Scope Component Test Unit

David Botto

In view of the increasing complexity of present day TV sets and VCRs, anything that makes life easier for the service engineer is welcome. You'll find the component test unit described in this article one of the most useful and time saving instruments on your bench – it won't stand idly on a shelf. It can be used with almost any oscilloscope to test transistors, diodes, thyristors, zener diodes, capacitors and even resistors, the condition of the component being displayed on the scope's screen.

The component tester really proves its worth when checking semiconductor devices. The usual method of checking a transistor or diode is with an ohmmeter. This is quite good, up to a point: as engineers know from hard and sad experience however, it's not a method that's one hundred per cent reliable. With the scope component tester the slightest leakage or fault in a transistor or diode is revealed – the test method has proved to be completely reliable. With the exception of thyristors, there's a further advantage – only two test leads are required. This is a lot easier than juggling with three test prods to check a transistor.

Basic Principle

A knowledge of how the tester works will help in getting the best results from it. Fig. 1 shows a simplified circuit. An a.c. voltage is applied to resistors R-low and R-high via terminals A and B. Experiments have shown that the frequency of this a.c. input can be anything between about 25Hz and 20kHz. For convenience, the tester uses the 50Hz mains frequency. The scope's internal horizontal timebase is not used. Instead, the oscilloscope's external horizontal input (X input) is connected to point X. Point E goes to the scope's chassis and point Y to the vertical (Y) input. With the scope correctly set up, the screen display will consist of a horizontal line. This is because resistor R-high has an ohmic value several hundred times that of resistor R-low. If test points E and T are joined together, a vertical line will appear on the screen.

If a semiconductor junction, for example a diode, is connected across points E and T with the cathode to E,

the diode will conduct when the a.c. waveform is such that point T is positive with respect to point E. When the waveform swings negatively, the diode will cease to conduct. Fig. 2 shows the display on the screen. Reverse the diode and you get the waveform shown in Fig. 3.

Capacitors connected across test points E and T will produce ellipses of varying width depending on their capacitance value. A resistor produces a line set at an angle dependent upon its ohmic value.

Circuit

The complete circuit of the scope component test unit is shown in Fig. 4. Resistors R1 and R2 were not included in the original prototype but were added later. With no load connected to the transformer, the voltage across the primary winding is 240V a.c. When a load is connected to the secondary winding, the a.c. voltage across the primary winding is considerably reduced. The power applied to the component under test is thus limited, protecting small diodes and transistors.

Preset resistor VR1 controls the voltage applied to the scope's Y input while VR2 controls the voltage applied to the X input.

The battery and variable resistor VR3 (level control) are used for thyristor testing. A battery rather than a diode fed from the transformer is used to turn on the thyristor under test as this produces a good, clean waveform. The battery lasts a long time – almost its shelf life.

Construction

There's nothing critical about the construction – the photographs show the finished appearance and the internal layout. The small board used was designed to hold two i.c.s but proved to be ideal for use in the tester. If you decide to make your own board, the only point to watch is that the a.c. mains input circuitry is spaced well away from the rest of the circuit. An on/off switch was not included as we always unplug the tester when it's not in use – one could be incorporated as shown in Fig. 4. Fuses can also be added.

The screened leads that feed the scope's X and Y inputs were fitted with 75Ω BNC connectors, but this is not critical – fit connectors that suit the scope's input terminals.

The test leads have 4mm plugs at one end and mini or micro clips at the other end – these are very useful for making in-circuit tests.

It's a sound policy to apply a very thin coat of circuit varnish to the print side of the board when the basic construction has been completed. Then use a small brush to apply a thin coat of circuit varnish to all solder tags, joints, etc. This will help to ensure trouble-free operation in the long term.

Setting Up

Set the two controls VR1 and VR2 to the mid-position and the level control VR3 to its minimum position
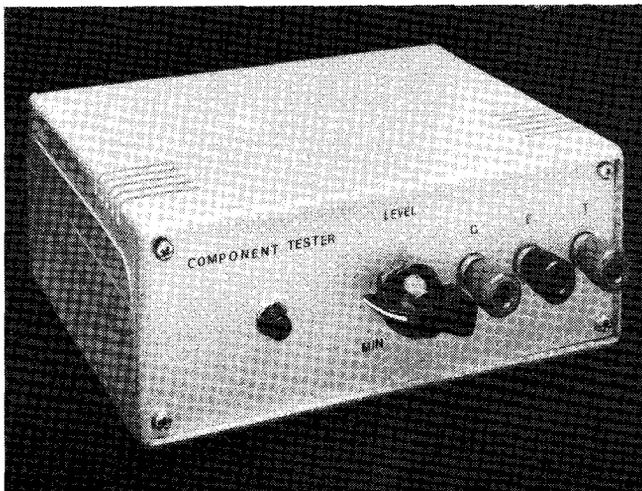
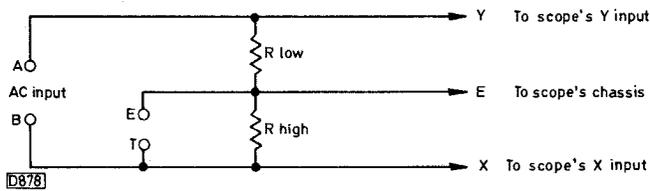*External view of the unit.*

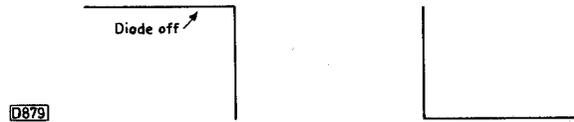Fig. 1: Principle of the tester.

Fig. 2 (left): Diode off/on display.

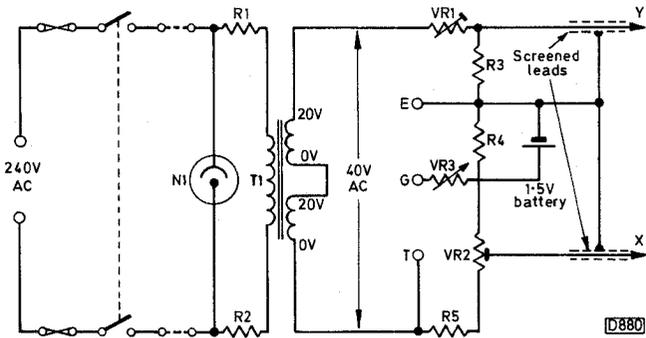Fig. 3 (right): Diode on/off display.
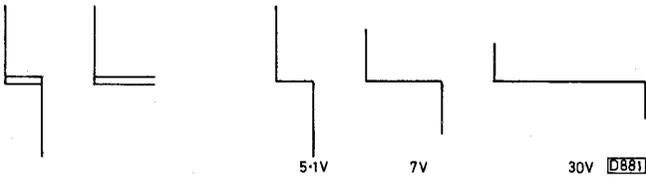

Fig. 4: Circuit of the test unit.

Fig. 5 (left): Double image obtained with a.c. coupling.

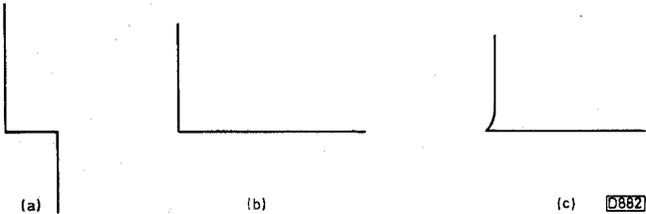Fig. 6 (right): Displays obtained with zener diodes.

Fig. 7: Silicon npn transistor displays. (a) Base-emitter. (b) Base-collector. (c) Collector-emitter.
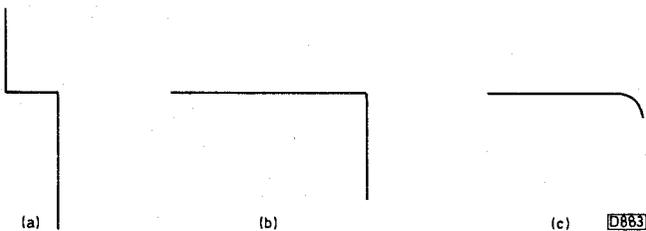

Fig. 8: Silicon pnp transistor waveforms. (a) Base-emitter. (b) Base-collector. (c) Collector-emitter.

(maximum resistance). Switch the scope to external X drive and set the Y input to the least sensitive d.c. range. The tester will work if an a.c. input is used, but with some scopes a double image may be obtained – see Fig. 5.
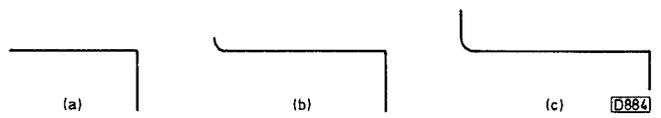

Fig. 9: Displays obtained with germanium transistors. (a) Base-collector. (b) Base-emitter. (c) Collector-emitter.
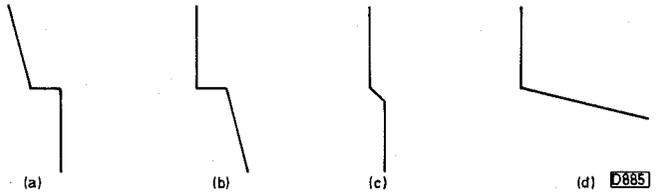

Fig. 10: Transistor fault conditions. (a)-(c) Leakage in a transistor's base-emitter junction or a zener diode. (a) In or out of circuit check. (b)-(c) Out of a circuit check. (d) Transistor base-collector junction or diode leakage, out of circuit check.

Adjust the scope's controls for a centred horizontal line with slight over scanning. Short test leads E and T to produce a vertical line, then adjust the vertical gain control so that the line just scans the screen. VR1 is included for fine setting if needed.

Checking Zener Diodes

A very useful feature of the tester is the ability to check zener diodes and measure their voltage ratings against the scope's graticule. You'll need about four or five zener diodes for calibration, with voltage characteristics between 5V and 38V. With the cathode connected to E and the anode to T, a zener diode gives the waveform shown in Fig. 6: the higher its zener voltage, the wider the horizontal part of the trace. By using the scope's horizontal gain control to keep the width correct, at the same adjusting the preset VR2, the zener voltages can be calibrated against the graticule divisions. VR1 and VR2 should then be sealed with a tiny spot of sealant.

Transistor Tests

To check an npn transistor, connect lead E to its base and lead T to its emitter. The waveform displayed should be as in Fig. 7(a). Transferring lead T to the collector should produce the waveform shown in Fig. 7(b). With lead E connected to the emitter and lead T to the collector, the waveform should be as shown in Fig. 7(c). It's not usually necessary to make emitter-collector checks in day-to-day testing.

Use exactly the same procedure with a silicon pnp transistor to get the waveforms shown in Fig. 8(a-c).

The transistors used in power supplies and line output stages produce the same traces except that the horizontal section is wider. Germanium transistors give waveforms similar to those shown in Fig. 9.

Field effect transistors of either the junction or MOS type cannot be checked and could be damaged if you try.

A short-circuit device will produce a vertical line, an open-circuit device a horizontal line. Some other fault conditions are shown in Fig. 10.

Checking Thyristors

To check a thyristor, connect the E test lead to the cathode and the T test lead to the anode. The display
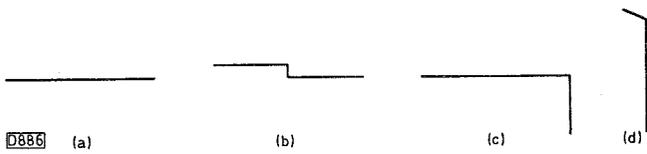
Fig. 11: Waveforms obtained with a BT106 thyristor. (a) With VR3 at minimum. (b) Thyristor just starting to conduct. (c) Thyristor on. (d) Saturation.

Fig. 12: Testing a diode-thyristor combination. (a) Diode test only. (b) Thyristor turned on.
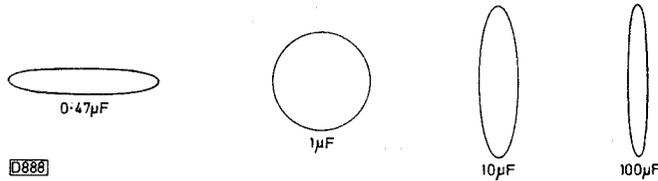

Fig. 13: Measurement of capacitance.

Fig. 14: Tests on LEDs. (a) Waveform for a small LED. (b) Waveform from a seven-segment LED.
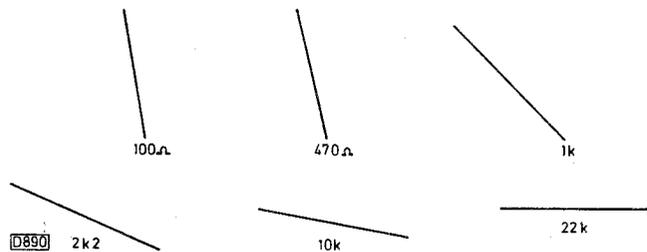

Fig. 15: Waveforms produced by various resistor values.

should then consist of a horizontal line. With the level control at minimum (maximum resistance), connect the

lead from socket G to the thyristor's gate. Some small thyristors, such as the TIC44, will then produce the waveform shown in Fig. 2. With larger thyristors such as the BT106, the level control must be turned slowly to obtain this waveform.

This test is also useful if you suspect that a thyristor is turning on too early or too late. Compare it with a known good thyristor of the same type.

On disconnecting the G lead, the horizontal line should reappear. Fig. 11 shows waveforms for the BT106.

The thyristors used in applications such as TV line output stages often have a diode incorporated in the same encapsulation, connected across the thyristor's anode and cathode. With the E lead to the cathode and the T lead to the anode, the waveform shown in Fig. 12(a) should be seen. This shows that the diode is o.k. Next connect the G test lead to the thyristor's gate and slowly turn up the level control. When the thyristor turns on, you'll see the waveform change as shown in Fig. 12(b).

Measuring Capacitance

Capacitors with values between about $0.22\mu F$ and some hundreds of microfarads can be measured. With the capacitor connected to test leads E and T, an ellipse will be seen, the size depending on the capacitor's value – see Fig. 13.

