VECTOR WAVEFORM MONITOR MN6/504

Introduction

The MN6/504 accepts one or two PAL coded colour signals and provides a time-division multiplex display of the information contained in the input signal or signals. The information can be shown either in vector form or as a line display. For a vector display the hue of a colour is indicated by the angle its vector makes with the reference burst; the degree of saturation is indicated by the vector amplitude, measured from the centre of the graticule. For a line display the hue of a colour is indicated by the known position of that colour in the test-signal line waveform and the degree of saturation is indicated by the amplitude of the waveform at that point. The line display facility is used, in conjunction with a calibrated phase shifter, to measure the colour-bar angles on the unswitched lines of the incoming signal and provides a much more accurate result than can be achieved with the vector display. (For further information on vectorscopes see BBC Engineering Practice, Instruction P2).

A reference feed of subcarrier and a 7·8-kHz PAL switching signal are derived from the colour-burst component of the A-input signal. Facilities are provided for using externally-generated subcarrier and 7·8-kHz signals in place of the internally-generated signals if required. An internally-generated test-circle is provided to help in aligning the monitor.

The MN6/504 is mounted on a modified PN3/23 chassis; it comprises a display unit and a calibrated phase-shifting unit (which are part of the main assembly) together with the following units:

PAL Vector Switch Unit UN9/542
PAL Vector Demodulator DM1/502
Sync Separator UN1/540
E.H.T. Power Supplier PS1/14

The way in which the component units of the monitor are interconnected is shown in Fig. 1 and the layout of the front panel is shown in Fig. 2. The five-way push-button switch located below the *Phase Error* control is mechanically interlocked so that only one button can be depressed at a time. This switch is used to change the phase-angle of the subcarrier signal by an amount depending on the colours associated with each button. The abbreviations engraved on the buttons stand for *0°*, *90°*, *Blue and Yellow*, *Red and Cyan*, *Green and Magenta* respectively. Also mounted on the front of the unit, but not shown in Fig. 2, is a mains *On/Off* switch, with mains and e.h.t. neon indicators.

