in Fig. 4

Fig. 2. Typical strip-chart x-t recorder designed for industrial panel mounting. (Record Electrical Co.).

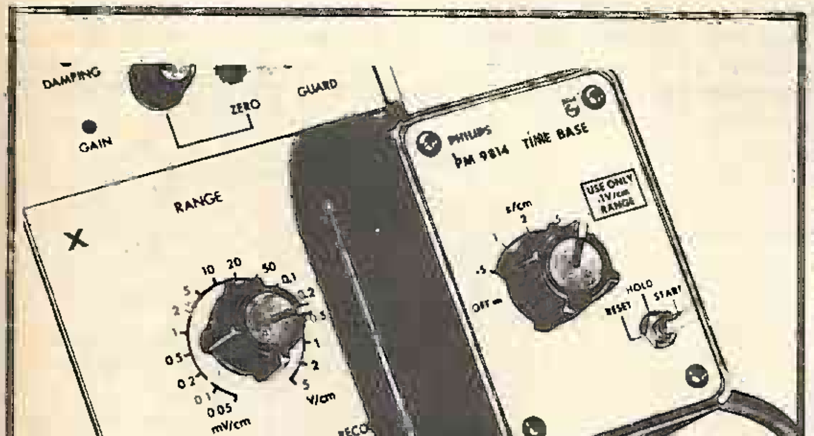


Fig. 4. Plug-in used to convert x-y flat bed recorder to x-t mode of operation.

Fig 3 Plotting an hysteresis curve for material under test in the large magnet shown at the rear.

ELECTRONICS–it's easy!

Circular:— Where the Geometry of the measurement task is circular, such as recording out-of-roundness of a ground shaft, or where the measure has a cyclic time function, such as daily temperature changes, a circular form of chart is easier to use. The chart rotates under the marking device at a rotational velocity locked to the geometrical position or the appropriate sub-unit of time — hours, days, weeks and months. An example of a circular-chart recorder is given in Fig. 5.

The size of chart papers varies greatly from recorder to recorder. Strip charts are used from 50 mm width to around 800 mm with lengths as much as 150 m. The duration of the maximum record that can be taken on a roll is decided by the chart length and the chart speed. Flat bed units begin in paper size at about 200 by 300 mm ranging to huge computer-controlled automatic-draughting units with beds as much as 6 m x 4 m. Circular charts rarely exceed 300 mm diameter.

Supply of chart papers can be difficult at times because stockists find difficulty in holding large stocks of the numerous options available. It is wise for the operator to hold a generous supply in hand at all times.

When reading values from paper charts care must be exercised in ensuring that inaccuracies caused by paper size changes, paper wander across its platen and marking mechanism offsets are allowed for. Good quality charts are a necessity with high-quality measurements.

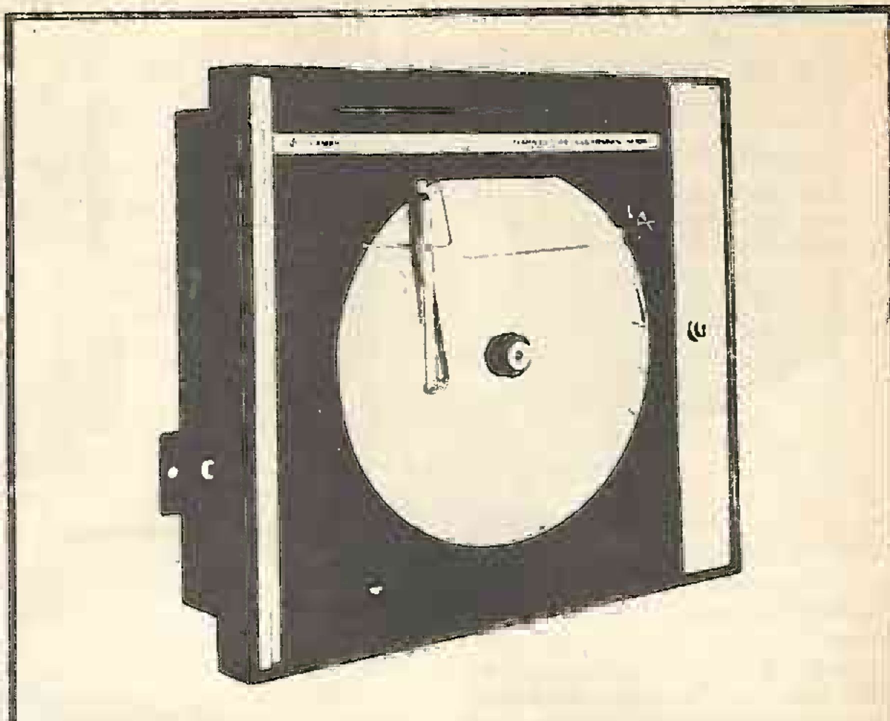


Fig. 5. Circular chart recorder.

PAPER MARKING TECHNIQUES

In these units an electronic amplifier coupled to a mechanical drive moves a mechanical point across the chart. It is then necessary to mark the paper in order to show where the point has travelled. Five commonly used techniques will be encountered.

Ink pen— Samuel Morse's telegraph recorder used a pencil to mark the paper strip. A limitation is that the lead wears away making a feed mechanism necessary. Ink can flow from a reservoir continuously: Kelvin introduced the siphon system in 1873. This system is used extensively today in one form or other. Ink feed rate is a factor of the pen, paper absorbency and ink viscosity. Figure 6a shows pen details.