Large value capacitors will produce an almost vertical line. With these, use either the scope's X times five (or ten) control or increase the setting of the X gain control. If you calibrate settings with capacitors of known value, you'll find this test extremely useful and reliable.

LED Tests

To test an LED, connect the E lead to the cathode (usually identified by a flat side or notch) and the T lead, with a 100Ω resistor in series, to the anode. The LED should light and the waveform shown in Fig. 14(a) should be seen. Reversing the leads will simply reverse the waveform – the LED will still produce light.

Seven-segment LEDs can also be tested. This test is particularly useful when one segment is not lighting. Is it due to the LED or the complex drive circuitry? Connect the E lead to the common cathode (or anode) connection and the T lead, via a 100Ω series resistor, to each segment

Components list

R1	4.7k 2W	VR1	1k miniature horizontal preset
R2	4.7k 2W	VR2	100k miniature horizontal
R3	1.2k 1W		preset
R4	330k 1W	VR3	3k wirewound potentiometer
R5	820k 1W		

T1 RS 207-661 mains transformer.
N1 Tandy 272-708 or similar miniature 240V a.c. neon.
PCB Tandy 276-159 experimenters' board.
Plastic case with feet – Tandy 270-9501 or similar.
Two BNC 75Ω connectors, RS, or as required.
Battery holder and 1.5V battery – UM3 or equivalent.
Screened audio lead, mini-clip test leads, etc.
Three terminals, two red one black, Tandy 274-661.
Optional: Double-pole on/off switch; two 630mA 20mm anti-surge fuses with holders.
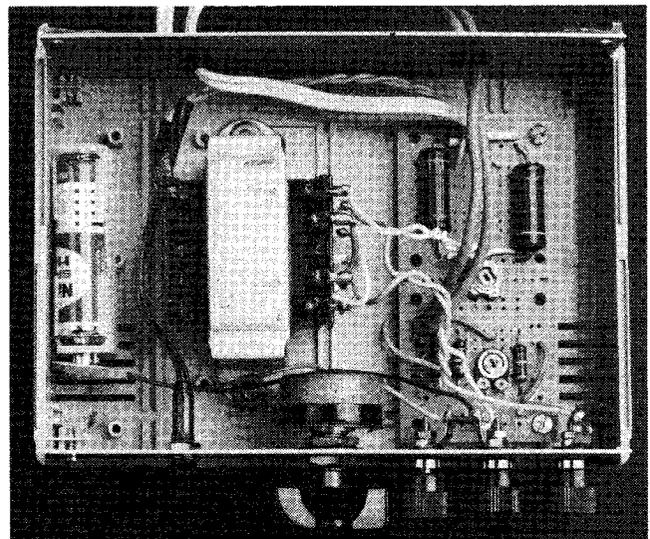
Internal view of the unit.

connection in turn. The segments should light and the waveform shown in Fig. 14(b) should be displayed – an FND500 was used to get this trace.

Resistor Waveforms

The displays obtained when resistors of various values are connected across T and E are shown in Fig. 15. This test won't replace your ohmmeter, but is useful when making in-circuit checks.

In-circuit Tests

A helpful feature of the tester is its use for in-circuit tests. Many transistors, diodes, capacitors, etc. can be tested whilst still in circuit – disconnect the equipment from the mains supply of course! Also make sure that reservoir/smoothing capacitors and the c.r.t.'s final anode are discharged.

In some cases the waveforms will be affected by other components in the circuit, i.e. those shunting the component being checked. In practice you'll soon get used to this. If you service particular TV sets or VCRs regularly, it's helpful to note various key waveforms you should obtain. If there's room, these can be drawn on or around the circuit diagram.

If it's necessary to isolate a transistor, unsolder only two of its leads and keep them clear of the print. Check the transistor, then resolder the two leads if it tests good. This saves time and also avoids the problems of finding the board unmarked after removing a transistor completely – and perhaps putting it back the wrong way round . . .

The same principle applies with diodes, capacitors etc. – with only one lead being unsoldered of course.

Continuity Testing

Continuity checks on print and transformer windings etc. can also be made. Doubtless you'll find many additional uses for your component tester.

TV Test Pattern Generator

Part 2   *Tony Jenkins, G8TBF*

This month we'll look at the colour encoder section and the power supply. A separate printed circuit board has been prepared for both of these and details, along with constructional and setting up details, will be given next month.

Coder and Modulator

The colour encoder takes in separate sync, red, green and blue signals (also the grey-scale signal) and produces a composite video output. This is available at v.f. or, via the modulator, at u.h.f.

The encoder/modulator circuit is shown in Fig. 6. The heart of the encoder is a Mullard i.c. (IC3), type TEA1002. A block diagram for this device is shown in Fig. 7. It has an internal 8·86MHz oscillator from which the R−Y and B−Y carriers are generated. Composite sync, burst gate enable, PAL switch and composite blanking timing signals are required in addition to the RGB and grey-scale inputs. The output is a 16-colour (including black and white) composite video signal, based on 75 per cent colour bars.

The RGB, composite sync and composite blanking signals are fed directly to the i.c. from the logic board where they are generated and inverted as required. The burst gate enable and PAL switch signals are generated on the colour encoder board from the composite sync signal. The grey-scale drive is also generated on the encoder board. The burst gate enable signal is derived from one half of IC4, type 4528, a dual retriggerable-resettable monostable. A CMOS device is used deliberately to introduce a small delay at the start of the signal. The *RC* network R4/C2 sets the pulse width at around $2 \cdot 2\mu$sec. The output goes to pin 15 of the TEA1002.

The other half of IC4 is used to provide a line frequency trigger pulse for one half of the 4013 dual D-type flip-flop IC5. This produces the 7·8kHz PAL switch signal which is fed to pin 12 of the TEA1002.

The three-bit binary-coded grey-scale information is fed to IC1 (a quad two-input OR gate) along with the grey-scale enable signal. The outputs from these OR gates (when enabled) are fed to sections of IC2 (hex driver with open-collector outputs) and arrive, via the three presets VR1, VR2 and VR3, at a common summing point that drives the TEA1002's luminance input (pin 7). FC2 is the most significant bit, causing a single transition from black to white. FC1 is the next most significant bit, producing the "almost black" and "almost white" bars. FC0 is the least significant bit, filling in the greys. The background enable signal simply inserts a level of grey, set by VR4, to lift the crosshatch background out of black.

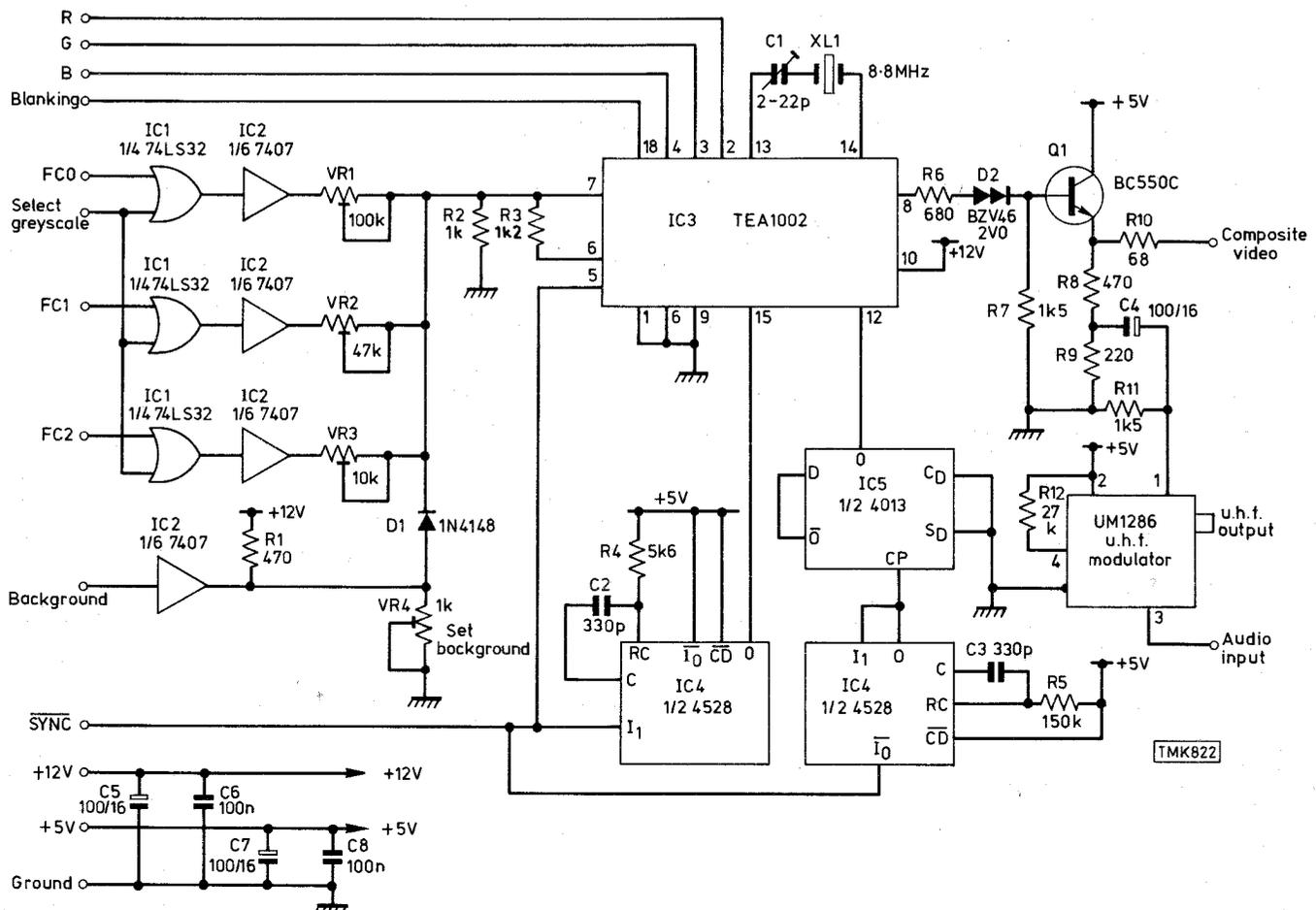Since the current capability of the video output from the

Fig. 6: Circuit diagram of the encoder and modulator sections of the pattern generator.
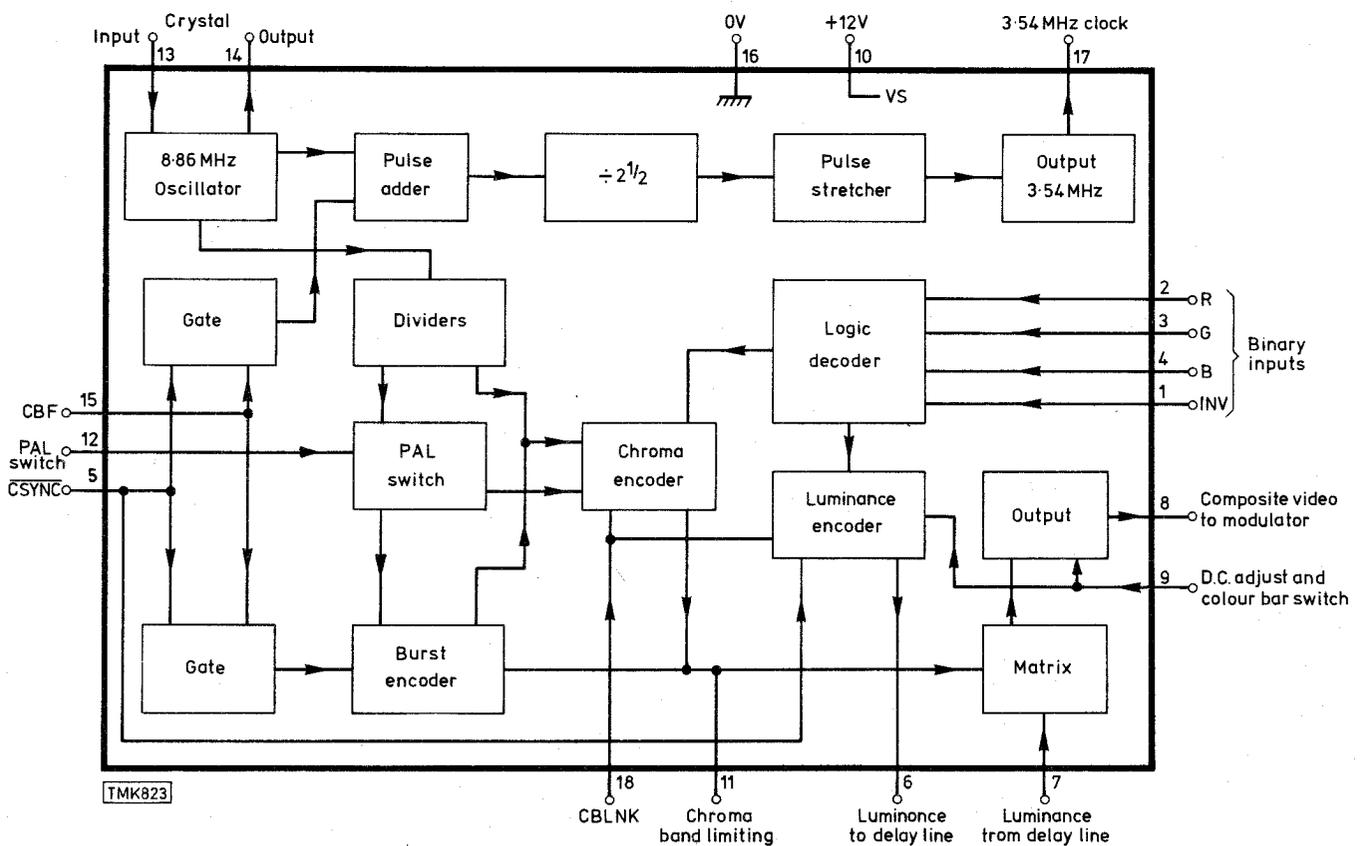
Fig. 7: Block diagram of the TEA1002 encoder i.c. The 3.54MHz clock output is not used.