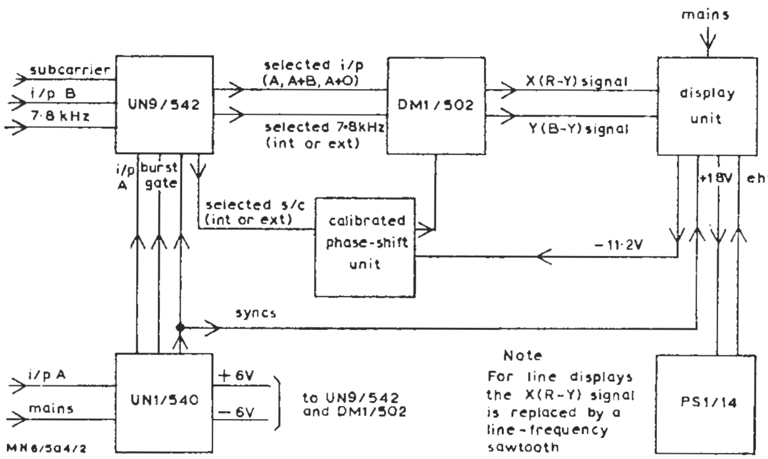


Fig. 1 Block Diagram of the MN6/504

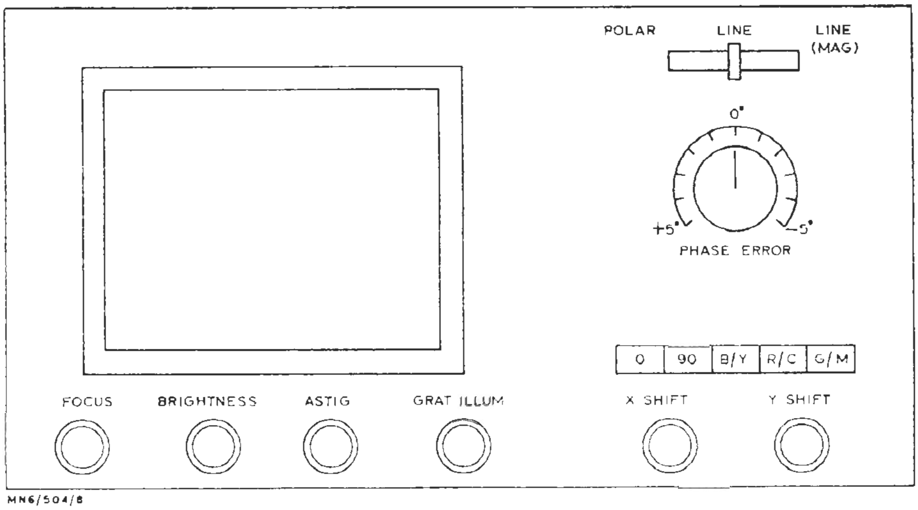


Fig. 2 Front Panel of the MN6/504

General Specification

A and B inputs	1 V p-p
External Subcarrier Input	1 V p-p
External 7·8-kHz Input	1 V p-p
Input Impedances	75 ohms
Subcarrier Frequency	4·43361875 MHz
A and B Timing	coincident (time-division multiplex)
Time-division Multiplex Rate	3·9 kHz
Operating Temperature	0—50 °C
Display Area	3·5″ + 3″
Vector Display Accuracy	±2°, ±2% (an additional error, due to trace resolution, of ±1° and ±1% is possible)
Line Display Magnification Factor	about 3
Line Display Phase Resolution (magnified position)	±0·1°
Calibrated Phase Shifter Accuracy	±0·4°, ±line display resolution
Range of Phase Error Control	±5° continuously variable
Accuracy of Phase Error Control	±5% of measured phase error, ± line display resolution
Mains Input	240 V ±6% at 50 Hz
Power Consumption	33 W
Weight (complete with all units)	about 24 lb.
Dimensions	19″ rack-mounting, 14″ deep, 5·5″ high

Note that this specification is that of the master unit. Individual specifications for the plug-in units are given in the appropriate Instructions.

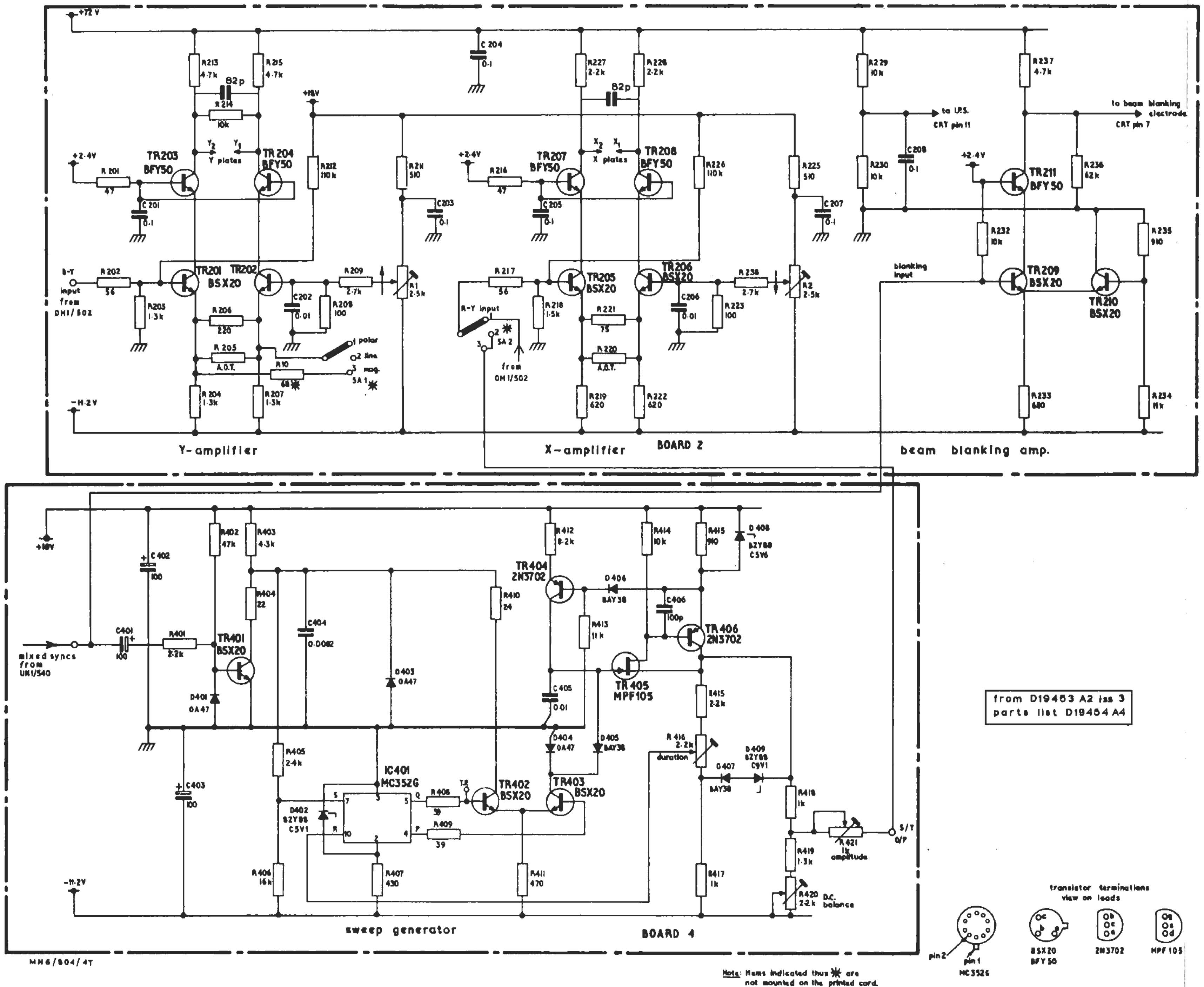


Fig. 3 Circuit of the Vector Waveform Monitor MN6/504

Circuit Description

The circuit diagram is given in Figs. 3, 4 and 6. Many of the components are mounted on printed-wiring boards and, to avoid confusion when servicing, these components are given a three-figure number which indicates the board on which they are mounted. For example; TR103 is mounted on board 1 and R307 is mounted on board 3. Those components not mounted on the boards are given numbers which start at 1 in the usual way.

