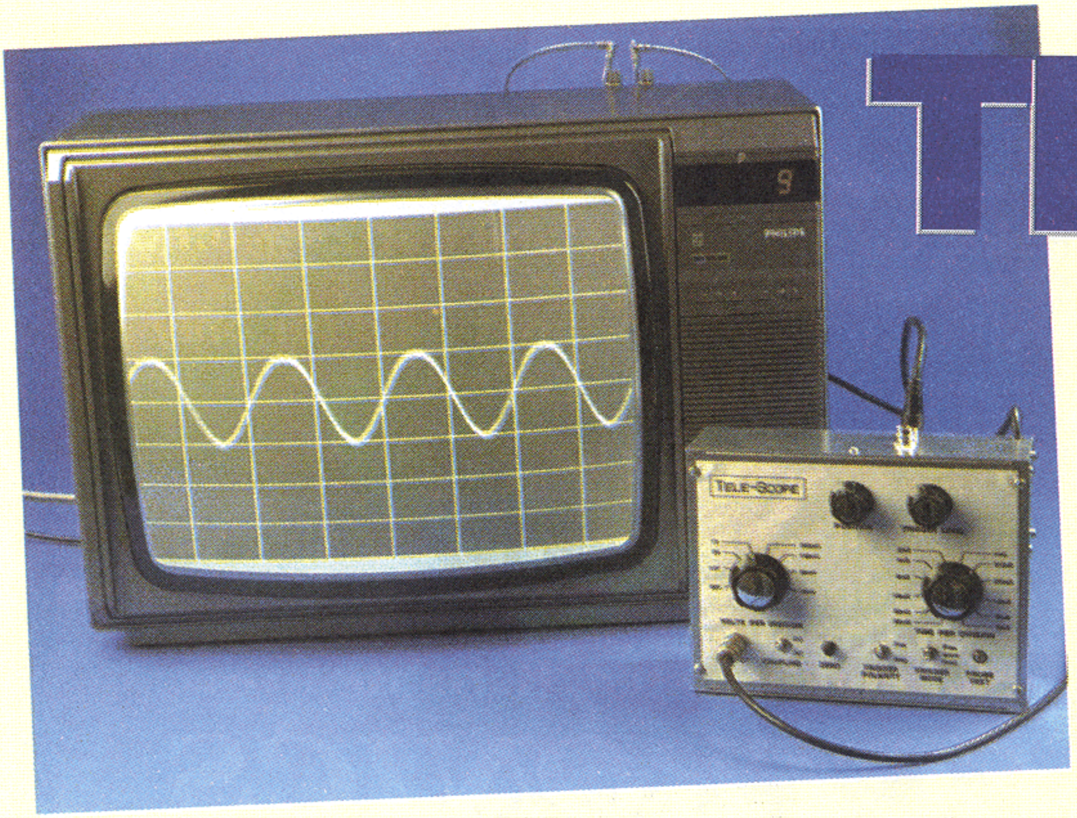


The T

Here is a Tele-scope that will not see stars but it is astronomically cheap. Paul Stenning provides the details.

PART ONE

Anyone who has used an oscilloscope would say it is equipment you can't do without because it gives a new insight into circuit operation. However a commercial oscilloscope is an expensive piece of equipment, which many people, hobbyists alike, cannot afford or justify.

The Tele-Scope presented here allows a normal television (black and white or colour) to be used as an oscilloscope display. No modification is required to the television, connection being made via the aerial (or video input) socket.

The unit is reasonably low cost, and uses readily available components. Setting up is straightforward and requires no test equipment.

The Tele-Scope may be useful in education and other applications where a number of people need to view the display. The composite video output could also provide a useful way of incorporating waveform displays into training videos etc.

Advantages over a conventional oscilloscope include a display hold facility, and the absence of flicker on slower timebase settings.

Limitations

The unit is not a full oscilloscope and was designed to be made at reasonable cost. Consequently there are some limitations, and it is only fair that you are made aware of these before starting construction.

The most significant limitation is ▶

Features and Specifications

Input Voltage Range	10mV/div to 30V/div in 8 steps
Input Coupling	AC to DC
Input Impedance	1M nominal
Input Bandwidth	(DC) - DC to 20KHz (AC) - 2Hz to 20KHz
Timebase Range	32us/div to 66ms/div in 12 steps
Triggering modes	Automatic Free Running Display Hold
Graticule	8 x 8 rectangles
RF o/p	UK Channel 36
Video o/p	PAL Composite Video approx 0.8V pk-pk into 75R
Probe adjustment o/p	1V pk-pk nominal at approx 1KHz

Trace vertical position adjustment with zero button
Adjustable triggering level, switchable to positive or negative going edge

