Service manual

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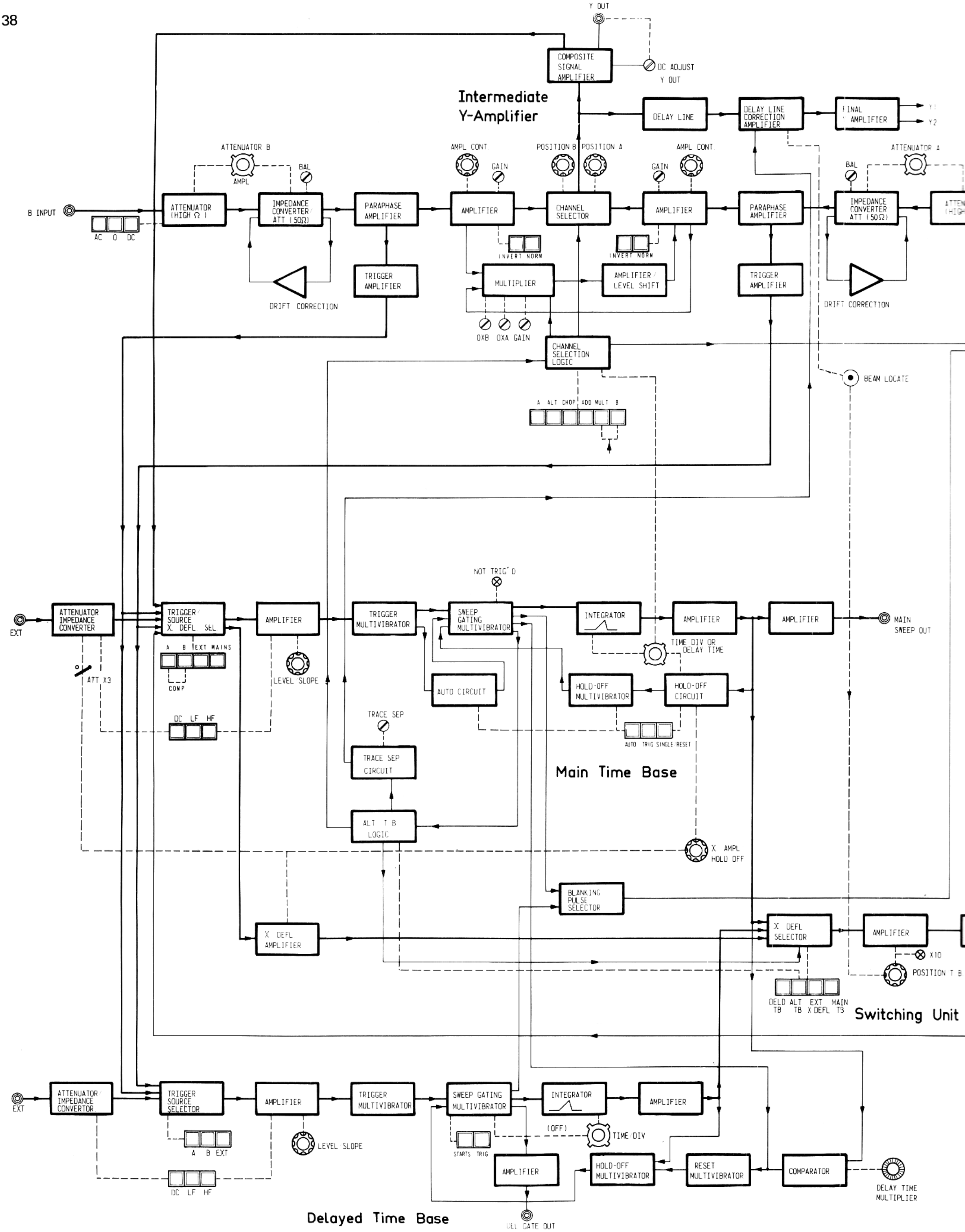
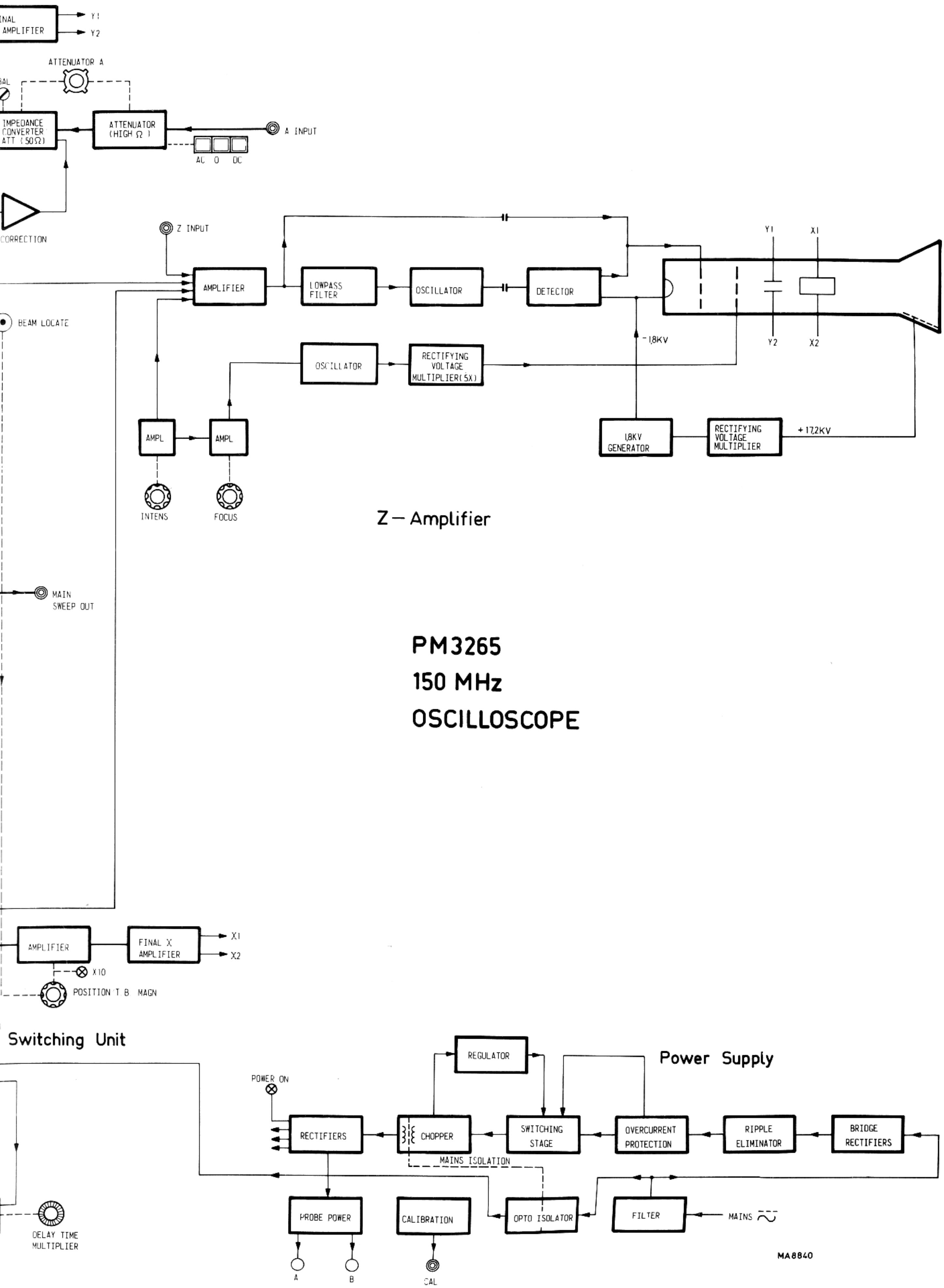


Fig. 3.1. Block diagram



FINAL AMPLIFIER
Y1
Y2
ATTENUATOR A
BAL
IMPEDANCE CONVERTER ATT (50Ω)
ATTENUATOR (HIGH Ω)
A INPUT
AC O DC
CORRECTION
Z INPUT
AMPLIFIER
LOWPASS FILTER
OSCILLATOR
DETECTOR
Y1
X1
Y2
X2
BEAM LOCATE
-1,8KV
OSCILLATOR
RECTIFYING VOLTAGE MULTIPLIER(5X)
AMPL
AMPL
1,8KV GENERATOR
RECTIFYING VOLTAGE MULTIPLIER
+17,2KV
INTENS
FOCUS
Z — Amplifier
MAIN SWEEP OUT
PM3265
150 MHz
OSCILLOSCOPE
AMPLIFIER
FINAL X AMPLIFIER
X1
X2
X10
POSITION T.B. MAGN
Switching Unit
Power Supply
REGULATOR
POWER ON
RECTIFIERS
CHOPPER
SWITCHING STAGE
OVERCURRENT PROTECTION
RIPPLE ELIMINATOR
BRIDGE RECTIFIERS
MAINS ISOLATION
DELAY TIME MULTIPLIER
PROBE POWER
CALIBRATION
OPTO ISOLATOR
FILTER
MAINS
A
B
CAL
MA8840

3. Service manual

3.1. DESCRIPTION OF THE BLOCK DIAGRAM

3.1.1. General information

The PM 3265 oscilloscope comprises the following parts:

- a dual-channel vertical system with signal multiplication facility.
- a main time-base
- a delayed time-base
- a switching unit
- an X amplifier
- a Z amplifier
- a c.r.t. circuit
- a stabilized power supply

3.1.2. Dual-channel vertical system

Both vertical channels contain identical circuits. An input signal to one of the channels is, via a coupling switch AC/0/DC, applied to the input attenuator. In the AC position of the coupling switch there is a capacitor in the signal path. In the DC position the coupling is direct. If the coupling switch is set to the 0 position, the connection between the input socket and the attenuator input is interrupted, the latter being earthed.

The input attenuator, which is controlled by the AMPL switch, enables the adjustment of the vertical-deflection sensitivity in calibrated steps.

The attenuator is followed by a split-band low-drift impedance converter, which gives the circuit a high input impedance. The impedance converter also contains a voltage divider which works in conjunction with the input attenuator.
The d.c. balance is set by compensating for the d.c. offset voltage of the impedance converter by means of the BAL potentiometer.

The signal that leaves the impedance converter on a 50 Ohm level is applied to a paraphase amplifier where it is transformed into a push-pull signal. The paraphase amplifier has two outputs. From one of these outputs the signal is applied to a trigger pre-amplifier, and, from the other one to a second amplifier stage. This stage comprises the switch NORMAL/INVERT by means of which the phase of the signal can be inverted, and a CONT. AMPL. potentiometer which allows the overall gain of the channel to be set between the input attenuator steps. The second amplifier stage comprises also a GAIN preset potentiometer to allow calibration of the input step attenuator.
The signals to be multiplied, are taken out of these amplifier stages in channels A and B, are multiplied in the multiplier circuit and the resulting signal is amplified by the level-shift amplifier and reinserted into the amplifier of channel A.

The following stage is a channel selector which either blocks or passes the signal as dictated by the channel selector logic. The channel selector also comprises the controls for vertical trace positioning.
In the A, B, Multiply or ADD modes the channel selector logic is controlled by means of fixed levels and in the ALT, CHOP, Multiply and B together mode, it is pulse-controlled. In the ALT mode those pulses are supplied by the sweep-gating multivibrator of the main time-base generator during the flyback of the sweep, so that alternately the complete signals of channel A and channel B are displayed.
If ALT. TB is depressed, four traces can be displayed in the sequency: A-MTB, A-DTB, B-MTB and B-DTB.
In the CHOP mode the drive pulses are generated by an oscillator which supplies a fixed frequency of approximately 1 MHz.
Those pulses cause the electronic switches in the channel selector to be successively opened and closed so that successively parts of the signal of channel A and of channel B are displayed. If Multiply and B are depressed simultaneously, switching is done in the chop or alternate mode, depending on the position of the Time/div. switch.

After the channel selector, the following circuits are common to both vertical channels.
A composite signal amplifier for trigger purposes and, at the same time, for the external Y output, a delay line that delays the vertical signals to such an extent that the steep leading edges of fast signals are still displayed, a correction circuit in which the losses caused by the delay line are compensated for, and a final output stage which feeds the signals to the vertical-deflection plates.

3.1.3. Time bases

3.1.3.1. Main time-base

The trigger source/X deflection selector receives its signal from one of the vertical channels or both (COMPOSITE) from the external input or from the power supply (MAINS). One of those signals can be selected by operating one of the controls incorporated in this stage.

From the selector stage the signal is fed to either the X amplifier for horizontal deflection, or the trigger amplifier for starting the time-base generator. This amplifier contains the controls for trigger-level adjustment, slope selection and DC/LF/HF selection. The slope selector allows the polarity of the trigger signal to be inverted, enabling triggering on the positive as well as on the negative slope.

The three modes of operation of the main time-base are determined by the three-position switch AUTO/TRIGG/SINGLE.
In the AUTO mode, the automatic free-run circuit is operative when triggering pulses are absent. Thus a trace, though not necessarily a stationary one, is always displayed even though the trigger controls may not be correctly adjusted. In this way, correct adjustment of the oscilloscope trace is greatly facilitated. However, when trigger pulses are present the circuit reverts to the normal triggered mode. If trigger pulses disappear, the time-base free-runs after a lapse of approx. 50 ms. In the TRIGG. mode, a display is present only when suitable trigger pulses are available.
In the SINGLE mode, events that occur only once can be observed and photographed if necessary. It is often desirable to ensure that only one sweep is generated, even though other trigger pulses might follow the phenomenon of interest. In this mode, after the trigger pulse has initiated the main time-base to produce one sweep, the circuit is unaffected by further trigger pulses until it is reset for the next event by operating the reset push-button.
The sweep-gating multivibrator starts and stops the integrator which delivers the sawtooth signal required for the horizontal deflection. The integrator comprises the charging capacitors and resistors selected by the TIME/DIV switch in order to set the time coefficients in calibrated steps. Continuous control of the time coefficients is obtained by varying the charging current of the time determining capacitors by means of the TIME/DIV potentiometer.
The amplified output signal of the integrator is fed to the X deflection selector, the hold-off multivibrator and the comparator which is part of the delayed time-base unit. The hold-off multivibrator switches back the sweep-gating multivibrator and blocks its input during the flyback of the sawtooth signal.

3.1.3.2. Delayed time-base

The saw-tooth voltage derived from the main time-base generator is passed to a comparator where it is compared with an accurately adjustable d.c. voltage. The comparator output voltage is then pulse shaped by a reset multivibrator to provide the required delayed pulse. As indicated in the relevant waveforms of Fig. 3.2, the pulse shaper output voltage drops to its original value at the end of the forward sweep of the main saw-tooth voltage.

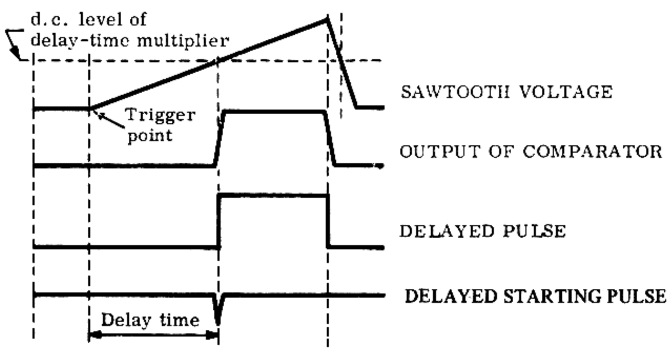


Fig. 3.2. Derivation of Delayed Pulse

The delayed pulse is fed to the delayed time-base generator which then initiates a saw-tooth voltage and an unblanking pulse, both of which are fed to the c.r.t. The time relationship between these waveforms is shown in Fig. 3.3.

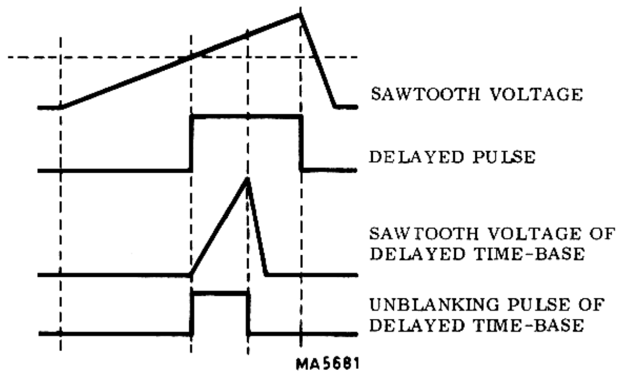


Fig. 3.3. Delayed Time-Base Waveforms

With the DELAY TIME switch in the START position, the delayed time-base starts immediately on receipt of a pulse from the reset multivibrator.

Triggered Operation of the Delayed Time-Base

With the DELAY TIME switch in the TRIGG. position, the delayed starting pulse prepares the time-base for the normal triggered mode of operation. The next trigger pulse from the internal trigger unit or from an external source (dependent on switch setting) arriving after the set delay time actuates the delayed time-base, which is then locked to this trigger signal. The waveforms of Fig. 3.4 illustrate this gating procedure. The total delay is now the sum of the set delay time (i.e., the product of the values indicated by the DELAY TIME and DELAY TIME MULTIPLIER controls) and the extra delay indicated in Fig. 3.4.

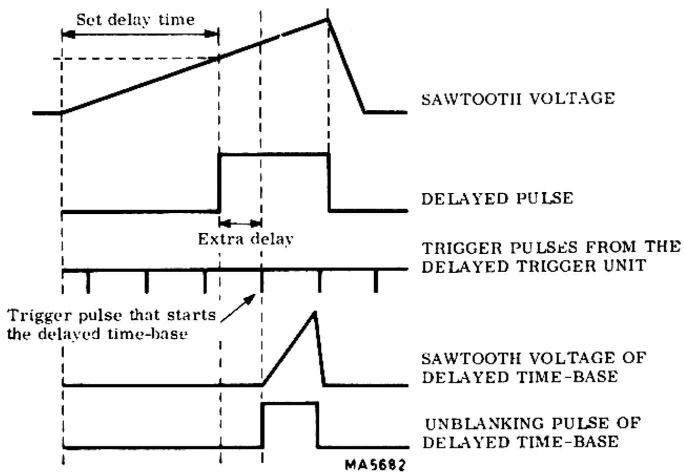


Fig. 3.4. Gating waveforms of Delayed Time-base

HORIZONTAL DISPLAY MODES

A choise of five different modes of display is possible by means of the X DEFL. selector switch and the DTB on/off switch.

MAIN T.B. with DTB in OFF. position

When the X DEFL. switch is set to MAIN T.B., a saw-tooth voltage derived from the main time-base generator is fed via the horizontal amplifier to the horizontal deflection plates of the cathode ray tube.
In addition, the gating pulse from the main time-base is applied to the control grid (Wehnelt cylinder) of the c.r.t. via the unblanking circuit in order to intensify the trace during the sweep.

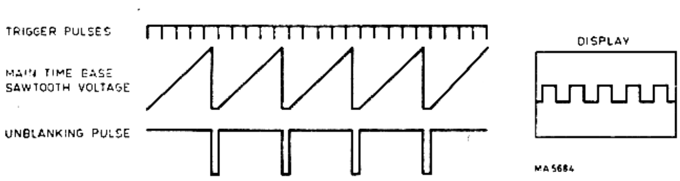


Fig. 3.5. Main Time-Base Display

MAIN T.B. with DTB switched in

When the X DEFL. switch is set to MAIN T.B. the saw-tooth voltage derived from the main time-base generator is again fed to the c.r.t. via the time-base amplifier. However, in these positions of the DTB switch, the gating pulses from the main time-base and the delayed time-base are combined and applied to the control grid of the c.r.t. During the operation of the delayed time-base generator the trace undergoes extra intensification. The start of the intensified portion can be shifted by means of a ten-turn potentiometer, the DELAY TIME MULTIPLIER.

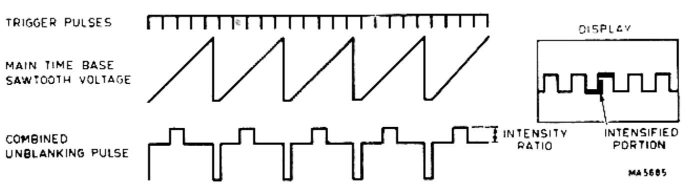


Fig. 3.6. Main Time-Base Intensified Display

DEL'D T.B.

When the X DEFL. switch is set to DEL'D T.B. the saw-tooth voltage from the delayed time-base generator is fed to the deflection plates of the c.r.t. and the gating pulse from the delayed time-base is fed to the control grid of the c.r.t. As a result, the intensified portion of the display, produced by the previous setting is now expanded to fill the entire screen.

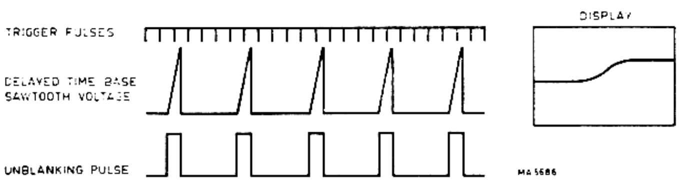


Fig. 3.7. Delayed Time-Base Display

ALT. T.B.