Amplifier Circuits

The circuit of the X, Y and blanking amplifiers, which are all mounted on printed-wiring board 2, is given in Fig. 3. The circuits of the X and Y amplifiers are similar and so the following description of the X amplifier will serve for both.

Transistors TR205 and TR207 form a cascode amplifier and transistors TR206 and TR208 form a similar amplifier. TR205 is emitter-coupled to TR206 so that the two cascode stages together form a push-pull amplifier. Signals applied via switch SA2 to the X input appear in amplified form at the collector of TR208 and in amplified and inverted form at the collector of TR207. From these points they are fed to the c.r.t. X-deflection plates. Variable resistor R2 can be used to vary the bias of TR206 and so provides an X-shift control.

The X amplifier is fed with the R-Y output of the associated DM1/502 unit when switch SA is in the *Polar* position and with the output of the sweep generator when SA is in the *Line* or *Line Mag.* positions. The Y amplifier is fed with the B-Y signal from the DM1/502 unit for all positions of SA. Positive-going signals applied to the X amplifier deflect the beam downwards and positive-going signals applied to the Y amplifier deflect the beam to the right.

The blanking amplifier consists of a long-tailed pair chopper stage, TR209 and TR210, and a grounded-base buffer stage TR211. When negative-going sync pulses are applied to the amplifier input, TR209 is cut off and TR210 conducts. Between pulses TR209 conducts heavily, this causes TR211 to conduct heavily also and its collector potential falls from 67 volts to between 2 and 3 volts. Thus the applied sync pulses cause a square wave with a peak-to-peak amplitude of about 65 volts to appear at the collector of TR211. This square wave is then applied to the beam-blanking electrode in the c.r.t.

Sweep Generator

The sweep generator is mounted on printed-wiring board 4 and the circuit is given Fig. 3.

Negative-going mixed-sync pulses are inverted by TR401 and applied to the S input of integrated-circuit module IC401. The module functions as a bistable multivibrator and a positive-going pulse applied to the S input drives the Q output positive and the P output negative. These outputs feed the long-tailed pair stage TR402-TR403 and drive TR402 into conduction while cutting TR403 off. The negative-going pulse developed at the collector of TR402 is fed back via an integrating circuit to the collector of TR401; it inhibits the signal present at that point and so ensures that only the leading edge of inverted sync pulses are applied to the S input of module IC401. The function of diode D403 is to prevent TR402 from bottoming.