Tele-scope

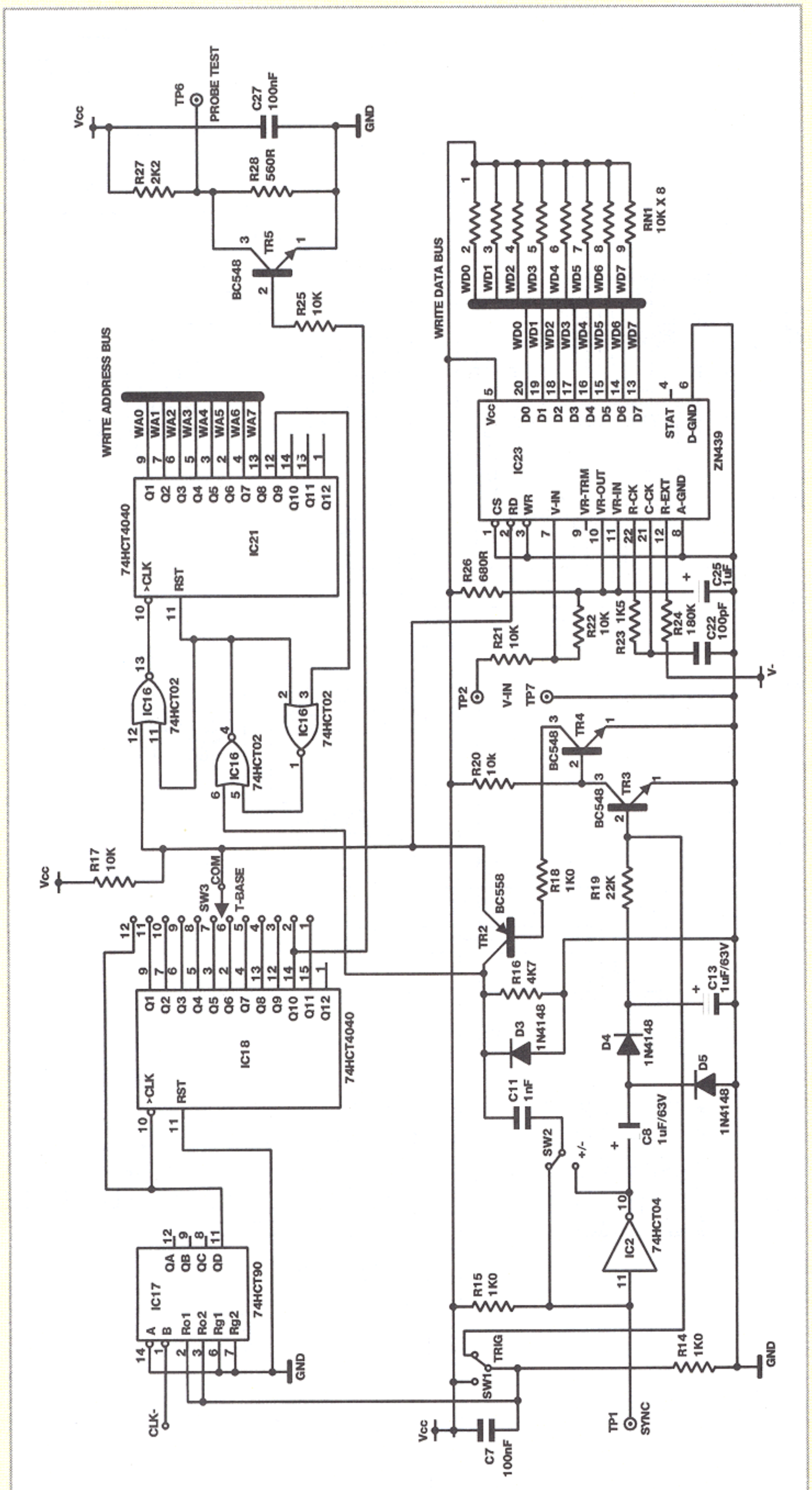


Fig.1Main circuit showing the timebase, sync and A/D sections

The Works

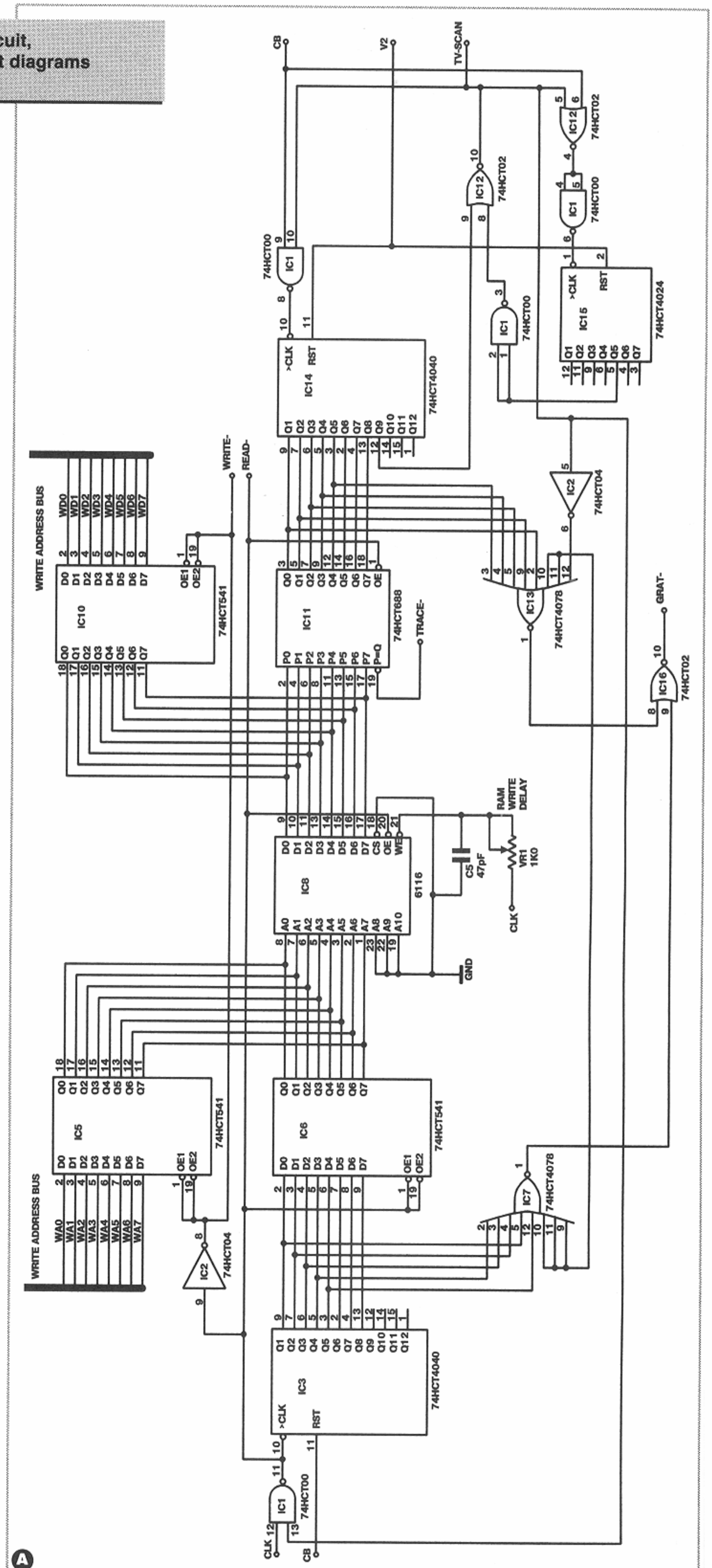
Memory Write

The timebase is selected by choosing a division of the clock frequency. This is carried out by IC17 (divide by 5) and IC18. This is then fed to IC21 via the sync circuit, the outputs of which drive the RAM address lines via IC5 when WRITE- is low. The A/D output drives the RAM data lines via IC10 at this time. The timing is critical for the Write Enable (WE-) pulses to the RAM, and appear to vary slightly with different makes of IC. As we are running this device at the limit of it's speed specification, a variable time delay is used and can be adjusted for best results with the device used.

In Sync

With SW2 in centre position (Normal), the SYNC signal from the input PCB is pulled up by R15 (open collector), and fed to an inverter in IC2. SW2 provides either positive or negative edge triggering. If pulses are present, C13 will be charged, switching TR3 on. This then switches TR4 and TR5 off. The rising edges of the sync pulses pass to pin 6 of IC16 via C11. With no sync pulses, TR3 turns off (TR4 & 5 on) and sends the timebase frequency to pin 6 of IC16, resulting in a free running sync. This also occurs if SW2 was set so that TR3 base is grounded via R14 (Free Run position).
The three gates of IC16 between IC18 and IC21 form an S-R flip-flop, being set (pin 6)by the signals from the sync circuit, and reset at the end of a scan by pin 12 of IC21 going high. The first state allows the timebase clock to go to IC21 and the second state holds IC21 in reset. The third position of SW2 holds IC17 in reset, disables the timebase and A/D, and freezes the display.
One output from IC18 is buffered by TR5 and attenuated by R27-R28 for a probe test output.

Fig.2 A,B & C Main Circuit, Logic and Video output diagrams respectivily



the input bandwidth (frequency range). The maximum frequency signal that the unit can display is 20KHz. This is due primarily to the A-D convertor used, faster 8 bit convertors are available but are considerably more expensive than the one used here. Although it means the unit cannot be used with microprocessors, it is still handy for audio work, and digital projects operating at lower frequencies.

The timebase settings are not convenient figures, owing to a divider circuit on the main system clock (see

Setting up is straightforward and requires no test equipment

'The Works'). However the time per division figures are given and the period or frequency of any waveform can easily be established (although a calculator may be required).

The input is not protected against excessive input voltages, since adding protection caused more problems than it solved. The Input Range attenuator will give some protection on all but the 10mV range. Fortunately the input amplifier IC is an extremely low cost device, and can readily be replaced if the worst happens!

Since the trace is made up of 256 dots it will not necessarily appear as a continuous line (see screen photo), however the shape of the trace will normally be apparent if a suitable timebase setting is chosen.

There is no external triggering facility. If the signal is too large to display it will clip at the top and/or bottom of the display.

Finally before looking at the construction, when reading about the circuit operation is is wise to start with the main circuit on page 61.

PCB Construction

The input circuit is constructed on a single sided PCB, 2" x 3.8" in size. The component overlay of will be shown next month. Construction is straightforward but do not forget the two links. IC sockets can be used if desired - one is recommended for IC1 as this may have to be replaced if an excessive input voltage is applied to the unit. Veropins should be fitted for the ▶

The Works

Main PCB

The main circuit diagram is shown in Figure 1 & 2, whilst the input circuit will be shown next month.

In this description, any signal name which is followed by a minus sign (e.g. READ-) is active low.

The heart of the circuit is IC8, a 2K 6116 RAM chip. One section of the circuit writes data from the A-D convertor into RAM, whilst another reads the RAM and displays the trace on the screen. These two processes run asynchronously, conflict being avoided by the use of tri-state buffers controlled by the READ- and WRITE- lines. This will all be explained in detail as we continue!

Only 256 RAM locations are used, the remaining address lines are tied low. A 2K IC was used because it was the cheapest device available, that was fast enough for this application. Each memory location contains a value between 0 and 255, which comes from the A-D. A value of 0 will give a dot in the appropriate position on the top active line of the display, whilst a value of 255 equates to the bottom line. The A-D gives a value of 0 for zero input and 255 for maximum input. This is the opposite of what is required and is resolved by an inverting stage in the input amplifier.

The timing of the whole circuit is controlled by IC4, a universal sync generator, which in this case in configured to operate in 624 line video game mode. This results in frames of 312 lines, and gives less flicker than standard 625 line interlaced mode, whilst retaining compatibility with 625 line PAL equipment. The circuit clock is derived from the crystal oscillator of this IC, via two gates of IC2.