When the X DEFL. switch is set to ALT. T.B. an electronic switch enables the display of Fig. 3.6 and the display of Fig. 3.7 to be alternately traced on the screen. The two displays can be separated by varying the voltage applied to the vertical amplifier, derived from the driving circuits of the electronic switch. This separation is symmetrically variable by means of the TRACE SEPARATION control.

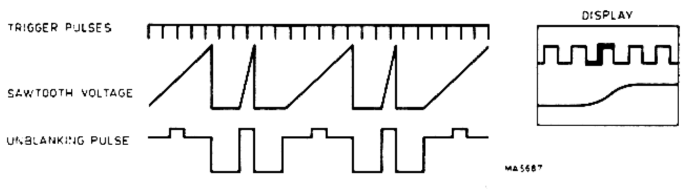


Fig. 3.8. Alternate Time-Base Display

EXT. X DEFL.

When the X DEFL. switch is set to EXT., this permits an external voltage to be applied to the X pre-amplifier to provide horizontal deflection via the time-base amplifier.
This facility can be used for XY applications, where phase relationships between the X and Y deflections above 100 kHz are not important.

3.1.4. Switching unit and X amplifier

Apart from the blanking pulse selector and the X deflection selector, the switching unit comprises an amplifier for external X deflection signals and an intermediate amplifier. The X deflection selector, couples the external X deflection signal, the output signal of the main time-base generator or the combined output signals of the main and delayed time-base generators to the intermediate X amplifier and from there via the final amplifier to the horizontal-deflection plates. The intermediate amplifier comprises the horizontal trace positioning and 10x magnification controls.

The blanking pulse selector supplies blanking pulses to the Z amplifier.
These pulses blank the trace at the end of the sweep of the main time-base and provide the extra bright-up pulse if the oscilloscope operates with a portion of the trace intensified. The blanking pulses during the switching of the traces in the chopped mode go direct from the channel selector logic to the Z amplifier.

3.1.5. Z Amplifier and c.r.t. circuit

The Z amplifier receives three input signals. One originates in the time-base generator and is, via the switching circuit, applied to the Z amplifier to blank the trace during the flyback. The second one is supplied by the channel selector logic to blank the trace during switching from channel to channel in the chopped mode. The third is the ext. Z input signal. The INTENS potentiometer determines the amount of input current fed to the Z amplifier. At the output of the amplifier, the signal is split into two parts: an d.c. part and an a.c. part.
The a.c. part is fed direct to the Wehnelt cylinder of the c.r.t. The d.c. part is modulated on to an oscillator signal and afterwards detected in a peak-detector. Both signal parts are combined again on the Wehnelt cylinder.

The focus voltage for the c.r.t. is generated in an oscillator. The output voltage of the oscillator is rectified, multiplied by a factor of 5 and applied to the focussing anode. The focussing voltage is controlled by the FOCUS potentiometer which is electronically coupled with the INTENS potentiometer. In this way, defocussing due to operation of the INTENS potentiometer is largely obviated.

The high voltage for the post-acceleration anode of the c.r.t. is supplied by a stabilized oscillator whose output voltage is rectified and multiplied by a factor of 9.
Furthermore, the c.r.t. circuitry comprises preset potentiometers for trace rotation, astigmatism, distortion and orthogonality.

3.1.6. Stabilized power supply

The mains voltage is rectified and fed to a switching voltage regulator.
The regulated voltage is fed to a 20 kHz chopper. The secundary voltages of the chopper transformer are full-wave rectified, smoothed and applied to the various circuits.
The MAINS triggering signal is taken direct from the mains and, via a photo coupler, insulated, fed to the trigger circuitry on a safe level.

The calibrator is a square-wave generator which supplies an accurate voltage and current for calibration purposes.

Probe power is supplied for two active probes.

3.2. CIRCUIT DESCRIPTION

3.2.1. Vertical Deflection System

3.2.1.1. Input attenuators

The input stage comprises two identical attenuator units A and B. Each attenuator consists of a triple high-ohmic voltage divider followed by an impedance converter. The latter consists of an a.c. path, and a d.c. path which is also used in conjunction with a drift correction circuit. The impedance converter output stage consists of a triple low-ohmic divider and is followed by an emitter follower stage.

The overall attenuation of the input stage is determined by the combination of the selected sections of both voltage dividers. The various combinations are selected by the position of the front-panel attenuator switch SK10 in conjunction with reed relays.

The high-ohmic voltage divider sections attenuate by a factor of x1, x10 and x100, each section being switched by two reed relays. In combination with the common parallel resistor R108 the attenuation is increased to x1.25,x12.5 and x125. The low-ohmic divider of the impedance converter, IC101, gives attenuations of x1, x2 and x4 at outputs 5, 6 and 8 respectively. With the overall combinations of attenuation, nine Y deflection coefficients are realised from 5 mV/DIV to 2 V/DIV in a 1 - 2 - 5 sequence.

Constant input capacitance for the various attenuator positions is achieved by trimmers C102, C107 and C111. The high-ohmic voltage divider sections are made independent of the input frequency (i.e., the capacitive attenuation for a.c. signals is adjusted to the resistive attenuation for d.c. signals) by means of trimmers C101, C108 and C109.

A diode-clipper GR101, interposed after the voltage divider protects the input circuit of the impedance converter from excessive voltage excursions. The a.c. component of the input signal is used on pin 20. The d.c. component developed across R108 is amplified by TS101 followed by IC102 and then inserted in the d.c. path of the impedance converter at pin 2.

Part of the impedance converter output (pin 4) is used as feedback to one input of a unity gain operational amplifier, IC102, the other input being a reference voltage from the BAL potentiometer R131. The output of the operational amplifier provides a d.c. feedback voltage, controlled by the DC GAIN, R138, for comparison at the virtual earth at the junction of R118 and R108. This comparison voltage at the source input of TS101 (left-hand) is referred to the DC/0/BAL potential from R15 applied to the other source input (TS101 right-hand) of this differential amplifier.

Any d.c. drift in the attenuator circuit, for instance due to temperature changes, is fed via this differential amplifier to the input of operational amplifier IC102 which provides a correcting d.c. feedback voltage via pin 2 to the impedance converter.

The low-ohmic output from the impedance converter is fed to integrated circuit IC103 which comprises an emitter follower and a transistor coupled as a diode for level-shifting. The output provides a correct impedance match for the coaxial cable to the intermediate amplifier.

Input coupling switch, SK16 (pushbuttons AC - O - DC) also forms part of the input attenuator stage. When the AC position is selected, capacitor C104 is in series with the input and reduces the lower frequency limit to 10 Hz. When the DC position is selected, RE106 is energised and C104 is bypassed via resistors R109 and R111 in series. Selection of the 0 pushbutton energises RE108 and provides an earth path for the impedance converter input via R114. In addition, it de-energises all other attenuator reed relays and isolates any external signals applies to the Y input.

3.2.1.2. Intermediate amplifier

The intermediate amplifier also, mainly comprises hybrid integrated circuits for better temperature control and increased stability. The signal paths for channel A and channel B are identical in the input stages of the intermediate amplifier.

Amplifier I
The Y output signal from the channel A attenuator is applied via R318, part of an h.f. boost circuit TS302, to pin 12 on AMPLIFIER I (IC302). Transistors TS301 and TS303 provide constant-current sources for this integrated circuit. The RC network comprising C308, C309, C311 to C314 and R319, R321, R322, corrects the h.f. response in conjunction with the preset potentiometer R323 (HF) connected to pin 14.

The NTC resistor complements the temperature coefficient of freq. bandwidth variations. The integrated circuit AMPLIFIER I has two symmetrical outputs: one to the next amplifier stage and another to the trigger amplifier, IC301. Two h.f. boost amplifiers TS304 and TS306 are provided between the outputs of AMPLIFIER I and the inputs of AMPLIFIER II.

Amplifier II

The Y signal is applied to pins 11 and 15 of AMPLIFIER II (IC304). In this amplifier, the overall gain of the channel is adjustable by the front-panel GAIN preset, R16A which is connected via the AMPL Y amplitude continuous control, R11A. Any unbalance due to re-adjustment of the GAIN preset can be compensated for by the GAIN BAL preset R311, which varies the current source TS301 of the AMPLIFIER I integrated circuit block.

The AMPL control is given a high degree of stability by applying its output to an operational amplifier (IC303) and a bridge circuit comprising transistors TS307 to TS309. Controlled by the AMPL potentiometer, the circuit sets the gain of AMPLIFIER II by means of a diode bridge between the balanced signal paths. Rotation of the AMPL control varies the dynamic resistance of the bridge circuit and, via 7 and 19, short-circuits a greater or less part of the symmetrical signal.

The NORMAL/INVERT switch SK6 is connected via series resistors R354 and R357 to points 2 and 24 on AMPLIFIER II to allow the Y signal of the A channel to be inverted by transistor switching within the circuit block. Any unbalance between the two positions of this switch can be compensated for by the POL BAL preset, R353. The switching earth is derived from the SK1 MULT contact via R363 and is routed via the NORMAL/INVERT switch SK7 to ensure inversion irrespective of the position of the latter, which applies for the Multiply mode only.

Diodes GR304 and GR306 are blocked by an earth applied in the MULTIPLY mode in order to provide diode switching in AMPLIFIER II to route the A signal through the multiplier circuits as described later.

Channel selector

In all other modes, the output signal of AMPLIFIER II is routed via points 26 and 29 to points 14 and 12 of the integrated circuit IC208 (CHANNEL SELECTOR). The signals of channel B are also applied to this integrated circuit on points 27 and 29. Inputs from the channel selection logic (section 3.2.1.3.) on points 7 (A) and 4 (B) provide the control signals for determining the output signals from the CHANNEL SELECTOR to the delayline (points 22 and 19) and the COMPOSITE SIGNAL AMPLIFIER (points 24 and 17). The outputs that can be selected by the vertical mode switch are:

- channel A signal
- channel B signal
- channels A and B added, chopped or alternated
- channels A and B multiplied
- channels A and B multiplied, together with channel B displayed.

In the ADD mode, emitter-follower TS211 is conducting as the earth is removed from R283. The collector supply provides (via point 5) the extra current needed for both channels.

The front-panel POSITION potentiometers R3 and R7 provide vertical-shift potentials for the A and B signal channels in the CHANNEL SELECTOR.

Composite signal amplifier

The COMPOSITE SIGNAL AMPLIFIER, integrated circuit block IC209, accepts the output signal from the CHANNEL SELECTOR and, after amplification provides two outputs. One is fed from point 19 to socket BU10 on the rear of the instrument as an external Y output. The other is fed via points 23 and 18 as a balanced composite trigger signal to the main time-base. The DC BALANCE Y OUTPUT preset R23 controls the emitter supply of one of the output transistors in the COMPOSITE SIGNAL AMPLIFIER.

Trigger amplifier

In addition to the composite trigger signals, balanced trigger signals are available for the main and delayed time-base from points 14, 15 and 11, 12 respectively of the A channel TRIGGER AMPLIFIER circuit block IC301 (IC201, B channel). The symmetry of the outputs, which are at 0 V levels, can be set by preset potentiometer R301 (SHIFT). The zero-volt level can be set by preset R304 (ZERO).

Multiplier

In the multiplier mode, signals are diverted by diode switching in AMPLIFIER II of both the A and B channels to the input of the MULTIPLIER integrated circuit block IC206. The A input is connected to points 27 and 29, and the B input connected to points 22 and 21. In the A signal path, transistors TS1605 and TS1606 are switched off and the negative blocking potentials normally applied to points 4 and 22 of AMPLIFIER II are removed. The A signals are therefore diverted via diodes in AMPLIFIER II to the input of the multiplier. Similarly, the B channel signal is diverted to the multiplier since TS1608 is non-conducting and therefore TS1607 conducts to provide diode switching potentials in the B channel AMPLIFIER II via GR1603 and GR1604.

Since TS1608 is non-conduction, TS1609 conducts and switches off emitter-follower TS1611. The emitter load resistor R1631 now absorbs current via point 24, thus compensating for the current normally fed back from the multiplier to AMPLIFIER II when the internal diodes connected to points 4 and 22 are blocked.

The multiplier principle involved is based on the property of the bipolar transistor whereby its mutual transconductance varies linearly with the emitter current. Consequently the A input voltage is applied to a voltage-to-current converter network for application to the multiplier as emitter current. The B input voltage is applied to the base of the bipolar transistor.

Front-panel presets 0xA (R6) and 0xB (R5) provide zero compensation for any offset voltages in the multiplier circuits. The GAIN preset control R4, connected via R6 and points 3 and 6, varies the bias potential on the multiplier circuit.

The multiplier part of IC206 is followed by level-shifting circuits and a cascode amplifier to provide outputs of AxB on points 14 and 12.

Amplifier III

The outputs from the MULTIPLIER are fed via resistors R266 and R268 to points 25 and 30 on AMPLIFIER III (IC207). The integrated circuit block comprises an amplifier and level-shifting stage.

Emitter-follower TS1604 absorbs current via point 8 in all other modes except the MULT mode, to maintain circuit stability.

The HF correction preset potentiometer R272 is applied via point 28 to a varicap diode in the input amplifier emitter circuit. It operates in conjunction with the correction network C241, C239 and R267 across points 27 and 29.

The outputs from AMPLIFIER III (points 14 and 12) are connected direct to points 23 and 3 on AMPLIFIER II. Here the AxB signal is amplified and passed to the CHANNEL SELECTOR.

3.2.1.3. *Channel selection logic*

The channel selection logic consists of digital circuits employing dual-in-line TTL integrated circuits IC1601, IC1602, IC1603 and IC1604. Vertical mode selection is made by the six-pushbutton switch SK1. Horizontal mode selection is made by the four-position switch SK2.

Positive logic is used in the digital circuits, the levels being as follows:

logic '1' = +5 V (high)
logic '0' = 0 V (low)

In the vertical channel selection circuits, logic '1' enables the A and B channels from the outputs 6 and 3 of the NAND gates IC1604.

The different functions of the logic circuits are now described according to the vertical display mode controls (SK1).

A – selects channel A only. Input 2 of flip-flop IC1603 is low, consequently output 15 is high. Input 1 to NAND gate IC1604 is therefore high thus giving a low output on pin 3 to block channel B. Output 14 of the flip-flop is low, consequently output 6 of the NAND gate is high and channel A is enabled.

B – selects channel B only. Input 3 of the flip-flop IC1603 is low, consequently output 14 is high, input 4 of NAND gate IC1604 is therefore high and the resulting low output on pin 6 blocks the A channel. Output 15 of the flip-flop is low, consequently the output on pin 3 of IC1604 is high and channel B is enabled.

ADD – adds channels A and B. Gate inputs 2 and 5 of NAND gates IC1604 are both low, consequently both outputs are high irrespective of the state of the flip-flop. Both A and B channels are therefore enabled. An earth is also removed from R283 to deliver more current via TS211 to the CHANNEL SELECTOR in the ADD mode.

CHOP – selects channels A and B chopped. In this position the chopper generator (part of IC1601) is switched into the circuit by an earth applied to pins 9 and 10. The input initiates oscillations due to the feedback loop between pins 3 and 2, and 6 and 2 of IC1601. The frequency of oscillation is 2 MHz. This output is fed via an AND/NOR gate of IC1602 to trigger input 1 of flip-flop IC1603. The flip-flop divides the incoming frequency by 2 and switches at a frequency of 1 MHz. The resulting high switching levels on outputs 3 and 6 of IC1604 providing the chopping signals for the A and B channels.

During switchover in the CHOP mode, the c.r.t. is blanked by pulses supplied by transistors TS1601, TS1602 and TS1603. Normally, TS1601 and TS1602 are made fully conducting by the +5 V base supplies via R1604 and R1607. However, in the CHOP mode the negative-going edges of the 2 MHz chopper signal are differentiated by C1602 and produce positive-going pulses at the collector of TS1602. These blanking pulses are fed via TS1603 to the Z amplifier.

ALT – selects channel A and channel B alternately for display. This is a dummy pushbutton without contacts that releases all the other pushbuttons of SK1. The hold-off pulse of the main time-base generator is fed via R817 to the base of TS1613. During the sweep, this pulse is low but during hold-off it is high. Consequently, the hold-off pulses are applied via the collector of TS1613 to input 9 of AND gate IC1602. The output is coupled via the IC1602 gates to the trigger input 1 of flip-flop IC1603. Consequently, it is triggered by a signal which is a replica of the main time-base hold-off pulses. Outputs 3 and 6 of NAND gate IC1604, are, in turn, high and low and the input signals applied to the oscilloscope are alternately displayed by channels A and B.

MULT – selects A channel and diverts A and B signals through multiplier channels. Input 2 of the flip-flop IC1603 is low, consequently output 15 is high and the B output channel is blocked. Output 14 of the flip-flop is low, output 6 of the NAND gate IC1604 is high, consequently the A channel is enabled in the CHANNEL SELECTOR. The high output on point A is also routed via R1612 to block GR1602. As point 1 at conn. T is also high in the MULT mode, GR1601 is also blocked. As described earlier, TS1608 is cut off, TS1607 conducts and −15 V is routed via GR1603 and GR1604 to divert the B signal to the multiplier via internal diode switches. Similarly, the high logic level on T1 cuts off TS1605 and TS1606 to enable the diodes in AMPLIFIER II of the A channel in the multiplier input path. An earth applied to point T3 in the MULT mode blocks diodes GR304 and GR306 to provide blocking potentials (via points 2 and 24) for the through-circuit diodes in AMPLIFIER II of the channel A.

MULT+B – selects multiplier function and B channel. Emitter of TS1612 is eathed and a high logic level on the base in the 0.5 s to 2 ms positions of the MTB TIME/DIV switch SK14 applies a low input to pins 9 and 10 of NAND gate IC1601. Consequently, in these slower positions of SK14 the CHOP mode is selected and points A and B are successively switched at 1 MHz between low and high to select AxB or B channel. In the faster positions of SK14 (1 ms to 0.2 μs) pin 4 of IC1602 is high and consequently the ALTERNATE mode is selected. The A and B points are switched between low and high at the end of each trace to select AxB and B traces alternately.

In both the CHOP and ALTERNATE positions, during the instant when A is low (B channel selected), GR1602 conducts, consequently TS1608 conducts and switches off TS1607 to block diodes GR1603 and GR1604. This enables the B channel whilst the A channel (AxB) is momentarily blocked.

For convenience, the foregoing logic functions are summarised in the following truth table:

SK1 Mode	FLIP-FLOP IC1603 inputs 2	3	outputs 15	14	NAND GATE IC1604 outputs 3(B)	6(A)	Multiply switch logic T1	CHANNEL SELECTOR
A	O		I			I	O	A enabled
B		O		I	I		O	B enabled
ADD					I	I	O	A+B enabled
MULT	O		I			I	I	AxB enabled
MULT+B			O/I	O/I	O/I	I/O	I	AxB/B enabled

The logic circuits controlled by the horizontal mode switch SK2 are now described.

MTB — selects main time-base. This is a dummy pushbutton without contacts, that releases all other pushbuttons of SK2. An earth on input 8 of the alternate flip-flop IC1603 makes output 10 high. This logic level is fed via R1642 to R1472 on the horizontal deflection selector circuit to select the main time-base.

DTB — selects delayed time-base. An earth on input 7 of the alternate flip-flop IC1603 makes output 11 high. This logic level is fed via R1643 to R1497 on the horizontal deflection selector circuit to select the delayed time-base. An earth is also routed to inhibit the +6 V signal applied to the base of TS1614 that automatically selects MTB in the OFF position of the delayed time-base TIME/DIV switch.

ALT TB — selects main and delayed time-bases alternately. Removes an earth from forcing inputs of alternate flip-flop IC1603 and applies it to input 10 of AND gate IC1602 to prevent the A and B channels being directly switched by the alternate pulse. The alternate pulse now switches input 6 of the flip-flop IC1603 to give alternate outputs on 11 and 12 to switch the MTB and DTB in the X deflection selector. The earth is also applied to inputs 12 and 13 of the NAND gate IC1601. The resulting high output is applied to the inputs of three gates. The inputs to 10 and 13 of NAND gates IC1604 allow an adjustable trace separation potential to be alternatively applied to the two paths of the vertical final amplifier depending on whether MTB or DTB is selected by input 6 of alternate flip-flop IC1603. Trace separation is adjustable by front-panel control R9 in series with an internal preset R1657. A variable potential between 0 V and 6 V is applied to the gate of field-effect transistor TS1618, which together with R1652 and R1653 acts as a variable resistance network. The trace separation potential is routed via TS1616 (when MTB switched) or TS1617 (when DTB switched) to the vertical final amplifier. When the ALT TB pushbutton is released, the trace separation potential is bypassed to earth.

The high output 11 on IC1601 is additionally fed to input 13 of AND gate IC1602. Consequently, the output of this gate only changes over the A and B channel select flip-flop when MTB is selected by the alternate flip-flop (i.e. output 11 low).

In the vertical and horizontal ALT modes the switching sequence is therefore as follows, together with the relevant logic levels:

	Selected mode or switching sequence	X alternate flip-flop outputs 10	11	IC1602 AND gate control of Y flip-flop Input 1	Y alternate flip-flop outputs 15	14	Trace IC1604 outputs 8	11	Separation to vertical final amplifier
sequence ↓	MTB and A	I	O	O	I	O	I	O	IC401-16
	DTB and A	O	I	(I)	I	O	O	I	IC401-25
	MTB and B	I	O	O	O	I	I	O	IC401-16
	DTB and B	O	I	(I)	O	I	O	I	IC401-25

EXT.X DEFL — selects external source for horizontal deflection. Inhibits MTB and DTB signals and blanking pulses (see Section 3.2.6).