A second ink feed method uses a combination of gravity feed and capillary action through small bores. These are the ballpoint and fibre-tip pens. A third ink method pressurizes the ink, recording being performed by a very fine ink jet. This method is suitable for fast writing speeds (as high as 60 metres per second compared with around 1 m per second for unpressurized ink feeds). There is no mechanical contact with the paper in pressurized systems, the fast writing rate arising because of the very small size of nozzle built into the deflecting system. Figure 6b shows the schematic of such a recorder. The pressure is automatically adjusted to suit the chart speed set.

The correct choice of ink and paper for the speed of operation is essential.

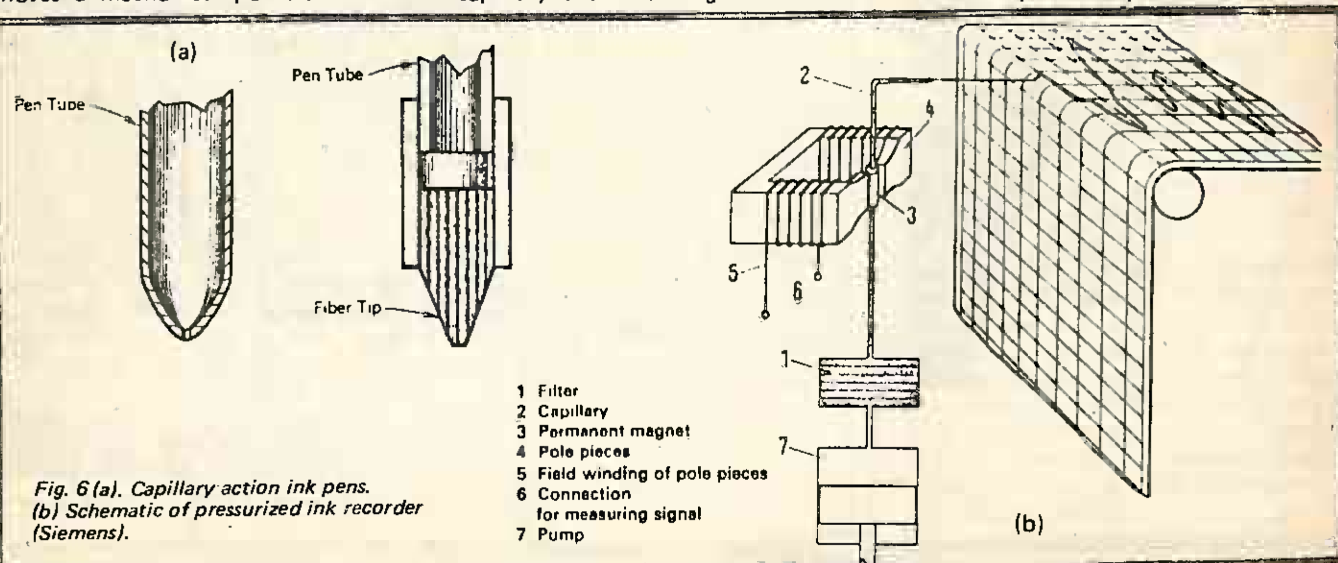


Fig. 6 (a). Capillary action ink pens.
(b) Schematic of pressurized ink recorder (Siemens).

Water-based inks are to be avoided as the record can be destroyed by accident. Fast drying inks are needed or else the trace may be rolled-up before the ink is dry. In short, although the alternatives to ink offer certain advantages we are still forced to use ink as the best all-round choice in many applications.

Pressure sensitive papers-- Black paper treated with tiny wax beads appears white until the beads are flattened to form a transparent cover window thereby exposing the black. Pressure sensitive papers are marked by the action of a gentle pressure exerted by the stylus. The relatively high contact-force needed restricts these to slow response application. Pressure-sensitive papers are more usually used with marking mechanisms that are periodically pressed against the paper to form a dot.

Electro-sensitive papers: Some recorders use paper which is marked when an electric current is passed through it. The earliest was carbon impregnated; dielectric breakdown producing the mark by applying a high voltage between the stylus and the platen.

Another method electroplates onto the surface of paper made conductive by saturation with salts. It requires wet paper use but will operate with lower voltage levels than the above carbon paper method.

Zinc oxide reduced to free zinc is the process used in another kind of recording system. Metallized papers in which the metal film is fused to its paper backing are another. Yet another is based on providing a change in the paper surface which takes up toner (similar to the Xerox process) — it is fine for very fast systems but not those that occur slowly.

Heat senstitive papers: Yet another method of making the record is to use a heated stylus melting a wax-like coating on black paper. These papers can be manufactured with greater resistance to marking (during handling) than the pressure sensitive papers. Stylus temperature can also be varied with ease to suit the writing speed concerned.

Photographic paper: The earliest photographic systems used negative film. Such systems are still in use today but the majority of the highest speed recorders (30 kHz is possible) use ultraviolet light to expose specially treated paper. Exposure produces a latent (invisible) image which needs further exposure to form the visible image. This is shown in Fig. 7: the fluorescent lamp intensifies the traces.