Memory Read

The CB (Composite Blanking) line from IC2 is high during the frame sync period, and pulses high during the line sync period. Counters IC14 and IC15 are reset by the V2 signal, which pulses high during the frame sync. Initially pin 5 of IC15 is low so the CB pulses are fed to IC15. After 16 such pulses IC15 pin 5 goes high, switching subsequent CB pulses to IC14. The effect of this is to give 16 blank lines at the top of the screen before the display starts.

The next 256 CB pulses drive counter IC14, and these are the 256 active lines of the display. On the 256th pulse pin 12 of IC14 goes high, diverting the CB pulses back to IC15 for the remainder of the frame.

During the 256 active lines, the TV-SCAN line is high and the CLK signal is fed to counter IC3. This IC counts to 255 during each line, and is reset at the end of the line by the CB signal.

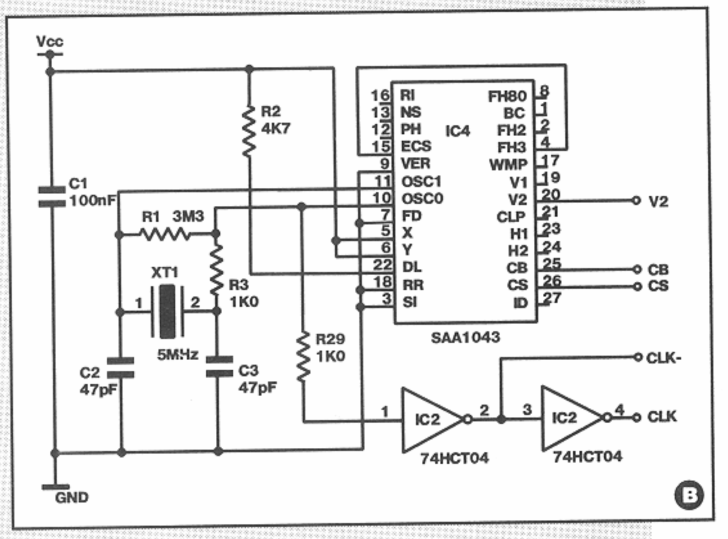
Hence we have two counters, one counting the active lines (0 to 255), and the other counting from 0 to 255 along each line. The graticule is generated by NOR gates on the Q1 to Q5 outputs of these two counters, resulting in a GRAT- signal.

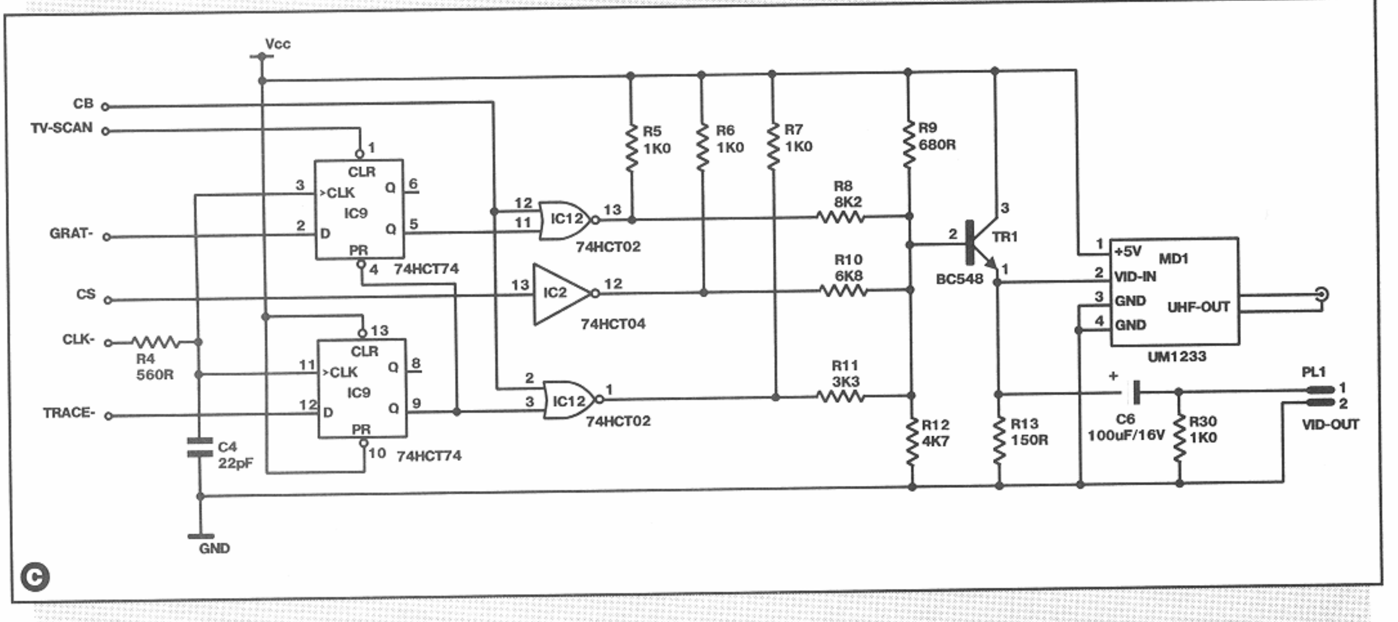
The clock pulses to IC3 are also used as the READ- signal, and an inverted form of this is the WRITE- signal.

When READ- is low, the outputs of IC3 are coupled to the RAM (IC8) address lines via tri-state driver IC6. The READ- line also drives the RAM Output Enable (OE-) line, and the contents of the memory location addressed is output on the data lines. IC11 is a logic comparator, the output of which goes low if the data on P0 to P7 is the same as that on Q0 to Q7. This compares the output of counter IC14 with the data from the RAM, if the two are the same then a trace dot will appear on the screen (TRACE- signal).

The GRAT- and TRACE- signals are latched into two D-type flip-flops (IC9), which extend the pulses over the write period. The timing of the TRACE- signal is fairly critical (the pulse is short due to propagation delays), hence the time delay circuit on the clock inputs of the D-types.

The signals from the D-types are combined with CB and CS (Composite Sync) through logic gates and resistors to form the composite video signal, which is buffered by TR1 before driving the modulator (MOD1) and the video output socket.





off-board connections.

The switch is fitted by cutting the loops from the ends of the pins, the holes in the PCB may have to be enlarged to accommodate the pins. Alternatively short lengths of tinned wire may be soldered to the pins and the assembly then fitted to the PCB. The switch stop should be set to 8 positions.

The main circuit is constructed on another single sided PCB, 5" x 7" in size. The component overlay is shown in figure 3.

This board is a little more fiddly to assemble. Firstly the links should be fitted. There are about 80 of these, and some run underneath the bodies of IC's. Thin (about 28SWG) tinned copper wire is recommended for these.

The remaining components can then be fitted, in the usual size order. IC sockets may be used, and are recommended for IC's 4, 8 and 23 since these are more expensive. Veropins or 0.1" header strip connectors should be used for the off-board connections.

If standard 7812 and 7912 devices are used for IC22 and IC23, they should be fitted with their metal tabs towards C21 and C23 (see photo of main PCB).

The 5V regulator (IC19) will run rather warm and a small heatsink or metal bracket should be fitted. Alternatively the regulator could be mounted on a metal panel of the case, and connected to the PCB with short lengths of wire.

Check the PCB very thoroughly after construction, as errors can be difficult to track down with this sort of circuit - particularly if you do not have an oscilloscope!