3.2.1.4. Final Y amplifier

The final Y amplifier comprises three circuit blocks, IC401, IC402 and IC403 and two output transistors, TS401 and TS402. The output signal of the delay line is applied to inputs 18 and 23 of IC401 (DELAY LINE CORRECTION AMPLIFIER).

As the delay line is a source of distortion for higher frequencies, there is a h.f. correction network included between the emitters of both input transistors of IC401. This network consists of capacitors C400 to C407 and resistors R403 to R407. Correction of the highest frequencies is possible with the aid of varicap diodes which are incorporated in the DELAY LINE CORRECTION AMPLIFIER block. The bias of the varicap diodes is set by means of preset potentiometers R409 and R410.

Inputs from the TRACE SEPARATION circuit are applied on pins 16 and 25 of IC401.

The DELAY LINE CORRECTION AMPLIFIER block is provided with two symmetrical outputs: 12-15 and 11-14. Output 12-15 is connected to input 26-30 of circuit block IC402 (FINAL AMPLIFIER), and output 11-14 is connected to the input 26-30 of similar circuit block IC403 (FINAL AMPLIFIER).

The outputs of the FINAL AMPLIFIER blocks are connected in parallel and symmetrically applied to output transistors TS401 and TS402.

The overall gain of the final amplifier can be set by means of potentiometer R432 which controls the voltage on point 27 of circuit block IC401 (DELAY LINE CORRECTION AMPLIFIER). When selected, the front-panel BEAM LOCATE switch, SK23, provides an earth to shunt preset GAIN control R432.

The collectors of the output transistors are connected to the Y deflection plates of the c.r.t. Each Y deflection plate consists of four parts which form filters together with coils L401 to L404 and L406 to L409 and the stray capacitances of the deflection plates. The constants of this filter network are chosen in such a way that the propagation velocity of a pulse equals the velocity of the electron beam. In this way, transit-time distortion is kept to a minimum. The filter chain terminates in resistors R418 to R431. The termination is optimized by means of potentiometer R423.

3.2.2. Main Time-base triggering

The trigger unit of the main time-base generator can select any of the following input sources:

- an external source
- the signal of channel A
- the signal of channel B
- a composite signal of channel A and channel B
- a signal derived from the mains supply

All these sources can be used for both triggering and X deflection purposes. Source selection is by means of a five-position pushbutton switch SK21 that feeds the trigger signals to the trigger amplifier.

3.2.2.1. Trigger input circuits and amplifier

A signal on EXT trigger socket BU8 is applied to the gate of input field-effect transistor TS601A, via voltage divider R601-R602 and capacitor C610. When selected, the x3 ATTENUATOR, SK24, connects a further resistor, R604, into the voltage divider chain. The gate of the field-effect transistor is protected against overload by means of two sets of two diodes in series, GR600 and GR601, which limit the gate voltage to + and −1.4 V. Switch SK19 enables selection between a.c. and d.c. coupling of the input signal. If SK19A is depressed, resistors R606 and R607 bypass capacitor C610 with the result that d.c. voltages are applied to the gate of field-effect transistor TS601A. Capacitor C607 suppresses possible interference signals that might be picked up by the long lead between switch SK19A on the front panel, and the trigger unit.
In the source circuit of field-effect transistor TS601B, which is connected in series with TS601A, there is a potentiometer R631. This potentiometer allows balancing of the signal for the next amplifier stages.

The output signals of field-effect transistors TS601 are applied to the base of transistor TS608. This transistor is, together with transistor TS604, switched in by current source TS607. The latter is controlled by EXT TRIG switch. If this switch is depressed, current source TS607 causes a current to flow through transistors TS604 and TS608, which can then transmit the signals to the trigger amplifier.

The trigger signals from channels A and B are symmetrically applied to similar circuits. For channel A the circuit comprises transistors TS611 and TS613 as gates, and transistor TS612 as a current source. The current source is switched in by means of TRIG A switch.

For channel B the gates are transistors TS614 and TS617, the current source being TS616. The current source is switched in by means of TRIG B switch. Both input A and B are provided with a preset potentiometer to adjust the balance of the stage: R636 for channel A and R656 for channel B.

Signals from the Composite Trigger Amplifier are symmetrically applied to transistor gates TS619 and TS622. Transistor TS621 provides the constant-current source for this circuit. The current source is switched in by the selection of both TRIG A and TRIG B switches.

The other possible trigger source is the MAINS. The trigger signal is transmitted to the trigger unit via a photo coupler in the power supply and applied "common mode" via C616 to transistors TS623 and TS626. This "common mode" drive suppresses fast interference signals and high frequencies in the trigger signal. Transistors TS623 and TS626 are the gates and transistor TS624 is the current source, which can be switched in by means of TRIG MAINS switch.

Depending on which pushbutton of the horizontal deflection controls SK2 is selected, one of the signals described above is used for either triggering or for horizontal deflection. When pushbutton DEL'D TB or MAIN TB is selected, the signal is used for triggering. Alternatively, if pushbutton EXT X DEFL is operated, the signal is fed to the horizontal amplifier on the switching unit. In that case, the signal is picked off from the collector of transistor TS609 which is then switched in, together with transistor TS602, via pushbutton EXT X DEFL.

If pushbutton EXT X DEFL is released, the signal is fed to transistors TS603 and TS618. From these, the signal is applied to that part of the trigger amplifier where the choice is made between h.f., l.f. and d.c. trigger coupling. The choice is made by means of trigger coupling controls SK19.

l.f. trigger coupling

Current source TS728 is switched in. The cathodes of diodes GR603 and GR604 then carry a voltage of approximately +5 V. Consequently, the signal from the trigger pre-amplifier cannot be transmitted via transistors TS627 and TS633. Instead, it is transmitted via the signal path with R681 and R698, amplified by transistors TS629, TS632, TS639, TS637, TS641 and TS636 and applied to the bases of transistors TS642 and TS634. On these points, the trigger signal is integrated and the h.f. components eliminated with the aid of capacitors C622 and C623 which are, at one side, connected to the +5 V voltage mentioned above. Consequently, triggering on the l.f. component of the triggering signal is obtained.

h.f. trigger coupling

Current source TS728 is switched off as pushbutton l.f. is released. Transistors TS629 and TS632 are turned off because their bases are earthed via double diode GR602 and pushbutton h.f. The triggering signal is applied to the bases of transistors TS642 and TS634, via transistors TS627 and TS633 and capacitors C622 and C623. Capacitors C622 and C623 now act as differentiators. Consequently, the l.f. components are blocked and triggering on the h.f. component of the triggering signal is obtained.

d.c. trigger coupling

This is a dummy switch which releases pushbuttons LF and HF. In the DC position, SK19B and SK19C are open and, therefore, both the l.f. and the h.f. paths are in operation. Consequently, the entire triggering signal is transmitted. By means of potentiometer R712 in the emitter circuit of TS641 and TS636, the sensitivity of the l.f. path is equalized to that of the h.f. path. Therefore, the d.c. trigger signal will be undistorted.

The trigger level is set by means of LEVEL potentiometer in the base circuit of transistor TS637. The control range of this potentiometer is preset with the aid of potentiometer R709 in the base circuit of transistor TS639.

Via transistors TS642 and TS634, the signal is applied to the push-pull amplifier with transistors TS643-646 and TS644-647. The amplified triggering signal is applied to the trigger pulse shaper.

3.2.2.2. *Trigger pulse shaper*

The trigger pulse shaper is incorporated in circuit block IC601 (TRIGGER PULSE SHAPER). The input of this circuit block consists of four transistors, two of which are operating as a Schmitt-trigger at any one time. The position of the +/– trigger SLOPE switch, that enables triggering on either the positive- or negative-going edge of the triggering signal, decides which two transistors are operating.

The next circuit in the TRIGGER PULSE SHAPER block is the trigger multivibrator, which is switched over by the triggering signal. The resulting square-wave signal is differentiated and sharp trigger spikes are obtained. The negative-going spikes are available on output 16 of IC601 and from there are applied to the sweep-gating multivibrator of the main time-base generator. The positive-going pulses are available on output 14 and are used to control the automatic triggering circuit. Potentiometer R737, which is connected to input 23 of IC601, is used to set the overall trigger sensitivity.

3.2.2.3. *Auto-circuit*

Basically, the auto-circuit comprises electrolytic capacitor C643 across the complementary transistors TS648 and TS749. Positive-going trigger pulses at the base of TS749 cause it to start conducting. Likewise, TS648 starts to conduct and capacitor C643 discharges. The output voltage of the auto-circuit is then approximately −15 V. This voltage is applied to the diode GR803, in the main time-base sweep generator, to make it non-conductive. The sweep-gating multivibrator levels are therefore such that it is driven by the negative-going pulses received via TS851.

When no trigger pulses are available, TS648 and TS749 are non-conducting and C643 charges. Hence, GR803 conducts and the sweep-gating multivibrator levels are set so that initiation of the sweep is dependent only on the sweep feedback voltage. The main time-base sweep generator is therefore free-running.

3.2.3. Main Time-base Generator

The main time-base generator comprises the sweep-gating multivibrator, TS801, TS802, feeding switching transistors TS807 and TS808, the latter being effectively in parallel with the time-base capacitors of the integrator circuit. Transistor TS806 is used as a current source to charge these capacitors. Selection of the appropriate timing capacitors is by means of the TIME/DIV switch SK14 via switching transistors TS815, TS819 and TS821. The sawtooth voltage is developed across the selected time-base capacitor(s) by charging it to a certain level from the constant-current source. The capacitor is then short-circuited very rapidly which results in the characteristic sawtooth waveform.

The sawtooth voltage is fed to TS826 and the left-hand transistor of TS827 in Darlington pair configuration. This stage feeds the sawtooth voltage to the X deflection selector stage and also back to the input of the sweep-gating multivibrator via the hold-off circuit.

The main time-base generator circuit also includes a stage which serves to indicate whether the main time-base generator is triggered or not (GR2). The various stages of the main time-base generator circuit are now considered in some detail.

3.2.3.1. *Sweep-gating multivibrator*

Sweep-gating multivibrator TS801 and TS802 is controlled by the following signals:

- the negative-going trigger spikes supplied by the main trigger multivibrator via the differentiating circuit,
- the voltage supplied by the hold-off multivibrator,
- the bias voltage supplied by the auto-circuit.

Potentiometer R806 provides a preset control of trigger stability. Transistor TS805 is a current source to make the sweep-gating multivibrator insensitive for possible fluctuations in the supply voltage. The output square-wave of the sweep-gating multivibrator is applied to the switching transistors TS807 and TS808.

3.2.3.2. *Switching transistors TS807 and TS808*

Transistor TS808 is the switching transistor that is effectively in parallel with the selected time-base capacitance. Whenever this transistor receives a positive-going pulse from the sweep-gating multivibrator, it starts conducting and the time-base capacitance is discharged. Transistor TS806 provides the constant-current source to charge the capacitance. Transistor TS807, the other switching transistor, short-circuits the charging current to earth when the time-base capacitors are being dischanged. Both switching transistors are driven with the same control signa, supplied by the sweep-gating multivibrator.

3.2.3.3. *Sweep speeds*

The sweep speed or time coefficient is determined by the value of the time-base capacitance in circuit, and by the magnitude of the charging current selected.

The time-base capacitors are C805, C806, C807 and C808. Capacitor C806 is always in circuit; the other three capacitors are selected by transistors TS815, TS819 and TS821. These operate as electronic switches and are either fully cut-off or fully-conducting. They are switched on by the application of a positive voltage to their bases from the TIME/DIV switch (SK14). According to the position of SK14, these transistors switch in the relevant capacitor in parallel with C806. As mentioned, the sweep speed is also dependent on the magnitude of the constant-current charge supplied by transistor TS806. This current can be adjusted in steps by selecting the emitter resistance of TS806 by means of the TIME/DIV switch SK14. Continuous control of the charging current can be effected by varying the base drive to TS806 with the vernier sweep control, TIME/DIV potentiometer R14. In the CAL position of this potentiometer, switch SK15 closes and the charging current is solely determined by the calibrated emitter resistance. A correction circuit on the Horizontal Deflection Selector circuit increases the charging current for the highest sweep time in the x10 position (2 ns/DIV).

To compensate for the temperature coefficient of the transistor (2 mV/deg C) the base voltage of TS806 is supplied via transistor TS809. This also has the advantage of reducing the load on the TIME/DIV potentiometer. Electrolytic capacitor C800 suppresses any possible ripple and interference present on the supply voltage rail.

Time-base capacitors C805, C806 and C808 are precision capacitors. Capacitor C807 (4.7 μF), however, has a ±10 % tolerance. This is compensated for by potentiometer R834 in the collector circuit of transistor TS811. With the aid of this potentiometer, the base voltage of TS809 is additionally controlled in those positions of the TIME/DIV switch SK14, where capacitor C807 is switched in. In positions of SK14 where C807 is not switched in, diode GR802 is blocked and the additional control is inoperative.

3.2.3.4. *Sawtooth take-off circuit*

The sawtooth waveform generated by the time-base is applied to the darlington pair, comprising TS826 and the left-hand transistor of TS827, the emitter output of the latter being coupled to the X deflection selector, the comparator circuit and to the hold-off circuit of the main time-base via diode GR808.

3.2.3.5. *Hold-off circuit*

The hold-off circuit prevents the sweep-gating multivibrator from responding to trigger pulses before the time-base capacitor has fully dischared. The sawtooth output from the Darlington pair is applied via diode GR808 to the base of emitter follower TS824. Switching transistors TS820, TS822 and TS823 select the appropriate hold-off capacitor, C809, C810 or C811, according to the position of SK14, in a similar manner as described for the main time-base integrator timing capacitors. Capacitor C812 is always in circuit irrespective of the TIME/DIV switch position.

The selected hold-off capacitor is charged via transistor TS824 and discharged via TS825. Discharging in this case takes a considerably longer time than the discharging of the time-base capacitors. The bias of transistor TS825 can be varied by means of front-panel potentiometer X DEFL/HOLD-OFF (R22), in order to manually vary the hold-off time.

The voltage across the selected hold-off capacitor drives the Schmitt trigger TS816, TS817, the hold-off multivibrator. The output signal of the hold-off multivibrator is applied to the input of the sweep-gating multivibrator via emitter follower TS814. This emitter follower, TS814, buffers the hold-off multivibrator from the triggering spikes of the trigger pulse-shaping circuits.

Switch SK9, located in the base circuit of transistor TS824 is closed when pushbuttons AUTO and TRIG of the trigger-mode controls are operated. If these buttons are released (pushbutton SINGLE operated), switch SK9 is open. Then diode GR808 stops conducting and the hold-off multivibrator TS816, TS817 is no longer reset by the sweep voltage. The hold-off multivibrator is now reset via transistor TS818, by pressing SINGLE pushbutton SK9C.

When the oscilloscope is used with an external X deflection signal, the internal time-base generator is switched off by depressing the EXT X DEFL pushbutton of SK2 in the base circuit of transistor TS818. This transistor holds the hold-off multivibrator so that its output prevents the sweep-gating multivibrator from responding to trigger pulses.

3.2.3.6. "NOT TRIG'D" indicator

Light emitting diode GR2 in the collector circuit of transistor TS812 serves two purposes:

- it provides a front-panel indication when the time-base generator is not triggered in the AUTO and TRIG modes; i.e., it indicates the absence of trigger pulses. In this condition, electrolytic capacitor C643 of the auto-circuit in the main trigger circuit is charged. Consequently, the emitter of TS813 becomes less negative and the transistor cuts off. The earth applied via R838 switches on TS812 and the NOT TRIG'D diode, GR2, lights. On receipt of trigger pulses, C643 is discharged, TS813 conducts and cuts off TS812, thus extinguishing GR2.
- in the SINGLE mode, the NOT TRIG'D lamp also serves as a reset indicator, On selection of the SINGLE pushbutton, the lamp remains on until the sweep is initiated by a trigger pulse. In this mode, the trigger pulse drives the base of TS813 dependent on the state of the hold-off multivibrator TS816, TS817.

Note: The instrument also operates in the SINGLE mode if none of the trigger-mode controls is depressed.

3.2.3.7. Switching transistors TS803 and TS804

Transistors TS803 and TS804 are part of the output circuit of the sweep-gating multivibrator. Transistor TS803 supplies pulses for the ALT supply of channels A and B to the channel selector logic, and reset pulses for the delayed time-base generator. Transistor TS804 provides blanking pulses that are applied to the Z amplifier, via the switching unit, in order to suppress the beam when the time-base generator is in the hold-off position.

3.2.3.8. Delay-time function

The function of the DELAY TIME potentiometer R1 is to provide an adjustable d.c. voltage for comparison with the sweep voltage of the main time-base generator. This comparison voltage is then used to start the delayed time-base generator at a pre-determined time during the sweep of the main time-base. The comparator circuit is described in the delayed time-base generator section (3.2.5.3.). The DELAY TIME potentiometer is a 10-turn front-panel control.

3.2.4. Delayed Time-base Triggering

The trigger unit of the delayed time-base is almost identical to that of the main time-base trigger unit, the circuits of which are described in section 3.2.2. Unlike the main time-base trigger unit, the delayed time-base trigger unit has no provision for external X deflection, triggering from the mains frequency, or for composite triggering.

3.2.5. Delayed Time-base Generator

As the delayed time-base generator is basically similar to the main time-base generator (section 3.2.3), only the essential differences are described.

3.2.5.1. Sweep speeds

The circuit is similar to that of the main time-base generator, but the constant-current source for the time-base capacitors is provided with an extra preset potentiometer R1227. This potentiometer enables the sweep speeds of the delayed time-base generator to be equalized to those of the main time-base generator.

3.2.5.2. Hold-off circuit

The sawtooth voltage is applied, via diode GR1204 and emitter-follower TS1224, to the hold-off multivibrator TS1218, TS1219. The output voltage of the hold-off multivibrator brings the sweep-gating multivibrator in the hold-off position via emitter-follower TS1217. The sweep-gating multivibrator is reset with the aid of reset multivibrator TS1222, TS1223. The base of TS1223 is driven by the output signal of the sweep-gating multivibrator in the main time-base generator and by the output signal of the comparator. The reset multivibrator is switched over by the combination of these signals. As a result of this, the hold-off multivibrator is reset via emitter follower TS1221 and, thus, the sweep-gating multivibrator TS1201, TS1202. If pushbutton STARTS (SK8A) has been operated, the next sweep is then initiated. If, however, the TRIG pushbutton has been selected, the sweep-gating multivibrator is switched over by a trigger pulse on the base of transistor TS1201. In the OFF position of TIME/DIV switch SK12, the sweep-gating multivibrator is kept in such a state that is responds to neither trigger pulses nor reset pulses of the hold-off multivibrator.

3.2.5.3. Comparator

The comparator comprises the transistors TS1226 and TS1227. Transistor TS1226 is a double transistor in long-tailed pair circuit, TS1227 being a current source for this circuit. The d.c. voltage set by DELAY TIME potentiometer R1 is fed to the base of the right-hand transistor of TS1226, via R1282. The sawtooth voltage of the main time-base generator is fed to the left-hand transistor of TS1226, via R1281. As soon as the amplitude of the sawtooth exceeds the set d.c. voltage, the collector voltage of the left-hand transistor of TS1226 drops. This voltage drop is, together with the output signal of the sweep-gating multivibrator of the time-base generator, fed to the reset multivibrator TS1222, TS1223 as described in the previous section. A delayed pulse output is available on socket BU11 at the rear of the instrument.

3.2.6. Horizontal Deflection Selector

The horizontal deflection selector board U8 comprises the following circuits:

- a selector for the X deflection source
- a switching circuit for the c.r.t. blanking pulses
- an X preamplifier for external X deflection signals
- an X intermediate amplifier.

3.2.6.1. X deflection source selector

Depending on the selected position of SK2, the circuit provides for X deflection by the main time-base signal, the delayed time-base signal, alternate deflection by both time-base signals or deflection by the signal from an external source. The logic circuits have already been described in section 3.2.1.3.

With MAIN TB pushbutton selected, transistor TS1427 emitter receives a high logic signal from the alternate flip-flop (via R1642) and it starts to conduct. Transistor TS1407 also conducts and, via R1423, switching diodes GR1401 and GR1402 are unblocked. Consequently, the output signal from the main time-base is fed to the intermediate X amplifier. The conductance of TS1407 also results in TS1408 and TS1409 being turned off. Diodes GR1403, GR1404 and GR1406, GR1407 are therefore blocked and signals from the delayed time-base or external X deflection signals are blocked. Transistor TS1404 also conducts when MAIN TB is selected and TS1406 turns off. Resistor R1422, the load of the main time-base generator, is then out of circuit and is replaced by R1423. Thus, a constant load is maintained for all positions of the X deflection controls. The MTB SWEEP OUT facility on rear-panel socket BU12 is fed from emitter-follower TS1410. This external output is derived before the switching diodes. It is therefore available irrespective of whether the main time-base is displayed.