Components list: encoder

Resistors:
R1 470
R2 1k
R3 1k2
R4 5k6
R5 150k
R6 680
R7 1k5
R8 470
R9 220
R10 68
R11 1k5
R12 27k
All ¼W, 5%
carbon film
VR1 100k
VR2 47k
VR3 10k
VR4 1k
miniature skeleton
presets, horizontal
mounting

Capacitors:
C1 2-22pF trimmer
C2 330pF ceramic
C3 330pF ceramic
C4 100μF, 16V radial el.
C5 100μF, 16V radial el.
C6 0·1μF ceramic
C7 100μF, 16V radial el.
C8 0·1μF ceramic

Semiconductor devices:
D1 1N4148
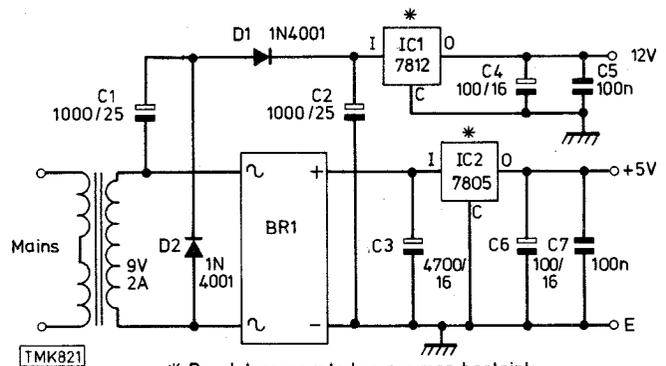D2 BZV46-2V0
Q1 BC550C
IC1 74LS32
IC2 7407
IC3 TEA1002
IC4 4528
IC5 4013

Miscellaneous:
XL1 8·8MHz crystal with HC18/U case
Astec UM1286 u.h.f. modulator. PCB.

Components list: power supply

C1	1,000μF, 25V axial el.	D1	1N4001
C2	1,000μF, 25V axial el.	D2	1N4001
C3	4,700μF, 16V axial el.	BR1	KLB02
C4	100μF, 16V axial el.	IC1	7812
C5	0·1μF ceramic	IC2	7802
C6	100μF, 16V axial el.		
C7	0·1μF ceramic		

Mains transformer RS 208-333, 18VA.
Heatsink 50mm length of RS 401-497 (for IC1/2).

of 2V. Its purpose is to remove 2V from the 2·6V d.c. pedestal on which the video signal sits. Q1's base-emitter voltage drop removes the residual 0·6V. In practice there's a very small residual d.c. voltage, though it's insignificant. D2 can be omitted if a 2V pedestal can be tolerated.

TEA1002 is rather limited, a buffer transistor (Q1) is used. Resistors R6 and R7 reduce the input level at the base of this transistor to 2V peak-to-peak. The output is a 75Ω signal which is reduced to the normal 1V peak-to-peak when terminated at 75Ω. D2 is the equivalent of two diodes in series but giving a close-tolerance forward voltage drop

Fig. 8: Power supply circuit.

Another potential divider, in Q2's emitter circuit, reduces the signal to the level required to drive the UM1286 u.h.f. modulator. R11 sets the modulator's d.c. working point. This should be 2·2V: any significant departure from this voltage will cause sync crushing or even loss of sync. The value of R11 may need to be adjusted.

The modulator selected is a good-quality wideband type which also contains an intercarrier oscillator. If required, the frequency of this can be changed to 5·5MHz. An add-on audio oscillator will be described later. Constructors can if they wish use a CMOS divider circuit fed from the 7·8kHz output of IC5 to produce several frequencies, one of which can be fed directly to the modulator's audio input pin.

Power Supply

The power supply is straightforward, using a 7805 regulator to produce the 5V rail and a voltage doubler followed by a 7812 for the 12V rail. This arrangement is an economical design requiring only one mains transformer providing one secondary voltage, without excessive dissipation in the 5V regulator. Connect the transformer's primaries in series and the secondaries in parallel.

IR Remote Control Handset Tester

George Bagley

Infra-red remote control is now being used with an increasing amount of equipment of different types. Inevitably, faults occur. It's not always practical to have the equipment brought into the workshop when the problem concerns just the handset. I found that a remote control handset tester that would work with a wide range of remote control transmitter units was required so I decided to make my own. Its design was kept as simple as possible, with adjustable sensitivity to match the output of any unit under test.

The circuit is shown in Fig. 1. To simplify construction a ready-made IR receiver unit was adopted – the Philips IR receiver part no. 4822 218 20293, though it's possible that other units will work just as well. The output from the receiver unit goes directly to the base of transistor Tr1 which drives a meter giving deflection over a wide range of handset outputs. Control VR1 sets the meter's range. The meter used in the prototype is a battery-level type but any small meter should do – adjust the value of R2 to suit (in the prototype the value is $10k\Omega$). D2 is included to suppress any back-e.m.f. produced by the meter.

The LED D1 provides visual indication when testing handsets for range: a clear LED is used since it's easier to see at up to thirty feet. The test socket enables an oscilloscope to be connected to monitor the receiver's output.

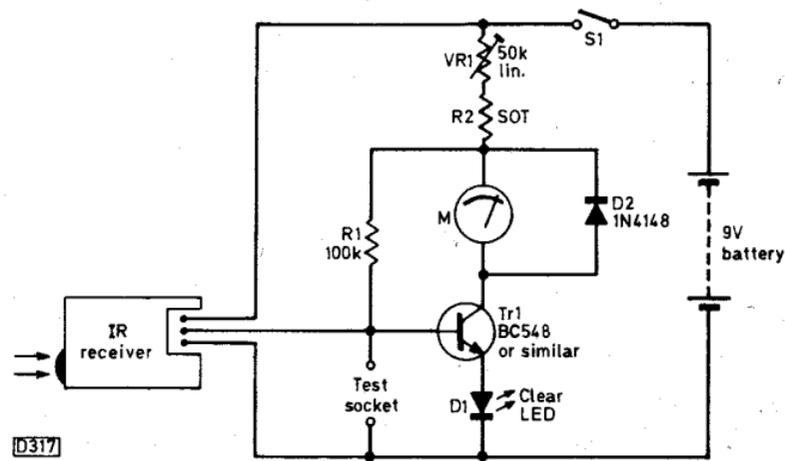The tester has proved to be a very useful and valuable addition to my test gear.

Fig. 1: Circuit diagram of the handset tester.

Simple RGB Interface Circuit

Brian Webb

Having recently bought a computer with RGB output, and realising the advantages of using this mode of direct c.r.t. drive to eliminate the cross-colour and bandwidth limitations that are inherent in the PAL system, I decided to convert a ten-year old GEC colour set to RGB input as cheaply and as simply as possible while still maintaining safety.

The first requirement (a must) was to provide mains isolation for the chassis. A suitably VA rated 1:1 ratio transformer is used for this purpose, with the set's chassis earthed via the earth pin of the mains plug. Such a transformer can be expensive: I have it in a separate box so that it can be readily used for other purposes, e.g. servicing, making the purchase more economic.

Circuit Description

The circuit I decided upon (see Fig. 1) was kept as simple as possible while maintaining an upper working frequency of around 10MHz. The 74LS240 TTL chip was chosen for its high speed and cheapness. It's an eight-stage inverting buffer with separate enabling for the two groups (A and B) of four buffer/inverters. The RGB inputs are applied to three of the A group buffer/inverters with enabling from the sync input, ensuring good blanking. The sync input goes to one of the B group buffers. Another can be used depending on the requirement for positive- or negative-going sync pulses in the timebase department. The output from a TTL circuit at 5V peak-to-peak may be too large for some timebase arrangements. Fig. 2 shows a simple emitter-follower to enable the pulses to be potted down. It may also be necessary to use this circuit where there's a long run to the timebases – a suitable screened cable may also be required.

The GEC solid-state C2110 series chassis, like many of its contemporaries produced during the early 70s, uses a TBA920 sync separator/line generator chip. This will work directly from a TTL buffer, positive-going sync pulses being required.

Should connecting the sync input to the timebase section of the set be rather impractical an alternative option that could be adopted is to use an off-air signal, feeding the demodulated video to the sync separator in the usual manner. The sync signal available at the RGB socket should still be used for blanking.

The digital RGB signals are fed to the emitters of the three BF259 RGB output transistors via 2·2kΩ presets. These are used in conjunction with the set's first anode controls to set up the black level.

Construction

Spread the circuit out as much as possible, bearing in mind that the output transistor collector load resistors dissipate a certain amount of heat – a heatsink should be provided for the transistors themselves. Also remember that since the upper working limit of the circuitry is hopefully around 10MHz suitable separation should be used – especially if construction is on Vero board.

I disconnected the i.f., sound, colour decoder and video drive sections of the set. This has the advantage of minimising the power across the isolating transformer.

The older type of delta-gun tube can give a good account of itself at up to 10MHz. The convergence has to be looked at carefully, especially with a computer display.

Remember good common chassis connections throughout.

I hope the circuit presented here will give you ideas for cheap ways to improve your computer displays. Have fun with it!
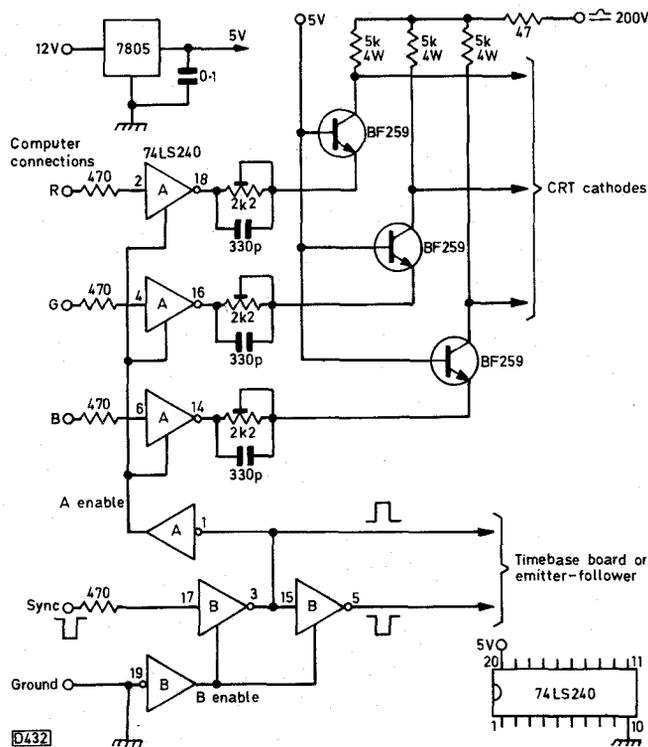

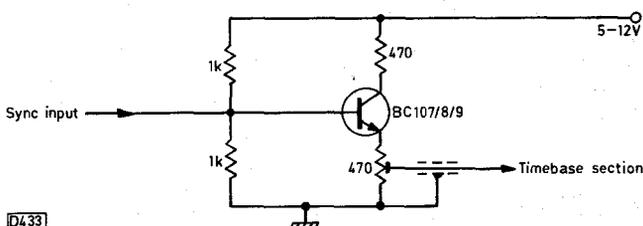Fig. 1: RGB/sync interface circuit.

Fig. 2: Emitter-follower stage for sync pulse interfacing.

Battery-powered CRT Tester

Nick Laidlaw

It's a gamble as to whether the tubes are serviceable or not when you buy second-hand CTVs "off the pile". A portable tester that gives a quick indication of tube emission is therefore useful. The unit described in this article will test both delta-gun and PIL type tubes. It's powered by a 6V, 3Ah sealed lead-acid battery.

Circuit Operation

The circuit diagram of the tester is shown in Fig. 1. It can be split into two sectons, the power supply and the testing circuitry. Tube emission is checked in the usual manner – by applying a positive voltage to the first anodes and a negative voltage to the cathodes and measuring the resultant current flow between them.

IC1 in the power supply section is connected as an astable multivibrator. It produces pulses which are amplified by Tr1 whose output drives the Darlington pair Tr2/3. The output is developed across the primary winding of transformer T1. This is the only critical component in the unit: it's the e.h.t. transformer used in the Thorn 3500 chassis – the line output transformers used in this and other chassis give markedly less voltage and are not really suitable. The voltage developed across the e.h.t. overwinding is rectified by bridge rectifier D1-4 which charges the reservoir capacitor C3 to around 250V. This voltage is applied via the meter selection switch SW2 and the meter to the tube's first anodes.

The meter needs to be able to read 1mA f.s.d. Resistor Rx is used to shunt the meter on the milliamperes range if a 1mA meter is not available. Ry is a series resistor to enable the h.t. voltage to be read while Rz enables a battery voltage check to be made.

Precaution

Since the power supply can produce a continuous current of about 30mA at 250V, and as C3 can produce an instantaneous discharge of around 10A and a rather nasty shock, C3 is shorted by R1 when the unit is switched off.

Testing and Use

When you've built the unit, switch on and check that you can hear the oscillator – it's fairly loud. Alter the value of R3 if you find the oscillator's frequency irritating. If the oscillator is running, measure the voltage across C3 – it should be about 250V. Operate the meter range switch and check that the meter reads both the battery and h.t. voltage correctly.

If all is well connect the unit to a good tube and switch on. Select battery and check that the voltage is not less than 5·5V. Switch to h.t. and check that the reading is about 250V. Switch to milliamperes and wait for the tube to warm up. A good tube will give a reading of greater than $200\mu A$, but it's as well to try several different tubes, good and bad, to calibrate the meter.

When using the meter, always check the battery voltage as the tube warms up: a drop of more than 0·5V gives a marked reduction in the tube's emission. The h.t. voltage is not critical, but it's as well to check it just to be sure that the unit is operating correctly.

Alternative Use

The power supply can also be used as a general 250V d.c. source from a 6V battery, the current consumption being about 1A.