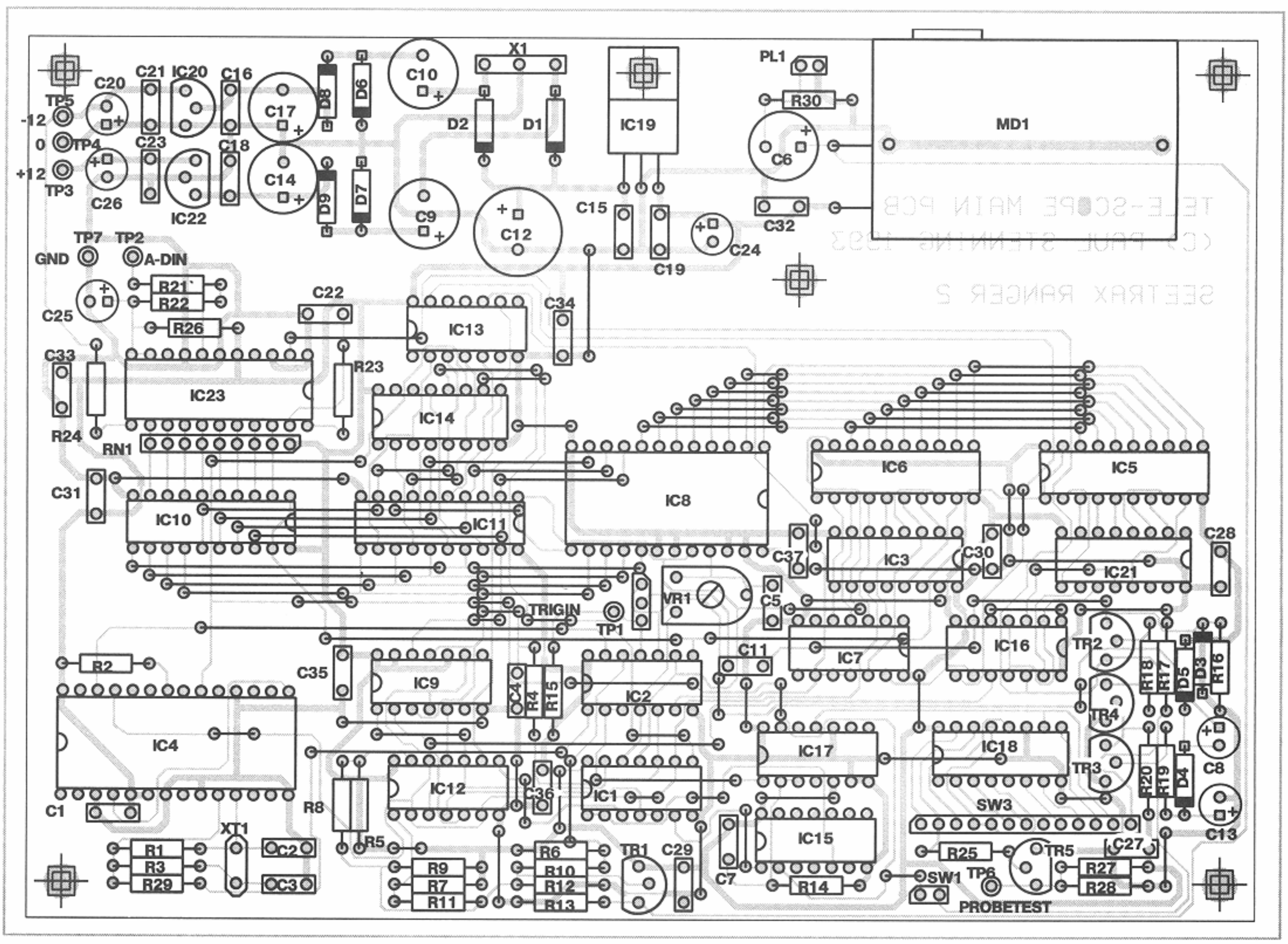
Main Circuit
Resistors
(All 0.25W, 5% or better).

R1	3M3
R2,12,16	4K7
R3,5-7,14,15	1K0
R18,29,30	1K0
R4,28	560R
R8	8K2
R9,26	680R
R10	6K8
R11	3K3
R17,20-22,25	10K
R13	150R
R19	22K
R23	1K5
R24	180K
R27	2K2
RN1	10K x 8 SIL Resistor Network
VR1	1K0 Horizontal Preset

The Case

The prototype was housed in a plain aluminum box, 6" x 8" x 2" being functional but not very elegant. It was also not quite large enough, so something slightly bigger might be advantageous. A metal box is preferable for screening, a painted die-

Fig.3 Component positioning on Main PCB



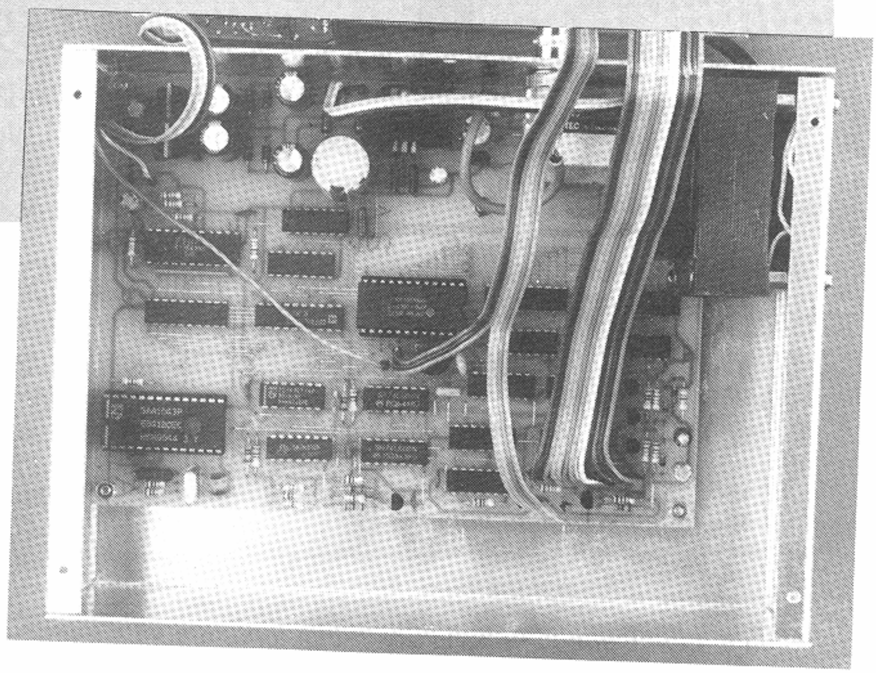
Parts

Semiconductors

TR1,3-5	BC548 or equiv
TR2	BC558 or equiv
D1,2,6-9	1N4001
D3-5	1N4148
IC1	74HCT00 or 74LS00
IC2	74HCT04 or 74LS04
IC3,14,18,21	74HCT4040
IC4	SAA1043
IC5,6,10	74HCT541 or 74LS541
IC7,13	74HCT4078
IC8	6116 2K x 8 RAM 150nS
IC9	74HCT74 or 74LS74
IC11	74HCT688 or 74LS688
IC12,16	74HCT02 or 74LS02
IC15	74HCT4024
IC17	74LS90
IC19	7805
IC20	79L12 or 7912
IC22	78L12 or 7812
IC23	ZN439

Capacitors

C1,7,15,16,18	100n
C19,21,23,27-37	100n
C2,3,5	47p
C4	22p
C6	100µ 16V Radial
C8,13,25	1µ0 63V Radial
C9,10,14,17	220µ 25V Radial
C11	1n0
C12	2200µ 16V Radial
C20,24,26	10µ 25V Radial
C22	100p



cast type may be suitable. There are a several controls on the front panel so a box with a large front area would suffice.

The input PCB is mounted on whatever surface is chosen for the control panel, by the switch mounting nut. The input socket and associated controls for this PCB should be mounted reasonably close to prevent noise pick-up.

The whole input PCB assembly could be screened if required by fitting a suitable die-cast box or similar around it. If the base of this box is drilled to match the panel of the case, it can be held in place by the control fixings. This may prove necessary as the prototype showed a little noise on the more sensitive input ranges.

The remaining controls should be positioned away from the input PCB if possible, again to reduce noise. The stop on the Timebase switch should be removed to allow the full 12 positions.

The main PCB should be mounted towards the rear of the case, and a suitable hole drilled for the RF output socket on the modulator. Holes are also required for the video output socket and the mains cable, the latter should be fitted with a cable clip or grommet.

The transformer can be mounted wherever there is room, but it should be well away from the input circuit and the A-D convertor. The unit is now ready for wiring up and will be described next month. Remember, any mains connections should be sleeved for safety and any metal panels on the case, and the 0V rail of the circuit, must be earthed.

Details of the input board, power supply and interwiring will appear in Part 2. The front panel controls will be shown next month together with a copy of the prototype artwork which may be photocopied, placed on the case and covered with clear self-adhesive vinyl.