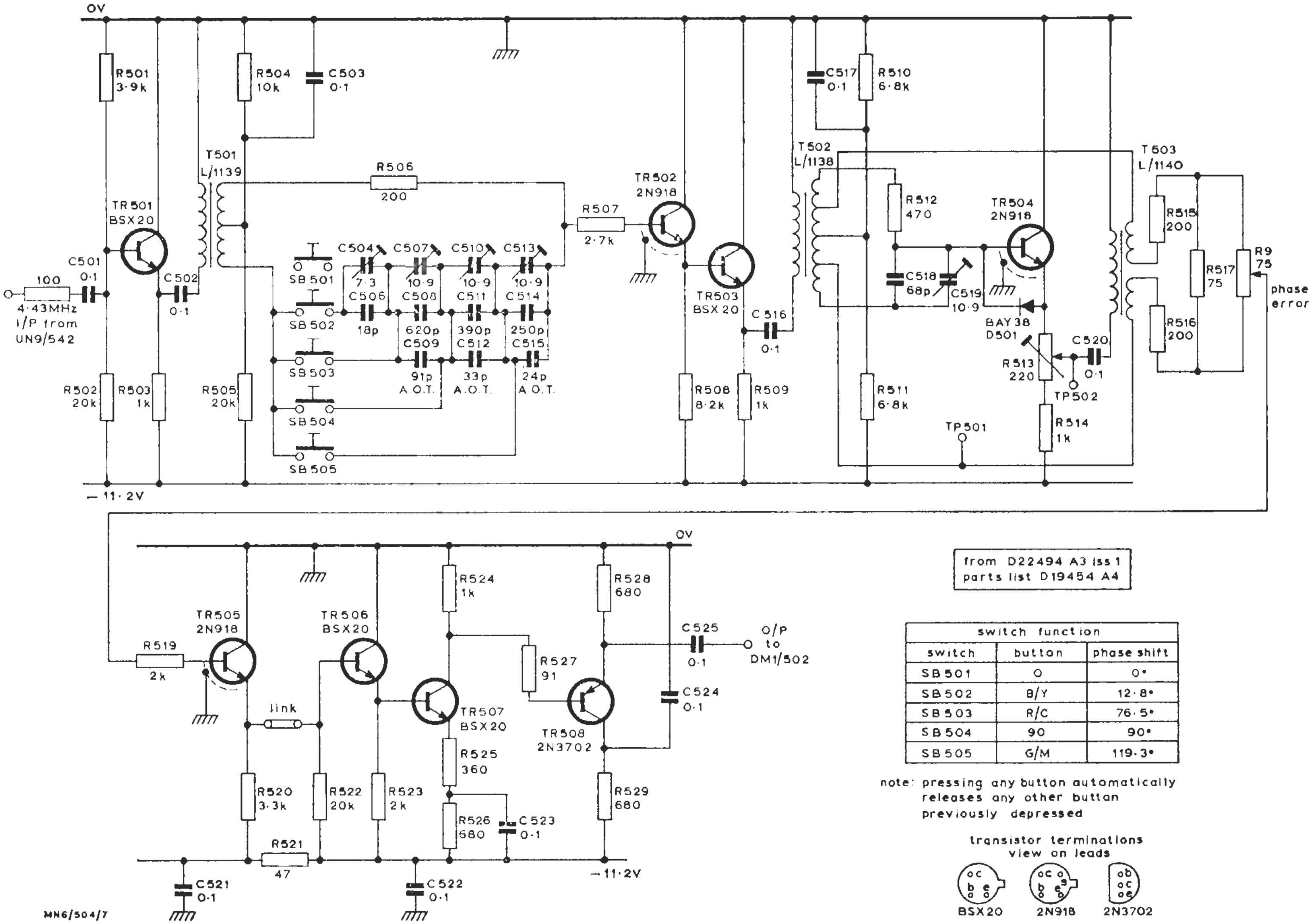
While TR402 conducts, TR403 is cut off and the sweep-rate capacitor C405 charges through TR304, which functions as a linear charging device, towards the +18-volt line. The waveform developed across C405 is applied via the non-inverting feedback amplifier formed by TR405 and TR406 to the X-amplifier input-selection switch SA2. Variable resistor R421 functions as an amplitude control and R420 is adjusted on test to obtain d.c. balance. A portion of the sawtooth developed at the emitter of TR406 is fed back, via R416, to the R input of module IC401. When this feedback signal becomes sufficiently positive it changes the state of the module and initiates the flyback stroke. Thus R416 functions as a sawtooth duration control.

Transistor TR403 conducts at the start of the flyback stroke and provides a discharge path for capacitor C405, through D405 and the transistor. Diode D404 stops the collector potential of TR403 from going appreciably negative with respect to chassis once the capacitor has been discharged and thus prevents the transistor from bottoming. If TR403 bottomed, the output transistors in the integrated circuit module would have to supply a relatively heavy current and might be damaged.

Subcarrier Phase Shifter

The subcarrier phase-shifter is located on printed-wiring board No. 5. The circuit is given in Fig. 4 and the phase of the signal at various points in the phase-error circuit is shown vectorially in Fig. 5.

The subcarrier input signal at an amplitude of 1 volt peak-to-peak is fed via emitter-follower TR501 to transformer T501. The centre-tapped secondary winding of this transformer feeds a phase-shifting network consisting of R506 and the capacitor combination selected by the operated



switch function		
switch	button	phase shift
SB501	O	0°
SB502	B/Y	12·8°
SB503	R/C	76·5°
SB504	90	90°
SB505	G/M	119·3°

note: pressing any button automatically releases any other button previously depressed