With the DEL'D TB pushbutton selected, transistor TS1428 receives a high logic signal on its emitter from the alternate flip-flop (via R1643) and starts to conduct. Transistor TS1408 also conducts and, via R1424, switching diodes GR1403 and GR1404 are unblocked and the delayed time-base signal is fed to the intermediate X amplifier.
Similarly, when EXT X DEFL is selected, TS1409 conducts by an earth applied to its base via R1434. Switching diodes GR1406 and GR1407 are unblocked to permit external X deflection signals to pass to the intermediate X amplifier.

3.2.6.2. Blanking pulse switching circuit

The switching circuit for blanking pulses from the main time-base comprises transistors TS1419, TS1421, TS1422 and TS1429. The switching circuit from the delayed time-base comprises transistors TS1423, TS1424, TS1426 and TS1431. The collectors of output transistors TS1422 and TS1424 are commoned to provide an input for the Z amplifier via R507. The current injected into the Z amplifier by these transistors is 0 mA for trace unblanking and 3 mA for complete trace blanking.
The emitters of TS1419 and TS1423 are connected, via load resistors R1474 and R1489, to resistors R819 and R1219 in the main and delayed time-bases respectively. During the sweep, 3 mA flows into the main time-base generator: 0 mA flows during the hold-off period. In the OFF position of the delayed time-base TIME/DIV switch 3 mA flows into the delayed time-base generator. These currents are supplied via resistors R1473 and R1491. The collector currents of TS1419 and TS1423 are 5 mA during the hold-off period and 2 mA during the sweep. Of these collector currents, 2 mA flows to the −15 V supply via resistors R1479 and R1492. This results in a current for trace unblanking of 2 − 2 = 0 mA and current for trace blanking of 5 − 2 = 3 mA.

Assume that the MAIN TB is selected; i.e. alternate flip-flop signal via R1642 is high. Transistor TS1429 conducts and TS1421 is turned off. The current step from 0 to 3 mA is applied to the Z amplifier via TS1421. Conversely, if MAIN TB is not selected transistors TS1421 conducts and the full current step from 0 to 3 mA is short-circuited via this transistor. The input current of the Z amplifier is then 0 mA and it gives bright-up information.

Assume that only the DEL'D TB is selected; i.e. alternate flip-flop signal via R1643 is high. Transistor TS1431 conducts and TS1426 is turned off. The 0 to 3 mA blanking information is fed to the Z amplifier via transistor TS1424.

If EXT X DEFL is selected, an earth applied from SK2(C) to the bases of TS1422 and TS1424 blocks these transistors and no blanking information is fed to the Z amplifier and the trace is unblanked.

The other possibility is the main time-base intensified by the delayed time-base. During the portion of the sweep where only the main time-base is running, i.e. before the delayed time-base starts, no current flows to the Z amplifier via TS1422 and the trace is unblanked. However, the Z amplifier receives 3 mA from the delayed time-base via TS1424. Thus, the trace is blanked as the nett input current to the Z amplifier is 3 mA. As soon as the delayed time-base starts and the intensified portion begins, the current through TS1424 is zero and the Z amplifier gives bright-up of the trace. At the end of the delayed sweep the current through TS1424 is restored to 3 mA and trace blanking occurs. In the foregoing explanation only the intensified portion of the trace is visible. However, it is possible to drain off some of the 3 mA blanking current of TS1424 via the parallel transistor TS1426. The current supplied by TS1423 is drained off by TS1426 depending on the position of the INTENS potentiometer R20. The dark level can be preset by the BRILLIANCE RATIO potentiometer R1498. The INTENS control operates so that the intensity relationship between the normal and intensified part of the trace is constant.

3.2.6.3. *X preamplifier for external X deflection signals*

The X preamplifier comprises transistors TS1400, TS1401, TS1402 and TS1405. The input signal is applied to the emitter of TS1400 via resistors R1404. The input signal may be one of those used for triggering, i.e. a voltage on EXT input socket BU8, channel A or B signals, a composite trigger signal or a mains-derived signal (section 3.2.2.1.).

If EXT X DEFL is selected, the collector signal of TS1609 in the main trigger circuit is fed to R1404. The signal is amplified by transistors TS1400 and TS1402 and then applied to switching diode GR1406 in the X deflection selector stage. The base bias of transistor TS1400 is adjustable by preset R1401 which is used to balance the amplifier against trace shift when AMPL X INPUT control R22 is rotated. The latter controls the gain of the amplifier via field-effect transistor TS1403 in conjunction with the preset X DEFL GAIN control R1419.

Transistor TS1401 is a constant-current source. Trimmer capacitor C1408 provides a bandwidth adjustment for the amplifier.

3.2.6.4. *Intermediate X amplifier*

The intermediate X amplifier comprises transistors TS1412 to TS1418. The asymmetrical output signal of the X deflection selector (anodes of GR1402, GR1404 and GR1407) is applied to the base of transistors TS1412 and TS1413. An anti-phase signal is generated by means of transistors TS1417 and TS1417, resulting in a symmetrical signal being fed to the X output amplifier. The base bias of transistors TS1417 and TS1418 can be varied by X POSITION potentiometer R2. Variation of the bias causes unbalance of the push-pull amplifier, which results in a horizontal trace shift on the screen.

The amplifier offers the possibility of using either the nominal gain (x1 position of TB MAGN switch SK3), or the gain increased by a factor of 10 (x10 position of the TB MAGN switch).

In the x1 position of TB MAGN switch SK3, current source TS1416 in the emitter circuits of transistors TS1413 and TS1418 is switched in and these transistors are then operative. However, transistors TS1412 and TS1417 are inoperative because their current source TS1414 is turned off. The gain of this stage can be set by means of potentiometer R1462.

In the x10 position of TB MAGN switch SK3, TS1414 starts conducting. Consequently, transistor TS1416 turns off. Transistors TS1412 and TS1417 are switched in and the amplifier stage with TS1413 and TS1418 is inoperative. The gain of amplifier stage TS1412 - TS1417 is ten times higher than that of the previously discussed stage, and can be set by means of potentiometer R1444. Light-emitting diode GR1 indicates the 10x TB MGAN condition. The x10 amplifier is also inoperative if either the EXT X DEFL pushbutton (SK2C) or the BEAM LOCATE pushbutton (SK23) is depressed.
The outputs of both amplifier stages are connected to the final X amplifier by means of coaxial cables.

3.2.7. Final X Amplifier

The final X amplifier consists of two amplifier stages in parallel (one for each deflection plate). In the following, one half is described.

The actual amplifier comprises the cascode circuit with transistors TS1702 and TS1703. Resistors R1704 and R1707 are feedback resistors. The cascode amplifier is controlled via transistor TS1704 in common-base configuration. Resistor R1712 is the termination for the coaxial cable between the intermediate X amplifier and the final amplifier. Current source TS1701 supplies the bias current for the amplifier. The average voltage on the deflection plate is kept at +26 V by means of zener diode GR1702. Capacitor C1701 improves the h.f. response and trimmer C1703 allows phase compensation in the feedback path of the cascode circuit.

3.2.8. C.R.T. circuits

3.2.8.1. Z modulator circuit

Basically, the Z unit comprises an amplifier and a modulator/demodulator circuit for the d.c. and low frequency components of the blanking signal. The latter circuit isolates the Z unit from the high potential (−1800 V) present on the c.r.t. cathode and Wehnelt cylinder.

Input signals to the Z amplifier are received from three sources:
- the blanking pulses from the time-base via R507
- the chopper blanking pulses from the channel selection logic via R506
- an external Z input on rear-panel socket BU9 via the complementary transistors TS501, TS502.

As stated in section 3.2.6.2., the blanking current is 3 mA and the unblanking current 0 mA. Transistor TS504, connected in common-base configuration, feeds the current pulses to the amplifier stage, TS508, TS509. Front-panel control R20, the INTENS potentiometer, provides an adjustment of trace brilliance by regulating the base bias of TS503. The slider of R20 is also coupled to the delayed time-base bright-up circuit via R1501 to maintain the desired intensity ratio for all settings of R20. (See also section 3.2.6.2.)

A portion of the input current is drained off via TS503 depending on the setting of R20; the larger the current drain, the more brilliant the trace. Conversely, the more brilliant the trace, the less the common-base transistor TS504 conducts. Since TS504 is cut off, GR504 is also non-conductive and a small current flows through R518 and prevents TS509 and TS508 from bottoming.

The blanking signal is passed by TS504 to the base of TS509 via GR504. The diode GR506 in the collector circuit of TS504 clamps the black level of the blanking current fed to the amplifier at 3 mA.

The output of the amplifier stage TS509, TS508 is coupled to emitter follower TS507, the output of which switches between 4 V and 40 V approximately for blanking and unblanking respectively. At this point, the a.c. and d.c. components of the blanking signal are routed along different paths. The high frequency components of the signal are passed via capacitor C522 to the Wehnelt cylinder of the c.r.t. The d.c. and low frequency components of the signal are passed via the low-pass filter R534, C511 and R532 to the emitter of TS512. Together with TS511, TS512 forms a multivibrator, the frequency of which is approximately 30 kHz. The oscillator output on the collector of TS512 is therefore modulated by the Z amplifier, the peak-to-peak value depending on the d.c. and l.f. components fed to the emitter of TS512. The black level can be adjusted by the preset R547. Capacitor C521 feeds this modulated signal to a peak-to-peak detector and also serves to isolate the high potential present on the c.r.t. cathode circuit. After demodulation by the detector circuit GR511, GR512, C524, R564, the d.c. and l.f. components are, via R567, recombined with the a.c. components and routed to the Wehnelt cylinder of the c.r.t.

3.2.8.2. Focusing circuit

The electron beam is focused with the aid of FOCUS potentiometer R21 which controls the emitter voltage of transistor TS514. This transistor constitutes, together with transistor TS513, a multivibrator identical to the one with transistors TS511 and TS512. Across the collector resistor of TS514, R555, a signal arises with amplitude dependent on the position of FOCUS potentiometer R21. This signal is rectified in the encapsulated circuit which comprises, to this end, a double peak detector. The rectified voltage, approximately 200 V, is applied to focusing anode g3 of the c.r.t.

The emitter voltage of transistor TS514 does not only depend on the position of the FOCUS potentiometer, but is also determined by the position of the INTENSITY potentiometer R20. The signal from this potentiometer is applied to the emitter of TS514, via transistor TS516. In this way a form of compensation is obtained: the focus of the electron beam is automatically adapted when the brilliance of the trace is varied. The necessity of readjusting the FOCUS control after rotating the INTENS potentiometer is thus largely obviated.

3.2.8.3. H.T. converter

The −1800 V supply for the cathode, Wehnelt cylinder and focus electrode, and the +18 kV supply for the post-acceleration anode g9 are derived from the h.t. converter circuit.

Transistor TS2004 together with transformer T2001 forms an oscillator, operating at a frequency of between 25 kHz and 30 kHz. An a.c. waveform of 1800 V is developed across the secondary winding of the transformer. This voltage is rectified by diode GR2001 and fed to the previously mentioned encapsulated circuit. The voltage on the anode of diode GR2001 is −2170 V. The secondary voltage of transformer T2001 is also rectified and multiplied by a factor of 9 in an encapsulated multiplier circuit, in order to obtain the required +18 kV.

The output voltage of the converter is kept constant by means of a regulator circuit. This circuit comprises transistors TS2001 and TS2003. The 2 kV voltage on the cathode of the c.r.t. is fed back to the base of transistor TS2003, via resistor R573 in the encapsulated circuit. If this voltage drops, the base current of transistor TS2003 increases, as its base voltage is also connected to the +46 V voltage via resistors R2002 and R2003. An increasing base current of transistor TS2003 causes the current through transistor TS2001 to increase. As a result of this, the base current of transistor TS2004 grows and the generated voltage increases. The regulation operates in an analogous way, but in reverse direction, when the 2 kV voltage rises.

The 2 kV voltage is also protected against short-circuits (the 18 kV voltage is protected by its high internal resistance). If the current drain from GR2001 becomes too high, diode GR2003 turns off. Under normal conditions, this diode is always conducting. This means that normally the cathode is approximately 0.7 V negative with respect to earth. In case of overload or short-circuit of the 2 kV voltage, this 0.7 V is cancelled out or may even become positive, depending on the magnitude of the short-circuit current. This causes the base voltage of transistor TS2002 to go positive and this transistor starts conducting. As a result of this, the current through transistor TS2003 decreases, causing a reduction of the current through transistor TS2001. Consequently, the base current of transistor TS2004 decreases and the converter switches off.

3.2.9. Calibration Unit

The calibration unit comprises a built-in square-wave generator using an operational amplifier IC1901 with feedback loops. The frequency-determining components are resistor R1909 and capacitor C1903. Point 3 of the operational amplifier IC1901 is kept equal to the average output voltage by capacitor C1902. In this way, the generator is independent of supply voltages. Zener diode GR1901 determines the amplitude of the square-wave output, and potentiometer R1906 allows accurate adjustment of output voltage and current.

The calibration unit gives an output of 3 V_{p-p} at 6 mA at a frequency of 2 kHz ±2 %. The output is protected against continuous short-circuits.

3.2.10. Power Supply

The power supply is designed on the switching regulator principle, thus permitting the PM 3265 oscilloscope to be connected to any a.c. mains voltage between 90 V and 264 V, or any d.c. voltage between 125 V and 264 V, without the need for mains voltage adapters. All voltage output rails are stabilised and a current-limiting circuit protects against overloads.

The basic circuit functions of the power supply are as follows:
- mains rectifier and ripple elimination circuit
- switching series regulator
- chopper circuit
- voltage sensing and regulator circuit
- current-limiting circuit
- surge protection circuit
- secondary supply voltage circuits.

General

In principle, the power supply operates as follows. After rectification and elimination of the ripple, the smoothed input voltage is fed to the switching series regulator. A pulse-width modulated switching transistor and commutating diode supply a filter network which averages the voltage. This voltage provides the supply for the chopper that provides the necessary alternating waveform for the supply transformer. In addition, part of the chopper squarewave output is rectified, compared with a reference voltage and is fed back to control the on-off ratio of the switching transistor. The power supply circuits are located on printed circuit board U5.

3.2.10.1. Mains rectifier and ripple eliminator

The mains voltage or an alternative source of supply is applied to the mains filter unit via the ON/OFF switch SK22 and the slow-blow fuse VL1. The mains filter consists of two double-wound chokes L1801 and L1802, together with capacitors C1801, C1802 and C1803, followed by a second filter consisting of two HF chokes. These filters suppress mains-borne interference to the instrument and also interference from the instrument; e.g., switching transients, to the mains supply.

The mains rectifier GR1801 ... GR1804 comprises four diodes in a bridge circuit. The ripple that remains after full-wave rectification is eliminated by the action of transistors TS1800 and TS1805 and their associated components.

The ripple elimination circuit operates as follows. The buffer capacitors C1806 and C1807 are charged to approximately the peak voltage of the mains supply. Assume that the output voltage at the collector of TS1800 tends to rise with the instantaneous value of the ripple. Transistor TS1805 then draws less current as its emitter goes more positive. Therefore, less base current is applied to transistor TS1800; consequently, its collector voltage drops and counteracts the tendency for the output voltage to rise. By this means, the d.c. output level coincides with the lower level of the ripple voltage superimposed on the unsmoothed rectified voltage, and the ripple is effectively eliminated.

3.2.10.2. Switching series regulator

Transistor TS1801 is the switching transistor, the base of which is driven by the pulse-width modulated rectangular waveform. The filter network comprises the choke L1804 and the capacitors C1808 and C1809. A current flows through L1804 during the turn-on time of TS1801. During the turn-off time, the back e.m.f. of L1804 provides a current via the commutating diode GR1811. This action is repeated at a frequency of approximately 20 kHz, the chopper frequency. An output voltage is thus developed across C1808 and C1809 dependent upon the on/off ratio of the switching transistor TS1801. Capacitors C1808 and C1809 are shunted by the series resistor network R1807 and R1808 which divides the voltage equally across them. To initiate starting, a small base current is fed to transistor TS1801 via resistors R1804, R1803, R1825, the auxiliary winding of L1804, and R1817.

To limit power dissipation in TS1801 during switching, positive feedback applied to the base circuit from the auxiliary winding of L1804 assists the transistor to reach saturation or to discharge the base. The choke, in series with TS1801 and L1804, also reduces the initial peak energy in TS1801, since for the leading edge it is effectively the only collector load.

3.2.10.3. Chopper circuit

The chopper circuit is formed by transistors TS1803 which, together with the base drive transformer T1801, form a push-pull oscillator. The primary windings 3-4-5 of the converter transformer T1802 provide the collector loads for the chopper transistors. Winding 7-8 supplies the driver transformer T1801 and also the necessary supply for IC1801. As the driver transformer T1801 saturates easily, a squarewave signal is generated.

The chopper is started by the voltage developed across zener diodes GR1813 and GR1814. When the combined zener voltage (95 V) is attained a starting base current is supplied to the chopper transistors via R1813 and the centre-tap of the driver transformer, T1801. As the chopper starts, the voltage across C1808 and C1809 falls but rises again due to the current supplied by TS1801 controlled by the regulator circuit. If, for any reason, the chopper fails to start, thyristor TS1802 is fired by the excess voltage developed across C1800. The thyristor thus provides a fusing function by discharging the output voltage build-up across capacitors C1808 and C1809.

During oscillation, a voltage is developed on the centre-tap of the driver transformer T1801 of approximately 1 V negative with respect to the anode of GR1816. With this negative potential on the base circuit faster discharging of the hole-storage capacitance for the chopper transistors is realised. Between base and collector of both transistors TS1803, diodes are connected to prevent excessive saturation.

3.2.10.4. Voltage sensing and regulator circuit

Regulation of the chopper output is achieved by comparing a portion of its output voltage against a stable reference and feeding the error voltage back via an operational amplifier to control the on/off ratio of the switching transistor. The basic components of the sensing and regulating circuit are primary winding 7-8 of TS1802, integrated circuit IC1800, potentiometer R1828 and transistor TS1806.

The circuit operates as follows. The squarewave voltage of approximately 20 V_{p-p} across winding 7-8 of T1802 is half-wave rectified by GR1824 and produces a d.c. voltage of approximately −8 V with a superimposed ripple of about 350 mV^{p-p} across C1817. An internal voltage reference (7 V with respect to the −8 V) between points 4 and 5 of IC1801 result in an input voltage at point 2, via R1826, of approximately −1 V. The ripple voltage superimposed on this d.c. reference via C1814 is used to control the switching level by comparison with the error voltage at the non-inverting input.

This input 3 of IC1800 is connected to the wiper of R1828, the potentiometer that measures the error voltage across C1817 via R1827, R1829 and diode GR1823 to the "O". The remaining ripple of this point is filtered by capacitor C1816. Diode GR1823 conducts via R1831 because of the positive potential across C1818 of approx. +8 V.

Although the ripple at the inverting input 2 approximates to a sawtooth waveform, because of the high gain of the amplifier, the output on point 6 is a rectangular waveform. The on/off ratio of this rectangular waveform is dependent upon the internal reference voltage with superimposed ripple compared with the error voltage on wiper R1828. This rectangular waveform on point 6 is applied to the base of TS1806 which, in turn, controls the on/off time of the switching transistor TS1801.

The overall function of the voltage sensing and regulator circuit is best considered by assuming a change in output. Any tendency for the output to increase would produce an increase in voltage across C1817. The voltage on input 2 of IC1800 will go more negative as a result. Likewise, the voltage on input 3 will go more negative, but to a lesser extent because of the dividing action of the potentiometer R1828 and its associated circuit. Because of this differential, input 2 will be more negative with respect to input 3. In terms of the output on point 6, this means that the positive-going rectangular waveform will be of longer duration over the duty cycle. This signal is inverted by transistor TS1806, which results in transistor TS1801 being blocked for a longer period. Consequently, the output of the switching series regulator decreases and restores circuit equilibrium.

In addition to output sensing, forward control is provided from the mains voltage. Input 3 of IC1801 is also coupled to the rectified mains voltage via resistor R1806. Any variation in mains voltage will be reflected at the input 3 of IC1801. The resulting differential with respect to input 2 will produce a compensating regulating action as described.

3.2.10.5. Current-limiting circuit

A current sensor circuit automatically cuts off the series regulator if excessive current is demanded by the circuit. The current-limiting circuit comprises transistor TS1811, thyristor TS1808 and their associated components.

The current supplied by the power unit flows through the series resistor R1802 and the potential drop across this resistor is used to control transistor TS1811. If the supply current becomes excessive, transistor TS1811 starts to conduct. In turn, TS1808 fires and feeds a positive current in to the base of TS1806. This transistor conducts and turns off switching transistor TS1801. Consequently, the chopper stops operating. However, the small base current fed to TS1801 via resistors R1804, R1803 and R1817 enables C1808 and C1809 to charge. When the zener potential of GR1813 and GR1814 is reached, the chopper restarts and is switched off again immediately if the overload or short-circuit persists. Depending on the mains voltage, this cycle is repeated so long as the fault condition persists.