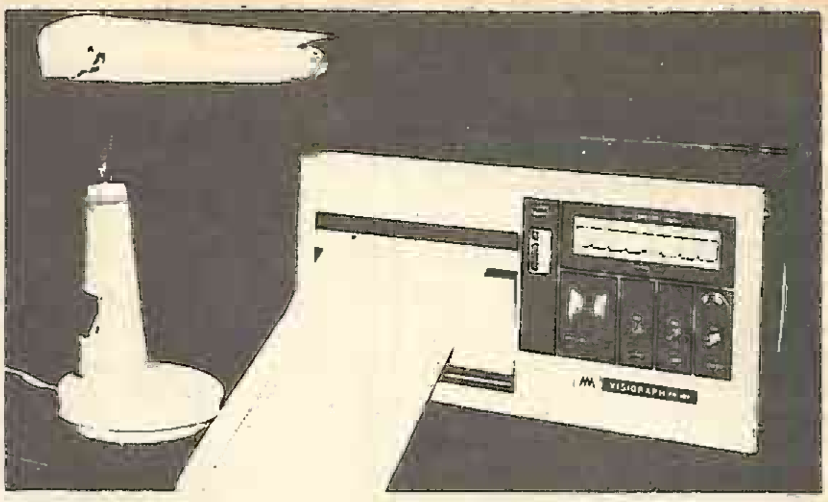


Fig. 7. UV recorders provide traces by exposure of photographic paper. Further exposure is needed to bring the latent image into view.

Continuous versus dotting mechanisms: Fast writing speeds require continuous marking and for these the writing mechanism functions continuously. For very slow speed needs, as are found in process plant monitoring an alternative, in which a dot is produced on the paper at regular periods, has certain advantages. Figure 8 shows one form of mechanical arrangement. A separate motor, or pick-off from the chart drive causes a point to periodically press on the paper, marking it by the appropriate method used. By incorporating a geneva mechanism (one that rotates a shaft in steps) the input signal can be switched sequentially over a number of different signal channels (six and twelve are usual). Also synchronised to the channel changing action is an inking system that steps from colour to colour to provide a different coloured dot for each channel. Inking may be as shown (different ribbons) or may be provided as individual pads each soaked with ink. A multipoint dotting head wipes through this ink. One maker uses a multicolour single ribbon, akin to a typewriter ribbon.

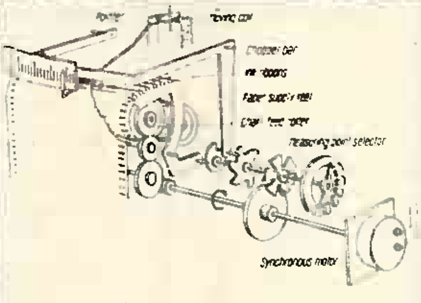


Fig. 8. Dotting recorders offer the advantages in slow-speed applications of being suitable for multi-channel multiplexing.

Multi-channel operation is also provided in some continuous trace recorders. This is almost always achieved by incorporating separate. Multi-trace recorders in which each trace has the full paper width capability are also available. Mechanical drives have the disadvantage in that the traces must be slightly out of phase so that the pens can pass one another without fouling. Optical recorders do not suffer from this drawback.

RECORDING MOVEMENTS

We now look at the methods used to transduce the electrical input signal into an equivalent mechanical movement.

Moving coil mechanisms: Basically these use modified moving coil and pointer. The end of the pointer carries an ink pen or acts as a marking point when forced onto the chart paper in dotting styles (see Fig. 8). Simple systems trace an arc across the chart giving a non-linear record. (curved markings on the paper overcome this but complicate the platen design). This can be linearized to provide better accuracy by various means such as that shown in Fig. 9.

Optical recorders also use a moving coil unit on which a mirror is mounted to reflect a high intensity focussed beam across the paper. These units have their origin in practical oscillographs designed by Duddell (to Blondel's ideas) at the turn of the century. The choice of galvanometer unit largely decides the frequency response. Today they are supplied as robust plug-in units like that shown in Fig. 10. The application, in many units, decides which galvanometer is

ELECTRONICS–it's easy!

used and the optimum terminating resistance value in order to know the deflection and sensitivity for a given frequency of signal. These recorders offer the ability to modulate the trace intensity producing 2-D half-tone chart records.

Potentiometric recorders: Around 1898 Professor Callendar devised his recording resistance pyrometer and in doing so, provided instrumentation with the potentiometric or self-balancing recorder. This method makes use of a closed-loop system that causes the pointer to follow input signals. Referring to Fig. 11 the recorder has a drive motor mechanism which translates the pointer in one direction or the other depending upon the polarity of the signal driving the motor. Attached to the shaft driving the pen is a rotary resistance balancing potentiometer, as shown in Fig. 11a. Schematically this can be shown as a linear equivalent (the more recent design style used) as shown in Fig. 11b. The potentiometer wiper moves across in unison with the pen and generates a changing value signal. The potentiometric system circuit layout is represented in Fig. 11c. A reference voltage is supplied across the potentiometer. Voltage from the wiper is compared with the input signal voltage to be recorded. If a difference exists this constitutes an error which causes the drive motor to move accordingly to correct the error. The input signal and reference signals are suitably attenuated to provide the sensitivity needed at full-scale deflection.