Fig. 4 Phase-shifter Circuit in the Vector Waveform Monitor MN6/504

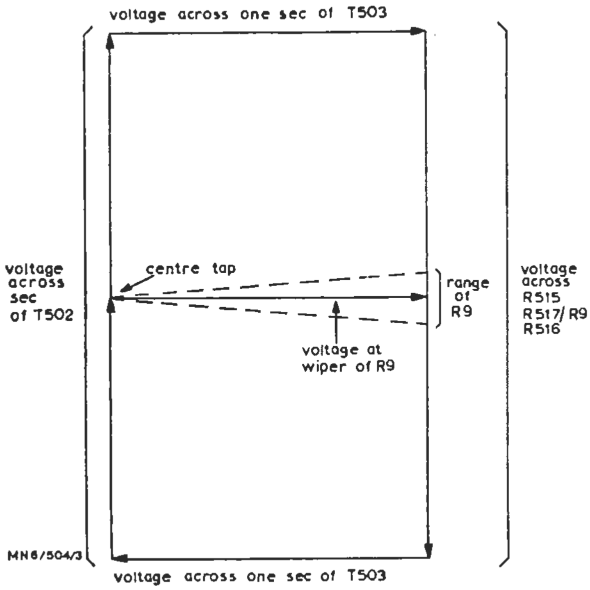


Fig. 5 Signal Phase at Various Points in the Phase-error Circuit

pushbutton on switch SB. The signal is then applied, via cascaded emitter-followers TR502 and TR503, to transformer T502. The secondary of T502 carries overwinds to compensate for subsequent losses. The signal developed between the extremities of the secondary winding is fed via a 90-degree phase-shifting network and emitter-follower TR504 to the primary winding of T503. Resistor R513 is adjusted on test so that the signals at test points TP502 and TP503 are in quadrature with each other and are of equal amplitude.

A resistor chain is connected between the two secondary windings of T503 and the output is taken from the wiper of the *Phase Error* control (R9) which forms part of the chain. Because the resistance of R9 in parallel with R515 is only a small percentage of the total resistance of the chain (less than 10 per cent) the phase of the signal at the wiper of R9 can be varied by only a small amount ($\pm 5°$) and over this limited range the control is effectively linear.

From R9 the signal is applied via emitter-followers TR505 and TR506 to the complementary amplifier stage formed by transistors TR507 and TR508. Here losses caused by the previous stages are made good and the signal amplitude is restored to one volt peak-to-peak.

Note that the preset controls on board 5 are for alignment only and must not be touched when the unit is in service. The transistors in the phase-shifting circuit can be changed without affecting its accuracy, but if the board requires re-alignment it must be returned to Equipment Department.

Power Supplies

(*a*) *General*

The circuit is given in Fig. 6 on page 9. Stabilised outputs are provided at:

+ 6·7 kilovolts
+112 volts
+72 volts
+18 volts
+2·4 volts
−11·2 volts
−830 volts

Two unstabilised 6·3-volt 50-Hz outputs and an unstabilised feed of 0 to +6 volts are also provided.

The 6·7-kV, 112-volt and 830-volt supplies are derived from a PS1/14 e.h.t. power supplier; this unit is fed from the stabilised 18-volt supply.

The 11·2-volt, 18-volt and 2·4-volt stabiliser circuits use a common-emitter output stage instead of the more usual emitter-follower output stage. Such a circuit is derived from a two-stage negative-feedback amplifier, as shown in Fig. 7(a). A similar circuit, using a complementary output stage, is shown in Fig. 7(b). This circuit is shown also in Fig. 7(c) used as a voltage stabiliser. The more usual emitter-follower output circuit is shown for comparison, in Fig. 7(d). Fig. 7(e) is a more elaborate version of Fig. 7(c) with the first stage changed to a long-tailed pair and an emitter-follower preceeding the output stage.

(*b*) *Mains Input Circuit*

A 240-volt mains supply is applied to transformer T1, the secondaries of which feed the various rectifier circuits and also provide power for the thermal cut-in element and the cathode-ray tube. A neon indicator is connected across the mains transformer primary winding.

(*c*) *72-volt Circuit*

This is a conventional stabiliser circuit with an emitter-follower output stage. The amplifier load resistor R109 is decoupled, not to earth but to the +72 volt supply rail. The output of the stage is compared by the emitter-coupled pair TR104—105 with a reference voltage derived from zener diode D109. Resistor R106 can be adjusted to vary the bias of TR104 and so provides a fine control of the regulator output. Diodes D107, 108 and 110