Results

The unit gives very reliable results and has proved to be invaluable. At one retailer I visited there were ten Philips G8s I could have purchased: eight were found to have dud tubes and I came away with the only two good sets from the pile!
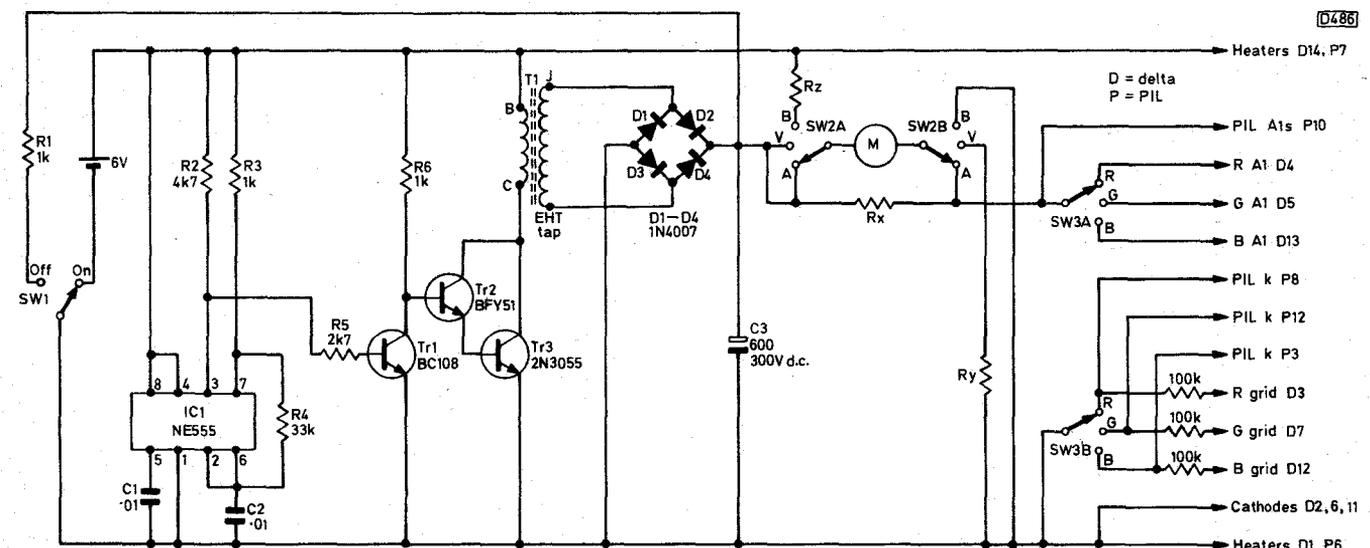

Fig. 1: Circuit of the battery-operated c.r.t. tester. SW2A/B provides meter selection, SW3A delta-gun tube first anode selection and SW3B PIL cathode/delta-gun tube grid selection. The battery is an RS type 591-360.

De Luxe Component Tester

Part 1   *David Botto*

More and more TV/video service engineers are finding that a component tester makes their life easier. The de luxe component/signature tester described in this article is easy to construct and simple to use. You'll find that it's often quicker to use the tester to check every component on a PCB rather than having to spend time tracing out the circuitry then testing likely suspects. Colleague Pete, who has been using my first component tester unit since details of it were published back in 1984, now wants to get his hands on this latest one which incorporates many extra features.

The de luxe tester will rapidly check bipolar transistors, diodes, zener diodes, thyristors, LEDs, VCR end sensors, capacitors, resistors, chokes, mains transformers, loudspeakers and many other components. It also operates as a signature tester, and is particularly helpful when you're trying to identify unmarked surface-mounted or other components.

The tester can be used with almost any oscilloscope. If you've an old one that's gathering dust because it doesn't meet modern requirements you can connect it to the tester permanently. Set the scope to its X/Y mode: the internal timebase isn't used because the tester supplies a horizontal scanning voltage. The waveform displayed on the scope's screen instantly and accurately reveals the condition of the component under test.

The usual way of checking transistors and diodes is with an ohmmeter. This is o.k. when the fault is a dead short or an open-circuit, but it's not a completely reliable test procedure. The component tester really scores here, by revealing the slightest defect or leakage in a transistor or diode. Another benefit, except when testing thyristors, is that only two test leads are required. This is a lot easier than having to do the juggling act that some transistor testers call for, as you try to hold three prods in contact with a transistor's leads.

The unit also serves as a useful continuity tester for general servicing work.

Principle of Operation

The tester operates as an extension of an oscilloscope's circuitry. To obtain the best results, it's essential to understand exactly how the tester works.

Fig. 1 shows at (a) to (f) the operation of the tester. In Fig. 1(a) an a.c. voltage is connected across the two resistors R-low and R-high via terminals A and B. Almost the full a.c. voltage is applied to the scope's X (horizontal) input, producing a horizontal line on the screen – see Fig. 2(a). If terminals Ch and T are shorted across, as shown in Fig. 1(b), the entire a.c. voltage is applied to the scope's Y (vertical) input, producing a vertical line on the screen – see Fig. 2(b).

If a diode or transistor junction is connected across T and Ch (chassis), as shown in Fig. 1(c), the diode will conduct when the a.c. waveform at Ch is positive-going – the diode is reverse biased when the waveform at Ch is negative-going. Fig. 2(c) shows the resultant waveform display on the scope. Reverse the diode and you'll see the waveform shown at Fig. 2(d). With a good diode (or transistor) junction the waveforms displayed will be

sharp and clear, with sharp right-angled corners.

A zener diode produces the waveform shown in Fig. 2(e). The diode's barrier potential produces one upright line, the other being produced by the reverse conduction zener characteristic.

Fig. 1(d) shows a thyristor connected with its anode to terminal T and its cathode to terminal Ch. With a good thyristor you'll see the waveform shown in Fig. 2(a). When a suitable d.c. voltage is applied to thyristor's gate the device will fire, producing a diode waveform of the type show in Fig. 2(d).

A resistor connected across T and Ch – see Fig. 1(e) – lowers the value of R-high. As a result less a.c. voltage is fed to the scope's X input while the a.c. voltage at the Y input increases. This produces an angled line, see Fig. 2(f), because an a.c. voltage is present at both the X and Y inputs of the oscilloscope. The angle of this line depends on the ohmic value of the test resistor. If the scope's sensitivity at its X and Y inputs is the same, the angle of the line will be 45° when the ohmic values of R-low and the parallel combination of R-high and R-test are equal.
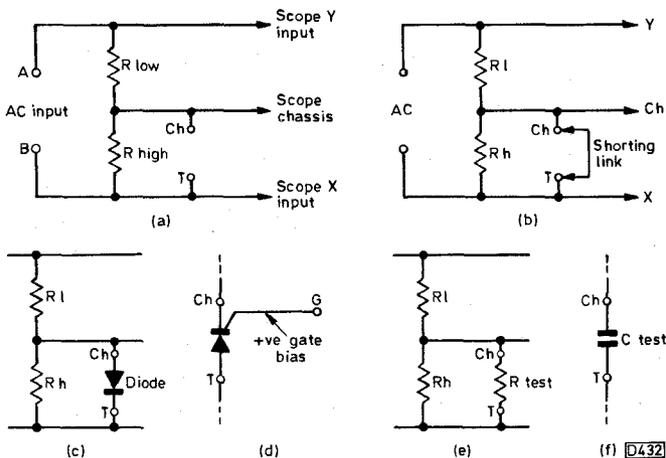

Fig. 1: Principle of the tester (a-b); (c) shows a diode test, (d) a thyristor test, (e) a resistor test and (f) a capacitor test.
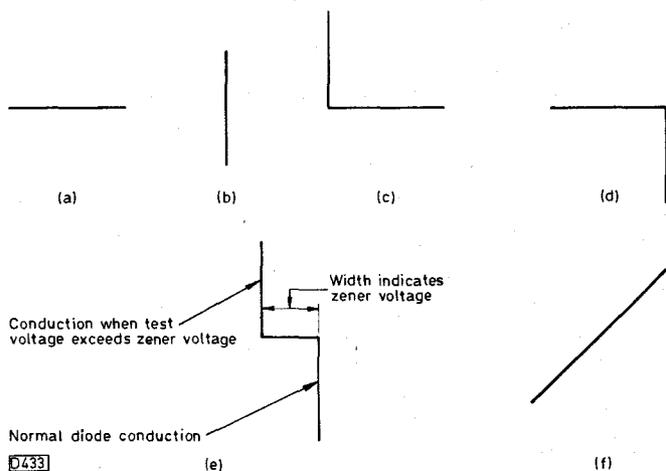

Fig. 2: Basic waveforms (a-d); zener diode waveform (e); resistor waveform (f).
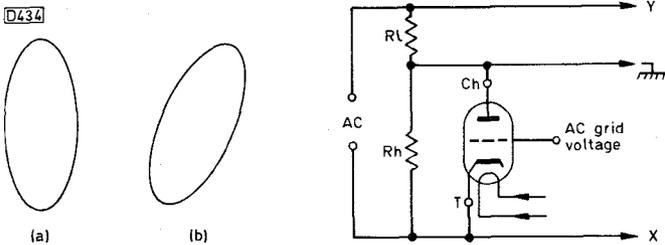
Fig. 3 (left): Waveform produced by a good capacitor (a) and a leaky capacitor (b).
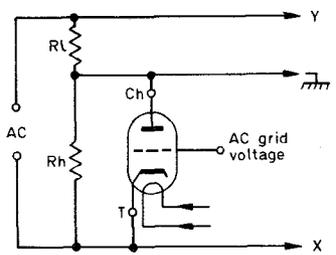
Fig. 4 (right): Valve testing circuit.

A capacitor connected across T and Ch will charge first in one direction then the other. The result is an elliptical display on the screen as shown in Fig. 3(a). The size of the ellipse depends on the value of the test capacitor. Leakage in the capacitor shows up as a badly tilted ellipse – see Fig. 3(b) – since this is the same as connecting a resistor across R-high. Because of the low test voltage used, electrolytic capacitors can be checked.

The a.c. voltage applied to points A and B can range in frequency from 20Hz to 25kHz. The tester makes use of the 50Hz mains frequency because this is convenient and stable.

The tester's principle is not new – it dates back to the days when the valve was supreme in fact. When a diode valve is connected with its anode to Ch and its cathode to T it will conduct only when Ch is positive with respect to T. With a triode or multigrid valve the anode current will vary with changes in the a.c. or d.c. voltage at the control grid. If the a.c. grid voltage is of a different frequency to the mains the circuit operates as an effective dynamic valve tester. Anyone interested in servicing vintage equipment might find this feature useful. See Fig. 4.

Circuit Description

Fig. 5 shows the complete circuit of the de luxe component tester. The 240V a.c. mains supply is applied to points A and B, the miniature green neon N1 providing an indication that the instrument is powered. Fuses F1/2 and resistors R1/2 connect the mains input to the primary windings of the two miniature mains transformers M1 and M2. Resistors R1 and R2 limit the power applied to the component under test. With no load connected to the secondary windings of transformers M1 and M2 the a.c. voltage across their primary windings is 240V. When a load is connected across either secondary winding however the a.c. voltage across the primary windings drops. This limits the power applied to the component under test, protecting small diodes, transistors and i.c.s.

Two miniature transformers, from RS Components, were used to obtain the correct voltage drop and to save space and cost. It's best to use the transformers specified. The secondary windings are connected in series so that, off load, 20V, 40V and 80V a.c. test voltages are fed to switch SW4A. When a component is being tested these voltage levels fall considerably. SW4B is ganged with SW4A: when position 2 is selected the amber neon N2 lights, indicating that the correct a.c. input voltage has been selected for i.c. testing. By selecting position R on switch T4 the voltage applied to the i.c. under test is reduced still further. Switch SW4 is rated at 125V a.c., which is appropriate since it's connected to the centre tap on M1: the neon N2 still

lights brightly at this reduced voltage.

User control VR1 sets the amplitude of the vertical trace. Initial adjustment is done with the "set" position of switch T4 selected. VR2 adjusts the horizontal drive output voltage applied to the scope's X (horizontal) input. It has a calibrated scale so that the user can measure the voltage of a zener diode under test. The zener voltage scale's range of 1·1-63V could be extended to cater for higher voltage zener diodes, but for general servicing a maximum of 63V is usually sufficient.

ICH1 is a 28-pin, zero-force insertion type i.c. socket. Switches SW1/2/3 together with toggle switches T1/2/3 select the i.c. pins so that waveform tests can be made between all adjacent pins. Each pin of socket ICH2 is directly wired to the same number pin of socket ICH1.

Small transistors or diodes can be inserted in sockets Q1 and Q2. Switch SW3B selects these sockets in turn: they are handy for making comparison checks between two devices.
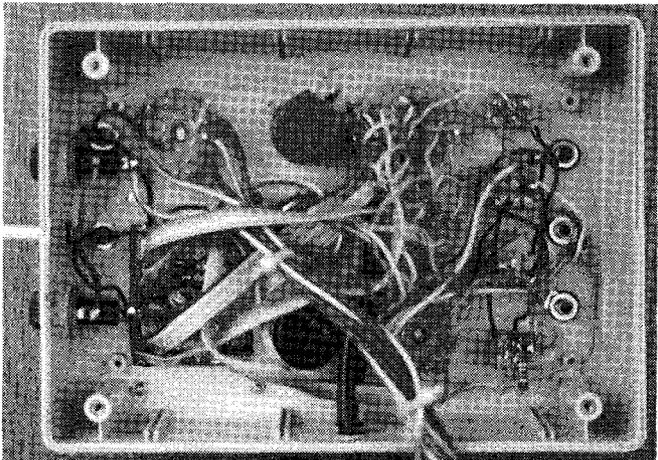
T is the thyristor test socket. VR3 adjusts the gate bias voltage applied to the device from the 1·5V battery. This socket is intended for use with small thyristors: larger ones can be checked by using three test leads plugged into the instrument's T, G and Ch sockets.

Construction

The accompanying photographs show the finished unit and its interior layout. Everything possible has been done to ensure ease of construction and reliability in use. The case, obtained from RS Components, is a tough one designed to stand up to everyday use in the workshop. It's made of a type of plastic that's easy to drill. The useful built-in battery compartment holds four batteries, though the tester uses only one. The case size is such that all the components can be housed without being packed too closely. It doesn't take up much room on the bench.