The advantages of recorders such as those described above are that the mechanism plots a linear scale, and there is considerable power available to move the pen against frictional forces. The system, being potentiometric, draws little current once the unit has achieved balance and, as considerable drive power is available under closed-loop control, the pen response can be made tighter than for the open-loop pointer-type moving coil units. Sensitivity is decided more by the amplifier gain than mechanical constants. The majority of flat-bed recorders use this principle: at full trace movement their writing speeds can reach several metres per second. The method also overcomes the restriction on traverse length suffered by rotationally driven recorder mechanisms. Although a simple dc servo control is shown, potentiometric recorders, especially those built before around 1970 more usually used ac control systems.

CRT — Fibre Optic Recorders: A recent design concept couples a CRT linear sweep trace to photosensitive paper via an optical fibre connection. This provides the highest response of all chart recorders so far available — dc to 1 MHz.

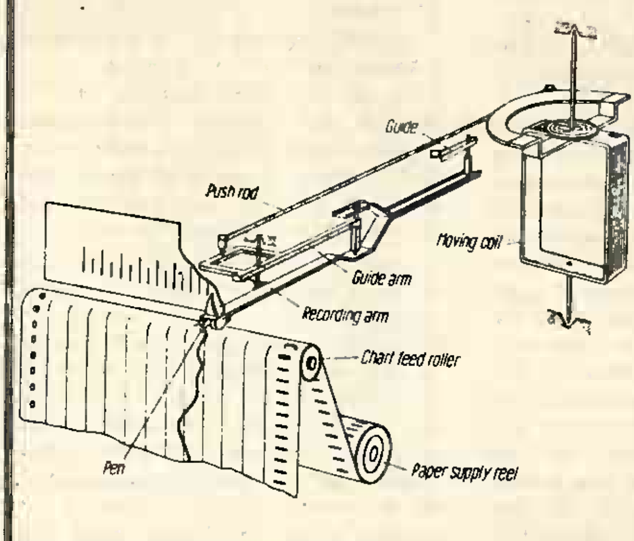


Fig. 9. Special linkages are used to linearize the non-uniform movement produced by a moving coil pen drive.

Fig. 10. Galvanometer unit for UV recorder (Hathaway Instruments).

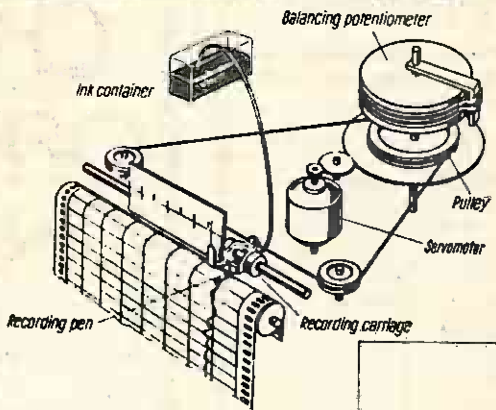
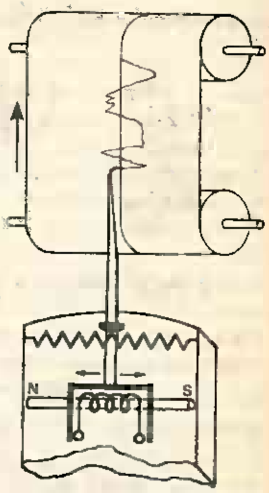
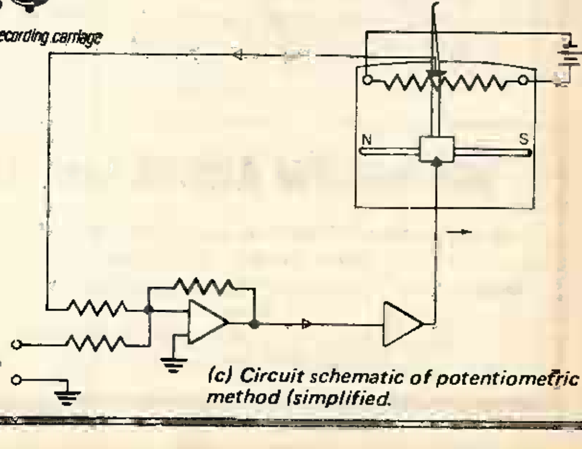


Fig. 11 (a). Arrangement of motor form of potentiometric recorder.



(b) Schematic using linear motor.



(c) Circuit schematic of potentiometric method (simplified.

DYNAMIC RESPONSE

A point commonly overlooked is that chart recorders have a certain dynamic response and are effectively low-pass filters of the input signal. The response of a recorder to a sine signal, that is, the recorded trace, will look like the original but will lack adequate amplitude if the pen cannot follow fast enough. When quoting response rates it is therefore necessary to state amplitude as well as frequency. For example, moving-coil recorders with short pen arms have a typical response that is flat from dc to 100 Hz at 10 mm peak-to-peak deflection for a sinewave. If the frequency is increased the recorder will still operate but the amplitude of a sinewave record falls off. Plots of complex waveforms may be severely distorted for the fundamental may be recorded at full amplitude with harmonics attenuated progressively. A square-wave input may be recorded as a near sine-wave if the response is inadequate. It is better to use a smaller signal amplitude in such cases.

Simple moving-coil chopper-type recorders will roll off from as low as 1 Hz. Ink jet units extend to 800 Hz: beyond that optical recorders are needed providing up to 1 MHz in the CRT design. Frequencies above this must be viewed by oscilloscopes using cameras to record the image.