3.2.10.6. Surge protection

In similar manner to the current-limiting circuit, a surge protection circuit cuts off the switching series regulator if, for any reason, the output voltage of the power supply is too low for the amplifier IC1801 to give satisfactory control. Voltage sensing is performed by transistor TS1807. During initial switch-on of the instrument, if the voltage across winding 7-8 is too low, TS1807 is cut off because of the voltage threshold of 3.6 V on its base.

Consequently, the positive potential developed across C1819 is applied via R1832 to the base of TS1806. This transistor conducts and turns off switching transistor TS1801. The circuit prevents damage to the switching transistor, which could occur if it were operated with insufficient base current.

When its threshold voltage is reached, TS1807 conducts and passes the base current of TS1806. Transistor TS1806 is blocked and allows TS1801 to conduct via R1818. The RC time-constant of R1832 and C1819 is shorter than that of the +8 V supply to the integrated circuit at switching on and, due to lower power consumption, is stable for a longer period at switching off.

3.2.10.7. Secondary supply voltages

The primary windings of the supply transformer T1802, as previously stated, are the collector load circuits of the chopper transistors. The secondary windings providing the voltages for the various circuits in the instrument are completely isolated from the mains power supply.

The filament of the c.r.t. is supplied by the voltage across secondary winding 17-18, rectified by GR1831 and smoothed by electrolytic capacitor C1824. One side of the winding is a.c.-coupled to earth via C1825.

All other supply feeds are derived from tapping points on a single secondary winding, earthed at a single point (10) to the transformer screen to reduce interference. Each supply is individually rectified and smoothed.

3.2.10.8. Mains triggering opto-isolator

The trigger source or X display derived from the mains supply is completely isolated from dangerous mains voltages by an opto-isolator TS1809. This consists of a light-emitting diode and photo-transistor in one envelope. The a.c. mains derived from the mains filters is rectified by diode GR1828, smoothed by C1821 to provide a d.c. current through the light-emitting diode. A portion of the a.c. mains is superimposed on this d.c. current, the magnitude being determined by the value of resistor R1836. The output is routed to the trigger amplifier via capacitor C1812.

3.3. DISMANTLING THE INSTRUMENT

3.3.1. General information

Warning: The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.

The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened.
If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only be a skilled person who is aware of the hazard involved.
Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.

This section provides the dismantling procedures required for the removal of components during repair operations. All circuit boards removed from the oscilloscope should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed. During dismantling procedures, a careful note must be made of all disconnected leads so that they may be reconnected to their correct terminals during assembly.
The E.H.T. cable is unbreakably connected to the c.r.t.
When the E.H.T. cable to the post-acceleration anode of the c.r.t. is disconnected at the E.H.T. unit end, the E.H.T. cable must be discharged immediately by shortening them to earth.

Damage may result if the instrument is switched on when a circuit board has been removed, or if a circuit board is removed within one minute after switching off the instrument.

3.3.2. Removing the cabinet plates and the screen bezel

Both upper and lower cabinet plate can be removed after slackening one or two turns the four quick-release fasteners at the corners of each plate. Do not slacken the fasteners more than two turns, otherwise they may come apart.

The screen bezel can be detached by pressing the longer edges and pulling out.

3.3.3. Removing the knobs

3.3.3.1. Single knobs

- Prise off cap A
- Slacken screw (or nut) B
- Pull the knob from the spindle

3.3.3.2. Double knobs

- Prise off cap A and slacken screw B
- Pull the inner knob from the spindle
- Slacken nut C and pull the outer knob from the spindle

When fitting a knob or cap, ensure that the spindle is in a position which allows reference lines to be coincident with the markings on the text plate of the oscilloscope.

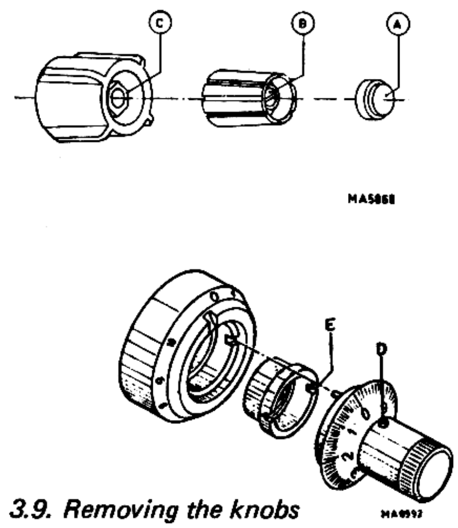


Fig. 3.9. Removing the knobs

3.3.3.3. Delay-time multiplier knob

- Slacken screw D using a hexagonal key and pull the knob from the spindle
- Remove the nut E and withdraw the ring from the spindle

When fitting the vernier control, turn the spindle of the potentiometer fully anticlockwise. Place the ring on the spindle so that the reference line corresponds to the zero mark on the calibrated scale. Then lock it with nut E. Fit the inner knob so that its cam is engaged with the slot in the ring. Rotate the inner knob until its zero mark coincides with the reference line on the ring. Secure the assembly by tightening screw D.

3.3.4. Removing the circuit boards of: Main time-base
Delayed time-base
Switching unit
Intermediate amplifier

These circuit boards can be easily removed after disconnecting the various plugs and unscrewing the screws that secure the boards to the chassis. For the intermediate amplifier also unsolder the Delay-line connections

3.3.5. Removing the circuit board of the final X amplifier

- Remove the rear plate of the instrument (two screws)
- Remove the two screws A that secure the supports to the rear panel
- Disconnect the miniature coaxial plugs and the single-wire connectors
- Unplug the four multipole connectors and disconnect the two wires from the c.r.t. pins
- Remove the circuit board from the oscilloscope

3.3.6. Removing the circuit board of the final Y amplifier

- Remove the rear plate of the instrument (2 screws)
- Slacken both screws of the final X amplifier
- Remove the two screws B which secure the supports to the rear panel
- Disconnect the miniature coaxial plugs
- Unplug the multipole connectors and disconnect the two wires from the c.r.t. pins
- Remove the delay-line connections
- Remove the c.r.t. filter connections (2 soldering connections and 2 single-wire connectors on the soldering side of the board) and carefully lift out the circuit board

3.3.7. Removing the circuit board of the power supply

- Remove the rear plate of the instrument (2 screws)
- Remove the screws which secure the circuit board to the rear panel
- Unplug the three multipole connectors and disconnect the two single-wire connectors
- Disconnect the three wires of the mains filter
- Carefully withdraw the circuit board from its compartment

3.3.8. Removing the E.H.T. circuit board

- Remove the metal housing
- Unplug the multipole connectors
- Disconnect the E.H.T. connector after unscrewing the swivel nut and discharge the cable
- Unscrew the three hexagonal spacers and remove the circuit board
- Before screwing the E.H.T. cable on to a replacement E.H.T. unit, the E.H.T. connector should be greased with Silicon Dielectric Compound. Order no. 4822 390 20023).

3.3.9. Removing an attenuator unit

- Remove the appropriate V/div. knobs and the nut under these knobs
- Unplug the multipole connector and the miniature coaxial plug on the circuit board of the intermediate amplifier
- Disconnect the earthing wire
- Remove the two screws that secure the lower part of the attenuator unit to the front panel
- Carefully lift the attenuator unit out of the oscilloscope

3.3.10. Removing the focus unit

- Remove the circuit board of the X output amplifier in accordance with section 3.3.5.
- Remove the metal housing of the E.H.T. unit (3 screws) and unplug the multipole connector of the focus unit
- Unsolder the three wires on the c.r.t. base (white, blue and yellow)
- Remove the focus unit by pressing the longer edges together

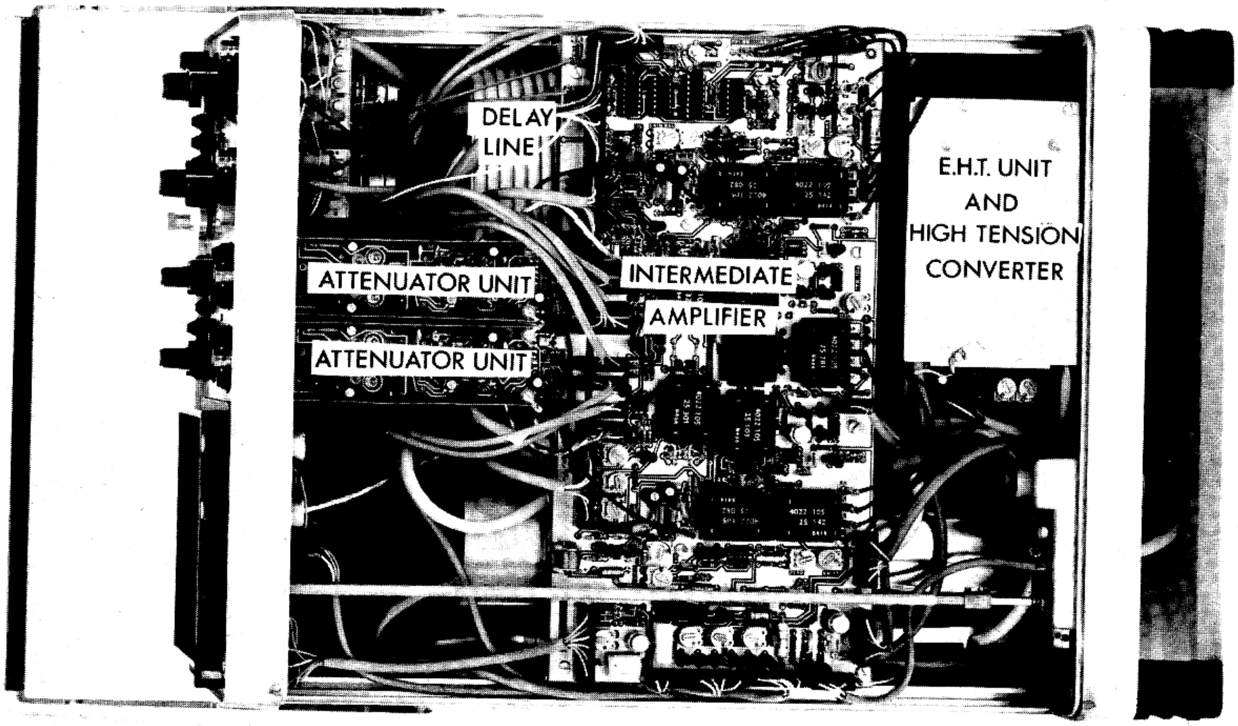


Fig. 3.10. Bottom view

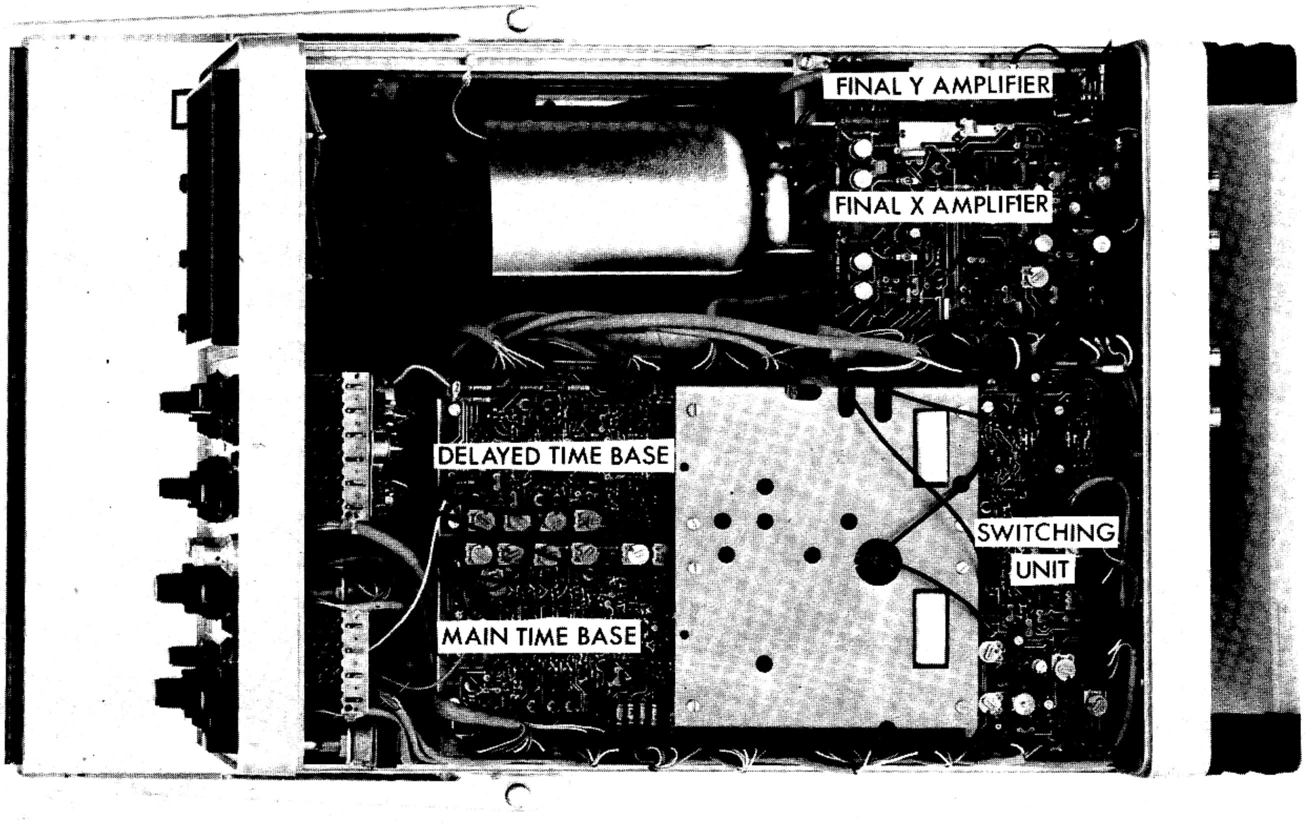


Fig. 3.11. Top view

3.3.11. Removing the cathode-ray tube

ATTENTION: Be very careful with the side connections of the c.r.t. If these pins are bent, the c.r.t. is likely to develop a gas leak.

- Slacken the brace round the c.r.t. neck and remove the connections between c.r.t and Y output amplifier
- Remove the tube base
- Unplug the multipole connector of the orthogonality and trace-rotation coils on the intermediate amplifier
- Remove the metal housing of the E.H.T. unit and disconnect the E.H.T. cable (discharge the cable)
- Slacken the upper plastic centring bracket at the c.r.t. front
- Slacken the two screws that secure the mu-metal screening pipe to the rear chassis.
- Remove the bezel
- Carefully withdraw the c.r.t. through the front panel of the instrument
- If the rubber sleeve around the neck of the c.r.t. must be slid over the neck of a replacement tube, the use of industrial talcum powder is strongly recommended.

3.3.12. Removing the push-button sets

Each of the push-button sets mentioned below is fitted to the front panel by means of two clamping devices:

The A/ALT/CHOP/ADD/MULT/B set
The DEL'D TB/ALT TB/EXT X DEFL/MAIN TB set
The NORM/INVERT & NORM/INVERT set
The STARTS/TRIG & AUTO/TRIG/SINGLE set
The DC/LF/HF & DC/LF/HF & A/B/EXT & A/B/EXT/MAINS set

To remove a push-button set, the two recessed-head screws that secure the set to the front panel must be removed.
To replace one switch of a push-button set, refer to Fig. 3.12.

Before a push-button set is refitted, it is advisable to stick the two parts of the clamping device together by means of adhesive tape or non-hardening glue, in order to facilitate the replacement.

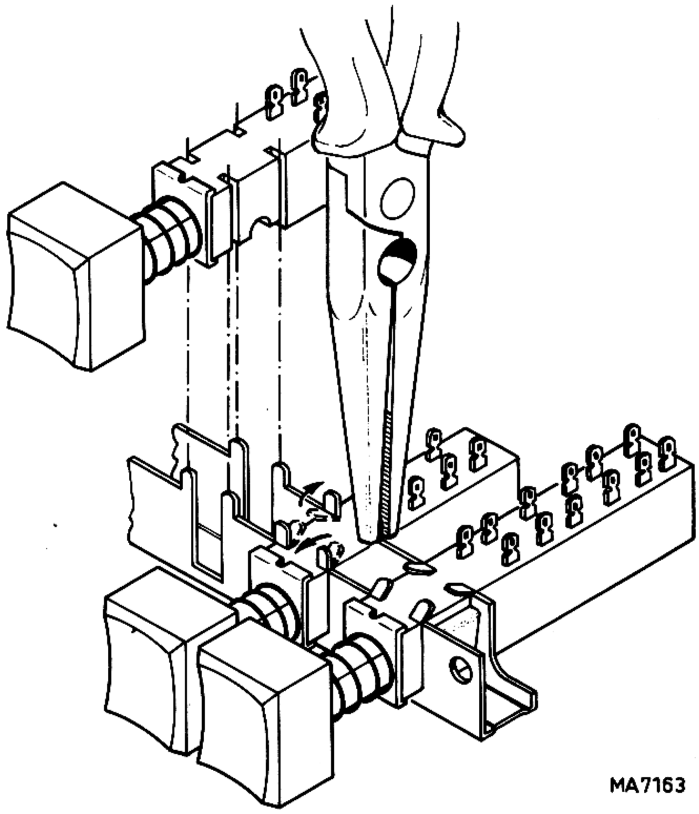


Fig. 3.12. Replacing a switch of a push-button set

3.3.13. Removing the carrying handle

1. Remove the upper and lower cabinet plates
2. Remove the plastic strip which is snapped on to the grip
3. Remove the two screws which secure the grip to the right-hand bracket
4. Remove the two hexagonal bolts which secure the right-hand bearing to the side strip
5. Depress the push-button of the right-hand bracket and take the bearing from the bracket.
6. Remove the grip from the remaining bracket
7. Depress the push-button of the left-hand bracket and turn the latter as far as possible to the lower side of the instrument
8. Keep the push-button depressed and pull the bracket from its bearing

3.3.14. Special tools

ATTENTION: When you are soldering inside the instrument it is essential to use a low-voltage soldering iron, the tip of which must be earthed to the mass of the oscilloscope.

3.3.14.1. Soldering iron for semi-conductors in micro-miniature encapsulations (SOT23)

Because of the small dimensions of these SOT23 semi-conductors and the lack of space between the components on the printed-wiring board, it is necessary to use a miniature soldering iron with a pin-point tip (max. dia 1 mm) to solder a SOT on to a printed-wiring board.

Work method:

– Unsolder pin A (Fig. 3.13)

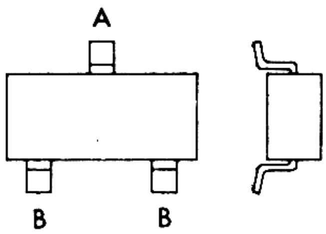


Fig. 3.13. SOT23 transistor

– Unsolder pins B and remove the SOT from the printed-wiring board
– Remove the superfluous solder and smooth down the soldering spots on the printed-wiring board. In this way, all three connection pins of the SOT are in contact with the printed conductors at the same time and damage to the SOT as a result of bending the pins, is prevented.
– Place the new SOT onto its soldering spot and keep it in place
– Solder the pins A and B to the printed-wiring board

NOTE: Bear in mind that the maximum permissible soldering time is 10 seconds during which the temperature of the pins must not exceed 250 °C. We, therefore, recommend the use of a solder with a low melting point, e.g. silver-containing solder (59 %tin, 34 % lead, 6 % silver, melting point 180 °C, order number 5322 390 84001).

Take care not damage the plastic encapsulation of the SOT during the soldering procedure (softening point of the plastic is 150 °C).

A suitable soldering-iron is e.g.
Low Voltage Mini Soldering Iron, Type 800/12 W - 6 V, power 12 W, voltage 6 V, order no. 4822 395 10004, in combination with 1-mm-pin-point tip, order no. 4822 395 10012.

3.3.14.2. Special tool for the slotted nut of attenuator switches A and B, order no. 5322 395 54023

For those who want to make such a tool, we give a sketch with the dimensions in mm in Fig. 3.14. The material is silversteel N094, tempered 40-45 Rc.

3.3.14.3. Special tool for the slotted nut of the POSITION and LEVEL/SLOPE potentiometer, order no. 5322 395 54024

For those who want to make such a tool, we give a sketch with the dimensions in mm in Fig. 3.15. The material is silversteel N094, tempered 40-45 Rc.