The components list includes everything you'll need to build the tester. The parts have been carefully selected taking quality, price and ease of construction into account. By using them you'll need only to drill some round holes and make the cut-out section behind the PCB. To ensure trouble-free construction and operation it's best to stick to the recommended parts. The specified resistors are of higher wattage rating than is strictly necessary, but this will contribute to long-term stability and reliability. To avoid scratching the case it's best to have a rubber instrument mat on the bench while constructing the unit.

Begin by drilling the round holes required in the top

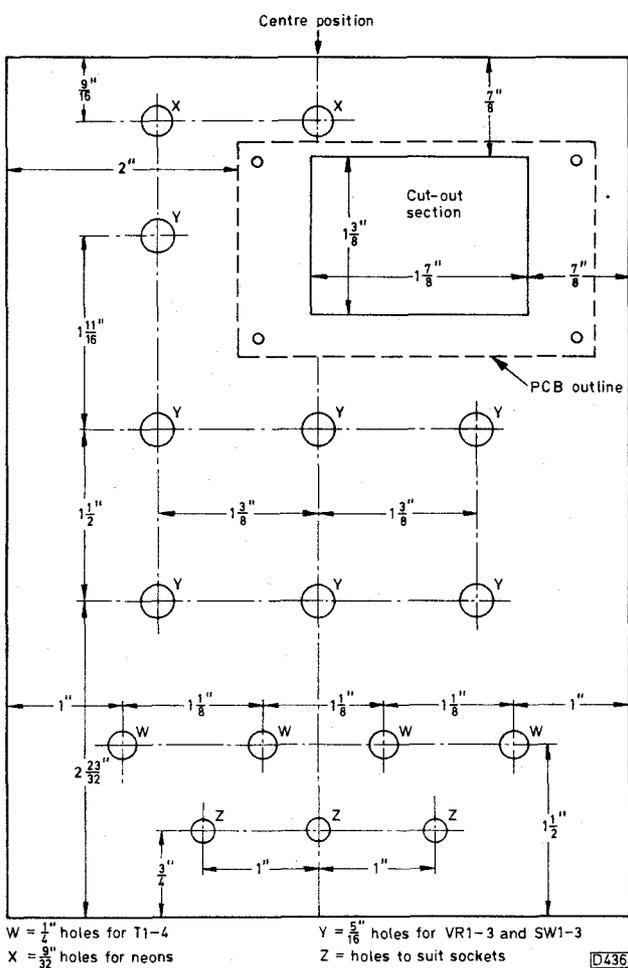Inside view of the top section of the tester.

Fig. 5: Circuit diagram of the de luxe component tester.

panel. This is the larger section of the case: the lower section is the one with the battery compartments. Fig. 6 shows the top panel layout and measurements. The hole sizes suit the specified components. Next drill the holes at the top of the case for the two fuseholders and the mains lead grommet, see Fig. 8. Then drill the two holes (see Fig. 7) for the X and Y black coaxial cables that go to the scope: these holes are on the right-hand side of the case and are fitted with grommets.

You can now fit all the panel-mounted controls, lamps and sockets. Leave the fixing nuts for switches SW1/2/3 slightly loose. Fit the fuseholders and the grommets for the mains lead and the leads to the scope. Continue by drilling four small holes at each corner of the rectangular plastic section that has to be removed. Use the small PCB as a template. The rectangular hole is easy to cut out using a trimming knife with a suitable saw blade fitted.

Be sure to wear a pair of safety goggles Kitemarked to BS2092 standard when you drill and cut the holes. Flying plastic chips can cause serious damage to your eyes.

The positions of the two miniature mains transformers and resistors R1/2 can be seen in the accompanying photograph. It's preferable to use nylon plastic nuts and bolts to secure the parts to the case. Four heavy-duty self-sticking cushion feet should be fitted to the bottom of the tester: these will keep it rock-steady on your bench.

Complete the instrument wiring as shown in the circuit diagram but leave the wiring to switches SW1/2/3 and the small panel-mounted PCB for the present.

Fig. 9 shows the socket layout on the small PCB, which is available from Tandy. It's not necessary to make you own panel: the two i.c. holders and three transistor sockets fit nicely on the Tandy one. Use either

Fig. 6: Top panel layout.

W = $\frac{1}{4}$" holes for T1–4
X = $\frac{9}{32}$" holes for neons
Y = $\frac{5}{16}$" holes for VR1–3 and SW1–3
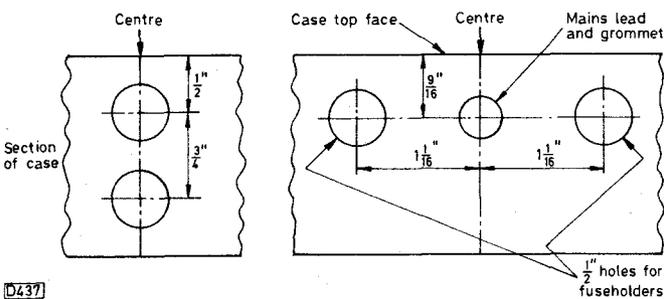Z = holes to suit sockets

D436

Fig. 7 (left): Side holes for the coaxial cable leads – sizes according to grommet and cable diameter.

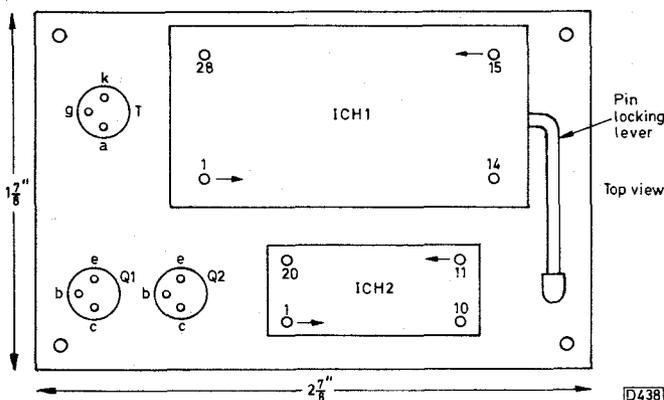Fig. 8 (right): Holes at top of case for the fuseholders and mains cable. Mains lead hole to suit cable/grommet.

Fig. 9: Layout of the small PCB.

a small 17W iron or preferably a temperature-controlled iron fitted with a suitable bit to wire up the panel.

Wire pins 1-20 of holder ICH1 to pins 1-20 of holder ICH2, using light-gauge insulated wire. Take care when working on the PCB that solder blobs don't short sections of the copper print together.

Next solder strips of ribbon cable to the panel for connection to switches SW1/2/3. Cut and divide a sufficient quantity of ten-conductor bonded-ribbon cable into pieces of 14in. length – this length gives you a little extra tolerance during the wiring process. The specified cable is colour coded and the divisions and colours used in the original unit are shown in Table 1. Solder the cables to the i.c. socket pins, marking each bunch of coloured cables with the numbers of the i.c. pins to which they are connected. Bolt the PCB to the top of the case so that the cables feed into the instrument. You can

Table 1: Connections to SW1-3.

Suggested colour coding for ribbon cable divided into strips. Pin numbers are for holders ICH1 and ICH2.

Colour	ICH pin	Switch
Strip 1		
Brown	1	SW1A
Red	2	SW2A
Orange	3	SW1A
Yellow	4	SW2A
Green	5	SW1A
Blue	6	SW2A
Strip 2		
Green	7	SW1A
Blue	8	SW2A
Mauve	9	SW1A
Grey	10	SW2A
White	11	SW1A
Black	12	SW2A
Strip 3		
Brown	13	SW3A
Red	14	SW1B
Orange	15	SW3A
Yellow	16	SW1B
Strip 4		
Green	17	SW3A
Blue	18	SW1B
Mauve	19	SW3A
Grey	20	SW1B
White	21	SW3A
Black	22	SW1B
Strip 5		
Brown	23	SW3A
Red	24	SW1B
Orange	25	SW2B
Yellow	26	SW3B
Strip 6		
Green	27	SW2B
Blue	28	SW3B
Strip 7 to transistor holders	Q1/2	SW3B
Yellow	Q1 collector	SW3B
Orange	Q1 emitter	SW3B
Red	Q2 collector	SW3B
Brown	Q2 emitter	SW3B

Components List

Electrical items

M1, M2	6VA miniature mains transformers with 0-20V/0-20V secondary windings. RS Components stock no. 196-319
F1, F2	1AT 20mm fuses
N1	240V a.c. green neon light. Tandy stock no. 272-708
N2	240V a.c. high-brightness amber neon light. Tandy stock no. 272-707
VR1	1kΩ linear taper potentiometer
VR2	1MΩ linear taper control. Preferred type Tandy 271-211
VR3	3kΩ wirewound linear taper control
R1, R2	4·7kΩ, 5W small wirewound
R3	1·2kΩ, 1W
R4	10kΩ, 1W
R5	470kΩ, 1 W
R6	4·7kΩ, ½W

1·5V Ever Ready Silver Seal RS6 or equivalent battery

Switches

SW1-4	Rotary two-pole six-way switches. Tandy stock no. 275-1386. SW4 could be a three-way type
T1-4	Miniature d.p.d.t. toggle switches, on-off-on. Tandy stock no. 275-620

Case

Plastic instrument case, style 3, RS Components stock no. 505-117. 190mm long, 138mm wide, 68mm high

Four heavy-duty cushion feet, Tandy stock no. 642-342

Small sheet of thin transparent plastic to cover panel scale

Lettering plus Klarlack clear varnish. See text

Mechanical parts

Length of terminal block for transformer leads

4BA nylon nuts and screws to secure transformers and tagstrip. RS Components stock no. 522-055.

Two 2ft 6in lengths of good-quality black co-axial cable to connect to scope plus two BNC plugs

Mains cable, 3ft, white

Moulded grommets to suit mains and scope leads

Experimenter's i.c. Perfboard, Tandy stock no. 276-150. Four screws, nuts, washers and spacers to suit

One zero-insertion force 28-way i.c. socket. RS Components stock no. 402-248

One 20-pin i.c. holder

Three PCB transistor holders (Q1, Q2, T). RS Components stock no. 401-661

Ten-conductor bonded ribbon cable. Tandy stock no. 278-7050

Three 4mm insulated panel mounting sockets, two black one red

Three miniclip test leads with 4mm plugs, Tandy stock no. 278-1160

Nylon wire ties

Six moulded knobs with ¼in shaft fittings and white line indicator, ¾in diameter. Tandy stock no. 274-415

One moulded knob with ¼in shaft fitting and white line indicator, 1in diameter. Tandy stock no. 274-416

Circuit varnish

Panel scale – see text

Calibration zener diodes

1·1V, 2·7V, 3·3V, 4·4V, 5·1V, 5·6V, 7·5V, 9·1V, 12V, 30V, 47V, 56V, 61V

---

now cut the cables to the correct lengths to reach switches SW1/2/3. Allow a little extra length in case you need to remove the PCB. Fig. 10 shows the switch contact arrangement used by the two-pole, six-way Tandy switches which are well made and reasonably priced. Finally wire the PCB leads to the switches. At this stage it's worth making ohmmeter checks to ensure that the ribbon cables from the switch connections of SW1/2/3 go to the correct i.c. pins and transistor holders. Check all wiring carefully.

Fit 4mm plugs at one end and mini or micro clips at the other end of the three test leads that plug into sockets Ch, T and G. The small clips are useful when holding small devices and when making in-circuit tests.

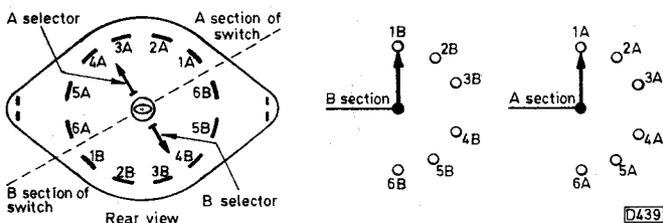The last job, after completing the construction, is to fit the scales with the zener diode voltage indications and the SW1/2/3 switch position indications. Fig. 11 shows the scale full size. Copy it on to white paper and then photocopy it on to a thin white card. The fixing nuts of the panel controls will hold the card in position.

The lettering on the front of the tester is best done with dry-transfer lettering. Apply a coat of Pelikan Klarlack clear varnish over each letter, using a tiny

Fig. 10: Details of the Tandy switch suggested for use in positions SW1-4.
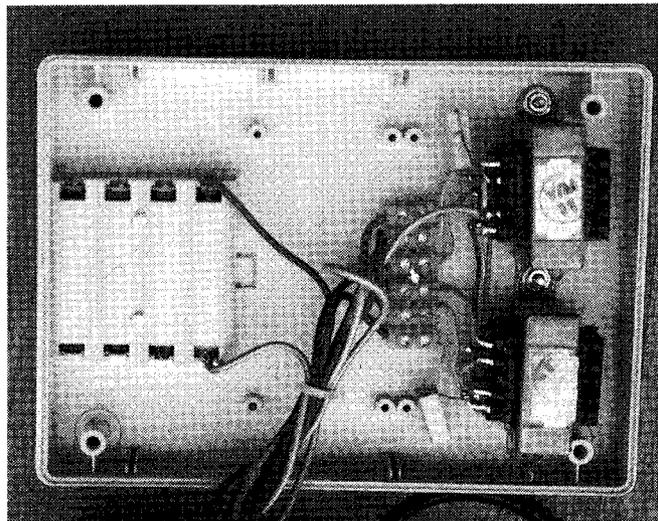
Inside view of the bottom section of the tester.
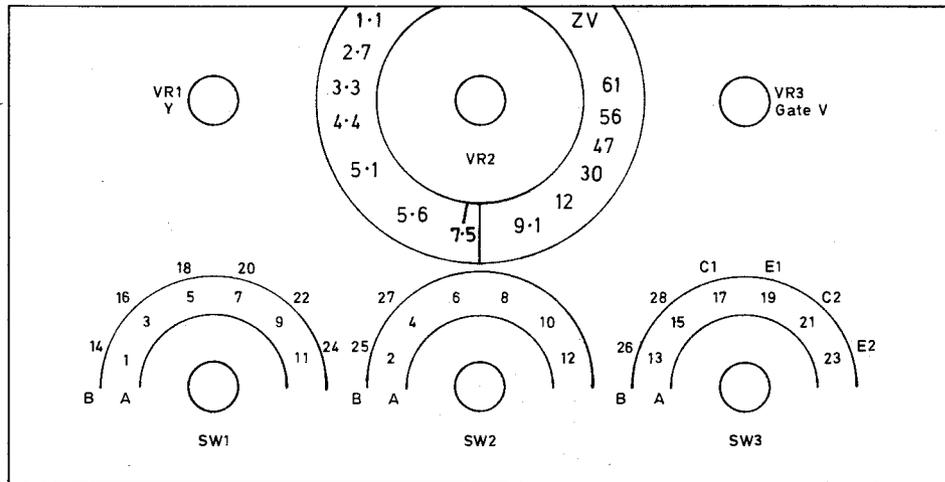
brush, to prevent the letters being rubbed off. You can get the letters and varnish from a local art shop. Don't use cellulose varnish – this will remove the letters and the surface of the case.