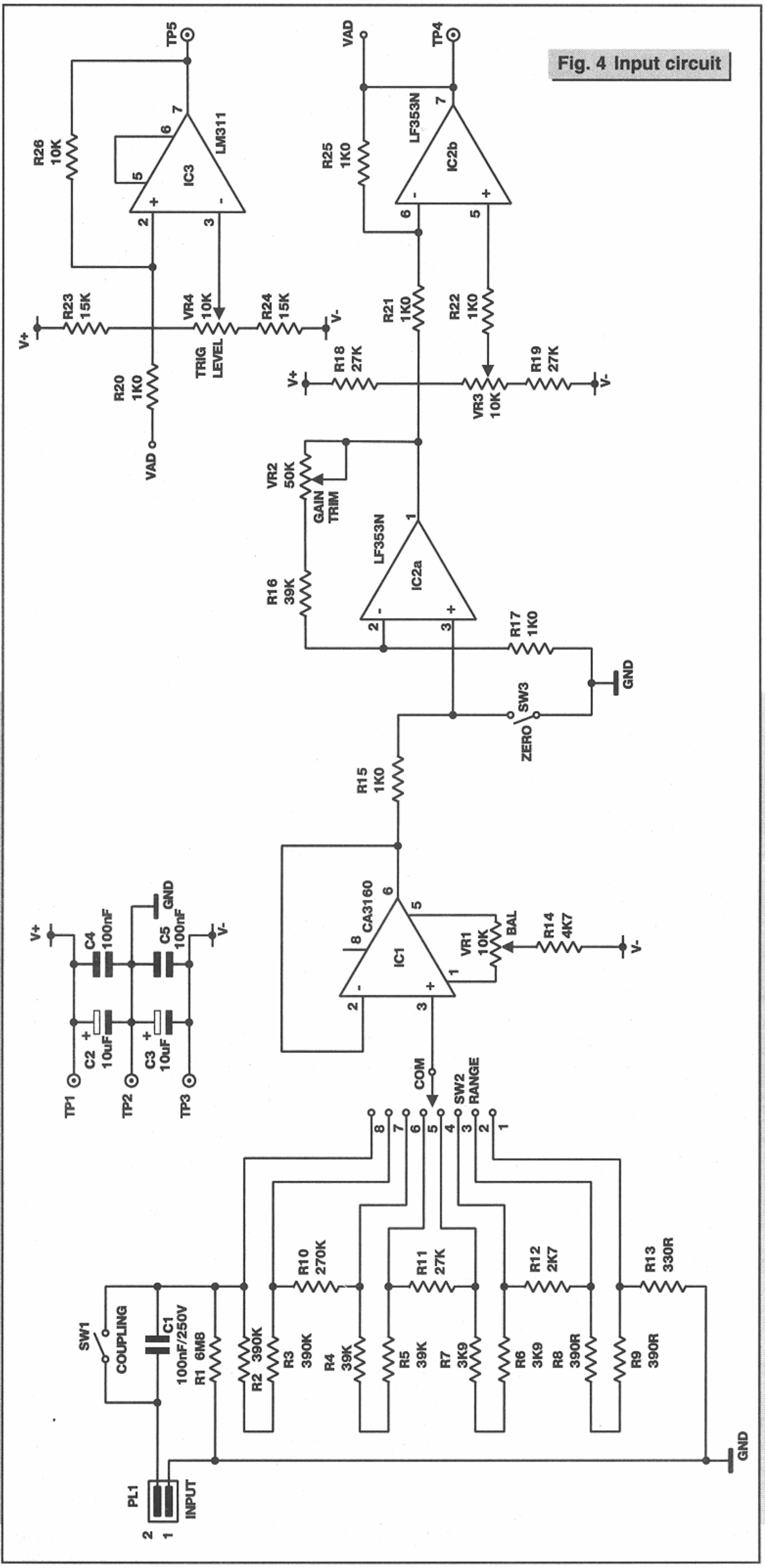


Fig. 4 Input circuit

The

Paul Stenning brings you the concluding episode of his economical 'scope

The majority of the circuit requires a supply of 5V at about 0.5A. In addition the input PCB and the A-D require +/- 12V at a few milliamps.

The output of transformer T1 is full wave rectified by D1 and D2, and smoothed by C12, producing about 8.5V DC which is fed to the 5V regulator IC19.

In addition, one output from the transformer is half wave rectified and voltage doubled by D7, D9, C9 and C14, producing about 16V to drive the +12V regulator IC22. A similar

The Works

Input Circuit

This is contained on a separate PCB to enable screening if necessary.

The input first passes to the switched attenuator, the input impedance of which is approximately 1M0. The output of the attenuator will be 80mV pk-pk for full scale (10mV/div).

This passes to IC1 which is configured as a unity gain buffer with very high input impedance. An offset null control is provided to ensure that the output is exactly zero volts with the input shorted.

The signal then passes to IC2, the gain of which is set to about 62 and is trimmable by VR2. This amplifies the 80mV pk-pk to 5V pk-pk, which is the full range of the A-D. SW3 shorts the input of this amplifier to ground for base line adjustment. The circuit around the second part of IC2 allows for base line position adjustment. This stage also inverts the signal, for the reason mentioned previously.

IC3 is a comparator which is used to generate the sync pulses. The trigger level is set by VR4, and positive feedback via R26 gives some hysteresis which prevents false triggering on noise.

Tele-scope

PART TWO

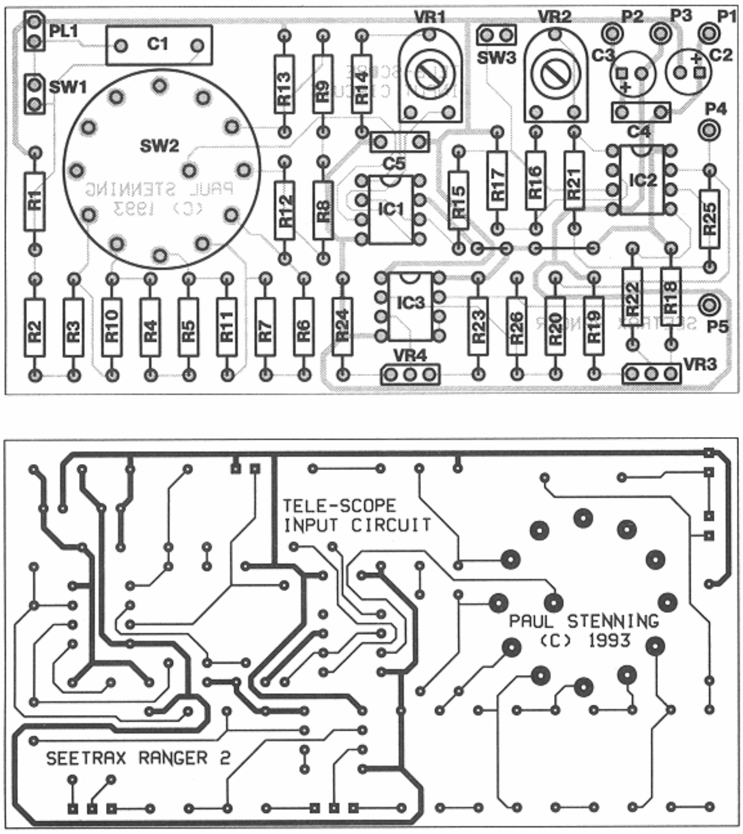
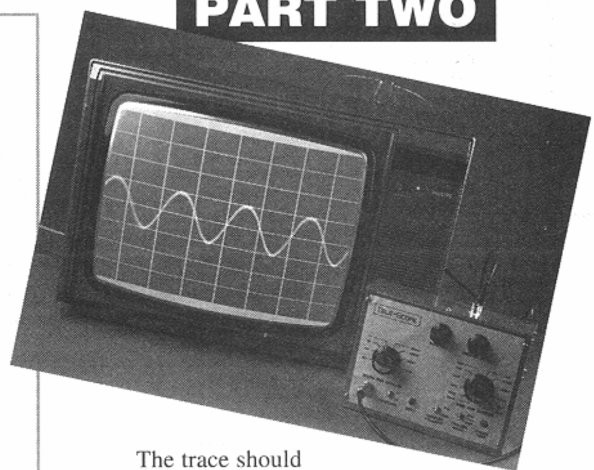


Fig.5 Component positioning on Input board and Foil below



arrangement is used to produce the -12V.

Thus the three voltages are derived from one standard transformer. This should be rated at 12VA or greater, since a lower rated unit may not have good adequate regulation for this arrangement to work.

No mains switch or fuse were fitted on the prototype for simplicity; a 3A fuse was fitted in the mains plug.