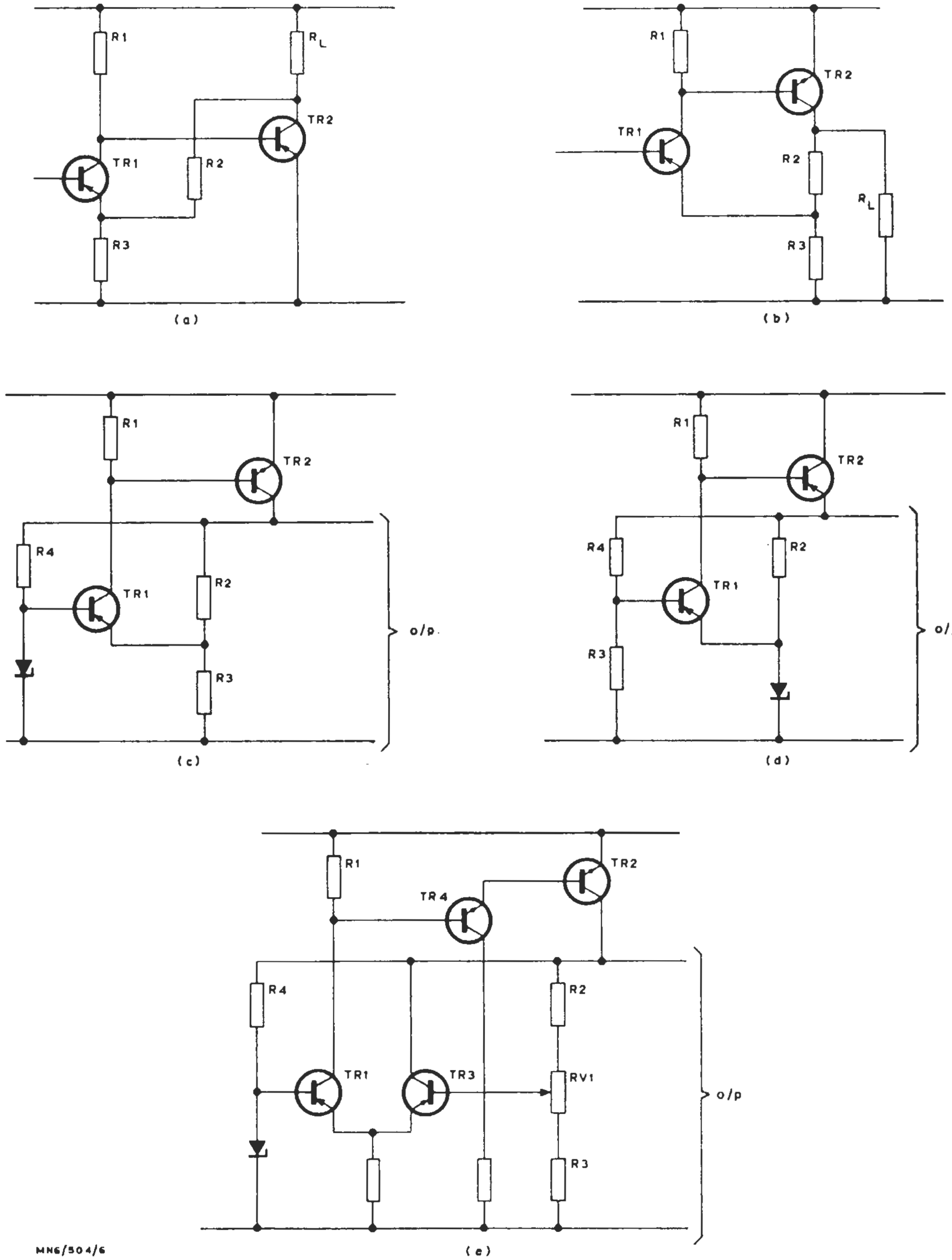


Fig. 7 Derivation of a Complementary Stabilising Circuit

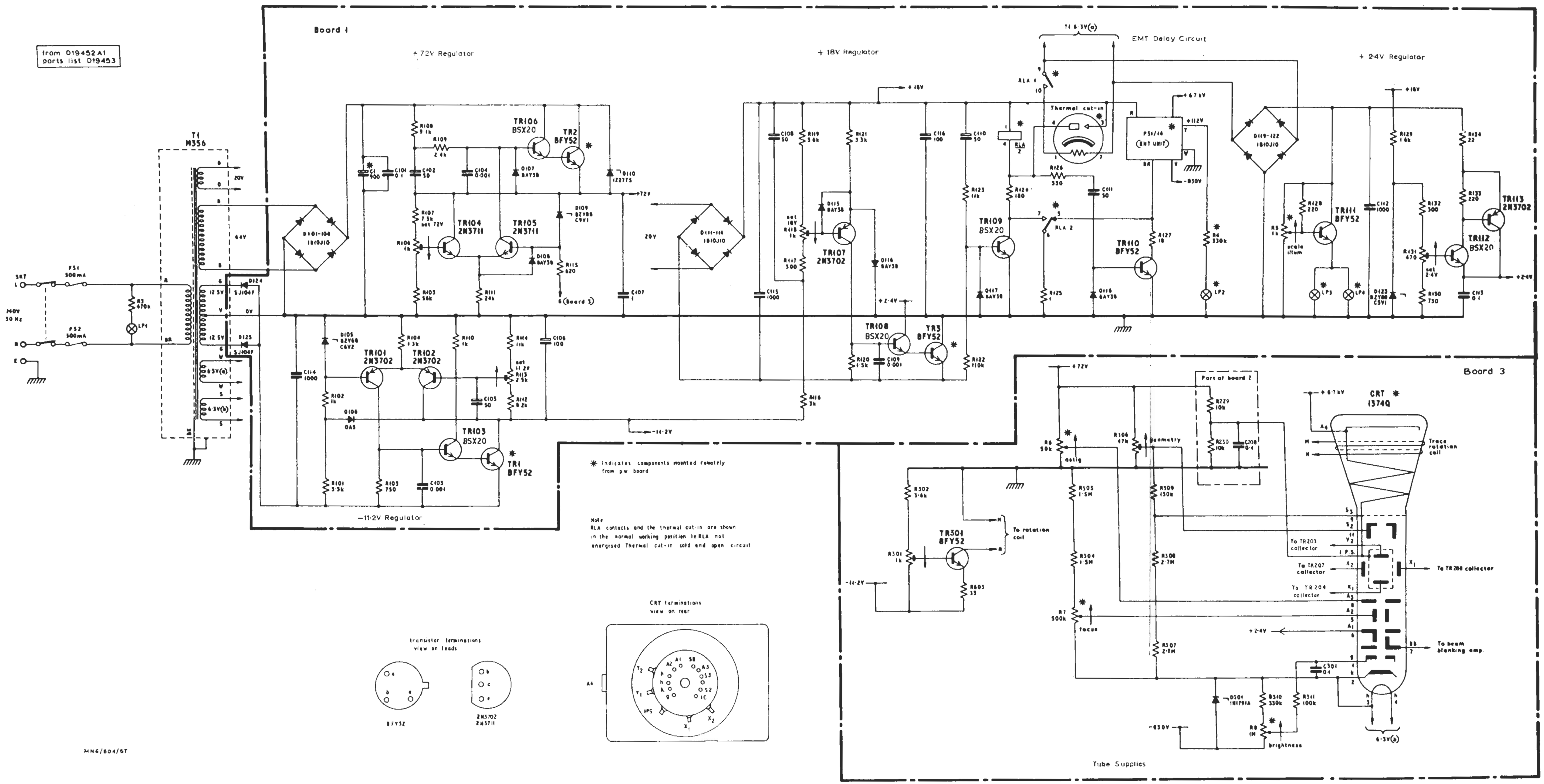


Fig. 6 Circuit of the Power Supplies for the Vector Waveform Monitor MN6/504

protect their respective transistors against excessive transient voltages that may occur when the mains supply is switched.

(d) 11·2-volt Circuit

The circuit of this stabiliser closely resembles the circuit shown in Fig. 7(e). Resistor R101 provides current to zener diode D105 when the supply is switched on. However, when the circuit is operating, the current to the zener diode is fed from the stabilised output via D106.

The collector of transistor TR103 is connected, via resistor R110, to earth rather than to the —11·2 volt rail to extend the stabilisation range and to provide current limitation under overload conditions.

(e) 18-volt Circuit

This circuit resembles the basic circuit of Fig. 7(c) with the addition of an emitter follower TR108 preceeding the output transistor TR3. The feedback is taken from the collector of TR3 to the emitter of TR107 via diode D116; this prevents TR107 bottoming when the input voltage is low. The collector of TR108 is taken to the +2·4 volt supply rail rather than to earth to increase the regulation range.

(f) E.H.T. Delay Circuit

When the unit is first switched on TR109 passes a pulse of current from the 18-volt supply and capacitor C110 charges.

When the unit is functioning normally TR109 is cut off. However, when the unit is first switched on, the charge on capacitor C110 causes the base of TR109 to be driven positive for a short period and so the transistor passes a pulse of current. This current pulse operates relay RLA which then holds on via contact RLA-2. Contact RLA-1 connects 6·3 volts to the cut-in element which operates after about 90 seconds. The operation of the cut-in short-circuits the relay and produces a positive-going pulse at the base of