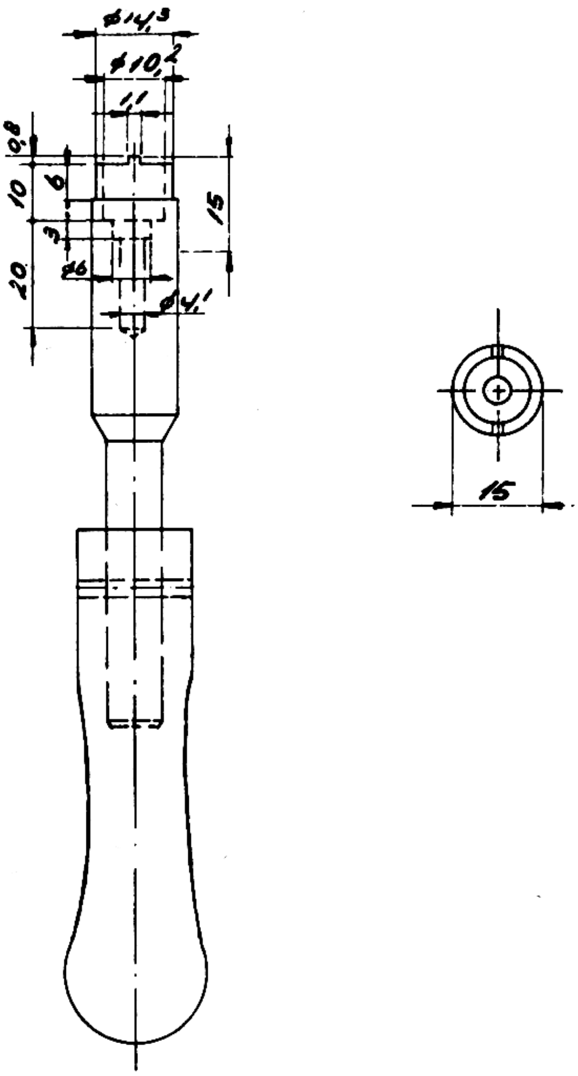


Fig. 3.14. Tool for attenuator unit order nr. 5322 395 54023

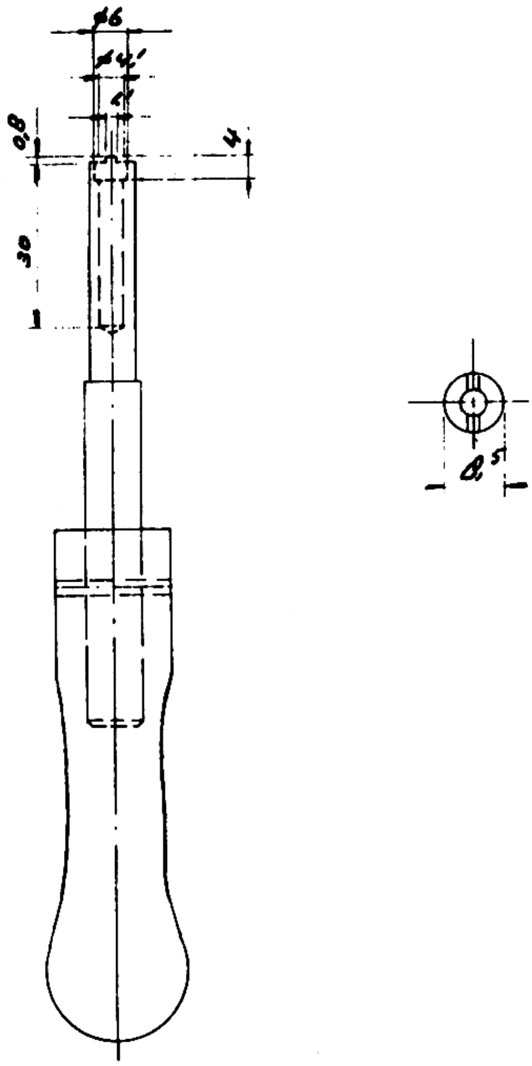


Fig. 3.15. Tool for positioning potentiometer order nr. 5322 395 54024

3.4. CHECKING AND ADJUSTING

3.4.1. General information

Refer also to 3.3.1.
The following information provides the complete checking and adjusting procedure for the PM 3265 oscilloscope. As various control functions are interdependent, a certain order of adjustment is often necessary. The procedure is, therefore, presented in a sequence which is best suited to this order, cross-reference being made to any circuit which may affect a particular adjustment. Before any check or adjustment, the instrument must attain its normal operating temperature. Under average conditions this will be approximately 30 minutes after switching on.

All controls that are mentioned without item numbers are located on the front panel of the oscilloscope.

3.4.2. Recommended test equipment

Digital multimeter, e.g. PHILIPS type PM 2421 or PM 2422A.
Pulse generator, rise time ≤ 1 ns, e.g. Tektronix type 106 or 284.
Constant amplitude signal generator, e.g. Tektronix type 067.0532.01.
R.C. Standardizer, 1 MOhm//15 pF, e.g. Tektronix type 067.0537.00.
Time-marker generator, e.g. Tektronix type 2901.
Oscilloscope with ≥ 250 MHz bandwidth e.g. PM 3400.

3.4.3. Preliminary control settings

- Depress push-buttons NORM of the polarity controls.
- Depress push-buttons DC of the signal-coupling controls.
- Set the DELAY TIME control to 0 (fully anti-clockwise).
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Push the TB MAGN control to position x1.
- Depress push-buttons STARTS and AUTO of the trigger-mode controls.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to OFF.
- Set the continuous TIME/DIV controls to CAL.
- Depress push-buttons DC of the trigger-coupling controls.
- Depress push-buttons A of the trigger-source controls.

3.4.3.1. If necessary, check the power supply voltages first, refer to 3.4.9.

3.4.4. Cathode-ray tube circuit

3.4.4.1. Focus and astigmatism

- Depress push-button A of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Apply a sine-wave signal at a frequency of 100 kHz to input A.
- Adjust the display height to 6 div, using the AMPL switch and vernier.
- Set the MAIN TIME/DIV switch and the LEVEL potentiometer to such a position that several complete cycles are displayed.
- Set the INTENS potentiometer for normal brilliance.
- Check that a reasonably sharp trance can be obtained with the aid of the FOCUS potentiometer. If necessary, readjust potentiometer R579 (ASTIGM.) on the H.T. converter board.
- Increase the trace brilliance using the INTENS potentiometer.
- Check that still a sharp trace can be obtained with the aid of the FOCUS potentiometer.

3.4.4.2. Brilliance

- Depress push-button A of the display-mode controls.
- Depress push-button DEL'D TB of the horizontal-deflection controls.
- Turn the INTENS potentiometer clockwise.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to 1 μs.
- Depress push-button 0 of the signal-coupling controls.
- Check that the dot at the start of the trace is just visible.
  If necessary, readjust potentiometer R547 (INTENSITY) on the horizontal output-amplifier and Z amplifier circuit board.

- Set the MAIN TIME/DIV switch to 0.02 μs and the DEL'D TIME/DIV switch to OFF.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Pull the TB MAGN switch to x10.
- Set the INTENS potentiometer for normal brilliance.
- Check that the brilliance is uniform over the entire trace.
  If necessary, readjust trimmers C509 and C525 (BLANK. PULSE) located on the horizontal output-amplifier and Z-amplifier circuit board.

3.4.4.3. Intensity ratio

- Depress push-button A of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Turn the DELAY TIME control to 5.0 (mid-position).
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to .2 ms.
- Depress push-button AC of the signal-coupling controls.
- Apply a sine-wave signal at a frequency of 100 kHz to input A.
- Set the display height to 6 div.
- Set the INTENS potentiometer to a position 90° from the anti-clockwise stop.
- Check that the trace of the main time-base generator is just visible over the entire screen and that the part determined by the delayed time-base generator is more brilliant. If necessary, readjust the INTENS RATIO potentiometer R1498 on the X deflection selection circuit board.

3.4.4.4. Trace rotation

- Depress push-button A of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Centre the time-base line, using the POSITION controls.
- Check that the time-base line runs exactly in parallel with the horizontal lines of the graticule; if necessary, readjust TRACE ROT potentiometer R589 on the intermediate amplifier circuit board.

3.4.4.5. Shift correction

- Depress push-button A of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Connect a d.c. voltmeter to the vertical-deflection plates.
- Set the channel A POSITION potentiometer to obtain a voltage of 0 V (±300 mV) between the deflection plates.
- Check that the time-base line is displayed exactly in the centre of the screen; if necessary, readjust SHIFT CORR. potentiometer R588 on the intermediate-amplifier circuit board.

3.4.4.6. Orthogonality

- Depress push-button ALT of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Depress push-button 0 of the channel A signal-coupling controls.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TB switch to 5 μs/DIV.
- Set the channel B AMPL switch to 5 mV/DIV and its vernier control to CAL.
- Apply a sine-wave voltage of 120 mV, frequency 100 kHz, to input B.
- Centre the intensified part, using the DELAY TIME control.
- Centre the channel A time-base line, using the channel A POSITION potentiometer.
- Check that the angle between the horizontal and vertical line is 90° see Fig. 3.16. if necessary, readjust X-Y CORR potentiometer R587 on the intermediate-amplifier board.
- Check also trace rotation (chapter 3.4.4.4.).

3.4.4.7. Geometry (= Barrel-pin cushion distortion)

- Depress push-button A of the display-mode controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Apply a sine-wave voltage at a frequency of approx. 100 kHz to input A.
- Set the AMPL. controls to obtain a display of 7,4 div.
- Apply a sine-wave voltage at a frequency of approx. 50 Hz to input B.
- Depress push-button EXT X DEFL of the horizontal-deflection controls.

– Set the channel B AMPL switch and the X AMPL control to obtain a display width of 9,4 div.
– Check that the edges of the display lie within the hatched area shown in Fig. 3.17; if necessary, readjust the GEOMETRY potentiometer R568 on the H.T. converter board.

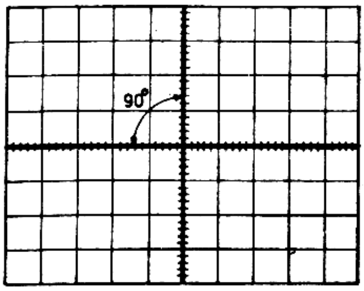


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Fig. 3.16. Orthogonality check

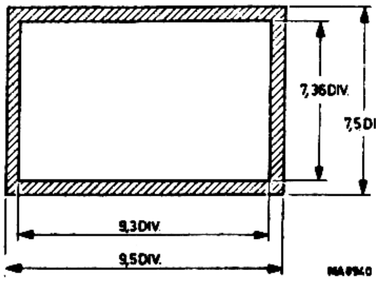

Fig. 3.17. Geometry check

3.4.5. Vertical deflection

3.4.5.1. Balance

1. D.C./O Balance

   – Set the Ampl. Switch to 5 mV/DIV.
   – Depress alternately the DC and O coupling switch and adjust for min. jump with R15 (Bal. control on the front panel).

2. Attenuator Balance

   – Depress push-button A (B) of the display-mode controls.
   – Centre the time-base line, using the POSITION control.
   – Turn the AMPL switch between 20 mV/DIV to 5 mV/DIV.
   – Check that the trace does not jump more than 0,3 DIV; if necessary, adjust the BAL potentiometer R131.

3. Gain balance

   Before adjusting the Gain Balance, first check D.C. Balance and Att. Bal.

   – Rotate the AMPL vernier control between maximum and minimum.
   – Check that during this procedure the time-base line does not shift more that 0,3 DIV; if necessary, readjust GAIN BAL potentiometer R211 (R311) on the intermediate-amplifier board.

4. Polarity balance

   Before adjusting the Polarity Balance; the D.C. Balance, Att. Bal. and the Gain Balance must be adjusted in accordance with previous sections.

   – Check that the time-base line does not shift more than 0,3 DIV when push-button INVERT of the polarity controls is depressed; if necessary, readjust POL BAL potentiometer R353 (R253) on the intermediate-amplifier board.

5. D.C. Balance Y-output

   – Centre the time-base line using the position control.
   – Connect a DC voltmeter to the Y-output (rear of the instrument).
   – Adjust the DC balance on the rear panel so that the voltage is zero volts (±10 mV).

6. AC/D.C. Gain Balance Attenuator

   Apply a square-wave-voltage of approximately 100 mV at 20 mV/DIV of 200 Hz and adjust the D.C.-gain, R138 such that the square-wave response is correct.

3.4.5.2. Gain

– Depress push-button A (B) of the display-mode controls.
– Depress push-button NORM of the polarity controls.
– Set the AMPL switch to .5 V/DIV.
– Set the AMPL vernier control to CAL.
– Depress push-button DC of the signal-coupling controls.
– Apply a square-wave voltage of 200 Hz with an amplitude of exactly 3 V to input A (B).
– Check with an auxiliary oscilloscope the Y-output at the rear for exactly 50 mV/div (loaded with 50 Ω) if

– Check that the display height is exactly 6 div. If necessary adjust R432 (Final Amplifier). Check that the display height is more than 6,5 div. with gain (front) control complete clock-wise.
– Check that the control range of the AMPL vernier control is at least 1:2,5.

3.4.5.3. Frequency response of vertical amplifiers

In the following section the three stages are checked: Final Y amplifier, Intermediate amplifier, Attenuators. For adjustment of the final Y amplifier first the channel-selector chopper output voltage is used as a calibration signal.
The channel selector is controlled by an external variable frequency square-wave generator which is connected to the ALT control socket on the intermediate amplifier circuit board.
Later on, the final Y amplifier, in combination with intermediate amplifier and attenuators is calibrated with the aid of a ⩽ 1 ns rise time pulse.

1. Final Y amplifier

For good h.f. response check also the filter-coils which are mounted in the c.r.t. Y deflection pins (check the pins for clean contact).

– Depress push-button ALT of the display-mode controls.
– Depress push-buttons COMP of the trigger-mode controls.
– Set the POSITION controls to obtain a distance of 6 div between both time-base lines.
– Remove the main-time base connector from the alternate-control pulse socket on the intermediate-amplifier board.
– Connect the square-wave generator to the alternate-pulse socket via a 330 ohm resistor.
– Set the output voltage of the square-wave generator to approx. 1 V pos.
– Both time-base lines will be displayed alternately at a frequency determined by the frequency of the square-wave voltage.

1 kHz, R407
– Set the generator frequency to 1 kHz.
– Set the main-time base controls to obtain a suitable, triggered display.
– Check that the top of the displayed pulse is straight; if necessary, select a different value for resistor R407.

10 kHz, R403, C402
– Set the generator frequency to 10 kHz.
– Set the main-time base controls to obtain a suitable, triggered display.
– Check that the top of the displayed pulse is straight; if necessary, select a differenct value for resistor R403 and capacitor C402.

100 kHz, R404, C403
– Set the generator frequency to 100 kHz.
– Set the main-time base controls to obtain a suitable, triggered display.
– Check that the top of the displayed pulse is straight; if necessary, adjust potentiometer R404.

1 MHz, R406, C404
– Remove the external generator.
– Depress push-button CHOP of the display mode controls.
– Centre both time-base lines to obtain one line.
– Reconnect the ALT control pulse plug to its relevant socket.
– Set the main time base controls to obtain a suitable triggered display.
– Check that the displayed line is straight; if necessary, adjust potentiometer R406.

2. Intermediate amplifier

To be sure that the intermediate amplifier is driven by the correct signal, first the attenuator is checked.

– Depress push-button NORM of the polarity controls.
– Depress push-button DC of the signal-coupling controls.
– Set the AMPL vernier control to CAL.
– Set the AMPL switch to 10 mV/DIV.
– Apply a square-wave voltage with a rise time ⩽ 200 ns and a frequency of approx. 20 kHz to input A (B).
– Set the amplitude of the input signal to obtain a trace height of 6 div.
– Connect an oscilloscope to the attenuator output: point 12 of IC 352 (IC 302) on the Intermediate amplifier board.
– Check that the top of the displayed pulse is straight; if necessary, readjust trimmer C108 on the

– If required, the frequency correction of the intermediate amplifier is possible with correction networks connected between points 13 and 15 of Amplifier I and between points 12 and 14 of Amplifier II. Start always with the longest RC time network, with a square wave voltage of 1 kHz and increase to 10 kHz, 100 kHz and 1 MHz.

3. H.F. overall Response

1 MHz, R323 (R223), R408, R409, R410, C407
– Depress push-button A (B) of the display-mode controls.
– Depress push-button NORM of the polariaty controls.
– Set the AMPL switch to 10 mV/DIV.
– Apply a square-wave voltage with a rise time of $\leqslant$ 1 ns and a frequency of 1 MHz to input A (B).
– Set the MAIN TIME/DIV switch to 0.1 μs.
– Pull the TB MAGN switch x10.
– Check that there is an optimum pulse response; if necessary, adjust R323 (A) and R223 (B) on the intermediate amplifier board and R408, 409, 410 and C407 on the final amplifier board, at the same time readjusting TERMINATION potentiometer R423.

After this adjustment check the gain as follows:
– Set the generator frequency to 1 kHz.
– Set the generator output voltage to 60 mV.
– Check with an auxiliary oscilloscope the 50 Ω Y output for exactly 300 mV.
– Check that the trace height is 6 div, if necessary, readjust potentiometer R432 on the final Y amplifier board.

4. Multiplier, Balance, H.F. corrections, Gain, Bandwidth and Noise reduction.

Pol. Balance
– Depress push-button MULT. of the display-mode controls.
– Depress alternately NORM/INVERT for channel B or A and adjust for min. jump with R276.

H.F. Corrections
– Depress push-buttons DC for both A and B input-coupling controls.
– Set the Ampl. Switch for both A and B to 10 mV/DIV.
– Apply a DC voltage of ±10 mV to input B.
– Apply a square-wave voltage of 40 mV^{p-p} to input A with the following frequencies:

100 Hz	Check for correct response
1 kHz	Check for correct response
10 kHz	Check for correct response
100 kHz	Check for correct response, if necessary select different values for the HF correction elements R267 and C239. Correction of the leading edge with C241. For the highest frequencies adjust R272.

Multiply Offset compensation (OxA), (OxB)
– Apply a 80 mV^{p-p} sine wave voltage 50 kHz to input A at 10 mV/DIV setting.
Depress push-button O for the input-coupling controls for channel B.
Adjust with front-panel potentiometer OxA to minimum.
– Apply a 80 mV^{p-p} sine voltage, 50 kHz, to input B at 10 mV/DIV setting.
Depress push-button O for the input-coupling controls for channel A.
Adjust with front-panel potentiometer OxB to minimum.

Multiply Gain
Input A and B at 10 mV/DIV and DC coupling.
Apply to the A input a Sine voltage 50 kHz of 40 mV^{p-p}.
Apply to the B input a DC voltage of exactly 10 mV.
Adjust the multiply gain (front panel) control to a product of exactly 4 div.

Multiply Bandwidth
– Both Attenuators to 10 mV/DIV.
– Apply to input A a constant sine voltage of 40 mV.
Apply to input B a DC voltage of 20 mV.
The upper limit where the bandwidth falls down to –3 dB must be $\geqslant$ 100 MHz.

– Apply to input B a constant sine wave voltage of 40 mV.
Apply to input A a DC voltage of 20 mV.
The upper limit where the bandwidth falls down to –3 dB must be ≥ 100 MHz.

Noise reduction

– Noise reduction with bandwidth limitation is possible by connecting rc networks on the output of amplifier III (12 and 14).

5. H.F. compensation Y output

– Connect an oscilloscope with 50 Ω input impedance to the Y output on the rear.
– Apply a square-wave voltage at channel A of 6 div at 10 mV/DIV, DC coupling.

100 Hz	Check for correct response
1 kHz	Check for correct response
10 kHz	Check for correct response
100 kHz	Check for correct response, if necessary select different values for C259 and R292. Correction of the leading edge with C261.

– Check the bandwidth with a constant sine wave voltage up to the –3 dB point which must be ≥ 150 MHz.

6. Attenuator

– Depress push-button A (B) of the display-mode controls.
– Depress push-button NORM of the polarity controls.
– Depress push-button DC of the signal-coupling controls.
– Apply a square-wave voltage with a rise time ≤ 200 ns and a frequency of 20 kHz to input A (B).

Frequency compensation

– Set the AMPL switch to the positions indicated in the following table, at the same time setting the input amplitude to the appertaining value.
– Check that there is a correct display of the input signal; if necessary, readjust the relevant trimmer.

AMPL switch to	Signal at input A (B)	Adjust with
10 mV/DIV	Already adjusted (C108) in intermediate amplifier adjustment; refer to 3.4.5.3.2.	
.1 V/DIV	600 mV	C101
1 V/DIV	6 V	C109

Input capacitance

– Apply the square-wave input voltage (rise time ≤ 200 ns, frequency 20 kHz) to input A (B) via an RC Standardizer of 1 MOhm//15 pF.
– Set the AMPL switch to the positions indicated in the following table, at the same time setting the input amplitude to the appertaining value.
– Check that there is a correct display of the input signal; if necessary, readjust the relevant trimmer.

AMPL switch to	Signal at input A (B)	Adjust with
10 mV/DIV	60 mV	C107
.1 V/DIV	600 mV	C102
1 V/DIV	6 V	C111

3.4.5.4. Chopping

– Depress push-button CHOP of the display-mode controls.
– Depress push-button MAIN TB of the horizontal-deflection controls.
– Set the MAIN TIME/DIV switch to 0.2 μs.
– Check that there are two time-base lines displayed which can be shifted in relation to one another by means of the POSITION controls.
– Set the POSITION potentiometers to obtain a distance of 3 div between the two lines.
– Depress push-button EXT of the main time-base trigger-source controls.
– Apply the chopper signal (available at point 6 of IC1602 on the intermediate amplifier circuit board) to the EXT input of the main time-base. It is then possible to trigger the time-base generator with the chopper frequency.

- Set the LEVEL potentiometer for a triggered display.
- Check that the chopper frequency is approx. 1 MHz.
- Check that each signal is displayed for approx. 300 ns.
- Check that the trace is blanked during the channel-switching.
- Check that this blanking time is approx. 200 ns.