Testing

Do not fit any socketed ICs at this stage. Temporarily cover the mains connections with insulation tape if they are not already adequately insulated. Connect to the mains and switch on.

Set your test meter to a suitable DC voltage range, connect the negative probe to TP4 and the positive probe to the pin of IC19 (7805) nearest the modulator. The meter should read 5V DC (+/- 0.25V). Now measure the +12V and -12V supplies on TP3 and TP5, these should both be within +/- 0.5V.

Switch off and insert all the ICs. Set all three presets and both pots to the central positions. Set input coupling to AC, input range to 3V/div, trigger polarity to +ve, trigger mode to normal and timebase to 8ms/div.

Link the centre pin of the input connector to one of the outer transformer pins on the main PCB, and connect the unit to a TV. Switch on.

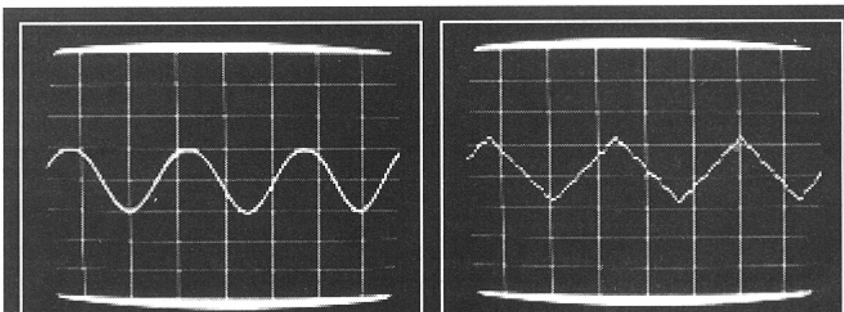
Turn the volume on the TV right down, and tune a spare channel selector to channel 36. If all is well (fingers crossed) the graticle and some sort of trace should appear.

The trace should be about 3-4 cycles of an approximate sine wave, but with the top and/or bottom slightly flattened. If the Zero button is pressed it should become a straight line, adjust the position control to place this near the centre line of the graticle if necessary.

Adjust RV1 on the main PCB. The effect obtained will depend upon the make of RAM chip fitted. With RV1 fully anti-clockwise the trace may freeze (this can be confirmed by pushing the Zero button) whilst with the preset fully clockwise, some of the trace dots will be in the wrong positions (this may appear as random dots or more than one trace). Set the preset to a position between these two extremes, which gives a proper trace. Best results were obtained on the prototype using RAM chips made by HMS and Hitachi, although all the devices tried gave acceptable results.

Set the Trigger Mode switch to Hold, and the display should freeze. Now set it to Free Run, and the trace should appear to roll sideways, since the sync is disabled. Return the switch to the Normal position.