TR110. This transistor then conducts and charges a capacitor which is connected across the input circuit of the PS1/14 unit; the charging current is limited to 1 amp by R127. The release of RLA is delayed by the inductive decay of the current in the relay. When the relay releases, the negative end of the 18-volt supply is fed to the PS1/14 unit via resistor R125.

A neon lamp, LP2, indicates that the PS1/14 is switched on.

(g) Graticule Illumination

Graticule illumination lamps LP3 and LP4 are fed with unstabilised d.c. via emitter-follower TR111. Resistor R128 modifies the law of dimmer resistor R5.

(h) 2·4-volt Circuit

This circuit is the basic circuit shown in Fig. 7(c) with the feedback fraction increased to unity. Zener diode D123 is fed from the 18-volt supply rather than from capacitor C112. This arrangement reduces the hum level in the output.

Tube Supplies

The connections to the c.r.t. are conventional though there are some points to be noted.

Because the tube is rectangular it cannot be rotated to give a level display. Therefore, display rotation is carried out electromagnetically by feeding a current from TR301 through a rotation-coil.

An interplate screen (IPS), used to reduce X-Y crosstalk, is connected to a decoupled d.c. source which is at the mean potential of the deflector plates, +36 volts.

A 68-volt zener diode, D301, makes the tube electrode potential-divider chains independent of the loading of the beam current.

The internal connection shown between anode A4 and the interplate screen is a high-resistance (100 megohm minimum) spiral coating on the inside surface of the tube. It provides a post-deflection accelerating field.

Alignment and Operating Procedure

Note that the monitor carries two controls with similar labelling, a *Phase* control (located on the DM1/502 sub-unit) and a *Phase Error* control on the main assembly of the monitor. Care must be taken not to confuse these two controls.