3.4.5.5. Common mode rejection

- Depress push-button ADD of the display-mode controls
- Depress the INVERT push-button of the channel B signal-polarity controls
- Set the AMPL switches to 5 mV/DIV
- Apply a sine-wave voltage simultaneously to sockets A and B
- Check the rejection in accordance with the following table

Note: Adjust the continuous AMPL control of channel A or channel B for minimum trace height

Input voltage	Generator frequency	Max. trace height	Rejection factor
120 mV	100 kHz	0,24 DIV	> 100
120 mV	2 MHz	0,24 DIV	> 100
120 mV	50 MHz	1,20 DIV	> 20

- Disconnect the input voltage

3.4.6. Triggering

When checking and adjusting the trigger amplifiers, bear in mind that the various trigger circuits are interdepending as shown in the block diagram.

3.4.6.1. Trigger amplifiers (channel A and B) on intermediate amplifier circuit board

1. Shift
   - Depress push-button O of the channel A (B) signal-coupling controls.
   - Measure the voltage between points C and D (A and B).
   - Check that the voltage is 0 V ±10 mV; if necessary, readjust SHIFT potentiometer R301 (R201).

2. Zero level

   Before checking the zero level, the trigger amplifier must be checked in accordance with the previous section.

   - Depress push-button O of the channel A (B) signal-coupling controls.
   - Measure the voltage between point D (B) and earth.
   - Check that the measured voltage is 0 V ±10 mV; if necessary, readjust ZERO LEVEL potentiometer R304 (R204).

3.4.6.2. Trigger amplifier of the main time-base

Before checking and adjusting the trigger amplifier of the main time-base, the trigger amplifiers of channels A and B must be checked in accordance with the previous section.

1. Level
   - Depress push-button MAIN TB of the horizontal-deflection controls.
   - Depress push-button DC for channel A.
   - Depress push-button DC of the trigger-coupling controls.
   - Connect a sine voltage with 6 div. at 0,2 V/DIV, 100 kHz to the A input (B).
   - Set the TIME/DIV switch such that several cycles are displayed.
   - Change the slope switch between + and –. Adjust R737 (Trigg. sens.) for a gap of 0,2 div. between the trigger starting points.
   - Set the ATT switch to 2 V/div.; triggering must be possible with this 0,6 div signal. If necessary, readjust R737.
   - Depress push-button HF of the trigger-coupling controls.
   - Connect test point C to earth. (Base of TS637).
   - Shift with R709 (level) the trigger start point symmetrically around the zero line of the sine wave.

– Depress push-button DC of the trigger-coupling controls.
– Depress push-button A (B) (Comp.) of the trigger-source controls.
– Check that the trigger start point is symmetrical around the zero-line of the sine by changing the SLOPE switch from + to –; if necessary, readjust YA (YB) (COMP.) potentiometer R636 (R656), (R659).
– Depress push-button EXT of the trigger-source controls.
– SK24 depressed. (X AMPL/HOLD OFF KNOB).
– Connect the same input voltage of the Y channel to the EXT input.
Shift with R631 the trigger start point symmetrically around the zero-line of the sine.
– Remove earth connection from testpoint C.

2. L.F.

This control (R712) compensates for equal gain of the lf- and hf path of the trigger amplifier circuit. In this procedure a signal is applied to ch. A input, while the signal in the trigger circuit is shown on ch. B.

– Depress push-button B of the display-mode controls.
– Depress push-button NORM of the polarity controls.
– Depress push-button DC of the channel A signal-coupling controls.
– Depress push-button AC of the channel B signal-coupling controls.
– Depress push-button A of the trigger-source controls.
– Set the AMPL switch of channel A to 20 mV/DIV and the AMPL switch of channel B to 0.1 V/DIV.
– Apply a square-wave voltage of 120 mV, frequency 30 kHz, to input A.
– Apply the signal of test point A (TS634) or B (TS642) to channel B input.
– Set LEVEL control on the frontpanel for maximum signal to channel B.
– Check that the top of the displayed pulse is straight; if necessary, readjust LF GAIN potentiometer R712.
– Depress push-button LF of the trigger-coupling controls.
– Check that the displayed pulse is shaped as shown in Fig. 3.18.
– Depress push-button Hf of the trigger-coupling controls.
– Check that the displayed pulse is shaped as shown in Fig. 3.19.

3.4.6.3. Trigger amplifier of the delayed time-base

1. Level

– Depress push-button DEL'D TB of the horizontal-deflection controls.
– Depress push-button DC for channel A.
– Depress push-button DC of the del'd tb trigger-coupling controls.
– Set the TIME/DIV switch such that several cycles are displayed.
– Connect a sine voltage with 6 div. at 0,2 V/DIV 100 kHz to the A input (B).
– Change the slope switch between + and –. Adjust R1137 (TR GAIN) for a gap of 0,2 div. between the trigger starting points.
– Set the ATT switch to 2 V/DIV; triggering must be possible with this 0,6 div. signal. If necessary, readjust R1137.
– Depress push-button HF of the trigger-coupling controls.
– Connect test point C to earth (Base of TS1039).
– Shift with R1109 (level) the trigger start point symmetrically around the zero line of the sine wave.
– Depress push-button DC of the trigger-coupling controls.
– Depress push-button A (B) of the trigger-source controls.
– Check that the trigger starting point is symmetrical around the zero-line of the sine wave by changing the slope switch from + to –.
If necessary, readjust YA (YB) potentiometer R1036 (R1056).
– Depress push-button EXT of the trigger-source controls.
– Check that the trigger starting point is symmetrical around the zero-line of the sine wave by changing the slope switch from + to –.
If necessary, readjust EXT potentiometer R1031.
– Remove earth connection from test point C.

2. L.F. Gain

This control (R1112) compensates for equal gain of the lf- and hf path of the trigger amplifier circuit. In this procedure a signal is applied to ch. A input while the signal in the trigger circuit is shown on ch. B.

- Depress push-button B of the display-mode controls.
- Depress push-button NORM of the polarity controls.
- Depress push-button DC of the channel A signal-coupling controls.
- Depress push-button AC of the channel B signal-coupling controls.
- Depress push-button A of the trigger-source controls of the delayed-time base.
- Set the AMPL switch of channel A to 20 mV/DIV and the AMPL switch of channel B to 0.1 V/DIV.
- Apply a square-wave voltage of 120 mV, frequency 30 kHz, to input A.
- Apply the signal of testpoint A (TS1042) or B (TS1034) to ch. B input.
- Set LEVEL control on the front panel for maximum signal to ch. B.
- Check that the top of the displayed pulse is straight; if necessary, readjust LF GAIN potentiometer R1112.
- Depress push-button LF of the trigger-coupling controls of the delayed time-base.
- Check that the displayed pulse is shaped as shown in Fig. 3.18.
- Depress push-button HF of the trigger-coupling controls.
- Check that the displayed pulse is shaped as shown in Fig. 3.19.

Fig. 3.18. LF trigger coupling

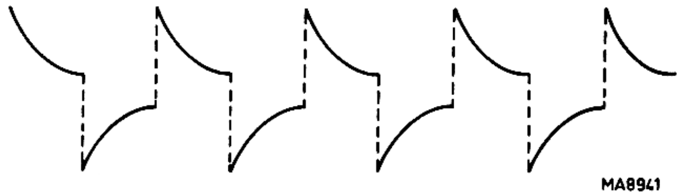

Fig. 3.19. HF trigger coupling

3.4.7. Sweep circuits

3.4.7.1. Main time-base

1. Stability

- Depress both O push-buttons of the signal-coupling controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Depress push-button TRIG of the trigger-mode.
- Set the DEL'D TIME/DIV switch to OFF.
- Rotate the LEVEL control fully anti-clockwise.
- Turn STAB potentiometer R806 fully clockwise.
- Rotate STAB potentiometer R806 anti-clockwise approx. 20^{o} past the point where the time-base line ceases to be displayed.
- Depress push-button AUTO of the trigger-mode and check if the sweep circuit is running.

2. Time coefficients

As the power supply may affect the sweep times, it must be checked when the sweep times are not correct.

- Connect a time marker generator to an Y input.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Push the TB MAGN control to position x1.
- Set the MAIN TIME/DIV switch to 0.1 ms.
- Apply a time-marker signal of 0,1 ms.
- Check that the 8 centre cycles cover exactly 8 div; if necessary, readjust X1 potentiometer R1462.
- Pull the TB MAGN control to position X10.
- Set the time-marker generator to 10 µs.
- Check that the 8 centre cycles cover exactly 8 div; if necessary, readjust X10 potentiometer R1444.
- Set the Time-marker to 2 ns.
- Set the MTB switch to 0,02 µs/DIV.
- Adjust with R1512 for 1 Marker/div (X position potm. middle position), see also linearity.
- Set the MAIN/TIME/DIV switch to 10 ms.
- Push the TB MAGN control to position X1.
- Set the time-marker generator to 10 ms.
- Check that for the 8 centre cycles a display of one cycle per div is obtained; if necessary, readjust 10 ms potentiometer R834.

3. Linearity

- Depress push-button MAIN TB of the horizontal-deflection controls.
- Pull the TB MAGN control to position X10.
- X position potm. middle position.
- Depress push-button AUT of the trigger-mode controls.
- Set the MAIN TIME/DIV switch to 0,02 μs.
- Time-marker signal 2 ns.
- Check that the 8 centre cycles cover 8 div; if necessary, readjust trimmers C1703 and C1707.

3.4.7.2. Delayed time-base

1. Stability

- Depress push-button O of the signal-coupling controls.
- Set the DELAY TIME control to zero.
- Depress push-button DEL'D TB of the horizontal-deflection controls.
- Depress push-button TRIG of the DEL'D TB trigger-mode controls.
- Depress push-button AUT of the MAIN TB trigger-mode controls.
- Set the MAIN TIME/DIV switch to 0.2 ms and the DEL'D TIME/DIV switch to 0.1 ms.
- Rotate the del'd tb LEVEL control fully anti-clockwise.
- Rotate STAB potentiometer R1206 on the delayed time-base board fully anti-clockwise.
- Rotate STAB potentiometer R1206 clockwise approx. 20^{o} past the point where the time-base line ceases to be displayed.

2. Time coefficients

- Connect a time marker generator to ch. A input.
- Set the DELAY TIME control to zero.
- Depress push-button DEL'D TB of the horizontal-deflection controls.
- Depress push-button TRIG of the DEL'D TB trigger-mode controls.
- Depress push-button AUTO of the MAIN TB trigger-mode controls.
- Set the MAIN TIME/DIV switch to 0.2 ms and the DEL'D TIME/DIV switch to 0.1 ms.
- Depress push-button DC of the del'd tb trigger-coupling controls.
- Depres push-button A of the del'd tb trigger-source controls.
- Apply a time-marker signal of 0.1 ms.
- Check that the 8 centre cycles cover exactly 8 div; if necessary, readjust 0.1 ms potentiometer R1227.
- Set the MAIN TIME/DIV switch to 20 ms and the DEL'D TIME/DIV switch to 10 ms.
- Set the time-marker generator to 10 ms.
- Check that the 8 centre cycles cover exactly 8 div; if necessary, readjust 10 ms potentiometer R1234.
- Set the Time-marker to 2 ns.
- Set the Delayed Time/Div to 0,02 μs/DIV.
- Pull the TB MAGN control to position X10.
- X position potmeter middle position.
- Adjust with R1517 for 1 Marker/Div.
- Check the sweep times in all other positions of the DEL'D TIME/DIV switch. Keep during this check the DELAY TIME control fully anti-clockwise and the MAIN TIME/DIV switch one position slower than the DEL'D TIME/DIV switch. In this way, the delayed time-base can complete an entire sweep.

3. Delay time

- Depress push-button A of the display-mode controls.
- Depress push-button DC of the signal-coupling controls.
- Depress push-button MAIN TB of the horizontal-deflection controls.
- Depress push-button AUTO and STARTS of the trigger-mode controls.
- Set the MAIN TIME/DIV switch to 1 ms and the DEL'D TIME/DIV switch to 0.5 ms.
- Turn the DELAY TIME Multiplier fully anti-clockwise.
- Adjust R1503 (DTB pos) so that the dtb starts at the same point as the mtb.
- Set the MAIN TIME/DIV switch to 0.1 ms and the DEL'D TIME/DIV switch to 0.05 μs.
- Depress push-button DC of the trigg-coupling controls.
- Depress push-button A of the trigger-source controls.
- Apply a time marker of 0.1 ms.
- Set the DELAY TIME control to 1.00.
- Check that the spot of the delayed time-base coincides with the starting point of the second time-marker pulse; if necessary, readjust START potentiometer R1514 on the switching-unit board.

– Set the DELAY TIME control to 9.00.
– Check that the spot of the delayed time-base coincides with the starting point of the tenth time-marker pulse; if necessary, readjust STOP potentiometer R1513 on the switching-unit board.

As the START and STOP adjustments are slightly interdependent, they must be repeated until both conditions are fulfilled.

4. Alternate Time-base

Check that with the Trace Sep. (front control) separation of min. 4 div can be obtained, if necessary adjust with R1657.

3.4.8. Horizontal deflection

3.4.8.1. Balance of the horizontal amplifier

If necessary, first check trigger amplifiers on the intermediate amplifier circuit board.

– Depress push-button MAIN TB of the horizontal-deflection controls.
– Push the TB MAGN control to X1.
– Set the X POSITION control to such a position, that the time-base line starts at the first vertical graticule line.
– Depress push-button EXT X DEFL of the horizontal-deflection controls.
– Depress push-button A of the X deflection-source controls.
– Check that the spot does not move more than 0.3 DIV when the X AMPL potentiometer is rotated clockwise and anti-clockwise; if necessary, readjust POS potentiometer R1401 on the switching-unit board.
– Check that after this adjustment the spot lies within one div from the screen centre.

3.4.8.2. X Deflection via channel A

– Depress push-button B of the display-mode controls (the vertical A channel is now blocked).
– Set the channel A AMPL switch to 0.5 V/DIV.
– Depress push-button AC of the signal-coupling controls.
– Depress push-button EXT X DEFL of the horizontal-deflection controls.
– X ampl control (R22) in the cal. position..
– Depress push-button A of the X deflection-source controls.
– Apply a sine-wave voltage of exactly 3 V^{p-p} frequency 2 kHz to input A.
– Check that the trace length is exactly 6 div; if necessary, readjust GAIN potentiometer R1419 on the switching-unit board.

3.4.8.3. X Deflection with the mains frequency

– Depress push-button EXT X DEFL of the horizontal-deflection controls.
– Depress push-button MAINS of the X deflection-source controls.
– Check that the trace width is 8 div ±1,5 div; (mains 220 V) if necessary, readjust potentiometer R669 on the mains time base circuit board.

3.4.8.4. X Deflection with external input

– X Ampl. control (R22) in cal. position and depressed.
– Apply a sine-wave voltage of 2400 mV, 2 kHz.
– Check for 8 div horizontal display.
– SK24 pulled out (Att. ÷ 3). (X AMPL. Knob)
– Apply a sine wave voltage of 7.2 V, 2 kHz.
– Check for 8 div horizontal display.

3.4.9. Power supply

Warning: Use an isolating mains transformer when working in the power supply unit.
Bear in mind that the main part of this unit is connected direct to the mains.

Attention: The power supply unit is provided with one pre-set potentiometer (R1828) which controls the d.c. output of the circuit.
Only adjust this potentiometer when strictly necessary. Adjusting this potentiometer includes that all d.c. output voltages change, so that several circuits of the oscilloscope (e.g. time base sweep) must be recalibrated.
Iñ the factory this potentiometer has been adjusted to the nominal value of the +15 V output (measured on point 6 of the 6-pole connector of the power supply).
This voltage must be +15 V + or −200 mV.

3.4.10. Calibration unit

- Check the CAL square wave for irregularities.
- Check that the amplitude is 3 V ±0.7 %; if necessary, readjust CAL potentiometer R1906 on the intermediate-amplifier board.
- Check that the frequency of the CAL voltage is 2 kHz ±2 %.
- Check that the CAL current is 6 mA ±1 %.

3.5. TEST AND REPAIR HINTS

3.5.1. General information

Refer also to 3.3.1.

- Use an isolating transformer when measurements must be made in the power supply.
- For measuring on the printed-wiring boards, test-pins with sharp points must be used. Be careful not to cause a short-circuit by letting the test-pin slip from the test point.
- Use an appropriate soldering iron and solder with a low melting point, if micro-miniature semi-conductors must be replaced (for recommended iron and solder, refer to section 3.3.15.1.). It is essential to earth the tip of the soldering iron to the mass of the oscilloscope.
- Be very careful not to bend the pins on the neck of the c.r.t., since this is likely to result in a gas-leak.
- Do not remove or insert hybrid circuits when the instrument is switched in.
- Do not plug and unplug connectors when the instrument is switched in.
- Do not touch any trim potentiometers or trimmers before a fault has been located.

3.5.2. Y Channels

3.5.2.1. General

If there is a fault in one of the Y channels, it can easily be traced to a certain unit by combining the attenuator of one channel and the intermediate amplifier part of the other channel.
This is simply a matter of plugging coaxial cables.

3.5.2.2. Attenuator

Be careful if a reed relay must be replaced. Such a relay consists of a glass tube, containing the contact points, and a coil. The coil is fitted around the glass tube, with a piece of foil in between for shielding. Since the glass tube is rather fragile, the connection wire of the relay must be bent and soldered with caution. Do not twist the connection wires, as this may cause broken glass-metal seal and unreliable contact inside the glass-tube.

3.5.2.3. Intermediate amplifier

- When you are measuring in the intermediate amplifier, do not remove the circuit blocks.
- If the AMPL vernier control does not work, first check IC203 (for channel A) or IC203 (for channel B).
- If the chopper square-wave is asymmetrical, which shows on the screen as a difference in brilliance of the two traces in the CHOP mode, check circuit block IC208.
- If the common-mode rejection factor is too low, check IC204 and IC304.

3.5.2.4. Final amplifier

- The final amplifier unit is unaccessible for measurements when it is still inside the oscilloscope. It is, however, possible to take the unit out of the oscilloscope (refer to section 3.3.6.) and operate it there.
  The multipole connector, the 50-Ohm-cables and the delay line must remain connected. The connections to the c.r.t. are too short, but is is possible to bypass the c.r.t. filter and leave it out of the circuit. The bypass can be made by interconnecting the lead from the collector of TS401 and the lead to R420 on the amplifier board, and the lead from TS402 and the lead to R431. In this way, there is a current path and a test oscilloscope may be connected across R420 ... R431. Only l.f. and d.c. measurements are possible, of course, with this method.
- If pulse-top errors arise spontaneously, check the c.r.t. filter for interruptions and contact failure.
  Check also the c.r.t. pins on corrosion.

3.5.3. Triggering

- The input stage can be normally measured on the base of the transistors. On the collectors, however, the signal is current. On the collectors of TS603 and TS618 the signal is voltage again. We refer all the time to components of the main time-base, but the same details apply to the delayed time-base.
- The emitter of TS634 is connected to test point A and the emitter of TS642 to test point B
  The signal on these test points is voltage and can be measured with the aid of an oscilloscope.

- Test point C is connected to the base of transistor TS637. The signal on this point is also voltage.
- Test point D is connected to point 4 of IC601.
  With an input signal of approx. 6 DIV applied to the oscilloscope, a square-wave can be measured on this point.
  If this signal is there and the oscilloscope cannot be triggered, the presence of an output signal on point 16 of IC601 must be checked. This signal consists of very narrow negative-going spikes which are best displayed on a sampling oscilloscope. You may also measure the pulses on point 14 of the circuit block. These pulses which are positive-going and control the auto-circuit are not as steep as the ones on point 16 and as such, easier to display.
  If there are pulses on point 14, you may almost take it for granted that there are also pulses on point 16.
- If there is no triggering, another fault possibility is stabistor GR606. On point 15 of IC601 is normally a voltage of 9 V, but with a faulty stabistor this voltage will be approx. 15 V.

3.5.4. Time-base generator

- The easiest way to test the time-base generator (we refer here to the main time-base generator, but a similar procedure applies to the delayed time-base) is to remove transistors TS807 and TS808, switch in a low sweep speed and short-circuit the cathode of GR801 to earth. During the time that this short-circuit exists, C807 is charged. The charging process can be traced through the time-base generator, where the changing level must be measured in all circuits.
  A fault is then located at a point which does not follow the changing level.
- Transistor TS807 can be removed without disturbing the working of the time-base generator.

3.5.5. Final X amplifier

- To check the d.c. balance of this stage, you may remove transistors TS1704 and TS1706. It is not possible to remove transistors furtheron in the circuit for this measurement, since one half of the circuit has been connected to +110 V and the other half to −110 V.
- All signals in the final X amplifier are currents, but voltage can be measured on the X deflection plates.
  The voltage on each plate must be approx. 32 V. If one of the plate voltages shows a considerable deviation from this value, the corresponding side of the amplifier must be checked. The must likely fault would be a faulty zener diode.

3.5.6. Z Unit

- If the trace brilliance cannot be turned down with the INTENS control, transistor TS509 and diode GR505 must be checked. The cause may be the following.
  If the connection wire of C522 is unplugged while the oscilloscope is operating, capacitor C522 is charged. When the cable is plugged in again, transistor TS509 and may-be diode GR505 are likely to be destroyed by the surge. So if you have disconnected the cable of C522 and you want to plug it in again, switch off the oscilloscope, discharge the capacitor, plug in the cable and switch the oscilloscope on again.
  Also be very careful if the unplugged capacitor-cable is dangling about in the circuitry, because this too may cause the same damage.
- If the 2-kV-generator breaks down, check transistor TS2004.