Faithful response is also a function of amplifier characteristics. With the exception of simple moving-coil recorders most units have built-in amplification because the majority of signals to be recorded, have insufficient power to provide an adequate response. Recorder sensitivities may be fixed in manufacture, as in process industry dotting recorders, or have adjustable ranges. The manufacturers of recorders usually provide the amplifiers as part of the recorder, the purchaser only has to make the selection.

Event-marking recorders: In many recording applications, the variable remains constant for more of the time than it varies. An example might be recording rainfall in dry areas. If the record must provide fine time-resolution the chart must run fast which means using immense lengths of paper for little data recorded. An approach, slowly finding acceptance, is to use a time/date printer which prints a value each time an increment of event occurs. Each increment print-out causes the chart to advance a unit. The result is a record chart completely filled with non-zero data. It is harder to interpret but much more efficient for spasmodic data situations. At present, however, this form of equipment is hard to procure commercially.

ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

Hear No Evil . . .

FOR ABOUT £3,500 you can buy a microcomputer system complete with VDU, Printer, Multi-cassette system, 18KRAM, software, etc — all you need to be up and running is a mains plug. The most likely add-on to this sort of system is a floppy disk, more RAM or telecommunications facilities to be able to use it with a telephone to talk to a mainframe computer.

One problem with the idea of communicating with a mainframe from a micro is that the micro could possibly be more intelligent than the mainframe. For example I used the word "talk" earlier and I was not kidding. A company called Heuristics Inc, 900 N San Antonio Rd, Los Altos, California is now offering a product called "Speechlab" which adds to an S-100 bus to enable you to talk to your micro via a microphone. The signal from the microphone is amplified and then passed into three filtering networks with time averagers following each. The filter outputs are digitised by using a standard A/D converter and multiplexer, the resulting digital voltage levels are stored in RAM and another microphone sample taken. As each spoken word can be analysed into sections of high, medium or low frequencies sustained for different times the micro can build up a digital "picture" of the word. This "picture" can then be compared to word pictures already stored for comparison and hopefully a match found.

An interesting side application of this unit is for handicapped persons, even those with a serious speech handicap. Speechlab can recognise repetitions of sound patterns which do not necessarily need to be from a spoken language. Thus a slightly extended version of the Speechlab program could give a handicapped person the ablity to operate household or office equipment, including a typewriter, simply with a set of sound commands. The really remarkable thing about this MPU add-on kit is its relative simplicity and its price of $250, with the hopeful or perhaps inevitable advent of the Speechchip in a few months time we might well be able to look forward to micros with a vocabulary in excess of 1,000 words — well above that of a lot of adults!

Speak No Evil

Of course the 1000+ word vocabulary mentioned above is only the number of spoken words that the micro can understand. A microprocessor will never be able to produce anything like human speech with a level of vocabulary of anything near 1000 words. Unless, of course, you happen to have something like the Al Cybernetic Model 1000 speech synthesiser from Al Cybernetic, Box 4691, University Pk, NM88003, USA. Again this unit plugs on to an S-100 bus at one end and an audio amplifier at the other, to give, according to reports, an understandable if slightly robotic speech output. The output sounds are made up from a conversion of a phonetic interpretation of the ASCII character set, supplied as a string of characters. Essentially the Model 1000 is a hardwired analogue of the human vocal tract with various parts of the circuit emulating the vocal chords, the lungs, mouth, tongue, lips and teeth.

See No Evil . . . ?

Just to complete the trio, I should mention the digital camera seen recently at the Build Your Own Computer Exhibition. I can't recollect which company were showing it or exactly what it was capable of doing but it is enough to recognise that we can now build a machine with ears, mouth and eyes. With RAM and PROM now being designed in 64KByte packages and mass production leading to low prices how long will it be before machine intelligence becomes an everyday fact of life? Perhaps one of the first applications is in a telephone answering system that is able to answer an unattended phone, take a message, give a message, ring you at another number and pass on any important messages. Connect up a digital camera and TV screen to it before 1984 and you get a free Big Brother thrown in!

Green Fields and Blue Water.

If you already have or are considering building one of the TV games kits using the General Instruments AY-3-8500 then the fact that GI have just released the pin compatible AY-3-8550 may interest you. The 8550 plays the same six games as the 8500 but allows for changes in colour of the background, ball and players. The colour coding of the players allows one player to be "Blue" and the other player to be "Red", thus making their pieces on the screen easy to identify.

With the ability to encode the background according to the type of game you can produce new games from the existing logic. Changing the football background from green grass to blue water changes the game from football to water polo — same type of game but different rules.

The main physical differences between the 8500 and the 8550 are changes at pins —

1, 14 and 15 allow the bats to be moved horizontally as well as vertically by use of two more variable controls.

6, now Black/white bat select, allows payer colour coding.

28 is now a composite output being the sum of the signals for bats, ball, field and score and can be used in lieu of the data on pins 9, 10 and 24.