Adjust the Trigger Level control,



Two traces showing sine and triangular waveforms

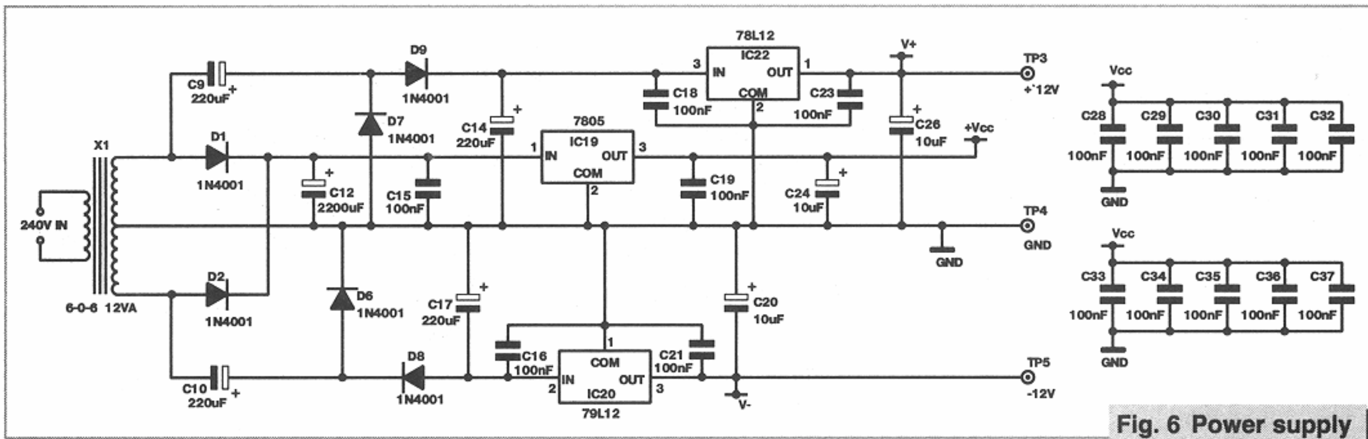


Fig. 6 Power supply circuitry

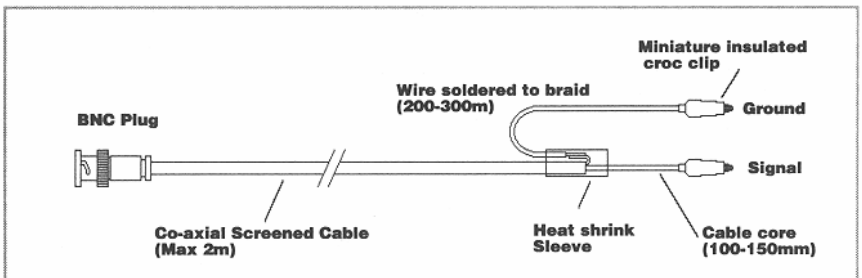


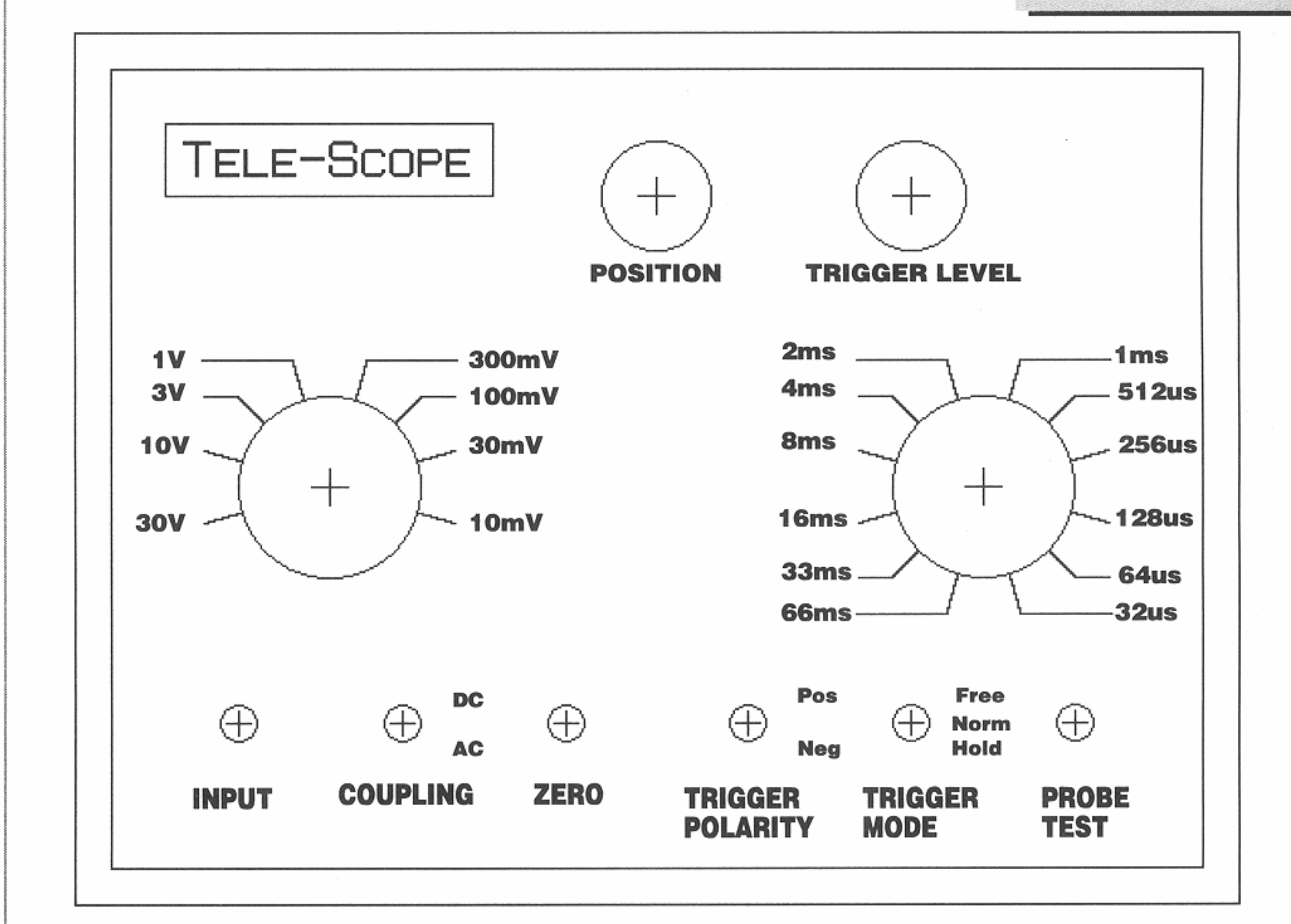
Fig.7a Tele-scope probe details

the trace should appear to move sideways as the circuit triggers to different points on the waveform. As the control nears the ends of its range the trace will roll due to the sync being lost. Return the control to a point where the unit is triggered and set the trigger polarity to -ve. The trace should appear to invert as the trigger circuit is now operating on the falling edge of the waveform.

Check the operation of the Input Range and Timebase switches by operation them two or three positions either way. Do not set the Input Range to the 10mV/div setting as the input signal is large enough to damage the amplifier on this setting.

Disconnect the input from the transformer, and short circuit the input. Press the Zero button and adjust the

Fig.7b Template for front panel shown at 75% full size



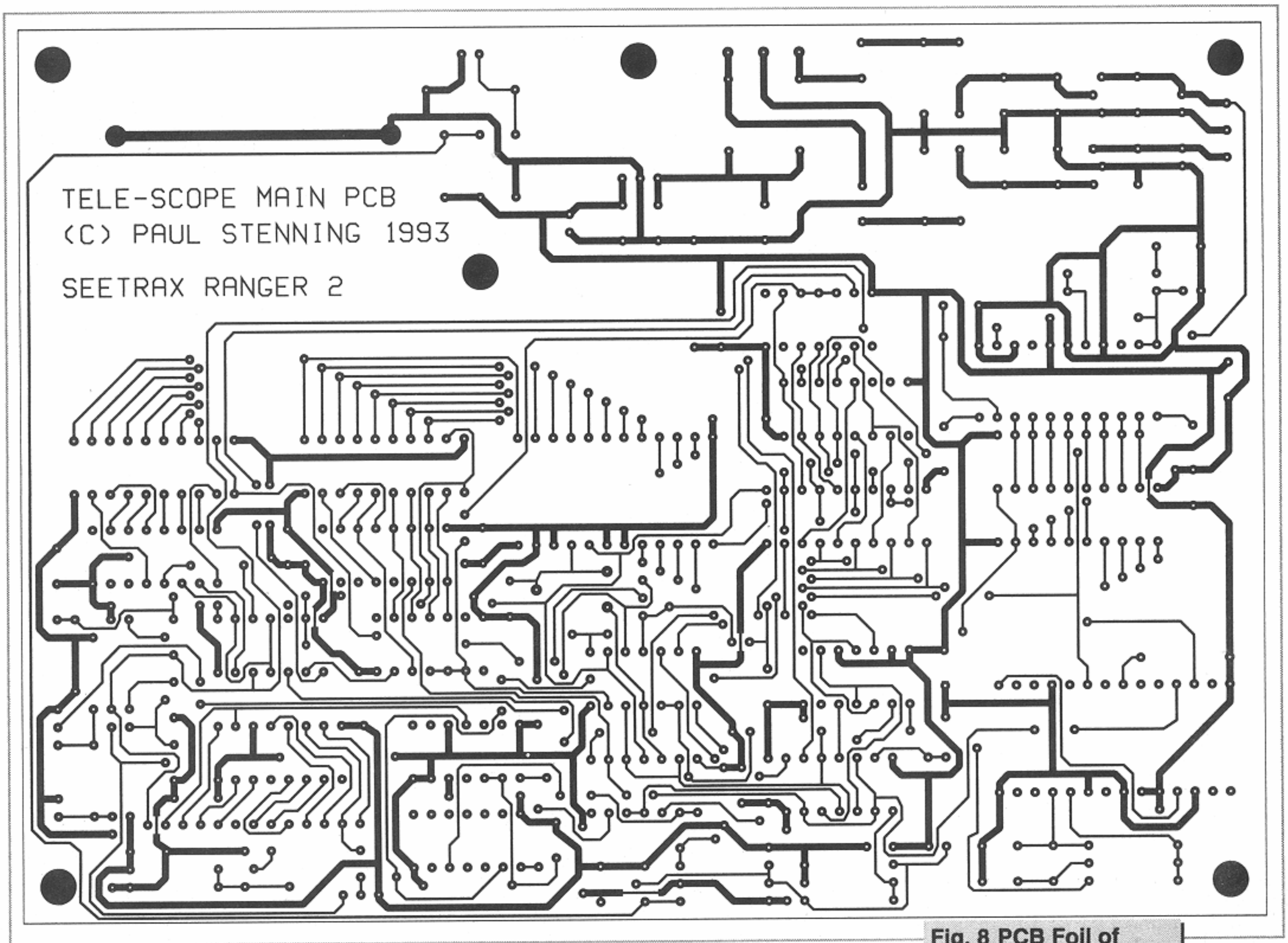


Fig. 8 PCB Foil of main Tele-scope board

Position control to place the line exactly on the centre line of the graticle. Release the Zero button and adjust preset VR1 on the input PCB to bring the trace back onto the centre line. Continue to trim VR1 until the trace does not move when the Zero button is operated.

The best way to adjust the input gain preset (VR2 on input PCB) is by comparison with another oscilloscope, however the following information assumes you do not have this luxury. Set the Input Range to 3V/div, input coupling to DC, and connect the input to TP3 on the main PCB (+12V). Press the Zero button and position the line on the second graticle line up from the bottom. Release the button and adjust VR2 to position the line exactly 4 divisions up from its previous position. If you have a reasonably accurate meter, measure the +12V and set VR2 accordingly. Disconnect the input.

Finally set the Timebase to 256us/div and the Input Range to 300mV/div. Connect the input to the probe test output, the display should show about 2 cycles of a square wave, 1 Volt (3.3 divisions) high, above 0V. Switch the input coupling to AC and the trace will drop down the screen about 1.6 divisions.

If you have access to an audio signal generator you can now try the unit on all Timebase and Input Range settings. Take care not to apply more than +/- 10V on the 10mV/div range.

If you've got through all this successfully, the unit is working and set up correctly. In addition you will hopefully have begun to get the feel of using the equipment!

Operation TV 'scope

This is not the place for a full description of the use of an oscilloscope. If the equipment is new to you, a number of books are available, as well as recent magazine articles.

Much of the use of this unit has been covered in the previous sections, however the following information should be borne in mind.

The maximum frequency signal that can be successfully displayed is 20KHz.

The input is not fully protected against overload. On the 10mV/div range the input signal is applied directly to the op-amp, and therefore must not exceed +/- 10V. On other ranges the attenuator will give some protection, unless the input is excessive. It is generally safest to start on a high voltage range and switch down until a suitable display is obtained.

The ground of the unit is connected to mains earth. Therefore the input must not be connected directly to the mains or to mains powered equipment, unless an isolating transformer is used on the equipment being tested.

AC input coupling is generally used to display a signal which has a DC offset. A good example of this is viewing the ripple on a power supply's output - this may be only a few millivolts but offset by 5 volts or more. Note that the AC coupling capacitor is rated at 250V DC and this must never be exceeded.

The Trigger Mode switch would generally be left in the Normal position, since this will cause the display to free run if it cannot trigger. If measuring static or slow moving DC voltages it may be better to switch to Free Run, to eliminate jitter as the voltage passes the trigger point.

Switching the Trigger Mode to Hold freezes the display, so the probe may be removed. This can be useful if you cannot see the screen and the probe position at the same time. It may also be useful for catching transients and edges, but this relies on you operating the switch at the right moment.