3.5.7. Power Supply

The best way to check the power supply is, when this unit is connected to the normal circuitry of the PM 3265. Provisions have been taken that the unit, after being taken out, remains connected to the instrument. To facilitate the removal, first disconnect the various connections of the power supply unit.
For locating a possible overload or short-circuit in the various units of the oscilloscope, the supply connectors of the units may be disconnected, one at the time. Also the supply currents can be measured on each contact of these connectors. To disconnect one contact of a connector carefully press (twice) the spring at the side of the contact and lift the contact out. Inserting an additional contact provided with a piece of extension wire simplifies current measurement. After replacing the original contact check the spring locking-action to prevent the contact from coming loose later-on.

When the power supply unit is overloaded, the current limitation is actuated. As a result of this, the power supply goes in the "hiccup" mode (3-seconds cycle time approx.). This is caused by, successively, slow charging of the capacitors C1808, 1809, starting of the chopper, activiation of current limiting transistor TS1808, discharging of the regulator capacitors and so on.

Another reason for the power supply going in the "hiccup" mode is, when the switching transistor TS1801 gets no base current from the regulator circuit. In this case capacitors C1808, 1809 are slowly charged until the chopper circuit starts which causes the discharge of these capacitors in a short time, and so on.

If necessary, the power supply unit only, can be checked with the aid of a dummy load, consisting of load resistors and capacitors and a 6 V pilot lamp; see Fig. 3.21.
If a fault is suspected in the power supply, the following procedure may help you to find what is wrong.

NOTE: The power supply must always be loaded with the nominal load.

Required instruments

- Variable mains transformer with isolated windings
  (e.g. Philips bench model 2422 529 00005 or
  panel model 2422 529 00006;
  input 220 V, output 0-248 V/3 A).
- Watt meter (to measure mains power input).
- Oscilloscope (5 MHz bandwidth).
- Resistor 100 Ω, 25 W (5322 115 50011).
- Resistor 22 Ω, 25 W (5322 115 50006).
- Resistors of 1 kΩ and 50 kΩ, 0.5 W.

Checking procedure

In the first part of this procedure the power supply circuit is checked while the regulating circuit is out of service. In this case always check that the sum-voltage across C1808 and C1809 never exceeds the sum of the voltages of GR1813 and GR1814.

- Connect the isolating/variable transformer to the mains.
  Connect the power supply in series with a 22 Ω, 25 W resistor, via a Watt meter to the isolating/variable transformer.
  Mains voltage 40 V. Remove current limiting transistor TS1808.
  Check that the sum voltage over C1808, C1809 rises to approx. 56 V within 2 or 3 seconds when the mains voltage is switched-on (the chopper circuit is not oscillating).
  The speed of the charging depends on the current-gain of TS1801.

  If this voltage over C1808, 1809 does not appear check the ripple eliminator circuit (TS1800, TS1805), check R1802 and check the chopper circuit on short-circuit.
- Connect a 1 kΩ resistor in parallel to the series-circuit of C1808, 1809 and check that the sum voltage over these capacitors drops to zero. Remove the 1 kΩ resistor and check that the voltage rises again to 56 V.
- Short circuit emittor-collector of TS1801. Keep the mains voltage on 40 V and start the chopper circuit (TS1803) by connecting for a short moment one base of TS1803 via a 50 kΩ resistor to point 4 of transformer T1802. The voltage over the 22 Ω resistor in the mains circuit must be approx. 3 V. The voltage over C1808, 1809 is then approx. 35 V.

  If the chopper does not oscillate, check the chopper circuit itself.
  If the chopper goes in the "hiccup" mode when the 50 kΩ resistor remains connected, check the d.c. output circuits of the power supply, and check the circuit connected to points 7 and 8 of T1802.
- Check the voltage on point 5 of T1802 with an oscilloscope.
  This must be a square wave of approx. 70 V_{p-p}, frequency approx. 17 kHz.
- Remove the 22 Ω resistor in the mains circuit.
  Increase the mains voltage until the voltage over C1808, 1809 amounts to 100 V (not higher otherwise the zener diodes GR1813 and 1814 will blow up). The chopper must start automatically.
  Check the pulse on the base of TS1801; the duty cycle of this pulse can be varied with R1828. If not, check the regulator circuit.
  Power consumption must be 50 W approx.
- Remove the short-circuit across TS1802; check that the pulse on the base of TS1801 changes at this moment.
- Fit current limiting transistor TS1808. Check whether the chopper circuit cuts out (goes in the "hiccup" mode) when the load of the power supply is increased by 50 % approx. To this end connect a 100 Ω, 25 W resistor to the +46 V output.
  There must be current limitation when power input exceeds approx. 72 W.
  Also when the +46 V output is short circuited the power supply goes in the "hiccup" mode.

– Mains voltage 90 V; if necessary adjust the +15 V output voltage (+ or – 150 mV tolerance is allowed) with the aid of R1828
Check again the voltage on point 5 of T1801 with an oscilloscope.
Frequency must be 18 to 22 kHz; check the shape of the chopper square-wave voltage.

– Vary the mains voltage between 90 and 248 V.
Check that the +15 V output remains constant (between + or – 75 mV).
Check the 50 % overload current limitation at 248 V (do not short circuit the output at 248 V mains).

WAVEFORMS IN THE POWER SUPPLY

(Photographs taken from storage oscilloscope PM 3251)

1. Mains ripple eliminator (TS1800)

a. A.C. Voltage on the emitter of TS1800
b. A.C. Voltage on the collector of TS1800
Both voltages are measured with respect to the negative pole of electrolytic capacitor C1806.
Mains voltage 220 V
PM 3251 settings: 5 V/DIV; 5 ms/DIV; external triggering from the mains.

2. Regulator input voltage versus voltage across switching transistor TS1801

a. Voltage on p3 with respect to p2 of IC1801
b. Collector-emitter voltage of TS1801; lower line is 0 V
mains voltage 220 V
PM 3251 settings: 220 mV/DIV for a; 100 V/DIV for b;
20 ms/DIV; external triggering from p5T1802.

3. Chopper

a. Voltage between p2 and p3 of transformer T1801
b. Voltage between p7 and p8 of transformer T1802
Mains voltage 220 V
PM 3251 settings: 5 V/DIV; 10 μs/DIV; external triggering from p5T1802.

4. Switching transistor TS1801

Current flowing through R1802

a. Mains voltage 110 V
b. Mains voltage 220 V
PM 3251 settings: 0.5 V/DIV (=0.4 A/DIV); 20 μs/DIV; external triggering from p5T1802.

5. Regulator input voltage at 220 V and 110 V mains voltage

Voltage on p3 with respect to p2 of IC1801
a. at 220 V
b. at 110 V
PM 3251 settings: 200 mV/DIV; 20 ms/DIV; external triggering from p5T1802.

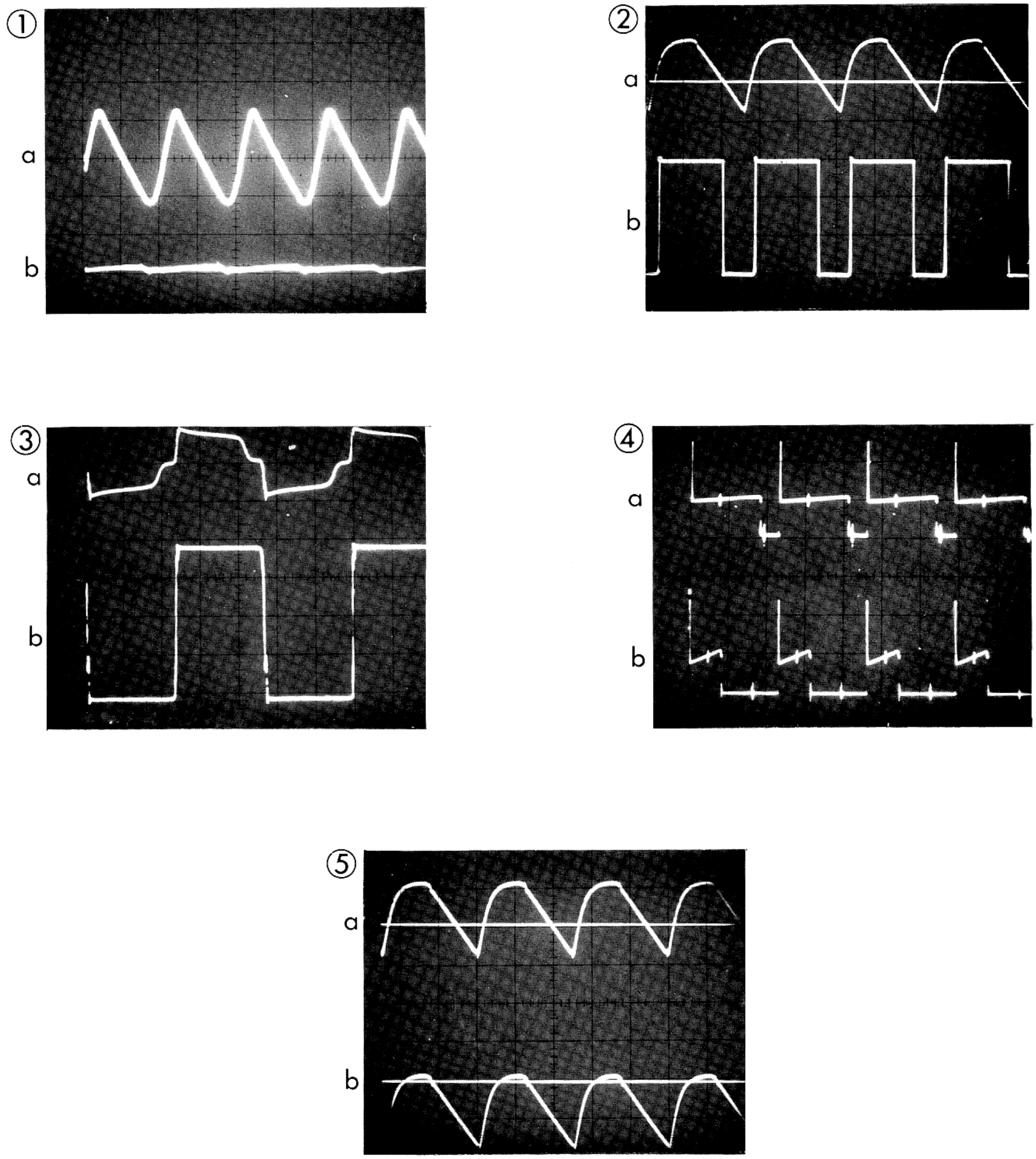

Fig. 3.20. Waveforms in the power supply

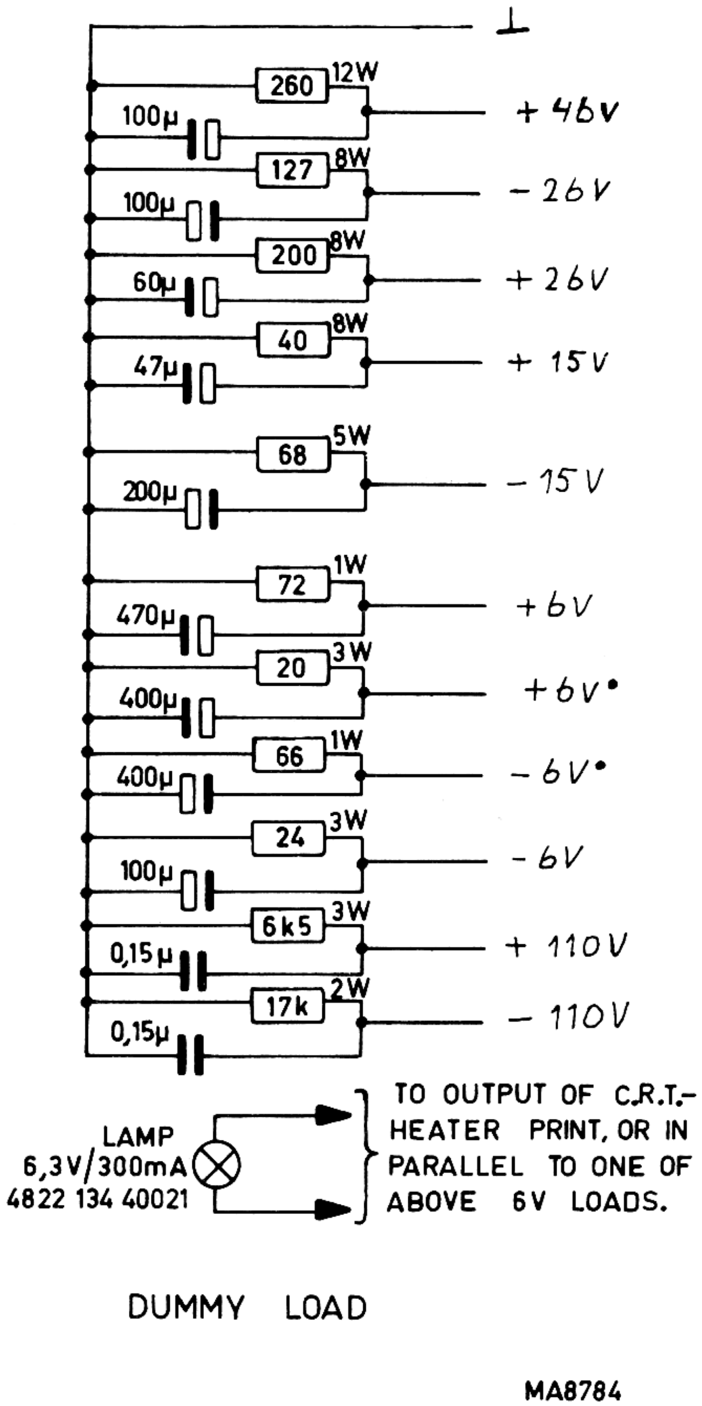

Fig. 3.21. Dummy load for power supply

3.6. MAINTENANCE

After removal (see section 3.3.) the cabinet plates may be cleaned with a mild non-abrasive houshold detergent. Do not use chemical solutions such as trichlorethylene and acetone.

The text plate may be cleaned with the same detergent, with alcohol or with white spirit. Always use a soft cloth or cotton wool.

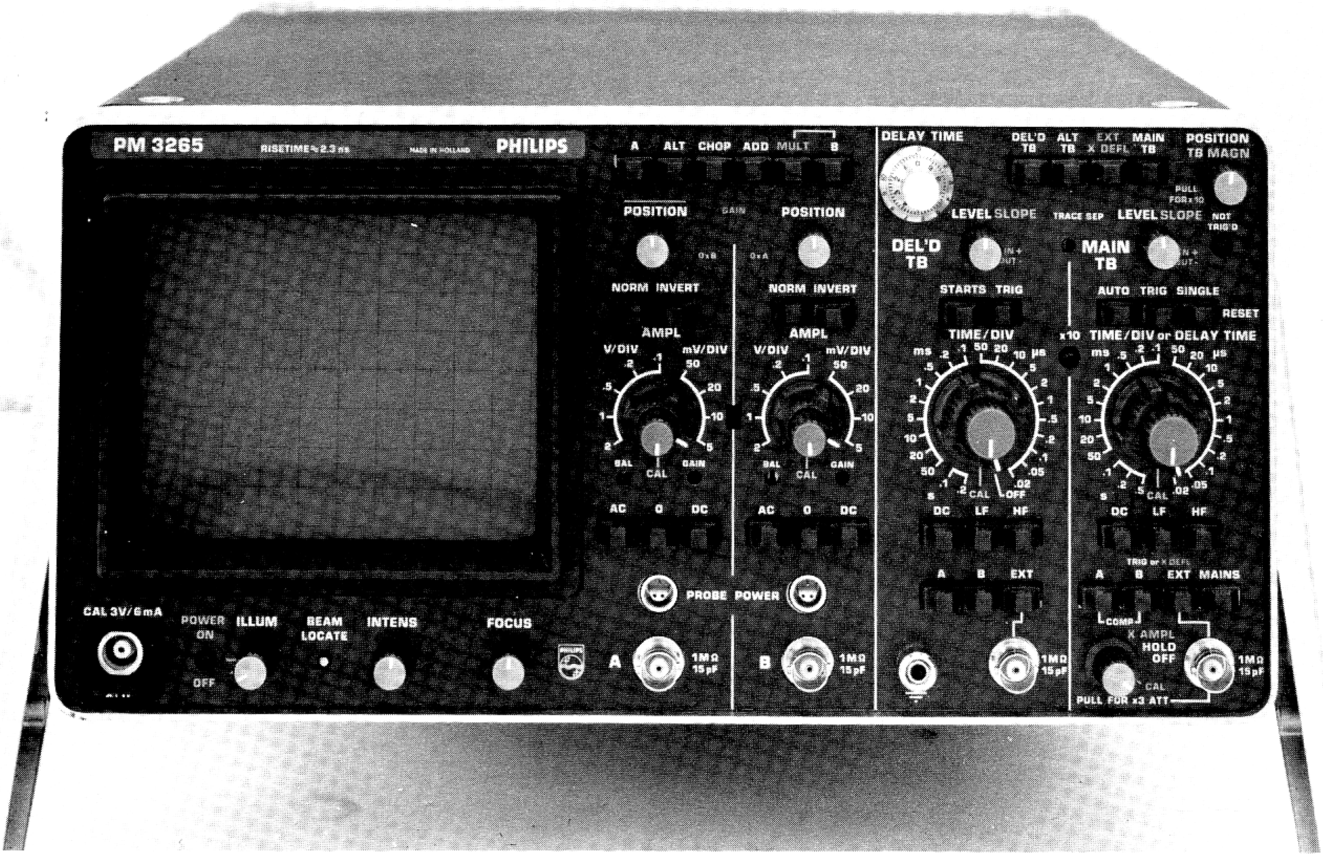

Fig. 3.22. Front view

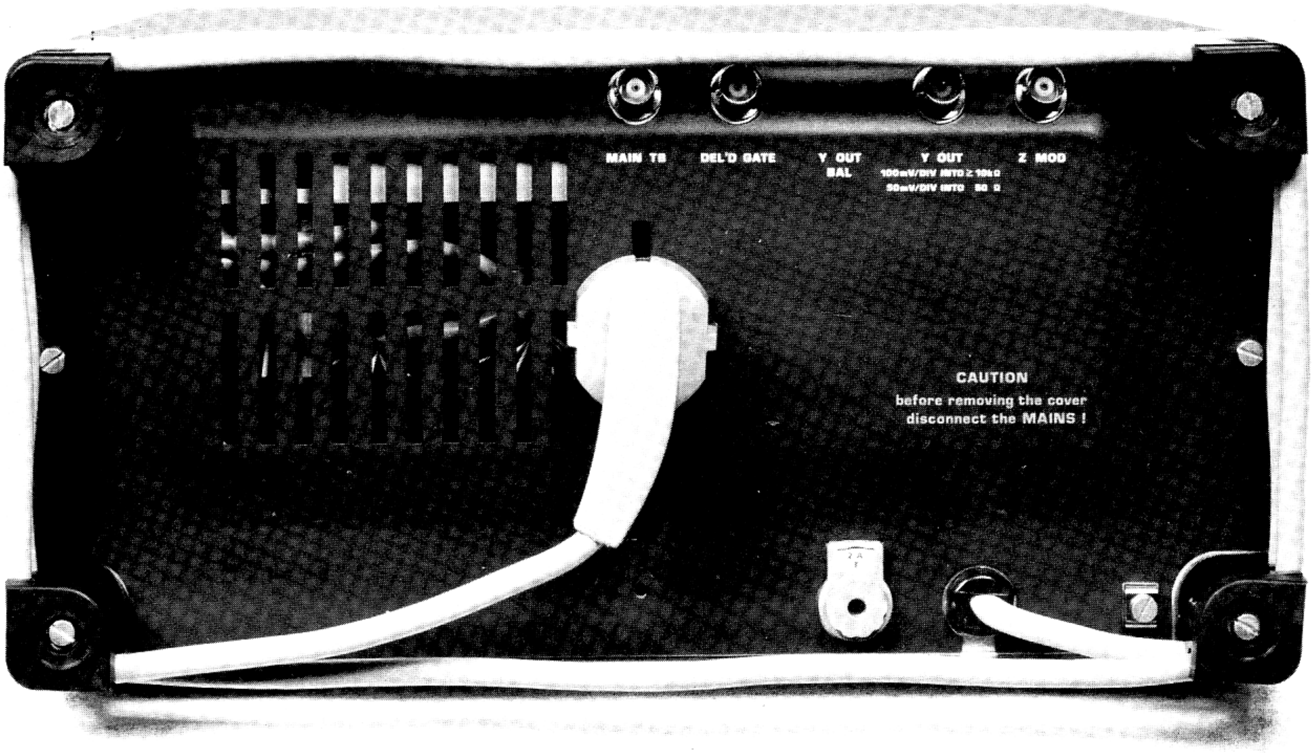

Fig. 3.23. Rear view