Data on the 8550 and other GI TV games is available from GIM, 57/61 Mortimer St, London W1N 7TD ●

tech-tips

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

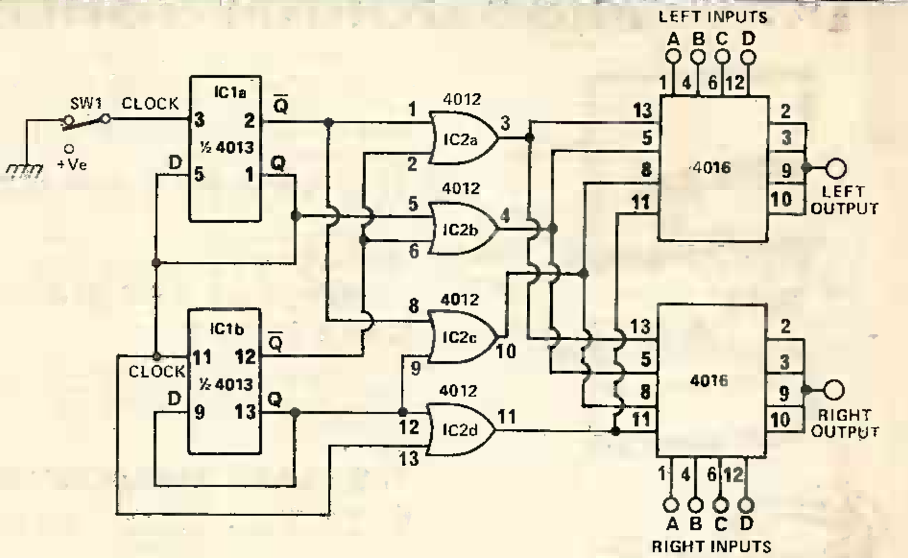
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.

Stereo Input Selector

T. E. Huffinley

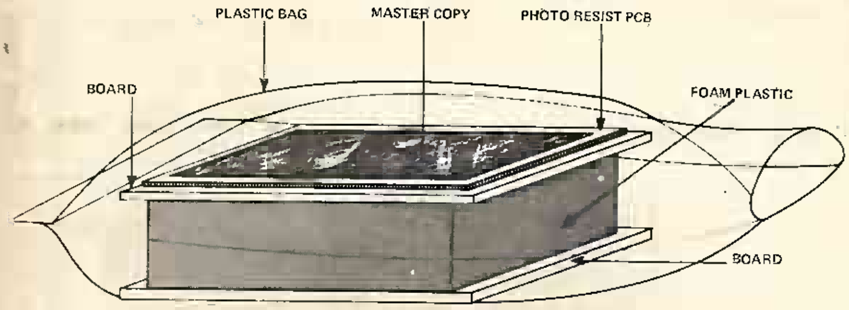
Four different inputs can be switched through by the continual pressing of SW1. IC1 is a dual 'D' type flip flop. The Q outputs are connected to the D inputs so that the clock inputs are divided by two. The two flip-flops are connected in series, giving a two stage binary counter.

IC2 is a quad OR gate. This is used to decode the four states of the counter. The outputs are used to control the quad switches of IC3 and IC4 (4016AE).



PCB Bag

L. Rink



A piece of foam plastic is placed between two boards of about the same size as the PCB being printed, on top of this is placed the Photo-resist PCB with the master copy transparency in position on top. The whole of this is put inside a plastic bag and then sqaushed flat.

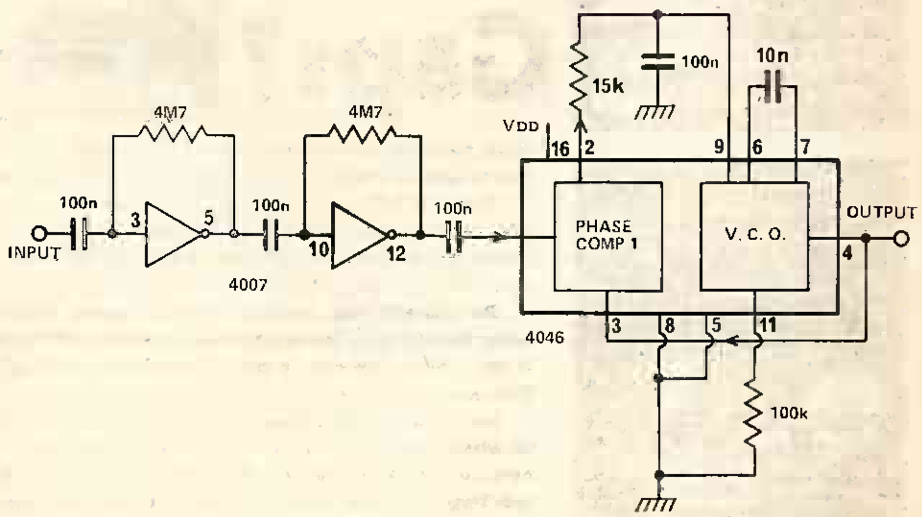
The end of the plastic bag is then sealed by folding over, and then when the pressure is released, and the plastic foam tries to expand, air pressure presses the transparency tight against the PCB and usually can hold it for several minutes.

Guitar Synthesiser

R. Barnett

This circuit uses a CMOS Phase Locked Loop, the 4046, to produce a very unusual sound from a guitar, which sounds something like a syntheiser.

The signal from the guitar is amplified by two of the amplifiers in the 4007. The amplified signal is used by the phase comparator to lock the VCO to the frequency of the note played. The VCO does not oscillate until a note is played, when using the low pass filter shown (i.e. the 15 k resistor and 100 n capacitor). If the value of the resistor is increased, the VCO oscillates continuously at about 1 kHz (with no input signal). This gives very smooth note changes. The basic frequency may be changed by varying the 100 k resistor.