Testing and Calibration

Check that the four toggle switches T1-4 are set to their centre positions. Connect the tester to the mains supply. The green neon should light. With SW4 in position 2 the amber neon should light.

Disconnect from the mains supply and turn VR1 and VR2 to their centre positions. Plug the screened leads, fitted with BNC connectors, to the scope's X and Y inputs. If these connectors won't fit your scope fit ones that will. Select external X drive – with some older scopes this may be labelled external horizontal drive. If in any doubt consult the instruction book. Set the scope's Y input to its least sensitive d.c. range. If the scope is an older model with just an a.c. input the tester will work but you may get a double image.

Reconnect to the mains supply and set the tester's volts knob (SW4) to position 2. Adjust the scope's X (horizontal) gain control until you obtain a centred horizontal line that slightly overscans the screen. Move

Fig. 12: Zener scale calibration: (a) 7·5V, (b) 12V and (c) 5·1V zener diodes.

Fig. 13: How the ZV scale calibration is checked: for accuracy the lines connecting the figures to the scale edge should be drawn in on Fig. 11, using a range of zener diodes.

T4 to the set position. This should produce a vertical line. Turn VR1 to half-way and adjust the scope's Y (vertical) gain control until the line almost scans the screen. Centre the line then switch T4 to its N (normal) position.

Connect a diode across sockets T and Ch, anode to the Ch socket. If all is well you'll obtain a sharp, clear waveform of the type shown in Fig. 2(c).

To calibrate the ZV (zener voltage) scale, first make sure that the volt selection switch SW4 is still in position 2 and that the centre position of VR2 coincides with the centre scale line, then connect a 7·5V zener diode via the test leads between sockets Ch and T, with its anode to socket Ch. You should see the waveform shown in Fig. 2(e). Move the pointer line of VR2 to the 7·5V scale marking on the ZV scale. Adjust the scope's X gain (width) control until the horizontal section of the waveform covers just a small section of the screen – see Fig. 12(a). Replace the 7·5V zener diode with a 12V one. The horizontal section of the trace should widen as shown in Fig. 12(b). Turn VR2 to reduce the width until the horizontal section of the trace again covers exactly the same small section of the screen as in Fig. 12(a). The pointer line should now be opposite the 12V marking on the ZD scale. Connect a 5·1V zener diode across the test terminals and the horizontal section of the trace should narrow as in Fig. 12(c). Turn VR2 until the horizontal section of the trace is again as in Fig. 12(a). VR2's white line should read off 5·1V on the scale.

Provided you've used the specified Tandy control the ZV scale should be fairly accurate as drawn. Just the 7·5V calibration line is shown in Fig. 11. Fig. 13 illustrates the calibration procedure just outlined. Although the scale shown in Fig. 11 has been found to be accurate with several different scopes, to allow for component tolerances it's best to calibrate the scale using a range of known good zener diodes, drawing in the rest of the calibration lines yourself.

In addition to checking zener diode voltages the ZV scale enables you to identify the voltage of a zener diode whose markings have rubbed off.

After the instrument has been tested and the zener scale has been correctly calibrated, cover the scale with a thin sheet of clear stiff plastic to keep it clean. The panel control nuts will hold the scale and plastic cover without the need for glue that could damage the case.

Finally, using a small brush, apply a thin coat of circuit varnish to all soldered joints.

Next month we'll describe a broad range of tests that can be made with the unit.
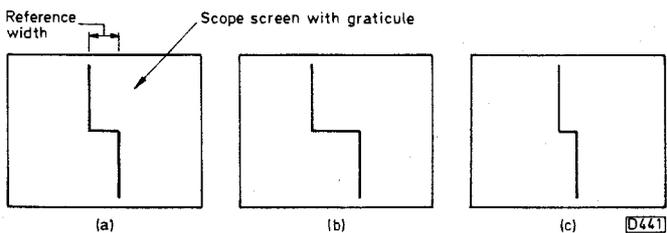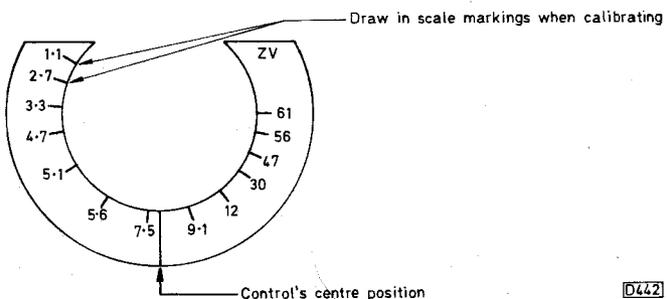
De Luxe Component Tester

Part 2: Uses

<div align="right">David Botto</div>

Last month we described the design and construction of the de luxe component tester. This month we'll describe the wide number of tests for which it can be used.

Zener Diode Tests

In addition to measuring the voltage rating of a zener diode, using the ZV scale, good/bad tests can be made. Waveforms produced by good zener diodes are shown in Fig. 1.

Testing Transistors

For transistor testing set the voltage selector switch SW4 to position 2 or, for large power transistors, position 3.

The base-emitter junction of a transistor can be checked by connecting test lead Ch to its base and test lead T to its emitter. With a good silicon npn transistor the waveform will be as shown in Fig 2(a), with the longer vertical line at the top. Moving test lead T to the collector will produce the waveform shown in Fig. 2(b). With test lead Ch connected to the emitter and test lead T to the collector the waveform is as shown in Fig. 2(c). Emitter-collector tests need not usually be made. The waveforms should be sharp-angled and clear. If you are using an old a.c.-coupled oscilloscope you may get the displays shown in Fig. 2(d) and (e).

(a) (b) (c) D451
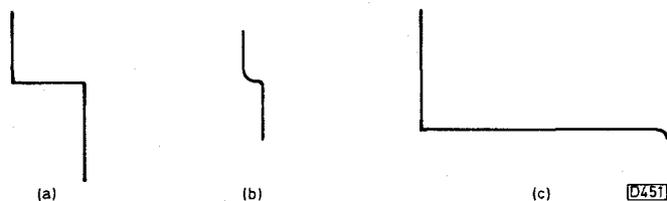
Fig. 1: Zener diode waveforms: (a) 14V zener diode, (b) 1·6V zener diode, (c) 47V zener diode.
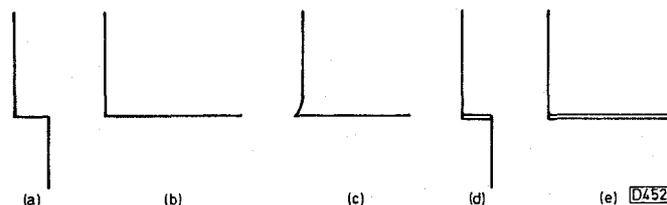

(a) (b) (c) (d) (e) D452

Fig. 2: Silicon npn transistor waveforms: (a) base-emitter, (b) base-collector, (c) emitter-collector. An a.c. coupled scope may produce the waveforms shown in (d) and (e).
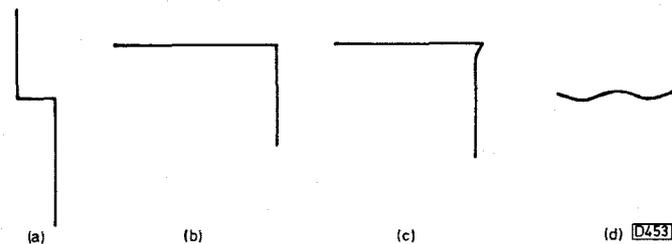

(a) (b) (c) (d) D453

Fig. 3: Silicon pnp transistor waveforms: (a) base-emitter, (b) base-collector, (c) emitter-collector. The centre pin-base waveform with an STR450 is shown at (c).

Fig. 3 shows the waveforms produced by pnp transistors. With a pnp transistor the longer vertical line is at the bottom and the base-collector waveform is inverted. Thus it's possible to establish whether an unknown transistor is an npn or a pnp type.

Fig. 4 shows fault conditions with silicon transistors. Leakage in a transistor's base-emitter junction, or in a zener diode, gives the display shown at (a). This is an in or out of circuit check. An out of circuit leakage check is shown at (b). Another out of circuit check is shown at (c). Diode or base-collector leakage out of circuit is shown at (d).

A germanium transistor produces waveforms of the type shown in Fig. 5. An STR450 produces the waveforms shown in Fig. 3(a), (b) and (d).

Small transistors can be plugged into test sockets Q1 and Q2. Set SW4 to position 2. Switch T3 to its B position and SW3 to its C1 position. You'll then see the base-collector waveform of the transistor fitted into socket Q1. Turn SW3 to its E1 position and you'll see the base-emitter waveform. Turn SW3 to the C2 and E2 positions to view the test waveforms for a transistor in socket Q2.

Large power transistors often have an internal diode inside the encapsulation, across the base-emitter junction. At first glance there may appear to be a base-emitter short. Turn SW4 to position 3 and increase the scope's X amplifier gain. You'll also need to turn up the brightness. The base-emitter waveform you obtain must be compared with that of a known good transistor of the same type.

An interesting effect that you may encounter on rare occasions is when a small-signal transistor tests open-circuit then suddenly tests o.k. It may work in the
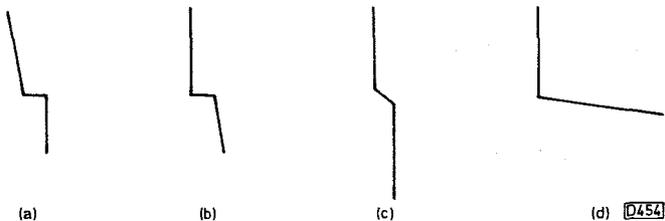

(a) (b) (c) (d) D454
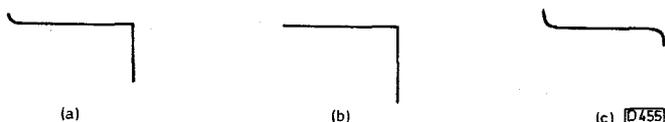
Fig. 4: Displays produced by faulty transistors.

(a) (b) (c) D455

Fig. 5: Germanium transistor waveforms: (a) base-emitter, (b) base-collector, (c) emitter-collector.
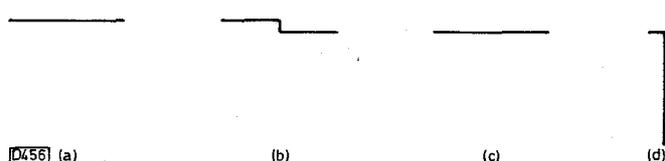

D456 (a) (b) (c) (d)

Fig. 6: Waveforms produced by a BT106 thyristor: (a) thyristor off, (b) just starting to conduct, (c) thyristor on, (d) the saturated state.
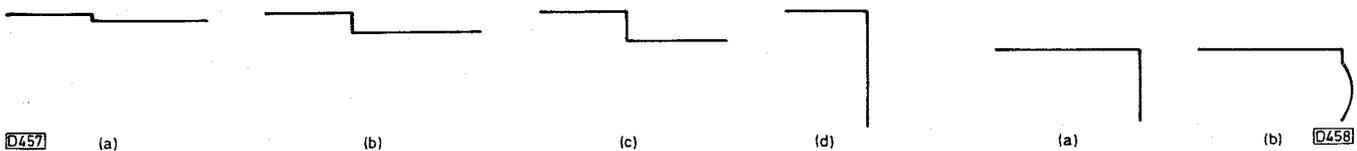
Fig. 7 (left): Waveforms obtained with a Sony SG264A device: (a) the SG264A barely conducting, (b) starting to conduct, (c) conduction increasing, (d) device on.

Fig. 8 (right): Thyristor with an integrated diode: (a) diode test, (b) thyristor turned on.
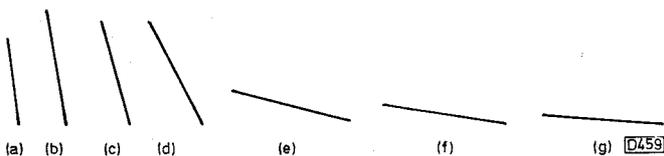

Fig. 9: Waveforms produced by various resistors: (a) 50Ω, (b) 100Ω, (c) 470Ω, (d) 1kΩ, (e) 2·2kΩ, (f) 10kΩ and (g) 22kΩ.
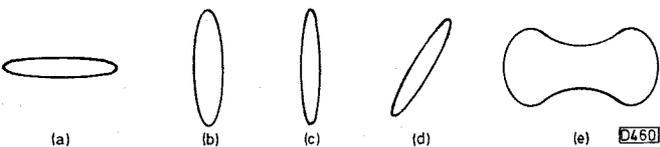

Fig. 10: Capacitor test waveforms: (a) 0·22μF capacitor, (b) 10μF capacitor, (c) 100μF capacitor, (d) leaky capacitor, (e) 0·01μF capacitor with high Y gain.
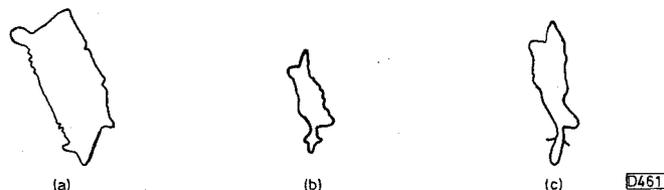

Fig. 11: Displays produced by large-value capacitors: (a) 800μF, (b) 8,000μF, (c) 10,000μF. See text for the scope X and Y settings.

receiver for some hours, months or even years. It's sound policy to replace the transistor however.