Setting Up the Display

1. Check that the inputs to the monitor are correctly connected.
2. Switch on and allow five minutes to warm up.
3. Adjust the *Brightness* and *Focus* controls to obtain a correctly-focused spot of the required intensity, and then adjust the *X-Shift* and *Y Shift* controls to position the vector-origin spot in the centre of the graticule.
4. Set the mode switch to *A+O*, the subcarrier switch to *Sinewave Int.* and the 7·8-kH switches to *Squarewave On* and *Squarewave Int.*

Note that the internal reference signals are derived from the A input to the unit.

5. Adjust the *B Gain*, *X Gain* and *Quadrature* controls until the two ellipses displayed merge into a single circle which is aligned with the test circle inscribed on the graticule.
6. Rotate the *Phase* control to position the reference burst in the first quadrant of the circle inscribed on the graticule. Check the position of the circular trace and readjust the *Quadrature* control if necessary.
7. Adjust the *A Gain* control until the amplitudes of the displayed vectors are the same as those inscribed on the graticule.
8. Set the mode switch to *A* + *B* and adjust the *B Gain* control until the amplitudes of the B-display vectors are the same as those inscribed on the graticule.

Subcarrier Phase Comparison (Internal Reference)

1. Carry out step 4 above.
2. Set the mode switch to *A* + *B* and compare the B-signal reference burst with the A-signal reference burst.

Subcarrier Phase Comparison (External Reference)

1. Set the subcarrier switch to *Sinewave Ext*, the 7·8-kHz *Int/Ext* switch to *Squarewave Ext* and the mode switch to *A* + *O*. Adjust the *Phase* control to align the burst to the graticule.
2. Substitute the signal to be compared for the original A signal. Compare the reference burst of this signal with the burst position inscribed on the graticule. The angle of error of the second signal can be read from the graticule. To bring the two signals into phase, adjust the phase of the coder from which the second signal is derived until the reference burst is aligned with the burst inscribed on the graticule.

Phase Comparison (7·8 kHz)

If, during the subcarrier tests, the reference burst appears in the second or fourth quadrant of the display then the phase of the 7·8-kHz signal is incorrect.

Phasing (7·8 kHz)

1. Carry out step 4 of *Setting Up the Display*.
2. Set the 7·8-kHz switch to *Squarewave Ext*. If the two signals are in phase the phase of the reference burst will not change.

To Measure the Angle between the Subcarrier Bursts on Adjacent Lines

1. Set the *Display* switch to *Line*, turn the *B Gain* control fully anticlockwise (to reduce the gain of the B channel to zero) and set the mode switch to *A*.
2. Set the *Phase Error* control to zero.
3. Press the *O* button (one of a row of push-buttons adjacent to the *Phase Error* control) and rotate the *Phase* control until the decoded burst signals are both positive-going. Then rotate the *Phase* control anticlockwise until one of the burst signals is zero in amplitude; the other burst signal will remain positive.
4. Press the *90* button. Any error in the angle (nominally 90 degrees) between the two colour bursts can now be measured by adjusting the calibrated *Phase Error* control for zero amplitude on the other burst signal, the burst adjusted to zero in step 3 is now negative-going on the display.

To Measure the Angles of the Colour Bar Signals on Lines n

Note: Lines *n* are the odd lines of the first and second fields and the even lines of the third and fourth fields.

The order of colours along the line and the nominal angles relative to the B-Y axis are as follows:

Yellow	167·2°
Cyan	283·5°
Green	240·7°
Magenta	60·7°
Red	103·5°
Blue	347·2°

1. Reset the *Phase Error* control to zero.
2. Press the *90* button and adjust the *Phase* control so that the two burst signals are positive and superimposed (this procedure assumes that the burst amplitudes on adjacent lines are equal).
3. Press the button appropriate to the colour being measured and adjust the *Phase Error* control for zero signal amplitude in the position on the display corresponding to that colour. The *Phase Error* reading then gives the error with respect to the nominal angle for that colour.

Note that two colour angles can be measured in each position of the push-button switch.

To Measure the Angles of the Colour Bar Signals on Lines n + 1

The nominal angles on these lines are as follows:

Yellow	192·8°
Cyan	76·5°
Green	119·3°
Magenta	299·3°
Red	256·6°
Blue	12·8°

1. Set the *Display* switch to *Polar* and reset the *Phase Error* control to zero.
2. Put the 7·8-kHz switch to *Squarewave On* (this identifies the $n + 1$ lines) and adjust the *Phase* control to superimpose the burst phasors.
3. Adjust the *Phase Error* control for each colour in turn to superimpose the n and $n + 1$ phasors. Because both phasors move when the adjustment is carried out, the reading obtained must be doubled to obtain the relative phase error. Note that when making a measurement on line $n + 1$ any angular error on line n must be taken into account.

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