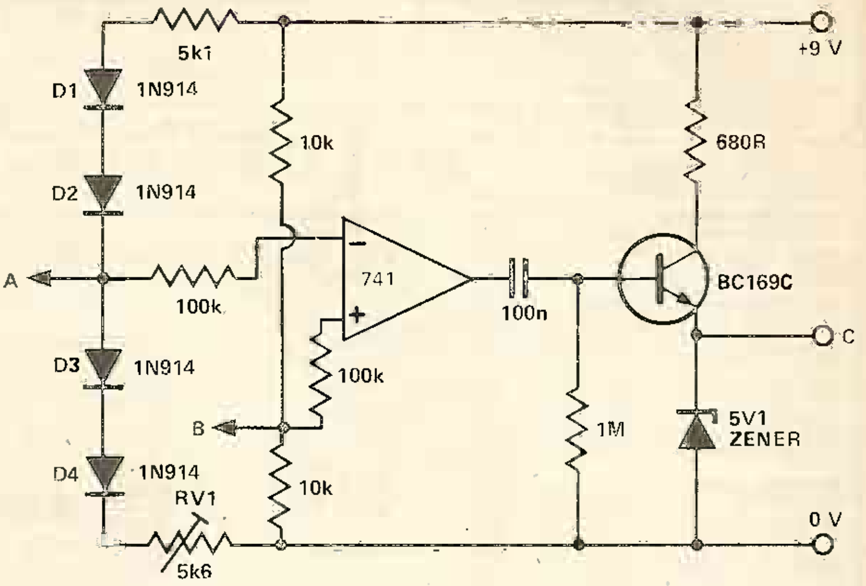
Thermo Touch Switch

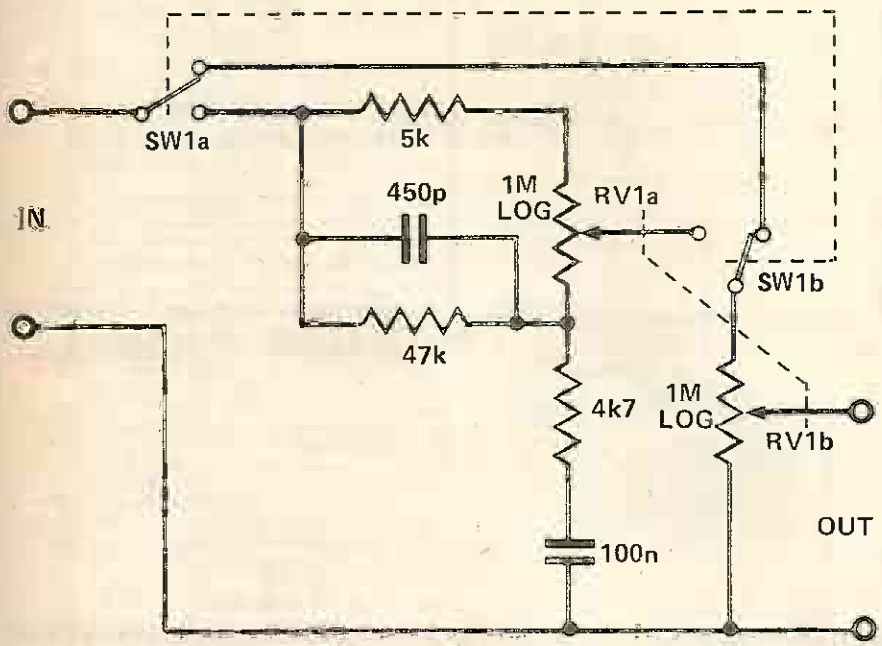
S. B. Dick

The following touch switch works on the temperature dependence of the forward voltage of silicon diodes. At 0 °C this is about 650mV, but drops by 2mV per °C increase in temperature.

When a finger is placed on D3 and D4 the voltage at A will drop below that at B and the O/P of the Op-Amp will go high, causing a TTL compatible pulse to appear at C. D1 and D2 provide compensation against ambient temperature changes. VR1 is initially set so that VA is greater than VB by about 10mV.

The system has the intrinsic advantage that it may be used in moisture-prone conditions in which ordinary touch switches would be most unsatisfactory due to their principle of operation.



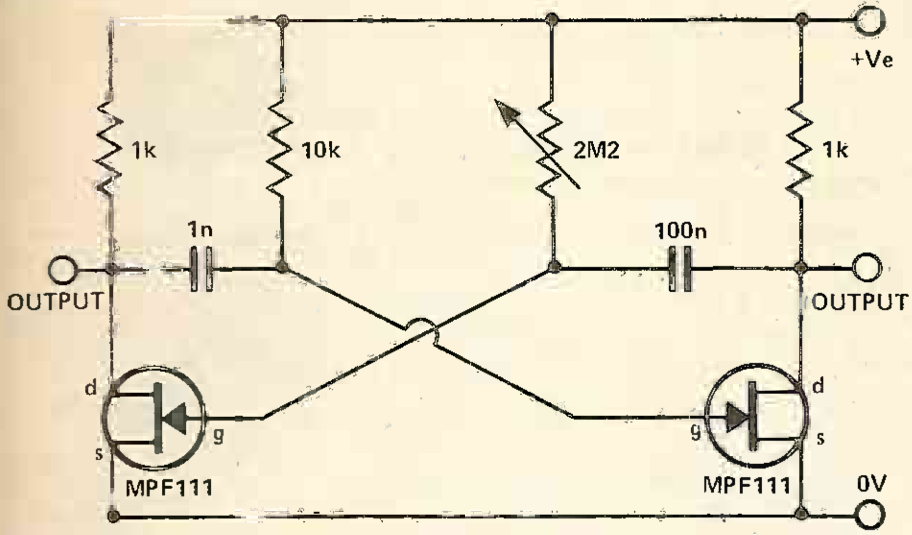


Loudness Control

David Chivers

This loudness control works with the volume control to provide a more even listening contour. Since the human ear can hear sound in the middle of the audio spectrum better than at the extremities, it is desirable to attenuate high and low frequencies less than the middle frequencies as the volume is cut.