Junction f.e.t.s can be checked for shorts. Before checking one of these transistors switch SW4 to position 1 and add a 1kΩ resistor in series with test lead T. MOS field-effect transistors cannot be checked and could be damaged if you try.

Checking a Thyristor

To check a thyristor connect test lead Ch to its cathode and test lead T to its anode. Set SW4 to position 2. Turn the gate voltage control VR3 fully anti-clockwise and connect test lead G to the thyristor's gate. Slowly turn VR3 clockwise and the thyristor should conduct. Fig. 6 shows the waveforms obtained with a BT106 thyristor while Fig. 7 shows the waveforms obtained with a Sony SG264A. On disconnecting test lead G a good thyristor will stop conducting and a horizontal line will appear. Small thyristors can be plugged into socket T on the PCB. Very little gate voltage is required to turn one of these on.

This thyristor test is useful if you suspect that a thyristor is turning on too late or too early. You can compare the results obtained with a known good thyristor of the same type.

Thyristors used in applications such as the line output stage of a TV set often have an internal diode connected across the anode and cathode. With test lead Ch connected to the cathode and test lead T to the anode

you should get the waveform shown in Fig. 8(a). This shows that the diode is in order. Connect test lead G to the thyristor's gate and, as you advance VR3, the thyristor should turn on, producing the waveform shown in Fig. 8(b).

Resistor Checks

With SW4 in position 2 resistors with values from about 50Ω to 22kΩ can be checked. Fig. 9 shows the waveforms produced by an assortment of resistors. By increasing the scope's Y gain resistors with values up to about 2·2MΩ can be checked. This test won't replace the ohms ranges on your digital multimeter, but you'll find that it saves time when you make in-circuit tests.

Continuity Testing

A handy function of the tester is its use as a continuity tester. It's ideal for locating breaks in printed circuit tracks. Looking at your scope's large display is far easier than peering at a meter needle or the relatively small display on your digital multimeter. Set SW4 to position 1.

Capacitor Checks

For capacitance measurement adjust the scope's horizontal (X) gain until the horizontal scanning line nicely scans the screen and set SW4 to position 2. Capacitance over a range of about 0·22μF to 100μF can now be measured, see Fig. 10.

With the capacitor under test connected between test leads T and Ch a circle or an ellipse will be seen, the size and shape depending on the capacitor's value. If an electrolytic is leaky the ellipse will be tilted as shown in Fig. 10(d).

Provided the oscilloscope being used is a dual-channel type its X gain can be increased to 0·01V/cm and its Y gain set at 5V/cm. This enables capacitors with values up to 10,000μF to be checked. To make such tests you may need to turn up the brightness. Fig. 11 shows the waveforms produced by capacitors with values of 800, 8,000 and 10,000μF. The waveforms are not exact ellipses because the capacitors don't charge fully.

For capacitors with values between 100-800μF, set the X gain to a suitable level.

Keep a record showing the scope settings for various capacitor values. You can then check a wide range of capacitors quickly.

Use position 1 of SW4 for capacitors of over 250μF value. Use position 3 for capacitor values of less than 0·47μF and increase the Y gain – see Fig. 10(e).

Checking LEDs and VCR End Sensors

To test a LED connect its cathode, which is usually identified by a flat side or a notch, to the Ch lead and its
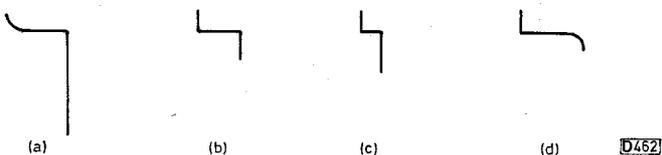
Fig. 12: LED waveforms: (a) small LED, (b-d) typical waveforms produced by the segments of a seven-segment display.
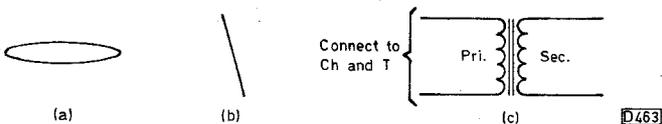

Fig. 13: Mains transformer tests: (a) waveform across the primary, (b) waveform obtained with a short across the secondary, (c) test lead connections.
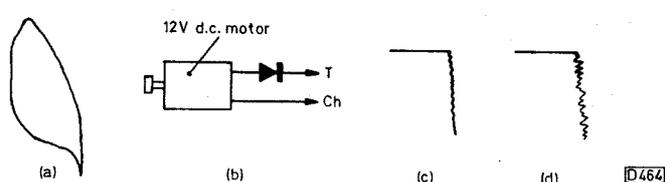

Fig. 14: The signature waveform produced by a 12V d.c. motor is shown at (a). Adding a diode in series as shown at (b) will produce waveform (c) with a good motor and waveform (d) with a faulty motor.
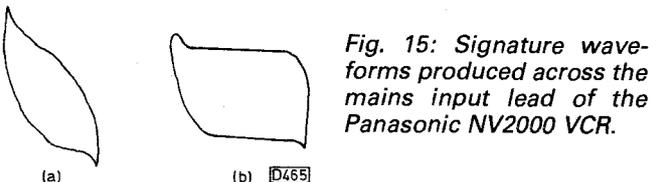

Fig. 15: Signature waveforms produced across the mains input lead of the Panasonic NV2000 VCR.
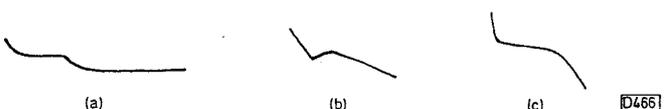

Fig. 16: Signature waveforms produced between various pins of a TDA4503 i.c.: (a) between pins 20 and 21, (b) between pins 22 and 23, (c) between pins 25 and 26.

anode to the T lead. A good LED will light and display the waveform shown in Fig. 12(a). Switching SW4 to position 3 will increase the LED's brightness.

If a seven-segment LED won't light, or one segment stays out, is the problem due to the LED itself or to the complex drive circuitry? Connect lead Ch to the common cathode (or anode) and the T lead to each segment in turn. The segments should light and waveforms similar to that in Fig. 12(b-d) should be seen. It's often possible to check LEDs in circuit: use position 1 of SW4 to do this.

Many types of VCR end sensor can be checked – usually in circuit, with the mains power disconnected of course. Connect test leads Ch and T across the sensor connections. The waveform should be as shown in Fig. 2(b). Shine a light on to the sensitive part of the sensor and, if it's o.k., you'll see the waveform change to that shown in Fig. 2(a).

Mains Transformer Test

A mains transformer or mains choke should show a waveform similar to that in Fig. 13(a). If the winding has shorted turn(s) or the secondary load has shorted the waveform will be as shown in Fig. 13(b).

Checking a Loudspeaker

To test a loudspeaker turn SW4 to position 1. Applying test leads Ch and T across a good loudspeaker's speech coil should produce a slightly angled upright line. It will also make the loudspeaker emit a soft buzz. Now turn SW4 to position 3. If the speech coil is scraping on its polepiece magnet you'll hear it.

Signature Waveform Tests

Connecting test leads Ch and T across almost any component or across any two points in the circuitry of a piece of equipment will produce a unique and distinctive waveform. This is known as a signature waveform.

The signature waveform shown in Fig. 14(a) was obtained by connecting leads Ch and T across the power

input leads of a small 12V d.c. motor of the type used in many VCRs. SW4 was set to position 3, the scope's Y channel gain was set to a sensitivity of 5V/cm and the X channel to 1V/cm. With a diode in series with one lead, as shown in Fig. 14(b), the waveform shown in Fig. 14(c) was obtained. The power from the tester made the motor run. A good motor produces a steady waveform. A motor whose speed varies produces the waveform shown in Fig. 14(d).

Fig. 15(a) shows the signature waveform across the a.c. mains input lead of the Panasonic NV2000 VCR, with SW4 in position 2. Should fuse F1002 go open-circuit the waveform appears as shown in Fig. 15(b).

In-circuit Tests

A helpful feature of the tester is its use in making in-circuit tests. Before making such tests disconnect the equipment from the mains supply and make sure that the capacitors in the power supplies and, in the case of a TV set, the c.r.t.'s final anode capacitance are discharged. Many transistors, diodes, capacitors, transformers, LEDs etc. can be checked in-circuit – it's another form of signature testing. Compare the waveforms you obtain with those from a known good unit. If you regularly service particular TV and VCR models it pays to keep a record of key signature waveforms. Draw them in the service manual – you'll find that they can save you much time and frustration. But like everything else in life, you'll find that in-circuit signature testing skill requires practice.

If you need to isolate a transistor, unsolder only two of its three leads and keep them clear of the print. If the transistor tests o.k. you can then resolder the leads. This

avoids the problem of removing a transistor then finding that the PCB is unmarked and that you have to waste time working out which way to reconnect it. Use the same method with diodes, capacitors and resistors, with only one lead being unsoldered of course.

Integrated Circuit Tests

Integrated circuits with up to 28 pins can be tested by checking the waveforms between adjacent pins. This is another form of signature testing. Check known good i.c.s and keep a record of the waveforms. Fig. 16 shows some typical signature waveforms obtained from an i.c. We can't claim that this is an infallible method of checking i.c.s, but it does reveal a surprising number of i.c. faults including short- and open-circuit failures.

Switch SW4 to position 1. The amber neon should then light. Set toggle switches T1 to T3 to their centre positions and T4 to its N position. Switches SW1-3 and T1-3 then enable the waveforms of an i.c. with up to 28 pins to be checked.

For checks between pins 1 and 12 of a 28-pin chip switch T4 to N and T1 and T2 to their A positions. Set SW4 to 1 and SW2 to 2. Then select 3 with SW1 then 4 with SW2. As you rotate the switches you'll see the signature waveforms on the scope.

To check between pins 12 and 13, return toggle switch T1 to its centre position and set T2 and T3 to their A positions. Use SW2 to select pin 12 and SW3 to select pin 13. Then view the waveform.

For checks between pins 14 and 24, set T1 to its B position, T3 to its A position and T2 to its centre position. Use SW1 and SW3 to select the i.c. pins.

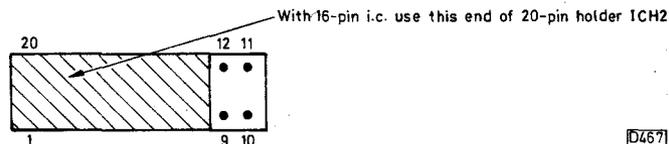To check between pins 24 and 25, set T1 and T2 to

Fig. 17: Testing a 16-pin i.c. in the 20-pin holder ICH2. The same method is used with 8-pin and other small i.c.s.

their B positions and select the pins with SW1 and SW2. For i.c. pins 25-28, set T2 and T3 to their B positions and T1 to its centre position.

Plug smaller chips with fewer pins into the 20-pin holder. Fig. 17 shows the idea. With an 8-pin chip you use the switches to select pins 1-4 and 17-20. With a 16-pin chip you check the waveforms produced by switch positions 1-8 and 13-20.

With a little practice you'll find that the switch settings for various i.c.s are quite straightforward.

Large, multipin memory and microcomputer chips cannot be tested. This is not a problem however as in-circuit checks with a logic probe and pulser are easy.

CMOS i.c.s are easily damaged so I wouldn't recommend that you check them with the tester. I have however checked a number of CMOS i.c.s, with toggle switch T4 in its R position, and have not so far damaged one. With T4 in position R resistor R6 is in circuit. The scope's Y gain must be increased when this is done.

By now you'll appreciate that this tester presents new approaches to measurement for the TV/video engineer. It also enables full use to be made of the oscilloscope. You'll probably find many other useful tests in addition to those described above.

are doubts about the viability of the service.

Both Malaysia and Intelsat have applied to use the orbital slot at 91·5°E. Malaysia has a dish ban at present. Vietnam TV (VTV) has booked Ku band transponder facilities aboard the Thaicom 2 craft which is due for launch this August. The sateliite's footprint will extend well into Europe, covering east and south-east Asia and points between.

Echostar, perhaps best known for satellite receiving equipment, intends to launch two DBS craft via a Chinese Long March rocket by the end of next year. Orbital position will be 119°W. By using a 3:1 compression ratio Echostar hopes to be able to transmit over ninety channels for reception using 18in. dishes. By that time DirectTV plans to be on air with up to 150 channels.

The Japanese PTT is developing digital compression/transmission technology, the aim being to transmit fifty channels via Jsat in early 1996 with terrestrial services starting by the year 2000.

Colin Grellis (Bridport) tells us that NASA runs a daily TV service, with live space coverage when applicable, via Spacenet 2 at 69°W. The vision carrier is at 3·880GHz with the audio subcarrier at 6·8MHz. Though the position is very low in the sky in the UK, readers in the west country and Ireland could stand a chance of reception. Signal amplitude would be very low however as Spacenet 2's footprint covers North America.

The Sri Lankan government has been pressing the German authorities to end the World Tamil Television uplink from Berlin via Eutelsat II F3 at 16°E: it's thought that the service is used for anti-government propaganda amongst Tamils in Europe.

In the May issue (page 503) we featured Bandula Gunasekera's simple u.h.f. satellite receiver circuit for use with the 714/754MHz transmissions from the Ekran craft. It has proved to be very popular in Sri Lanka and India. If any other readers have made simple satellite receiving equipment we'd be pleased to include the details in this column with the aim of inspiring other potentional sat-zappers.

The Super D100

HS Publications, 7 Epping Close, Mackworth Estate, Derby DE3 4HR (telephone 0332 513 399) tells us that a super version of the D100 DX converter is now available. It's based on the well-established D100 but has in addition an integral a.g.c. circuit to avoid overloading with strong signals and give freedom from manual gain control operation, and an auto bandwidth circuit that reduces the bandwidth with weak signals, widening it with strong ones. The u.h.f. output is now at ch. E65 instead of around ch. E35. The units are hand-built to order, at about £125 inclusive.