The TV set used may not show the full width of the display. This is not generally a problem, although the set's width control could be adjusted to suit, if one exists. Alternatively it may be possible to move the display from side to side slightly with one of the hold controls, in which case adjust it so the left edge can be seen. These adjustments should only be carried out using external controls if they exist, do not dismantle a TV set unless you are absolutely sure you know what you are doing.

For most purposes an adequate probe can be made using a length of reasonable quality co-axial screened cable about 1.5 metres long with a BNC plug on one end and two small crocodile clips on the other. The clip on the core of the cable could be replaced with a purchased or home made probe of some description if preferred.

The probe test output is used for adjusting X10 and X100 attenuator probes. The probe tip is connected to the output and the adjustment screw on the probe or connector body is adjusted for the best square wave. The leaflet supplied with the probe will give more information.

The Timebase switch offers the following times per division:- 65.536ms, 32.768ms, 16.384ms, 8.192ms, 4.096ms, 2.048ms, 1.024ms, 512us, 256us, 128us, 64us and 32us. These are rounded to slightly more tidy numbers on the front panel overlay.

The Input Range offers the following voltages per division:- 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV.

Final Note

The author is currently looking for a good home for his prototype Tele-Scope. He would prefer to donate it to a charity, voluntary group or educational establishment. The unit will be supplied working but no further support will be available. Any interested parties should write to the author via Electronics in Action.

Parts

Input Circuit

Resistors

(0.25W, 5% or better).
1% recommended for R1-13.

R1	6M8
R2,3	390K
R4,5	39K
R6,7	3K9
R8,9	390R
R10	270K
R11,18,19	27K
R12	2K7
R13	330R
R14	4K7
R15,17	1K0
R20-22,25	1K0
R16	56K
R23,24	15K
R26	10K
VR1,2	10K Horizontal Preset
VR3,4	10K Lin Rotary Pot

Capacitors

C1	100n 250V (0.4" lead pitch)
C2,3	10u 25V Radial
C4,5	100n
IC1	CA3140 or CA3160
IC2	LF353N
IC3	LM311
PL1	BNC Socket
SW1	SPST Min Toggle
SW2	1 Pole 12 Way Rotary Make Before Break (S)
SW3	Push To Make Switch

Additional Items

XT1	5.000 MHz, HC18U case
PL1	BNC Socket
TP6	1mm Socket
SPST	Centre Off Toggle
SW2	SPST Toggle
SW3	1 Pole 12 Way Rotary Break Before Make (NS)
MD1	UM1233 UHF Modulator
X1	Transformer 6-0-6V, 12VA or greater

Veropins and/or SIL header strip
IC sockets if desired 3 x 8 way, 9 x 14 way, 4 x 16 way
4 x 20 way, 1 x 22 way 0.4", 2 x 24 way
Thin tinned copper wire
Case
Heatsink or bracket for IC19
5 Knobs
3 Amp 3 core mains flex
13A mains plug with 3A fuse
Cable clamp or grommet
Oscilloscope probe or parts
Phono to Aerial UHF lead
Wire
PCB and transformer mounting hardware

Shoppers' Notes

The majority of the components should be readily available from your usual supplier. In case of difficulty, all items are listed in the current Maplin catalogue.

All the non-polarised capacitors except the 100n 250V, should have a 0.2" (5mm) lead pitch. Other types may fit if the leads are formed to suit.

The 74 series logic ICs may be either 74LS or 74HCT, if you are ordering specify the 74HCT. The 4040 and 4024 however must be the 74HCT types, as standard 4000 series devices are not fast enough.

The 78L12 and 79L12 regulators may be replaced with standard 7812 and 7912 types, if these are to hand.

The two rotary switches are identical in appearance. For identification, the Make Before Break is marked "S" on the base, whereas the Break Before Make is marked "NS".

The two PCBs are available from the Electronics in Action PCB service.

Next Month

Paul Stenning provides us with a project for budding film makers - create a professional finish with his Video effects unit

Signal to NOISE

A selection of your views and thoughts

I am new to Electronics in Action and therefore wish to comment.
I find this monthly very stimulating, remember I am 69 years old and have been in electronics all my life, and I welcome a change of monthly. I thoroughly agree with the letter about teaching science. I could add more such thoughts, the bright scholars are led into the Arts such that they can attain more GCSEs more easily and enhance the name of the school. We need more champions of electronics to enthuse people!
On a different note, can I ask for articles on organ voices, I have programmed many of these on synthezisers, and have constructed many formants but I cannot as yet obtain a voice anything like the Wurlitzer or Blackpool organ. I find all magazines ignore this area. Perhaps you might mention why.

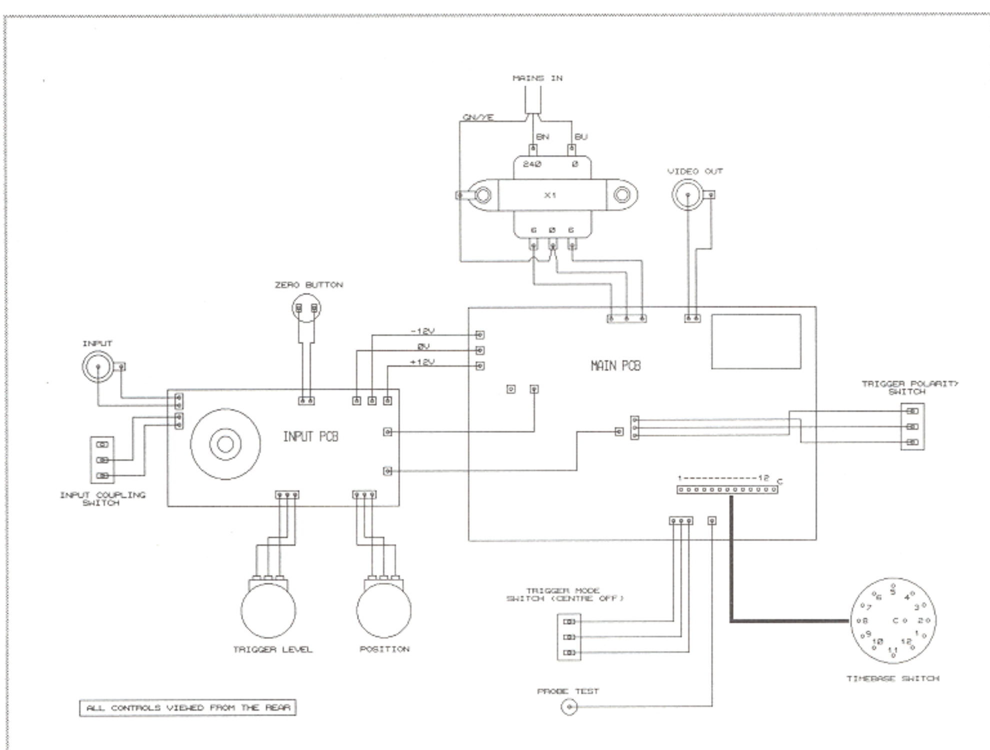
H W C Hollings
Witney
Oxon

Thank you for your comments. I have also spent some time in teaching and I'm afraid the answer to why more young people go for the Arts, apart from the financial incentive, is deep rooted. It certainly does not help to have the vast majority of politicians with an Arts based education totally ignorant of Science and Technology. The course of British society tends to lead from those that govern us. Given the right incentives, science presented in a stimulating way in schools can lead to far more exciting challenges and new discoveries. Taking a sideways look at our world in the way it works instead of taking the established way of conservative development could, in the words of the now famous phrase 'boldly go where no man or woman has gone before'- or should I say go boldly....?

*On to your other point, we could have the answer to your question when we ask 'our man from Yamaha' to come up with a solution. Hold on for a few editions and we will see what can be done ......unless of course any reader out there has some answers. - **Ed**.*

I have enjoyed reading your magazine especially the test equipment section as I am taking my CG Part 2 year two and I need just the right type of equipment as you have had in your magazine in the last two issues.
I only took up electronics as I was classed disabled and I like helping old age pensioners with their electrical problems that are within my scope. I really like the telescope idea and I am thinking of building one for my own use. Keep up the good work especially the test equipment and you will have a loyal reader for all your future issues. Good Luck to you.

K G Pullen
Swansea



Owing to unforseen circumstances the interwiring diagram for The Telescope (featured in our October and November issues) was omitted. We apologise for this oversight and reproduce it here.