With SW1 on, bass and treble are boosted relative to middle frequencies. RV1a is ganged to the volume control, this varies the strength of loudness control so that at low volume the effect is more noticeable. This unit will replace the volume control in a present system, coming between the preamp and power amplifier. It a stereo unit is to be made, SW1 should be four pole two way, and it is best to have separate volume / loudness controls for each channel since four way potentiometers are hard to find.



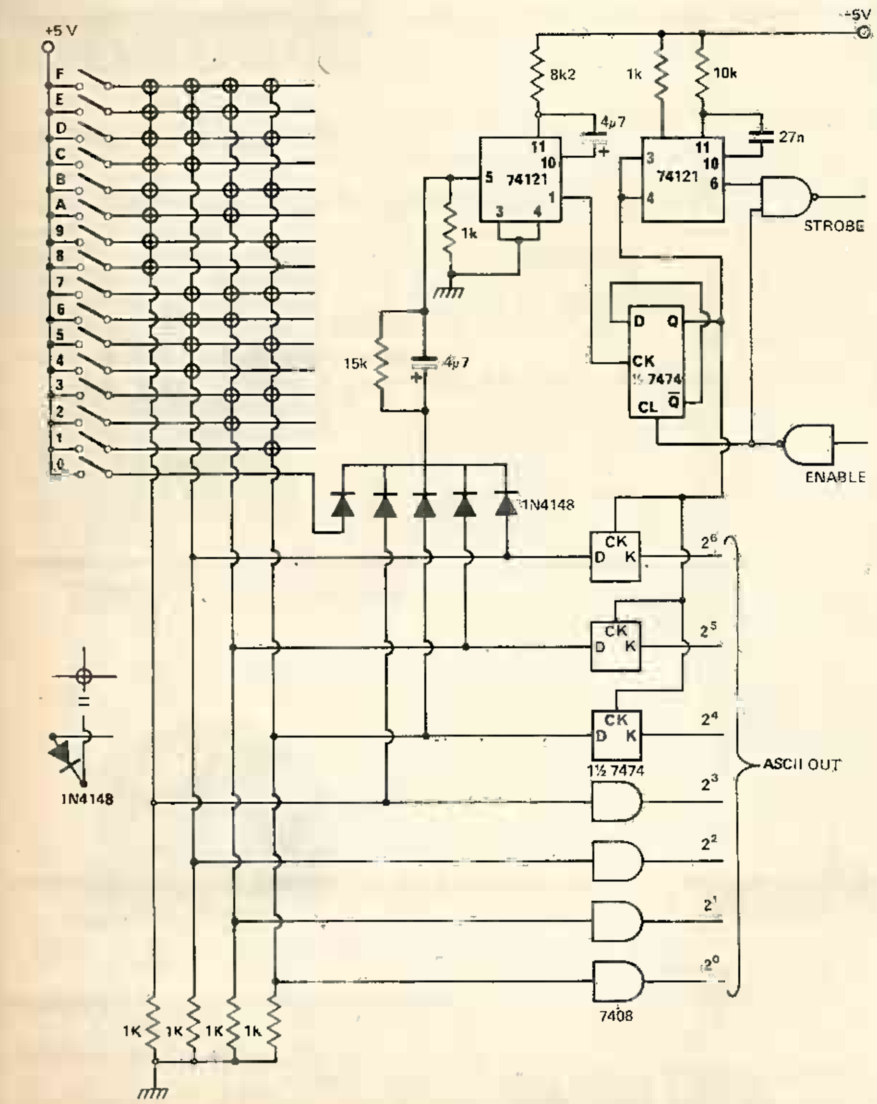
Wide Range Astable

P. D. Maddinson

In a conventional astable, the bipolar transistors take a significant amount of base current, which limits the use of high value timing resistors. By replacing bipolar transistors with FET's, which consume a much smaller 'gate' current, we can use much higher values of timing resistor and hence get a much wider range.

N-channel FET's were chosen, so that a positive Vcc rail could be used, and with a 5V supply the circuit was able to drive TTL without trouble.

With the component values given one time constant was approx. 5μS, and the other was variable from 5μS to approx. 2mS; a range of 400:1.



ASCII Keyboard

R. Barnett

This circuit uses a 16 key calculator keyboard to generate the 7 bit ASCII code, using two hex numbers to define ASCII character.

If, for example, the code for A (41 hex) is required, '4' is pressed first. After 10mS (to avoid switch bounce) the binary code from the diode matrix is latched into three D-type flip-flops. '1' is now entered. This time, after the 10mS delay, a 200uS pulse is produced by the second 74121. If the ENABLE input is low, a negative pulse appears on the STROBE output, while the ASCII code for A appears on the other outputs. If the enable input is high, the circuit remains in its initial state with the strobe pulse disabled.