The Squashed Quad Aerial

In the July issue we provided details (page 665) of the squashed quad aerial that Brian Williams uses. He has pointed out that we didn't show the feeder connections correctly – see Fig. 1 this month for further elaboration. The loft-mounted aerial provides a gain of typically 1·5dBd. He has also provided details of an improved design with the feed point at the upper corner. At a centre frequency of 52MHz 19ft 4in. of wire is required, proportioned at approximately 2·5:1 (side to end dimensions). The feed is taken via a quarter-wave section of 75Ω balanced feeder to a 75Ω downlead which can be balanced or coaxial. Brian prefers the performance of balanced feeder. To connect this to a 75Ω unbalanced aerial socket or preamplifier input a balanced-to-unbalanced transformer or cable conversion is required. This design provides omnidirec-
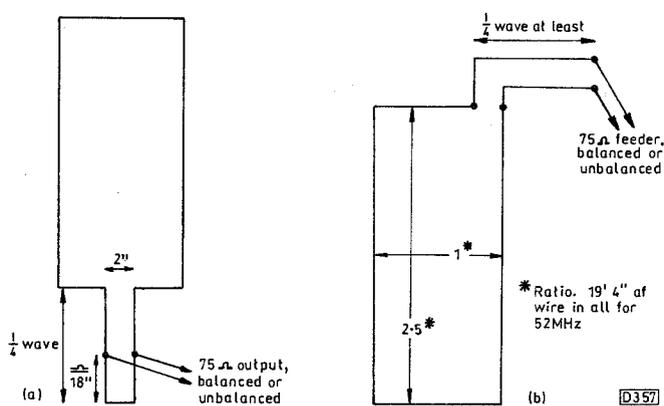

Fig. 1: The squashed quad aerial. (a) Original version, showing correct connection details. (b) Improved version with feeder connection at the corner.

tional pick-up in the vertical plane and is ideally suited to SpE reception in Band I. Use the formula 1,005/f(MHz) to calculate squashed quad dimensions (in feet) for other frequencies.

Canary Wharf

Residents in the East End of London took property developer Canary Wharf Ltd. to the High Court on July 25th to claim damages for "public nuisance" following the loss of good-quality TV signals after the construction of the 242m high, stainless-steel clad block – the claim includes compensation for dirt and noise during the construction period. Ghosting is severe in the area and the BBC has installed a relay transmitter to help overcome the problem. South Poplar and Limehouse are the areas most affected by the office block.

Previous court action in the UK (Bridlington Relay v Yorkshire Electricity, 1965) ruled against the right to good-quality TV reception following loss by building works, though Canadian law (1978) has upheld the right to quality reception. Arsenal Football Club paid for viewers who lost good signals following construction of its new North Bank all-seater stand to have new aerials pointing at another transmitter installed.

Installing a CD-ROM Drive

Part 2   *David Botto*

In Part 1 we described how to install the CD-ROM drive and set up the software. The next job in the project is to install and set up the Creative Labs SB1600 sound card.

Preparation

Make sure that the PC is switched off, and remove the power plug from the wall socket. Before the sound card is installed its hardware settings must be checked. The 'jumpers' on the card are mainly two-pin types with enabled and disabled positions. Fig. 1 shows the layout of the SB1600 card with its jumpers in their default positions.

The jumpers enable the hardware settings to be defined. They are usually set to the default positions and you prob-
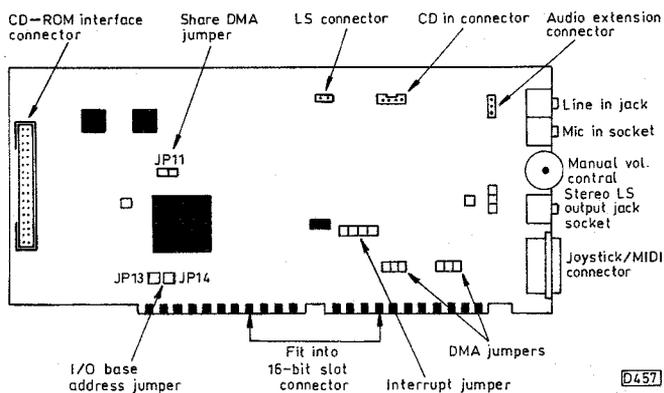

Fig. 1: Layout of the installation/user features on the sound card.

ably won't need to touch them. If you do need to change a setting, pull off the block gently then push it on to appropriate pins.

I/O (input/output) addresses are to areas of the PC memory. They enable it to distinguish between the various peripheral devices connected to the system when data is sent or received. Ranges are 220H-207H for the game port, 220H-22FH for the sound interface (220H default) and 388H-38BH dor the f.m. music synthesizer.

The IRQ (interrupt) line is used to tell the PC's central processor unit that a device wants to send or receive data. Five is the factory default.

The DMA (direct memory access) line is used to transfer digital data to the PC's memory directly. The default position is one. DMA sharing enables the sound card to share the line with another device – the default position disables the sharing.

If your PC has a joystick port, the sound card's joystick port setting enables it to be disabled. The factory default position enables the joystick port. There's no need to have a joystick permanently connected to the workshop PC, since it's used only for games. But since some of your customers may want this facility it's a good idea to test the port.

Installing the Sound Card

It's important that you wear an antistatic wrist-strap when carrying out this installation.

Locate an empty 16-bit expansion slot in the PC. Knock the metal endplate from the selected slot and put the screw in a safe place. Align the sound card with the empty slot, then push it firmly into place. Fix it with the screw you took out.

A line out audio connector is supplied with the Mitsumi FX400 CD-ROM drive. Use Fig. 2 to check that the connections are correct. Change them over if necessary.

Set the volume control knob to its half-way position then, the final installation step, insert the 3·5mm jack plug from the stereo loudspeakers into the sound card's speaker output socket.

Reconnect the monitor, printer, keyboard and any other peripherals to the PC. Examine all connections and settings carefully. If all is in order, connect the PC's power card to a 240V wall outlet and switch on. The PC and the CD-ROM drive should now work correctly, but the software for the Creative Labs SB1600 card must be loaded before it will function.

Loading the Software

Full sound and speech require 6Mbytes of hard disc space. To install, use the sound card software back-up discs you made (see Part 1). Insert the sound card installation disc in drive A. Type

A: Install

and press the enter key. You will be offered a choice of custom or full installation. Choose full. The installation adds the following lines automatically to your Autoexec.bat file

```
SET BLASTER=A220 15 DI T4
SET SOUND=C:\SBPRO
C: SBPRO\SBSET /P
```

and these to your Config.sys file

```
DEVICE=C:\SBPRO\DRV\CTSBPRO.SYS /UNIT=0/
Blaster=A420 1.5 D:1
DEVICE=C:\SBPRO\DRV\CTMMSYS.SYS
```

They ensure an automatic sound set-up whenever the PC is started or rebooted.

DOS and Windows applications are automatically installed on your hard disc. A command is also added to the Windows WIN.INI files to run WINSET.EXE. This creates an audio card group window and the various application icons.

When you've completed the software installation you must restart or reboot your PC so that the new settings can take effect. When you load Windows you'll hear bursts of music and a new Windows audio group should be present.

Testing

The next step is to test the installation. Exit Windows and return to the C: DOS prompt. Type CD\SBPRO and press the enter key, then type DIAGNOSE and press enter. The

program then checks all the interface settings automatically. The DIAGNOSE program has a facility to correct the situation should hardware conflicts arise because two or more peripheral devices try to use the same signal lines.
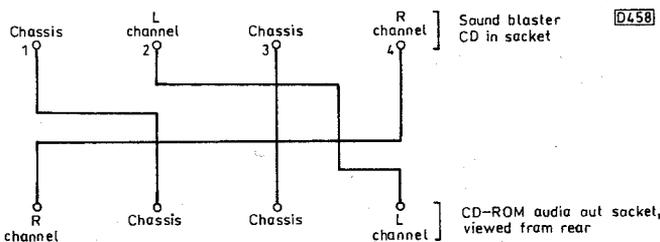

Fig. 2: Audio lead connections between the CD-ROM drive and the sound blaster CD in socket. If the connections are not as shown they must be changed.

To check the sound when the DIAGNOSE program has completed its work, choose 8-bit testing. You will then hear a voice, accompanied by music, saying "8-bit testing". Select the FM SYNTHESIZED MUSIC setting and you should hear stereo music. Leave it playing while you adjust the volume control at the back of the SB1600 card to the required level. The built-in stereo amplifier has an output of 4W per channel: be careful not to overload the speakers.

The Joystick

The joystick plugs into the joystick/MIDI socket on the sound card. It's needed only for games. If it doesn't work, it may be conflicting with an existing joystick port in the system. To correct this, either remove this joystick or disable the SB1600 joystick port by unplugging the jumper block from JP4. If it works intermittently with some programs the PC's speed may be too fast. If there's a CPU speed selection control on the PC's front panel, use this to reduce the speed. Before doing any of these things, check the amount of conventional memory available.

Recovering lost Memory

Exit the DIAGNOSE program and return to the C: DOS prompt. Type MEM. Compare the readings you obtain with the original memory listing you printed out before installing the CD-ROM drive and sound card software. You may find that your basic 640K of conventional memory has decreased considerably. This could cause problems when certain programs that specify a minimum memory figure are run. Fig. 3 shows how conventional memory is allocated in a PC.

If you are using the MSDOS 6 or higher operating system, read the sections on memory in the MSDOS owner's manual then type MEMMAKER at the DOS
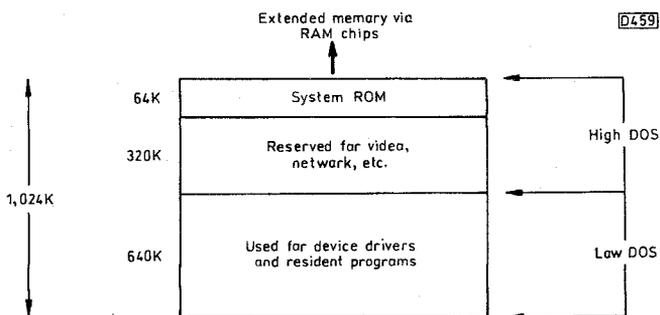

Fig. 3: How the basic 1Mbytes (1,024Kbytes) of memory are allocated in a PC.

prompt and follow the on-screen instructions. Load everything possible, including your operating system, into upper memory. This should recover for you a large chunk of your lost conventional memory. If you are using an earlier version of MSDOS without a memory-manager program it's best to upgrade to the latest version.

If your operating system is DRDOS 6 or higher, use the DRDOS SET UP program to obtain maximum memory. Read the relevant sections of the DRDOS manual first.

Using the CD-ROM Drive

A glance at any CD-ROM catalogue shows the variety of programs available. Software and multimedia encyclopaedias with sound, speech and moving pictures can be obtained at reasonable prices. A multimedia encyclopaedia such as MS ENCARTA enables you to see and hear important events – for example Neil Armstrong landing on the moon and making his famous "one small step for a man" speech.

Always load CD-ROM discs with great care. Never leave the tray in the open position. CD-ROM trays are fragile and easily broken.

Using the Sound Card

Your service department is unlikely to need to use all the SB1600 sound card's facilities. It's nevertheless important to understand each application in order to be able to advise your customers. Table 1 explains some of the terminology used. There is space to mention only a few applications here. The following are some of the Windows applications that come with the sound card software.

Creative WaveStudio: This easy-to-use but powerful application enables the user to record, play and edit wave data and enhance it with special effects. To use it, double-click on the WaveStudio icon in the audio card's group window.

FM Organ: This turns you into an instant musician, enabling you to play music (not just organ music). The PC keyboard becomes a musical keyboard.

Creative Ensemble AV: Enables an assortment of players to be controlled by the on-screen EnsembleRemote, including CD, cassette tape and floppy disc. Start by double-clicking on the EnsembleCD icon in the audio card group.

EnsembleMIDI (Musical Instrument Digital Interface): Does what it says!

Creative Soundo' LE: Plays and records data and supports OLE (object linking and embedding – see Table 1).

Creative Mixer: A powerful Windows application that enables you to combine and manipulate sound from various sources. You can control the sound volume while running sound in other Windows programs. You can use the RECORD command to record from an audio CD to a sound file.

Creative Mosaic: A board game with striking sounds.

Listening to Documents

The sound card can read aloud to you what you have typed out. Study the *Text-to-Speech User's Guide.*

SBTALKER is a DOS text-to-speech synthesizer program that resides in memory. It uses phoneme codes that consist of computer ASCII characters – known as the ARPABET.

When using your wordprocessor, record your documents on the hard disc (or floppy disc) in ASCII format. Then, in the DOS format, use the following batch file to load SBTALKER. I've named it TALK.

```
C:
CD\SBPRO
CD\SBTALKER
SBTALK SET-ECHO1000
```

To listen to a document, type READ<C:file name/w. You will then hear the document read out while the text appears simultaneously on the screen. Type REMOVE to take SBTALKER out of memory.

The **Monologue for Windows** program adds speech to almost any Windows application. To check whether it's installed correctly, start Monologue for Windows then click the mouse pointer on the sample button. You should hear the "testing 1, 2, 3" message.

To add sound to a program, plug a microphone into the 3·5mm jack socket at the rear of the sound card.

Another facility, **Talking Scheduler**, provides an audible and visual reminder of any appointments you have made.

Playing CD-ROM Audio

The Sound Blaster Pro SB1600 software enables audio CD-ROMs to be played in stereo through the speakers. Do this either via the **DOS QuickCD** or **Windows EnsembleCD** programs. An external stereo amplifier can be connected if you wish. The screen will show a picture of a CD player with controls that you operate by mouse clicking. You can run your wordprocessor or almost any other program and at the same time listen to soft background CD stereo music. The following batch file loads QuickCD from the C: DOS prompt. I've named it CDMUSIC.

```
C:
CD\SBPRO
QCD
```

In Conclusion

You'll find that there are plenty of uses for a CD-ROM drive and sound card. But best of all once you are familiar with them you can undertake profitable installation and servicing work.

My thanks to Mitsumi Electric Co. Ltd. (0127 629 029) and Simply Computers (0181 523 4020) for supplying technical information.